Monterey Bay
National Marine Sanctuary

CONDITION REPORT 2009

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NATIONAL MARINE SANCTUARIES

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Bathymetric grids provided by: Office of National Marine Sanctuaries. Feb. 2003. 70 meter bathymetric data. Original data sets from NOAA's Office of Coast Survey, and Monterey Bay Aquarium Research Institute. http://www.ccma.nos.noaa.gov/products/biogeography/canms_cd/htm/data.htm

Photos (clockwise):
Sea otter, S. Lonhart; Team OCEAN kayaker, NOAA/MBNMS; anemone, S. Lonhart; giant kelp, S. Lonhart; blood star, S. Lonhart; Snowy Egret, S. Lonhart; *Delta* submersible, C. King; copper rockfish, C. King

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Monterey Bay National Marine Sanctuary

- *6,094 square statue miles (4,602 square nautical miles)*
- *Congressionally designated in 1992 as a National Marine Sanctuary for the purpose of resource protection, research, education, and public use.*
- *Includes bays, estuaries, coastal and oceanic waters*
- *High diversity of flora and fauna including 33 species of marine mammals, 94 species of seabird, 345 species of fishes, and numerous species of invertebrates and plants*
- *Contains the Monterey Canyon, a submarine canyon that rivals the Grand Canyon in size*
- *Contains an estimated 225 documented shipwrecks or lost aircraft and 718 historic sites*

About this Report

This "condition report" provides a summary of resources in the National Oceanic and Atmospheric Administration's Monterey Bay National Marine Sanctuary, pressures on those resources, current condition and trends, and management responses to the pressures that threaten the integrity of the marine environment. Specifically, the document includes information on the status and trends of water quality, habitat, living resources and maritime archaeological resources and the human activities that affect them. It presents responses to a set of questions posed to all sanctuaries (Appendix A). Resource status of Monterey Bay is rated on a scale from good to poor, and the timelines used for comparison vary from topic to topic. Trends in the status of resources are also reported, and are generally based on observed changes in status over the past five years unless otherwise specified. In some cases, it was necessary to consider a longer time series to provide context for describing a current condition or trend. Sanctuary staff consulted with external experts familiar with the resources and with knowledge of previous and current scientific investigations. Evaluations of status and trends are based on interpretation of quantitative and, when necessary, non-quantitative assessments, and the observations of scientists, managers and users. The ratings reflect the collective interpretation of the status of local issues of concern among sanctuary program staff and external experts based on their knowledge and perceptions of local problems. Sanctuary staff determined the final ratings after reviewing all available data. This report has been peer-reviewed and complies with the White House Office of Management and Budget's peer review standards as outlined in the Final Information Quality Bulletin for Peer Review.

This is the first attempt to describe comprehensively the status, pressures and trends of resources at Monterey Bay National Marine Sanctuary. Additionally, the report helps identify gaps in current monitoring efforts and highlights areas where additional information is needed. The data discussed will enable sanctuary staff to not only acknowledge prior changes in resource status, but will also provide guidance for future management challenges imposed by issues such as increasing coastal populations, developing alternative energy sources, and climate change.

Summary and Findings

Monterey Bay National Marine Sanctuary is the largest national marine sanctuary and one of the largest marine protected areas in the United States. Within the boundaries of the sanctuary is a rich array of habitats, from rugged rocky shores and lush kelp forests to one of the largest underwater canyons in North America. These habitats abound with life, from mircoscopic organisms to enormous blue whales. The sanctuary is home to a diversity of species including marine mammals, seabirds and shorebirds, sea turtles, fishes, invertebrates, and marine algae.

Activities that put pressure on sanctuary resources are diverse. Some of the most prominent pressures include vessel traffic, commercial and recreational fishing, agricultural and urban runoff, harmful algal blooms, coastal development, marine debris, the introduction of non-indigenous species, and disturbances to wildlife.

Because of the considerable differences within the sanctuary between the offshore, nearshore, and estuarine environments, each question found in the State of the Sanctuary Resources section of this report was answered separately for each of these environments. The offshore environment is defined as extending from the 30-meter isobath out to the offshore boundary of the sanctuary and includes the seafloor and water column. The nearshore environment is defined as extending from the shoreline boundary of the sanctuary (mean high water) to the 30-meter isobath and includes the seafloor and water column. Though many small estuaries occur along the central California coastline, they are not within the boundaries of the sanctuary. Elkhorn Slough is the only large estuary located inside the boundaries of the Monterey Bay National Marine Sanctuary, and is thus the focus of the estuarine environment section in this report.

Water quality parameters in the offshore environment of the sanctuary suggest degraded conditions. The main contributors to degraded water quality conditions are land-based activities, such as those linked to urban development and agriculture that input contaminants and nutrients into offshore sanctuary waters, and vessel traffic that can result in the discharge of ballast water, bilge oil, and marine debris. Habitat modification has occurred in the offshore environment of the sanctuary; the most significant physical alteration of sanctuary habitats has likely resulted from fishing with bottom-contact gear, such as otter trawls. Among the various environmental impacts resulting from use of this type of gear are removal of structure-forming organisms and the smoothing of bedforms. A variety of recent management measures directed towards trawling may allow for an improvement in the condition of offshore habitats due to some recovery of seafloor habitats in the areas that were previously trawled. Living resource conditions within the offshore environment of the sanctuary are considered to be diminished as the relative abundance of many species, such as marine mammals, seabirds, and predatory fishes, have been altered substantially by both natural and anthropogenic pressures over the past several hundred years. In addition, the health of several key species has been compromised by exposure to neurotoxins produced by harmful algal blooms, entanglement in active and lost fishing gear, ingestion of marine debris, and accumulation of persistent contaminants. Recent management actions to reduce marine debris and to recover overfished stocks and impacted habitats were implemented to improve the state of living resources, and in some cases they have begun to do so. There is great uncertainty regarding the integrity of submerged maritime archaeological resources in the offshore environment in the sanctuary. The sanctuary's inventory contains information on known vessel losses, with little to no verified location information, and few visited sites. In addition, NOAA has conducted only one offshore archaeological site location inventory in the sanctuary.

Water quality parameters in the nearshore environment of the sanctuary suggest slightly more degraded conditions in comparison to the offshore environment. Specific stressors to water quality include the input of contaminants, nutrients, sediments, and pathogens from land-based activities that are linked to urban development and agriculture. Efforts to reduce pollution in the sanctuary may be offset by intensification of human activities in coastal watersheds that introduce pollutants to the nearshore environment. In the nearshore environment of the sanctuary there has been localized modification or loss of coastal habitat, primarily through armoring of coastal bluffs and beaches, erosion of sandy shoreline, and landslide disposal on rocky reef. On-going monitoring studies indicate that large, structural algae, seagrasses, and sessile habitat-forming invertebrates (e.g., sponges, anemones, tube worms) appear to be healthy and no major perturbations have been observed. The relative abundance of native species, including abalone, mussels, and sea otters, in the intertidal and nearshore subtidal zones has been altered throughout the sanctuary by a variety of factors including human activities, such as trampling and harvesting for human consumption. The recent implementation of multiple marine reserves and conservation areas in nearshore waters may facilitate recovery of reduced populations. Little is known about the submerged maritime archaeological resources in the nearshore environment of the sanctuary. To date, only one nearshore archaeological site location inventory has been conducted in the nearshore environment of Monterey Bay National Marine Sanctuary.

Over the past 150 years human actions have altered the tidal, freshwater, and sediment processes in the Elkhorn Slough and its watersheds. Such impacts have substantially changed the water quality conditions and have increased the levels of pollution in Elkhorn Slough. In addition, these alterations have resulted in substantial erosion and habitat conversion. Most notably, there has been a severe reduction in abundance of the two native species that form biogenic habitat in the main channel of Elkhorn Slough, eelgrass (*Zostera marina*) and native oyster (*Ostrea lurida*), as compared to historic levels. In addition, there is strong evidence that these changes to estuarine habitats have substantially altered local biodiversity in the past 150 years – some species, including burrowing sand anemones and the Atlantic soft-shell clam, that were noted as abundant in portions of the Elkhorn Slough in the 1920 and 1930s are now rarely encountered. Also, there is a very high percentage of non-native species in Elkhorn Slough, including the Japanese mud snail and the bright orange sponge. Management agencies have worked with local stakeholders to create regulatory, monitoring, education, and training programs and to implement better agricultural and urban management practices aimed at reducing or eliminating impacts to Elkhorn Slough. Little is known about the integrity of maritime archeological resources in Elkhorn Slough.

A new management plan for Monterey Bay National Marine Sanctuary was released in November 2008, and it contains a number of management actions that will address current issues and concerns. The plan stresses an ecosystem-based approach to management, which requires consideration of ecological interrelationships not only within the sanctuary, but within the larger context of the California Current ecosystem. It also makes essential an increased level of cooperation with other management agencies in the region. The management plan includes twenty-nine action plans that will guide the sanctuary for the next five to ten years.

National Marine Sanctuary System and System-Wide Monitoring

The Office of National Marine Sanctuaries manages marine areas in both nearshore and open ocean waters that range in size from less than one to almost 140,000 square miles. Each area has its own concerns and requirements for environmental monitoring, but ecosystem structure and function in all these areas have similarities and are influenced by common factors that interact in comparable ways. Furthermore, the human influences that affect the structure

One of the arches in Natural Bridges State Park in Santa Cruz is home to pelicans and cormorants.

and function of these sites are similar in a number of ways. For these reasons, in 2001 the program began to implement System-Wide Monitoring (SWiM). The monitoring framework (NMSP 2004) facilitates the development of effective, ecosystem-based monitoring programs that address management information needs using a design process that can be applied in a consistent way at multiple spatial scales and to multiple resource types. It identifies four primary components common among marine ecosystems: water, habitats, living resources and maritime archaeological resources.

By assuming that a common marine ecosystem framework can be applied to all sites, the Office of National Marine Sanctuaries developed a series of questions that are posed for every sanctuary and used as evaluation criteria to assess resource condition and trends. The questions, which are shown on the following page and explained in Appendix A, are derived from both a generalized ecosystem framework and the Office of National Marine Sanctuaries mission. They are widely applicable across the system of areas managed by the sanctuary program and provide a tool with which the program can measure its progress toward maintaining and improving natural and archaeological resource quality throughout the system.

Similar reports summarizing resource status and trends will be prepared for each marine sanctuary approximately every five years and updated as new information allows. Although this report follows a new Monterey Bay National Marine Sanctuary management plan, the information presented here is intended to help set the stage for management plan reviews at each site. The report also helps sanctuary staff identify monitoring, characterization and research priorities to address gaps, day-to-day information needs and new threats.

Monterey Bay National Marine Sanctuary Condition Summary Table

Offshore Environment

The following table summarizes the "State of Sanctuary Resources" section of this report. The first two columns list 17 questions used to rate the condition and trends for qualities of water, habitat, living resources, and maritime archaeological resources. The Rating column consists of a color, indicating resource condition, and a symbol, indicating trend (see key for definitions). The Basis for Judgment column provides a short statement or list of criteria used to justify the rating. The Description of Findings column presents the statement that best characterizes resource status, and corresponds to the assigned color rating. The Description of Findings statements are customized for all possible ratings for each question and are consistent across all sanctuary condition reports. Please see Appendix A for further clarification of the questions and the Description of Findings statements. The "State of Sanctuary Resources" section of the report provides a more thorough and detailed summary of the ratings and judgments described in this table.

Because of the considerable differences within the sanctuary between the offshore, nearshore, and estuarine environments, each question found in the State of the Sanctuary Resources section of this report was answered separately for each of these environments. **The offshore environment is defined as extending from the 30-meter isobath out to the offshore boundary of the Monterey Bay National Marine Sanctuary and includes the seafloor and water column.**

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends:
- Conditions appear to be improving .... ▲
- Conditions do not appear to be changing .... –
- Conditions appear to be declining .... ▼
- Undetermined trend .... ?
- Question not applicable .... N/A

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	Fair ▼	Elevated levels of contaminants (e.g., persistent organic pollutants), and ocean temperature and chemistry changes, some of which have been linked to changes in the offshore ecosystem.	Selected conditions may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats.	Improved vessel routing strategies reduce the risk of collisions and spills. Active water quality protection program is in place and involves planning, research, monitoring, education, and outreach. Recent addition of regulations limiting discharges from cruise ships.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	Good/Fair ▼	Nutrient enrichment in selected areas, increased nutrient loading, and increased frequency and intensity of harmful algal blooms.	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.	
3	Do sanctuary waters pose risks to human health?	Good/Fair ?	Measurable levels of biotoxins and contaminants in some locations that have the potential to affect human health; no reports of human impacts.	Selected conditions that have the potential to affect human health may exist but human impacts have not been reported.	
4	What are the levels of human activities that may influence water quality and how are they changing?	Fair ▲	Inputs of pollutants from agriculture and urban development; reduced risk of impacts from vessels due to regulation of traffic patterns and discharges; removal of oil from sunken ships.	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.	

Table is continued on the following page.

Monterey Bay National Marine Sanctuary Condition Summary Table Offshore Environment (Continued)

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
HABITAT					
5	What is the abundance and distribution of major habitat types and how is it changing?	?	Benthic habitat loss and modification due to fishing with bottom-contact gear; recovery of seafloor habitats resulting from management measures is unknown.	Selected habitat loss or alteration may inhibit the development of assemblages, and may cause measurable but not severe declines in living resources or water quality.	Trawl fishing closures in some areas are expected to reduce damage to bottom habitats. Installation of submerged cables is regulated and monitored. The recent incorporation of the Davidson Seamount into the sanctuary will increase protection of fragile structure-forming organisms. Multi-year, collaborative project to identify and remove lost fishing gear from the sanctuary.
6	What is the condition of biologically-structured habitats and how is it changing?	?	Damage to and loss of structure-forming and structure-building taxa due to trawl fishing; recovery of biogenic habitat resulting from management measures is unknown.	Selected habitat loss or alteration has caused or is likely to cause severe declines in some but not all living resources or water quality.	
7	What are the contaminant concentrations in sanctuary habitats and how are they changing?	▼	No evidence of strong ecosystem level effects; no attenuation of persistent contaminants in sediments; continued input and delivery of some contaminants to deep-sea habitats.	Selected contaminants may preclude full development of living resource assemblages, but are not likely to cause substantial or persistent degradation.	
8	What are the levels of human activities that may influence habitat quality and how are they changing?	▲	High levels of previous trawl fishing, but recent reductions in trawling activity. Accumulations of marine debris from land and ocean-based human activities.	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.	
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	?	Changes in relative abundance, particularly in targeted, by-catch, and sensitive species.	Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.	Research and monitoring programs supported by SIMoN focus heavily on addressing causes of impacts to living resources and evaluating the effectiveness of management actions. The sanctuary is developing ecosystem models and interagency collaborations to increase understanding of offshore resources. Sanctuary regulations and permits have minimizerd damage from submerged cables and human generated acoustics. The sanctuary is participating in a multi-year, collaborative project to identify and remove lost fishing gear from the sanctuary. Numerous areas are closed to trawl fishing. The recent incorporation of the Davidson Seamount into the sanctuary will increase protection of fragile structure-forming organisms.
10	What is the status of environmentally sustainable fishing and how is it changing?	▲	Abundance of many harvested species reduced below unfished levels, some targeted and non-targeted species have been drastically reduced by past fishing activity. Fishery management measures have assisted the initial recovery of some overfished groundfish.	Extraction may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.	
11	What is the status of non-indigenous species and how is it changing?	—	Very few non-indigenous species identified in offshore waters.	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).	
12	What is the status of key species and how is it changing?	—	Reduced abundance of a number of key pelagic species; some reductions caused by activities outside the sanctuary.	Selected key or keystone species are at reduced levels, perhaps precluding full community development and function, but substantial or persistent declines are not expected.	
13	What is the condition or health of key species and how is it changing?	▼	Compromised health due to exposure to neurotoxins produced by HABs, entanglement in active and lost fishing gear, ingestion of marine debris, and accumulation of persistent contaminants.	The condition of selected key resources is not optimal, perhaps precluding full ecological function, but substantial or persistent declines are not expected.	
14	What are the levels of human activities that may influence living resource quality and how are they changing?	▲	Fishing and inputs of marine debris have resulted in measurable impacts; recent management actions to reduce marine debris and to recover overfished stocks and impacted habitats.	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.	

Table is continued on the following page.

Monterey Bay National Marine Sanctuary Condition Summary Table
Offshore Environment (Continued)

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
MARITIME ARCHAEOLOGICAL RESOURCES					
15	What is the integrity of known maritime archaeological resources and how is it changing?	?	To date, only one of potentially hundreds of archaeological site inventories has been conducted.	Not enough information to make a determination.	Shipwreck characterization efforts are underway to locate, document, and assess submerged resources. Conducted surveys of the oil tanker *Montibello* in 2003, and the USS *Macon* in 2005 and 2006.
16	Do known maritime archaeological resources pose an environmental hazard and is this threat changing?	▼	Known resources containing hazardous material continue to deteriorate.	Selected maritime archaeological resources may pose isolated or limited environmental threats, but substantial or persistent impacts are not expected.	
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	?	Archaeological resources, particularly those that are undocumented, are vulnerable to degradation from trawling.	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.	

Monterey Bay National Marine Sanctuary Condition Summary Table

Nearshore Environment

The following table summarizes the "State of Sanctuary Resources" section of this report. The first two columns list 17 questions used to rate the condition and trends for qualities of water, habitat, living resources, and maritime archaeological resources. The Rating column consists of a color, indicating resource condition, and a symbol, indicating trend (see key for definitions). The Basis for Judgment column provides a short statement or list of criteria used to justify the rating. The Description of Findings column presents the statement that best characterizes resource status, and corresponds to the assigned color rating. The Description of Findings statements are customized for all possible ratings for each question. Please see Appendix A for further clarification of the questions and the Description of Findings statements. The "State of Sanctuary Resources" section of the report provides a more thorough and detailed summary of the ratings and judgments described in this table.

Because of the considerable differences within the sanctuary between the offshore, nearshore, and estuarine environments, each question found in the State of the Sanctuary Resources section of this report was answered separately for each of these environments. **The nearshore environment is defined as extending from the shoreline boundary of the Monterey Bay National Marine Sanctuary (mean high water) to the 30-meter isobath and includes the seafloor and water column.**

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends:
- Conditions appear to be improving ..... ▲
- Conditions do not appear to be changing ..... –
- Conditions appear to be declining ..... ▼
- Undetermined trend ..... ?
- Question not applicable ..... N/A

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	▼	Elevated levels of contaminants (e.g., POPs, heavy metals), nutrients, sediments, pathogens in some locations; ongoing input of established and emerging pollutants.	Selected conditions may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats.	Hazardous materials have been removed from some sunken or grounded vessels. Active water quality protection program is in place and involves planning, research, monitoring, education, and outreach. Sanctuary management plan increases focus on reducing point and non-point sources of contaminants into nearshore waters and decreasing beach closures.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	▼	Frequent, localized, and enhanced nutrient enrichment; frequent algal blooms sometimes linked to biotoxin accumulation in fish, birds and mammals.	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.	
3	Do sanctuary waters pose risks to human health?	?	Warnings and closures of some beaches and lagoons due pathogen indicators; contaminated shellfish at some locations and during some seasons.	Selected conditions have caused or are likely to cause severe impacts, but cases to date have not suggested a pervasive problem.	
4	What are the levels of human activities that may influence water quality and how are they changing?	?	Efforts to reduce pollution may be offset by intensification of human activities in coastal watersheds.	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.	
HABITAT					
5	What is the abundance and distribution of major habitat types and how is it changing?	–	Localized modification or loss of coastal habitat, primarily through armoring of coastal bluff, erosion of sandy shoreline, and landslide disposal on rocky reef.	Selected habitat loss or alteration has taken place, precluding full development of living resource assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.	Vessel routing patterns reduce the risk of groundings. Bottom trawling has been banned in state waters. Sanctuary management plan increases focus on coastal development through the coastal armoring, desalination, and dredging action plans. The sanctuary supports the monitoring of contaminants in nearshore habitats.
6	What is the condition of biologically-structured habitats and how is it changing?	–	Monitoring programs indicate healthy populations and no major perturbations.	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.	
7	What are the contaminant concentrations in sanctuary habitats and how are they changing?	▼	Elevated contaminants near urban, maritime, or agricultural sources; continued input of contaminants from point and non-point sources.	Selected contaminants may inhibit the development of assemblages and may cause measurable but not severe declines in living resources or water quality.	
8	What are the levels of human activities that may influence habitat quality and how are they changing?	?	Trampling, all forms of extraction, and sediment disposal can have measurable, localized impacts; cumulative trend for the numerous activities not determined.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.	

Table is continued on the following page.

Monterey Bay National Marine Sanctuary Condition Summary Table
Nearshore Environment (Continued)

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	?	Fishing, collecting, and poaching have reduced overall biodiversity; improvements likely in new protected areas, but continued impacts at some locations on rocky shores.	Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.	Research and monitoring programs supported by SIMoN focus heavily on addressing causes of impacts to living resources and evaluating the effectiveness of management actions. Shoreline and kayak-based interpreters help visitors reduce impacts to wildlife. Sanctuary management plan increases focus on conservation of living resources through the Marine Protected Areas, Introduced Species, and Wildlife Disturbance action plans. Participation in research and a long-range management plan to reduce impacts from landslide repair and disposal activities. Public outreach programs to promote stewardship of endangered and protected species.
10	What is the status of environmentally sustainable fishing and how is it changing?	▲	Studies have found decreased abundance and size structure in fished areas compared to marine reserves. Restrictive management strategies have improved the status of previously overfished stocks.	Extraction may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.	
11	What is the status of non-indigenous species and how is it changing?	▼	A few non-indigenous species have been identified, and some appear to be spreading.	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).	
12	What is the status of key species and how is it changing?	—	Abundance of some key species in each habitat type is lower than would be expected in a natural state. Possible community-level impacts on rocky shores.	Selected key or keystone species are at reduced levels, perhaps precluding full community development and function, but substantial or persistent declines are not expected.	
13	What is the condition or health of key species and how is it changing?	—	Evidence of recent impacts from withering syndrome on black abalone. Clear evidence of health problems in sea otters, but limited or no data for other species that may be affected.	The diminished condition of selected key resources may cause a measurable but not severe reduction in ecological function, but recovery is possible.	
14	What are the levels of human activities that may influence living resource quality and how are they changing?	▼	Variety of visitation, extraction, and coastal development activities, some of which are increasing in frequency.	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.	
MARITIME ARCHAEOLOGICAL RESOURCES					
15	What is the integrity of known maritime archaeological resources and how is it changing?	?	Divers have looted sites, but not all sites have been studied to determine trend.	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, scientific, or educational value, and may affect the eligibility of some sites for listing in the National Register of Historic Places.	Shipwreck characterization efforts are underway to locate, document, and assess submerged resources. Sanctuary management plan increases focus on identifying, protecting, and raising awareness of maritime archaeological resources in the sanctuary.
16	Do known maritime archaeological resources pose an environmental hazard and is this threat changing?	—	MBNMS Resource Inventory indicates no known environmental hazards.	Known maritime archaeological resources pose few or no environmental threats.	
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	?	Recreational diving occurs on wreck sites, but activity level is unknown.	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.	

Monterey Bay National Marine Sanctuary Condition Summary Table

Estuarine Environment

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Because of the considerable differences within the sanctuary between the offshore, nearshore, and estuarine environments, each question found in the State of the Sanctuary Resources section of this report was answered separately for each of these environments. **Though many small estuaries occur along the central California coastline, only Elkhorn Slough is located inside the boundaries of the Monterey Bay National Marine Sanctuary.**

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends:
- Conditions appear to be improving .... ▲
- Conditions do not appear to be changing .... –
- Conditions appear to be declining .... ▼
- Undetermined trend .... ?
- Question not applicable .... N/A

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	▼ (Fair/Poor)	Major alternations to tidal, freshwater, and sediment processes has increased the level of pollution and eutrophication; inputs of pollutants from agricultural and urbanized land sources.	Selected conditions have caused or are likely to cause severe declines in some but not all living resources and habitats.	Active water quality protection program is in place and involves coordination with regulatory programs, agriculture and municipalities to reduce inputs and impacts.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	— (Fair)	Low dissolved oxygen levels and high nutrient concentrations are observed but strong tidal flushing dilutes concentrations in main channel.	Selected conditions may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats.	
3	Do sanctuary waters pose risks to human health?	? (Fair/Poor)	Elkhorn Slough and connected waterbodies are impaired by pesticides and pathogens. High levels of contaminants in harvested crustaceans and bivalves could pose a risk to human health.	Selected conditions have caused or are likely to cause severe impacts, but cases to date have not suggested a pervasive problem.	
4	What are the levels of human activities that may influence water quality and how are they changing?	? (Fair)	Substantial inputs of pollutants from non-point sources, especially agriculture. Significant efforts over past ten years to implement best management practices and educate local land owners. No evidence yet of improving water quality due to changes in land management practices.	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.	
HABITAT					
5	What is the abundance and distribution of major habitat types and how is it changing?	▼ (Fair/Poor)	Over 150 years of hydrologic alteration has resulted in substantial erosion and habitat conversion.	Selected habitat loss or alteration has caused or is likely to cause severe declines in some but not all living resources or water quality.	Active involvement in the Elkhorn Slough Tidal Wetland Project strategic planning and science teams. SIMoN program provides support for research projects in Elkhorn Slough, including monitoring tidal erosion and modeling hydrodynamics and sedimentation.
6	What is the condition of biologically-structured habitats and how is it changing?	▼ (Poor)	Severe reductions in the abundance of native structure-forming organisms from historic levels.	Selected habitat loss or alteration has caused or is likely to cause severe declines in most if not all living resources or water quality.	
7	What are the contaminant concentrations in sanctuary habitats and how are they changing?	▼ (Fair)	Numerous contaminants present and at high levels at localized areas with limited evidence of community level impacts; on-going input of currently applied pesticides and lack of attenuation of legacy pesticides.	Selected contaminants may inhibit the development of assemblages and may cause measurable but not severe declines in living resources or water quality.	
8	What are the levels of human activities that may influence habitat quality and how are they changing?	— (Poor)	Past hydrologic changes, continued dredging and maintenance of water diversion structures, and input of agricultural non-point source pollution. Management activities have the potential to reduce the input of pollution.	Selected activities warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts have occurred or are likely to occur.	

Table is continued on the following page.

Monterey Bay National Marine Sanctuary Condition Summary Table
Estuarine Environment (Continued)

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	?	Changes in the relative abundance of some species associated with specific estuarine habitats. Overall trend cannot be determined.	Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.	Partnered with Elkhorn Slough National Estuarine Research Reserve to create an early detection program for non-indigenous species. SIMoN program provides support for research projects on living resources in Elkhorn Slough, including characterization of the benthic and planktonic communities in the main channel and the fish and crab assemblages in shallow-water habitats.
10	What is the status of environmentally sustainable fishing and how is it changing?	▲	There is limited take of shellfish and mudflat invertebrates in the lower slough as well as limited fishing and hunting. New state marine protected areas reduce or eliminate fishing.	Extraction takes place, precluding full community development and function, but it is unlikely to cause substantial or persistent degradation of ecosystem integrity.	
11	What is the status of non-indigenous species and how is it changing?	—	High percentage of non-native species, no known recent introductions.	Non-indigenous species have caused or are likely to cause severe declines in ecosystem integrity.	
12	What is the status of key species and how is it changing?	▼	Abundance of native oyster, eelgrass, and salt marsh are substantially reduced compared to historic levels; continued loss and conversion of salt marsh.	The reduced abundance of selected keystone species has caused or is likely to cause severe declines in some but not all ecosystem components, and reduce ecosystem integrity; or selected key species are at substantially reduced levels, and prospects for recovery are uncertain.	
13	What is the condition or health of key species and how is it changing?	?	No direct measurements of health or condition have been made for eelgrass and oysters, and salt marsh.	Not enough information to make a determination.	
14	What are the levels of human activities that may influence living resource quality and how are they changing?	?	Impacts result from hydrologic modifications, inputs of pollutants from agriculture and development, introduction of non-indigenous species, harvesting, entrainment of larvae in power plant intakes; no clear overall trend in human activities.	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.	
MARITIME ARCHAEOLOGICAL RESOURCES					
15	What is the integrity of known maritime archaeological resources and how is it changing?	?	Very little is known for this area.	Not enough information to make a determination.	No current management efforts directed at the two known archaeological sites within sanctuary areas of Elkhorn Slough.
16	Do known maritime archaeological resources pose an environmental hazard and is this threat changing?	—	No known environmental hazards.	Known maritime archaeological resources pose few or no environmental threats.	
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	—	Existing human activities do not influence archaeological resources.	Few or no activities occur that are likely to negatively affect maritime archaeological resource integrity.	

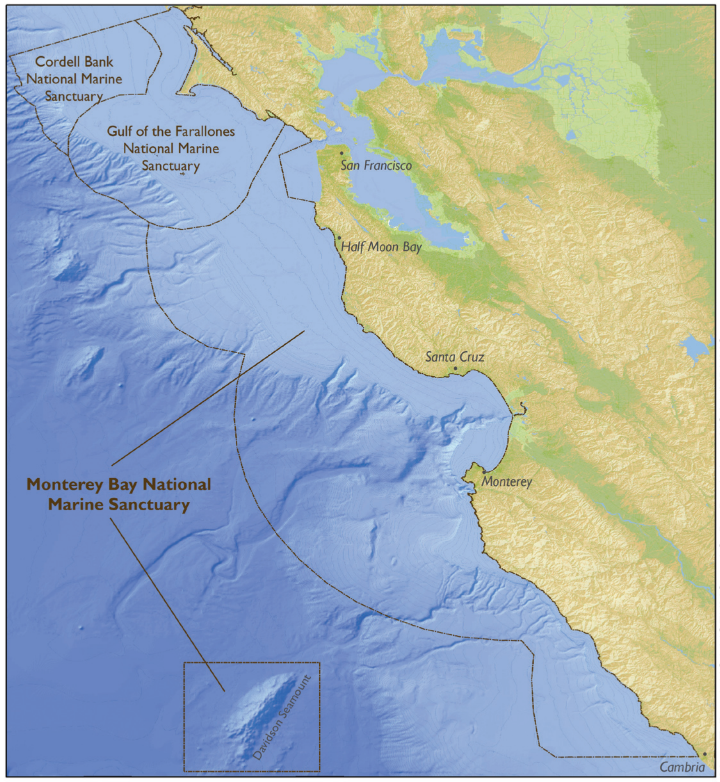
Site History and Resources

The Monterey Bay National Marine Sanctuary (Figure 1) is the largest national marine sanctuary and one of the largest marine protected areas in the United States. The sanctuary encompasses a shoreline length of approximately 276 statute miles (240 nmi) between Marin Rocky Pt. in Marin County in the north to Cambria in San Luis Obispo County in the south (about one-fourth of the California coast). It encompasses 6,094 square statute miles (4,602 square nmi) of ocean, which is larger than the state of Connecticut (73 FR 70487).

Within the boundaries of the sanctuary is a rich array of habitats, from rugged rocky shores and lush kelp forests to one of the largest underwater canyons in North America. These habitats abound with life, from microscopic organisms to enormous blue whales. The sanctuary is home to a diversity of species including marine mammals, seabirds and shorebirds, sea turtles, fishes, invertebrates, and marine algae.

There is a substantial human dimension to the Monterey Bay sanctuary with several urban centers and approximately 3 million people living within 80 kilometers of its shoreline, many of whom rely on sanctuary resources for pleasure or work. With its great diversity of habitats and life, and due to the human communities along its shoreline, the sanctuary is a national focus for recreation, research, and education.

Maritime archaeological resources abound as well. Four hundred forty-five vessel and aircraft losses were documented between 1595 and 1950 within or adjacent to the boundary of the sanctuary (Smith and Hunter 2003). Many wrecks were a result of the significant maritime exploration and commerce that historically occurred in the region, coupled with a coastline dotted with shallow, rocky headlands,



Map: T. Reed, NOAA/GFNMS and S. De Beukelaer, NOAA/MBNMS

Figure 1. The Monterey Bay National Marine Sanctuary, located along the coast of central California, encompasses 6,094 square statute miles (4,602 square nmi). It shares its northern boundary with the Gulf of the Farallones National Marine Sanctuary. In November 2008, NOAA released the new management plan for the sanctuary, which includes the expansion of the sanctuary to include the Davidson Seamount, one of the largest underwater mountains in U.S. coastal waters. The boundary change adds a 775 square statute mile area to the sanctuary, approximately 29 miles per side around the seamount. This condition report does not include a consideration of the resources contained in this undersea mountain habitat due to the very recent addition of the seamount to the sanctuary. However, these resources will be considered in future condition reports.

Sharing Boundaries

Three of the 13 marine sanctuaries have contiguous boundaries. Cordell Bank, Gulf of the Farallones and Monterey Bay National Marine Sanctuaries all reside within a coastal marine ecosystem dominated by the California Current. While each has distinct features and settings, many resources are similar and some even move freely between the sanctuaries. Therefore, site management is not always determined by site boundaries. Staff of the three sanctuaries share responsibilities for research, monitoring, education, enforcement, management plan development and other activities required to protect the region's natural and cultural heritage resources.

largely exposed to prevailing winds, storms, and fog. The sanctuary is responsible for the protection and management of historical and cultural resources within its boundary.

Early Settlement and Exploration

For more than 4,000 years before the arrival of the Spanish in the 1700s, the Monterey Bay region was inhabited by approximately 50 or more groups of Native Americans, collectively referred to as the Ohlone (Terrell 2007). The rich and stable environment at that time permitted the development of organized societies that used clamshell disk beads and other items as currency for trading with other groups, such as the Chumash to the south (Terrell 2007). They subsisted through collection of acorns and shellfish, and hunting of birds, fishes, small mammals, seals, and sea lions (Terrell 2007). In 1603 the Spanish briefly explored and named Monterey Bay, but European settlement of the area did not begin until 1770 (Terrell 2007). The Spanish built missions at Santa Cruz, Monterey and Carmel.

Within decades of Spanish settlement, Monterey had become one of California's trade centers, with sea otter and seal pelts being one of the main trade items. Trade rapidly expanded to include Mexican, English, Russian and Yankee traders. In the mid-1800s Monterey was primarily a hub of the ranchero economy dominated by Spanish and Mexican settlers (Terrell 2007). Santa Cruz, on the northern side of the Bay, became a hub of the Yankee trade economy as the number of American and foreign settlers rose rapidly in the early decades of the 19th century (Terrell 2007). The Gold Rush economy, centered in San Francisco, spurred coastal trade and the abundant fisheries in Monterey Bay and agricultural resources of the Salinas Valley became a main commodity for the region, a pattern that continued well into the 20th century (Terrell 2007).

Designation of the Sanctuary

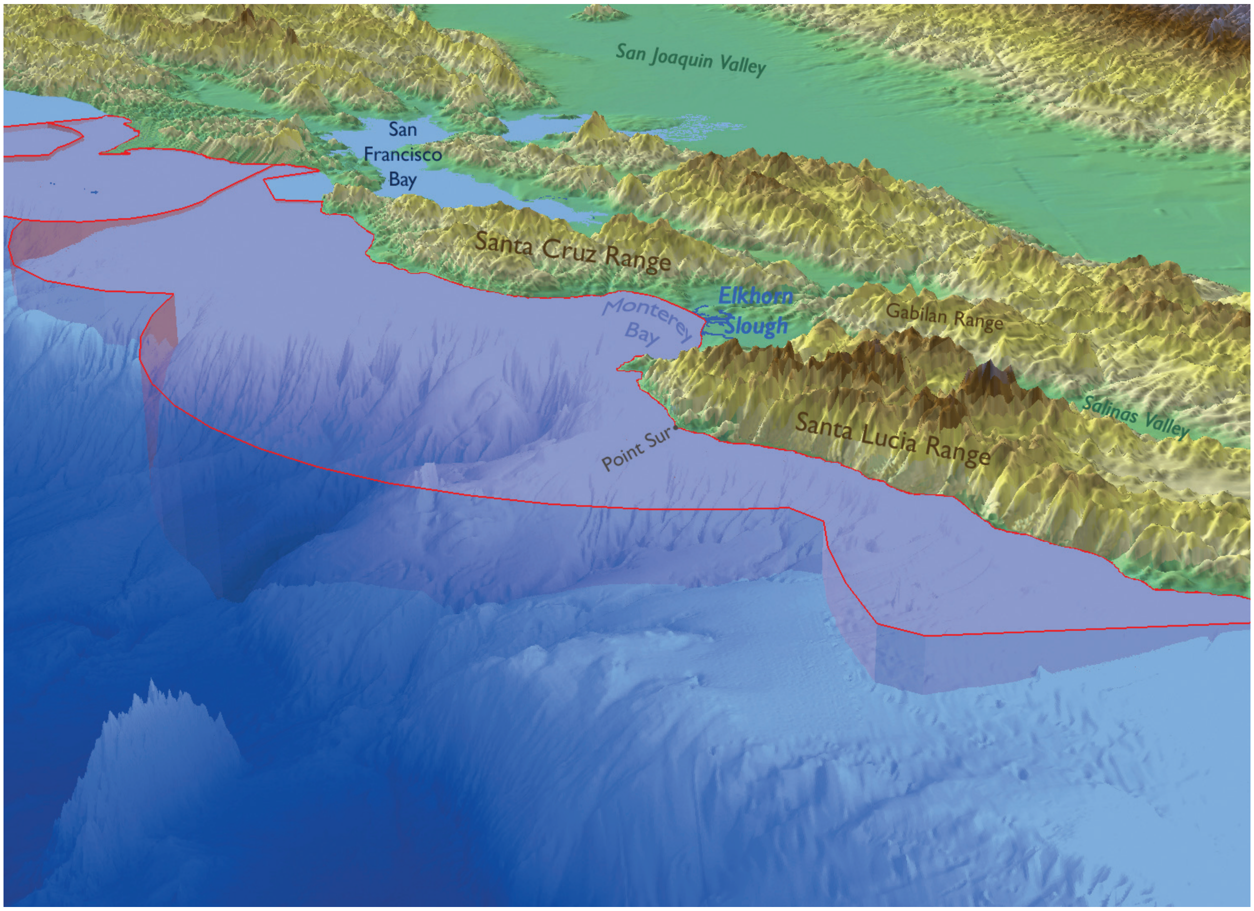
In 1977, the state of California nominated Monterey Bay and nine other locations along the Pacific Coast for consideration as national marine sanctuaries. Based on favorable public response, three of these sites were declared active candidates for designation: Monterey Bay, Channel Islands, and Point Reyes-Farallon Islands. This process eventually led to the designation of Channel Islands National Marine Sanctuary in 1980 and the Point Reyes-Farallon Islands National Marine Sanctuary (later renamed Gulf of the Farallones National Marine Sanctuary) in 1981. In 1983, NOAA removed Monterey Bay from its list of active candidates, recognizing that similar marine environments were already protected by California's two new sanctuaries and that a sanctuary of Monterey Bay's size would impose a heavy administrative burden on a program with limited resources.

Davidson Seamount

On Nov. 20, 2008, NOAA released final revised management plans, regulations and a joint final environmental impact statement for Cordell Bank, Gulf of the Farallones and Monterey Bay national marine sanctuaries. The plans include the expansion of Monterey Bay National Marine Sanctuary by 775 square statute miles to include the Davidson Seamount (Figure 1), one of the largest known underwater mountains in U.S. coastal waters and home to a wide variety of marine species.

In order to address the set of 17 questions related to this condition report, a workshop with local subject matter experts was convened in May 2007, and in August 2007 a draft report was reviewed by a team of peer reviewers. The comments and recommendations of these reviewers were received, considered by sanctuary staff, and incorporated, as appropriate, into a draft document prior to the release of the new management plan (more information on this process is explained in Appendix B of this report). Because input from subject matter experts and external reviewers was received before the Davidson Seamount was included as part of Monterey Bay National Marine Sanctuary, the condition report does not include a consideration of the resources contained in this undersea mountain habitat. However, these resources will be considered in future iterations of the condition report.

More information on the Davidson Seamount is available at http://www.montereybay.noaa.gov/research/dsmz/welcome.html. The final revised management plans, regulations and joint final environmental impact statement are available at http://sanctuaries.noaa.gov/jointplan.



Map: S. De Beukelaer, NOAA/MBNMS

Figure 2. Bathymetry of the Monterey Bay National Marine Sanctuary highlighting the submarine canyons and deep sea. There is a 1.5-unit vertical exaggeration in this map.

The citizens of central California, however, would not give up on the idea of a sanctuary for their region. Following five years of grassroots campaigning, along with the dedicated support of then-Congressman Leon Panetta, Congress directed NOAA to reinstate Monterey Bay as an active candidate for sanctuary status in 1988. After another four years of public meetings and preparation of several detailed planning documents, Monterey Bay National Marine Sanctuary was officially designated on Sept. 18, 1992 (NMSP 2002).

Geology

The Monterey Bay sanctuary contains one of the world's most geologically diverse and complex seafloors and continental margins (Figure 2). The Monterey Bay sanctuary is located on a plate boundary that separates the North American Plate from the Pacific Plate and is marked by the San Andreas fault system. This is an active tectonic region with common occurrences of earthquakes, submarine landslides, turbidity currents, flood discharges and coastal erosion.

Coastal topography varies greatly, encompassing steep bluffs with flat-topped terraces and pocket beaches to the north; large sandy beaches bordered by cliffs and large dune fields around Monterey Bay; and predominately steep, rocky cliffs to the south. The Santa Cruz mountain range dominates the topography in the northern portion of the sanctuary. Two major rivers (San Lorenzo and Pajaro Rivers) and a major creek (Scott Creek) enter Monterey Bay from these highlands through well-defined valleys. Elkhorn Slough, an old river estuary that today is occupied by tidal salt marshes, extends inland as part of the sanctuary from Moss Landing for more than 10 kilometers. The broad, extensive Salinas Valley is located between the Santa Lucia and Gabilan Ranges which are the dominant topographic features in the southern region; the Salinas River is the major drainage system. South of Monterey, the west flank of the Santa Lucia Range drops abruptly into the ocean. Here, the valleys of the Carmel

Photo: N. Capps, NOAA/MBNMS

Figure 3. Container ships traveling between major shipping ports in southern California and San Francisco transit through the offshore waters of the Monterey Bay National Marine Sanctuary.

and Little Sur Rivers are dominant topographic features. From Point Sur to Morro Bay many streams and creeks drain the southern Santa Lucias and cut the steep western face of the mountain range.

The Monterey Bay sanctuary seafloor can be divided into three segments based on seafloor morphology. The northern segment, which lies between the southern Farallon Islands-Tomales Bay area and Point Año Nuevo, is composed of a relatively broad-shelfed, smooth and undissected seafloor. The most prominent features here are the headward parts of Pioneer Canyon, which continue from within the Monterey Bay sanctuary down the continental slope and out onto the abyssal plain west of the sanctuary boundary. The central segment extends from the Point Año Nuevo area to south of Point Sur. It contains the most geologically diverse seafloor within the Monterey Bay sanctuary. The most dramatic features are the Ascension-Monterey Canyon system, which has extensively dissected the continental shelf and slope in the Monterey Bay area, and the many heads of Sur Canyon, which have cut the continental slope just south of Point Sur. The southern segment extends from south of Point Sur to Morro Bay. Here the sanctuary averages only 25 kilometers wide, and contains a very narrow, moderately dissected continental shelf.

Commerce

There is a rich history of human use of central California's marine resources, beginning with the Native Americans and continuing to the present. Today the sanctuary's spectacular scenery, moderate climate, abundant marine life, and relatively clean ocean waters all draw large numbers of divers, kayakers, boaters, fishermen, surfers, tidepoolers, and bird and mammal watchers. Coastal tourism, agriculture, and commercial and recreational fisheries are all contributors to the regional economy with direct links to the sanctuary.

Travel and tourism is one of the most significant industries, with a total travel-spending revenue in 2003 of $5.9 billion for the five counties adjacent to the sanctuary (NOAA 2008a). Two of the main reasons given for travel to the coastal region are its natural and scenic beauty and recreational opportunities. Agriculture was valued at $3.65 billion for the region, including inland counties Santa Clara and San Benito, in 1999. Monterey County, valued at $2.44 billion, is by far the most significant producer in the region and ranks third highest statewide (NOAA 2008a). In 2007, 560 fishing vessels made commercial landings at the five main ports in or adjacent to the Monterey Bay National Marine Sactuary: Princeton/Half Moon Bay, Santa Cruz, Moss Landing, Monterey, or Morro Bay (Bob Leos, CDFG, pers. comm.).* Ex-vessel revenues for landings at these five ports totaled $12.7 million paid to commercial fishers in 2007 (CDFG 2008a). Additional revenue is generated from the businesses associated with both commercial and recreational fishing operations, including packing, processing and retail sales, marinas, maintenance operations, and equipment.

Other sanctuary-related industries include aquaculture, kelp harvesting, sand mining, and commercial shipping (Figure 3). The rich biodiversity and close proximity of the deep sea also provide unparalleled research opportunities for approximately 25 marine science facilities that, in 2004, employed almost 2,000 staff and researchers with a combined budget of over $200 million (NOAA 2008a). This includes government agencies, public and private university research institutions, and private facilities such as the Monterey Bay Aquarium.

Water

The oceanography of the sanctuary is closely tied to processes of the California Current. This current is an eastern boundary current that has been characterized generally as a broad, shallow, slow southward moving current. Below this surface flow is the northward moving California Undercurrent. During the late fall and winter, the undercurrent often surfaces inshore of the California Current. This

**Data Source: State of California, Department of Fish and Game, Commercial Fisheries Information System (2007)* seasonal northward flow along the coast is often referred to as the Davidson Current. These currents vary in intensity and location, both seasonally and from year to year.

Each year, there are three oceanographic seasons in the sanctuary called the upwelling, oceanic, and winter storm seasons. These seasons overlap and do not follow a strict cycle. The upwelling season generally occurs from mid-March through mid-August. During this season, strong northwest winds move surface waters offshore. These waters are replaced by cool, nutrient-rich water from below. Upwelling areas can be observed as cool sea surface temperatures in satellite images (Figure 4). Two upwelling centers are located in the Monterey Bay sanctuary: one near Point Año Nuevo and one near Point Sur.

The oceanic season generally occurs from mid-August through mid-November. During this time, winds are light and variable, upwelling is not active, and offshore waters move inshore where surface water is heated by sunlight. The winter storm season generally occurs from late November through mid-March. During this period, low pressure systems moving south of the Gulf of Alaska generate southerly winds off California, along with large waves. Under the influence of these processes, the northward flow of the Davidson Current is enhanced.

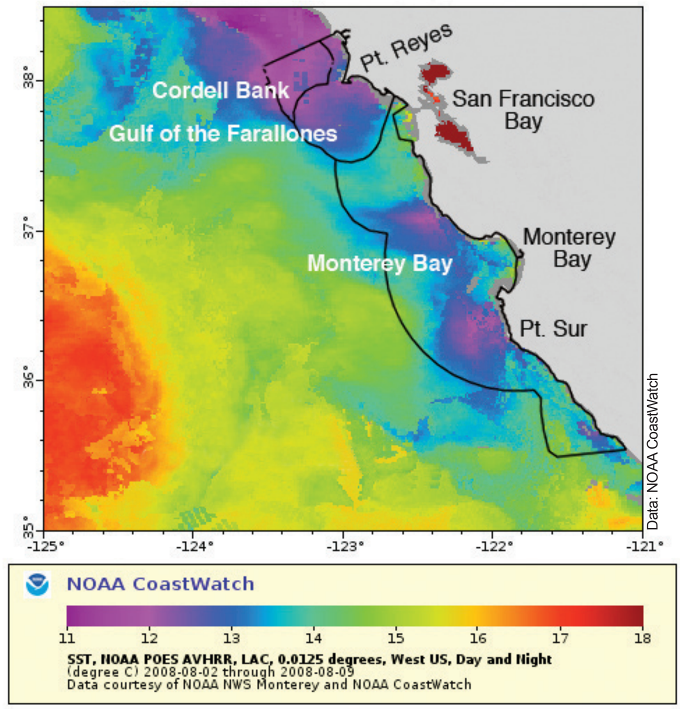


Figure 4. A satellite image of sea surface temperature (°C) along the central California coast from August 2008.

The California Current system experiences large variations of the atmosphere and ocean that can strongly affect environmental conditions. The most familiar anomalies, El Niño (warm-water) and La Niña (cold-water) events, tend to last about a year and reoccur about every two to seven years. The 1997-98 El Niño event, now recognized as the strongest of the century, affected sanctuary ecosystems more than any other natural phenomenon in recent history. Another recurring pattern of climate variability, called the Pacific Decadal Oscillation, is characterized by interdecadal fluctuations in sea surface temperature and sea level pressure. Oceanographic conditions appear to have reversed around 1899, 1925, 1947, 1977, and 1998. During the cool phase the ocean off California is characterized by higher salinity, lower sea surface temperature, a shallower thermocline, stronger upwelling, a faster California Current, and elevated nutrients, primary production, and zooplankton biomass (Chavez et al. 2003). The reverse pattern characterizes the warm phase. Existing data indicate we are currently in a cool phase.

Habitats

Monterey Bay National Marine Sanctuary, which extends from the mean high water line along the coast to the offshore boundary, contains many diverse biological communities ranging from beaches and lush kelp forests in the nearshore to one of the deepest offshore underwater canyons in North America.

Coastal Wetlands and Estuaries

Coastal wetland and estuarine habitats occur in and immediately adjacent to the sanctuary. These coastal habitats support unique biological communities with both aquatic and terrestrial characteristics. Terrestrial organisms that live in estuaries must be able to tolerate high salinity, periodic inundation and desiccation, and those that are aquatic must be able to survive low concentrations of dissolved oxygen. The flow of water and organisms through coastal wetlands and estuaries helps connect the sanctuary to the adjacent terrestrial habitats.

Coastal streams along the north coast of the Monterey Bay sanctuary form lagoons immediately adjacent to sanctuary waters. These coastal lagoons serve as corridors for salmon between feeding grounds in sanctuary waters and freshwater spawning grounds.

Elkhorn Slough, which harbors the largest tract of tidal salt marsh in California outside of San Francisco Bay, is an ecological treasure at the center of the Monterey Bay coastline. There are dozens of algae and plant species, over 100 fishes, more than 340 bird species, and over 550 invertebrate species that inhabit the slough (Caffrey et al. 2002). The relative rarity of estuarine habitats along the Pacific coast makes Elkhorn Slough's role in supporting species dependent on estuarine habitats essential. This estuary also serves as a spawning and nursery ground for some marine fish species, such as leop-

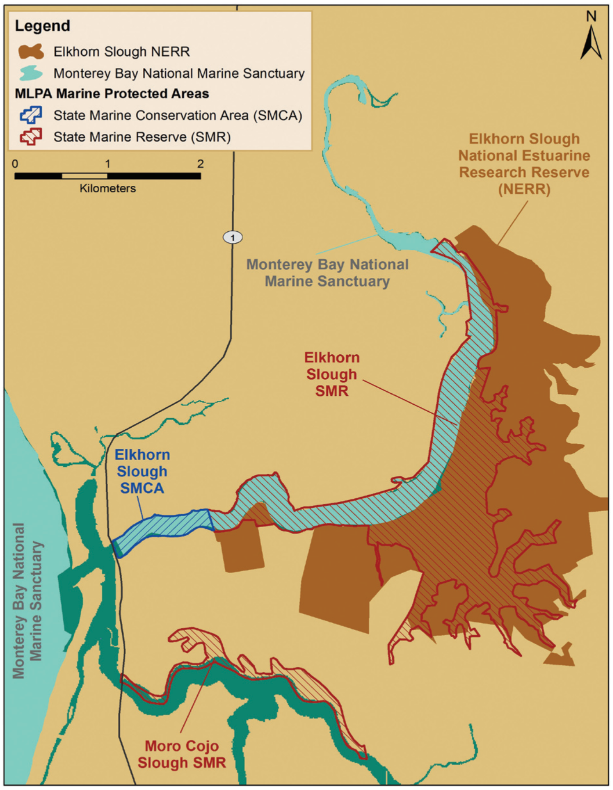


Figure 5. The Monterey Bay National Marine Sanctuary (light blue) includes Elkhorn Slough east of the Highway One bridge and west of the tide gate at Elkhorn Road and toward the center channel from the mean high water line, excluding areas within the Elkhorn Slough National Estuarine Research Reserve (brown). Two California Marine Life Protection Act (MLPA) Marine Protected Areas overlap with Monterey Bay National Marine Sanctuary in this area: Elkhorn Slough State Marine Reserve (red hatching) and Elkhorn Slough State Marine Conservation Area (blue hatching). The data used to map the MLPA MPAs do not replace the legal description of boundaries found in Title 14, California Code of Regulations. Submerged areas not in the sanctuary (green) include Moss Landing Harbor and Moro Cojo Slough.

Figure 6. The beaches of the Monterey Bay National Marine Sanctuary, including Lover's Point in Pacific Grove, are popular destinations for sun bathers and swimmers.

Figure 7. Pajaro Dunes State Beach.

ard sharks, California halibut and English sole. The main channel of Elkhorn Slough, which snakes more than ten kilometers inland, is the only estuarine habitat located inside the boundaries of the Monterey Bay sanctuary (Figure 5).

Human activity and coastal development have negatively impacted many estuarine and lagoon habitats. For example, over the past 150 years, human actions have altered the tidal, freshwater, and sediment processes that are essential to support and sustain Elkhorn Slough's estuarine habitats. The cumulative impacts of these actions have been to convert Elkhorn Slough into a tidal wetland with strong daily tidal currents and substantially altered distribution of estuarine habitat types (Caffrey et al. 2002). Major threats to estuarine habitats result from increased rates of tidal erosion, marsh drowning, and dikes. The accelerated rate of bank and channel erosion is causing tidal creeks to deepen and widen, salt marshes to collapse into the channel and die, and soft sediments to be eroded from channel and mudflat habitats (Caffrey et al. 2002).

Nearshore

Beaches are one of the most visible and popular sanctuary habitats. Every year travelers from around the world come to enjoy the natural scenery, wildlife, and recreation that sanctuary beaches offer (Figures 6 and 7). Beach habitats include long exposed beaches, protected pocket beaches, and transient beaches, which are eroded to bedrock in the winter, then reappear during summer when wave energy is reduced. Sand in the Monterey Bay sanctuary is derived from several sources, including alongshore transport, local erosion of cliffs, and transport down local rivers. Sand transport along the open coast is generally from north to south, as a result of the prevailing northerly winds. However, this is only an average trend, as periodic reversals of alongshore transport in response to storms from the south can result in significant sporadic northward transport. Sand beaches are very harsh environments, with high wave action, high abrasion levels and lack of firm substrate for attachment. Beach fauna exhibit the characteristics of communities in harsh environments, namely low species diversity but high abundance.

Photo: J. Pederson, NOAA/MBNMS/SIMoN

Figure 8. Coastal area south of Rocky Point on the Big Sur coast. Giant kelp can be seen on the surface of the water.

Rocky shores are one of the sanctuary's most accessible habitats and, at low tide, a wide diversity of organisms are exposed for humans to enjoy. The accessibility of organisms attracted early marine ecologists, and the experimental field methods they developed have influenced the study of ecology well beyond the marine realm. One reason that rocky shores have received such keen scientific attention, particularly in the sanctuary region, is their extensive, and highly structured, biological diversity. Different species assemblages grow in distinct zones that vary with tidal height, wave exposure, and a variety of other physical and biological factors. The physical setting of the sanctuary region may explain the relatively high biodiversity found on its rocky shores: substantial tidal range (2.3 m), upwelling of nutrient-rich water, and fog associated with upwelling that prevents desiccation during low tides in otherwise dry summer months. The extent of rocky shoreline habitat in the sanctuary is estimated to cover 2 to 7 square miles, making it one of the rarest habitats in the sanctuary (P. Raimondi, UCSC, per. comm.).

One of the most recognizable elements of the nearshore environment is the kelp community. The sanctuary's rocky nearshore environment is characterized by forests of giant kelp and bull kelp that occur on rocky substrates from 2 to 30 meters deep (Figure 8). Like terrestrial forests, kelp forests consist of multiple layers. Below the surface canopy is the understory, a layer one to two meters above the bottom that is dominated by stalked brown algae and fleshy red algae. The lowest layer, turf algae, consists of several red algae rising only a few centimeters above the rocky bottom.

By providing vertical structure in the waters above the rocky reef, kelp forests provide a unique, living habitat that is utilized by numerous species, including marine mammals, fishes, other algae, and vast numbers of invertebrates. Though some large kelp species can persist for up to three years, the overall structure of the kelp forest is very dynamic. It has long been known that kelp populations in the sanctuary exhibit seasonal patterns of abundance, with maximum surface canopies in early fall and minimum canopies in winter.

Nearshore soft bottom areas, composed of loose sand and mud sediments, are the most extensive bottom habitats in the sanctuary and one of the least studied. Two major groups of invertebrates are found in this habitat: 1) the infauna, which live buried within the sediment (about 90 percent of all the bottom-dwelling organisms); and 2) the epifauna, which live on or move over the bottom. The subtidal invertebrate fauna of the shallow offshore waters are far more diverse than intertidal fauna. However, less is known about these subtidal species. The dominant invertebrates in shallow subtidal waters are worms, clams, snails, crabs, and other crustaceans.

Deep Sea

The deep-sea environment starts below 1,000 meters and extends to the seafloor. This cold realm of total darkness and immense pressure is poor in nutrients and dissolved oxygen. The deep sea is

Figure 9. This Big Red Jelly (*Tiburonia granrojo*), a newly named and described species, was found slightly above the Davidson Seamount crest at 1,363 meters.

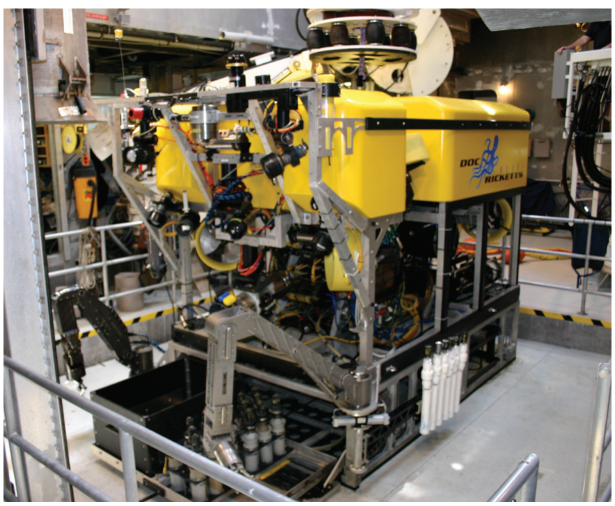


Figure 10. The ROV *Doc Ricketts* is a remotely operated vehicle used to explore the midwater and deep-sea habitats in the Monterey Bay region and broader Eastern Pacific ocean.

populated by a wide array of animals, specially adapted to live under the tremendous water pressure and low oxygen levels found in this habitat. Deep-sea animals, such as the big red jelly (Figure 9), typically have small eyes or no eyes at all, but instead rely on other highly developed senses to find mates and food and to escape predators. Unlike most communities on Earth that rely on sunlight as a primary energy source, deep sea communities derive energy by eating debris that sinks from the surface layer or by creating chemical energy from fluids that seep from the seafloor.

Submarine canyons are prominent geomorphic features within the Monterey Bay National Marine Sanctuary. One of the deepest and largest submarine canyons on the coast of North America is the Monterey Canyon, located in the center of Monterey Bay. Similar in size to the Grand Canyon in Arizona, it is 470 kilometers long and approximately twelve kilometers wide at its widest point, with a maximum rim-to-floor relief of 1,700 meters. Numerous smaller canyons cut into the continental shelf and slope, especially along the Big Sur coastline. Submarine canyons are ecologically important to many species. For example, canyons provide habitats for larger sized rockfish that seem to prefer structures of high relief such as boulders, vertical walls, and ridges. Submarine canyons are also foraging areas for marine mammals and birds that eat the large schools of prey, such as krill, that can congregate in the canyon head or along canyon edges.

Offshore Waters

In the offshore surface waters of the sanctuary (from the surface to 200 meters depth), food webs are supported almost entirely by phytoplankton (tiny plants). Zooplankton (tiny animals such as fish larvae and krill) and small schooling fishes (e.g., anchovy and sardine) are a major food source in the open waters of the sanctuary, and their abundant populations draw many birds, fishes, and whales to the area. In the midwater environment (from 200 to 1,000 meters) light, nutrients, and dissolved oxygen diminish and water pressure increases with depth. Midwater fishes and some invertebrates have developed large and elaborate eyes that allow them to see under the low-light conditions in this environment. Many small midwater fishes and zooplankton, including krill, feed on phytoplankton by migrating hundreds of meters to the surface layer after sunset. At dawn, they return to their midwater habitat.

The midwater habitat and its inhabitants are currently being studied with remotely operated vehicles (ROVs) to develop a dynamic model of the community (Figure 10). Initial data show positive coupling between the seasonal cycles of productivity by phytoplankton and the abundance cycles of gelatinous predators (jellyfish) that feed on phytoplankton grazers.

Living Resources

Flowering Plants and Algae

A diverse group of photosynthetic organisms exploits the shallow margins of wetlands where they receive high levels of sunlight and nutrients. Algae, such as sea luttuce, grow in the high intertidal flats. Eelgrass, a flowering vascular plant, occurs in protected waters, including patches in all larger bays and estuaries off central and northern California. Salt marshes develop along the shores of some protected


Photo: C. King, NOAA/MBNMS/SIMoN

Figure 11. Surfgrass and algae-covered rocks at Pt. Pinos.


Photo: S. Lonhart, NOAA/MBNMS/SIMoN

Figure 12. A Cooper's nutmeg and a tube anemone living on the sandy bottom in Lover's Point State Marine Reserve in Monterey Bay.

river mouths and estuaries. A variety of herbaceous plants, including pickleweed, saltgrass, cattails, sedges, and rushes, grow along the margins of salt marshes.

Along the rocky coast, certain types of algae tend to be found in different tidal height zones based on exposure to air during low tides. Rockweeds, a group of brown algae, and low growing, bushy red algae are the most common indicators of the high intertidal zone. Dense patches of upright, calcified forms of red algae, called coralline algae, typically dominate the middle intertidal zone. The presence of surfgrass and small kelp species, such as the sea palm and feather boa kelp, are indicators of the low intertidal zone (Figure 11).

In the subtidal zone, a rich algal assemblage is associated with the kelp forest. Beneath surface canopies formed by giant and bull kelp are several species of understory kelp. Other algae, such as fleshy red species, can form dense algal turfs under the canopies and are often distributed along a depth gradient with the more robust species occurring shallower and the more delicate species occurring deeper. Coralline algae occur throughout the kelp forests and are generally more tolerant of increased water motion and thus abundant in exposed sites.

Invertebrates

The invertebrate assemblage in the sanctuary is extremely diverse. More than 2,500 species of invertebrates are known to inhabit the beaches and rocky shorelines of the Monterey Bay region (J. Pearse, UCSC, pers. comm.) and 204 species of invertebrates were found living in one kelp forest along the exposed coastline south of Carmel. Some groups of sedentary and sessile invertebrates, such as anemones and tube worms, occur in both the soft-bottom and rocky reef habitats while other groups (e.g., mussels, barnacles, sponges, tunicates, corals) are found primarily attached to hard structure or only in soft sediments (e.g., sea pens, sea whips, clams). Invertebrates that are more mobile, such as snails (Figure 12), sea stars, sea urchins, octopus, and crabs, prefer either rocky or soft bottom habitats, but are capable of moving between these different habitat types. Soft bottom habitats also contain a diverse assemblage of infaunal invertebrates (animals that live buried in the sediment) dominated by polychaete worms and small crustaceans. Invertebrates in open water habitats range from solitary active predators (e.g., large squid and octopus), to densely schooling forms (e.g., krill and market squid), to gelatinous suspension feeders and filter feeders (e.g., salps, comb jellies, larvaceans). The Monterey Bay Aquarium Research Institute has cataloged approximately 771 species of invertebrates living in the midwater and on the surface of the deep seafloor and 1,200 infaunal species in the Monterey Bay National Marine Sanctuary, including Davidson Seamount (J. Connor, MBARI, pers. comm.).

Fishes

Hundreds of species of fishes are found in the sanctuary. Fish assemblages can be categorized according to where they reside. Estuaries and lagoons support a distinctive assemblage of fish species that tolerate a variety of salinity conditions. Some species (e.g., flatfishes, sharks and rays) use estuaries during the juvenile phase, but move out onto the continental shelf as they mature. A number of small and specialized fishes, such as gunnels, pricklebacks, and tidepool sculpins, are found in tide pools along the rocky coast. Rockfishes (genus *Sebastes*) compose a very diverse group found in many subtidal habitats in the sanctuary, but they are especially common on rocky reefs (Figure 13). Flatfishes (sole, halibut, flounder, turbot, and sanddab), skates and rays, sablefish, and Pacific hake are typical of soft bottom habitats on the shelf and upper slope. Most deep-sea bottom fishes off central California belong to one of four families: grenadiers, eelpouts, codlings, and skates. The open waters of the sanctuary are occupied by a large diversity of pelagic fishes ranging from small schooling fishes (e.g., anchovy, sardine, mackerel, and mesopelagic fishes like lanternfishes, deep-sea smelts, and bristlemouths) to large solitary predators (e.g., tuna, sharks).

Figure 13. A copper rockfish on the rocky reef at Whaler's Cove, Point Lobos.

Figure 14. Adult and juvenile brown pelicans roost at Natural Bridges State Beach.

Figure 15. A harbor seal hauls out onto a rock along Cannery Row.

Sea Turtles

The leatherback is the only species of sea turtle that is commonly observed in the sanctuary. The leatherback is the largest turtle in the world and it is found in all of the world's major oceans. Leatherbacks are also one of the deepest diving air-breathing animals known - descending to depths in excess of 1,300 meters. Annual aerial surveys along the central California coast indicate that leatherbacks are most common in the sanctuary during summer and fall when jellyfish, which are the major prey items of leatherback turtles, are seasonally abundant. Leatherback turtle populations in the Pacific Ocean are declining at a precipitous rate and the accidental killing of leatherbacks by high seas commercial fishing fleets is a major contributor to that decline.

Seabirds and Shorebirds

Sanctuary waters are among the most heavily used by seabirds worldwide (Figure 14). Ninety-four species of seabird are known to occur regularly within and in the vicinity of the nearshore and offshore environments of the sanctuary, and approximately 346 species of birds are known to visit or live in Elkhorn Slough (http://www.elkhornslough.org/birdlistTOC.htm). Several environmental features are responsible for the diverse assemblage of birds in the area. Monterey Bay is located on the "Pacific Flyway," allowing migratory birds a place to stopover during both north and south migrations between southern wintering grounds and northern breeding sites. The upwelling of nutrient-rich waters supports highly productive food webs, which provide abundant prey, as well as the diversity of habitat types along the shore, which increases the variety of bird species utilizing the sanctuary. Thus, many birds found in sanctuary waters have come to feed, some from as far as New Zealand.

Marine Mammals

The sanctuary has one of the most diverse and abundant assemblages of marine mammals in the world, including six species of pinnipeds (seals and sea lions), 27 species of cetaceans (whales, dolphins, and porpoises), and one fissiped (sea otter). Presently, approximately 82% of the southern sea otter population occurs within the sanctuary (Tinker et al. 2006).

Five species of pinnipeds commonly occur in the Monterey Bay National Marine Sanctuary. Four of these species - California sea lions, Steller sea lions, northern elephant seals, and Pacific harbor seals (Figure 15) - are observed frequently along the coast because they use rocky shorelines and beaches to rest and give birth. The northern fur seal is seasonally abundant in the sanctuary, but usually found in offshore waters. An additional species, the Guadalupe fur seal, has been reported from records of sick animals stranded on the beach.

Of the 27 species of cetaceans seen in the Monterey Bay area, about one-third occur frequently. Most of the cetaceans in the sanctuary are highly transitory, although some individuals may be residents within the area. The large baleen whales either migrate through the sanctuary (e.g., gray whales) or move into the area seasonally to feed (e.g., blue and humpback whales). Movements of smaller cetaceans are probably associated with changes in prey abundance and oceanographic conditions. Of the sanctuary's cetacean population, blue, humpback, and gray whales and harbor porpoises have been monitored regularly. Other cetacean populations are assessed less frequently.

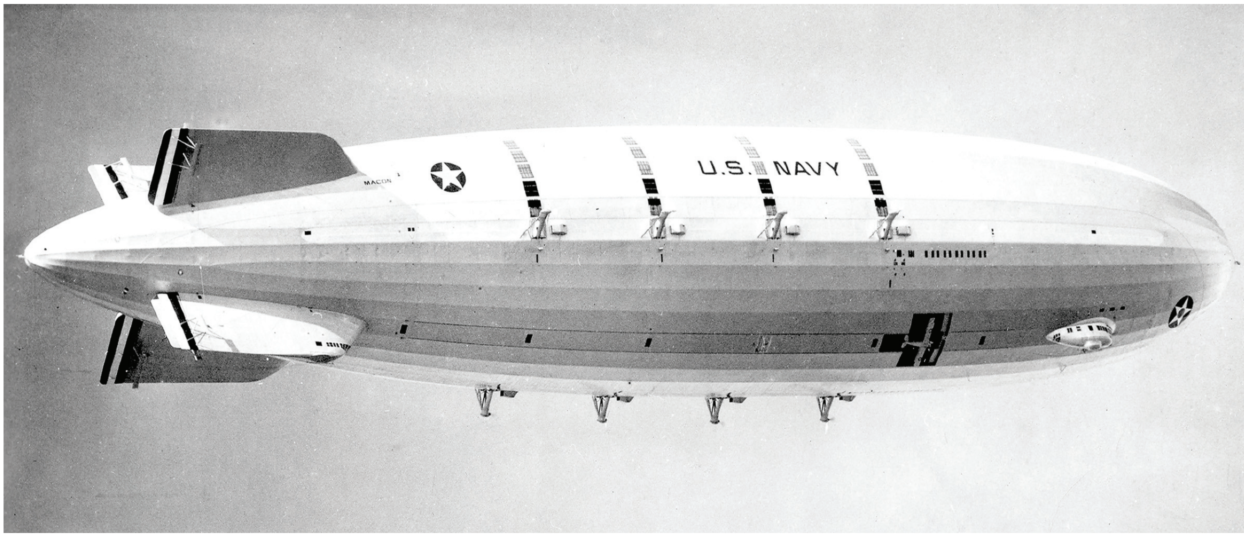


Photo: Robert Schwemmer Maritime Library

Figure 16. USS *Macon* (ZRS-5) Airship 1933-1935.

Endangered and Threatened Species

Twenty-six species that use resources in the sanctuary are listed by the U.S. federal government as endangered or threatened. Eleven of these species (including multiple populations for steelhead and Chinook salmon) have been placed on the federal list of endangered and threatened wildlife since sanctuary designation in 1992. Examples of these more recently listed species are the Western Snowy Plover, winter and spring runs of Chinook salmon, central coast and south central coast steelhead, tidewater goby, and black abalone. A few species bring a hopeful sign for the future: the gray whale, American Peregrine Falcon, and Bald Eagle were delisted in 1994, 1999, and 2007, respectively; and the California Brown Pelican is proposed for delisting.

Maritime Archaeological Resources

Submerged archaeological resources include shipwrecks, aircraft, wharves and dock sites, prehistoric archaeological sites, and associated artifacts. Hundreds of shipwrecks have occurred in the Monterey Bay National Marine Sanctuary, and were a result of the significant maritime exploration and commerce that historically occurred in the region, coupled with a coastline dotted with shallow, rocky headlands, largely exposed to prevailing winds, storms, and fog. The sanctuary is responsible for the protection and management of historical and cultural resources within its boundary. Sanctuary stewardship responsibilities include a mandate to inventory sites, encourage research, provide public education, and oversee responsible visitor use.

In 2003, the Monterey Bay National Marine Sanctuary archaeology database contained 445 reported losses of vessels and aircraft located in Pacific waters directly within or on the border of the sanctuary (Smith and Hunter 2003). One of the most historically significant wrecks in the sanctuary is the USS *Macon* (Figure 16). The USS *Macon*, a 785-foot dirigible carrying four Sparrowhawk biplanes, was lost offshore of Point Sur on February 12, 1935. For decades the underwater location remained a mystery. In 1990 and 1991, the Monterey Bay Aquarium Research Institute and the U.S. Navy located the *Macon's* remains at a depth of over 1,000 feet. In 2005 and 2006, a team of scientists, including sanctuary staff, conducted a side-scan sonar survey at the wreck site, and an ROV survey was used to record artifacts and create a photo mosaic of the site. The *Macon* expedition marks the sanctuary's first archeological survey within the boundary of the sanctuary. The remains of the *Macon* provide an opportunity to study the relatively undisturbed archeological remnants of a unique period in aviation history.

Pressures on the Sanctuary

Numerous human activities and natural events and processes affect the condition of natural and archaeological resources in marine sanctuaries. This section describes the nature and extent of the most prominent human induced pressures in Monterey Bay National Marine Sanctuary.

Vessel Traffic

The sanctuary is located in an area of critical importance to the conduct of maritime commerce, which is a major component of the regional and national economy. There are approximately 4,000 coastal transits of the sanctuary each year by large vessels. Approximately 20 percent of these transits are crude oil tankers. The majority of the remainder is large commercial vessels such as container ships and bulk product carriers. Vessel traffic within the sanctuary was a major issue of concern raised during the sanctuary designation process. Large commercial vessels were of particular concern for spills because they traveled closest to shore and can carry up to 1 million gallons of bunker fuel, a heavy, viscous fuel similar to crude oil, which they use to power themselves. The historical record of spills for the Pacific Coast indicates that the total number of spills from transiting vessels is relatively small in number, but the impacts could be enormous given the number and volume of these vessels and the potential size of a spill.

Lost cargo from container ships poses an additional pressure to sanctuary resources. The potential impact of lost containers on natural resources includes the crushing and smothering of benthic organisms, the introduction of foreign habitat structure and shifts in local ecology. There is likely to be an expanding benthic footprint over time as the containers degrade and collapse, spreading their contents along the ocean floor. There is potential for entrapment of marine organisms, ingestion of foreign objects, as well as deposition of plastics and other chemical pollutants.

Military Activity

Military use of the sanctuary includes air, surface, and underwater activity. Some activity includes the use of non-explosive ordinance, sonar, smoke markers, and the temporary placement of objects for torpedo firing or sonar location training. Air activities include aircraft carrier takeoffs and landings, and low-level air combat maneuvering. The U.S. Navy uses special zones for submarine operations and minesweeping training exercises. On occasion, U.S. Marines practice amphibious landings on sanctuary beaches. The military also conducts non-combat-related preparedness activities such as underwater cable repair and breakwater maintenance. Concerns regarding the military activity in the sanctuary are primarily related to conflicts and disturbances with marine life or benthic habitat, and disturbance of seabird roosting areas by aircraft. Concerns have also arisen regarding military proposals to use underwater acoustic devices that could interfere with marine mammal communications, behavior, or health.

Commercial and Recreational Fishing

Commercial and recreational fishing are important components of the culture and economy of the sanctuary, with 560 commercial vessels making landings at the five main ports in and near the sanctuary (Bob Leos, CDFG, pers. comm.)*, along with substantial recreational fishing. Over 50,000 recreational anglers fished for rockfish and salmon from fifty party or charter boats in the area in 2007 (CDFG 2008a), while others fished from private boats and from shore. About 200 species are typically caught in the commercial and recreational fisheries, with the bulk of the commercial landings composed of sardine, anchovy, squid (Figure 17), sablefish, Dover and petrale sole, mackerel, and Dungeness crab (Starr et al. 2002). The five primary

Photo: R. Stamski, NOAA/MBNMS/SIMoN

Figure 17. Squid fishing boat in Moss Landing Harbor.

Data Source: State of California, Department of Fish and Game, Commercial Fisheries Information System (2007) gear types used are purse seines, trawl nets, hook-and-line gear, pots and traps, and gill nets. Although many harvested stocks are at or above fisheries management targets, marine resource managers are concerned about the depressed levels of certain stocks, habitat threats from some fishing gears, bycatch of sensitive species, and potential community and ecosystem-level effects of fishing.

Pressures to Water Quality

Runoff

Water quality is a key element that unites all sanctuary resources. The sanctuary is adjacent to 450 kilometers of California's coast, with eleven major watershed areas draining over 18,000 square kilometers, ranging from relatively pristine conditions to heavily agricultural and urbanized areas. The runoff from rainfall and irrigation water can pick up a variety of pollutants and carry them into storm drains, streams, rivers, wetlands, harbors, bays, and shorelines, which can impair the quality of these water bodies (Figure 18).

Urban runoff is a leading cause of water pollution. Urban areas contain up to 90 percent hard surfaces such as rooftops and pavement, where water collects and quickly runs off. Urban runoff is difficult to prevent because it is nonpoint pollution with sources such as yards, sidewalks, streets, construction sites, and parking lots. Deposits of contaminants (e.g., oil, grease, pesticides, herbicides, soil, pet droppings) in these areas are flushed by rainwater and other means down the storm drains and directly into a river or bay. The water flowing through storm drains is untreated and therefore carries pollutants into local waterways. Problems that result from pollution and alteration of flow pathways are exacerbated by population growth which drives further urbanization in watersheds. In addition, rain runoff volumes are increased in urban areas due to the increase in impervious surfaces, such as streets and parking lots. Under such conditions, the discharge rate can easily double or triple, causing increased chances for flooding. The pollution content of rainwater runoff is greatest during the first few hours of a storm as all standing deposits are washed away. This "first flush" can cause stress for aquatic organisms. High bacterial loads in urban runoff can also lead to beach closures, reducing recreational opportunities.

Runoff from agricultural land is another source of pollution. Potential problems include: elevated nutrient levels (e.g., nitrate, urea), sedimentation, pesticides (e.g., DDT and toxaphene), suspended solids, and bacterial and protozoan contamination. These contaminants can have a variety of biological impacts including algal blooms, toxicity, reproductive anomalies, reduced recruitment of anadromous species, morbidity and mortality to marine mammals, transfer of human pathogens, and interference with recreational uses of the sanctuary due to beach closures.

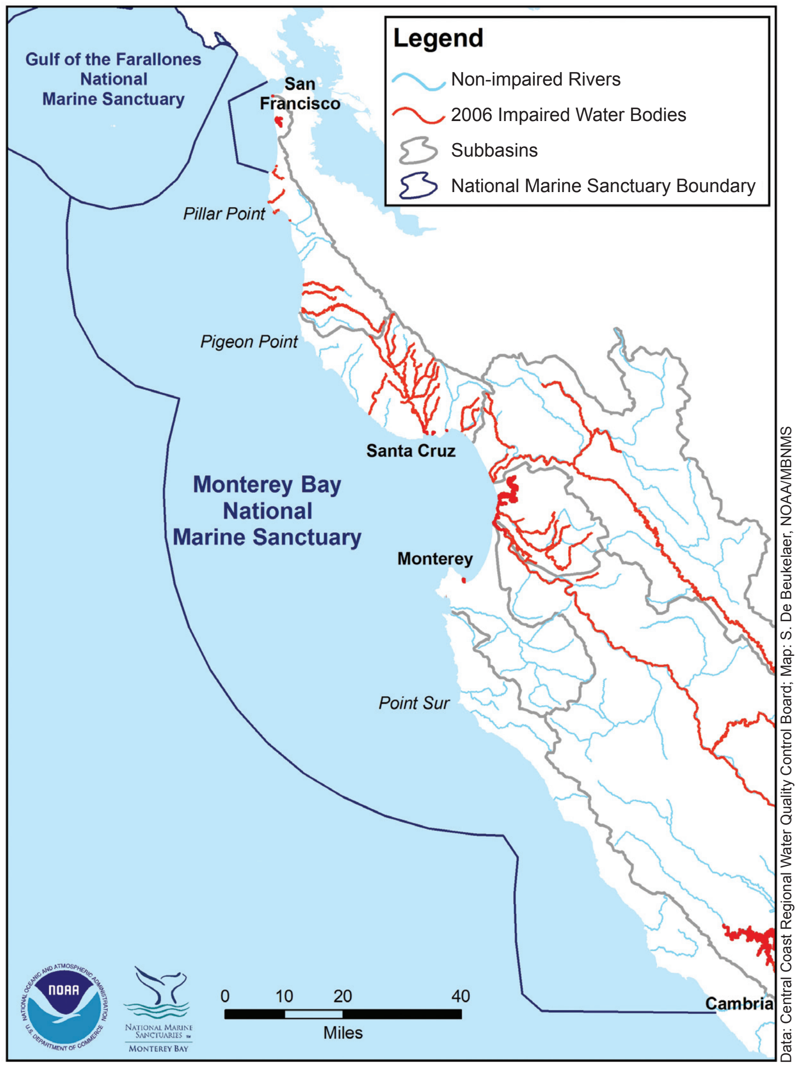


Figure 18. Location of impaired water bodies in the Monterey Bay National Marine Sanctuary and in sub-basins that drain to the sanctuary. Impaired water bodies include river segments, coastal shorelines, harbors, bays, and estuaries that do not meet, or are not expected to meet, Federal Clean Water Act water quality standards.

Beach Closures

Since the sanctuary designation in 1992, runoff and spills along the sanctuary's coastline have periodically resulted in high levels of coliform bacteria in coastal waters, resulting in hundreds of beach closures or warnings annually (Figure 19). Coliform bacteria are used as indicator organisms, and while they may not cause disease in humans, their presence tells us that water may be contaminated with organisms that do cause human health impacts such as fever, flu-like symptoms, ear infection, respiratory illness, gastroenteritis, cryptosporidiosis, and hepatitis. Sources of contaminated water include runoff from urban, suburban and rural areas, aging sewer infrastructure systems pressed to meet increasing demands, and contaminated flows from creeks and rivers. Contributing factors that generate these sources include illicit storm drain connections, improper disposal of materials which clog pipes and cause overflows, cracked or damaged pipes, overflow of sewer systems during storm events, septic system leaching, and various domestic and wildlife sources.

Photo: S. Lonhart, NOAA/MBNMS/SIMoN

Figure 19. The water flowing through storm drains is untreated and can carry pollutants into local waterways or directly into the sanctuary.

Photo: C. King, NOAA/MBNMS/SIMoN

Figure 20. A cruise ship anchored inside Monterey Bay. This anchoring site is one of two designated by the sanctuary to avoid impacts to sensitive habitat. Passengers are ferried to the streets of Monterey via a boat tender.

Harmful Algal Blooms

A harmful algal bloom (HAB) can occur when certain types of microscopic algae grow quickly in water, forming visible patches that may harm the health of the environment, plants, or animals. HABs can deplete the oxygen and block the sunlight that other organisms need to live, and some HAB-causing algae release toxins that are dangerous to animals and humans. In Monterey Bay and other coastal waters in the sanctuary, populations of naturally occurring algae occasionally grow to very high concentrations and some can produce extremely potent biotoxins. These biotoxins can be transferred up the food chain, sometimes poisoning seabirds and marine mammals or closing the harvest of commercial species such as shellfish. However, not all blooms are toxic, and even species that can produce toxins do not always do so, making the timing and location of harmful algal blooms difficult to predict.

In the last decade one particular species, *Pseudo-nitzschia australis*, has received a great deal of attention in Monterey Bay. It blooms in Monterey Bay from late spring to early fall and can produce domoic acid, a potent neurotoxin that can cause neural damage, disorientation, short-term memory loss, and even seizures and brain damage in vertebrates. Domoic acid is readily passed up the food chain. The toxin is consumed along with the phytoplankton by small fishes and zooplankton, which are in turn eaten by larger fishes, seabirds, and mammals. Domoic acid can become concentrated in filter feeding animals that are eaten by humans, such as mussels, and can cause serious illness and even death.

Marinas and Boats

Water pollution from activities associated with marinas and boating within the sanctuary is also a pressure on sanctuary resources. Boater-generated impacts on water quality generally fall into four categories: toxic metals primarily from anti-fouling paints, hydrocarbons from motor operations and maintenance procedures, solid waste and marine debris from overboard disposal, and bacteria and nutrients from boat sewage.

Cruise Ships

Large cruise ships began visiting Monterey in 2002 (Figure 20). These ships provide local businesses with economic benefits, but both the public and businesses have raised concerns about environmental issues associated with these ships. Cruise ships are of enormous size, and are capable of generating massive volumes of waste. The main pollutants generated by a cruise ship are sewage (also referred to as black water), gray water, oily bilge water, hazardous wastes, and solid wastes. While large cruise vessels are the equivalent of small cities in regard to waste production, they are not subject to the strict environmental regulations and monitoring requirements imposed on land based facilities, such as obtaining discharge permits, meeting numerous permit conditions and monitoring discharges.

Oil or Chemical Spills

Oil and chemical spills in the sanctuary could range from small, localized spills to large events that span hundreds of kilometers of coastline. Small spills tend to be associated with fuel and oil discharges due to vessel groundings, sinkings and plane crashes. A larger oil or chemical spill may result from offshore shipping traffic, sunken vessels, or natural seeps. A large spill could have a major impact on foraging birds, marine mammals and fishes, as well as important habitat like kelp beds, wetlands and rocky shores, and on tourism and the coastal economy.

Coastal Development

Desalination

The demand for an already overtaxed fresh water supply continues to increase with the growing population of California's coastal communities, and more communities are exploring the feasibility of desalination plants to augment fresh water supplies. Three desalination facilities currently operate within the boundaries of the sanctuary (Figure 21); however there has recently been an increase in interest for both private and public desalination plants. Approximately ten facilities have recently been proposed. Desalination plants have the potential to negatively impact the marine environment through the introduction of brine waste effluent and other substances to sanctuary waters. Additionally, the construction of desalination facilities and associated pipelines often causes alteration of the seabed. Larval and adult forms of marine invertebrates and fishes can be sucked into intake pipes, thus potentially having detrimental impacts on sea life.

Dredging and Dredge Disposal

Periodic dredging of the local harbors is necessary to continue to allow access for vessels (Figure 22). There are four major harbors adjacent to the Monterey Bay sanctuary: Pillar Point, Santa Cruz, Moss Landing, and Monterey. Santa Cruz and Moss Landing regularly dredge the bottom of the harbor. The Monterey Harbor has dredged on a sporadic basis in recent years. Pillar Point Harbor has historically had little need for dredging, though that status may change in the future.

Dredging impacts seafloor communities both at the dredging site and at the disposal site. The physical disturbance of dredging damages or removes organisms living in or on the seafloor and can mobilize buried chemical contaminants. The disposal of dredge material can smother organisms and introduce chemical contaminants at the disposal location. In addition, dredging to deepen channels in harbors can alter water flow dynamics and future sediment deposition rates in the harbor and adjacent habitats.

Erosion and Coastal Armoring

About 86 percent of the California coast experiences active erosion due to natural and anthropogenic causes (Griggs 1999). Shore-

Photo: California Coastal Records Project

Figure 21. The power plant in Moss Landing contains a desalination plant that produces fresh water for use in the power production process.

Photo: NOAA/MBNMS

Figure 22. Dredging, which is used to improve access to harbors for vessels, is a pressure on benthic habitats and communities.

line protective structures have been used in the sanctuary to protect infrastructure and other development from wave action, or to retain soil and avoid erosion (Figure 23). This practice is commonly known as coastal armoring. By 1998, coastal armoring had been installed to protect about 10 percent of the coastline statewide (Griggs 2005). With increases in development, continued natural erosion of coastal bluffs, and projected sea level rise, additional requests will come to install structures both to access the coast and to protect private and public property from erosion. Poorly planned erosion control structures can cause even more erosion of adjacent beaches, possibly displacing sanctuary resources, and can lead to diminished beaches.

Landslide Disposal

Deposition of material from landslides along the sanctuary's steep coastline can bury intertidal and subtidal habitat, and increase sand scour that inhibits larval settlement in certain habitats. Some of these slides occur naturally, while others are created or exacerbated by highway design, repair, and maintenance practices.

Submerged Cables

The rapid expansion of Internet technology has created a surge of proposals to install submerged fiber optic cables in the sanctuary. Installation of submerged cables in the sanctuary alters the seabed, causing environmental impacts and creating potential hazards for fishing activities. Monterey Bay National Marine Sanctuary regulations currently prohibit alterations of the seabed, yet allow, via permit or authorization, for some otherwise prohibited activities. Monterey Bay sanctuary regulations recognize certain activities that may benefit the sanctuary, such as education, research, or management; thus a cable that provides these benefits could be permitted under existing regulations. Cables that are for commercial purposes, such as telecommunications, are less preferred under existing regulations.

Non-Indigenous Species

Second only to direct habitat loss, non-indigenous species (also called introduced or invasive species) are recognized world-wide as a major threat to ecosystem integrity. Non-indigenous species in the marine environment can alter species composition, threaten the abundance and/or diversity of native marine species, interfere with ecosystem function, and disrupt commercial and recreational activities. They can cause local extinction of native species either by preying on them directly or by out-competing them for food or space. Once established, non-indigenous species can be difficult to eradicate (Figure 24). Non-indigenous species also exacerbate biotic homogenization, the process of communities becoming more similar due to growing proportion of shared non-native species (Lockwood et al. 2007, Sax et al. 2005).

Photo: R. Stamski, NOAA/MBNMS/SIMoN

Figure 23. Exposed cliffs are reinforced to slow erosion caused by wave action.

Photo: S. Lonhart, NOAA/MBNMS/SIMoN

Figure 24. The Asian kelp *Undaria pinnatifida* is a non-indigenous species that occurs on floating docks in Monterey Harbor.

The most important pathway for the world-wide introduction of marine species is transportation via large vessel ballast tanks and hull-fouling, though other mechanisms, such as introduction through improper disposal of aquarium materials, bait and seafood packing materials, aquaculture operations, and research activities, also contribute to the problem. The main vectors that have introduced species into the sanctuary, and into Elkhorn Slough in particular, are small boat traffic and oyster culture (Wasson et al. 2005).

Terrestrial non-indigenous species can have negative impacts on living resources in the sanctuary. Nest predation by rodents that have been introduced to many offshore islands by human activities can have devastating impacts on nesting seabird colonies. Feces of the non-indigenous opossum and the domestic cat are the main sources of the parasites *Sarcocystis neurona* and *Toxoplasma gondii*, two of the most important infectious diseases affecting southern sea otters (Kreuder et al. 2003).

Figure 25. Kayaking is a popular way to enjoy the costal habitats of the sanctuary. Here kayakers explore Elkhorn Slough.

Figure 26. A kelp harvester operating off San Simeon. Kelp is harvested in the sanctuary at a variety of locations to sustain aquaculture operations and to be turned into a variety of products.

Wildlife Disturbance

The sanctuary provides many opportunities for observation of nature. Rocky shorelines provide pedestrians with opportunities to view the flora and fauna associated with the intertidal habitat. Kayaks (Figure 25) and partyboats are used for nearshore and offshore tours, often focused on viewing marine mammals and seabirds. With the multitude of opportunities for observation come the potential for wildlife disturbance that may result in flushing birds from their nesting roosts, harassment of pinnipeds or sea otters, as well as trampling and excess collecting of intertidal organisms. Other sources of wildlife disturbance include motorized personal watercraft, low-flying aircraft, and fireworks displays that can flush seabirds and marine mammals.

Motorized and Non-motorized Vessels

The use of motorized or non-motorized vessels outboard or in-board boats, kayaks, canoes, underwater scooters, or other types of water craft) to interact with marine mammals in the wild is a rapidly growing activity nationwide. NOAA National Marine Fisheries Service and the Monterey Bay National Marine Sanctuary have received complaints from members of the public that describe operators of motor vessels driving through groups of dolphins in order to elicit bow-riding behavior, whale watching vessels getting too close to whales or chasing animals in order to get a better view of them, and kayakers utilizing the quiet nature of their vessels to approach too closely to sea otters and harbor seals. Fatal blunt trauma injuries to sea otters suggest that they are being hit by small boats, particularly in areas near Elkhorn Slough and harbors.

Overflight Impacts

Low flying aircraft are known to cause seabirds, shorebirds, pinnipeds, and whales to exhibit avoidance responses, such as rapid surface diving and flushing from roosts, nests and haul-outs. There are a variety of user groups associated with this activity, including commercial film making flight operations, private non-profit aviation, and military and agency aircraft. Potential impacts from low-flying aircraft are addressed by a specific prohibition on flying below 1,000 feet (300 meters) in designated overflight zones with sensitive wildlife. Some implementation problems have occurred due to pilots' lack of understanding and acknowledgement of the zones.

Commercial Harvesting and Aquaculture Activities

Commercial harvesting of certain fishes, invertebrates, and kelp resources may result in varied types of disturbance to wildlife. The use of nighttime lighting in the commercial squid fishery may disturb certain seabirds such as pelicans, petrels, and auklets as well as sea otters by disrupting natural behavior. The California Department of Fish and Game regulations require shielding the entire filament of all lights used to attract squid in order to reduce light scatter and decrease potential wildlife disturbance. Kelp harvesting may disturb some fauna associated with the kelp canopy, such as juvenile rockfishes and sea otters (Figure 26).

Acoustic Impacts

Concern about the cumulative impacts of noise from a variety of sources has grown as the ocean has become noisier over the past half-century. Anthropogenic sources of noise include large commercial shipping traffic, recreational and commercial vessels, military low frequency testing, and research activities. Projects like the Navy's Low Frequency Acoustics and the expansion of a Navy bombing range in Big Sur have elevated these concerns. Marine mammals have been observed to deviate from their migration paths to avoid noise, or interrupt their communications in response to elevated noise levels (reviewed in NRC 2005). Certain anthropogenic noise is thought to mask sounds used for mating, feeding, and avoiding predators. Responses vary depending on the acoustic frequency, decibel level, proximity to the source and other species-specific sensitivity factors. Long-term cumulative impacts are uncertain and range from minimal impacts in some situations, to possible physical damage to hearing structures, to stranding events.

Marine Debris

Levels of debris in both the ocean and at the land-sea interface are of growing concern. Various types of debris, including lost fishing gear, plastic bags, foamed polystyrene, balloons, and other consumer goods (Figure 27), are known to have adverse effects on marine species. Ingestion and entanglement are two of the many problems associated with marine debris, and may lead to death for many organisms. Plastics in the marine environment never fully degrade and recent studies found that forms of plastic are consumed by organisms at all levels of the marine food web (Derraik 2002).

Lost fishing gear can create long-term entrapment mechanisms that continuously kill mobile fauna for many years. Net materials are constructed to be strong and resilient, thus preventing escape of entangled wildlife and persisting in the environment for decades. Lost cage traps continue to catch prey on a continuing cycle as predators enter the traps to feed on dead and dying entrapped organisms. Nets and traps can physically scrape organisms off of hard reef habitat or sweep immobile invertebrates from sandy areas.

Photo: Save Our Shores

Figure 27. Trash collected from Twin Lakes State Beach during a cleanup event on July 5th, 2008. A large portion of marine debris comes from human activities on land.

State of Sanctuary Resources

This section provides summaries of the condition and trends within four resource areas: water, habitat, living resources, and maritime archaeological resources. Sanctuary staff and selected outside experts considered a series of questions about each resource area. The set of questions derive from the mission of the Office of National Marine Sanctuaries, and a system-wide monitoring framework (NMSP 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on, and study the ecosystems encompassed by the sanctuaries. Appendix A (Rating Scheme for System-Wide Monitoring Questions) clarifies the set of questions and presents statements that were used to judge the status and assign a corresponding color code on a scale from Good to Poor. These statements are customized for each question. In addition, the following options are available for all questions: " N/A" - the question does not apply; and "Undetermined" - resource status is undetermined. In addition, symbols are used to indicate trends: "▲ " - conditions appear to be improving; "—" - conditions do not appear to be changing; "▼ " - conditions appear to be declining; and "?" – trend is undetermined.

This section of the report provides answers to the set of questions. Answers are supported by specific examples of data, investigations, monitoring, and observations, and the basis for judgment is provided in the text and summarized in the table for each resource area. Where published or additional information exists, the reader is provided with appropriate references and web links.

Judging an ecosystem as having "integrity" implies the relative wholeness of ecosystem structure and function, along with the spatial and temporal variability inherent in these characteristics, as determined by the ecosystem's natural evolutionary history. Ecosystem integrity is reflected in the system's ability to produce and maintain adaptive biotic elements. Fluctuations of a system's natural characteristics, including abiotic drivers, biotic composition, complex relationships, and functional processes and redundancies are unaltered and are either likely to persist or be regained following natural disturbance.

Questions 4, 8, 14, and 17 examine the levels of human activities that may influence resources in the sanctuary. While each question has received a status and trend rating and an associated basis for judgment explanation, it should be noted that trend data are lacking for many of the human acitivites that were considered. In addition, the relationship between impacts resulting from an increased population in the area with the various management and educational efforts that are designed to mitigate the impacts of anthropogenic pressures was difficult to assess.

Because of the considerable differences within the sanctuary between offshore, nearshore, and estuarine environments, each question was answered separately for each of these environments. The offshore environment is defined as extending from the 30-meter isobath out to the offshore boundary of the Monterey Bay National Marine Sanctuary and includes the seafloor and water column. The nearshore environment is defined as extending from the shoreline boundary of the Monterey Bay National Marine Sanctuary (mean high water) to the 30-meter isobath and includes the seafloor and water column. Though many small estuaries occur along the central California coastline, Elkhorn Slough is the only large estuary located inside the boundaries of the Monterey Bay National Marine Sanctuary.

State of Sanctuary Resources: Offshore Environment

Offshore Environment Water Quality

The following information provides an assessment of the status and trends pertaining to water quality in the offshore environment.

1. ***Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?*** Stressors on water quality in the offshore environment, specifically persistent organic pollutants (POPs), fluctuations in nutrient levels, and changing ocean conditions, may inhibit the development of assemblages and may cause measurable declines in living resources and habitats. For this reason the rating for this question is "fair" with a "declining" trend. Offshore waters have shown elevated levels of contaminants (CCLEAN 2007), ocean temperature and chemistry changes (MBARI 2006), some of which have been linked to changes in the offshore ecosystem (Tanner 2006).

Certain POPs, including polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), have exceeded California Ocean Plan objectives (CCLEAN 2007). Monitoring data indicates the majority of POP and some nutrient (nitrate and urea) loading are mostly due to inputs from large rivers such as the Salinas, Pajaro, San Lorenzo, and Carmel and that orthophosphate and urea loads from these rivers have been increasing during recent years (CCLEAN 2007). Hartwell (2008) analyzed sediment samples and concluded that Monterey Bay watersheds are the primary source of DDT for an expanse of the Central California continental shelf that includes San Francisco Bay. Water samples collected by the CCLEAN program show that sites approximately five miles offshore in northern and southern Monterey Bay exceed the Ocean Plan water quality standards for polychlorinated biphenyls (PCBs) (Figure 28) and dieldrin (a persistent, bioaccumulative, toxic insecticide that was used from 1950 to 1974). Contaminants in sediment samples (which may indicate potential problems in the water column) do not exceed NOAA persistent organic pollutant (POP) alert levels. However, concentrations of the legacy pesticides DDT and dieldrin frequently exceed the NOAA Effect Range Low (ERL) guideline at which amphipod toxicity is typically measured in 10% of laboratory bioassays (CCLEAN 2007, 2009). Moreover, DDT concentrations are relatively higher in these offshore locations than the average concentrations measured in San Francisco Bay and have not declined at most locations since the 1970s (CCLEAN 2007). Concentrations of dieldrin exceeded

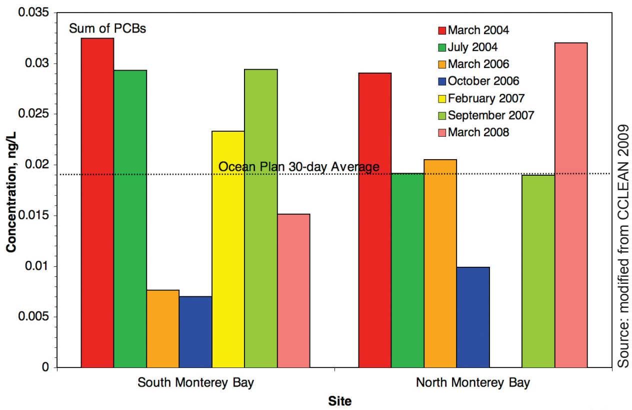


Figure 28. Concentrations of PCBs in water samples collected between 2004 and 2008 at two marine water quality background sites located five miles offshore in Monterey Bay. Some samples exceed the water quality standards for PCBs set forth in the California Ocean Plan.

the ERL in 22 out of 40 samples collected from 2005 to 2006 (CCLEAN 2007).

While the overall ecological effects of stressors are difficult to measure because they are the result of complex interactions among biological and environmental factors, there is recent evidence of the deleterious effects of POPs in the marine environment. CCLEAN (2007) has found that suspended sediment from rivers, primarily the Pajaro River, may have negative effects on benthic organisms along the 80-meter contour. Moreover, the cumulative concentrations of POPs were associated with decreased abundance of some benthic infauna. Preliminary work from Miller et al. (2007) showed that southern sea otters with moderate or high exposure to freshwater flows had significantly higher concentrations of certain POPs (DDDs, DDE, HCH delta, dibenzothiophene C2 and PBDE 017) compared to those that came from areas with low exposure to freshwater flows. This study also suggests that some POPs may contribute to the risk of sea otter death due to infectious agents and trauma.

Oceanographic monitoring data collected by the Monterey Bay Aquarium Research Institute (MBARI) shows that since 1999 there has been a regime shift from warmer to cooler water conditions and that nitrate levels at 60 meters have been above normal (MBARI 2006). The taxonomic structure of the offshore

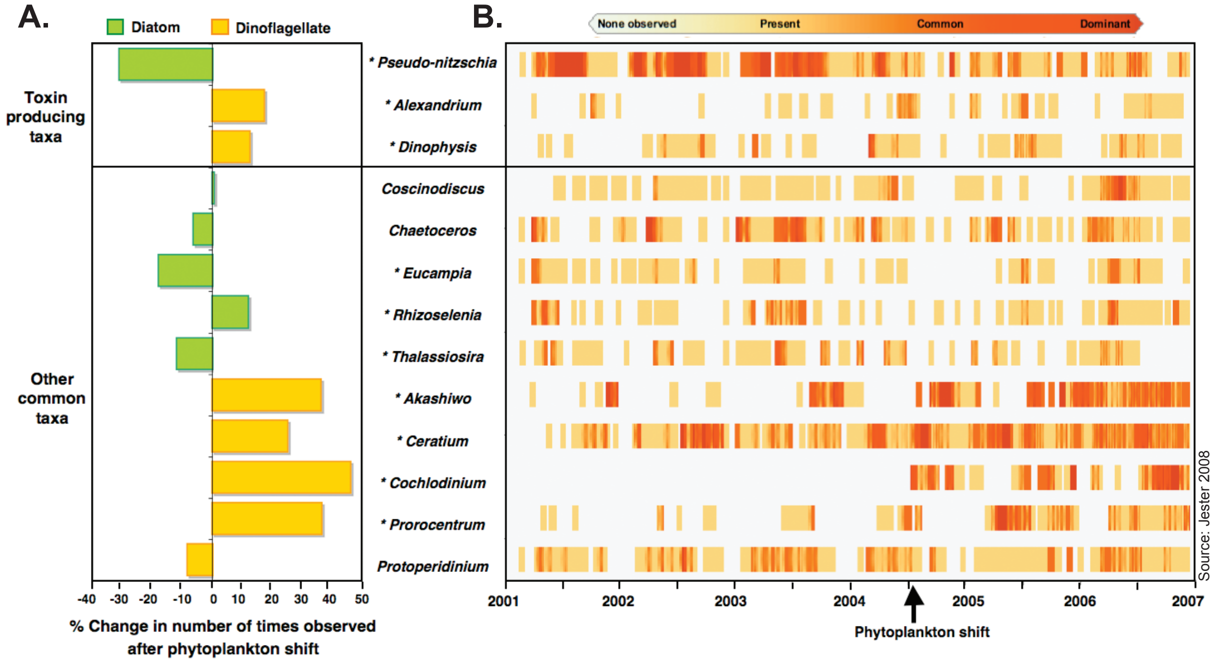


Figure 29. Relative abundance of diatoms and dinoflagellates common to Monterey Bay, California: (A) Change in the % of samples in which a given genus was observed after the floral shift [asterisks indicate a statistically significant difference (p<0.05); (B) Time series showing the relative abundance of diatom and dinoflagellate genera. Each row represents the change in relative abundance over time for the genus indicated on the y-axis; intensity of color increases with dominance and the arrow indicates the phytoplankton shift. Relative abundance ranges from not present to dominant, as shown in the overlying arrow bar.

phytoplankton community in Monterey Bay shifted during the summer of 2004 from the typically diatom-dominated community to a red-tide, dinoflagellate-dominated community and was associated with the presence of toxins in higher trophic level species (Jester 2008) (Figure 29). Since the taxonomic structure of the phytoplankton community affects how these toxins move through local food webs, the shift in this community is likely to have affected fish and higher trophic level organisms in ways that are important for the ecosystem both ecologically and commercially (MBARI 2006). The shift is possibly related to changes in water mass, nutrient levels, water column structure, or other environmental phenomena (Tanner 2006).

2. ***What is the eutrophic condition of sanctuary waters and how is it changing?*** The offshore environment is rated “good/fair” relative to this question because monitoring data suggests that selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines. A “declining” trend is supported by evidence of nutrient enrichment, increasing nutrient loading, and increasing frequency and intensity of harmful algal blooms in selected areas of the offshore environment. In this context, eutrophication refers to the human accelerated process of organic enrichment of water bodies that can lead to hypoxia and anoxia, habitat degradation, alteration of food-web structure, loss of biodiversity, and alteration of harmful algal bloom (HAB) dynamics (Howarth 2008). Humans could be influencing algal blooms by increasing nutrient availability via runoff, causing climate change, or by assisting in the transport of new species into an area (Gilbert et al. 2005, CIMT 2006). Human-derived runoff, sewage, and fertilizers may be interacting with increased sea surface temperatures to alter the natural pattern of algal blooms.

HAB dynamics in California appear to be dominated by large-scale oceanographic forcing of nutrient dynamics (Anderson et al. 2008, Kudela et al., 2005, Kudela et al., 2004), however, there is growing evidence to suggest that the spatial extent, duration, and toxicity of events can be influenced by anthropogenic nutrient inputs. While evidence for direct causative links between HABs and coastal runoff and/ or eutrophication are lacking, there is abundant correlative evidence within Monterey

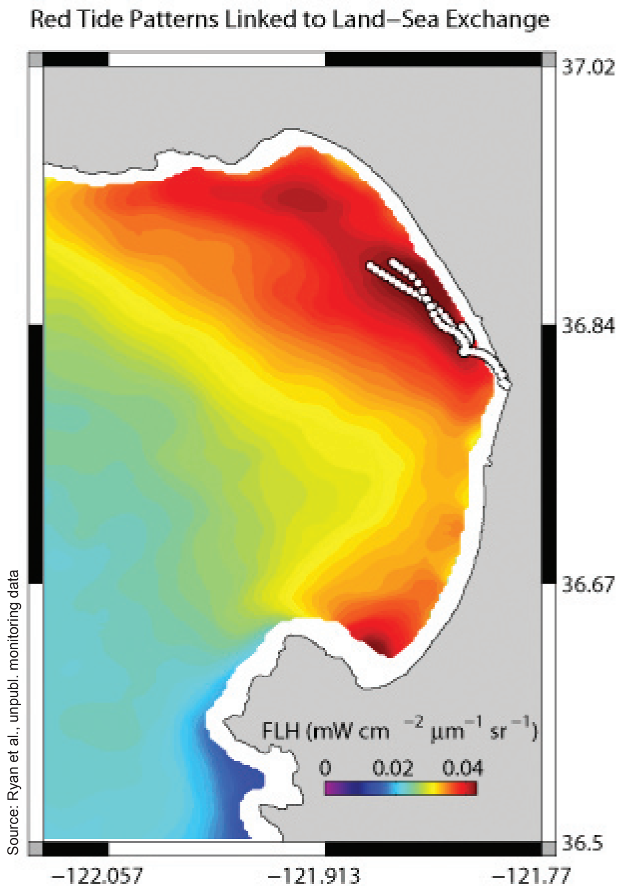


Figure 30. Satellite-collected Fluorescence Line Height (FLH) data, 2002-2007, was used to calculate the mean concentration (red is high, purple is low) of microscopic algae during the months of August-November, a period when red tides have been observed with high frequency in the northern Monterey Bay. Representative drifter tracks, which mark the northward surface transport pattern of land-derived nutrients and material, indicate highest average bloom intensity in the wake of land-sea exchanges.

Bay and in other areas of California (Anderson et al. 2008). Strong linkages have been demonstrated between nutrient enrichment and phytoplankton production in estuarine and marine waters for a wide range of geographic scales (Nixon 1992, Mallin et al. 1993). Scholin et al. (2000) provided indirect evidence that a massive HAB event in Monterey Bay was triggered by post-El Niño runoff. Domoic acid production by *Psuedo–nitzchia* species has been shown to be responsive to inputs from coastal watersheds including copper (Ladizinsky 2003) and urea (Howard et al. 2006). Toxic HAB species (*Pseudo-nitzchia* and *Alexandrium catenella*) may use dissolved organic nitrogen forms such as urea, which has been measured at substantial concentrations in nearshore waters and is likely derived from anthropogenic sources (Cochlan et al. 2008, Anderson et al. 2008).

Satellite and surface currents data in Monterey Bay suggest that inputs from coastal watersheds may contribute to the occurrence of algal blooms (Figure 30). Studies of a major red tide event in Monterey Bay during 2007 indicated bloom inception occurred where rain induced flushing of watersheds entered the ocean (Ryan et al. 2008). Although nutrient inputs are likely to be small relative to seasonal upwelling, the influence of nitrogen sources such as urea on HAB dynamics in Monterey Bay is important since such inputs are likely linked to populous zones of the coast (Kudela et al. 2008a). The massive increases in eutrophication globally that have occurred during recent decades may play an important role in local increases in the frequency, spatial extent and duration of HABs (CIMT 2006). Heisler et al. (2008) conclude that there is a scientific consensus that nutrient pollution promotes the development and persistence of many HABs and that management of nutrient inputs can lead to a significant reduction in HABs.

HABs can negatively affect the ecosystem either due to their production of toxins or due to the manner in which the cells' physical structure or accumulated biomass affect co-occurring organisms and alter food web dynamics (Anderson et al. 2002). In California, HAB problems are dominated by two organisms, *Alexandrium catenella*, which produces a toxin that causes paralytic shellfish poisoning (PSP) and *Pseudo-nitzchia*, which produces the neurotoxin domoic acid (Anderson et al. 2008). Domoic acid and PSP toxins have been detected in the offshore food web in Monterey Bay and in some cases have been linked to mortality events of seabirds and marine mammals (Fritz et al. 1992, Scholin et al. 2000, Jester 2008). HABs (including those from algal species that do not produce toxins) can deplete oxygen levels as the blooms decay or they can destroy habitat for fish or shellfish by blocking light from reaching submerged vegetation. In 2007, a bloom of the dinoflagellete *Akashiwo sanguinea* was responsible for a mass-stranding event of seabirds in Monterey Bay. Jessup et al. (2009) determined that the algae did not produce a biotoxin, but instead produced a detergent-like protein that dissolved the natural oils found in the feathers of seabirds, which prevented the birds from flying, hunting, and keeping warm. In all, 550 birds were found stranded, while 207 were found dead.

3. Do sanctuary waters pose risks to human health? A rating of "good/fair" is given in response to the question with an "undetermined" trend since selected conditions have the potential to affect human impacts, but impacts have not been reported. Selected conditions in offshore waters, including low levels of a number of toxic pollutants and toxins produced by HABs have the potential to affect human health. While there is some evidence of increasing loads of biotoxins and contaminants, a clear trend in the risk to human health could not be determined.

POPs and biotoxins tend to biomagnify as they are passed up the food chain, and long-term exposure can be toxic to a wide range of animals, including humans. Some large, wide-ranging species of fish, marine mammals (e.g., killer whales), and pelagic seabirds (e.g., Black-Footed Albatross) found in offshore waters of the sanctuary have been tested for contaminants and show detectable levels of some contaminants such as DDT, PCBs, and chlordanes (Black et al. 2003, Kannan et al. 2004, Finkelstein et al. 2007). Such contamination, however, has not been directly linked to the water quality conditions in the offshore environment of the sanctuary. Similarly, elevated concentrations of some trace metals, such as mercury, are a health concern for humans who consume some species of large pelagic fishes, such as swordfish and albacore tuna. However, trace metal concentrations are not being monitored in either the offshore waters or in offshore species. Thus, it is not known if fishes harvested in the sanctuary have elevated levels of these contaminants or if the offshore environment of the sanctuary is a significant source of trace metals into the offshore ecosystem.

The toxins produced during harmful algal blooms can accumulate in the marine food web, especially in some fishes and shellfish, and therefore, pose a health risk when consumed. For example, in 1991 and 1998 large blooms of *Pseudo-nitzschia* australis, a diatom that can produce the neurotoxin domoic acid, were observed in Monterey Bay. Subsequently, domoic acid was detected in planktivorous fishes (e.g., anchovy, sardines) and linked to the deaths of fish-eating birds and mammals (Fritz et al. 1992, Scholin et al. 2000). Recent studies have shown that inputs of urea and copper may promote the growth of domoic acid-producing phytoplankton and may increase the production of domoic acid resulting in higher toxicity blooms (Armstrong et al. 2007). A shift in the taxonomic structure of the phytoplankton community occurred in 2004 towards dinoflagellate species that produce paralytic shellfish poisoning toxins rather than domoic acid (Jester 2008). PSP toxins were detected in samples of northern anchovies and Pacific sardines collected between 2003 and 2005, which was the first time these toxins have been detected in California's pelagic food web (Jester 2008).

4. *What are the levels of human activities that may influence water quality and how are they changing?*

The level of human activities that directly influence offshore water quality are considered to be "fair" in that they result in measurable local impacts to the ocean and "improving" due to increased regulation and remediation efforts since establishment of the sanctuary. In many instances it is difficult or impossible to directly measure the impacts of human activity on offshore water quality conditions, but select activities have notable impacts. The main contributor from land-based activities is inputs of contaminants and nutrients linked to urban development and agriculture. The main activity occurring in the offshore waters of the sanctuary is vessel traffic, which can result in acoustic impacts and discharge of ballast water, bilge oil, and trash.

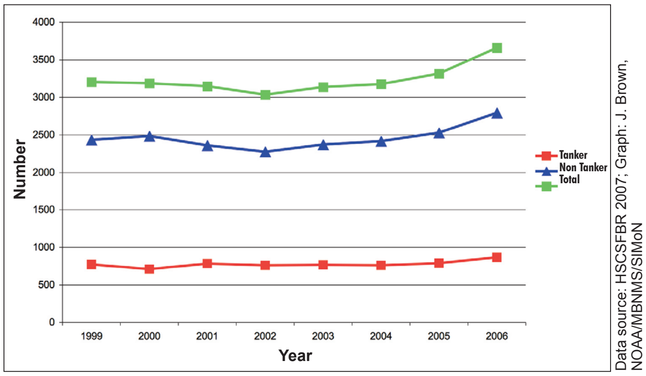


Figure 31. The number of deep draft vessel arriving in San Francisco Bay each year from 1999 to 2006.

In recent years, algal blooms in Monterey Bay have occurred more frequently and have been more persistent than in past years (CIMT 2006). Humans could be influencing algal blooms by increasing nutrient availability via runoff, climate change, or by assisting in the transport of new species into an area (Glibert et al. 1995, CIMT 2006). Human-derived runoff, sewage, and fertilizers may be interacting with increased sea surface temperatures to alter the natural pattern of blooms.

Vessel traffic in and out of San Francisco Bay and Monterey Bay ports has the potential to negatively impact water quality in the offshore environment of the sanctuary. Based on trends in the number of deep draft vessels entering San Francisco Bay, it is likely that vessel traffic through the offshore waters of the sanctuary has increased in recent years (Figure 31). Oil spills from on-going vessel activity, as well as oil releases from sunken vessels in and adjacent to the sanctuary, pose substantial risk to sanctuary resources. In response, the sanctuary developed strategies to move vessel traffic zones farther offshore and use north-south transit lanes to reduce threats of spills from vessels such as tankers, ships containing hazardous materials, barges, and large commercial vessels. These strategies have been approved at the international level and were implemented in 2000.

Beach COMBERS

The Beach Coastal Ocean Mammal and Bird Education and Research Surveys (Beach COMBERS) Program uses trained volunteers to survey beached marine birds and mammals monthly at selected sections of beaches throughout the Monterey Bay area.

Recent remediation efforts to remove oil from submerged vessels have reduced further the risk of oil spills. Oil leaking from the SS *Jacob Luckenbach*, which sank offshore of the Golden Gate in 1953, was responsible for significant seabird oiling events in the winter of 1997-98, 2001-2002, and 2004-05. Removal of approximately 100,000 gallons of bunker oil from this submerged vessel has removed this source of oil into the offshore waters of the sanctuary.

Sanctuary regulations prohibiting the dumping of grey water and bilge water, including recent additional limitations on discharges from cruise ships, serve to reduce some impacts of these activities on water quality. For example, the Beach COMBERS monitoring program found that the average oiling rate of beach-cast bird carcasses (percent oiled carcasses per kilometer per month) was 2% during 1997-2002, which was less than the 8% oiling rate recorded by Pt. Reyes Bird Observatory during 1971 – 1985 (Nevins et al. 2003). This comparison indicates that oil pollution prevention measures implemented during the past 20 years have likely reduced oiling rates in the sanctuary. However, the continued observation of oiled bird carcasses on sanctuary beaches (Nevins et al. in prep) and the observation of oil slicks during aerial surveys of offshore living resources from 2001 to 2008 (K. Forney, NMFS-SWFSC, unpubl. monitoring data) suggest that continued mitigation and enforcement of sanctuary regulations is needed to further reduce the release of oil discharge into the offshore waters of the sanctuary.

Offshore Environment Water Quality Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
1	Stressors	▼ (Fair)	Elevated levels of contaminants (e.g., persistent organic pollutants), and ocean temperature and chemistry changes, some of which have been linked to changes in the offshore ecosystem.	Selected conditions may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats.
2	Eutrophic Condition	▼ (Good/Fair)	Nutrient enrichment in selected areas, increased nutrient loading, and increased frequency and intensity of harmful algal blooms.	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.
3	Human Health	? (Good/Fair)	Measurable levels of biotoxins and contaminants in some locations that have the potential to affect human health; no reports of human impacts.	Selected conditions that have the potential to affect human health may exist but human impacts have not been reported.
4	Human Activities	▲ (Fair)	Inputs of pollutants from agriculture and urban development; reduced risk of impacts from vessels due to regulation of traffic patterns and discharges, removal of oil from sunken ships.	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Declining (▼), Undetermined Trend (?), Question not applicable (N/A)

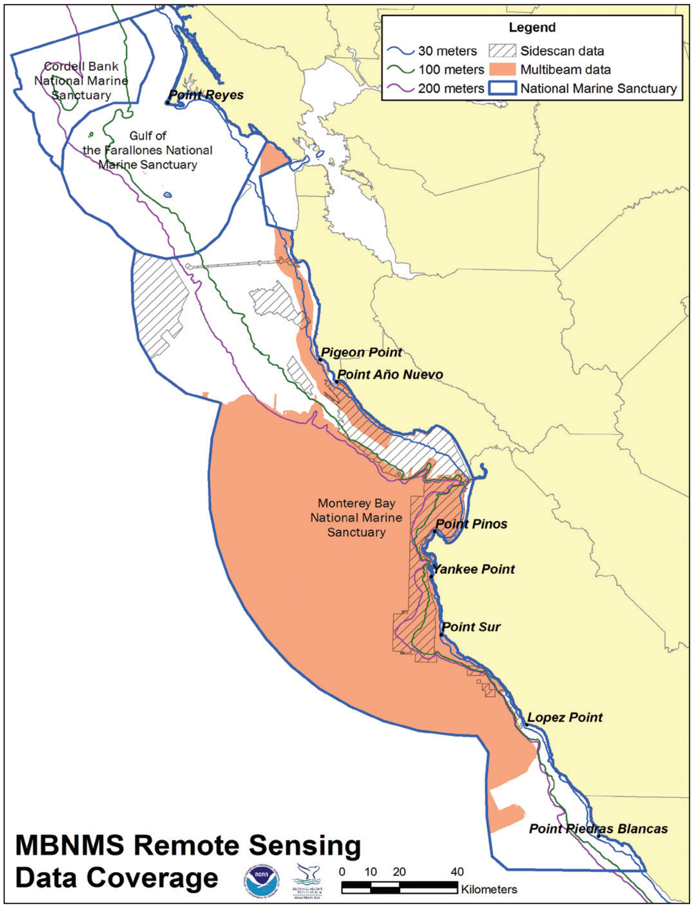
Offshore Environment Habitat

The offshore environment of the sanctuary can be divided into pelagic habitats (i.e., the water column) and benthic habitats (i.e., the seafloor). Pelagic habitats are more difficult to define than benthic habitats, and although these habitats play a key role in the sanctuary ecosystem, they are less well studied than the benthic habitats. This is due, in part, to the logistical and economic hurdles that must be overcome when using large vessels to deploy nets, remotely operated vehicles or submersibles to sample and explore this vast volume of water that is in a constant state of flux. Nevertheless, it is widely recognized that the productivity of the offshore ecosystem supports a great diversity and abundance of invertebrates, fishes, seabirds, and marine mammals. It should be noted, however, that due to the relative dearth of biological knowledge on the water column itself, the offshore environment status and trends are focused primarily on benthic habitats, since this is where the bulk of knowledge resides. The physical and chemical oceanography of the offshore pelagic habitat was discussed in the Water Quality section (above).

The following information provides an assessment of the status and trends pertaining to the current state of offshore marine habitats.

5. ***What is the abundance and distribution of major habitat types and how is it changing?*** The abundance and distribution of major habitat types in the offshore environment of the sanctuary is rated as "fair" based on the past and current levels of human activities that influence the distribution, abundance, and quality of benthic habitats and associated living resources. The trend could not be determined due to a lack of information on both the rate and degree of recovery of habitat and associated living resources inside areas recently closed to bottom-contact fishing gear and the associated changes in the distribution and intensity of fishing activities in the remaining open areas.

The most abundant habitats in the Monterey Bay sanctuary are the open waters - three-dimensional habitats not associated with the seafloor. The total volume of open waters of the sanctuary is 12.026 trillion cubic meters or approximately 4.8 billion Olympic-sized swimming pools. Open water can be subdivided into three zones by depth. The epipelagic zone, which includes the upper 200 meters of the water column, comprises 18% of the open water habitat. The mesopelagic zone, from 200 to 1,000 meters, makes up nearly half of the open water. The remaining 35% of the volume of the open water is deeper than 1,000 meters and is called the bathypelagic zone. The abundance and distribution of the major water column habitats in the sanctuary have not changed over the last few decades, but the quality of these open water habitats is influenced by natural and anthropogenic factors. These changes in the quality of open water habitats have been discussed in the water quality section of this report.



Map: C. King, NOAA/MBNMS/SIMoN

Figure 32. Areas in the Monterey Bay National Marine Sanctuary where major benthic habitat type has been mapped using sidescan sonar (hatched areas) or multibeam sonar (orange areas).

As of September 2007, approximately 72% of the benthic habitats in the offshore waters of the Monterey Bay sanctuary have been mapped with good resolution using sidescan sonar (16%) and multibeam (64%), including some areas of overlap (National Marine Sanctuary: Seafloor Mapping Data Inventory, Figure 32). The remaining 28% of the area has been mapped with a resolution of 200 meters using drop-line surveys (NOAA National Ocean Service). The majority of the benthic habitat in the offshore environment is composed of soft sediments with various mixtures of sand, mud, and silt. Under natural conditions, these soft-bottom habitats are structured by both physical processes, such as currents, and the activities of animals that increase the physical complexity of the habitat by creating mounds, burrows, and depressions. Hard substrates, such as deep reef, rock, and gravel, occur in patches of various sizes, but tend to be less abundant in the deeper portions of the sanctuary. Attached and emergent living organisms, such as deep-sea corals, sponges, and sea pens, provide additional structure. All these different types of fine-scale habitat structure can be used by fishes, crabs, and other taxa as refugia from predation and currents.

Most of the offshore environment in the Monterey Bay sanctuary has not received the detailed characterization and monitoring necessary to quantify the impact of human activities on the distribution, abundance, and quality of major and finescale benthic habitat types and associated living resources. It is unlikely that human activities, such as the installation of submerged cables and fishing with bottom-contact gear, have substantially altered the abundance and distribution of major habitat types. However, based on limited study within major habitat types, these human activities can alter the physical complexity of sediments and alter or remove less common meso-scale habitat types (e.g, bolder, rock, corals) and their associated living resources.

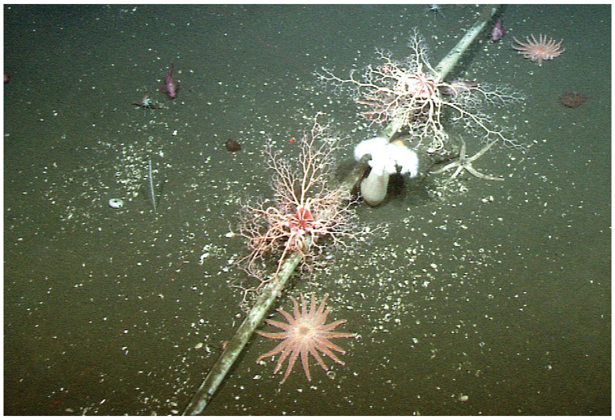
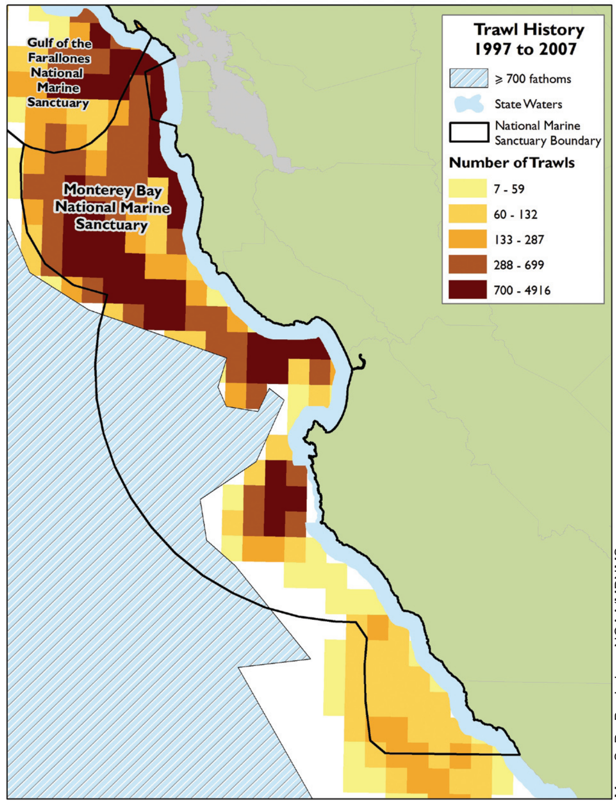


Photo: (c) 2003 MBARI

Figure 33. Several invertebrate species living on or near the Pioneer Seamount cable, which crosses the continental shelf offshore of Half Moon Bay. The animals in this image include sea stars and basket stars, an anemone, and a number of young rockfish. For scale, the cable is about 3.2 centimeters (1.25 inches) in diameter.



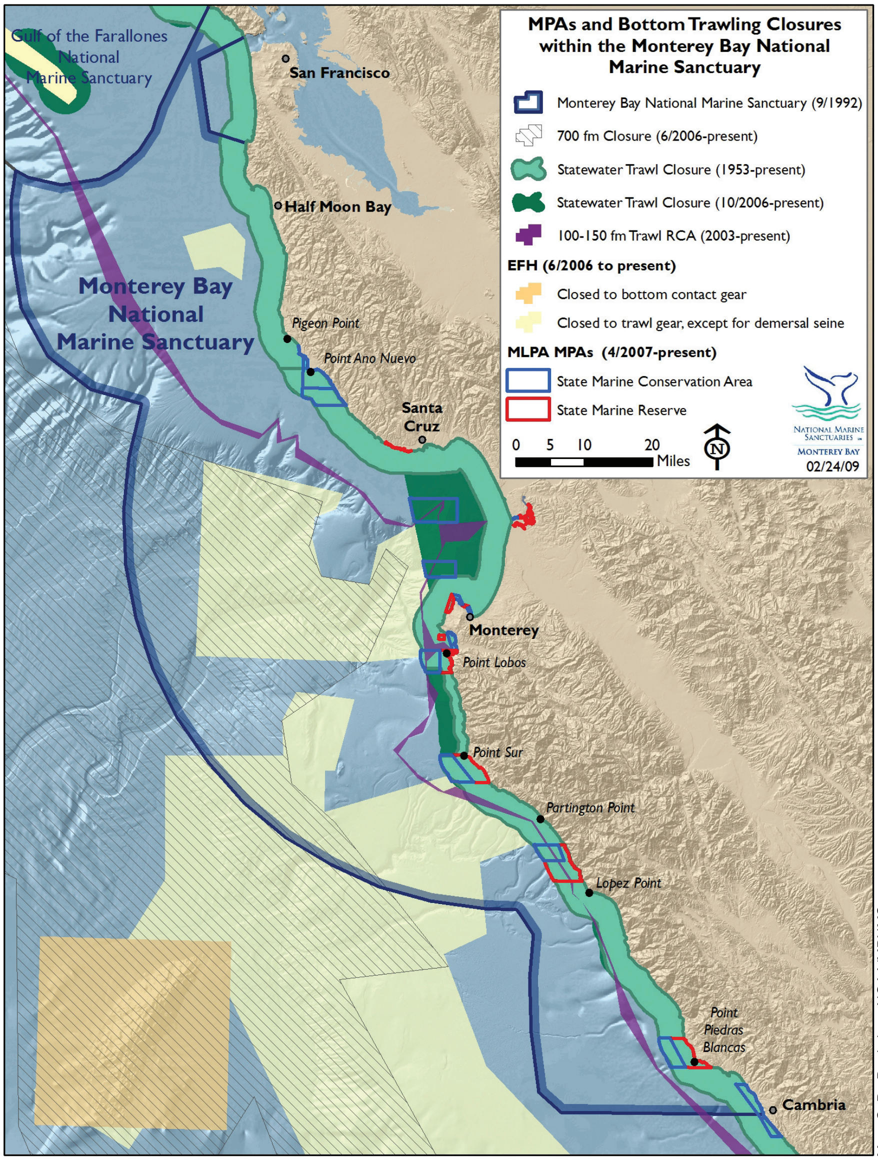
Map: S. De Beukelaer, NOAA/MBNMS

Figure 34. The history of groundfish trawling along the central California coast from 1997 to 2007. Number of trawls per block was calculated by counting trawl tracks that started, ended, or passed through each block. It is based on trawl logbook data provided by the California Department of Fish and Game. Blocks with less than seven trawls (an average of one trawl per year) or fewer than three unique vessels fishing within them are not shown for reasons of confidentiality. Trawling was prohibited during the study period in the light blue portion of state waters. Due to gear limitations, trawling is unlikely to occur in waters deeper than 700 fathoms (blue with grey hatching). This "untrawlable area" comprises 1,343 square miles, or approximately 25% of the area, inside the Monterey Bay National Marine Sanctuary boundary.

In 2002 NOAA's Office of Oceanic and Atmospheric Research (OAR), in collaboration with researchers from the Monterey Bay Aquarium Research Institute and the sanctuary, studied the impact of the Pioneer Seamount cable, a 95 kilometer long coaxial cable installed in 1995 (Kogan et al. 2006). At depths below 20 meters, there was little evidence of effects of the cable on the seafloor habitat. The cable did appear to influence the abundance and distribution of a few benthic species. Sea anemones colonized the cable when it was exposed on the seafloor, and were therefore generally more abundant on the cable than in surrounding, sediment-dominated seafloor habitats (Figure 33). Some fishes were also more abundant near the cable, apparently due to the higher habitat complexity it provides.

The most widespread physical alteration of sanctuary habitats has likely resulted from fishing with bottom-contact gear, such as otter trawls. Among the various environmental impacts resulting from use of this type of gear are removal of structure-forming organisms and the smoothing of bedforms (Auster and Langton 1999, Lindholm et al. 2004). The results of a recent habitat recovery project along the central coast of California (de Marignac et al. 2009) indicate that microtopographic structures on the seafloor, such as biogenic depressions and biogenic mounds, were significantly more abundant in an area that was recovering (3+ years) from trawling as compared to an area that continued to be actively trawled. Similar effects were observed in the Monterey Bay sanctuary in the late-1990's (Engel and Kvitek 1998). Although detailed information on historic and current conditions in the sanctuary's offshore seafloor habitat is limited, the degree and extent of alteration to the physical complexity of these habitats resulting from past activity are a cause for concern. Based on the known physical impacts of bottom trawling (NRC 2002), the limited study of trawling impacts to habitat in the sanctuary, the known extent of trawling effort in the sanctuary over the past eleven years (Figure 34), and the long history of bottom-contact gear use in the offshore environment, the condition of offshore habitats is considered to be "fair". While many impacts to soft-sediments may be less persistent (e.g., homogenization of sediment structure and loss of microhabitat structure), other impacts are long-term (e.g., removal or displacement of boulders and rocks).

A variety of recent management measures directed towards trawling, including an expansion of the prohibition on the use of bottom trawling gear in state waters, the Rockfish Conservation



Map: S. De Beukelaer, NOAA/MBNMS

Figure 35. Existing Marine Protected Areas (MPAs) and bottom trawling closures in the Monterey Bay National Marine Sanctuary. Some portions of state waters in the sanctuary have been closed to bottom trawling since 1913 (Scofield 1948). The current closure began in 1953 (CDFG 1961) as a prohibition on the use of bottom trawling gear from the shoreline out to 3 nautical miles in most areas of the sanctuary (light green) and was expanded to include all state waters in 2006 (dark green). State Marine Life Protection Act MPAs (red and blue areas) were implemented in state waters in September 2007. Essential Fish Habitat (EFH) areas prohibit trawl gear (yellow) or all bottom contact gear (orange). The Trawl Rockfish Conservation Area (RCA) has prohibited trawling since 2003. The minimum extent of the Trawl RCA has been 100-150 fathoms (purple), but the extent of this boundary has fluctuated with a maximum extent of 0 to 200 fathoms.

Area, and the Essential Fish Habitat Closures (Figure 35), have limited the extent of trawling activity in the sanctuary. Due to gear limitations, trawling is unlikely to occur in waters deeper than 700 fathoms. The prohibition on the use of bottom trawl gear at depths below 700 fathoms, which began in 2006, prevents an expansion of trawling into this untrawled area. The combined effect of these management measures by NOAA's National Marine Fisheries Service and the Pacific Fisheries Management Council is to prohibit the use of bottom trawling gear in 55.5% of the Monterey Bay sanctuary. The effect of these measures may be an improvement in the condition of offshore habitats due to some recovery of seafloor habitats in the areas that were previously trawled, though a directed study to determine the degree and the speed of recovery for different ecosystem components is needed.

6. ***What is the condition of biologically-structured habitats and how is it changing?*** The condition of offshore, biologically-structured habitats is rated as "fair/poor" and the trend is "undetermined." A variety of structure-forming and structure-building species occur in the offshore environment of the sanctuary.

However, information on the distribution and condition of these organisms is limited, especially in more remote areas and in comparison to historic abundance and distribution patterns. ROV surveys have recorded a variety of structure-forming species, including soft-corals, gorgonians, sponges, and brachiopods, on the continental slope and submarine canyons in the central and northern portions of the sanctuary (J. Barry, MBARI, unpubl. data). NOAA National Marine Fisheries Service trawl surveys of the continental shelf and slope provide additional records of corals, sponges, anemones, sea pens, and sea whips in the sanctuary (NMFS 2004). These data are augmented by recent towed camera sled and submersible video surveys by the sanctuary in limited areas and occasional observations by West Coast research institutions (Etnoyer and Morgan 2003). The Monterey Submarine Canyon was identified as an area with a relatively high concentration of deep-sea corals compared to other areas along the west coast (Morgan et al. 2005).

Two additional types of biologically-structured habitats in the sanctuary, cold seep communities and whale falls, are known to support very diverse and unique biological communities. Cold seep communities, which are characterized by bacterial mats and chemosynthetic clams and tubeworms, have been found most frequently on steep slopes at depths exceeding 550 meters (Figure 36) (Barry 1996, Paull et al. 2005). It is likely that these long-lived communities occur throughout the sanctuary, but very little exploration of deep-sea habitats has occurred outside the Monterey Bay region. Researchers monitoring whale falls (the sunken carcasses of whales) in the sanctuary have found that these carcasses support a wide diversity of species, including mobile scavengers, dense assemblages of worms and crustaceans, and sulphur-loving bacteria, some of which are newly discovered species (Goffredi et al. 2004).

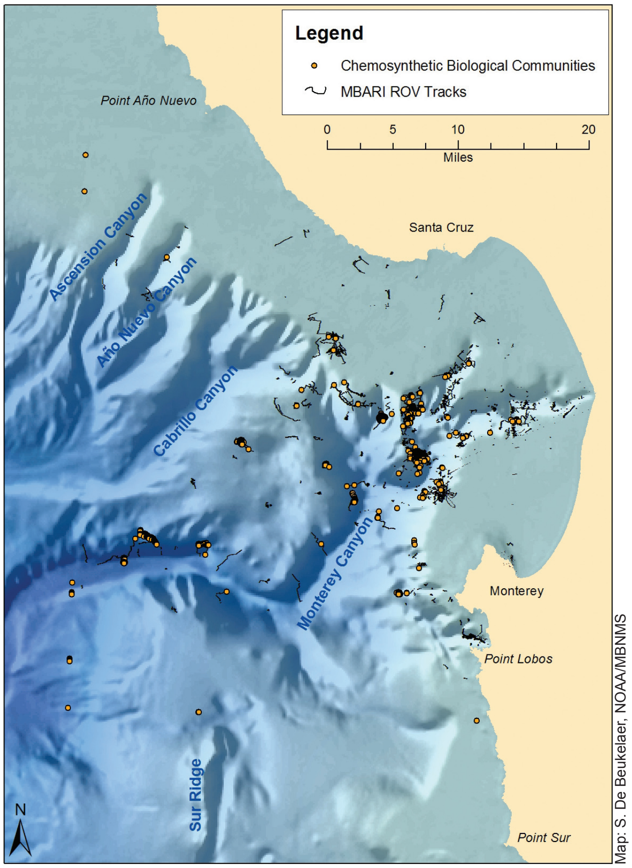


Figure 36. The location where cold seeps (orange circles) have been observed in the Monterey Bay region. Black lines show the locations where the Monterey Bay Aquarium Research Institute (MBARI) conducted remotely operated vehicle (ROV) surveys from April 1989 to June 2002.

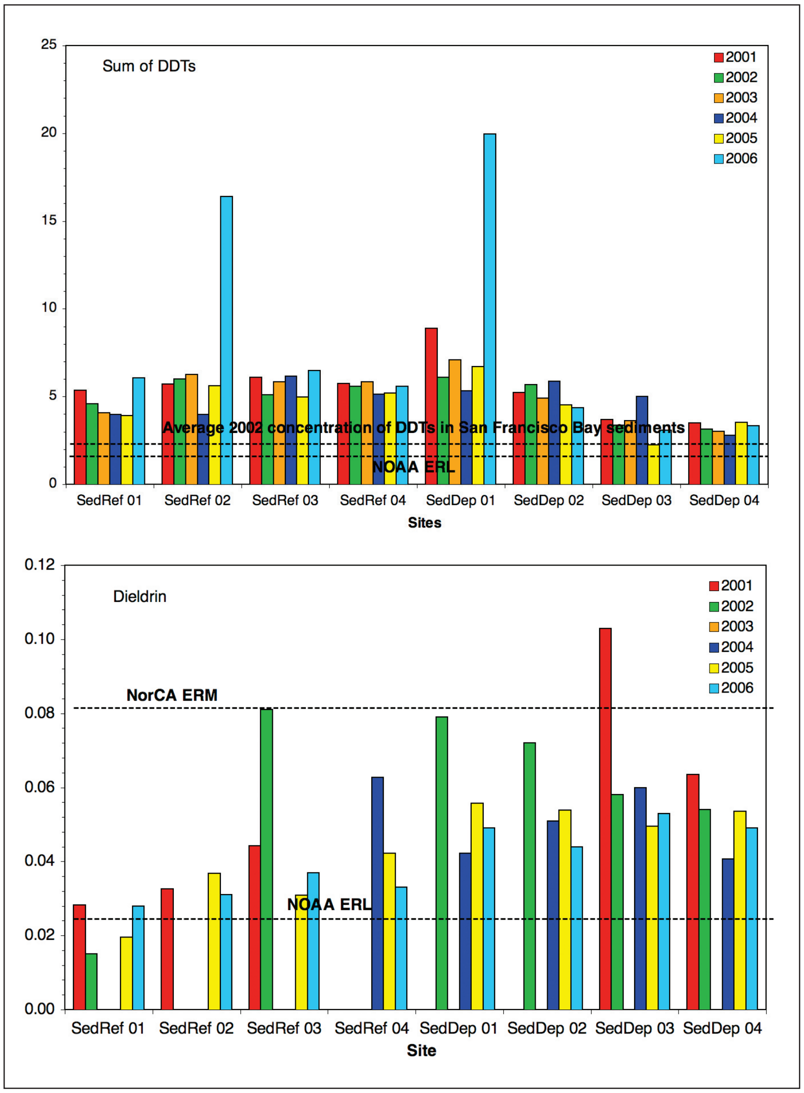
Activities that injure or remove structure-forming invertebrates and associated physical structures result in losses of habitat that supports the offshore living resource assemblage. The most significant impact to structure-forming invertebrates has likely resulted from fishing with bottom-contact gear, such as otter trawls. The results of a recent habitat recovery project along the central coast of California (de Marignac et al. 2009) show that significant differences exist in both microhabitat structure (biogenic mounds and depressions) and macrofaunal invertebrate community structure between an area that was recovering (3+ years) from trawling as compared to an area that continued to be actively trawled. During ROV surveys of the deep seafloor, researchers have observed that areas without trawl marks on the soft bottom tend to have more benthic invertebrate megafauna and associated species and show more advanced community development compared to areas with trawl marks (J. Barry, MBARI, pers. comm.). The impacts of bottom-contact gear on the benthos are very evident and it is possible that ecosystem integrity has suffered as a result of degradation of the benthic community. However, this is an area of research that is, in general, data poor.

Based on the known negative impacts of bottom-contact fishing gear on biologically-structured habitats (Morgan and Chuendpagdee 2003) and the extensive use of these gears in the offshore environment in the past (Figure 34), it is likely that these habitats have been impacted in portions of the sanctuary where these gears were used. However, studies of these deep-sea communities are very limited and the impact of trawling and other human activities have not been assessed broadly. Approximately 25% of the sanctuary is deeper than 700 fathoms and thus inaccessible to existing bottom trawl gear (blue grey hatching in Figure 35). Given the recent closures of approximately

30% of the trawlable area to bottom trawling gear (see Figure 35), the status of structure-forming habitats may be improving in the closed areas. The trend is undetermined at this time. These habitats may not recover quickly or may never re-establish to their original abundance or composition even in the absence of future pressures.

7. ***What are the contaminant concentrations in sanctuary habitats and how are they changing?*** Based on elevated levels of pesticides in shelf and canyon sediments at sites offshore of urban and agricultural pollution sources the condition of offshore habitats is rated as "good/fair". The trend in contaminant concentrations in offshore habitats has not been well studied. However, limited research suggests little to no attenuation in the concentration of some persistent contaminants in sediments on the continental shelf and continued inputs and delivery of some contaminants to deep sea habitats, such as submarine canyons. This limited information suggests an overall "declining" trend for this question.

Sediment samples have been collected annually since 2001 from eight sites along the 80-meter contour in Monterey Bay to test for persistent organic pollutants (CCLEAN 2006). Sediment quality guidelines predictive of toxicity called the NOAA Effects Range-Low (ERL) were exceeded for dieldrin in 30 of the 48 samples (Figure 37) (CCLEAN unpubl. monitoring data). Concentrations of DDTs in every sediment sample exceeded the ERL and also exceeded the average concentration of DDTs in San Francisco Bay sediments collected in 2002 (Figure 37) (CCLEAN 2009). Comparison of these DDT levels with those in sediments collected from nearby sites in 1969-1970s indicated that only one site in southern Monterey Bay has experienced a significant decline in DDTs (CCLEAN 2006).



Source DDT data: modified from CCLEAN 2009; Source dieldrin data: CCLEAN, unpubl. monitoring data

Figure 37. Concentration of DDT and dieldrin, two types of persistent organic pollutants, in sediments collected from eight CCLEAN sites in 2001- 2006. NOAA ERL (Effects Range Low) refers to sediment guidelines developed by the U.S. National Oceanic and Atmospheric Administration based upon the incidence of acute toxicity to amphipods in laboratory tests. NorCA ERM is based on the NOAA Effect Range Median, calibrated to Northern California data (north of Pt. Conception).

Samples from the shelf and slope (down to 1200 meters), and in submarine canyons between San Francisco and the Big Sur coast indicate that DDT concentrations are highest in sediments on the shelf between Half Moon and Monterey Bays and in Ascension, Año Nuevo, and Monterey/Soquel Canyons (Hartwell 2008). Watersheds in the Monterey Bay, especially the Salinas and Pajaro watersheds, appeared to be the primary source of DDT, which were then delivered to the deep ocean via all three canyons (CCLEAN 2006, Hartwell 2008). A similar pathway was identified by Paull et al. (2002) based on a trail of residues of the pesticide DDT. The residues marked the axis of Monterey Canyon as the pathway for sediment transport between the continental shelf and the deep sea. Dilution of the pesticides appeared to

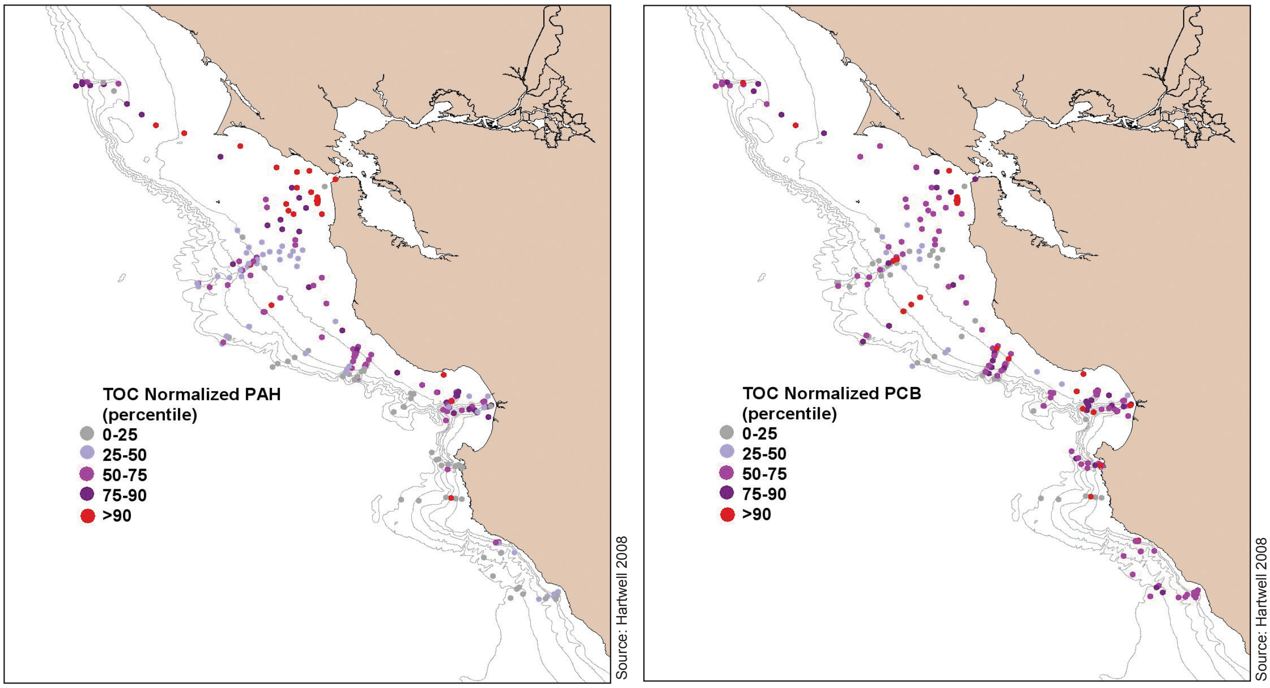


Figure 38. Relative concentration of total PAHs and PCBs normalized for sediment total organic carbon content. PAH and PCB concentrations are the highest in the canyons and lowest on the shelf. Concentration ranges are 25th, 50th, 75th and 90th percentiles.

occur primarily at the coastline, with little further dilution as the sediments moved downslope into >3 kilometer water depths.

A comparison of PAH and PCBs concentrations in sediment samples from the shelf, slope, and submarine canyons between Point Reyes and the Big Sur coast, found the highest levels in the canyons, and the lowest concentrations on the shelf (Hartwell 2008) (Figure 38). Normalizing data for total organic carbon (TOC) content of the sediment shows where concentrations are elevated after adjusting for the affinity of the sediment to accumulate organic contaminants. For the PAH and PCB data, this procedure illustrates that the sediments in the Gulf of the Farallones appear to receive PAHs and PCBs from San Francisco Bay through tidal exchange through the Golden Gate and the offshore sewer outfall more than from longshore drift up the coast. This study suggests that San Francisco Bay is the primary source of PAHs and PCBs to the Monterey Bay sanctuary.

There has been very limited study of the impacts of contaminants in offshore sediments on living resources. As part of the CCLEAN program, ecological effects on benthic infaunal species have been investigated by examining the relationship between sediment characteristics, river discharges, and the numbers of organisms for the most abundant taxa. Results suggest suspended sediment from the rivers, primarily the Pajaro River, may be having negative effects on benthic organisms along the 80-meter contour. Moreover, total abundance may be negatively affected by the cumulative concentrations of POPs (CCLEAN 2006). In a separate study, analysis of the concentration of persistent organic pollutants in demersal fish and invertebrates in the Monterey Bay region found an enrichment of both the PCBs and DDTs up to a factor of four when going from surface to deepwater fish, and a species of deep-sea brittle star showed the highest concentration of DDTs, chlordances and toxaphenes of all samples from the region (Froescheis et al. 2000, Looser et al. 2000). These studies suggest persistent contaminants are being transported to and sequestered in deep-sea habitats through sediment transport processes and that they are being incorporated into the local food web.

8. What are the levels of human activities that may influence habitat quality and how are they changing?

The level of human activities that influence habitat quality in the offshore environment is rated as "fair/poor" because bottom-contact fishing gear has been employed widely for many decades and marine debris has been accumulating for decades in offshore habitats.

Recently, the level of fishing with bottom-contact fishing gear, particularly trawling, has been reduced by landing restrictions, gear restrictions, and area closures (see Figure 35). Two federal gear restrictions adopted area-wide that reduce impacts to physical and biogenic habitat are: a restriction on the use of large footrope (roller) gear for continental shelf species implemented in 2000 (PFMC 2005); and a prohibition on the use of trawl nets to take spot prawn adopted by the Fish and Game Commission in 2003. The area closed to trawling in state waters was expanded in 2006 to include all of Monterey Bay and state waters south of Yankee Point to Point Sur. In federal waters, area closures were implemented to help rebuild overfished populations (Rockfish Conservation Areas (RCA)) and protect groundfish essential fish habitat (EFH). The Trawl RCA restricts commercial bottom trawling for federally regulated groundfish near the outer edge of the continental shelf and the non-trawl RCA restricts longline, hook and line, and pot gear for groundfish on the continental shelf from 30 to 150 fathoms. The EFH areas in the Monterey Bay sanctuary restrict the use of bottom trawl gear. These changes in fisheries management have resulted in decreases in the overall trawling and bottom fishing effort, but may also lead to redistribution of fishing effort and increased fishing pressure in areas open to fishing.

Two other activities that can negatively influence the quality of offshore benthic habitats are installation of submerged cables and loss of fishing gear. Installing submerged cables is strictly regulated by the sanctuary. Four new cables, with a combined total length of 114 kilometers within sanctuary boundaries, have been permitted since the sanctuary was designated in 1992. A recent survey of the ATOC/Pioneer Seamount cable found no measurable impacts of the cable on benthic habitat below 30 meters and only minor influences of the cable on the abundance and distribution of benthic invertebrates (Kogan et al. 2006).

Marine debris directly alters physical habitats by settling on the seafloor (i.e., adding artificial structure) or by removing/damaging biologically structured habitat. In addition, marine debris in the water column, such as lost fishing nets, poses an entanglement risk to pelagic animals, especially large fishes, sea turtles, seabirds, and mammals. Watters et al. (2008) examined the distribution, abundance, type, and potential impacts of marine debris on shelf and canyon benthic habitats in the Monterey Bay region in 1993 and 1994 In this preliminary study 148 transects (typically 10-15 minutes in duration) with a combined length of 44,730 meters were surveyed. Marine debris was found along 47% of transects and was composed most frequently of plastic. Monofilament line used by recreational anglers was the primary source of the debris, followed by commercial fishing nets and longlines (Figure 39). The Monterey Bay sanctuary is working with partners to design and implement a multi-year project to remove lost fishing gear from the sanctuary. The dual purpose of the project is to help eliminate benthic and pelagic hazards to marine organisms posed by fishing debris lost on the bottom, and to provide outreach tools that would assist in the location of lost gear via reports from divers, researchers, fishermen and other parties.

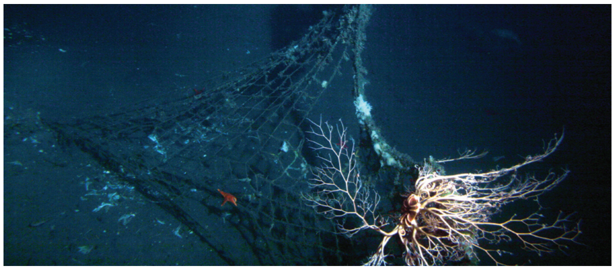


Photo: T. Laidig, NOAA/NMFS/SWFSC

Figure 39. Video surveys from submersibles help locate and quantify types of marine debris, such as this commercial fishing net which poses an entanglement risk for a variety of animals.

Offshore Environment Habitat Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
5	Abundance/ Distribution	? (Fair)	Benthic habitat loss and modification due to fishing with bottom-contact gear; recovery of seafloor habitats resulting from management measures is unknown.	Selected habitat loss or alteration may inhibit the development of assemblages, and may cause measurable but not severe declines in living resources or water quality.
6	Structure	? (Fair/Poor)	Damage to and loss of structure-forming and structure-building taxa due to trawl fishing; recovery of biogenic habitat resulting from management measures is unknown.	Selected habitat loss or alteration has caused or is likely to cause severe declines in some but not all living resources or water quality.
7	Contaminants	▼ (Good/Fair)	No evidence of strong ecosystem level effects; no attenuation of persistent contaminants in sediments; continued input and delivery of some contaminants to deep-sea habitats.	Selected contaminants may preclude full development of living resource assemblages, but are not likely to cause substantial or persistent degradation.
8	Human Activities	▲ (Fair/Poor)	High levels of previous trawl fishing, but recent reductions in trawling activity. Accumulations of marine debris from land and ocean-based human activities.	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Declining (▼), Undetermined Trend (?), Question not applicable (**N/A**)

Offshore Environment Living Resources

Biodiversity is variation of life at all levels of biological organization, and commonly encompasses diversity within a species (genetic diversity) and among species (species diversity), and comparative diversity among ecosystems (ecosystem diversity). Biodiversity can be measured in many ways. The simplest measure is to count the number of species found in a certain area at a specified time. This is termed species richness. Other indices of biodiversity couple species richness with a relative abundance to provide a measure of evenness and heterogeneity. When discussing "biodiversity" we primarily refer to diversity indices that include relative abundance. To our knowledge no species have become extinct within the sanctuary, so native species richness remains unchanged since sanctuary designation in 1992. Researchers have described previously unknown species (i.e., new to science) in deeper waters, but these species existed within the sanctuary prior to their discovery. The number of non-indigenous species has increased within the sanctuary. We do not include non-indigenous species in our estimates of native biodiversity.

Key species, such as keystone species, indicators species, sensitive species and those targeted for special protection, are discussed in the responses to questions 12 and 13. Status of key species will be addressed in question 12 and refers primarily to population numbers. Condition or health of key species will be addressed in question 13. Key species in the sanctuary are numerous and all cannot be covered here. Emphasis is placed on examples from various primary habitats of the sanctuary for which some data on status or condition are available.

The following information provides an assessment of the status and trends pertaining to the current state of the sanctuary's living resources in the offshore environment.

9. ***What is the status of biodiversity and how is it changing?*** Thorough historic and current inventories are not available to fully measure biodiversity status and trends in the sanctuary. Species richness remains unchanged; no species in offshore habitats are known to have become locally extinct. However, the relative abundance of those species has been altered substantially by both natural and anthropogenic pressures. Numerous species in the sanctuary have experienced population declines in recent decades to unprecedented low levels. Conversely, a few species that were uncommon visitors in past decades have increased in abundance in recent years, such as jumbo squid. Shifts in the relative abundance of multiple species, especially those at higher trophic levels, are indicators of compromised native biodiversity in the system and impact community and ecosystem structure and function. For these reasons, the status of native biodiversity in the offshore habitats of the sanctuary is rated "fair." However, the cumulative trend in biodiversity could not be determined due to a lack of information on the changes in relative abundance of many deep-sea species and an uncertainty in how to combine the individual trends in species abundance into a cumulative trend in biodiversity.

A historical perspective suggests that many of the higher trophic level species in the offshore environment, such as marine mammals, seabirds, and predatory fishes, have been dramatically reduced by hunting and fishing. The protection and active management of marine mammal populations by state, federal, and international entities has allowed a full recovery of a number of mammal stocks that occur in the sanctuary, such as gray whales, harbors seals, northern elephant seals, and California sea lions (Angliss and Allen 2009, Carretta et al. 2008). On-going monitoring by the National Marine Fisheries Service is finding that other mammals stocks in the sanctuary remain at reduced levels (e.g., blue whales, harbor porpoise), though some are slowly increasing in abundance (e.g., humpback whales) (Angliss and Allen 2009, Carretta et al. 2008).

Some locally breeding seabirds (e.g., Cassin's Auklets, Rhinoceros Auklets, Pigeon Guillemot, Pelagic Cormorant) have experienced reduced reproductive success in recent years due to poor feeding conditions in the coastal ocean (Goericke et al. 2007). Abundance of non-resident species, such as Sooty Shearwaters and Black-footed Albatrosses, have also declined within the waters of Northern California (Ainley and Hyrenbach unpubl. data), potentially due to population declines resulting from human impacts in remote locations. In addition, the central California population of Marbled Murrelets, a seabird that forages in sanctuary waters and nests in old growth forests adjacent to the sanctuary, was recently estimated between 122 and 225 individuals, which represents a 54-55% decline since 2007 and 71-80% decline since 2003 (Peery et al. 2008). This decline is attributed in large part to terrestrial human activities that result in the degradation or loss of breeding habitat.

Decades of fishery extraction have contributed to a shift in the biodiversity of the fish assemblage in offshore waters. Based on fishery-independent trawl surveys conducted from 1977-2001 along the U.S. West Coast (including sampling sites throughout the Monterey Bay sanctuary), Levin et al. (2006) found that there have been fundamental changes in the fish assemblage on the continental shelf and slope. Populations of flatfishes, cartilaginous fishes, and small rockfishes have increased, while populations of large rockfishes have decreased. In 1977, rockfishes were more than 60% and flatfishes were 34% of the fish captured in the survey. In 2001, rockfishes were 17% and flatfishes were nearly 80% of the fish captured in the survey. The species

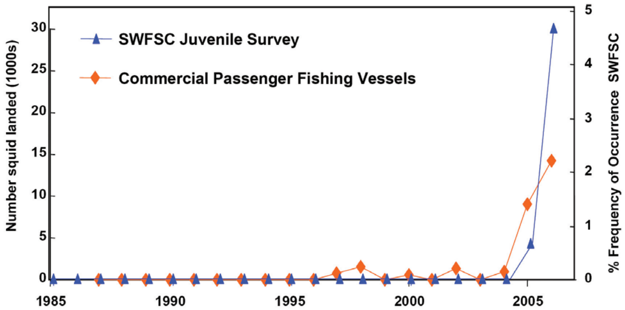


Figure 40. Indices of relative jumbo squid abundance over time. The number of squid caught by California commercial passenger fishing vessels north of Point Conception (orange diamond) and the frequency of occurrence of jumbo squid in pelagic midwater trawl surveys conducted in May and June off of the central California coast by the Southwest Fisheries Science Center (SWFSC) since 1985 (blue triangle) are shown. Source: Modified from Field et al. 2007.

that now dominate the shelf/slope assemblage have vastly different trophic roles and life-history strategies than the species they replaced.

The abundance of jumbo squid (*Dosidicus gigas*) has increased recently in the sanctuary (Figure 40) and may be having impacts on both regional and local biodiversity. Observations from remotely operated vehicle surveys in the Monterey Bay region show that these large squid have been present and sporadically abundant since the 1997-98 El Niño event, particularly between 2003 and 2006 (Zeidberg and Robison 2007). This voracious predator consumes a variety of pelagic and semipelagic fishes, including commercially harvested species (e.g., Pacific hake, sablefish, various rockfishes), and could drive changes in the pelagic food web (Field et al. 2007). For example, the presence of jumbo squid in Monterey Bay surveys has been associated with declines in observations of Pacific hake (Zeidberg and Robison 2007). Jumbo squid are also a key forage item for many higher trophic level fishes and marine mammals throughout their range, including toothed whales and commercially important tunas, billfishes and sharks (Field 2008). These animals are likely to play a major role in structuring offshore ecosystems. The cause of the observed range expansion of jumbo squid has not been determined; possible contributing factors include a switch in the Pacific Decadal Oscillation, harvesting of large pelagic predators, and global warming.

Biodiversity in deep-sea communities of the sanctuary is not well understood because of the logistical challenges of conducting research in deep water. Due to technological advances in undersea research, census and evaluation of ecological integrity of deep-sea habitats has only recently begun for midwater assemblages (e.g., MBARI Midwater Ecology ROV surveys) and benthic communities (e.g., MBARI Benthic Ecology ROV surveys). For example, surveys of whale falls and cold seep communities have led to the discovery of several new species (Barry et al. 1996, Goffredi et al. 2004). There are indications that deepwater sponge and coral communities in the sanctuary have been impacted before many aspects of their basic biology and ecology could be ascertained. Overall, there is much that is unknown about the species richness and evenness of several important communities within the offshore habitats of the sanctuary.

10. What is the status of environmentally sustainable fishing and how is it changing? Environmentally sustainable fishing or ecologically sustainable fishing may be defined as fishing at a level that the ecosystem can sustain without shifting to an alternative or undesirable state. To determine if environmental fishing is occurring, one has to simultaneously consider the impacts of all harvested species on an ecosystem, and community stability and resilience (Zabel et al. 2003). It is designed to consider fishery yield and the integrity of ecosystem structure, productivity, and function and biodiversity, including habitat and associated biological communities. The past decade has seen a paradigm shift in the management of fisheries from managing target stocks for maximum sustainable yield to ecosystem-based fisheries management. This shift leads to a more holistic consideration of sustaining fishery yield, as well as maintenance of marine ecosystems and their function.

The status and trend ratings of “fair” and “improving” for this question are based on the available scientific knowledge (e.g., published studies, unpublished data, and expert opinion) of targeted and non-targeted living resources that are directly and indirectly affected by fishing. Because this is the first Monterey Bay sanctuary condition report, the status rating reflects a more historical view of the potential effects of fishing activity on biological community development, function, and ecosystem integrity, over the last two to three decades. Subsequent reports will take a more contemporary view of the ecosystem-level impacts of fishing. The status rating does not serve as an assessment of the status of current fisheries management practices in the region. However, the determination of an increasing trend for this question does reflect recent changes in fisheries management practices and their positive effects on living resources in the sanctuary.

Historical accounts, ranging over several timescales from decades to centuries, demonstrate how commercial and recreational fisheries have extracted significant biomass from waters now encompassed by the Monterey Bay sanctuary, in part using methods that are known to reduce physical complexity and damage living structures of seafloor habitats. Several species of whales, pinnipeds, and large sharks were drastically reduced, at least in part as a result of historic fishing, and are currently at depressed population levels (Leet et al. 2001). The effects of reducing the abundance of currently fished stocks, in some cases to less than 50 percent of the unfished biomass, on ecosystem health and integrity are poorly researched and understood, but have the potential to alter ecosystems. Meanwhile, scientists are just beginning to understand fundamental elements of ecosystem function - the distribution and community composition of seafloor habitats, the distribution of and habitat requirements for different life stages of important commercial species, the significance of diverse age structures in sustaining fishery resources, and many other factors that influence community development and function. For these reasons, this question is rated "fair."

The major commercial fisheries that operate in the Monterey Bay sanctuary target groundfish (rockfishes, flatfishes), pelagic finfish (salmon, sardines, anchovy, mackerel), and invertebrates (market squid, Dungeness crab, spot prawn). In the recreational fishery, commercial passenger fishing vessel anglers traditionally target rockfish, salmon, lingcod, and, opportunistically, albacore tuna (CDFG 2008b). Dungeness crab and jumbo squid are the main invertebrates targeted by the central and northern California recreational fishery (CDFG 2008b). In general, fisheries managers appear optimistic that sustainable fisheries in the offshore waters of the sanctuary are possible under new management regimes following historical stock declines. Marine communities in the Monterey Bay sanctuary are subject to complex pressures and interactions and many targeted species are long lived, therefore fishery management actions aiming to allow population recovery may experience a long lag period before changes are observed.

Of the 80 species of groundfish managed under the PFMC's Groundfish Fishery Management Plan, 22 species are managed at the species level. The remaining species are either unassessed or managed in groupings or stock complexes, because individually they comprise a small part of the landed catch or stock assessments have not been completed. For some species, it is unlikely that sufficient information exists to develop adequate stock assessments.

The status and management of many groundfish stocks has undergone dramatic changes over the past few decades. Beginning in the 1970s, improved understanding of life history characteristics led fisheries scientists to conclude that many groundfish species were incapable of sustaining high-intensity fishing pressure using modern fishing methods. Over the next two decades, several groundfish stocks became depleted due to a combination of fishing and natural factors. Since the late

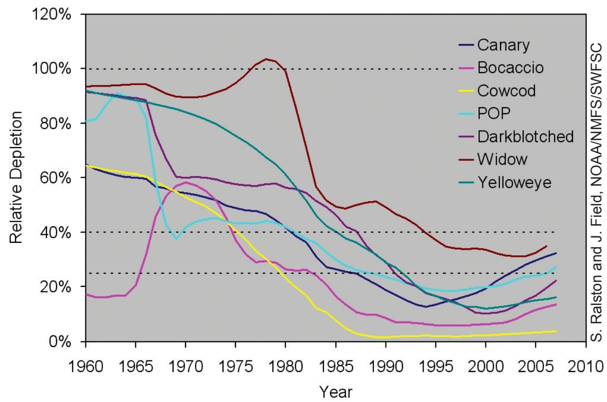


Figure 41. Trend in the relative depletion of overfished rockfish species that are managed by the PFMC. Relative depletion is the estimated size of the spawning population relative to the estimated size of the population if unfished. A stock size of 40% relative to the unfished level is the target management level while a stock size of 25% or less is considered overfished. Data is based on the most recent set of stock assessments.

1990s, some formerly depleted groundfish species have recovered quickly (e.g., English sole), while others are rebuilding more slowly (e.g., bocaccio). Four rockfish species — bocaccio, cowcod, yelloweye rockfish, and darkblotched rockfish — are currently considered overfished). All depleted rockfish species with stock assessment data are showing increasing trends in spawning biomass over the past ten years (Figure 41). Moreover, 11 out of 18 rockfish species show evidence of increasing average body size since 1999 (S. Ralston, NOAA/NMFS, unpubl. data). The recent increase in size of these fishes is consistent with a response to reduced fishing effort.

Salmon have been one the most important species in both commercial and recreational fisheries in the Monterey Bay sanctuary. Managing ocean salmon fisheries is an extremely complex task, due in large part to the wide oceanic distribution of the salmon and difficulty in estimating the size of salmon populations. Salmon at all life history stages are affected by a wide variety of natural and anthropogenic factors in the ocean and on land, including ocean and climatic conditions, habitat degradation and loss, and predation (including humans). Other challenges to a sustainable salmon fishery off central California coast include judging the effects of different regional fisheries on salmon stocks, competition between wild and hatchery salmon, and restoring freshwater habitat. In the last 20 years, commercial and recreational catches of salmon in California have fluctuated in response to population trends, regulatory seasons, and quotas. Many of the salmon stocks that occur off California are listed as threatened or endangered under the Endangered Species Act. Ocean salmon fisheries in California primarily target Chinook salmon since the retention of coho salmon was prohibited in the commercial and recreational fisheries in 1993 and 1996, respectively. Recently, the low returns of Chinook salmon in two stocks, the Klamath River fall run and the Sacramento River fall run, led to very restrictive limits on commercial and recreational fishing for salmon in 2006 and a complete closure of both fisheries south of Cape Falcon, Oregon in 2008 (PFMC 2006, 2008).

Pacific sardine, market squid, northern anchovy and Pacific mackerel are four of the largest volume fisheries in the state of California (CDFG 2008b). Sardine, anchovy, and mackerel stocks are assessed by the National Marine Fisheries Service, whereas market squid and anchovy stocks are monitored by the California Department of Fish and Game. Landing data dating back a couple decades show large fluctuations in harvest for each of these species (Leet et al. 2001, CDFG 2008b). Some of these fluctuations in landings may be due to changes in management, but it appears that population size for these species tends to be influenced strongly by prevailing oceanographic conditions (Leet et al. 2001). Currently, these coastal pelagic fisheries in California appear to be healthy (CDFG 2008b).

The commercial Dungeness crab fishery is one of the top value fisheries in the state (CDFG 2008b). Historically, this fishery has been cyclical with abundance peaking approximately every ten years (CDFG 2008b). The large fluctuation in landings is likely due to varying ocean conditions including water temperature, food availability and ocean currents (Leet et al. 2001). The Dungeness crab and spot prawn fishery are trap-based fisheries with low by-catch and both appear to be environmentally sustainable fisheries (Leet et al. 2001, Hankin et al. 2004, Larson and Reilly 2008).

Despite the improving trend for many harvested groundfish species and the more restrictive fisheries management measures that have been implemented for groundfish, finfish, and invertebrate fisheries, there is still concern over the ecological impact of the past and present fishing activities in the sanctuary. Fishing can alter marine ecosystems both by altering local environments, as when trawls drag across the ocean floor, and by modifying community composition (Zabel et al. 2003). MBARI ROV surveys of the continental shelf and slope in the sanctuary commonly observe trawl marks on soft bottom. Soft-bottom areas that were trawled have been denuded of benthic invertebrate microfauna and associated species, whereas areas that lack trawling show much more advanced community development (Jim Barry, MBARI, pers. comm.). The impacts of the trawl fishery to benthic habitats and communities are very evident and it is possible that ecosystem integrity has suffered as a result of degradation of the benthic community (Jim Barry, MBARI, pers. comm.). Even nominal amounts of trawling in a pristine area can lead to significant damage. Closures of some areas to trawling should lead to improvements over time, but other areas may receive higher pressure due to fishery displacement.

Very little is known about the community and ecosystem-level consequences of repeatedly removing a large portion (up to 60%) of the biomass of multiple species in the same ecosystem. However, some recent studies lead to concerns that past fishing activity has impacted community function and ecosystem integrity in the sanctuary. Levin et al. (2006) found that over the last 25 years there have been fundamental changes in the fish assemblage on the continental shelf and slope of the U.S. Pacific coast. Populations of flatfishes, cartilaginous fishes, and small rockfishes have increased, while populations of large rockfishes have decreased. The species that now dominate the shelf/slope assemblage have vastly different trophic roles and life-history strategies than the species they replaced. In a separate study, Yoklavich et al. (2000) compared the fish assemblage in an area of Monterey Bay that was a natural refuge from fishing to the assemblage in fished area. They found that sites that were less fished had larger fishes, and had significantly higher abundances of major commercial and recreational species, including boccacio and cowcod, than more heavily fished areas. Shifts in community composition may disrupt direct and indirect ecological processes inherent in food webs and alter community trophic interactions and energy flow. For example, in communities with complex species interactions, targeted removals of large predators from a population can reduce the resiliency of that community to perturbations (Baskett et al. 2006).

Fishing can directly affect communities, as when it changes key life-history traits (Zabel et al 2003). For example, fisheries typically seek larger, more valuable fish, decreasing the average size of fish in the target populations. Past fishing practices have resulted in a decrease in both the mean size (Figure 41; Mason 1998) and local density (Yoklavich et al. 2000) of some targeted species, such as large-bodied rockfish, in the sanctuary. Though population-level changes have been measured in the sanctuary, the potential community-level consequences are poorly studied. One recent study by Harvey et al. (2006) estimated the impact of size and density changes on energy consumption and fecundity in a rockfish assemblage that included bocaccio – a large-bodied, overfished species. They found shifts in the allocation of energy and reproductive potential within the assemblage that had the potential to affect the ability of bocaccio and other large rockfish species to recover from overfishing.

As mentioned above, a number of the fished stocks in the sanctuary are known to experience substantial fluctuations in abundance. Some of the fluctuation can be attributed to significant climate shifts that last from a couple of years to several decades. However, there is concern that fishing pressure may contribute to more frequent or more extreme fluctuations in abundance. A recent analysis of long-term monitoring data of the ichthyofaunal assemblage off of southern California found that fishing significantly increases temporal variability of populations in the ecosystem (Hsieh et al. 2008). Exploited populations were found to be more vulnerable to climate variability and lead to unstable boom and bust cycles. The likely cause of this increased variability is that selective harvesting can alter the basic dynamics of exploited population, such as intrinsic growth rates (Anderson et al. 2008). Drastic changes in the abundance of fished stocks could have substantial impacts on the offshore ecosystem, which consists of a complex web of pelagic and demersal fishes and invertebrates, marine mammals, and seabirds.

11. *What is the status of non-indigenous species and how is it changing?* Non-indigenous species in offshore habitats are not suspected or do not appear to affect ecosystem integrity because very few non-indigenous species have been identified in these habitats. Therefore, the rating related to this question is "good" and the trend is "stable." Maloney et al. (2006) reported that four of the species identified from infaunal samples collected in deeper waters (30-120 m) offshore of California were introduced: *Anobothrus gracilis*, *Laonice cirrata*, *Melinna oculata* and *Trochochaeta multisetosa*. All of these species are polychaete worms (phylum: Annelida), and represented only 1% of the total annelid taxa identified from infaunal samples.

Some species that forage in the open ocean are adversely affected by introduced species in habitats outside the boundaries of the Monterey Bay sanctuary, such as in other portions of their geographic range. For example, predation by introduced black rats on eggs and chicks has negatively impacted the reproductive success of nesting seabirds on Anacapa Island, near the Channel Islands sanctuary (http://www.nps.gov/chis/naturescience/restoring-anacapa-island.htm). Removal of this introduced species has resulted in substantial recovery of rare seabird populations on the island, including Brown Pelican and Xantus's Murrelets that forage during the non-breeding season in the Monterey Bay sanctuary.

12. *What is the status of key species and how is it changing?* The status of key species in the offshore environment is rated "good/fair" and the trend is "stable." There are many high-profile species in offshore habitats. These include cetaceans, seabirds, pelagic fishes (e.g., salmon, tunas, sharks), and sea turtles. Many of these are apex predators and play important ecological roles in the sanctuary ecosystem. Here we focus on a few examples from each of the major species groups.

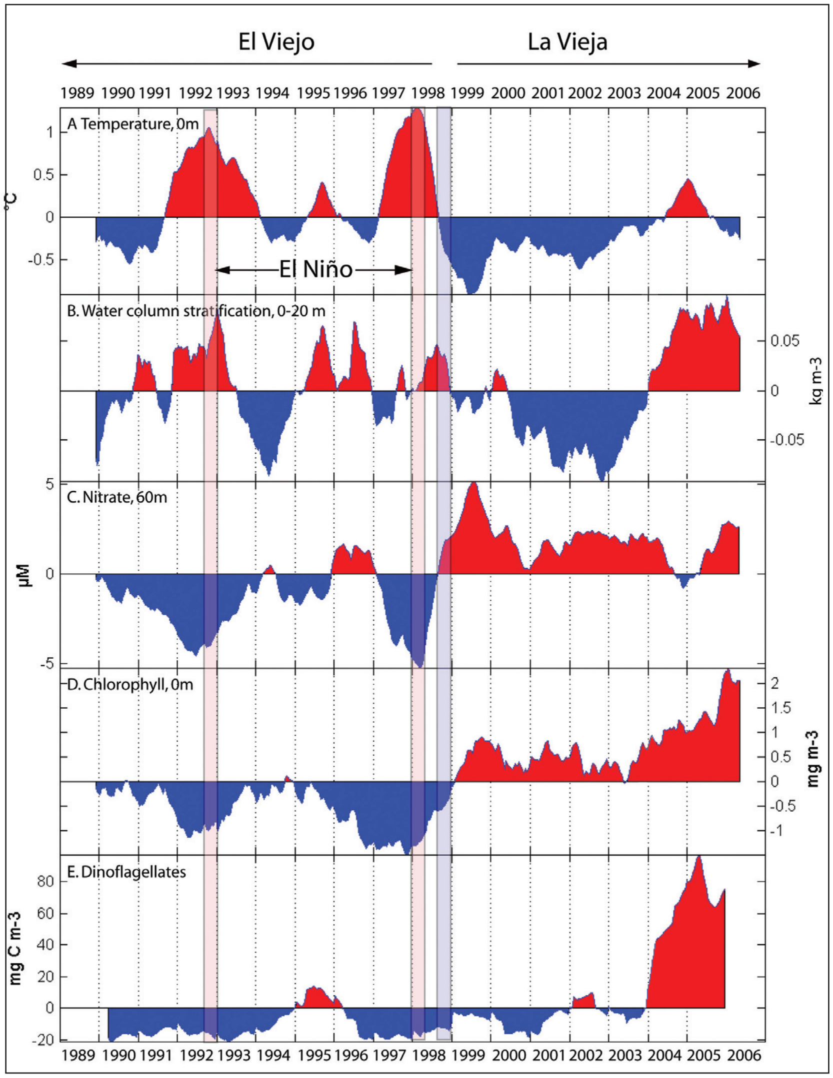
Among seabirds, Sooty Shearwaters are key species because of the extremely high densities reached during the summer, when hundreds of thousands of adults forage for fishes and squid in sanctuary waters after migrating from the southern hemisphere (Adams and Harvey 2006). A 32% decline in average densities of Sooty Shearwaters was calculated from the period 1985-1994 to the period 1997-2006 based on shipboard surveys in central California (Ainley and Hyrenbach, unpubl. data). This decline is due potentially to a number of factors occurring outside the Monterey Bay sanctuary including changes in oceanographic conditions and human impacts in remote locations (Hyrenbach and Veit 2003, Scofield and Christie 2002).

Stock assessments suggest that many of the populations of marine mammals that use sanctuary habitats are stable or increasing (Carretta et al. 2008, Angliss and Allen 2009). For example, there is evidence suggesting an increasing population for the eastern North Pacific humpback whale stock (Calambokidis et al. 2004). The population of Steller sea lions off California and Oregon is stable or increasing very slowly (Angliss and Allen 2009). The abundance of this threatened species in the sanctuary is monitored by observing the number of pups and non-pups at the breeding colony on Año Nuevo Island. Pup counts and non-pup counts taken in July have decreased from 1990-2004 at an average annual rate of -2.63% and -1.28%, respectively (M. Lowry, NMFS-SWFSC, pers. comm.). Similar declines have been observed at South Farallon Island, a breeding colony just north of the Monterey Bay National Marine Sanctuary.

Salmon are key species in the sanctuary due to their important role in both the offshore foodweb and in commercial and recreational fisheries. Historically, salmon were abundant in central California rivers, estuaries, and offshore waters. Currently, the abundance of salmon in the sanctuary is drastically reduced and many of the salmon stocks in central California have been listed under the federal Endangered Species Act. Salmon at all life history stages are affected by a wide variety of natural and human-caused factors in the ocean and on land, including ocean and climatic conditions, habitat degradation and loss, and predators (including humans). Ocean survival of salmon can be an important influence on overall population size, and differential ocean survival depends on oceanic conditions. Both the Pacific Decadal Oscillation (PDO) and climate change influence salmon abundance in the sanctuary.

Forage species (e.g., krill, anchovies, squid) are among the most important to the ecosystem as a whole. These forage species directly and indirectly support the tremendous abundances and species diversity of higher trophic levels. Squid serve as both predator and prey in offshore food webs. Market squid are seasonally abundant and population size appears to be influenced more by prevailing oceanographic conditions rather than by fishing pressure, though additional research is needed to better understand the relative influence of environmental variability and fishing pressures on the biomass of this stock (Porzio and Brady 2008). Krill is an abundant shrimp-like crustacean that directly or indirectly feeds much of the pelagic food web. To date there has never been an active fishery for krill along the U.S. West Coast. To assure the protection of this resource for the marine mammals, seabirds, and fishes that rely on krill as a primary food source regulations prohibiting the harvest of krill in state waters of California, Oregon, and Washington were passed in 2000 by each state's legislature. Similarly, a prohibition on the harvesting of krill in the Exclusive Economic Zone (EEZ) off the coasts of California, Oregon, and Washington was adopted in 2006 by the Pacific Fisheries Management Council. The National Marine Fisheries Service published a final rule in the Federal Register which went into effect on August 12, 2009.

Phytoplankton is another key component of the ecosystem, and consists of multiple species. Starting in 2003, the biomass of dinoflagellates increased dramatically in the surface waters of the sanctuary, and was correlated with a decrease in upwelling favorable winds and increases in both water column stratification and surface chlorophyll (an indicator of overall phytoplankton biomass) (Figure 42) (Pennington et al. 2007). This recent change in the phytoplankton assemblage, from a diatom-dominated to a dinoflagellate-dominated assemblage, persisted into 2006 and almost certainly has ecological consequences, most of which are unknown.



Source: Pennington et al. 2007

Figure 42. Monitoring data collected by the Monterey Bay Aquarium Research Institute were used to create time series of anomalies, with higher [or lower] than normal values in red [or blue]. (A) 0 m temperatures have in general remained cool since 1998, resulting in high (C) 60 m nitrate and (D) 0 m chlorophyll (overall phytoplankton biomass) values. However, centric diatoms decreased sharply in 2003 and were apparently replaced by (E) dinoflagellates in 2004. This phytoplankton switch may have been caused by increased (B) near-surface stratification (0-20 m difference in the water density parameter, sigma-t) which resulted from decreased wind-driven upwelling after 2003. Timing of two El Niños (pink column) and one La Niña (light blue column) are shown.

13. What is the condition or health of key species and how is it changing? The condition of key species in the offshore environment is rated "good/fair" and has a "declining" trend. The health of several key species has been compromised by exposure to neurotoxins produced by harmful algal blooms, entanglement in active and lost fishing gear, ingestion of marine debris, and accumulation of persistent contaminants. The continued input of non-biodegradable marine debris and persistent contaminants into the offshore waters of the sanctuary combined with the lack of attenuation of legacy contaminants, indicates that these threats to the condition of key species have steadily increased over the past decades and will continue to increase in the future.

Some species of phytoplankton produce natural toxins that adversely affect several apex predators, including marine mammals and seabirds that forage offshore. In particular, domoic acid, a neurotoxin produced by the diatom *Pseudo-nitzschia*, has been problematic. For example, along the central California coast over 400 California sea lions died and many others displayed signs of neurological dysfunction during May and June 1998, during the same time period that a bloom of *Pseudo-nitzschia* was observed in the Monterey Bay region (Scholin et al. 2000). Large blooms of domoic acid producing phytoplankton were observed in Monterey Bay during 2000, 2002, and 2007 and these blooms were suspected as the cause of increased numbers of stranded and dead seabirds and mammals recorded on beaches in the Monterey Bay region by the Beach COMBERS (Coastal Ocean Mammal / Bird Education and Research Surveys) monitoring program (Nevins et al. in prep).

A health concern for key species in the sanctuary, including marine mammals, seabirds, and sea turtles, is interaction with active and lost fishing gear. Monitoring of hauled-out seals and sea lions on Southeast Farallon Island (just outside the Monterey Bay sanctuary) during the period 1976-1998 documented a total of 914 individuals that were entangled in synthetic material (Hanni and Pyle 2000). Of a total of 6,196 live stranded seals and sea lions admitted to a rehabilitation center on the central California coast from January 1986 to September 1998, 107 (1.7%) had lesions caused by entanglement with manmade marine debris, including active or discarded fishing nets and monofilament line, packing straps, plastic bags, rope, and rubber o-rings (Goldstein et al. 1999).

Ingestion of plastic marine debris is a health concern for a number of seabird species in the sanctuary. The sanctuary's Beach COMBERS monitoring program has collected carcasses of dead seabirds for study by local researchers. Analysis of the stomach contents of 190 Northern Fulmars collected along Monterey Bay beaches in 2003-2004 found that 71% of the birds had plastic in their stomachs (Nevins et al. 2005). In similar studies, plastic was observed in the stomachs of 67% of the 27 Red Phalaropes collected in 2005-2006 (Zabka et al. 2006) and 56% of the 16 Horned Puffins collected in 2007 (Phillips et al. 2007). These species of seabirds, and other seabirds such as albatrosses and shearwaters, are migratory birds that depend on the highly productive waters of Monterey Bay to feed. These seabirds are susceptible to plastic ingestion everywhere they feed, including the sanctuary.

The high trophic level and longevity of marine mammals and seabirds put them at risk of accumulating contaminants in their bodies to levels high enough to cause potential health impacts. Measurable loads of organochlorides (e.g., PCBs, DDTs) have been observed in marine mammal and seabird species that occur in the sanctuary, including Steller sea lions (Jarman et al. 1996), harbor porpoise (Calambokidis and Barlow 1991), killer whales (Black et al. 2003, Krahn et al. 2007), Black-footed Albatross (Finkelstein et al. 2006, 2007), and the eggs of a number of species of locally nesting seabirds (Pyle 1999). However, a general lack of consistent long-term data coupled with the wide ranging movement patterns of these species make it difficult to determine whether habitats and prey resources in the sanctuary are a significant source of contaminants for these species. A recent meta-analysis of the available contaminant data in the sanctuary revealed the highest concentrations of multiple contaminants occurred in the Elkhorn Slough and Salinas Valley areas and are probably associated with legacy agricultural applications (Hardin et al. 2007). There has been no measurable attenuation for several legacy contaminants even though their application was banned 20-30 years ago, and PAHs and PCBs increased marginally at some sites (Hardin et al. 2007). Pinpointing the sources of these contaminants is difficult, since there are multiple processes and activities that could account for high contaminant concentrations in the sanctuary, including agricultural practices, urbanization, and some recreational activities.

The decline of the central California breeding population of Steller sea lions may be caused by a combination of factors, including disease, elevated levels of organochlorine and trace metal contaminants (Jarman et al. 1996), competition for prey resources, and entanglement in fishing gear and other marine debris. In some cases, exposure to one threat may make the animals more susceptible to the others (e.g., high level of contaminants may make an animal more susceptible to disease). The relative importance of many of these threats is not known.

Chronic oiling has negatively affected seabirds in Monterey Bay National Marine Sanctuary, despite efforts to mitigate sources such as illegal dumping of bilge water and leakage of oil from sunken vessels. On average, when more than 2% of seabirds surveyed on sanctuary beaches are oiled, a significant oiling event has occurred; such was the case in the winters of

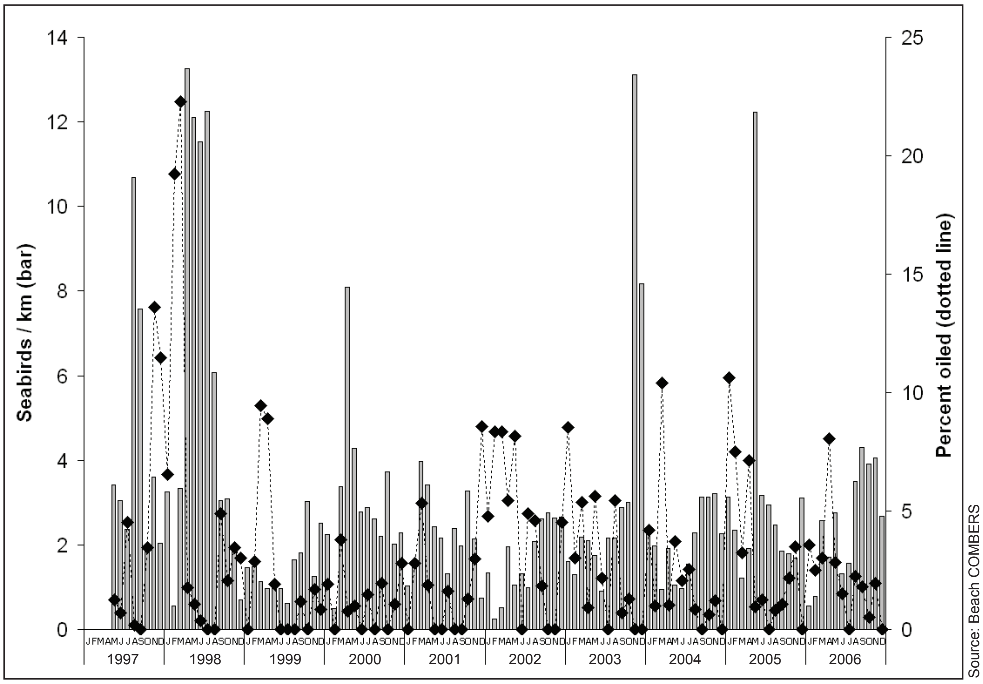


Figure 43. Since 1997, the Beach COMBERS monitoring program has documented trends in oiled seabirds relative to total seabirds recorded during surveys of stranded seabirds and mammals on beaches in the Monterey Bay National Marine Sanctuary. The percent of birds recorded that have externally visible oil is plotted (dotted line with diamonds) along with the total number of seabirds per kilometer of beach recorded during each monthly survey (gray bars). On average, when more than 2% of birds are oiled, a significant oiling event is declared.

1997-98, 2001-2002, and 2004-05 (Figure 43). These events were subsequently attributed to oil leaking from the SS *Jacob Luckenbach*, which sank offshore of the Golden Gate in 1953. Removal of approximately 100,000 gallons of bunker oil from this submerged vessel has eliminated this source of oil into the offshore waters of the sanctuary.

14. What are the levels of human activities that may influence living resource quality and how are they changing? A number of human activities, including fishing, inputs of marine debris, and the laying of submerged cables, influence the quality of living resources in the offshore portion of the sanctuary. The level of these human activities is rated “fair” because most of these activities have resulted in measurable impacts to living resource quality. However, recent changes in fisheries management that have resulted in improved status of fished species and reduced impacts to habitat and non-target species are the basis for an “improving” trend.

Fishing is a human activity that influences sanctuary habitats and living resources in a number of ways beyond the removal of targeted biomass. The offshore seafloor has been negatively impacted by bottom-contact gear that disturbs bottom sediments, damages fragile biogenic animals (e.g., long-lived sponges and corals), and removes non-target species as bycatch. The recent closure of large portions of the offshore seafloor to bottom trawling (see Figure 35 on page 38) should allow recovery of impacted habitats and associated living resources, though different species and habitats are likely to recover at very different rates and, in some cases, a full recovery may not be possible. Gear restrictions, such as changes in mesh sizes and deployment depths, have resulted in decreases in bycatch of protected and sensitive offshore species. For example, in 2002 the California Department of Fish and Game implemented a prohibition on the use of gillnets in waters shallower than 60 fathoms (approximately 110 meters) in central California to reduced the risk of entanglement of seabirds and marine mammals, including sea otters, harbor porpoise, and Common Murres (Forney et al. 2001).

Several fishery management actions over the last few decades led to a decline in the number of commercial fishing vessels registered statewide from approximately 9,200 in 1980 to 3,300 in 2004 (MLPA 2005). Similar declines in the number of commercial fishermen and vessels have been observed at the ports in the Monterey Bay sanctuary (for example see Figure 44). Decreases in the number of participants in commercial fisheries are due to a combination of many factors, including: the poor status of many rockfish stocks; increasingly restrictive fishery management regulations; attempts to reduce bycatch of species of concern; and the goal of reducing potential habitat damage from certain types of fishing gear. However, reductions in the number of participants and overall fishing effort in some sectors of the commercial fishery has not necessarily led to reductions in landings and values at all sanctuary ports. For example, although total landings at Half Moon Bay/Princeton area ports have declined over the period 1992 through 2006, total values have varied over these years, and show no consistent trend. Increased catches of higher value salmon and Dungeness crab in 2004 to 2006 helped maintain value as total landings declined (Figure 45). Commercial landings and values of finfish and invertebrates in Monterey over the period 1999 to 2004 are variable, but show no consistent trend (MLPA 2005).

Marine debris impacts marine life in many ways, most notably through entanglement and the ingestion of large plastics (greater than ten centimeters in dimension) that can clog the digestive tract. Microplastics (less than ten centimeters in dimension) are present and persist in the marine environment and originate from a variety of sources (Andrady et al. 1998). However, impacts of microplastics to organisms and the environment are largely unknown. Data that conclusively demonstrate negative impacts of microplastics on the marine environment are not available. The ability for plastics to transport contaminants has been documented, but the specifics of sorption and leaching are not fully understood (Arthur et al. 2009).

A large amount of marine debris comes from land, swept by wind or washed by rain off highways and city streets, down streams and rivers, and out to sea. The California Department of Transportation conducted a litter management pilot study during 1998-2000 that found foamed polystyrene represented 15% of the total volume of litter recovered from storm drains (CIWMB 2004). Other significant items included moldable plastic (16%), plastic film (12%), and paper (14%). The Ocean Conservancy coordinates annual International Coastal Cleanup days. In 2007 the top ten items collected worldwide included, in order of amount: cigarettes/cigarette filters, food wrappers/containers, caps/lids, bags, plastic beverage bottles, cups/plates/forks/knives/spoons, glass beverage bottles, cigar tips, straws/stirrers, and beverage cans. Foamed polystyrene is a significant component in coastal litter collection programs and monitoring studies. The 1999 U.S. Coastal Cleanup Day found that foamed polystyrene pieces were the fourth-largest amount of all materials collected, behind cigarette butts, plastic pieces, and plastic food bags and wrappers.

Cable laying is another human activity that disturbs benthic communities because it requires digging a trench to bury the cable. The laying of submerged cables is strictly regulated by the sanctuary. Four new cables, with a combined total length of 114 kilometers within sanctuary boundaries, have been permitted since the sanctuary was designated in 1992. In a recent survey of the

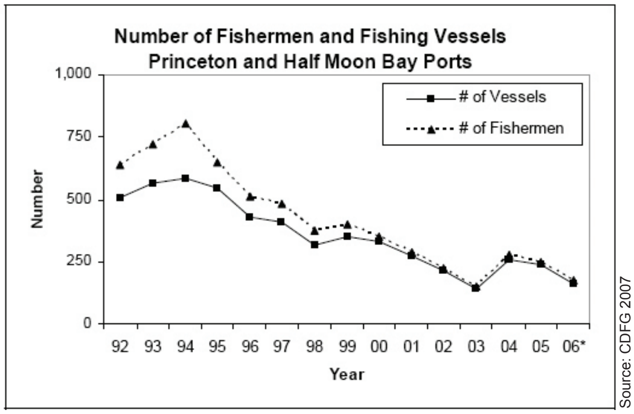


Figure 44. Total number of commercial fishermen and vessels for all ports within Princeton and Half Moon Bay Ports, 1992-2006. Data were compiled from the Commercial Fishery Information System database. The number of fishermen shown is the total number who made at least one landing for each year. Data for 2006 are preliminary.

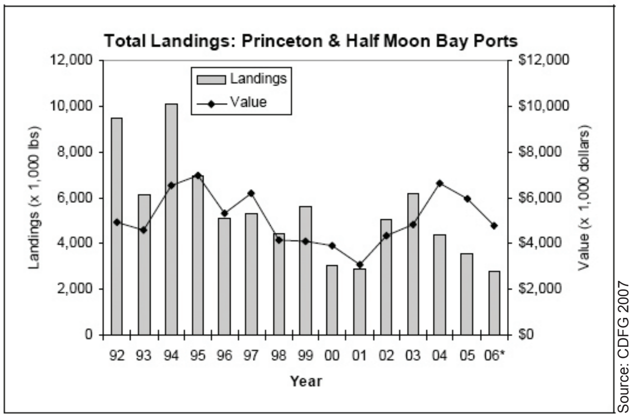


Figure 45. Total landings and values for the commercial fisheries from the Princeton and Half Moon Bay Ports, 1992-2006. Data were compiled from the Commercial Fishery Information System database. Data for 2006 are preliminary. Note: values were adjusted for inflation.

Acoustic Thermometry of Ocean Climate/Pioneer Seamount cable, few changes in the abundance or distribution of benthic fauna were detectable from video observations (epifaunal) and sediment core samples (infauna) indicating that the biological impacts of the cable are minor at most (Kogan et al. 2006). Sea anemones had colonized the cable when it was exposed on the seafloor. Some fishes were also more abundant near the cable, apparently due to the higher habitat complexity provided by the cable.

In comparison to the nearshore or estuarine ecosystems, the offshore ecosystem is more protected from the immediate influence of many human activities. While small-scale and acute impacts may be diminished due to the large size of the open ocean ecosystem, there are other large-scale phenomena that continue to impact this system. Global climate change is increasing sea surface temperatures – this increasing temperature combined with increasing concentrations of atmospheric carbon dioxide are causing the world's oceans to become more acidic. Ocean chemistry is changing at a rapid pace, and by 2100 it is predicted to drop an additional 0.3 pH units (Doney 2006). In addition, there is concern about the potential negative impacts of acoustic pollution (e.g., noise from ships, aircraft, research boats, and military and industrial activities) on living resources, especially marine mammals. Some studies have found that marine mammals will alter their behavior and movement patterns in response to loud noise (NRC 2005). However, it is not well understood if these changes in behavior result in significant negative impacts to the animals.

Offshore Environment Living Resources Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
9	Biodiversity	? (Fair)	Changes in relative abundance, particularly in targeted, by-catch, and sensitive species.	Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
10	Environmentally Sustainable Fishing	▲ (Fair)	Abundance of many harvested species reduced below unfished levels, some targeted and non-targeted species have been drastically reduced by past fishing activity. Fishery management measures have assisted the initial recovery of some overfished groundfish.	Extraction may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
11	Non-Indigenous Species	— (Good)	Very few non-indigenous species identified in offshore waters.	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).
12	Key Species Status	— (Good/Fair)	Reduced abundance of a number of key pelagic species; some reductions caused by activities outside the sanctuary.	Selected key or keystone species are at reduced levels, perhaps precluding full community development and function, but substantial or persistent declines are not expected.
13	Key Species Condition	▼ (Good/Fair)	Compromised health due to exposure to neurotoxins produced by HABs, entanglement in active and lost fishing gear, ingestion of marine debris, and accumulation of persistent contaminants.	The condition of selected key resources is not optimal, perhaps precluding full ecological function, but substantial or persistent declines are not expected.
14	Human Activities	▲ (Fair)	Fishing and inputs of marine debris have resulted in measurable impacts; recent management actions to reduce marine debris and to recover overfished stocks and impacted habitats.	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Declining (▼), Undetermined Trend (?), Question not applicable (N/A)

Offshore Environment Maritime Archaeological Resources

The following information provides an assessment of the status and trends pertaining to the current state of the maritime archaeological resources in the offshore environment.

15. What is the integrity of known maritime archaeological resources and how is it changing? There is great uncertainty regarding the integrity of submerged maritime archaeological resources in the offshore environment in the sanctuary. The sanctuary's inventory contains information on known vessel losses, with little to no verified location information, and few visited sites. To date, only one offshore archaeological site location inventory has been conducted in the sanctuary by NOAA (Schwemmer 2006a). No other site evaluations have been conducted by Federal, State, or private resource management agencies.

The USS *Macon*, a 785-foot dirigible (Figures 46a, b, c), was lost offshore of Point Sur on Feb. 12, 1935 when it foundered tail first into the waters of the Pacific Ocean. For decades, its underwater location remained a mystery. In 1990 and 1991, the Monterey Bay Aquarium Research Institute and the U.S. Navy located the *Macon's* remains at a depth of over 1,000 feet (304 meters). Archaeologists have concluded that sections of the *Macon's* aluminum girder show signs of degradation after 71 years in the offshore marine environment (Schwemmer 2006a). Although a rigid-frame airship cannot be compared to a seagoing vessel, it is expected that steel or iron shipwrecks at similar depths would retain a higher level of structural integrity and mass.

There is a high level of uncertainty for offshore wreck sites because the majority of sites have not been visited or investigated. Sites in deep water are naturally in better condition than those in shallow water because they are not impacted by strong currents and the cold, deepwater environment tends to have fewer biological processes accelerating ship degradation. One probable impact in

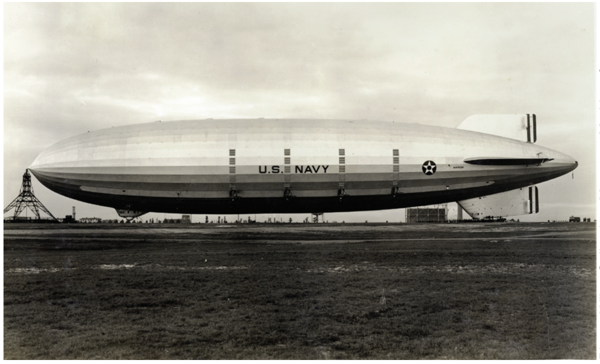


Photo: Wiley Collection, Monterey Maritime & History Museum

Figure 46a. The U.S. Navy "dirigible" USS *Macon* (ZRS-5) attached to the mooring mast which rode on railroad tracks and was used to move the airship to either end of the hanger. The 785-foot USS *Macon* was the nation's largest and the last U.S. built rigid lighter-than-air craft.

Photo: Wiley Collection, Monterey Maritime & History Museum

Figure 46b. Sparrowhawk bi-planes flying in formation over Moffett Field. The Curtiss aircraft company adapted their F9C-2 Sparrowhawk bi-plane fighters to be used aboard the "flying aircraft carriers." When the USS *Macon* was lost off Point Sur on Feb. 12, 1935, the airship went down with four bi-planes.

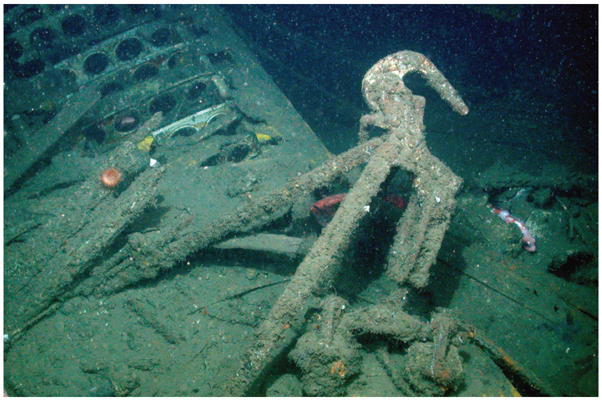


Photo: NOAA/MBARI 2006

Figure 46c. Submerged view of the sky-hook located at the center of the Curtiss Sparrowhawk F9C-2 biplane. The pilot, during flight, would position the aircraft below the USS *Macon's* hanger. A trapeze was lowered and the pilot would position the hook onto the trapeze. Sparrowhawk pilots were nicknamed the "men on the flying trapeze".

offshore waters is from bottom trawling, but because the majority of wreck locations are unknown, the impacts from historical and recent trawling are unknown. A few technical divers are capable of diving deep-water sites and have visited at least one offshore site (e.g., Dredge *Art Riedel Sr* lost 1990, 95 meters deep). The integrity of known maritime archeological resources in offshore habitats is "undetermined," and the trend is "undetermined."

16. Do known maritime archaeological resources pose an environmental hazard and is this threat changing?

The Monterey Bay National Marine Sanctuary's inventory of known maritime archaeological resources suggests offshore shipwrecks have the potential to pose an environmental hazard to sanctuary resources due to deterioration that would result in the release of hazardous cargo and/or bunker fuel (e.g., U.S. Navy aircraft carrier USS *Independence* scuttled 1951, passenger steamship *San Juan* lost 1929, lumber freighter *Howard Olson* lost 1956). Therefore, this question is rated "fair" with a "declining" trend. Additional threats to sanctuary resources are from shipwrecks located just outside the sanctuary boundary (e.g., tanker *Montebello* (Figure 47) sunk by Japanese submarine 1941, cargo freighter SS *Jacob Luckenbach* lost 1953, tanker *Puerto Rican* lost 1984, freighter *Fernstream* lost 1952, and other vessels scuttled by the military to dispose of weapons). Prevailing currents have a high likelihood of carrying hazardous materials released from these sources into the Monterey Bay sanctuary. The remains of the *Montebello* have been located and the structural integrity of the hull provides the capacity to hold bunker fuel and hazardous cargoes (Schwemmer 2005).

In 2001, extensive tarball deposits along the sanctuary's coastline were estimated to have killed thousands of seabirds, including grebes, cormorants and Common Murres. The source of these tarballs remained unknown for several months, but was ultimately tracked to the SS *Jacob Luckenbach* which sank off San Francisco in 1953 (currently located in the Gulf of the Farallones National Marine Sanctuary). Subsequent investigative work matching the oil samples indicated this vessel was the likely source of a number of tarball and oiled bird incidents dating back to at least 1992. The U.S. Coast Guard, California Department of Fish and Game, National Oceanic and Atmospheric Administration, and others collaborated to identify the extent of impacts, to identify means of removing the remaining oil, and to ultimately remove the fuel. During the period of spills linked to the SS *Jacob Luckenbach*, over 51,000 birds and eight sea otters were estimated to have been killed from north of Bodega to Point Lobos (Luckenbach Trustee Council 2006).

With the exception of the partial bunker fuel removal from the SS *Jacob Luckenbach* and monitoring of the *Montebello* (both outside the sanctuary boundary), no efforts have been undertaken to locate and investigate other offshore sites. The structural integrity of steel and iron shipwrecks will deteriorate over time in a corrosive ocean environment and eventually collapse.

17. *What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?* Historical and recent bottom trawling is one probable impact to offshore maritime archaeological resources that has reduced their quality to "good/fair." Archaeological resources are not able to recover once trawling destroys a site. Recently, the numbers of trawlers and areas available to trawling have decreased due to management regulations. With the recent trawl closures, the shift of fishing effort may increase the risk to resources that have not been impacted in the past. Because the majority of wreck locations are unknown, the impacts from historical and recent trawling are "undetermined."

The development of underwater technologies now affords the public the opportunity to locate and visit deep-water archaeological resources in the offshore environment. The sanctuary is working in collaboration with the technical diving community to locate new resources (e.g., *Art Riedel Sr.*). As with divers visiting accessible nearshore archaeological sites, the diving community must be educated on the regulations in place in order to protect these archaeological resources.

Archaeological resources in deeper and calmer offshore waters are generally in a more stable environment (limiting physical effects). Cold, deepwater environments tend to have fewer biological processes accelerating ship degradation compared to nearshore sites. However, because these sites are intact they may be attractive to looters, particularly those with technical diving capabilities who may access sites even though it's unlawful. Other emerging threats to offshore archaeological sites are the trenching of submerged communication cables that may impact submerged resources.

Photo: Unocal

Figure 47. Launch of the Oil Tanker *Montebello* on January 21, 1921, at Southwestern Shipbuilding Company in East San Pedro, California. The ship was sunk off Cambria during World War II and may still contain large quantities of oil.

Offshore Environment Maritime Archaeological Resources Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
15	Integrity	?	To date, only one of potentially hundreds of archaeological site inventories has been conducted.	Not enough information to make a determination.
16	Threat to Environment	▼	Known resources containing hazardous material continue to deteriorate.	Selected maritime archaeological resources may cause measurable, but not severe, impacts to certain sanctuary resources or areas, but recovery is possible.
17	Human Activities	?	Archaeological resources, particularly those that are undocumented, are vulnerable to degradation from trawling.	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (—), Declining (▼), Undetermined Trend (?), Question not applicable (**N/A**)

State of Sanctuary Resources: Nearshore Environment

Nearshore Environment Water Quality

The following information provides an assessment of the status and trends pertaining to water quality and its effects on the nearshore environment.

1. ***Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?*** Stressors on water quality in the nearshore environment, particularly inputs of contaminants, nutrients, sediments, and pathogens, may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats. For this reason, the rating for question 1 is "fair" with a "declining" trend. Measurements of ambient toxicity due to pesticides (e.g., toxaphene, DDT, diazinon, chlorpyrifos,) in waterways that drain to the sanctuary indicate a potential problem in the adjacent nearshore environment (Anderson et al. 2003, Hunt et al. 1999).

   Certain portions of the nearshore ocean, such as along the Big Sur Coast, are relatively free from direct inputs of watershed based contaminants, compared to areas that drain relatively large human-altered watersheds such as the Salinas and Pajaro (Conley et al. 2008). While there is no overall regional trend for changes in pollutant concentrations at coastal confluences of watersheds that drain to the sanctuary, significant increases at some locations are cause for concern (Conley et al. 2008). Non-point sources flow into rivers that drain to the sanctuary and deliver substantial loads of persistent organic pollutants (e.g., PCBs, PAHs, dieldrin, DDT) to the nearshore environment (CCLEAN 2006). The CCLEAN monitoring program has reported PCB levels that exceed the California Ocean Plan standards and determined that the four largest rivers that drain to Monterey Bay, the Salinas, Pajaro, Carmel, and San Lorenzo Rivers, were the source of most of the PCBs (CCLEAN 2006, CCLEAN 2007).

   The Central Coast Ambient Monitoring Program (CCAMP) conducted a study between 2001 and 2006 to assess the quality of water, sediment, and tissue samples collected from harbors, including three harbors adjacent to the sanctuary. An EPA Water Quality Index was calculated for samples based on levels of dissolved oxygen, dissolved inorganic nitrogen, ortho-phosphate, chlorophyll, and water clarity. While most of the sampling sites within the sanctuary were found to be healthy, two sites in Moss Landing Harbor were found to be problematic (Sigala et al. 2007).

   Impaired water bodies include river segments, coastal shorelines, harbors, bays, and estuaries that do not meet or are not expected to meet Federal Clean Water Act water quality standards. The State Water Board and the U.S. EPA have determined that there are a total of 51 impaired waterbodies within watersheds that drain directly to the sanctuary or are within the sanctuary itself (see Figure 18 on page 24; SWRCB 2006). These include 37 river segments, six estuaries, two harbors, and six coastal shorelines. This total excludes many impaired waterbodies that flow into San Francisco Bay that are likely to be additional water quality stressors for the sanctuary. The impaired estuaries, harbors, and coastal shorelines are listed in Table 1 along with the pollutants that are the cause of impairment.

   A number of emerging pollutant threats exist, however, little is known regarding their presence or effects in the environment. In addition, water quality standards for these pollutants, including pyrethroid pesticides, fire retardants (PBDEs), pharmaceuticals, and personal hygiene products, have not yet been developed. Increased input rates of these pollutants have prompted concern in the San Francisco Bay (SFEI 2007) and they may also pose a threat in sanctuary waters.

Table 1. Impaired estuaries, harbors, and coastal shorelines adjacent to the Monterey Bay National Marine Sanctuary and impairment causing pollutants. Impaired river segments are not shown.

Impaired Water Body	Pollutant/Pollutant Category
Monterey Harbor	Metals, Toxicity
Moss Landing Harbor	Pathogens, Pesticides, Sedimentation/Siltation
Elkhorn Slough	Pathogens, pesticides, Sedimentation/Siltation
Moro Cojo Slough	Ammonia, Low Dissolved Oxygen, Pesticides, Sedimentation/Siltation
Old Salinas River Estuary	Ammonia, Fecal Coliform, Low Dissolved Oxygen, Nutrients, Pesticides
Salinas River Lagoon (North)	Nutrients, Pesticides
San Lorenzo River Lagoon	Pathogens
Soquel Lagoon	Nutrients, Pathogens, Sedimentation/Siltation
Pacific Ocean at Fitzgerald Marine Reserve	Pathogens
Pacific Ocean at Pacifica State Beach	Pathogens, Metals/Metalloids
Pacific Ocean at Pillar Point Beach	Pathogens
Pacific Ocean at Rockaway Beach	Pathogens
Pacific Ocean at Venice Beach	Pathogens

Source: SWRCB 2006

CCAMP

The Central Coast Ambient Monitoring Program (CCAMP) is the Central Coast Regional Water Quality Control Board's regionally scaled water quality monitoring and assessment program. The purpose of the program is to provide scientific information to Regional Board staff and the public, to protect, restore, and enhance the quality of the waters of central California.

CCLEAN

The Central Coast Long Term Environmental Assessment Network (CCLEAN) is a long-term monitoring program that is designed to help municipal agencies and resource managers protect the quality of nearshore marine waters in the Monterey Bay area. CCLEAN, which began in 2001, is determining the sources, amounts and effects of contaminants reaching nearshore waters.

2. ***What is the eutrophic condition of sanctuary waters and how is it changing?*** Clear evidence of frequent, localized, and enhanced nutrient enrichment in the nearshore environment of the sanctuary, due to both point and non-point sources was the basis for a "good/fair" rating and a "declining" trend. These conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.

   Of the 51 waterbodies draining directly to the sanctuary that were monitored for impairment, 15 were determined to be impaired by elevated nutrient levels (SWRCB 2006). Sources of nutrients, such as phosphorus, nitrate, and urea, to the nearshore environment include waste products from mammals, runoff from agriculture fields, leaking septic tanks, and sewage discharge systems. The most abundant source of nitrate and urea is river discharges and the most abundant source of orthophosphate and ammonia is wastewater (CCLEAN 2007). Rivers vary in their load contributions relative to different nutrients (CCLEAN 2006). Nitrates from the Pajaro and Salinas Rivers and Tembladero Slough are far greater in comparison to other major rivers that

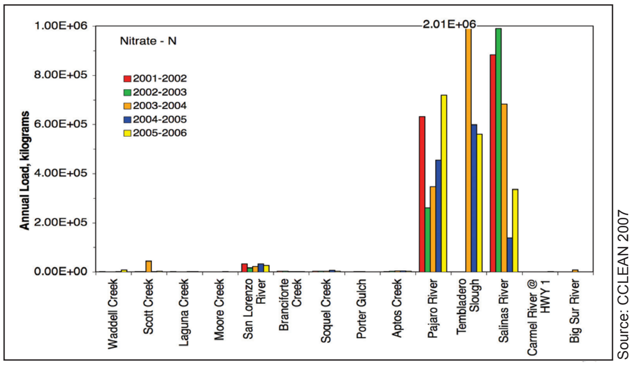


Figure 48. Annual nitrate load into nearshore waters from 14 streams and rivers sampled by the CCLEAN program during the period 2001-2006. Sampling locations are listed from north (Waddell Creek) to south (Big Sur River).

drain to the sanctuary (Figure 48) (CCLEAN 2007). Both coastal streams and wastewater effluent contribute urea to nearshore waters; coastal streams contribute higher loads with the Pajaro River and Tembladero Slough being the largest sources (Figure 49) (CCLEAN 2007). In general, nutrient enhancements to the nearshore environment are greatest during winter months coinciding with the high rainfall season.

Harmful algal bloom (HAB) events have been linked with freshwater runoff events (Kudela and Chavez 2004) and may be associated with nutrient loading from coastal watersheds in the Monterey Bay (Kudela et al. 2008a; Kudela et al. 2008b). There is sporadic, anecdotal evidence of fish and mussel mortality that may result from HABs. Recent studies suggest a possible relationship between HABs and inputs from coastal watersheds (see Question 2 in the offshore section). The total ecological response of the sanctuary system to the current level of nutrient loading may not yet be evident, since some changes in nutrient loading will be manifested as changes in physiological processes of algae species, rather than rapid changes in biomass (Anderson et al. 2002).

Biotoxins produced by HABs have been shown to accumulate in filter feeders, such as anchovy and mussels, and can cause health effects in nearshore mammals and seabirds that consume tainted prey (Fritz et al. 1992, Scholin et al. 2000, Kreuder et al. 2005). For example, a bloom of the diatom *Pseudo-nitzschia* occurring in Monterey Bay in early September 1991 was linked to an episode of mortality in Brown Pelicans and Brandt's Cormorants (Fritz et al. 1992). High levels of domoic acid were recorded in plankton samples and in anchovies, a principal food source for these seabirds. In addition, Kreuder et al. (2005) found that exposure to domoic acid was a leading risk factor for the development of cardiac disease in beach-cast sea otters.

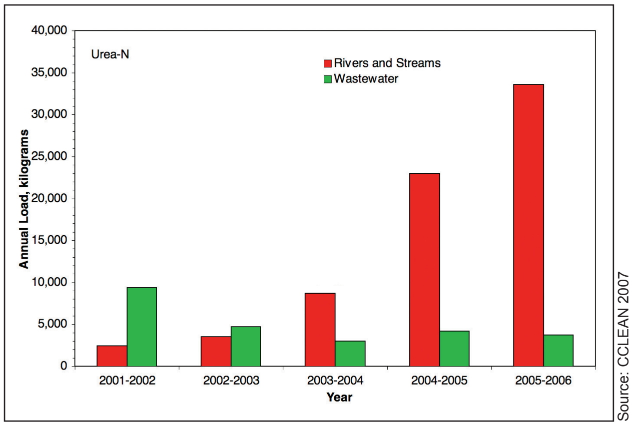


Figure 49. Comparisons of combined annuals loads in kilograms of urea from gaged rivers and wastewater 2001-2006. Gaged rivers included Scott Creek (added in 2003-2004), San Lorenzo River, Soquel Creek, Pajaro River, Salinas River, Carmel River and Big Sur River. Wastewater: City of Santa Cruz, City of Watsonville, Monterey Regional Water Pollution Control Agency and Carmel Area Wastewater District. Sampling at Tembladero Slough began in 2003-2004.

3. *Do sanctuary waters pose risks to human health?*

Health risks in nearshore waters are rated "fair/poor," and a trend is "undetermined," since selected conditions have caused or are likely to cause severe impacts, but cases to date have not suggested a pervasive problem. Although the majority of the sanctuary's nearshore waters generally do not pose risks to human health, there are localized areas and isolated impacts that pose serious health risks. Pollutants present in nearshore waters are absorbed into the tissues of organisms such as mussels and fish. High levels of contaminants such as pesticides and metals can pose a human consumption risk. Toxins (domoic acid and paralytic shellfish poison) are produced by certain algal species and have been observed at levels in Monterey Bay that are potentially harmful to human health via bioaccumulation in the food web (Jester 2008). An annual statewide mussel quarantine is issued from May 1 to October 31 by the California department of public health to protect consumers of harvested shellfish from paralytic shellfish poisoning (PSP) and domoic acid poisoning. Periodic beach warnings and closures, due to the presence of pathogen indicators (*E. coli*, fecal coliform, total coliform, *Enterococcus*) that can cause illness in beach goers, are common at some locations (Rickers and Peters 2006).

Several waterbodies directly adjacent to or within the sanctuary are impaired by pathogens (see Table 1; SWRCB 2006). Santa Cruz County monitors the beaches with the highest visitation rates for bacterial contamination between April and October (Figure 50). From 2000-2004 these beaches experienced levels of *Enterococcus*, *E. coli*, fecal coliform, and/or total coliform that exceeded State standards 5-20% of the time (Rickers and Peters 2006). The primary sources of bacterial contamination at beaches in Santa Cruz County are coastal lagoons that discharge to the ocean. Coastal lagoons within Santa Cruz County that discharge to the beaches exceeded State standards 50-80% of the time and are permanently posted as unsafe for body contact (Rickers and Peters 2006). Interviews of over 2,100 beachgoers in 2003-04 indicated that overall, 3.83% of swimmers reported illness that was likely caused by water contact. Occurrence of illness doubled during winter periods to 6.86% (Rickers and Peters 2006). Such illness (e.g., earaches, gastrointestinal distress) is typically the result of swimming near an outfall, river mouth, or other impacted area following a runoff event (Rickers and Peters 2006). Six beaches within Santa Cruz County are permanently posted as being generally unsafe for body contact due to regularly high levels of bacterial pathogens.

CCLEAN observations indicate that the greatest loads of *E. coli* (Figure 51) and *Enterococcus* bacteria to the nearshore environment over the last five years occurred during 2005-2006 at Tembladero Slough and San Lorenzo River, respectively. The San Lorenzo River and the Tembladero Slough are the only sites that seem to

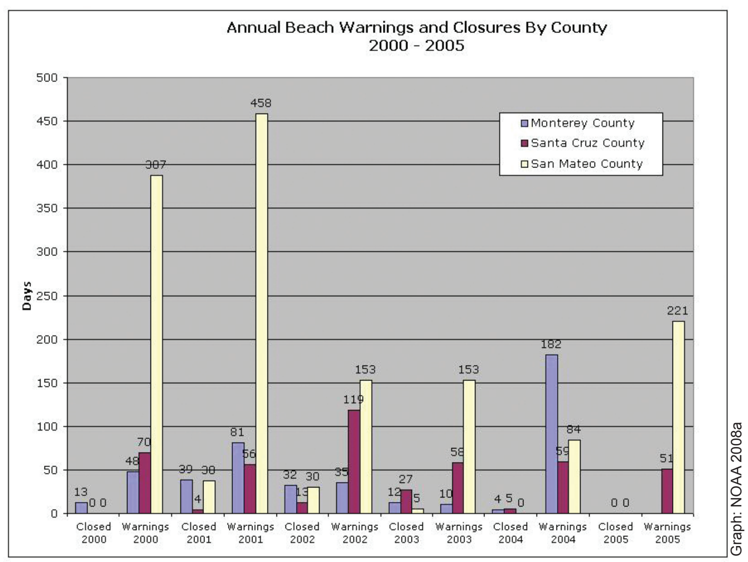


Figure 50. Number of days per year that beaches in Monterey, Santa Cruz, and San Mateo counties have been closed or had warnings posted. Weekly bacterial testing is conducted by local health officers between April 1 and October 31 in waters adjacent to public beaches having more than 50,000 visitors annually.

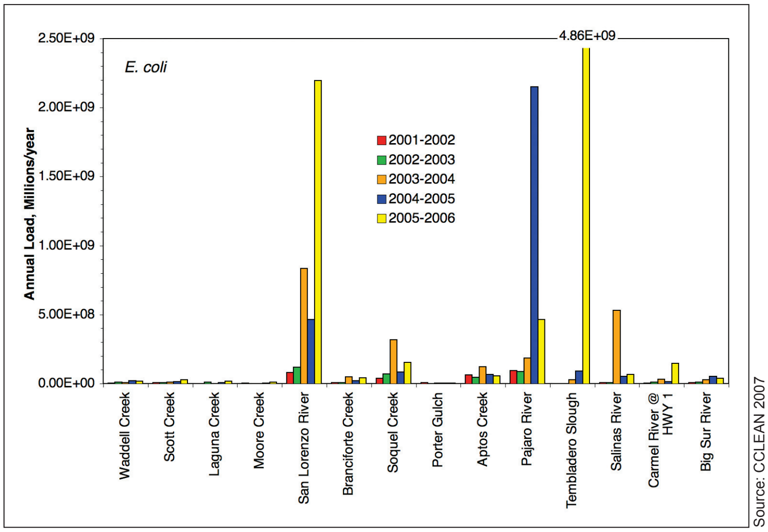


Figure 51. Comparisons of estimated loading of *E. coli* bacteria into nearshore waters during 2001-2006 for CCLEAN sites. Sampling locations are listed from north (Waddell Creek) to south (Big Sur River).

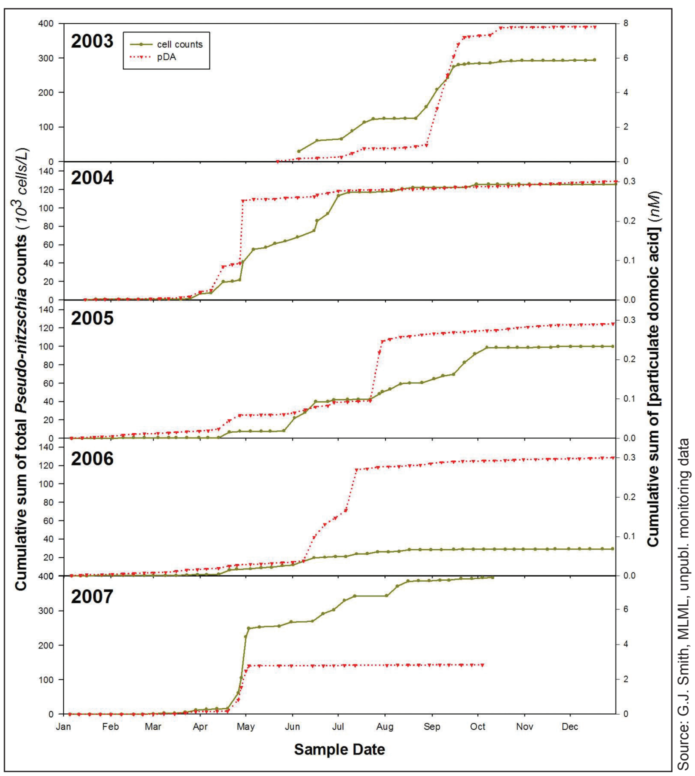


Figure 52. The cumulative abundance curves depict annual patterns of *Pseudo-nitzschia* occurrence and reflect the risk of exposure to domoic acid throughout the year. The plots show that the most important *Pseudo-nitzschia* events tend to occur in the summer, but timing during the summer season varies from year to year.

have generally increasing bacterial loads over the five years of the CCLEAN program (CCLEAN 2007).

Some of the chemical contaminants found in the nearshore waters of the sanctuary have been detected in the tissues of nearshore animals and in some cases exceed health standards. Mussels at most sites around Monterey Bay sampled by CCLEAN, NOAA's National Status and Trends, and State Mussel Watch exceeded the California Office of Environmental Health Hazard Assessment human health screening for dieldrin during 2006-2007 (CCLEAN 2007). There have been no statistically significant declines in DDT concentrations in lipid normalized mussel tissues over the last 15–20 years whereas PAHs and PCBs increased marginally at some sites (CCLEAN 2007). The CCLEAN program has concluded that contaminants are present, persistent and exceed allowances set forth in the California Ocean Plan; and recommended issuing a health advisory for mussels (CCLEAN 2007). NOAA's National Status and Trends' Mussel Watch program indicates that problem areas for metals and/or POPs within the sanctuary are at Elkhorn Slough, Moss Landing, Pacific Grove, and Santa Cruz Point (Kimbrough 2008). There are decreasing trends at a number of sanctuary sites for butyltins and arsenic, and for chlordanes at San Luis Obispo and an increasing trend for copper at San Simeon. Approximately one-third of the sanctuary sites that were sampled are categorized as high relative to all other U.S. sites for metals and/or POPs and show no increasing or decreasing trends (Kimbrough 2008).

The Surface Water Ambient Monitoring Program detected mercury in all samples of fish and shellfish collected from the San Mateo coast in the year 2000 with some sample sites showing concentrations above human health screening levels. Persistent organic compounds were generally low along the San Mateo coast, with only one exceedence for total PCBs. Salmon collected from the San Francisco County coast and the Farallon Islands had no screening value exceedences (SWAMP 2005).

Measurements taken at the Monterey Wharf between 2003-2007 indicate that there is almost always some level of particulate domoic acid present in the water, though the concentrations are usually extremely low and events with significant toxicity risk are rare (G.J. Smith, MLML, unpubl monitoring data). Most of the yearly blooms of the diatom *Pseudo-nitzschia* (and subsequent risk of exposure to domoic acid) seem to be associated with one or two events per year that are, so far, unpredictable (Figure 52). Between 1999–2006 there was a notable increase (from 1% to 10%) in the number of shellfish samples in which paralytic shellfish poisoning (PSP) toxins exceeded the regulatory limit in central California (Jester 2008), a region that had not experienced many PSP events since the 1980s (Price et al. 1991). PSP toxins have recently been detected for the first time in planktivorous fish, associated with the toxin producing species *Alexanidrium*, and therefore have the potential to pose a human health risk (Jester 2008). Marine biotoxins in the Monterey Bay sanctuary are monitored by the California Department of Health Services and by researchers at local institutes and universities. Warnings are issued or quarantines are established as needed for recreational and commercial shellfish harvesting to assure that shellfish are safe for human consumption.

4. ***What are the levels of human activities that may influence water quality and how are they changing?*** Human activities detrimental to water quality conditions in the nearshore environment are rated "fair" with an "undetermined" trend, which indicates that selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread. Efforts to reduce pollution in the sanctuary may be offset by intensification of human activities in coastal watersheds that introduce pollutants to the nearshore environment. Adequate data to determine the aggregate effect of pollution management efforts and their effects on water quality conditions for watersheds that drain to the sanctuary are not currently available.

Pollutants associated with urban development and agricultural cultivation exert pressure on nearshore water quality conditions in the sanctuary. The greatest loads of nutrients and persistent contaminants in the sanctuary are delivered via the rivers that drain heavily cultivated watersheds (Los Huertos et al. 2003, CCLEAN 2007). Regulation of non-point agricultural and urban sources has increased, and the technology, education, and implementation of better rural and urban management practices have improved in recent years via programs such as the Central Coast Regional Water Board's Agricultural Waiver Program and the State Water Resources Control Board's Phase II Stormwater Program.

In general, sewer systems in watersheds that drain to the sanctuary have been improving because of compliance with city and county management regulations. The County of Santa Cruz has implemented a comprehensive plan to assess and improve urban sources of bacterial pollution including repair of private sewer laterals, public education, and stormwater management (Rickers and Peters 2006). A survey completed by the County of Monterey indicates that nutrient management practices have been widely applied in the Salinas Valley (Monterey County 2002). Surveys by the Central Coast Regional Water Quality Control Board show that nutrient, pesticide, erosion, and irrigation management practices have been applied throughout the Central Coast (RWQCB 2007).

Nearshore Environment Water Quality Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
1	Stressors	▼ (Fair)	Elevated levels of contaminants (e.g., POPs, heavy metals), nutrients, sediments, pathogens in some locations; on-going input of established and emerging pollutants.	Selected conditions may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats.
2	Eutrophic Condition	▼ (Good/Fair)	Frequent, localized, and enhanced nutrient enrichment; frequent algal blooms sometimes linked to biotoxin accumulation in fish, birds and mammals.	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.
3	Human Health	? (Fair/Poor)	Warnings and closures of some beaches and lagoons due pathogen indicators; contaminated shellfish at some locations and during some seasons.	Selected conditions have caused or are likely to cause severe impacts, but cases to date have not suggested a pervasive problem.
4	Human Activities	? (Fair)	Efforts to reduce pollution may be offset by intensification of human activities in coastal watersheds.	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Declining (▼), Undetermined Trend (**?**), Question not applicable (**N/A**)

Nearshore Environment Habitat

The following information provides an assessment of the status and trends pertaining to the current state of the nearshore marine environment.

5. ***What is the abundance and distribution of major habitat types and how is it changing?*** The abundance and distribution of nearshore habitats is rated "good/fair" based on localized modification or loss of coastal habitat, primarily through armoring of coastal bluffs and beaches, erosion of sandy shoreline, and landslide disposal on rocky reef. The trend in habitat modification is "stable" because coastal armoring continues at a slow pace while dams are being removed in some locations. Though rates of shoreline erosion were found to have increased over the last few decades, the analysis only extended up to the 1998-2002 time period and does not include trends for the last five years.

Map: S. De Beukelaer, NOAA/MBNMS

Figure 53. Location of coastal armoring structures in the Monterey Bay National Marine Sanctuary (data source: 2005 California Coastal Commission, "Armoring" GIS data layer). Note: points only show the location of a structure, they do not accurately reflect the size of the armoring structure or the length of coastline armored.

Shoreline habitat type has been determined throughout the sanctuary and in 2006 this information was used to update environmental sensitivity index maps (Research Planning Inc. 2006). In this process the shoreline was classified into ten different habitat types (e.g., exposed rocky shores, marshes, and sandy beaches) and ranked according to the habitat's sensitivity to an oil spill. Associated at-risk resources, including biological and human-use resources, also were mapped (available through NOAA Office of Response and Restoration). As of September 2007, approximately 58% of the subtidal benthic habitats in the nearshore environment of the Monterey Bay sanctuary have been mapped with good resolution using sidescan sonar (27%) and multibeam (41%), including some areas of overlap (see Figure 32 on page 36; National Marine Sanctuary: Seafloor Mapping Data Inventory).

A recent comprehensive analysis of long-term (over 100 years) and short-term (1950s-1970s vs. 1998-2002) changes in the abundance of sandy shoreline habitat in California found that the average net long-term shoreline change rate in the central California region was undetectable, but the short-term average net rate was strongly erosional (-0.5 m/yr) (Hapke et al. 2006). This shift to overall increased erosion in the more recent time period may be related to the climatic shift that began in the mid-1970s when California's climate entered a period of more frequent and stronger storms, including two of the most intense and damaging El Niño winters of the last century (Hapke et al. 2006). Within the central region, short-term rates of shoreline change were calculated as -0.5 m/yr, -0.6 m/yr, and -0.2 m/yr for the San Francisco South, Monterey Bay, and Big Sur regions, respectively. These three regions cover most of the coastline of the entire Monterey Bay National Marine Sanctuary. In the Monterey Bay region, the net average rate of shoreline change more than doubled from the long-term to short-term. The general area within the Monterey Bay region where erosion became more predominant corresponded to the portion of Monterey Bay where sand mining practices throughout the 20th century removed large volumes of sand from beaches and dunes (Griggs et al. 2005, Thornton et al. 2006, as cited in Hapke et al. 2006).

Armoring of coastal bluffs and cliffs and damming in coastal streams can decrease the input of sediments into the sanctuary and alter the natural processes of erosion, sediment transport, and deposition. Though the cumulative impact of existing structures to the abundance and distribution of soft sediments in the sanctuary is not well understood, the localized impacts of armoring are better understood (Stamski 2005). Armoring has been shown to alter local sediment transport and delivery processes, for example, by reducing delivery of sediment to sites immediately downstream, as well as altering the abundance and distribution of associated living resources. Dugan et al. (2008) found that in front of coastal armoring structures upper intertidal beach zones were absent and mid-intertidal zones reduced in size. In addition, armored beaches had reduced abundance, biomass, and size of upper intertidal macroinvertebrates, lower species richness and abundance of foraging shorebirds, and lower abundance of roosting birds. Armoring also alters the type of habitat in a given location, converting soft-sediment habitats (e.g., sandy beaches) to hard substrates (e.g., rock, cement, steel) which support very different biological communities. Though armoring can have very strong local impacts, sanctuary-wide impacts are likely to be small given that it is estimated that 32.43 kilometers, or approximately 7%, of the sanctuary's coastline have been armored (Figure 53) (California Coastal Commission 2005).

The abundance and distribution of rocky intertidal and subtidal habitats have not been altered substantially in the sanc-

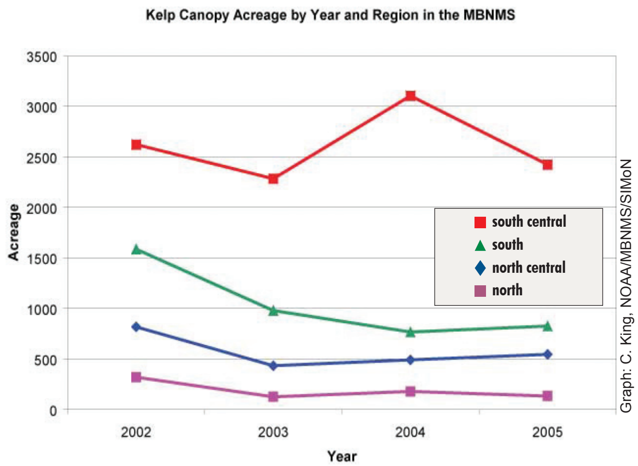


Figure 54. The annual trend in aerial extent of kelp canopy (in acres) as determined from aerial surveys by the California Department of Fish and Game using Digital Multi-Spectral Video (California Department of fish and Game, 2002-2005). Data from four regions are plotted separately: North - Northern sanctuary boundary south to Moss Landing jetty; North Central - Moss Landing jetty south to Malpaso Creek; South Central - Malpaso Creek to Ragged Point; South - Ragged Point south to southern sanctuary boundary.

tuary. Some hard bottom intertidal and subtidal sites along the Big Sur coast have been buried by sediment due to landslide disposal, but the impact of this activity is being monitored and appears to be highly localized. Natural, ongoing erosion of the head of the Monterey Canyon (located in the nearshore environment) is converting the habitat at the lip of the canyon from soft sand-mud to hard mud and appears to be moving the lip of the canyon closer to shore (Wong 2006). Continued encroachment of the canyon head threatens the jetties of Moss Landing Harbor and may exacerbate tidal erosion in Elkhorn Slough.

6. ***What is the condition of biologically-structured habitats and how is it changing?*** Existing data on the condition of biologically-structured habitats in the nearshore environment over the last five years indicate that this resource is in "good" and "stable" condition. A number of on-going monitoring studies in the nearshore subtidal habitats (e.g., Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO); MBNMS monitoring projects) indicate that large, structural algae, seagrasses, and sessile habitat-forming invertebrates (e.g., sponges, anemones, tube worms) appear to be healthy and no major perturbations have been observed. Though kelp is harvested in limited areas in the sanctuary, monitoring data from 2002 to 2005 indicate that canopy-forming kelps have been abundant and healthy (Figure 54; California Department of Fish and Game monitoring data).

On-going monitoring studies in the nearshore subtidal habitats (e.g., PISCO; Multi-Agency Rocky Intertidal Network, MARINe) indicate that some habitat-forming organisms are reduced in abundance in the rocky intertidal habitat compared to historic levels. For example, the abundance of mussels has been reduced at some locations due to repeated harvest for consumption by humans (P. Raimondi, UCSC/PISCO/MARINe, pers. comm.). A study of the impact of human visitation in the Point Piños area found that lower coverage of some types of algae in the upper intertidal zone and around the margins of tidepools may have been caused by chronic trampling from visitors (Tenera Environmental 2003). However, this study also found that for the most part, the abundance and diversity of structure-forming organisms in areas with high visitation did not differ substantially from areas with low levels of visitation.

7. ***What are the contaminant concentrations in sanctuary habitats and how are they changing?*** From limited studies of the levels of contaminants in the benthic formations and biogenic organisms in the Monterey Bay National Marine Sanctuary, the condition of nearshore habitats is rated "fair" and "declining" due to elevated contaminants at locations near urban, maritime, or agricultural activities and the continued input of contaminants into coastal waters from point and non-point sources.

The Central Coast Ambient Monitoring Program (CCAMP) assessed the environmental condition of central coast harbors including three in the sanctuary (Santa Cruz, Moss Landing, and Monterey) using sediment and tissue samples collected in 2004 (Sigala et al. 2007). Analytes of concern in Santa Cruz Harbor were elevated concentrations of arsenic (in sediment) and total PCBs (in sediment and tissue samples). Chlordane levels were also elevated in sediment and exceeded human health screening values in resident fish populations. Analytes of concern in Moss Landing Harbor were elevated total chlordanes (in sediment) and total DDTs (in sediment and tissue samples). Total PCB levels were also elevated in sediment and exceeded human health screening values in resident flatfish populations. Analytes of concern in Monterey Harbor in both sediment and tissue samples appear to be mercury and total PCBs. Concentrations of lead in resident flatfish populations are elevated compared to the other harbors, but lead does not appear to be a concern in sediment.

The potential use of sand crabs as bioindicators of contaminants in intertidal beach habitat was studied in 2000 at five sites in the sanctuary – Scott Creek Beach, Santa Cruz Main Beach, Elkhorn Slough Mouth, Salinas River Mouth, and Carmel Beach (Dugan et al. 2005). Oxychlordane, DDT, and PCBs were found to be elevated at the beaches closest to the mouth of Elkhorn Slough

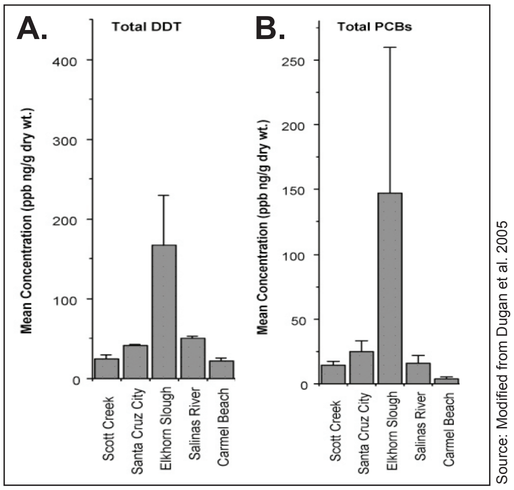


Figure 55. Mean dry weight concentrations (ng/g + 1 std. deviation) of total DDTs (DDD, DDE & DDT; Panel A) and total PCBs (Panel B) in tissues of sand crabs collected at beaches in August-September 2000.

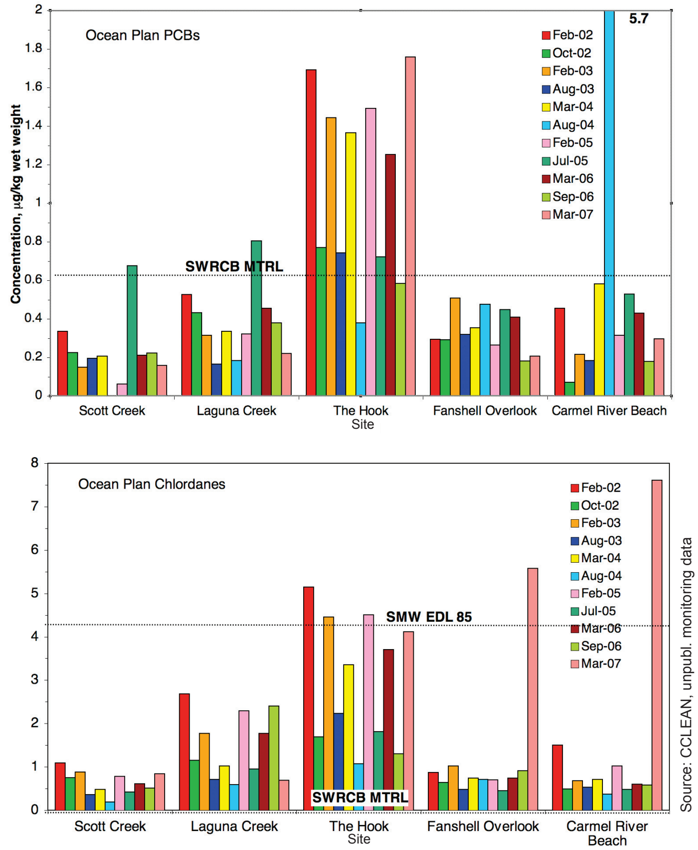


Figure 56. Wet-weight tissues concentrations of chlordanes and PCBs in mussels from five CCLEAN sites compared with various screening values and guidelines. Mussels were collected in February 2002, October 2002, February 2003, August 2003, March 2004, August 2004, February 2005, July 2005, March 2006, September 2006, and March 2007.

(Figure 55). The concentrations of DDT found in sand crabs at beaches near Elkhorn Slough in 2000 were similar to those found in a study completed in the early 1970s suggesting that comparable amounts of DDT persist and are biologically available 30 years after this pesticide was banned. Similarly, analysis of mussel data from the National Status and Trends and State Mussel Watch programs suggest that concentrations of DDTs and dieldrin have not changed significantly over the last 20–30 years at sites removed from large agricultural sources of these legacy pesticides (Dugan et al. 2005, CCLEAN 2006).

Contaminants in mussels, a type of biogenic habitat, have been monitored twice per year at five sites (Scott Creek, Laguna Creek, The Hook, Fanshell Overlook, Carmel River Beach) in the Monterey Bay region since 2001 (CCLEAN 2006) (Figure 56). Analysis of samples collected from 2001 through 2005 detected elevated concentrations of DDTs, chlordanes, and dieldrin in wet season samples from Laguna Creek and The Hook. The Hook has exceeded the 95th percentile of the most contaminated samples analyzed by State Mussel Watch over a 20-year period for chlordanes, endosulfans, and dieldrin. Every site had mussels that exceeded at least one Maximum Tissue Residue Level set by the State Water Resources Control Board for concentrations of persistent organic pollutants (POPs).

There is no evidence that the contaminant levels measured in mussels and sand crabs are having significant negative impacts on those organisms, but there is some evidence that these contaminants are accumulating in animals at higher trophic levels. A recent study conducted by the California Department of Fish and Game tested 227 wild sea otters stranded between 2000 and 2005 for the presence of most major classes of POPs, including PCBs, PBDEs, PAHs, organochlorine pesticides, and organotins. Sea otters with high concentrations of DDT, chlordanes, PCBs, and dieldrin tended to be collected from the same local areas as mussels with high concentrations of POPs (Miller et al. 2007).

8. What are the levels of human activities that may influence habitat quality and how are they changing?

The level of human activities that influence habitat quality in the nearshore environment is rated “good/fair” because some human activities can have substantial, localized negative impacts on habitat quality. However, a trend could not be determined due to a lack of information for many of the activities and uncertainty in how to combine the available information into a cumulative trend.

Rocky intertidal areas with easy access to the public receive a high level of human visitation, especially sites near the cities of

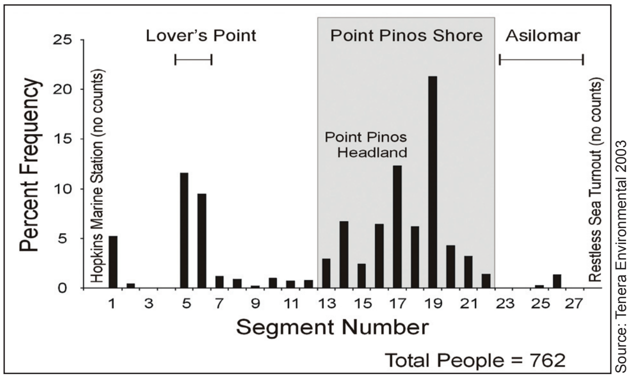


Figure 57. Levels of visitor use along the coast in the rocky intertidal zone (excludes beaches) along the Monterey peninsula. A total of 762 people were observed in 28 visitor surveys. Segments included a range of potentially affected locations in high use areas and reference stations with lower visitor use. Hopkins Marine Life Refuge and Restless Sea were assumed to experience only minor visitor use because of restricted access.

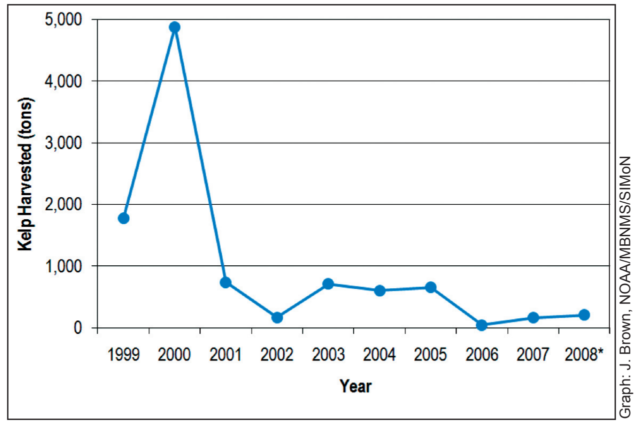


Figure 58. Amount of kelp harvested in the Monterey Bay National Marine Sanctuary from 1999 to 2008. Data for California Department of Fish and Game administrative beds 209 to 301 based on kelp harvesters monthly reports to the CDFG. Data from 2008 is preliminary.

Santa Cruz, Monterey, Pacific Grove, Half Moon Bay, and San Francisco. A recent study found that approximately 50,000 people visit the Point Pinos (Pacific Grove) intertidal zone annually (which equates to approximately 5,000 visitors per 100 meter length of shoreline), representing a small percentage of the total visitors to the rocky shores of the Monterey peninsula (Figure 57) (Tenera Environmental 2003). Public use is even higher at the Fitzgerald Marine Reserve (located south of San Francisco), where annual visitor attendance per 100-meter length of shoreline is estimated to be 20,000 people (Tenera Environmental 2003). Visitors to the rocky intertidal zone may negatively impact the habitat by trampling animals or algae or by collecting structure-forming organisms and turning over rocks and boulders. The harvesting of mussels for human consumption is increasing at some locations along the Big Sur coastline that were recently opened to human access (P. Raimondi, UCSC/PISCO/MARINe, pers. comm.).

Maintenance of existing armoring structures and development of new structures is a human activity that can impact habitat quality, particularly in the intertidal zone. This activity tends to be clustered near population centers and along sections of the coastal highway. Construction of new armoring structures is strictly regulated by the California Coastal Commission and requires a permit from the Monterey Bay sanctuary if the structure is placed below mean high tide line. There has been no obvious change in the intensity or frequency of this activity in the sanctuary.

Most sand mining operations along the coast of Monterey Bay were discontinued in the late 1980s and early 1990s. One mine continues to operate at Marina in southern Monterey Bay. As other mines closed, the operation at Marina increased its extraction to approximately 200,000 cubic yards per year, or the equivalent of all coastal bluff erosion in southern Monterey Bay (PWA 2008). Erosion rates at Marina increased after 1985, and are believed to be related to the increase in sand extraction at the Marina sand mine (PWA 2008).

The harvesting of kelp can impact the subtidal habitat. The amount of kelp harvested annually from kelp beds in the Monterey Bay sanctuary decreased over the last decade from a high of 4,880 tons in 2000 to approximately 200 tons in 2008 (Figure 58; data from CDFG Kelp Harvesters Monthly Reports). Kelco, which transferred its kelp harvesting holdings to ISP Alginates in 2001, landed the vast majority of kelp harvested in the sanctuary prior to 2006. This company processed kelp to extract algin, a polysaccharide used in many pharmaceutical, industrial and food products. This company no longer harvests in California, and as of 2006 the majority of kelp harvesters extracting kelp from beds in the sanctuary were abalone farmers (B. Owens, CDFG, pers. comm.). A few individuals have harvested kelp from the sanctuary for other reasons, including scientific research on the impact of kelp harvest on kelp canopy associated fishes.

A variety of land-based and water-based human activities result in the introduction of contaminants, including pesticides, microbial contaminants, and plastic debris, into the nearshore habitats of the sanctuary. These pressures to sanctuary habitats are likely to increase with continued coastal development and population growth. Management programs at the local, regional, and state level attempt to reduce point and non-point sources of contaminants. However, it is unknown whether these programs will be able to offset the increasing pressure of on-going development and population growth on sanctuary habitats.

Nearshore Environment Habitat Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
5	Abundance/ Distribution	— (Good/Fair)	Localized modification or loss of coastal habitat, primarily through armoring of coastal bluff, erosion of sandy shoreline, and landslide disposal on rocky reef.	Selected habitat loss or alteration has taken place, precluding full development of living resource assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.
6	Biologically-Structured	— (Good)	Monitoring programs indicate healthy populations and no major perturbations.	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
7	Contaminants	▼ (Fair)	Elevated contaminants near urban, maritime, or agricultural activities; continued input of contaminants from point and non-point sources.	Selected contaminants may inhibit the development of assemblages and may cause measurable but not severe declines in living resources or water quality.
8	Human Activities	? (Good/Fair)	Trampling, all forms of extraction, and sediment disposal can have measurable, localized impacts; cumulative trend for the numerous activities not determined.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Declining (▼), Undetermined Trend (?), Question not applicable (N/A)

Nearshore Environment Living Resources

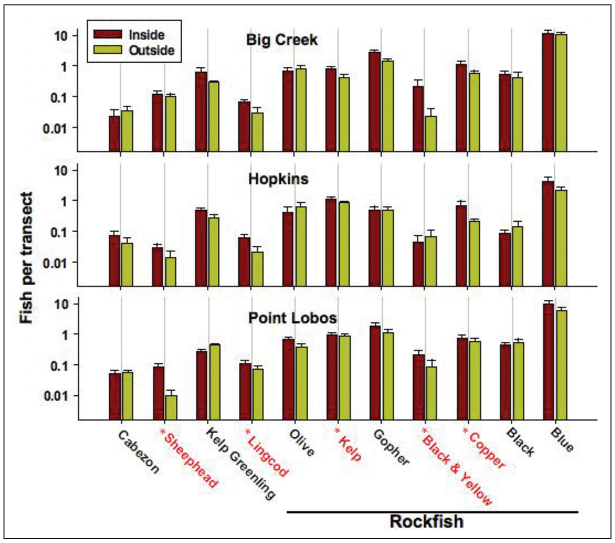
The following information provides an assessment of the status and trends pertaining to the current state of the sanctuary's living resources in the nearshore environment.

9. What is the status of biodiversity and how is it changing? Species richness in the nearshore habitats of the sanctuary has been unchanged over the last few decades with no local extinctions of native species. However, the relative abundance of native species in the intertidal and nearshore subtidal zones has been altered throughout the sanctuary by a variety of factors including human activities, such as trampling and harvesting for human consumption. The recent implementation of multiple marine reserves and conservation areas in nearshore waters (see Figure 35 on page 38) may facilitate recovery of reduced populations. Based on these patterns, the status of native biodiversity in the nearshore environment of the sanctuary is rated "fair," but the overall trend in biodiversity in nearshore habitats could not be determined.

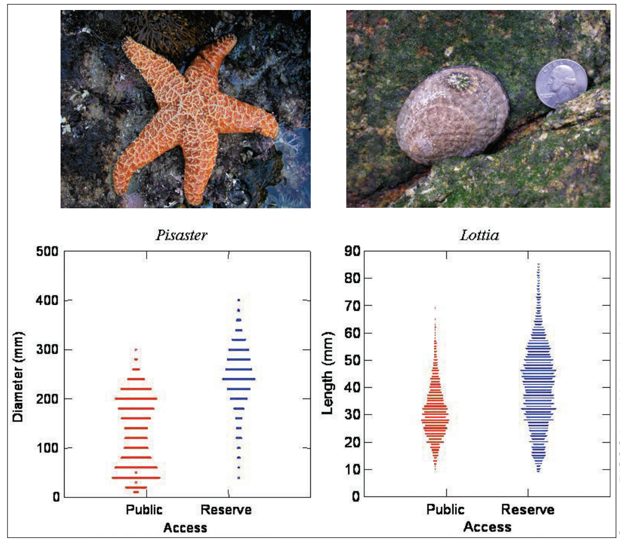
The sanctuary's rocky intertidal community is biologically rich, with 567 native species documented based on surveys of the more conspicuous species (Wasson et al. 2005). Long-term monitoring of the rocky intertidal community is conducted at multiple sites throughout the sanctuary by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) and Multi-Agency Rocky Intertidal Network (MARINe). Based on these surveys, trends in biodiversity differ in different regions of the sanctuary. In the southern portion of the sanctuary, between Ragged Point and Cambria, biodiversity in the rocky intertidal zone has declined in recent years as formerly private lands were opened to the public and subsequently the level of poaching in the intertidal zone in these areas increased (PISCO and MARINe unpubl. monitoring data; P. Raimondi, UCSC/PISCO/MARINe, pers. comm.). The rocky intertidal habitats between Carmel and Año Nuevo are very accessible to the public, and given their proximity to large population centers, it is likely that native biodiversity in these areas has been reduced relative to historic levels (pre-1900s) by both harvesting and trampling (P. Raimondi, UCSC/PISCO/MARINe, pers. comm.). Rocky intertidal areas between Ragged Point and Big Sur are protected from most direct human impacts (e.g., harvesting, trampling) due to limited or no public access.

Reduced abundance of some key intertidal species has the potential to alter native biodiversity and impact community structure. For example, black abalone populations at most sites in the sanctuary are at low levels due to a variety of factors including harvesting, sea otter predation, and disease. A recent study found that the composition of the intertidal community shifted after black abalone abundance declined (Miner et al. 2006). Cover of sessile invertebrates and number of sea urchins dramatically increased in areas formerly dominated by bare rock and crustose coralline algae. This shift in the relative abundance of species may be difficult to reverse because it decreases the quality of the habitat for juvenile abalone, thus making recolonization of the area less likely (Miner et al. 2006).

In subtidal rocky reefs and kelp forests past fishing practices have altered the relative abundance of targeted and non-targeted fishes (Figure 59) and invertebrates (Starr et al. 2004; PISCO subtidal monitoring data; M. Carr, UCSC/PISCO, pers. comm.). Because these impacts have been ongoing for many decades, there is no expected change in the status of native biodiversity (neither improving nor declining) based on the past five years of data, except possibly in marine reserves where fishing is not allowed and biodiversity may improve. In 2005 and 2006 there was no substantial rockfish recruitment to the nearshore environment,



Source: PISCO subtidal monitoring program



Source: PISCO intertidal monitoring program

Figure 59. The abundance (number per transect) of several fish species inside (maroon bars) of three marine reserves was compared to abundance outside (gold bars) of the reserves. Out of the eleven species surveyed, abundance was significantly higher inside the reserve at all three sites for the five species highlighted (asterisk and red text).

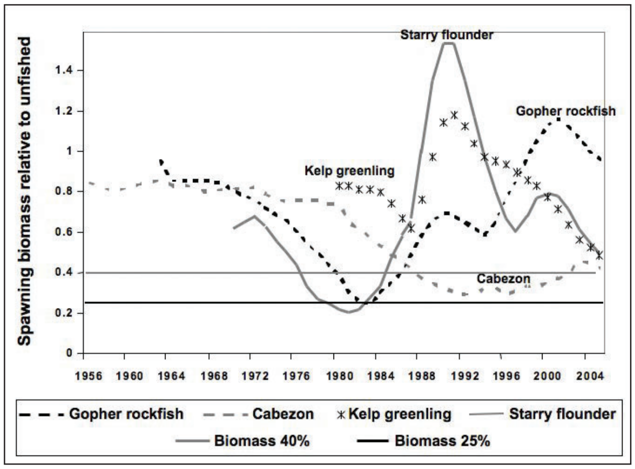
Figure 60. The size-frequency structure of the ochre star (*Pisaster ochraceus*) and the owl limpet (*Lottia gigantea*) are reduced in areas where the public has easy access to the rocky shore (red bars) compared to areas where public access is difficult or prohibited (blue bars). The width of the bars indicates the number of animals of a given size.

but the reason for this remains unknown (NOAA-SWFSC rockfish recruitment monitoring; PISCO monitoring). There has been a shift in distribution of some subtidal species, including snails, sea slugs, bivalves and brittelstars, along the coast, but the mechanism is unknown (Lonhart and Tupen 2001).

Less is known about biodiversity patterns in the sandy bottom habitats of the sanctuary. Some observed changes in biodiversity in the soft bottom habitats of the nearshore environment are likely in response to large-scale, long-term climatic shifts (e.g., Pacific Decadal Oscillation), but data detecting this pattern are limited to a small area (MLML 2006). Monitoring of beaches adjacent to the northern portion of the Monterey Bay sanctuary by the Long-term Monitoring and Experiential Training for Students (LiMPETS) program have found substantial declines in the abundance of mole crabs (George 2008). Mole crabs are an important component in the diet of many fishes, mammals, and birds inhabiting the sandy beach and surf zone and a substantial decline in the availability of this prey resource could impact local food web dynamics.

10. What is the status of environmentally sustainable fishing and how is it changing? The status of environmentally sustainable fishing in the nearshore environment is rated "fair" based on evidence that local abundance and size-frequency structures of some targeted species are reduced in areas open to fishing. These changes may influence community and ecosystem level processes in affected areas. However, it is difficult to assess the impacts that altered size-structure and reduced abundance of fished stocks has on ecosystem function since very little research has explored this question. Increasingly restrictive fisheries management strategies implemented by State and Federal agencies, including gear restrictions, bag limits, and closed areas are the basis for an "improving" trend.

Overall, sustainable fisheries in the rocky intertidal zone appear to be in fair condition, but the trend is declining in areas with elevated levels of human access and harvesting. Long-term monitoring of the rocky intertidal community has found that the abundance and size structure of some large, mobile species, such as sea stars and limpets, are lower in areas with easy access to the public as compared to areas where public access is difficult or prohibited (Figure 60) (PISCO intertidal monitoring data). The California Department of Fish and Game regulates harvest of many intertidal species, including owl limpets and black abalone. Commercial harvest of owl limpets is illegal throughout California and, where recreational harvest is allowed, the daily bag limit is 35 individuals. However, high-intensity poaching events (hundreds to thousands of individuals collected) have been observed at locations in central and southern California. Sagarin et al. (2007) found that sites with low levels of enforcement against poaching tended to have limpet populations with reduced size structure compared to areas with higher levels of enforcement. The commercial and



Source: S. Ralston and J. Field, NOAA/NMFS/SWFSC

Figure 61. Trends in the estimated size of the spawning population relative to the estimated size the population if unfished. Data are shown for the four nearshore stocks - gopher rockfish, cabezon, kelp greenling, and starry flounder – that were assessed in 2006 by the PFMC. A stock size of 0.4 (40% - gray line) relative to the unfished level is the target management level while a stock size of 0.25 (25% - black line) or less is considered overfished.

recreational fishery for black abalone has been closed since 1993. However, poaching of black abalone occurs at some sites in the Monterey Bay sanctuary (P. Raimondi, UCSC/PISCO/MARINe, pers. comm.) and may contribute to changes in the structure of intertidal communities that are observed following declines in abundance of this species (Miner et al. 2006).

The species commonly landed by recreational and commercial fisheries in the nearshore subtidal environment of the sanctuary include rockfishes, salmon, lingcod, cabezon, California halibut and other flatfishes (CDFG 2008b). The abundance of many of these species has been reduced compared to non-fished levels; however, it is difficult to determine their current level of abundance because many of the harvested stocks in nearshore waters are not assessed regularly. In 2005, the National Marine Fisheries Service approved stock assessments of four nearshore species: gopher rockfish, cabezon, kelp greenling, and starry flounder. These species were found to be above the fishery management target of 40% of unfished spawning biomass (Figure 61). However, cabezon, kelp greenling, and starry flounder were approximately 50% of the unfished level, and the combined removal of significant biomass of multiple stocks has the potential to alter nearshore ecosystems in the sanctuary. For example, there is evidence that local abundance and size-frequency structure for many target species has been reduced in areas open to fishing (Mason 1998, Paddack and Estes 2000, Dorn 2002, Starr et al. 2004; PISCO subtidal monitoring data, see Figure 59). The selective removal of the largest and oldest fish from a population may lead to changes in growth rate, size at maturity, reproductive potential of a population, and the ratio of males to females in species with sexual dimorphism (Berkeley et al. 2004, Palumbi 2004, PISCO 2007).

The squid fishery (the highest gross value fishery in the state) is in good condition but it is strongly influenced by oceanographic conditions, making this fishery highly variable (Porzio and Brady 2008). There are no known issues of physical bottom damage related to squid harvesting. It is unknown how squid harvesting directly or indirectly affects the ecosystem as a whole.

Recreational and commercial fisheries management in the nearshore environment has become more restrictive since the 1990s. New regulations, including stricter bag limits and gear restrictions, have reduced the harvest of some species (e.g., bocaccio, kelp greenling, lingcod, cabezon). Harvest has been prohibited in some cases (e.g., abalone, canary rockfish, salmon in certain years). The number of nearshore fishes taken in the live-fish fishery has declined recently due to changes in management; the fishery was changed to a restricted access fishery in which the number of participants receiving permits is strictly managed. In addition, 29 marine protected areas were implemented in September 2007 along the central California coast under the Marine Life Protection Act (see Figure 35 on page 38). Some of these areas completely prohibit take of all species while others allow limited take of certain species with approved gears. These regulatory changes have helped improve the status of some previously overfished stocks (e.g., cabezon) and are likely to lead to an improving trend in the status of environmentally sustainable fishing in the sanctuary.

11. What is the status of non-indigenous species and how is it changing? Non-indigenous species have been identified in the nearshore habitat of the sanctuary and a few of these species appear to be spreading. Therefore, this question is rated "good" with a "declining" trend. Surveys of rocky intertidal areas on the open coast adjacent to Elkhorn Slough documented 588 species, of which eight were introduced and 13 were cryptogenic (i.e., possibly native or possibly introduced) (Wasson et al. 2005).

Maloney et al. (2006) sampled four very distinct habitats throughout California (sandy and rocky intertidal and sandy and rocky subtidal), with many of the sites located in the sanctuary. The percentage of introduced species was very similar among habitats (1-2%), but the actual numbers of introduced species identified from each habitat type varied: 16 were found in the rocky intertidal, twelve in the rocky subtidal habitat, and seven each in the sandy intertidal and subtidal habitats. Of the 26 introduced species identified along the outer coast, six were not previously known from California and at least six other introduced species had recently

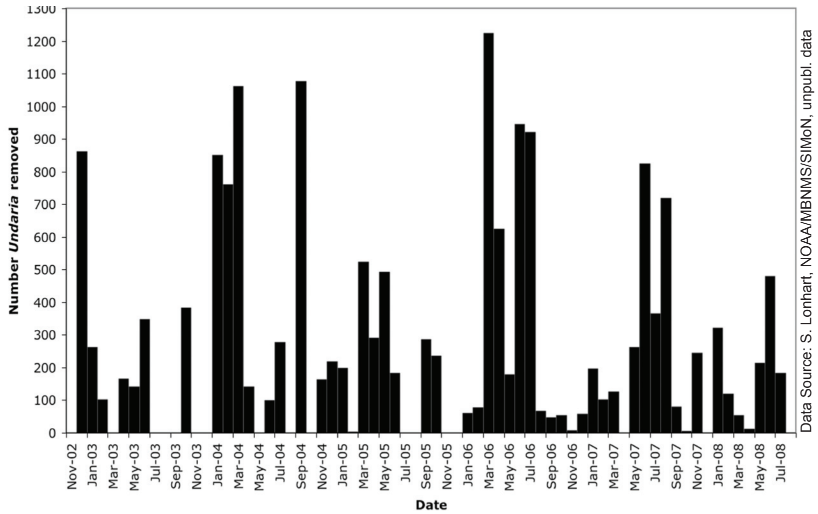


Figure 62. Between December 2002 and July 2008 17,522 individuals of the invasive Asian kelp *Undaria pinnatifida* were manually removed from Monterey Harbor. 120 removal dates were collapsed into monthly totals in this figure. Months with no data were not surveyed.

expanded from bays or estuarine habitats onto the outer coast.

The invasive Asian kelp, *Undaria pinnatifida*, was first identified in Monterey Harbor in August 2001 (Note: harbors are adjacent to, but not within the boundaries of the sanctuary). This species is a concern because of its relatively quick growth rate and wide blades that allow this seaweed to shade native understory algae. The Monterey Bay sanctuary has led an effort to monitor and remove this species from the harbor. Between December 2002 and July 2008, 120 surveys were conducted and 17,522 individual *Undaria* were manually removed from the harbor (Figure 62). Despite this extensive removal effort, there was no overall decline in the number of *Undaria* in the harbor over time (S. Lonhart, MBNMS, unpubl. data). Some vessels in the Monterey Harbor frequent Southern California harbors infested with *Undaria* and these vessels may periodically re-inoculate the Monterey harbor. Because many established invaders subsequently spread from the point of initial introduction, it is likely only a matter of time before this two-meter-long kelp reaches the breakwater and subtidal reefs in front of Cannery Row.

Other surveys (S. Lonhart, MBNMS, unpubl. data) have documented the spread of the introduced Japanese bryozoan, *Watersipora subtorquata*. This deep-red colonial animal, which forms brittle crusts and erect coral-like heads, cannot be eradicated by manual removal, since even small fragments can reproduce and spread asexually. This species smothers other organisms by growing on top of them, covering areas 1-2 meters in diameter. In the 1990s, this species was limited to harbors, but in early 2000 it was observed on the open coast at the Hopkins Marine Life Refuge. It is also on man-made structures in Moss Landing at depths of 15 meters. Another introduced seaweed from Japan, *Sargassum muticum*, has spread along the entire eastern Pacific from Baja California to Alaska. This species has apparently stabilized and has equivocal impacts on subtidal communities (Inderjit et al. 2006). A red alga, *Caulacanthus ustulatus*, is also present in some Southern California rocky intertidal areas (Maloney et al. 2006), but in the sanctuary it is only found on riprap in Elkhorn Slough.

12. What is the status of key species and how is it changing?

The status of key species in the nearshore environment is rated "good/fair" and the trend is "not changing" because of the reduced abundance of a limited number of key species in each habitat type. Key species in the rocky intertidal and subtidal zones include abalone, sea urchins, mussels, and habitat-forming algae. Abalone populations are severely depleted due to over-harvesting, sea otter predation, and disease (Haaker et al. 2004). Abalone are ecologically important herbivores that alter community structure by grazing on algae. Juvenile abalone are important prey for other species (e.g., cabezon, sea otters). Black abalone, historically the most abundant intertidal abalone species, has been decimated in southern and south-central California by withering syndrome (PISCO / MARINe intertidal monitoring data). Perhaps because of this decline in abalone, the status of habitat-forming algae is good (PISCO / MARINe intertidal monitoring data). Mussels provide important structure and biogenic habitat for dozens of other organisms. They are declining at some sites because of harvesting for human consumption and as bait for shoreline fishing (PISCO / MARINe intertidal monitoring data). Black Oystercatchers are important avian predators of limpets (another important herbivore in the rocky intertidal zone), but the birds disappear from areas with human visitation, which is increasing along the coast as private lands are opened up to the public. At some sites with high public use, trampling of algae and invertebrates is another significant human impact (Tenera Environmental 2003).

The kelp forest community is monitored at multiple sites in the Monterey Bay National Marine Sanctuary by PISCO and sanctuary staff. The status of some key subtidal species, particularly kelp and sea urchins, appears to be good (PISCO/MBNMS subtidal monitoring). Rockfishes, cabezon, and lingcod are important residents of the nearshore subtidal zone and the abundance of these stocks has been reduced (to varying ex-

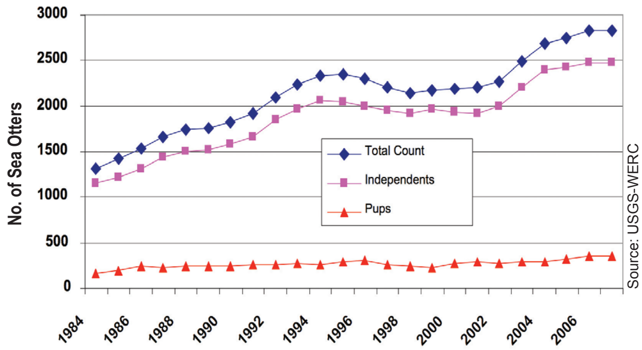


Figure 63. Number of southern sea otters counted during spring surveys, plotted as 3-year running averages. Total number (blue diamond), number of dependent pups (red triangle), and the number of independents (adults and subadults pink square) are shown. Surveys cover the central California coast from Half Moon Bay to Santa Barbara.

tents depending on the species) by recreational and commercial harvest. However, with new fishing regulations, most species with reduced population sizes have responded positively. For example, lingcod is rebounding quickly from very low levels in the early 1990s (Jagielo and Wallace 2005), while cabezon is showing a slower rate of recovery (Cope and Punt 2005, see Figure 61).

Sea otter numbers in central California are well below pre-harvest levels, and multiple mechanisms have been proposed to explain why the population has not rebounded quickly over the past 40 years (U.S. Fish and Wildlife Service 2003). In 1982, scientists at the USGS Western Ecological Research Center (WERC) developed and began using a standardized method to survey sea otters. Since 1999, counts have been quite variable, with a slight increasing trend over the whole range (Figure 63). Population trends for the southern sea otter are monitored using the three-year running average of the spring census counts (note that the census provides an uncorrected count of the entire population, and not a formal population estimate). The uncorrected total spring count for 2008 is 2,760, while the three-year running average count for 2007 (the average of the 2006, 2007, and 2008 spring counts) is 2,826.

Nearshore soft-bottom habitats in the shallow subtidal zone used to have high densities of Pismo clams (*Tivela stultorum*), but these populations have been decimated by the return of sea otters (Kim et al. 2006). Sand dollar beds, a type of biologically structured habitat found just beyond the surf zone, have not been monitored so their status is unknown. At depths greater than seven meters the ornate tubeworm, *Diopatra ornata*, is an important and ubiquitous stabilizing organism, and also provides structure and habitat for other organisms. Again, the status of this species is not being monitored.

13. What is the condition or health of key species and how is it changing? The health of key species in the nearshore environment is rated "fair" because the health of some key species is negatively impacted by disease or chemical contaminants. The trend is rated as "unchanging" because impacted populations are generally not declining in the sanctuary, but decreased health appears to be one reason that the populations are not recovering from depressed levels.

In the rocky intertidal zone, black abalone (*Haliotis cracherodii*) is ecologically extinct south of Point Sierra Nevada whereas populations north of Piedras Blancas are relatively intact (PISCO / MARINe intertidal monitoring). However, it is unlikely that these populations can recover based on their mode of reproduction, distance between remnant populations, and a lack of settlement habitat at sites with reduced adult numbers (Miner et al. 2006). The decline began with harvesting for human consumption and predation from sea otters, but in the last 20 years withering syndrome has decimated black abalone in Southern California. The disease has moved northward along the coast and appears poised to expand into central California (Figure 64) (Raimondi et al. 2002). Although there is no evidence that this disease is directly a result of an anthropogenic mechanism, spread of the disease may have been exacerbated by warmer coastal waters caused by factors such as long- and short-term changes in climate.

The sluggish recovery of the southern sea otter cannot be attributed to any single cause, but instead is the result of multiple impacts to the health of the population (U.S. Fish and Wildlife Service 2003). Infection or disease was found to be the cause of death in approximately half of fresh condition beach cast southern sea otters recovered over a twelve-year period (Tinker et al. 2006). Diseases affecting southern sea otters include protozoal infections (including *Toxoplasma gondii* and *Sarcocystis neurona*), infections with thorny headed worms (*Profilicolis* spp.), and domoic acid intoxication from harmful algal blooms. Exposure to chemical contaminants is another threat to the sea otter population. A recent study conducted by the Department of Fish and Game tested 227 wild sea otters stranded between 2000 and 2005 along the California coast for the presence of most major classes of persistent organic pollutants. DDTs had the highest mean liver concentrations of all major contaminant groups, followed by PCBs, and PBDEs (Miller et al. 2007). In addition, there is some indication that food resource limitation is a significant factor limiting population growth in at least some parts of their range (Oftedal et al. 2007, Tinker et al. 2006).

Recent studies suggest that exposure to one threat may make an animal more susceptible to others (Miller et al. 2007, Kreuder et al. 2003). For example, Kannan et al. (2006) found a significant association between infectious diseases and elevated concentrations of perfluorochemicals in the livers of adult fe-

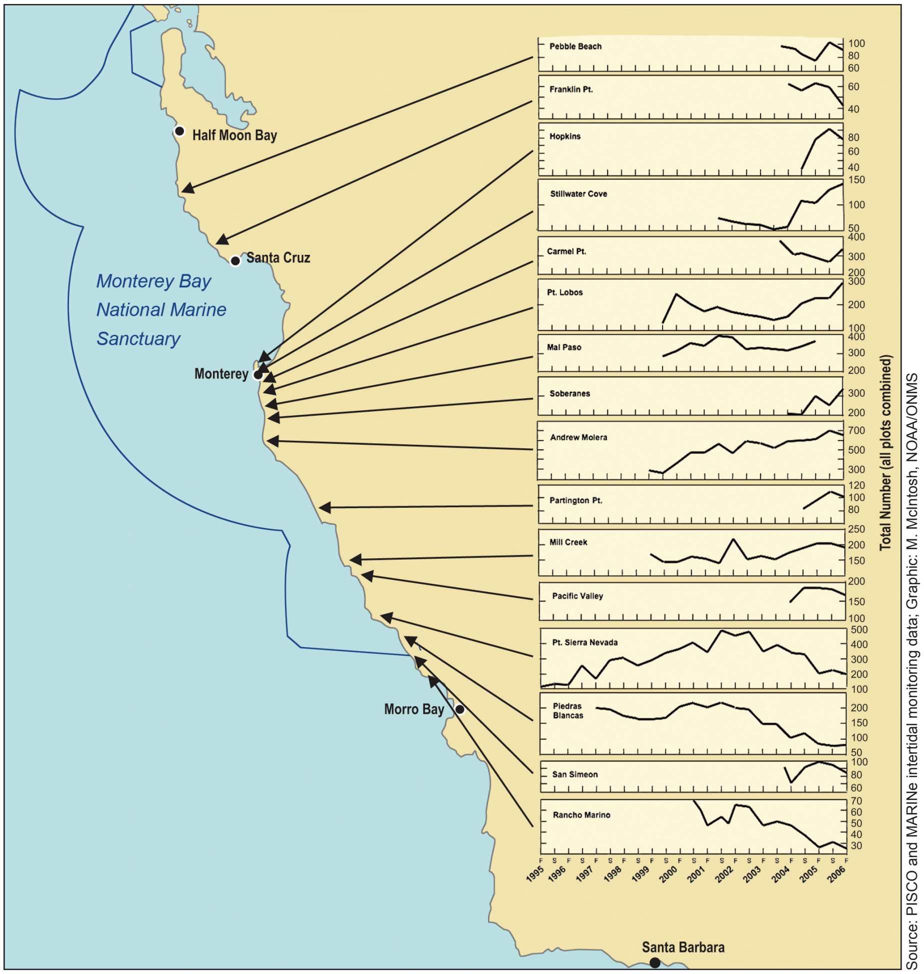


Figure 64. Trends in abundance of black abalone at monitoring sites in the sanctuary. Sites are listed from north to south. Abundance of black abalone has been unchanging or increasing at many northern and centrally located sites, but declining at sites near the south boundary of the sanctuary.

male sea otters collected from the California coast during 1992-2002. Environmental contaminants may compromise the otters' immune response or weaken them in some other way, which predisposes sea otters to disease-induced mortality.

14. What are the levels of human activities that may influence living resource quality and how are they changing? The status of human activities that may influence living resource quality in the nearshore environment is rated "fair" and the trend is "declining" because, in general, a number of human activities have negative impacts and most of these activities are continuing at current levels or are increasing in intensity. As more private lands along the coast are opened to public access, extraction - both legal and illegal - has increased in the rocky intertidal zone (P. Raimondi, UCSC/PISCO/MARINe, pers. comm.). Poaching is particularly problematic, and it is unlikely that enforcement efforts will ever match those of the poachers. Additional funding and personnel are needed to increase monitoring, enforcement, and public education efforts. Increased access also increases damage due to non-extractive activities, such as trampling, turning over rocks, flushing birds and marine mammals (Tenera Environmental 2003). Additional restrictive measures, including seasonal closures, bag limits, and new area closures created under the Marine Life Protection Act (see Figure 35 on page 38) have been implemented in the nearshore environment by fisheries management. These changes in fisheries management may result in decreases in the overall fishing effort, but may also lead to redistribution of fishing effort and increased pressure in areas open to fishing.

In contrast to the chronic pressure of humans along accessible sections of the rocky coastline, oil spills, although relatively rare, can have a tremendous impact on intertidal resources. Similarly, landslides occur infrequently on the Big Sur coast, but when they do, entire sections of the coastline are buried, and it can be decades before natural processes remove the intertidal and subtidal debris (Carr et al. 2006).

Organisms living in sandy beach and subtidal habitats also face several threats due to human activities. These include coastal armoring to reduce bluff erosion and protect buildings, grooming of the sand at popular beaches, sand mining (in the city of Marina), disposal of harbor dredge spoils, and the placement of outfalls from storm drains, sewage treatment facilities, desalination plants, and power plants. Recreational use can also negatively impact beach organisms. For example kite flying, horseback riding and dogs off leash can disturb birds, while picnicking increases trash.

Nearshore Environment Living Resources Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
9	Biodiversity	?	Fishing, collecting, and poaching have reduced overall biodiversity; improvements likely in new protected areas, but continued impacts at some locations on rocky shores.	Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
10	Environmentally Sustainable Fishing	▲	Studies have found decreased abundance and size structure in fished areas compared to marine reserves. Restrictive management strategies have improved the status of previously overfished stocks.	Extraction may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
11	Non-Indigenous Species	▼	A few non-indigenous species have been identified, and some appear to be spreading.	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).
12	Key Species Status	—	Abundance of some key species in each habitat type is lower than would be expected in a natural state. Possible community-level impacts on rocky shores.	Selected key or keystone species are at reduced levels, perhaps precluding full community development and function, but substantial or persistent declines are not expected.
13	Key Species Condition	—	Evidence of recent impacts from withering syndrome on black abalone. Clear evidence of health problems in sea otters, but limited or no data for other species that may be affected.	The diminished condition of selected key resources may cause a measurable but not severe reduction in ecological function, but recovery is possible.
14	Human Activities	▼	Variety of visitation, extraction, and coastal development activities, some of which are increasing in frequency.	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Declining (▼), Undetermined Trend (?), Question not applicable (N/A)

Nearshore Environment Maritime Archaeological Resources

The following information provides an assessment of the status and trends pertaining to the current state of the maritime archaeological resources in the nearshore environment.

15. What is the integrity of known maritime archaeological resources and how is it changing? The integrity of the known maritime archaeological resources in nearshore habitats is rated "fair." Little is known about the submerged maritime archaeological resources in the nearshore environment of the sanctuary. To date, only one nearshore archaeological site location inventory has been conducted in the nearshore environment of Monterey Bay sanctuary (1979-1981 National Park Service inventoried the California Gold Rush passenger steamship *Tennessee* lost 1853) (Schwemmer 2006b). No other site evaluations have been conducted by Federal, State, or private resource management agencies in the nearshore environment.

Recreational divers have located at least 27 shipwrecks in the nearshore environment of Monterey Bay sanctuary. Most of these nearshore sites are in less than 100 feet (30 meters) of water and are reported in various stages of degradation due to their close proximity to shore. Sites in shallow water environments within high energy zones are more likely to be subjected to degradation by waves, shifting sands, and strong currents. Submerged cultural material associated with Native American terrestrial sites is likely to be exposed in the nearshore environment as a result of coastal land erosion (Terrell 2007).

Some sites are regularly visited by divers and beachcombers and in some cases artifacts have been removed from accessible sites (e.g., former 19th century downeaster sailing vessel and later barge *William H. Smith* lost 1933 (Figure 65), steam

Photo: B. Yerena, NOAA

Figure 65. Remains of the schooner *William H. Smith* that grounded on Del Monte Beach on February 24, 1933. Winter storms periodically uncover the buried wreck (shown here).

Photo: Copyright (C) 2002-2007 Kenneth & Gabrielle Adelman, California Coastal Records Project

Figure 66. Barge (Sauce Brothers Ocean Towing) grounded near the Salinas River after a storm in December 1983.

schooner *Gypsy* lost 1905, former sailing bark and later oil barge *Roderick Dhu* lost 1909, and Salinas River Barge *Sauce Bros* lost 1983) (Figure 66). Although anecdotal information is available there is no baseline monitoring information available to detect a change or impact to the resources, therefore, a trend in their integrity is undetermined. It is assumed there is less relic hunting occurring today due to education, and most of the accessible sites have already been pilfered. Yet some of the less impacted sites are becoming well known due to an increase in information exchange among enthusiasts.

16. Do known maritime archaeological resources pose an environmental hazard and is this threat changing? The known maritime archaeological resources in the nearshore environment are rated as "good" and "not changing" in terms of posing an environmental hazard. Based on the sanctuary's inventory of known maritime archaeological resources in the shallow water (50 feet or 15 meters, or less), it is unlikely that the remains of shipwrecks hold hazardous cargos and/or bunker fuels. This is also true for shipwrecks located near the entrance to San Francisco Bay (just beyond the sanctuary boundary) that were either dynamited as a hazard to navigation or were part of the city of San Francisco's efforts to clear wrecks above the waterline that were considered unsightly. Sites in shallow water environments within higher energy zones are subjected to vessel hull collapse by waves, shifting sands, and strong currents. Known maritime archaeological resources in the nearshore pose few or no environmental threats, and the trend is not changing.

17. What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing? Human activity influencing maritime archaeological resources in the nearshore environment is rated "good/fair." Several human activities may influence the quality of maritime archeological resources in the nearshore environment including the removal of artifacts from archeological sites, diving, anchoring, and fishing activities (e.g., trawling, other gear impacts). Local museums and historical societies exhibit artifacts that were removed from archaeological resources prior to the establishment of Monterey Bay National Marine Sanctuary. Site looting (where objects are intentionally pilfered from submerged sites) may pose a major threat to submerged archaeological resources. Divers visiting sites may cause injury through poor diving techniques, inadvertently holding onto fragile artifacts or striking them with SCUBA tanks. Vessel activity, such as anchor drags or modern ship groundings, can also cause serious injury to submerged archaeological resources. Currently, bottom trawling is prohibited in California state waters, but historically trawling may have impacted resources. These potential impacts have not been measured, but for the known archeological sites, current human activities do not appear to have a significant negative impact on the integrity of these resources. The trend is "undetermined."

Nearshore Environment Living Resources Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
15	Integrity	?	Divers have looted sites, but not all sites have been studied to determine trend.	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, scientific or educational value and may affect the eligibility of some sites for listing in the National Register of Historic Places.
16	Threat to Environment	—	MBNMS Resource Inventory indicates no known environmental hazards.	Known maritime archaeological resources pose few or no environmental threats.
17	Human Activities	?	Recreational diving occurs on wreck sites, but activity level is unknown.	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (—), Declining (▼), Undetermined Trend (?), Question not applicable (**N/A**)

State of Sanctuary Resources: Estuarine Environment

Estuarine Environment Water Quality

Elkhorn Slough is the only large estuary on the central California coast located within the boundaries of the Monterey Bay National Marine Sanctuary. The following information provides an assessment of the status and trends pertaining to water quality and its effects on the estuarine environment in Elkhorn Slough.

1. ***Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?*** Stressors on water quality in the nearshore environment, particularly high levels of agricultural inputs such as sediments, and associated pollutants, have been historically documented in Elkhorn Slough, and may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats. For this reason, this question is rated "fair/poor" with a "declining" trend. Pollutants that have been measured at high concentrations in waterbodies adjacent to Elkhorn Slough have the potential to be transported into the slough (Monismith et al. 2005, Johnson et al. 2007, http://www.mbari.org/lobo). Although there have been few studies conducted to determine the impacts of such pollutants on living resources, it is likely that the abundance of pollution-intolerant species has been reduced (ESNERR et al. 2009).

   Over the past 150 years, human actions have altered the tidal, freshwater, and sediment processes in Elkhorn Slough and its watersheds. Such impacts have substantially changed the water quality conditions and have increased the levels of pollution and eutrophication in the slough (ESTWPT 2007). Approximately two-dozen wetlands comprising nearly 637 acres of estuarine habitats in the Elkhorn watershed are currently behind water control structures and levees. Changes in the erosion processes have been observed since the mouth of the slough was widened to build the Moss Landing Harbor (PWA 1992). Recent work by Monismith et al. (2005) shows that ebb dominant currents in the slough create pronounced bottom stresses that enhance erosion and lead to a net ocean-ward flux of sediments and loss of wetland habitat (Figure 67). Control structures have caused many sites in Elkhorn Slough to have very restricted tidal exchange, thus resulting in poor water quality conditions, as evident through low dissolved oxygen and elevated levels of organic matter accumulation (ESTWPT 2007). Studies of Azevedo Pond, which lies within the Elkhorn wetland complex, show that the site regularly experiences anoxia during the night (Beck and Bruland 2000, Chapin et al. 2004). Moreover, water quality changes that have resulted from the presence of water control structures may strongly influence spatial patterns of species distribution within Elkhorn Slough (Ritter et al. 2008).

   A main cause of water and sediment quality degradation is agricultural non-point source pollution (Caffrey 2002, Phillips et al. 2002, ESNERR et al. 2009). Relatively high levels of nutrients and legacy agricultural pesticides, such as DDT, have been documented within the Elkhorn Slough wetlands complex, with the highest concentrations measured in areas that receive the most freshwater runoff (Phillips et al. 2002, ESNERR et al. 2009). Pathogens, pesticides, sediments, low dissolved oxygen levels and ammonia have impaired sections of Elkhorn Slough and waterbodies adjacent to the slough (Moro Cojo Slough and Moss Landing Harbor) (see Table 1 on page 55). A Central Coast Ambient Monitoring Program (CCAMP) study conducted between 2001 and 2006 showed problematic levels of dissolved oxygen, dissolved inorganic nitrogen, ortho-phosphate, and chlorophyll, and poor water clarity at the mouth of the slough in Moss Landing Harbor (Sigala et al. 2007). Toxicity due to organophosphate (such as diazinon and chlorpyrifos) and pyrethroid pesticides

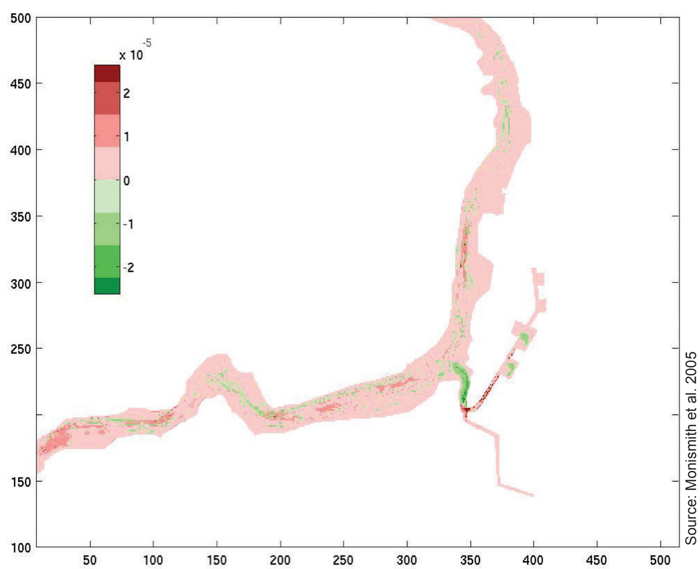


Figure 67. Erosion in the main channel of Elkhorn Slough as predicted by a computer model. Red areas show net erosion and green areas show net deposition over the course of the model run.

has been documented in adjacent watersheds (Hunt et al. 2003, Anderson et al. 2006, Phillips et al. 2006), pointing to the potential for similar toxicity problems in Elkhorn Slough.

2. ***What is the eutrophic condition of sanctuary waters and how is it changing?*** The eutrophic condition of estuarine environments within the sanctuary is rated as "fair" and "declining" based on impaired conditions in Elkhorn Slough and the adjacent water bodies that drain into the slough. Water bodies adjacent to the main channel of Elkhorn Slough, including Morro Cojo Slough, Old Salinas River Estuary, and Salinas River Lagoon, are impaired by nutrients and low dissolved oxygen levels (see Table 1 on page 55). A survey in 1999 classified Elkhorn Slough as a highly eutrophic environment due to the occurrence of low dissolved oxygen levels, high chlorophyll-a, and high nitrate concentrations (Bricker et al. 1999). A recent update to the study, which now includes data through 2004, showed improved chlorophyll-a and dissolved oxygen levels compared to 1999, leading to a re-classification of Elkhorn Slough as moderately eutrophic (Bricker et al. 2007). However, the report noted concerns for the future based on the susceptibility of the system and predicted nutrient loads (Bricker et al. 2007). Monitoring studies provide evidence of local nutrient increases within the Elkhorn Slough wetland system (Figure 68) and turbidity increases that are due to phytoplankton biomass and/or suspended sediments that may affect the eutrophic condition of the slough in the future.

An increased supply of nutrients has been an important contributor to eutrophication in estuaries in recent decades. Current nitrate concentrations in Elkhorn Slough are two orders of magnitude higher than in the 1920s (Caffrey 2002) and peak values at monitoring sites within the Slough are among the highest ever reported for estuarine ecosystems (Caffrey 2002). In addition, nitrate concentrations up to 125 mg/L have been recorded in the Old Salinas River Channel (Johnson et al. 2007), which is almost three times higher than the water quality standard for municipal and domestic water supply use (ESTWPT 2007).

In the main channel of Elkhorn Slough strong tidal flushing dilutes nitrate concentrations to a lower average of 5 mg/L or less. However, even in areas that are strongly flushed by tides, higher concentrations occur in the rainy season, partly due to sources within the Elkhorn watershed. The Elkhorn Slough National Estuarine Research Reserve's system-wide water quality monitoring program has detected higher levels of nutrients on outgoing tides, attributable to local sources, than on incoming tides. An array of *in-situ* nitrate monitoring instruments has recently documented nitrates from the Old Salinas River Channel and Tembladero Slough sources traveling into Elkhorn Slough (ESNERR et al. 2009, Johnson et al. 2007, http://www.mbari.org/lobo).

Eutrophication can lead to an array of harmful effects including reduction in water quality (specifically low dissolved oxygen levels), fish mortality, and the loss of biodiversity (Cloern 2001), and has been identified by the Millennium Ecosystem Assessment as one of the largest and most dangerous threats to coastal ecosystems in the United States and globally. Few studies have directly addressed the ecological impacts of eutrophication in Elkhorn Slough, but based on published studies elsewhere, it is possible that changes in water quality have increased the abundance of nutrient-limited producers (e.g., macroalgae such as sea lettuce) and pollution-tolerant animals, while decreasing the abundance of pollution-intolerant species (ESNERR et al. 2009). Hypoxia is common in many tidally restricted portions of the estuary, and occurs on occasion in fully tidal areas of the upper estuary (J. Haskins, ESNERR monitoring data; Ritter et al. 2008).

3. ***Do sanctuary waters pose risks to human health?*** The estuarine waters of the sanctuary are rated "fair/poor" and a trend is "undetermined." Elkhorn Slough and adjacent water bodies, including Moro Coho Slough, Moss Landing Harbor,

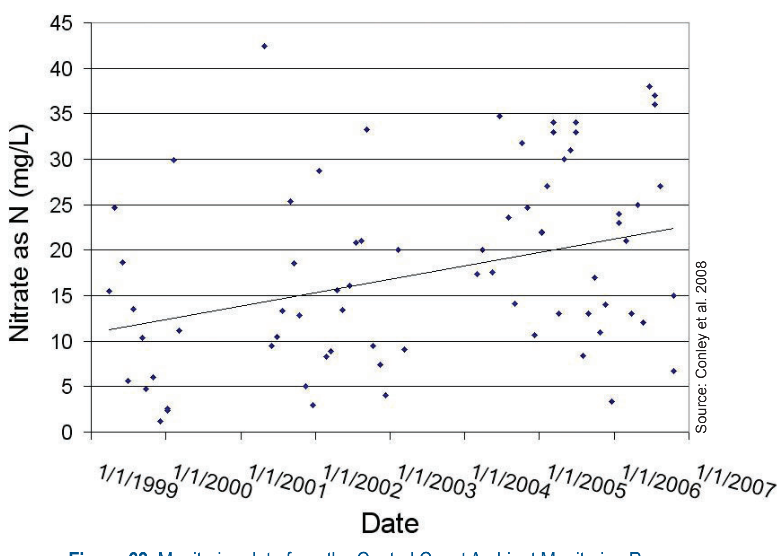


Figure 68. Monitoring data from the Central Coast Ambient Monitoring Program (CCAMP) in the Old Salinas River, adjacent to the Elkhorn Slough, show a significant increase (p=0.047) in nitrate levels using the Seasonal Mann-Kendall test. The rate of change between 1999-2006 is 1.57 mg/L/yr-1 using Sen's slope estimator.

Salinas River Lagoon, and Old Salinas River Estuary, are impaired by pesticides and pathogens (see Table 1 on page 55).

Bioaccumulation studies that measure the amount of chemicals being absorbed by animal tissues have detected high levels of DDT (and its metabolites) and other pesticides in both resident and transplanted bivalves in Elkhorn Slough (Phillips et al. 2002). NOAA's National Status and Trends' Mussel Watch program indicates that Elkhorn Slough has levels of cadmium, DDTs, and dieldrins that are high relative to other national sites (Kimbrough 2008).

Toxicity tests demonstrate that in some instances, contaminants in Elkhorn Slough have short-term impacts on individual organisms. Predation on toxic prey has implications for long-term effects on community structure and organisms at higher levels in the food chain (Phillips et al. 2002). Water collected from Tembladero Slough has been shown to cause toxicity to small crustaceans, attributed to organophosphate pesticides (Hunt et al. 2003, Anderson et al. 2004, ESNERR et al. 2009). High levels of contaminants in harvested crustaceans and bivalves could pose a risk to human health.

4. What are the levels of human activities that may influence water quality and how are they changing? Human activities that can influence water quality are rated "fair" and a trend is "undetermined." An important and relatively poorly understood threat to water quality in Elkhorn Slough is non-point source pollution from multiple sources, including substantial agricultural runoff from inputs along the Salinas River, Tembladero Slough, and the Elkhorn Slough watershed. Nutrients and significant concentrations of legacy agricultural pesticides, such as DDT, have been documented in some watershed wetlands, with highest levels in the areas receiving the most freshwater runoff (Phillips et al. 2002, ESNERR et al. 2009). Use of persistent pesticides for agriculture in the area has been phased out, but high concentrations are still present in the sediment and can become re-suspended by erosion (ESNERR et al. 2009). As legacy organochlorines were phased out in the 1970s and 1980s, organophosphate pesticides such as diazinon and chlorpyrifos became widely used, and these pesticides have been found at toxic concentrations in many central coast watersheds (Hunt et al. 2003). Pyrethroid pesticides are now increasingly applied along the central coast and have been found at toxic concentrations in watershed sediments (Anderson et al. 2006, Phillips et al. 2006).

Sediment and freshwater inputs to Elkhorn Slough have been dramatically altered over time through river diversion and modification, such as levee construction. Over 37 miles of levees and embankments were constructed between the 1870s and 1960s in Elkhorn Slough (Van Dyke and Wasson 2005). The diversion of the Salinas River in 1909 and levee construction on the Pajaro River likely led to a significant decrease in freshwater and sediment inputs to Elkhorn Slough. Levees restrict tidal exchange and can reduce water quality due to hypersalinity (ESTWPT 2007, ESNERR et al. 2009).

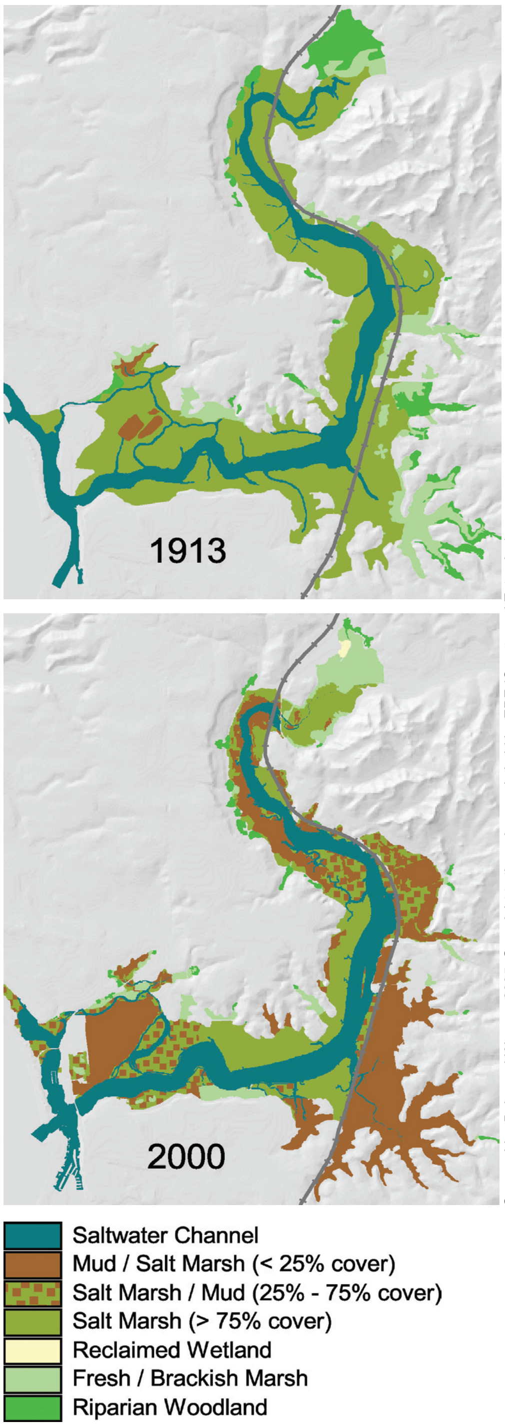
Over the past ten years management agencies have worked with local stakeholders to create regulatory, monitoring, education, and training programs and to implement better agricultural and urban management practices aimed at reducing or eliminating pollution sources. However, there is a poor understanding of the relationships between the cumulative effects of behavioral changes within the Elkhorn Slough watershed and changes in water quality conditions.

Estuarine Environment Water Quality Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
1	Stressors	▼ (Fair/Poor)	Major alternations to tidal, freshwater, and sediment processes has increased the level of pollution and eutrophication; inputs of pollutants from agricultural and urbanized land sources.	Selected conditions have caused or are likely to cause severe declines in some but not all living resources and habitats.
2	Eutrophic Condition	— (Fair)	Low dissolved oxygen levels and high nutrient concentrations are observed but strong tidal flushing dilutes concentrations in main channel.	Selected conditions may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats.
3	Human Health	? (Fair/Poor)	Elkhorn Slough and connected waterbodies are impaired by pesticides and pathogens. High levels of contaminants in harvested crustaceans and bivalves could pose a risk to human health.	Selected conditions have caused or are likely to cause severe impacts, but cases to date have not suggested a pervasive problem.
4	Human Activities	? (Fair)	Substantial inputs of pollutants from non-point sources, especially agriculture. Significant efforts over past ten years to implement best management practices and educate local land owners. No evidence yet of improving water quality due to changes in land management practices.	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (—), Declining (▼), Undetermined Trend (?), Question not applicable (**N/A**)



Source: Van Dyke and Wasson 2005. Copyright to these images is held by ERF (Coasts and Estuaries)

Figure 69. Aerial photograph interpretations of changes in estuarine habitat composition in Elkhorn Slough from 1913 to 2000.

Estuarine Environment Habitat

The following information provides an assessment of the status and trends pertaining to the current state of estuarine habitat.

5. ***What is the abundance and distribution of major habitat types and how is it changing?*** The abundance and distribution of major habitat types in the estuarine environment of the sanctuary is rated “fair/poor” and “declining” due to substantial changes in the relative abundance of estuarine habitat types resulting from over one hundred years of hydrologic alteration. Beginning in the late 1800s, a series of human activities removed marshes from tidal exchange and altered the slough’s basic circulation (Caffrey and Broenkow 2002). These activities included ditching and diking to create pasture for cattle and evaporative salt ponds, and diverting the Salinas River away from Elkhorn Slough, which removed the slough’s major source of freshwater and sediments. The most dramatic change occurred in 1946 when the mouth of Elkhorn Slough was moved to its current location and deepened by more than five times to create a fixed opening to Monterey Bay for Moss Landing Harbor. This alteration to the mouth of the slough is the main cause of subtidal erosion and more recent marsh erosion and conversion. Additional factors that may be contributing to habitat changes in Elkhorn Slough include a decrease in sediment supply due to river diversion, the Monterey Canyon Head that acts as a sediment sink at the mouth of the estuary, sea-level rise, and levee breaching (ESTWP 2007). The observed changes in estuarine habitat abundance and distribution has influenced the associated faunal communities, with declines in some marsh, mudflat, and tidal creek dependent species and increases in the abundance of marine fish and mammals (Van Dyke and Wasson 2005, Ritter et al. 2008).

   Analysis of a chronological series of maps and aerial photos by the Elkhorn Slough National Estuarine Research Reserve reveals dramatic changes in the relative abundance of estuarine habitats over the past 130 years (Figure 69). Approximately 65% of Elkhorn Slough habitat was dense salt marsh in 1870, with less than 5% mud and sparse salt marsh habitat. By 2000, the amount of estuarine habitat composed of dense salt marsh had decreased to less than 20% and the amount of mud or sparse salt marsh habitat had increased to approximately 50% (Figure 70, ESNERR, unpubl. data). Marsh drowning and bank erosion, which causes the edges of the marsh to collapse into the channel, is the main cause of this habitat conversion (Van Dyke and Wasson 2005). The tidal prism (the volume of water covering an area between a low tide and the subsequent high tide) has almost tripled since 1956 to 6,400,000 cubic meters (Broenkow and Breaker 2005, Sampey 2006) and tidal erosion results in the export of approximately 56,000 cubic meters of sediment into Monterey Bay each year (Sampey 2006). Field surveys by Elkhorn Slough National Estuarine Research Reserve staff and collaborators show that the banks of the main channel are eroding on average 30 centimeters per year (ESNERR, unpubl. data). The loss of significant sediment inputs to the slough from the Salinas River (diverted in the early 1900s), Pajaro River, and Monterey Bay (due

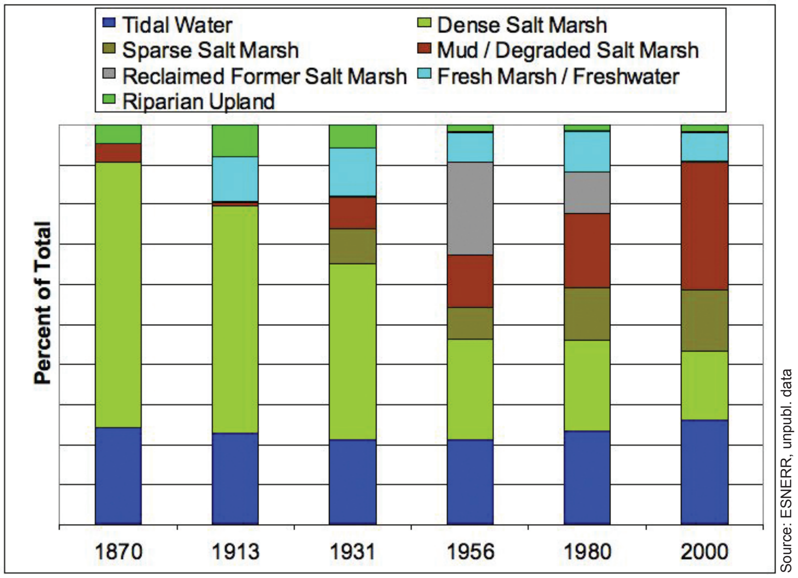


Figure 70. Analysis of a chronological series of maps and aerial photographs reveals a substantial decrease in dense salt marsh and increase in mudflat and sparse salt marsh over the past 130 years, resulting from human changes to tidal exchange and sediment inputs into the estuary.

to the jetties) are also considered to be significant in the imbalance of high erosion rates compared with low depositional rates (ESTWP 2007).

Erosion of bank and channel habitat is deepening and widening the main channel and tidal creeks and eroding soft sediments from channel and mudflat habitats. The mean cross-sectional area of the main channel increased by approximately 16 percent from 1993 to 2001 (Dean 2003, Malzone 1999). The annual rates of tidal creek widening during the period 1980-2003 were moderate to very high (>0.25 m/yr) across the lower and mid-slough and predominately very high in the upper slough (Van Dyke and Wasson 2005). This widening and deepening of the main channel and tidal creeks has facilitated the colonization of these habitats by large marine fishes and mammals. Leopard sharks, bat rays, harbor seals, and sea otters, are now abundant throughout much of the estuary (Harvey and Connors 2002, Yoklavich et al. 2002). The fish fauna in tidal creeks is becoming more similar to that of the main channel (Yoklavich et al. 2002). In addition, the diet of fish in tidal creeks has become more homogenous over time, with a lower diversity of prey items (Lindquist 1998). Continued erosion may lead to the eventual loss of species dependent on tidal creek habitat. In addition, scientists have observed a decrease in fine, unconsolidated sediment along the main channel of Elkhorn Slough since the 1970s (Kvitek et al. 1996). Scour of fine sediment from the subtidal channel between Hummingbird Island and Kirby Park has exposed a harder, more consolidated, older substratum (i.e., hard polished clay and patchy coarse rubble) in portions of the channel creating unsuitable conditions for a number of organisms (Kvitek et al. 1996).

6. What is the condition of biologically-structured habitats and how is it changing? The condition of biologically structured habitats in Elkhorn Slough are rated "poor" and "declining" based on the severe reduction in abundance of the two native species that form biogenic habitat in the main channel of Elkhorn Slough, eelgrass (*Zostera marina*) and native oyster (*Ostrea lurida*, also referred to as *Ostreola conchaphila*), as compared to historic levels. Though the size of eelgrass beds has been increasing slowly in recent years (ESNERR, unpubl. data), the abundance of native oysters is not improving and may be declining, in part due to competition for attachment sites with a non-native reef-forming tube worm (*Ficopomatus enigmaticus*) from Australia.

Based on photos and published accounts from the 1930s and early 1940s, eelgrass was very abundant in the central parts of Moss Landing Harbor and the main channel of Elkhorn Slough up to just below Seal Bend (MacGinitie 1935, E. van Dyke, ESNERR, pers. comm.). Recent analysis of historic photographs estimates the area of eelgrass beds to have been approximately 22 hectares (Figure 71; ESNERR, unpubl. data). Beginning in the late 1940s, dredging associated with harbor maintenance and high erosion in the main channel eliminated most of the shallow habitat that eelgrass requires to survive in turbid waters. Eelgrass habitat was reduced to approximately six hectares. In the late 1980s and early 1990s, broadening and shallowing of the main channel in some locations allowed the establishment of an eelgrass bed at Seal Bend and other smaller beds scattered throughout the main channel (Zimmerman and Caffrey 2002, E. van Dyke, ESNERR, pers. comm.). Currently, eelgrass beds are estimated to cover approximately twelve hectares (ESNERR, unpubl. data). The distribution of eelgass habitat is much different than the historical distribution, with the largest bed located at Seal Bend and eelgrass habitat absent from Moss Landing Harbor (Figure 72). Although the current abundance of eelgrass is higher than it was in the middle of the last century, it is still much reduced compared to historic

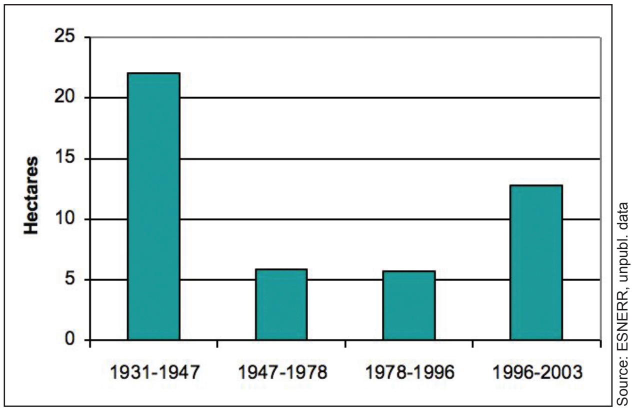


Figure 71. Analysis of a chronological series of aerial photographs reveals dramatic loss of eelgrass habitat following the opening of the artificial harbor mouth in 1946.

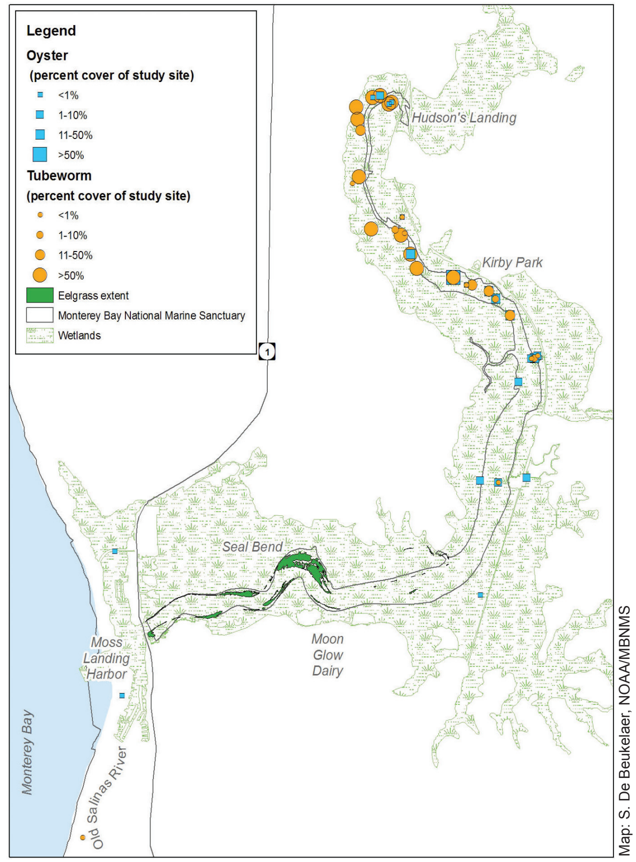


Figure 72. Distribution of eelgrass (*Zostera marina*), native oyster (*Ostrea lurida*, also referred to as *Ostreola conchaphila*), and non-indigenous tubeworm (*Ficopomatus enigmaticus*), three species that form biogenic habitat in Elkhorn Slough, California. The widest apparent extent of visible submerged eelgrass (green area) was identified from aerial imagery taken in April 2003 (E. van Dyke, ESNERR, unpubl. data). Oysters (blue square) and tubeworms (orange circle) were surveyed along the banks of the main channel in 2003 (Heiman 2006). Small circles/squares are survey sites where less than 1% of the available surface area was occupied by the focal species, whereas large circles/squares are survey sites where more than 50% of the available substrate was occupied.

levels (Figure 71). This is a significant conservation concern because eelgrass is a major contributor to productivity in California estuaries and provides important habitat for many invertebrates and fish species (Ricketts et al. 1985, Yoklavich et al. 2002).

The current population of native oysters is greatly reduced in both size and distribution compared to historic levels. Native oysters were described as very abundant in both the lower and upper slough in the early 1930s (MacGinitie 1935). Currently, extensive native oysters in Elkhorn Slough are limited to a few locations in the upper slough (Figure 72) where they grow on stable, hard substrates, including wood, rocks, and metal (Heiman 2006). There is only one large known intertidal oyster reef, which covers approximately seven square meters and rises 10 to 15 centimeters off of an anthropogenic rock bed (Heiman et al. 2008). More commonly, native oysters in Elkhorn Slough are found in low densities as clumps or as isolated individuals (Heiman 2006, Heiman et al. 2008). The total population size is estimated to be a few thousand individuals (K. Wasson and K. Heiman, ESNERR, pers. comm.). Dead oyster shells are far more numerous than live individuals. Recruitment of new juveniles appears to be very low (K. Heiman, ESNERR, unpubl. data) and there are very few small individuals in the population. Oysters appear to be limited by poor water quality, burial in sediments, and overgrowth by non-native species (Wasson in review).

New biogenic habitat is being created by a non-native reef-forming tubeworm (*Ficopomatus enigmaticus*) from Australia, which was initially identified in Elkhorn Slough in 1994 (Wasson et al. 2001). Since 1994, *F. enigmaticus* has spread to a number of sites in the northern half of Elkhorn Slough, with reefs observed in the most northern locations (Figure 72). Because this species requires a small piece of hard substrate to start colony formation, it is in direct competition with the native oysters for hard substrate attachment sites.

7. ***What are the contaminant concentrations in sanctuary habitats and how are they changing?*** The contaminant concentration in estuarine habitats of the Elkhorn Slough watershed is rated “fair” because numerous contaminants from a variety of sources, sometimes appearing in high levels at localized areas, have been identified. In this largely rural watershed, the main source of water and sediment quality degradation ap-

pears to be agricultural non-point source pollution (Caffrey et al. 2002). Significant concentrations of legacy agricultural pesticides such as DDT have been documented in some watershed wetlands, with the highest levels in areas receiving the most freshwater runoff (Caffrey et al. 2002). The trend in contaminants in Elkhorn Slough habitats is rated "declining" because of the lack of attenuation of legacy pesticides and the continued input of currently applied pesticides.

A review of the data available from various long-term monitoring programs of environmental contaminants in the Monterey Bay area found that the highest concentrations of many of the contaminants in the database (e.g, chlordane, DDT, dieldrin, PAHs, PCBs) occurred in the Elkhorn Slough and Salinas Valley areas and were probably associated with legacy agricultural applications (Hardin et al. 2007). Moreover, significant relationships between rainfall and lipid-normalized concentrations of dieldrin, DDT, and PCB in mussels from Elkhorn Slough and Moss Landing suggest that suspended sediments in storm runoff is the pathway into the estuary for some contaminants and that the source of these compounds are erodible legacy sources in the surrounding watersheds (Hardin et al. 2007).

Though watershed pollution levels are well documented, there have been few studies of the direct ecological impacts of this pollution on Elkhorn Slough habitats. The reproductive failure of a Caspian Tern colony in 1995 has been attributed to high levels of DDT and other contaminants found in eggs and embryos during a flood year (Parkin 1998). Sediments from the Moss Landing Harbor have been shown to cause toxicity to small crustaceans, and this toxicity has been attributed to organophosphate pesticides (Anderson et al. 2004). In addition to these documented impacts, other ecological changes may be occurring in response to agricultural pollutants, such as losses and declines of species directly due to sensitivity to high contaminant concentrations (ESNERR et al. 2009).

8. *What are the levels of human activities that may influence habitat quality and how are they changing?*

The greatest threats to estuarine habitats in Elkhorn Slough are the changes to hydrology caused by the estuarine mouth modifications that occurred in 1946, as well as diking and river diversions. These anthropogenic influences are considered to have severely degraded the estuarine portion of the sanctuary, thereby resulting in a "poor" rating. Though many of the structural changes were made many decades ago dredging and maintenance of water diversion structures are on-going human activities that result in the continuing degradation of estuarine habitats (ESNERR et al. 2009).

Agriculture activities in the Elkhorn Slough watershed are the main source of non-point source pollution to estuarine habitats. Significant concentrations of legacy agricultural pesticides such as DDT have been documented in some watershed wetlands, with highest levels in the areas receiving the most freshwater runoff (Caffrey et al. 2002). Management efforts by a number of organizations are aimed at reducing inputs of pollutants to estuarine habitats, however, these management activities have yet to show measurable decreases in contaminants in Elkhorn Slough (ESNERR et al. 2009).

Estuarine Environment Habitat Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
5	Abundance/ Distribution	▼ (Fair/Poor)	Over 150 years of hydrologic alteration has resulted in substantial erosion and habitat conversion.	Selected habitat loss or alteration has caused or is likely to cause severe declines in some but not all living resources or water quality.
6	Biologically-Structured	▼ (Poor)	Severe reductions in the abundance of native structure-forming organisms from historic levels.	Selected habitat loss or alteration has caused or is likely to cause severe declines in most if not all living resources or water quality.
7	Contaminants	▼ (Fair)	Numerous contaminants present and at high levels at localized areas with limited evidence of community level impacts; on-going input of currently applied pesticides and lack of attenuation of legacy pesticides.	Selected contaminants may inhibit the development of assemblages and may cause measurable but not severe declines in living resources or water quality.
8	Human Activities	— (Poor)	Past hydrologic changes, continued dredging and maintenance of water diversion structures, and input of agricultural non-point source pollution. Management activities have the potential to reduce the input of pollution.	Selected activities warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts have occurred or are likely to occur.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Declining (▼), Undetermined Trend (?), Question not applicable (**N/A**)

Estuarine Environment Living Resources

The following information provides an assessment of the status and trends pertaining to the current state of the sanctuary's living resources in the estuarine environment.

9. *What is the status of biodiversity and how is it changing?* Elkhorn Slough contains several estuarine habitats that support a diverse species assemblage. Caffrey et al. (2002) documented dozens of algae and plant species, over 100 fish species, over 300 bird species, and over 550 invertebrate species. Though species richness in the estuary is high, the status of native biodiversity in Elkhorn Slough is rated "fair" based on changes in the relative abundance of some species associated with specific estuarine habitats. Human actions (e.g., altered tidal flow by dikes and channels) have altered the tidal, freshwater, and sediment inputs, which has led to substantial changes in the extent and distribution of estuarine habitat types. There is strong evidence that these changes to estuarine habitats had substantially altered local biodiversity in the past 150 years (Caffrey et al. 2002). However, an overall trend in native biodiversity could not be determined.

Some species that were noted as abundant in portions of the Elkhorn Slough in the 1920 and 1930s are now rarely encountered. Scyphistomae (jellyfish polpys), burrowing sand anemones, the Atlantic soft-shell clam were once common, but were not observed during surveys in the 1970s or in subsequent surveys (Wasson et al. 2002). The native horn snail was likely displaced by the ecologically similar non-native Japanese mud snail (Byers 1999). A number of once common species, including three bivalve species and the blue mud shrimp, may be at drastically reduced levels due to overharvesting for human consumption or use as bait (Wasson et al. 2002).

A comparison of benthic intertidal sediment cores collected in the mid-1970s and mid-1990s found a significant decline in total invertebrate biodiversity over that time period (Wasson et al. 2002). Species that have declined in abundance between the 1970s and 1990s include the phoronid worm (*Phoronopsis harmeri*), the ghost shrimp (*Neotrypaea californiensis*), the gaper clam (*Tresus nuttallii*), and a cephalochordate (lancelet, *Branchiostoma californiense*). A number of species have increased in abundance, including the fat innkeeper worm (*Urechis caupo*) and a number of non-native species (e.g., the spionid *Streblospio benedicti* and the amphipod *Grandidierella japonica*). Diets of benthic foraging fishes (e.g., sanddab, starry flounder, shiner surfperch) in Elkhorn Slough, which reflect prey availability in core sediment samples, has changed since the 1970s to include increased relative abundance of epifaunal crustaceans and a decrease in infaunal worms (Lindquist 1998).

Habitat heterogeneity in Elkhorn Slough is increasing because of continued changes in the estuary, many of which are due to an increasing tidal prism and on-going changes to water control structures (e.g., berms, dikes, tidegates, culverts). These changes contributed to the subsequent conversion of a few dominant habitat types into a patchwork of several habitat types (Ritter et al. 2008). The loss of fine sediment from various subtidal channels caused a shift from gaper clams to boring clams in portions of the main channel between the 1970s and 1990s (Oliver et al., unpubl. data, as cited in ESNERR 2007). In addition, changes in the relative abundance of large predators may contribute to observed changes in the invertebrate assemblage. A shift in the diet of leopard sharks from clams and crabs in the 1970s to fish and fat innkeeper worms in the 1990s may be due to the increased abundance of southern sea otters in Elkhorn Slough, an important predator of clams, crabs and other large benthic invertebrates (Wasson et al. 2002).

Although eelgrass may be increasing in some areas within the main channel, past losses of eelgrass beds have reduced available nursery habitat for some fishes and invertebrates. For example, two species of polychaete worms and one species of sipunculid associated with eelgrass beds were reported as abundant in the 1930s, but are now rarely encountered (Wasson et al. 2002). Lower abundances of many fish species (for some species 30 percent lower than 1970s abundances) in deep channel sites and an overall decline in diversity from the 1970s to 1990s have occurred in the main channel of Elkhorn Slough and have been attributed to changes in sediment size (Yoklavich et al. 1991, Oxman 1995). In addition, the fish assemblages in the lower channel and tidal creeks have become more similar since the 1970s. Fish assemblages in the tidal creeks now resemble those of the lower slough; this change coincides with the continued erosion and scouring, which has made the geomorphology of the tidal creeks more similar to that of the main channel (Yoklavich et al. 2002).

10. *What is the status of environmentally sustainable fishing and how is it changing?* Harvesting of fishes and invertebrates from Elkhorn Slough habitats has occurred for thousands of years (Caffrey et al. 2002). Harvesting by humans for consumption or use as bait is believed to be a factor in the decline of some invertebrates. For these reasons, the question is rated "good/fair." Changes in harvesting practices and the recent implementation of marine protected areas are the basis for an "improving" trend in the status of environmentally sustainable fishing in Elkhorn Slough.

Digging for clams, shrimp, and worms has occurred during very low tides in the mudflats bordering the lower main channel

(Wasson et al. 2002). The limits of take are set by the California Department of Fish and Game and require a sport fishing license. Overharvesting may have been partially responsible for reduced abundance of three species of native bivalve, ghost shrimp, blue mud shrimp, and fat innkeeper worms observed in the 1990s (Wasson et al. 2002). However, very little is known about the effect of human harvesting on invertebrate communities near the mouth of the slough and the effect of this activity may be negligible compared to other influences such as sea otter foraging (Wasson et al. 2002).

Recreational fishing has long been a popular activity in the slough. Organized fishing events like elasmobranch (e.g., sharks, rays) derbies began in the 1940s and continued until 1996. Analysis of catch records from the derbies found some changes in the elasmobranch assemblages, but it is not possible to directly attribute this to the derbies since other factors (e.g. regime shifts, habitat alteration) also influenced the abundance and distribution of elasmobranchs (Carlisle et al. 2007). Recreational hook-and-line fishing has been occurring for decades and mainly targets perches, surfperches, and flatfishes (Yoklavich et al. 2002). There is little historical information on the level of effort or impact on the fish population, but the recent level of take by humans is not thought to have a significant impact on fish populations (Yoklavich et al. 2002).

Two marine protected areas were implemented in 2007 under the Marine Life Protection Act – the Elkhorn Slough State Marine Conservation Area and the Elkhorn Slough State Marine Reserve (see Figure 5 on page 17). These two contiguous protected areas encompass a large portion of the main channel and marsh habitats of the Elkhorn Slough National Research Reserve. Take of all living marine resources is prohibited, except in the Marine Conservation Area, where finfish may be taken by recreational hook-and-line and clams may be taken on the north shore.

11. What is the status of non-indigenous species and how is it changing? There is a very high percentage of non-native species in Elkhorn Slough and this question is rated "poor." A trend of "not changing" was based on no known recent introductions of non-indigenous species. There are significantly higher numbers of introduced species in Elkhorn Slough compared to the open coast. Wasson et al. (2005) documented 527 invertebrate species inhabiting Elkhorn Slough. Of these, 58 were introduced, 25 cryptogenic (i.e., possibly introduced or possibly native), and 444 were native species. In contrast, surveys of adjacent rocky intertidal areas on the open coast documented 588 species, but only eight were introduced, 13 were cryptogenic, and 567 were native species (Wasson et al. 2005). Non-native fish species collected from Elkhorn Slough and surrounding areas include American shad, yellowfin goby, striped bass, and western mosquito fish (Yoklavich et al. 2002).

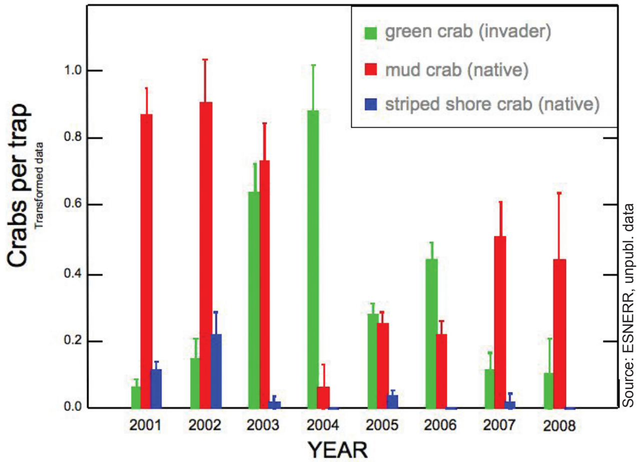


Figure 73. Field surveys have documented the invasion of the European green crab in Elkhorn Slough, which rapidly increased in abundance as native crabs decreased. In recent years, the green crabs have declined while the natives have recovered.

Some of the most commonly encountered invertebrates during low tide in Elkhorn Slough are non-indigenous species. The Japanese mud snail (*Batillaria attramentaria*) is the numerically dominant invertebrate on the surface of mudflats in Elkhorn Slough, while the native horn snail (*Cerithidea californica*), an ecological equivalent, is locally extinct (Byers 1999, 2000). The bright orange sponge (*Hymeniacidon sinapium*) forms massive aggregations in the upper slough channels with high flow and likely affects the plankton community and its availability as a food source to other filter feeding species (Wasson et al. 2002). Field surveys by researchers with the Elkhorn Slough National Estuarine Research Reserve have been monitoring the relative abundance of the European green crab (*Carcinus maenas*), first observed in Elkhorn Slough in 1994, and two native crab species. In the early stages of the invasion, the European green crab rapidly increased in abundance as native crabs decreased; in recent years, the European green crabs have declined while the natives have recovered (Figure 73).

The non-native, reef-forming tubeworm (*Ficopomatus enigmaticus*), which was initially identified in Elkhorn Slough in 1994 (Wasson et al. 2001), has spread to a number of sites in the northern half of Elkhorn Slough, with reefs observed in the most northern locations (see Figure 72 on page 77). These tubeworms can form calcium carbonate reefs up to one meter high and over five meters in diameter (Heiman et al. 2008). Although they require a small piece of hard substrate to start colony formation, adult tubes can act as hard substrate for subsequent generations, making the potential spread and impact of this species within a system dramatic. At one site, this tubeworm has colonized nearly 100% of the available hard structures, forming reefs that grow out from dock pilings and spread over the surrounding mudflats. The reefs greatly increase the amount of complex hard structure in the slough and create a new, unique habitat that has been shown to enhance the local abundance of invasive species, particularly non-native amphipods and polychete worms (Heiman 2006, Heiman et al. 2008).

Some of the non-indigenous species in the slough were introduced directly from distant locations with non-native oysters during the many decades of oyster aquaculture in the slough. This activity peaked in the 1930s and 1940s and ended in the 1970s (Wasson et. al 2002). The other key mechanism for introduction is hitchhiking on boats from San Francisco Bay or other regional ports with thriving populations of non-native species (Wasson et al. 2001). Oyster culture is not currently occurring in the slough, but the potential for future introductions from fouled boat hulls is high.

12. *What is the status of key species and how is it changing?* The status of key species, such as native oysters, eelgrass, and salt marsh plants, in the estuarine environment is rated "fair/poor" and the trend is "declining." Native oysters and eelgrass beds, the main native biologically-structured habitats in the channel, are in poor condition compared to historical levels (see Question 6 in Habitat section relating to the condition of biologically-structured habitats for more information on the status of oysters and eelgrass). Continuing tidal erosion may lead to further declines in these species. Restoration experiments for eelgrass in the late 1980s and early 1990s showed that the general environmental quality in Elkhorn Slough is adequate to support survival and expansion of eelgrass populations if substrate of appropriate depth (0 to 2 m Mean Lower Low Water) and water flow (10-30 cm/s peak flow) is available (Zimmerman and Caffrey 2002).

Pickleweed-dominated salt marsh is critical habitat for a number of marsh-dependant species. Salt marsh provides a number of other ecological functions, including sediment trapping and nutrient retention (Zimmerman and Caffrey 2002). For many decades, erosion and subsidence have converted previously extensive tracts of salt marsh into tidal mudflats (see Figures 69 and 70 on pages 75 and 76). Loss of salt marsh may facilitate further erosion and habitat conversion (Caffrey 2002).

Other species that play an increasingly important role in structuring ecological communities in Elkhorn Slough are not native to the system. It is likely that a number of these non-native species have significant direct and indirect negative impacts on the native faunal assemblage of the slough. For example, the Japanese mud snail out-competes the native horn snail and has completely replaced this native species on mudflats in the upper slough (Byers 1999). European green crabs and the tortellini slugs are voracious predators that affect a number of native invertebrate prey species including native crabs and small bivalves (Wasson et al. 2002).

13. *What is the condition or health of key species and how is it changing?* The key species in Elkhorn Slough are eelgrass, native oysters, and salt marsh plants (K. Wasson, ESNERR, pers. comm.). To date, there has been no monitoring of the health or condition of these species. Therefore, this question is rated "undetermined" for both its status and trend. It is suspected that water quality and hydrological issues are negatively affecting these species. Water quality in Elkhorn Slough has been monitored for the last 15 years by the Elkhorn Slough National Estuarine Research Reserve. A recent analysis of the turbidity data found that turbidity had increased at every monitoring site, which has negative implications for the condition of eelgrass habitat (M. Los Huertos, CSUMB, pers. comm.). Contaminants are high in Elkhorn Slough due to inputs from watershed land use practices (Hardin et al. 2007). Estuaries have long served as ecosystem filters, but the present level of anthropogenic input to Elkhorn Slough overwhelms its capacity to clean the water.

14. *What are the levels of human activities that may influence living resource quality and how are they changing?* A wide variety of human activities occur in and around the Elkhorn Slough, but there are few data available to quantify the level of these activities and how they have changed over time. Because many human activities exert negative pressures on living resources in the slough, the level of human activities is rated "fair/poor." Anecdotal information indicates that some of these activities appear to be increasing in intensity while others are decreasing, some in response to recent management actions. However, it is not clear how to combine this information to identify an overall trend, thus the trend in human activities was undetermined.

In 1946, a fixed opening between the slough's main channel and Monterey Bay was created and contributed to hydrological changes that altered and continue to alter the physical environment and biological communities of Elkhorn Slough. Sediment transportation from watersheds into the slough has also been severely altered by urban development and agricultural activities surrounding the slough. Much of the land surrounding Elkhorn Slough is still used for agriculture, and agricultural runoff leads to nutrient loading, elevated levels of chemical contaminants, and can cause sporadic reproductive failure (e.g., Caspian Tern) or die-offs (e.g., ghost shrimp) (Caffrey et al. 2002).

Past aquaculture practices (e.g., the deliberate introduction of non-native oysters) served as a pathway to introduce non-indigenous species, some of which continue to exert a negative influence on native species. Boating activities within Elkhorn Slough and the adjacent Moss Landing Harbor have facilitated the introduction of non-indigenous species and the potential for future introductions from this activity is high. Boating and kayaking activities related to ecotourism in the slough has increased over the last few decades. These activities have the potential to disturb wildlife, such as mammals and birds, if wildlife-viewing restrictions are not followed.

Harvest of living resources in the slough has been occurring for centuries. Digging for clams, shrimp, and worms in mudflats and fishing with hook-and-line are the two most common activities. Levels of this activity are not well understood, but the recent implementation of the State Marine Reserve and State Conservation Area (see Figure 5 on page 17) is likely to reduce the amount of living resources harvested from the slough. Duck hunting occurs in the adjacent wildlife area and it is likely that this activity has remained relatively stable.

The Moss Landing harbor houses the intake pipes for the seawater cooling system used by the Moss Landing Power Plant. Entrainment studies indicate that 60% of larvae are lost, but it is not known how this impacts the adult population of fishes and invertebrates in the slough and the adjacent shore (K. Wasson, ESNERR, pers. comm.).

Estuarine Environment Living Resources Status & Trends

#	Issue	Rating	Basis for Judgment	Description of Findings
9	Biodiversity	? (Fair)	Changes in the relative abundance of some species associated with specific estuarine habitats. Overall trend cannot be determined.	Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
10	Environ-mentally Sustainable Fishing	▲ (Good/Fair)	There is limited take of shell-fish and mudflat invertebrates in the lower slough as well as limited fishing and hunting. New state marine protected areas reduce or eliminate fishing.	Extraction takes place, precluding full community development and function, but it is unlikely to cause substantial or persistent degradation of ecosystem integrity.
11	Non-Indigenous Species	— (Poor)	High percentage of non-native species, no known recent introductions.	Non-indigenous species have caused or are likely to cause severe declines in ecosystem integrity.
12	Key Species Status	▼ (Fair/Poor)	Abundance of native oyster, eelgrass, and salt marsh are substantially reduced compared to historic levels; continued loss and conversion of salt marsh.	The reduced abundance of selected keystone species has caused or is likely to cause severe declines in some but not all ecosystem components, and reduce ecosystem integrity; or selected key species are at substantially reduced levels, and prospects for recovery are uncertain.
13	Key Species Condition	? (Undet.)	No direct measurements of health or condition have been made for eelgrass and oysters, and salt marsh.	Not enough information to make a determination.
14	Human Activities	? (Fair/Poor)	Impacts result from hydrologic modifications, inputs of pollutants from agriculture and development, introduction of non-indigenous species, harvesting, entrainment of larvae in power plant intakes; no clear overall trend in human activities.	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.

Status: Good, Good/Fair, Fair, Fair/Poor, Poor, Undet.

Trends: Improving (▲), Not Changing (—), Declining (▼), Undetermined Trend (?), Question not applicable (**N/A**)

Estuarine Environment
Maritime Archaeological Resources

The following information provides an assessment of the status and trends pertaining to the current state of the maritime archaeological resources in the estuarine environment.

15. What is the integrity of known maritime archaeological resources and how is it changing? The integrity of known maritime archaeological resources in the estuarine environment is "undetermined" because little is known about the integrity of maritime archeological resources in Elkhorn Slough. The Elkhorn Slough area contains Native American midden sites (a feature containing waste products relating to day-to-day human life, such as shellfish, broken animal bones, pottery, arrowheads, etc.), as well as an historic pier known as Hudson's Landing (also known as Watsonville Landing) (Figure 74). Although there are no known midden sites in the main channel of the slough, there are many midden sites along the edges of the slough. These areas were typically elevated (10-40 feet, or 3-12 meters) and away from a water source in order to avoid aquatic pests (e.g., mosquitoes). In particular, Native Americans occupied an elevated site along the channel 3,000 years before present (and 6,500-8,000 years before present) near the mouth of Elkhorn Slough at the south end of the Highway One Bridge (CA-MNT-229). Mitigation during the upgrade of the bridge in 1985 removed most of the midden.

16. Do known maritime archaeological resources pose an environmental hazard and is this threat changing? There are no known maritime archeological resources in Elkhorn Slough that pose an environmental threat; therefore this question is rated "good" and "not changing".

17. What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing? Existing human activities do not pose a threat to the quality of maritime archaeological resources in Elkhorn Slough. However, as the Elkhorn Slough channel widens and deepens because of erosion, the risk of impact to the Native American midden sites increases. However, management actions under consideration by the Elkhorn Slough Tidal Wetland Project have the potential to decrease the rate of erosion to the channels and tidal creeks, thereby diminishing the threats to the midden sites in the future. Therefore, this question is rated "good." Currently, the trend of impact to the maritime archeological sites is "not changing."

Figure 74. A view of Watsonville Landing (now remembered as Hudson's Landing) after the rail bridge was built across the north end of Elkhorn Slough.

Estuarine Environment Maritime Archaeological Resources

#	Issue	Rating	Basis for Judgment	Description of Findings
15	Integrity	?	Very little is known for this area.	Not enough information to make a determination.
16	Threat to Environment	—	No known environmental hazards.	Known maritime archaeological resources pose few or no environmental threats.
17	Human Activities	—	Existing human activities do not influence archaeological resources.	Few or no activities occur that are likely to negatively affect maritime archaeological resource integrity.

Status: Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

Trends: Improving (▲), Not Changing (–), Declining (▼), Undetermined Trend (?), Question not applicable (N/A)

Response to Pressures

This section describes current or proposed responses to pressures. Responses are based on the sanctuary's management plan that was released in November 2008 (NOAA 2008a). The management plan is the result of over seven years of study, planning, and extensive public input and addresses key issues and opportunities affecting the sanctuary. The plan contains information about the sanctuary's environment, priority management issues and actions proposed to address them, regulations, staffing and administration, operational and programmatic costs, and performance measures. Certain human activities within the sanctuary can have negative impacts on its sensitive physical and biological resources. One of the objectives of the plan is to minimize the adverse effects of permissible human activities on sanctuary resources. This is accomplished through a variety of approaches, including collaborative planning efforts to prevent and reduce human impacts, regulations, permits, and enforcement efforts. Management efforts also involve improving public awareness and understanding, conservation science, water quality, emergency response and enforcement, and maritime heritage.

The management plan was developed as part of a process known as the Joint Management Plan Review. The Office of National Marine Sanctuaries reviewed the management plans of the Monterey Bay sanctuary together with the Cordell Bank and Gulf of the Farallones because the three sanctuaries are adjacent to one another and share many of the same resources, issues, and user groups. Using a community-based process and providing numerous opportunities for public input, the Office of National Marine Sanctuaries examined the current issues and threats to the resources and whether the original management plan is adequately protecting sanctuary resources. The sanctuary evaluated management and operational strategies, regulations, and boundaries.

The management plan includes 29 action plans that will guide the Monterey Bay National Marine Sanctuary for the next five to ten years. The management plan is available on the Monterey Bay sanctuary Web site: http://montereybay.noaa.gov/intro/mp/mp.html.

Vessel Traffic

Activities are in place to mitigate potentially harmful impacts resulting from vessel traffic. For example, the Monterey Bay Sanctuary Resource Protection Program has developed and implemented strategies, now approved at the international level, to move vessel traffic zones farther offshore and use north-south transit lanes to reduce threats of spills from vessels such as tankers, ships containing hazardous materials, barges, and large commercial vessels. Vessel traffic zones are managed by the U.S. Coast Guard, U.S. Department of Transportation, NOAA, U.S. Department of Commerce, International Maritime Organization, and the United Nations. Adherence is voluntary but recommended and accomplished by agreements between large vessel operators and agencies. Collaborative educational products and outreach programs on resource protection issues, including vessel traffic, have also been put in place by the sanctuary (NOAA 2008a).

To fulfill a congressional mandate, in 1997, the United States Coast Guard (USCG) and the National Oceanic and Atmospheric Administration (NOAA) established a working group of key stakeholders,

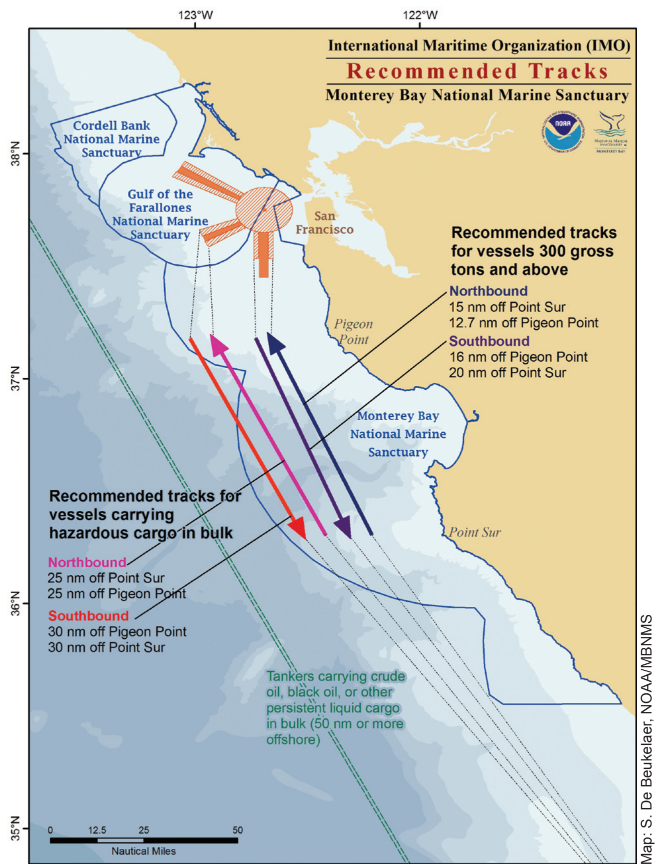


Figure 75. New vessel traffic routes through the Monterey Bay National Marine Sanctuary. The routes for large commercial vessels (blue and purple arrows), hazmat vessels (pink and orange arrows), and tankers (aqua lines) were moved to a minimum of 12.7 nm, 25nm, and 50 nm offshore, respectively.

including representatives from federal, state and local governments, environmental groups and industry, to review existing practices and risks. In the addition, the working group was tasked with identifying strategies to maximize protection of sanctuary resources while allowing for the continuation of safe, efficient and environmentally sound transportation. The group's recommendations included alteration of the Traffic Separation Scheme off San Francisco to move vessels away from the sensitive San Mateo shoreline. Most importantly, container ships, bulk freighters, and vessels carrying hazardous materials were moved approximately ten kilometers farther offshore to reduce the risk of groundings, and organized into north-south lanes to reduce the risk of collision (Figure 75). These recommendations were ultimately approved by the International Maritime Organization, and implementation began in 2000.

The Sanctuary Aerial Monitoring and Spatial Analysis Program (SAMSAP) has been established within the area using local NOAA aircraft and has been incorporated into the sanctuary's monitoring program. The SAMSAP program is designed to monitor the locations of different kinds of commercial and recreational vessels as well as distributions of some species of interest, including cetaceans (whales and dolphins), and some physical conditions, such as spilled oil. (NOAA 2008a)

In 2004, a container ship lost 15 large cargo containers overboard within the sanctuary. The contaitners' contents included a variety of cargo furniture, thousands of tires, several hundred thousand plastic items, miles of cyclone fencing, hospital beds, wheel chairs, recycled cardboard and clothing items. Resource protection staff, in coordination with a variety of state, federal and local agencies, investigated these violations, followed up with the responsible parties, and identified ways to prevent similar violations in the future. In 2006, a settlement of $3.25 million was received from the parties responsible for accidentally discharging the shipping containers. The funds will be used to fund projects to protect and restore the seabed (MBNMS 2005, 2006) and to monitor the fate of the 15 containers.

Military Activity

Military activities that were specifically identified at the time of sanctuary designation (e.g., submarine operations, helicopter tactical training) are exempt from most sanctuary regulations. For new activities, the sanctuary may request modifications to minimize impacts to sanctuary resources. The sanctuary may also prohibit some activities. Concerns have also arisen regarding military proposals to use underwater acoustic devices that could potentially interfere with marine mammal communications. Goals of the Marine Mammals, Seabird, and Turtle Disturbance Action Plan include addressing wildlife disturbance from marine vessels, such as military vessels, expanding research and monitoring of acoustic disturbances, and evaluating activities that have potential for causing acoustic disturbance.

Commercial and Recreational Fishing

Monterey Bay National Marine Sanctuary does not directly manage any aspect of commercial or recreational fisheries. Fishing in state waters (see green zone in Figure 35 on page 38) is generally managed by the California Department of Fish and Game. The responsibility for managing fishing in federal waters (offshore of state waters) rests with NOAA's National Marine Fisheries Service. In addition, NOAA has issued a report that provides an overview of NOAA's process for regulating fisheries in sanctuary waters as mandated by the Magnuson-Stevens Act and the National Marine Sanctuaries Act (NOAA 2008b). Current involvement of the Monterey Bay sanctuary in issues related directly or indirectly to fishing includes conducting fisheries-related research, sponsoring educational events, commenting to other agencies on fishery and ecosystem management issues, and the development of ecosystem protection plans related to fishing such as the Marine Protected Areas Action Plan and The Effects of Trawling on Benthic Habitats Action Plan.

There is a need to increase the public's understanding of fishes, their role in the ecosystem, the various fishing activities that occur in the sanctuary, and how they are managed. The Fishing-Related Education and Research Action Plan provides strategies to expand the knowledge base of the public about fishery management in the sanctuary and increase public education about sustainable fisheries. There has traditionally been a lack of fishermen involvement in research activities related to fish populations in the sanctuary. The action plan addresses that issue by providing a mechanism to bring their knowledge and data into the pool of information used in resource management and decision-making.

The Monterey Bay sanctuary has also continued its active role in the protection of the salmon and steelhead populations of the region through preservation of the watershed habitat and water quality that sustain these species during their migration and spawning activities. This includes watershed management and outreach activities with the agricultural community, cities and counties, education of the public about salmonid life cycles and habitat threats, and citizen monitoring of water quality in streams and rivers.

Bottom Trawling

Based on numerous scientific studies, the fishing technique of bottom trawling is widely believed to adversely impact benthic, or seafloor, habitats. The goal of the Bottom Trawling Effects on Benthic Habitats Action Plan is to protect the integrity of biological seafloor communities within the sanctuary by evaluating and minimizing the adverse effects of bottom trawling, while facilitating the long-term continuation of environmentally sustainable fisheries. By identifying the scope and impact of bottom trawling on different habitats within the sanctuary, management will be able to determine the need for protective actions and identify solutions to potential problems.

As part of this action plan, the sanctuary has been working with fisheries management agencies to compile information on the history of trawling activity in the sanctuary and the state and federal regulations that apply to this activity in sanctuary waters (for examples see Figures 34 and 35 on pages 37 and 38). In addition, sanctuary staff has partnered with researchers to study the impact of benthic trawling on seafloor habitats and associated benthic fauna in central California (de Marignac et al. 2009). The Monterey Bay sanctuary is also partnering with The Nature Conservancy, NOAA National Marine Fisheries Service, California State University Monterey Bay, and Morro Bay fishermen to study the impacts of modified groundfish trawling practices on soft sea-floor habitats and the time it takes for seafloor habitats to recover from trawling.

Marine Protected Areas

The goal of the Marine Protected Areas Action Plan was developed in 2004 and 2005 and states the following: "To determine the role, if any, of additional marine protected areas (MPAs) in maintaining the integrity of biological communities in the sanctuary, and to protect, and where appropriate, restore and enhance natural habitats, populations and ecological processes. If additional MPAs are to be created, design, and ensure implementation of MPAs that meet the sanctuary's goals and are compatible with the continuation of long-term sustainable fishing in the region" (NOAA 2008a). According to the MPA Action Plan, consideration of MPAs will be a joint effort with the participation of many diverse stakeholders, and as fishing is a key cultural and economic component of the region, this will include strong participation of the fishing community. Extensive interagency collaboration with the National Marine Fisheries Service, the Pacific Fisheries Management Council, and the California Department of Fish and Game will be an essential component of this process (NOAA 2008a).

Regarding additional marine protected areas in state waters, in early 2005 the California Resource Agency reinitiated a process pursuant to the 1999 Marine Life Protection Act to develop an improved network of MPAs. The Monterey Bay National Marine Sanctuary was an active participant in this process as one of many stakeholders in the central coast region, which extends from Pigeon Point (San Mateo County) south to Point Conception (Santa Barbara County). In September 2007, a network of 29 marine protected areas was implemented, of which 22 are located in the sanctuary (see Figure 35 on page 38). The nine state marine reserves encompass approximately 44 square miles and the 13 state marine conservation areas encompass approximately 102 square miles.

Since implementation of the new state MPAs, the sanctuary has been an active partner in research, enforcement, and education activities. Prior to 2007, only three no-take marine reserves existed in the sanctuary: Hopkins Marine Life Refuge, Point Lobos Ecological Reserve, and Big Creek Ecological Reserve. In 2007, all three reserves were expanded and renamed; and six additional no-take reserves were established. Understanding the role the new MPAs will play in protecting the ecosystem is a high priority for the sanctuary. Several collaborative research projects are collecting baseline information for the purpose of evaluating the efficacy of the state MPAs in the central coast region. The sanctuary is providing support, including vessel time and research divers, for some of these efforts.

Superintendent Paul Michel announced in February 2008 his decision to move forward with an MPA planning process that will consider the role of any additional MPAs in addressing three unmet needs related to ecosystem protection and management of marine resources in federal waters of the sanctuary. Those unmet needs are to: 1) preserve unique and rare places in their natural state for the benefit of future generations; 2) preserve areas where natural ecosystem components are maintained and/or restored; and 3) designate research areas to differentiate between natural variation versus human impacts to ecological processes and components. The sanctuary is working with the sanctuary advisory council and other agency partners to design an MPA planning process that has a strong scientific focus on ecosystem-based approaches to management involving a range of natural and social science disciplines, provides formal and informal opportunities for interagency collaboration (especially with NOAA National Marine Fisheries Service, the Pacific Fishery Management Council, and the California Department of Fish and Game), incorporates advice from the sanctuary advisory council, and ensures robust and multiple opportunities for public participation.

Current spatial closures in federal waters were implemented by the Pacific Fishery Management Council to address fishery management objectives, such as rebuilding of overfished populations (e.g., Rockfish Closed Areas, or RCAs) and protecting essential fish habitat (EFH) from bottom trawing or bottom contact gear within the sanctuary (Figure 35 on page 38).

Water Quality

Runoff

Pollutants running off the land often lower the quality of the water as both a habitat and resource for recreational and commercial use. The sanctuary's Water Quality Protection Program has developed seven multi-stakeholder action plans to prevent pollution and facilitate water quality improvements. Areas to be addressed include urban runoff, regional monitoring, marinas and boating, agriculture and rural lands, beach closures, cruise ships, and wetlands. Implementation of all of these plans has begun with a variety of partners (NOAA 2008a).

Two recent efforts by sanctuary staff to present and integrate the data from the diverse water quality monitoring efforts in the Monterey Bay sanctuary are the Water Quality Interactive Map Service and the Central Coast Water Quality Data Synthesis, Assessment, and Management Project. The interactive map service delivers information on water quality monitoring sites near or within watersheds that empty into the Monterey Bay National Marine Sanctuary. All water quality monitoring spatial data and relevant information were supplied by various agencies and institutions that monitor water resources on the Central California coast. Many of the data layers provide a link to the responsible organization or agency's website, as well as links to data, if available.

The Water Quality Data Synthesis, Assessment, and Management (SAM) Project involves water quality monitoring coordination, data management, and data analysis to address fundamental issues surrounding the sources, status, and trends of non-point source pollution in coastal watersheds and nearshore marine systems. Water quality and other spatial data sets have been collated into a database/GIS system that serves as a model for ongoing data integration and access in the region and is used as a tool for addressing research questions to improve our knowledge of pollution problems and pollution mitigation effectiveness. SAM is a partnership between the Monterey Bay National Marine Sanctuary, the Central Coast Regional Water Quality Control Board, and the California Coastal Commission with primary funding provided by the California Nonpoint Source Pollution Control Program (U.S. EPA/SWRCB) and the Resources Legacy Fund Foundation.

Sanctuary staff is also carrying out a variety of initiatives to decrease the impacts of urban runoff. Highlights include:

- Collaboration, participation and evaluation of the Phase I and Phase II NPDES stormwater programs for local jurisdictions on the Central Coast to better manage and minimize urban runoff flowing to the sanctuary.
- Support of ongoing monitoring by citizen's groups in watersheds that drain to the sanctuary.
- Development of a California Environmental Quality Act checklist to make planning efforts more uniform among cities.
- Development and distribution of educational materials for regional use.
- Technical training workshops for municipal staff.
- Agricultural Water Quality Alliance (AWQA) Partnership

The fundamental approach required to reduce inputs of pollutants to estuarine habitats is to reduce the amount of runoff from urban and agricultural lands that enters the watershed and/or decrease the concentration of contaminants in the runoff. As a result, management agencies have worked with local stakeholders to create regulatory, monitoring, education, and training programs and to implement better agricultural and urban management practices aimed at reducing or eliminating pollution sources and improving land-use practices in the Elkhorn Watershed. A watershed conservation plan has been developed by the Elkhorn Slough National Estuarine Research Reserve that serves as a guide for future conservation activities by both public and private organizations to implement strategies to protect the slough's resources over time (Scharffenberger 1999).

Finally, in 1999 the Agriculture and Rural Lands Action Plan was developed to address agricultural water quality issues related to the sanctuary, such as erosion control, nutrient runoff, and persistent pesticides. The plan includes 24 strategies intended to protect and enhance the quality of water that drains into the sanctuary while sustaining the economic viability of agriculture. This collaboration between environmental organizations, agencies, and the agricultural industry is unique, as is the leadership role that the Coalition of Central Coast County Farm Bureaus is taking in establishing networks of landowners and operators to address water quality issues.

Beach Closures

In the last ten years, beach closures and warnings due to microbial contamination have become more common. This issue is the focus of the Beach Closures and Microbial Contamination Action Plan (NOAA 2008a). The goal of this action plan is to eliminate beach closures by reducing microbial contamination in sanctuary waters. Additionally, the sanctuary seeks a significant decreasing trend in beach water quality warnings. This action plan identifies the following needs:

- enhanced use of geographic information systems to produce a beach sampling database and map infrastructure;
- expanded pathogen and contamination research;
- increased monitoring, education and enforcement programs;
- enhanced notification and emergency response programs;
- develop a source control program to reduce beach closures and postings due to microbial contamination;
- increased technical training for industry professionals.

The sanctuary's involvement in this issue has included working with the cities on addressing urban runoff, including coliform contamination, and investigating and jointly pursuing potential funding opportunities for local communities to better identify sources of coliform contamination and improve infrastructure systems. The Monterey Bay National Marine Sanctuary Citizen Watershed Monitoring Network is involved in monitoring coliform contamination in the watersheds and storm drain systems at various times of year to help

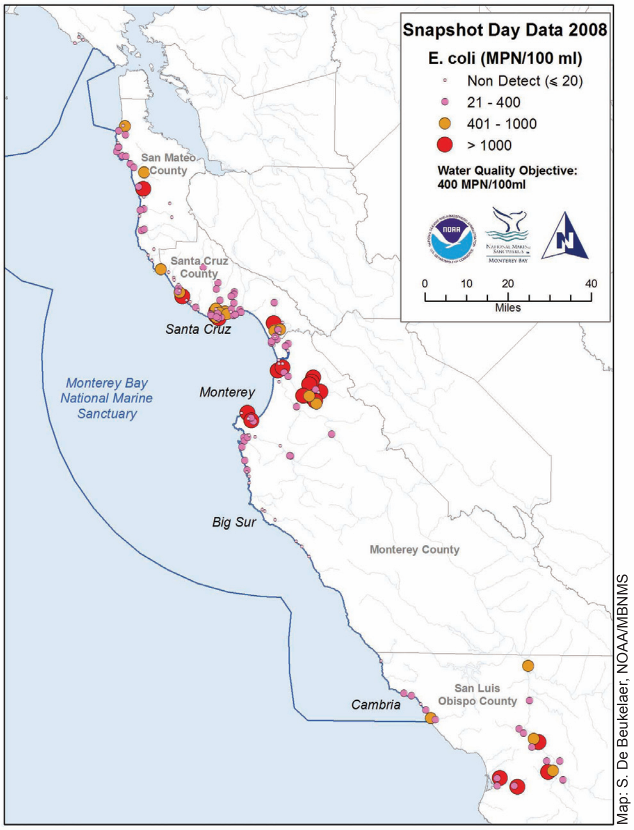


Figure 76. An example of the type of data that are collected by the Snapshot Day monitoring program. This map shows the concentrations of the bacteria *E.coli* recorded at monitoring sites during the one-day event in spring 2008.

identify sources. The Network coordinates two annual regional monitoring events, First Flush in the fall and Snapshot Day in the spring (Figure 76), and a summer-long water quality monitoring program called Urban Watch.

Harmful Algal Blooms

The Monterey Bay sanctuary has helped support research to better understand harmful algal blooms. Research by the Center for Integrated Marine Technology tracked the seasonal abundance and distribution of harmful algal species and identified the conditions under which blooms occurred in the Monterey Bay. Researchers at the University of California, Santa Cruz have been investigating critical aspects of harmful algal species. Data collected by the Beach COMBERS monitoring program, a collaborative effort between the Monterey Bay sanctuary and Moss Landing Marine Laboratories, have been used to detect impacts of harmful algal blooms to marine birds and mammals.

Actions of the sanctuary's water quality protection program may help to reduce the frequency or magnitude of harmful algal blooms, especially if there is a link between the input of terrigenous nutrients and subsequent use by phytoplankton species. The Agriculture Water Quality Alliance program is working to reduce inputs of nutrients in the Bay by working with local growers to implement best management practices for nutrient, sediment and irrigation management. The Monterey Bay Sanctuary Citizen Watershed Monitoring Network began collecting samples for urea in the First Flush program and is providing those data to local researchers.

Marinas and Boats

The Marinas and Boating section of the Water Quality Action Plan outlined in the Management Plan describes strategies designed to reduce water pollution from certain activities associated with marinas and boating within the sanctuary. This plan takes the approach that much of this pollution can be reduced through education and training programs, application of new technologies, and on-site facilities. The specific strategies in the plan are (NOAA 2008a):

- Increase public education, outreach, and enforcement;
- Develop and implement technical training program;
- Promote bilge waste disposal and waste oil recovery;
- Reduce harmful discharges into the sanctuary from topside and haul-out vessel maintenance;
- Reduce harmful discharges into the sanctuary due to underwater hull maintenance.

Cruise Ships

A wide array of pollutants may be discharged in large volumes from cruise ships. Although there are a number of existing federal laws and regulations, such as the Clean Water Act, that partly address this issue, there is a need for more comprehensive protection against cruise ship discharges within the sanctuary. The California Clean Coast Act, which became effective on Jan. 1, 2006, prohibits the release from large passenger vessels (cruise ships) and other oceangoing ships (300 gross tons or more) of hazardous waste, oily bilgewater, other waste, and sewage sludge into the marine waters of the state and marine sanctuaries. The Clean Coast Act also prohibits the release of graywater from cruise ships and oceangoing ships with sufficient holding capacity into the marine waters of the state. Furthermore, the Clean Coast Act requires the State Water Resources Control Board to request the appropriate federal agencies to prohibit the release of wastes from cruise ships and oceangoing ships into state marine waters and the four national marine sanctuaries in California. As outlined in the Monterey Bay National Marine Sanctuary Management Plan, sanctuary regulations now prohibit discharging or depositing from within or into the sanctuary any material or other matter from a cruise ship except clean vessel engine cooling water, clean vessel generator cooling water, clean bilge water, or anchor wash (NOAA 2008a). The management plan also outlines strategies to conduct outreach and coordination with the cruise ship industry (providing it with information about the sanctuary) and to monitor and enforce potential cruise ship discharges (Figure 77).

Figure 77. P/B *Sharkcat* is used by staff to monitor various activities in the sanctuary and enforce regulations such as those prohibiting discharges from cruise ships.

Oil or Chemical Spill

Emergency response within the sanctuary ranges from small events associated with fuel and oil discharges, debris and habitat damage from vessel groundings, sinkings and plane crashes, to larger oil spills from offshore shipping traffic, sunken vessels or natural seeps where damages can span hundreds of kilometers of coastline. In the three-year period from 2003 to 2005, 57 vessel groundings or sinkings were reported in the sanctuary. The majority of these incidents, which often involve spills of debris and fuel, involve pleasure craft, though some incidents involve commercial vessels.

Response to larger spills is led by the U.S. Coast Guard and California Department of Fish and Game's Office of Spill Prevention and Response, with the sanctuary participating to provide information and assess damage to resources. Staff members also participate on U.S. Coast Guard's contingency planning committee to coordinate response to large spills via advance planning. Interagency response coverage remains inadequate for some portions of sanctuary coastline, such as the Big Sur and Cambria areas, where rescue vessels and crews must travel long distances. In addition, sanctuary staff has been involved in an oil spill drill at Elkhorn Slough to prepare for spills from trains running through the slough on the main rail line between northern and southern California.

Sanctuary staff gained experience in responding to catastrophic oil spills by participating in "Safe Seas 2006", a major interagency oil-spill drill led by the National Oceanic and Atmospheric Administration in collaboration with the U.S. Coast Guard and the State of California. A series of trainings offered instruction on evaluation of habitat and species impacts, oil-spill response protocols, communications, and field and command center operations (MBNMS 2006).

On November 7, 2007, the M/V *Cosco Busan* hit the base tower of the San Francisco - Oakland Bay Bridge's western span in San Francisco Bay spilling 58,000 gallons of fuel oil. The spill escaped the Bay and oil sheens could be seen as far north as Point Reyes and south to Pacifica just north of San Pedro Point. The most affected beaches were in the Point Bonita area outside of the Bay area. This was the biggest spill since 1996 when 40,000 gallons of oil was spilled at the San Francisco Dry-dock, Inc. Monterey Bay sanctuary staff participated in both the oil spill response and natural resource damage assessment (NRDA) following the M/V *Cosco Busan* oil spill. Staff responders served in the unified command established for direction of spill response efforts. Sanctuary damage assessment personnel worked with a team of natural resource trustees from various federal and state agencies to assess environmental damage from the spill and response activities. It should be noted that the impacts from the M/V *Cosco Busan* oil spill are in process of being evaluated and therefore, are not part of this assessment.

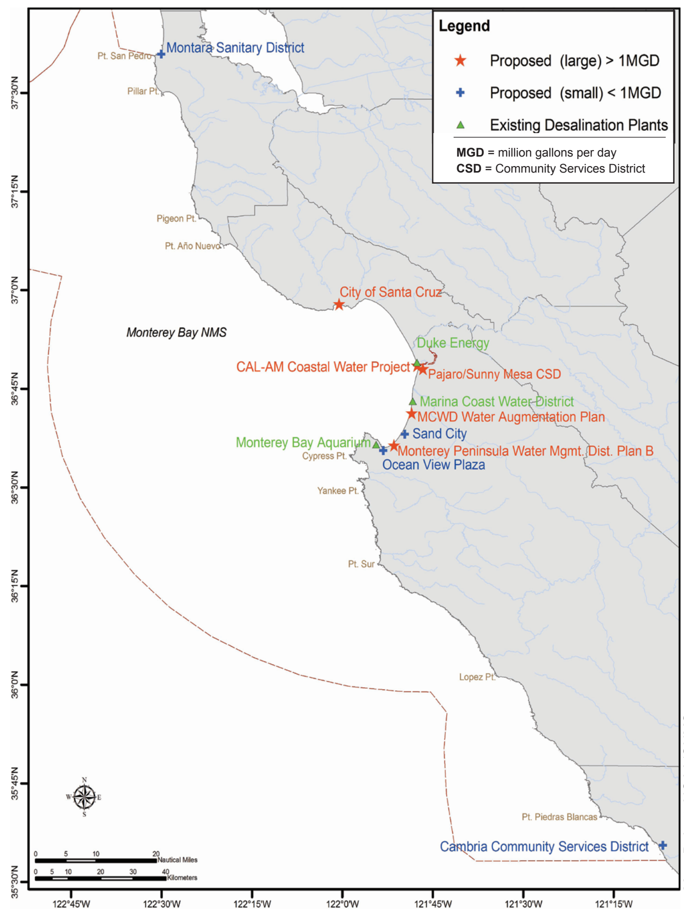
For smaller events and vessels (Figure 78), the sanctuary has often assumed a lead role in ensuring that fuel and oil, debris and where necessary, the vessel itself, is adequately removed to minimize damage. In addition, staff may conduct damage and recovery assessments, as well as restoration effort if needed. In 2006 sanctuary resource protection personnel worked with the California Office of Spill Prevention and Response to ensure clean up of fuel oil in the sunken ship *Palo Alto* (Figure 79). This oil had been linked to the death of more than 50 oiled seabirds since 2004. In addition, 173 seabird and two harbor seal carcasses were recovered from the bunker tank that contained all the fuel (Michaels 2006).

Photo: A. DeVogelaere, NOAA/MBNMS

Figure 78. The F/V *Lou Denny Wayne* ran aground on November 29, 2007 one mile sough of Pigeon Point, San Mateo County in the Monterey Bay National Marine Sanctuary.

Photo: CDFG/OSPR

Figure 79. The *Palo Alto*, also known as the "Cement Ship", located at Seacliff State Beach. Clean-up operations in 2006 removed approximately 505 gallons of oil and 125 cubic yards of oily sand that posed a threat to wildlife.



Map: D. Lott, NOAA/ONMS

Figure 80. The location of existing and proposed desalination plants in Monterey Bay National Marine Sanctuary.

Coastal Development

Desalination

Three desalination facilities currently operate within the boundaries of the sanctuary and approximately ten facilities have recently been proposed (Figure 80). Due to population growth in the area, continuing shortages and degradation of conventional water supplies, and advances in desalination technology, the trend will likely continue. The goal of the sanctuary's Desalination Action Plan is to minimize the impacts to marine resources from desalination activities through the development and implementation of a regional planning program and approach to desalination (NOAA 2008a). The action plan also includes development of facility siting guidelines, identification of environmental standards for desalination facilities, development of a modeling and monitoring program for desalination discharges, and the enhancement of outreach programs and the exchange of information.

Dredging and Dredge Disposal

Sanctuary staff will continue to review the disposal of dredge material in approved locations at sea or along the shoreline. The sanctuary's Harbors and Dredge Disposal Action Plan was developed jointly with a variety of stakeholders and partners and includes the following components (NOAA 2008a):

- Continuing to participate in and improve coordinated permit review with the California Coastal Commission, US Army Corps, and the U.S. Environmental Protection Agency;
- Reviewing dredge disposal activities in offshore sites with potential modifications to existing disposal sites;
- Tracking and evaluating increased sediment volumes disposed, as well as coordinating with appropriate agencies on reduction programs for upstream sources of sediment;

- Continuing to coordinate with the Army Corps and the Environmental Protection Agency on sediment size and suitability for offshore disposal;
- Evaluating future beneficial uses for dredge materials such as beach replenishment activities.

Erosion and Coastal Armoring

Sanctuary regulations prohibit alteration of the seabed, and all armoring structures placed below the mean high tide line require approval from the sanctuary (NOAA 2008a). The sanctuary regulates coastal armoring by authorizing California Coastal Commission permits, and placing specific conditions on those permits. Many seawalls have been constructed with no notification to or authorization from the sanctuary. Since 1992, the sanctuary review of seawalls primarily focused on minimizing impacts from the construction process rather than long-term impacts from the armoring itself. Since its designation, the sanctuary has reviewed and authorized California Coastal Commission permits for seawalls, riprap or other coastal armoring projects at 15 sites. Only a portion of the total coastal armoring projects underway in the region came to the sanctuary for review, clearly indicating a need for improved inter-agency coordination.

Because the armoring of the coastline for protection of private and public structures continues to expand throughout the sanctuary (Figure 81), the sanctuary has recently begun to take a more active role in addressing this practice, and has developed a Coastal Armoring Action Plan with the goal of developing and implementing a proactive regional approach to address coastal erosion that minimizes the negative impacts of coastal armoring on a sanctuary-wide basis. This action plan was developed jointly with a variety of stakeholders and partners and includes components such as:

- Compiling and analyzing existing information on coastal erosion and armoring and how it may impact sanctuary resources;
- Producing a comprehensive database and GIS maps for use as planning and permit review tools;
- Identifying specific planning sub-regions within the sanctuary, based on biological sensitivity, levels of development, and physical considerations, and developing specific planning guidelines for each sub-region;
- Improving coordination among agencies and jurisdictions involved in the permitting of coastal protection structures;
- Developing a long-term monitoring program that compares the ecological impacts of different types of coastal armoring structures to various habitats;
- Providing targeted education and outreach to decision makers and the general public about the issues of coastal erosion and armoring and the sanctuary's regional guidelines and policies;

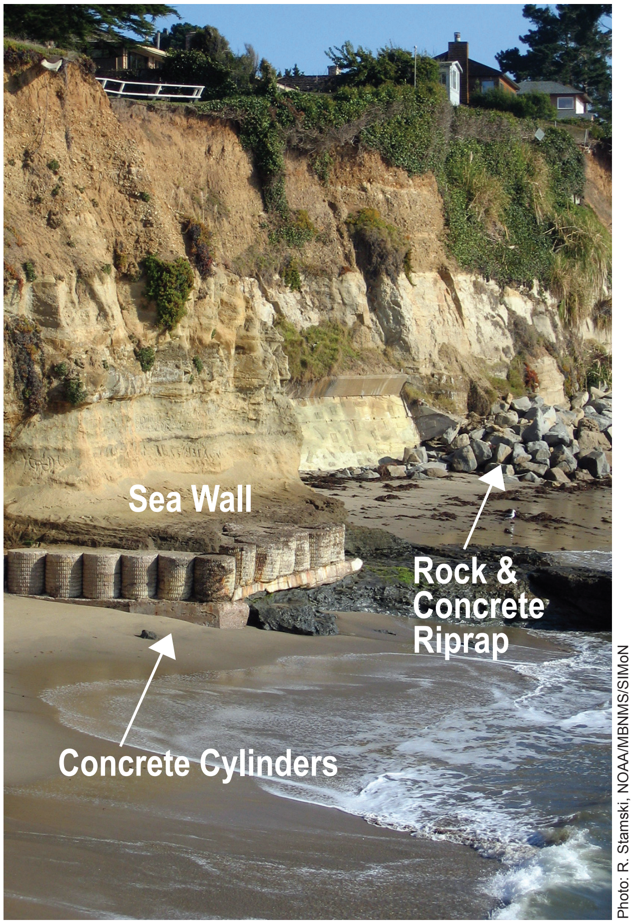


Figure 81. An unplanned assemblage of coastal armoring structures at Opal Cliffs near the city of Capitola (on the north side of Monterey Bay).

- Improving the maintenance and restoration of existing coastal armoring sites to minimize environmental damage;
- Predicting erosion and initiating work before sites become emergencies.

The staff of the Elkhorn Slough National Estuarine Research Reserve is leading a large, collaborative effort — the Elkhorn Slough Tidal Wetland Project — to develop and implement specific recommendations to conserve and restore estuarine habitat lost due to due tidal erosion. This collaboration, initiated in 2004, involves over 100 coastal resource managers, scientific experts, representatives from key regulatory and jurisdictional entities, leaders of conservation organizations, and community members. Members of the Monterey Bay sanctuary research team are involved with the project on both the Strategic Planning Team and the Science Panel.

Landslide Disposal

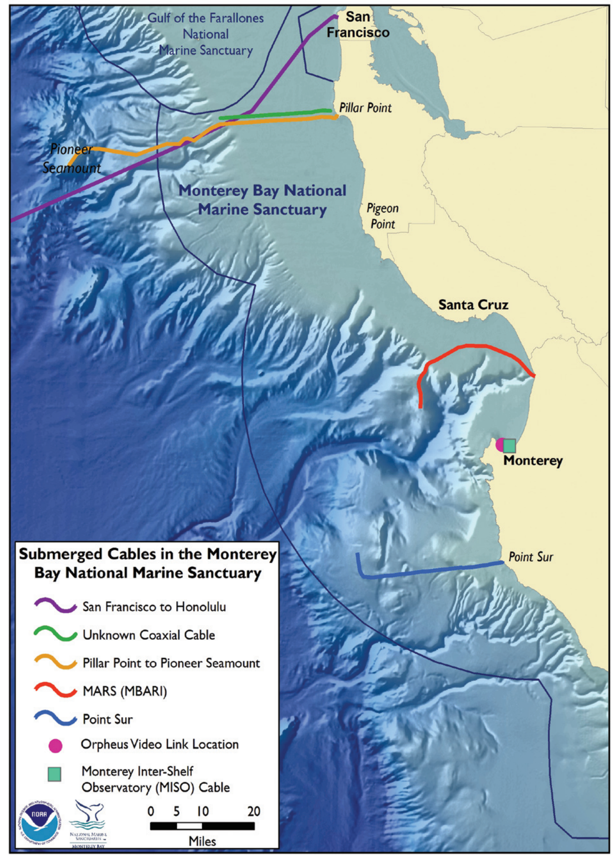
The need to proactively assess the sensitivity of intertidal and subtidal habitats in the Big Sur region to potential disposal of landslide debris was identified following severe winter storms and subsequent landslides in 1998, which closed the coastal highway and cut off local residents for several months. Because landslide debris disposal areas are very limited along the Big Sur coast due to the steep topography and because of the high cost and time of hauling debris to distant landfills, there was a strong interest by the public and elected officials to consider the possibility of disposing landslide debris on the seaward side of the highway, without harming sanctuary resources. The Monterey Bay National Marine Sanctuary is working with the California Department of Transportation and others to address landslide disposal, including development of a regional plan to improve highway practices to reduce the need for disposal, and assessments of the relative contribution of natural versus anthropogenic material. These actions are part of the sanctuary's Big Sur Coastal Ecosystem Action Plan.

In preparation for the 2008-2009 winter rainy season, the sanctuary began using a GIS-based decision support tool to identify landslide debris disposal options along the Big Sur coast. In addition, working closely with the California Department of Transportation (Caltrans), the California Coastal Commission, and Monterey County, response protocols were established for emergency notification, landslide debris data collection and analysis, and agreed upon procedures for coordinated and expedited permitting procedures. Concern for having these protocols in place was significantly heightened because of the possibility of severe debris flows during winter rain events following the Basin Complex and Chalk fires, which burned approximately 180,000 acres in the summer of 2008.

The GIS-based decision support tool incorporates data from a shoreline sensitivity assessment conducted by PISCO along with over 100 other natural resource and geologic spatial data sets that together allow the sanctuary to quickly identify sensitive areas along the shoreline that would be particularly vulnerable to scouring or smothering damage from potential landslide debris disposal, as well as less sensitive shoreline habitats that might be suitable to receive additional rock and soil inputs. The sanctuary used the GIS tool to help Caltrans plan its strategies to keep critical culverts from becoming clogged with landslide debris, which could cause a washout of the highway.

Submerged Cables

The installation, operation, and removal of submerged cables may disturb benthic habitats and may negatively impact areas of the seafloor. Sanctuary regulations prohibit the installation of submerged cables. Such regulatory prohibitions include those against: drilling into, dredging or otherwise altering the seabed of the sanctuary; constructing, placing or abandoning any structure, material or other matter on the seabed of the sanctuary; moving or injuring historical



Map: S. De Beukelaer, NOAA/MBNMS

Figure 82. Four submerged cables have been permitted since the designation of the Monterey Bay National Marine Sanctuary in 1992. The Pillar Point to Pioneer Seamount (orange), Orpheus Video Link (pink), MISO (turquoise), and MARS (red) cables were permitted in 1995, 2001, 2002, and 2005, respectively. The San Francisco to Honolulu (purple) and Point Sur (blue) cables were installed prior to sanctuary designation. A submerged coaxial cable (green) of unknown origin is also present in the sanctuary.

resources; and discharging or depositing any material or other matter in the sanctuary. However, sanctuary regulations allow, via permit or authorization, for some otherwise prohibited activities (Figure 82).

Currently submerged cable applications are reviewed on a case-by-case basis (NOAA 2008a). Policy guidance for future applicants would provide for a more efficient permitting process and inform future applicants as to preferred alternatives prior to submitting an application. In 1999, due to expanding interest in constructing submerged telecommunications cables in national marine sanctuaries, including the Monterey Bay sanctuary, the Office of National Marine Sanctuaries initiated a process to consider guidance for cable projects proposed for national marine sanctuaries. Also, there has been a recent increase in interest to develop cabled observatories nationwide for research and monitoring purposes, including in the sanctuary. In implementation of this Submerged Cables Action Plan, the sanctuary will develop a framework to identify sensitive areas of the seafloor within the sanctuary and provide clear structure with which to review future submerged cable development applications. The plan includes a program to provide siting guidelines in a Geographical Information System to identify environmental constraints. The sanctuary is also working with the Office of National Marine Sanctuaries to develop nationwide guidelines on appropriate locations and restrictions for underwater fiber optic cables based on habitat sensitivity and other criteria.

The Pioneer Seamount cable was originally installed in 1995 as part of an experiment to detect changes in ocean temperature by monitoring the speed of sound waves in the deep sea. The coaxial Type SD cable runs 95 kilometers between Pillar Point Air Force Station in Half Moon Bay and the Pioneer Seamount (Figure 82). To fulfill sanctuary permitting requirements to continue using the cable, NOAA's Office of Oceanic and Atmospheric Research, in collaboration with researchers from the Monterey Bay Aquarium Research Institute and the sanctuary, performed an underwater survey of the status of the cable (Kogan et al. 2006). Few impacts to the physical habitat and surrounding fauna were detected.

Non-indigenous Species

Eradication of non-indigenous species is difficult and often impossible, and management practices should focus largely on prevention of introductions. The goal of the Introduced Species Action Plan is to maintain the natural biological communities and ecological processes in the sanctuary and protect them from the potentially adverse impacts of introduced species by preventing new introduced species from establishing in the sanctuary and by detecting, controlling (limiting the spread), and where feasible, eradicating environmentally harmful species that are introduced to the sanctuary waters (NOAA 2008a). This action plan, developed jointly with a multi-stakeholder working group, calls for the following actions:

- Address known pathways of introduction
- Develop prevention and response programs for introduced species
- Develop a baseline information, research and monitoring programs

Sanctuary staff has conducted some research and education on this issue and occasionally has reviewed and provided comments to other agencies on ways to prevent introductions. In August 2001, the invasive alga *Undaria pinnatifida* was first noted in Monterey Harbor. In September 2002, sanctuary staff and the Harbor Master's office coordinated with the city of Monterey's Volunteer Program to begin a monitoring program to survey and remove *Undaria* by hand from the floating docks. The Undaria Management Program, funded by the NOAA Restoration Center from 2006 to September 2008, used staff and volunteers to monitor and manage the spread of this invader.

Figure 83. Volunteer docent with the Team OCEAN kayaker outreach program.

Wildlife Disturbance

The Monterey Bay sanctuary addresses wildlife disturbance through a mix of education, outreach, partnerships with docent programs, regulations and enforcement (NOAA 2008a). Sanctuary regulations explicitly prohibit take and harassment of wildlife protected under the Marine Mammal Protection Act, the Migratory Bird Treaty Act, and the Endangered Species Act. Previously, ecotourism operations within the sanctuary included white shark viewing with the aid of chumming or other attraction methods. Sanctuary adopted prohibitions for attraction of white sharks, due to the potential for alteration of the sharks' general behavior patterns and user conflicts with recreational activities such as surfing. Minimizing disturbance to wildlife is the goal of the Marine Mammal, Seabird, and Turtle Disturbance Action Plan.

One effort to reduce wildlife disturbance in the sanctuary is an education/outreach program called Team OCEAN (Ocean Conservation Education Action Network). Started in 2000, the Team OCEAN Kayaker Outreach Program is a seasonal field program that provides face-to-face interpretation of sanctuary natural history and programs, as well as guidelines on how to enjoy marine wildlife without disturbing it (Figure 83). The target audience is primarily ocean kayakers, but includes other sanctuary resource users who may be encountered on the water, such as boaters and divers. A large percentage of ocean kayakers are visitors to the area and are either unaware of or undereducated about the sanctuary's existence and sensitive wildlife. The naturalists serve as docents for the marine sanctuary, promote respectful wildlife viewing, and protect marine mammals from disturbance.

Similarly, the sanctuary has assisted in reducing harassment of the northern elephant seal population at Piedras Blancas, a location very near a highway where tourists were closely approaching the animals. These efforts have included assisting local nonprofit organizations in establishing an observer and docent network for the northern elephant seal haul-out sites to facilitate observation opportunities at safe distances and locations, and improving interagency enforcement for cases where an educational approach has not sufficed. Sanctuary staff has also developed educational signage for several highly visited shoreline locations to reduce impacts of trampling and collecting of intertidal species.

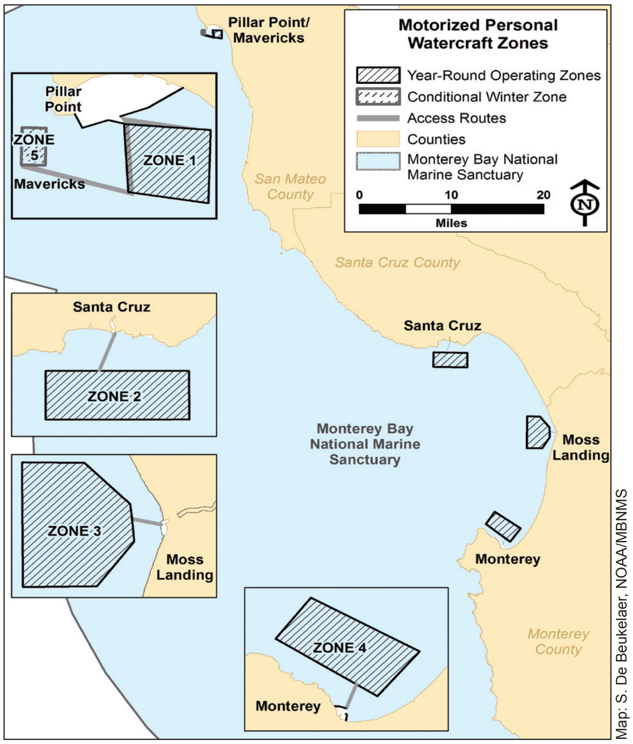


Figure 84. Operating a motorized personal watercraft is prohibited in the Monterey Bay National Marine Sanctuary except within five designated zones and access routes. Operation in Zone 5 at Pillar Point is allowed only when a High Surf Warning is in effect for San Mateo County in December, January or February.

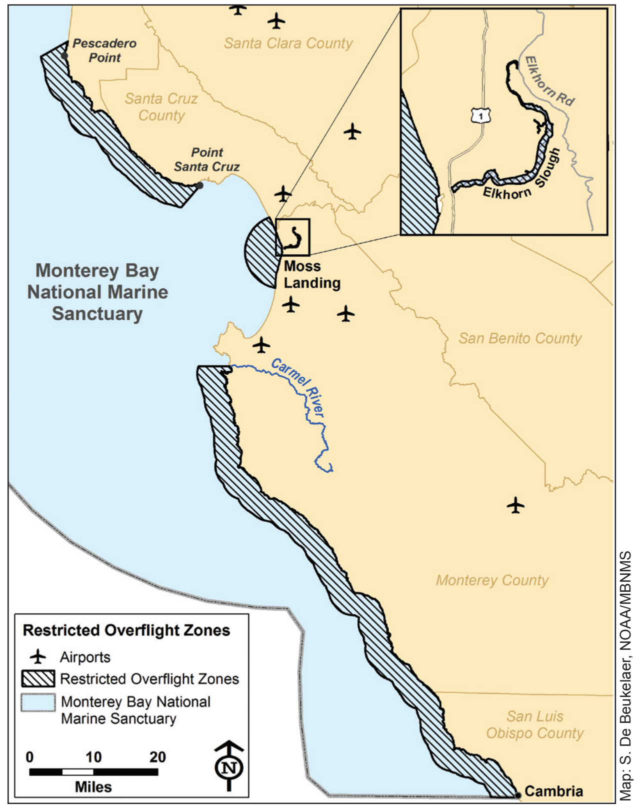


Figure 85. Aircraft are restricted from flying under 1,000 feet (300 meters) in zones with sensitive wildlife (black hatching).

Motorized and Non-motorized Vessels

Motorized personal watercraft activities have increased in the sanctuary with the development of larger and more powerful vehicles for use in the marine environment. The goal of the Motorized Personal Watercraft Action Plan is to minimize disturbance of marine wildlife by motorized personal watercraft, minimize user conflicts between motorized personal watercraft operators and other recreationalists, and provide appropriate opportunities for motorized personal watercraft use within the sanctuary (NOAA 2008a). In this action plan, the sanctuary provides an updated definition of personal watercraft in order to address the original intent of the existing sanctuary regulation, which was to restrict them to four zones (Figure 84). The action plan includes education and enforcement procedures and exploration of the need for certain exceptions.

Overflight Impacts

Potential impacts from low-flying aircraft are addressed by a specific prohibition on flying under 1,000 feet (300 meters) in designated overflight zones with sensitive wildlife (Figure 85). Implementation of this sanctuary regulation has encountered some problems due to a lack of understanding and acknowledgement of the zones by pilots since they are not noted on aeronautical charts. The sanctuary has begun an outreach campaign to pilot associations on the zones and the impacts of low flights, and is working to include notations on the Federal Aviation Administration's aeronautical charts. Additional outreach may be required to reach aviation companies that conduct whale watching trips within the sanctuary overflight restriction zones.

Aquaculture Activities

Kelp is harvested in the sanctuary at a variety of locations, to sustain aquaculture operations and for use in a variety of products. The Monterey Bay sanctuary conducted a thorough evaluation of the kelp harvesting issue in 2000 and provided eleven recommendations to the California Department of Fish and Game for the management of kelp in the sanctuary. Recommendations included areas where kelp harvesting should be limited or excluded, and implementation of more rigorous methods for collection, analysis, and dissemination of data on kelp harvesting. In 2001, the Department adopted many of these recommendations.

Acoustic Impacts

The sanctuary has been involved in evaluating and requesting limits or alterations of specific proposals to use acoustic devices in the region, such as the Navy's Low-Frequency Array proposal, but has not addressed the overall issue of cumulative noise impacts. An assessment of the distribution of deep-diving whales in the sanctuary has been compiled to assist in evaluating potential impacts from acoustic disturbances. Proposed future actions include encouraging passive acoustic monitoring to identify and quantify sources of anthropogenic noise in the air and underwater, and continuing to be apprised of survey and monitoring activities that are evaluating the effects of sound. In addition, the sanctuary will continue evaluating individual proposals on a case-by-case basis to determine impacts of proposed projects, and make management recommendations. The sanctuary will work with NOAA National Marine Fisheries Service and other partners to determine acceptable sound levels in the different frequency ranges affecting wildlife.

Marine Debris

In the Marine Mammals, Seabirds, and Turtle Disturbance Action Plan, the sanctuary outlines a plan to address the threat of marine debris to wildlife by developing a marine debris database, conducting education and outreach programs to illustrate the impacts of marine debris on wildlife, and working in cooperation with other agencies and municipalities to develop a notification and recovery program for lost fishing gear (NOAA 2008a).

The Monterey Bay sanctuary is supporting efforts by cities and the state to ban use of some non-recyclable plastic consumer products (e.g., polystyrene) and encourage incentives for the use of compostable materials. Recently, a number of cities adjacent to the sanctuary have implemented such bans, including the cities of Capitola, Santa Cruz, Carmel, Pacific Grove, Monterey, Oakland, and San Francisco, which may reduce the amount of debris entering sanctuary waters.

The sanctuary is working with partners to design and implement a multi-year project to remove lost fishing gear from the sanctuary. The dual purpose of the project is to help eliminate benthic and pelagic hazards to marine organisms posed by fishing debris lost on the bottom, and to provide outreach tools that will assist in the location of lost gear via reports from divers, researchers, fishermen and other parties.

Tidepool Protection

Most tidepool areas of the sanctuary do not have significant monitoring and enforcement, signage or educational outreach strategies to minimize human impacts. In addition, there has not been a regional effort to assess usage and potential impacts and to prioritize sites that need additional attention. The Tidepool Protection Action Plan was developed to provide a framework to collaborate with agencies and local communities to more thoroughly evaluate the issue and develop guidelines and programs for comprehensive education, enforcement, monitoring and management of the region's tidepools (NOAA 2008a). The goal of the Tidepool Protection Action Plan is to protect tidepool habitat and resources from impacts associated with visitation and harvest. Under this action plan, the sanctuary will evaluate and prioritize high-visitation tidepool areas and address possible impacts associated with potentially excessive use. The action plan includes education and enforcement programs, and implementation would include the development of guidelines for tidepool access and enjoyment.

The sanctuary has compiled a detailed survey of the research and monitoring programs focused on rocky intertidal habitat in central California (DeVogelaere et al. 1999). This provides basic information on tidepool resources, and also may serve as an initial estimate of locations of intertidal habitats that are accessible to visitors. This inventory of ongoing research at rocky intertidal sites is updated periodically in the Sanctuary Integrated Monitoring Network (SIMoN) inventory of research projects. Staff also collaborates with the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), a consortium of academic scientists conducting extensive monitoring of rocky intertidal habitats. In 2000, the Monterey Bay sanctuary partnered with the City of Pacific Grove and the David and Lucile Packard Foundation to fund a study of the impacts of human activities on the rocky intertidal shore and tidepools at Point Pinos (on the Monterey Peninsula). This study found that aside from apparent trampling effects, disturbances that have likely occurred at some level from visitor use did not appear to exceed the range of disturbances that may occur naturally (Tenera Environmental 2003). The authors recommended that planning for additional resource conservation measures and monitoring programs at Point Pinos may be warranted because visitor use will likely increase in the future.

Ecosystem Conservation & Biodiversity Protection

The sanctuary is mandated to approach resource protection from a broad, ecosystem-based perspective. To effectively protect an ecosystem, it is necessary to know the ecosystem components and to understand how these components interact and change through time. Monitoring is a tool for documenting change for the purpose of understanding why such a change has occurred and determine whether or not the change is attributable to human or natural causes. Monitoring is critical to resource managers who need to make informed decisions regarding ecosystem protection and to inform the public about their impacts on the environment.

Because the Monterey Bay, Gulf of the Farallones, and Cordell Bank national marine sanctuaries sit adjacent to one another, they share some of the same habitats, organisms, and management concerns. The Ecosystem Monitoring Action Plan provides a framework for close coordination in ecosystem monitoring amongst the three

SIMoN

SIMoN (the Sanctuary Integrated Monitoring Network) utilizes existing data sets, supports and augments current research and monitoring efforts, and initiates new efforts to address important gaps in our knowledge of the sanctuary. The strength of this program is that SIMoN serves as the hub for regional ecosystem monitoring. Regional scientists continue to collect the large majority of monitoring data, but the sanctuary helps generate funds and other support required to maintain or expand some existing efforts and to initiate new studies.

Through SIMoN, the sanctuary also integrates and interprets results of individual efforts in a large ecosystem-wide context, and continuously updates and disseminates data summaries to facilitate communication among researchers, managers, educators, and the public. Timely and pertinent information is provided to all parties through tools such as the SIMoN web site, an annual symposium, and a series of technical and general reports.

For more information:
http://www.sanctuarysimon.org/regional_sections/simon

Krill Harvesting

On August 12, 2009 the National Oceanic and Atmospheric Administration prohibited krill harvesting off the U.S. West Coast. Krill are a small shrimp-like crustacean and a key source of nutrition in the marine food web. While the States of California, Oregon and Washington had regulations prohibiting the harvesting of krill within three miles of their coastlines, there was no similar federal restriction within the three to 200-mile confines of the Exclusive Economic Zone. The krill harvest prohibition in federal waters was proposed by NOAA's Office of National Marine Sanctuaries to the Pacific Fishery Management Council (PFMC) and NOAA's National Marine Fisheries Service. The final rule implements Amendment 12 to the Coastal Pelagic Species Fishery Management Plan, which was developed by the PFMC under the Magnuson-Stevens Fishery Conservation and Management Act. The prohibition is intended to preserve key nutritional relationships in the California Current ecosystem, which includes five National Marine Sanctuaries.

sanctuaries, enabling the sanctuaries to more effectively address ecosystem monitoring issues (NOAA 2008a). One of the goals of Monterey Bay National Marine Sanctuary is to provide an ecosystem monitoring program within the sanctuary to determine human-induced and natural changes to natural resources, and to disseminate this information to the public and agency decision makers. Moreover, this effort is to be integrated with monitoring projects in the other two sanctuaries to efficiently address similar problems and to effectively study regional-scale, cross-sanctuary phenomena.

In 1999, Monterey Bay National Marine Sanctuary, in collaboration with the regional science and management community, designed the Sanctuary Integrated Monitoring Network – also known as SIMoN – to identify and track natural and human-induced changes to the sanctuary ecosystem (see sidebar). Given the success of the SIMoN program for the Monterey Bay sanctuary, this program is being expanded across the three central and northern California sanctuaries. This effort will significantly improve coordination of existing monitoring activities and aid in the identification of new opportunities for regional monitoring programs (NOAA 2008a).

During the scoping period of the Joint Management Plan Review, the Office of National Marine Sanctuaries received approximately 7,000 public comments requesting greater ecosystem protection for Monterey Bay National Marine Sanctuary through the establishment of a network of marine protected areas. The sanctuary advisory council also identified the consideration of new marine protected areas as a priority issue to be addressed in the new management plan. Similar to the Marine Life Protection Act efforts in state waters (generally within three nautical miles of shore), the sanctuary is now considering using marine protected areas as a management tool in federal waters (beyond three nautical miles). The Marine Protected Areas Action Plan outlines a program for identifying various types of ocean uses, integrated management, marine protected area design criteria, socioeconomic impact analysis, marine protected area enforcement, outreach, and monitoring (NOAA 2008a).

Maritime Archaeological Resources

The Maritime Heritage Action Plan, developed by working group members and the Office of National Marine Sanctuaries staff provides a framework for a Maritime Heritage Resources Program. The sanctuary is working with the Office of National Marine Sanctuaries, West Coast sanctuaries and local agencies to more fully develop a Maritime Heritage program.

The sanctuary began a project to characterize shipwrecks within the sanctuary, including a summary of the shipping routes and types of coastal settings that were conducive to maritime activities and trade and an assessment of known ship losses. Supporting research for this project comes from archival materials, existing databases, and an oral survey with the support of the diving community. This information has been included in the site characterization of Monterey Bay National Marine Sanctuary and incorporated into NOAA's Archeological Site Database ("NOAA's ARCH"). Several projects have been developed to characterize maritime heritage and submerged archaeological resources in the Monterey Bay National Marine Sanctuary:

- Two contributions to the Monterey Bay National Marine Sanctuary Site Characterization: "A Recent History of the Monterey Bay National Marine Sanctuary Region" and "Early Uses of the Resources"
- Monterey Bay National Marine Sanctuary Shipwreck Database: The Web site and database provide teachers and students with an online educational activity to learn more about important shipwrecks found within the Monterey Bay National Marine Sanctuary.
- Monterey Bay National Marine Sanctuary Submerged Cultural Resources Study 2001: Smith and Hunter (2003) indicate 445 reported losses (vessels, aircraft) are located in Pacific waters directly within, or near the border of, Monterey Bay National Marine Sanctuary

In 2003, sanctuary staff and local agencies visited the oil tanker *Montebello* to conduct reconnaissance dives to monitor and characterize the condition of the vessel, and characterize the fish and invertebrate assemblages (Figure 86). Over the course of two days, eight successful ROV dives revealed greater details of the tanker, with no observations of oil discharging into the water column or *Beggiatoa* bacteria, which feeds on hydrocarbons. 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. The sanctuary plans to continue monitoring the site of the *Montebello* in the future for signs of oil discharge or hull degradation (Schwemmer 2005)

In 2005, a team of scientists onboard the NOAA research vessel *McArthur II* conducted a side scan sonar survey in the Monterey Bay National Marine Sanctuary at the wreck site of USS *Macon*. In September 2006, researchers from Monterey Bay National Marine Sanctuary, sanctuary west coast regional office, the Monterey Bay Aquarium Research Institute, Stanford University, and the University of New Hampshire revisited the wreck site. The primary goal of the mission was to conduct comprehensive documentation of the site of the USS *Macon's* loss that can be used to evaluate the archaeological context of the craft. This will allow the Office of National Marine Sanctuaries and the U.S. Navy Historical Center to determine the condition of the site, the level of preservation of the archaeological remains and the potential for research at the site. Another goal of the expedition is to conduct a biological survey to characterize the habitat and species composition associated with the wreck and surrounding area. The expedition will aid in the assessment of the USS *Macon* for eligibility in the national register of historic places.

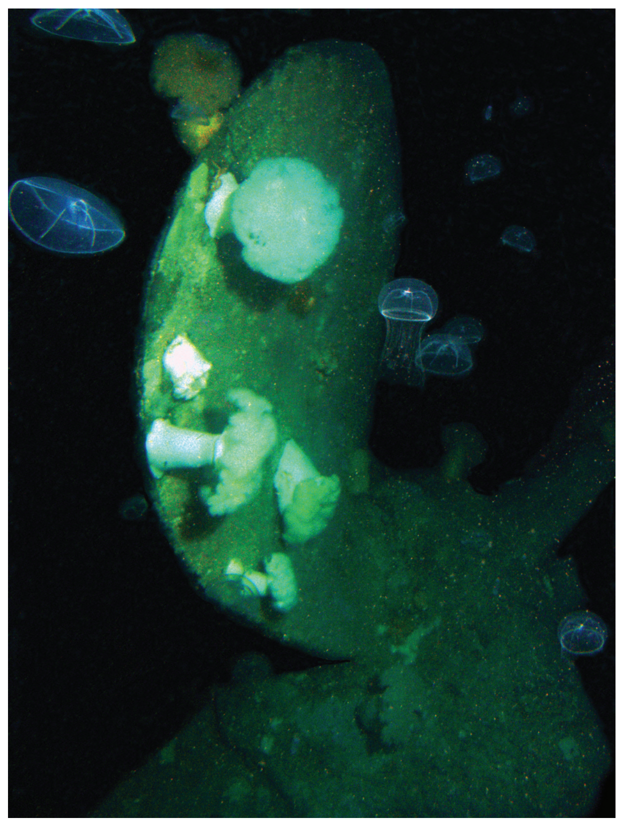


Photo: R. Schwemmer, NOAA

Figure 86. Oil tanker *Montebello* propeller covered with white-plumed anemones (*Metridium farcimen*).

Concluding Remarks

This condition report is the first attempt to describe the relationship between human pressures and the status and trends of resources within Monterey Bay National Marine Sanctuary. By doing so, this report helps to identify the pressures and their impacts on marine ecosystems that may warrant monitoring and remediation in the years to come. Some of the most prominent anthropogenic pressures, including vessel traffic, commercial and recreational fishing, agricultural and urban runoff, harmful algal blooms, coastal development, and the introduction of non-indigenous species, have reduced, to varying extents, the quality of resources in the sanctuary.

Sanctuary staff is actively involved in a wide variety of environmental protection activities due to the many pressures occurring over an extremely large portion of the California coast. Some approaches to management rely on existing sanctuary regulations and staff actions, but most require coordination with the many local, state, and federal agencies with jurisdictions over resources in the area, and with the users directly affected by agency decisions. Sanctuary management, policy, research, education, and outreach staff will continue to work aggressively to implement the action plans recently developed during the process to create the joint management plan for the Monterey Bay, Gulf of the Farallones, and Cordell Bank sanctuaries. These action plans direct the day-to-day activities of sanctuary staff, as well as the coordination needs that encourage cooperation among trustees and users.

However, while the sanctuary continues to build trust and make progress by working with partners and constituents, considerable challenges lie ahead. Emerging pressures and threats, including offshore energy generation, emerging contaminants (e.g., PBDE flame retardants, anti-fouling compounds), and climate change could all affect sanctuary resources in complex ways.

Management of these pressures will require even more comprehensive approaches that go beyond the jurisdictions within which the sanctuary currently operates. The sanctuary is poised to be actively and effectively involved in addressing emerging issues, applying the lessons it has learned in central California to tackle even more complex challenges affecting the balance between human and natural systems in the ocean environment.

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Additional Resources

Agriculture and Water Quality Alliance: http://www.awqa.org

Applied Marine Sciences: http://www.amarine.com

California Coastal Records Project: http://www.californiacoastline.org

California Department of Public Health: http://www.cdph.ca.gov

California State University Monterey Bay: http://csumb.edu

California State Water Resources Control Board: http://www.swrcb.ca.gov

California Coastal Records Project: http://www.Californiacoastline.org

Center for Integrated Marine Technologies: http://cimt.ucsc.edu

Central Coast Ambient Monitoring Program: http://www.ccamp.org

Central Coast Long-term Environmental Assessment Network (CCLEAN): http://www.cclean.org

Channel Islands National Marine Sanctuary, shipwrecks: http://channelislands.noaa.gov/shipwreck/dbase/montebello_2.html

Channel Islands National Marine Sanctuary: http://channelislands.noaa.gov

Cooperative Research and Assessment of Nearshore Ecosystems (CRANE): http://www.mbnms-simon.org/sections/kelpForest/project_info.php?pid=100154&sec

CSUMB Seafloor mapping lab: http://seafloor.csumb.edu

Elkhorn Slough Foundation: http://www.elkhornslough.org

Elkhorn Slough National Estuarine Research Reserve: http://www.nerrs.noaa.gov/ElkhornSlough

Elkhorn Slough Tidal Wetland Project: http://www.elkhornslough.org/tidalwetlandproject/index.html

Endangered Species Act Listing: http://www.nmfs.noaa.gov/pr/species/esa

Essential Fish Habitat: http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/Groundfish-Closed-Areas/Index.cfm

Fugro Pelagos International: http://www.fugro-pelagos.com

Gulf of the Farallones National Marine Sanctuary: http://farallones.noaa.gov

Land/Ocean Biogeochemical Observatory in Elkhorn Slough (LOBO): http://www.mbari.org/lobo

Marine Life Protection Act: http://www.dfg.ca.gov/mlpa

Marine Resources Survey in Big Sur: http://www.mbnms-simon.org/sections/kelpForest/project_info.php?pid=100280&sec=kf

Marine Wildlife Veterinary Care and Research Center: http://www.mwvcrc.org

MBARI Monterey Bay Multibeam Survey: http://www.mbari.org/data/mapping/monterey/default.htm

Model Urban Runoff Program: http://www.coastal.ca.gov/la/murp.html

Monterey Bay Aquarium Research Institute: www.mbari.org

Monterey Bay National Marine Sanctuary: http://montereybay.noaa.gov

Monterey Maritime Museum: http://www.montereyhistory.org

Multi-Agency Rocky Intertidal Network (MARINe): http://www.marine.gov

National Oceanic and Atmospheric Administration: http://www.noaa.gov

National Park Service: http://www.nps.gov

Nearshore Subtidal Characterization of Big Sur: http://www.mbnms-simon.org/sections/kelpForest/project_info.php?pid=100312&sec

NOAA's National Marine Fisheries Service Office of Protected Resources Species Under the Endangered Species Act: http://www.nmfs.noaa.gov/pr/species/esa

NOAA's National Marine Fisheries Service: http://www.nmfs.noaa.gov

NOAA's National Marine Fisheries Status of U.S. Fisheries: http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm

NOAA's National Marine Fisheries Service Marine Mammal Stock Assessment Reports: http://www.nmfs.noaa.gov/pr/sars/region.htm

NOAA's National Status and Trends Mussel Watch Program: http://ccma.nos.noaa.gov/about/coast/nsandt/welcome.html

NOAA's Office of National Marine Sanctuaries: http://sanctuaries.noaa.gov

NOAA's Safe Seas Exercise: http://sanctuaries.noaa.gov/safeseas

NOAA's Southwest Fisheries Science Center: http://swfsc.noaa.gov

The Ocean Conservancy: http://www.oceanconservancy.org

Pacific Fishery Management Council: http://www.pcouncil.org

Partnership for Interdisciplinary Studies of Coastal Oceans: http://www.piscoweb.org

Rockfish Conservation Areas: http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/Groundfish-Closed-Areas

Sanctuary Integrated Monitoring Program (SIMoN): http://www.sanctuarysimon.org

Save Our Shores: http://www.saveourshores.org

Save Our Shores Marine Debris Initiative: http://www.saveourshores.org/marine-debris-initiative

Seal Populations at Piedras Blancas: http://www.beachcalifornia.com/piedras.html

Surface Water Ambient Monitoring Program (SWAMP): http://www.swrcb.ca.gov/water_issues/programs/swamp/index.shtml

Synthesis, Assessment, and Management Project: http://www.ccamp.net/sam/index.php/Main_Page

The Nature Conservancy: http://www.nature.org

The Nature Conservancy, California Kelp Research: http://www.leaseown.org/Case_Studies/Lease_CA_research.html

University of California Davis: http://www.ucdavis.edu/index.html

University of California Santa Cruz: http://www.ucsc.edu

USGS Pacific Coast habitat mapping program: http://marinehabitat.psmfc.org

USGS Western Ecological Research Center: http://www.werc.usgs.gov

Appendix A: Rating Scheme for System-Wide Monitoring Questions

The purpose of this appendix is to clarify the 17 questions and possible responses used to report the condition of sanctuary resources in “Condition Reports” for all national marine sanctuaries. Individual staff and partners utilized this guidance, as well as their own informed and detailed understanding of the site to make judgments about the status and trends of sanctuary resources.

The questions derive from the National Marine Sanctuary System’s mission, and a system-wide monitoring framework (NMSP 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on and study the ecosystems encompassed by the sanctuaries. They are being used to guide staff and partners at each of the 14 sites in the sanctuary system in the development of this first periodic sanctuary condition report. Evaluations of status and trends may be based on interpretation of quantitative and, when necessary, non-quantitative assessments and observations of scientists, managers and users.

Judging an ecosystem as having “integrity” implies the relative wholeness of ecosystem structure and function, along with the spatial and temporal variability inherent in these characteristics, as determined by the ecosystem’s natural evolutionary history. Ecosystem integrity is reflected in the system’s ability to produce and maintain adaptive biotic elements. Fluctuations of a system’s natural characteristics, including abiotic drivers, biotic composition, complex relationships, and functional processes and redundancies are unaltered and are either likely to persist or be regained following natural disturbance.

Following a brief discussion about each question, statements are presented that were used to judge the status and assign a corresponding color code. These statements are customized for each question. In addition, the following options are available for all questions: “ N/A” - the question does not apply; and “Undet.” - resource status is undetermined.

Symbols used to indicate trends are the same for all questions: “▲ ” - conditions appear to be improving; “—” - conditions do not appear to be changing; “▼ ” - conditions appear to be declining; and “?” – trend is undetermined.

Water Stressors

1. Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?

This is meant to capture shifts in condition arising from certain changing physical processes and anthropogenic inputs. Factors resulting in regionally accelerated rates of change in water temperature, salinity, dissolved oxygen or water clarity could all be judged to reduce water quality. Localized changes in circulation or sedimentation resulting, for example, from coastal construction or dredge spoil disposal can affect light penetration, salinity regimes, oxygen levels, productivity, waste transport and other factors that influence habitat and living resource quality. Human inputs, generally in the form of contaminants from point or nonpoint sources, including fertilizers, pesticides, hydrocarbons, heavy metals and sewage, are common causes of environmental degradation, often in combination rather than alone. Certain biotoxins, such as domoic acid, may be of particular interest to specific sanctuaries. When present in the water column, any of these contaminants can affect marine life by direct contact or ingestion, or through bioaccumulation via the food chain.

[Note: Over time, accumulation in sediments can sequester and concentrate contaminants. Their effects may manifest only when the sediments are resuspended during storm or other energetic events. In such cases, reports of status should be made under Question 7 – Habitat contaminants.]

Good	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.
Good/Fair	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.
Fair	Selected conditions may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats.
Fair/Poor	Selected conditions have caused or are likely to cause severe declines in some but not all living resources and habitats.
Poor	Selected conditions have caused or are likely to cause severe declines in most, if not all, living resources and habitats.

Water Eutrophic Condition

2. What is the eutrophic condition of sanctuary waters and how is it changing?

Nutrient enrichment often leads to planktonic and/or benthic algae blooms. Some affect benthic communities directly through space competition. Overgrowth and other competitive interactions (e.g., accumulation of algal-sediment mats) often lead to shifts in dominance in the benthic assemblage. Disease incidence and frequency can also be affected by algae competition and the resulting chemistry along competitive boundaries. Blooms can also affect water column conditions, including light penetration and plankton availability, which can alter pelagic food webs. Harmful algal blooms often affect resources, as biotoxins are released into the water and air, and oxygen can be depleted.

Good	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.
Good/Fair	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.
Fair	Selected conditions may inhibit the development of assemblages and may cause measurable but not severe declines in living resources and habitats.
Fair/Poor	Selected conditions have caused or are likely to cause severe declines in some but not all living resources and habitats.
Poor	Selected conditions have caused or are likely to cause severe declines in most if not all living resources and habitats.

Water Human Health

3. Do sanctuary waters pose risks to human health and how are they changing?

Human health concerns are generally aroused by evidence of contamination (usually bacterial or chemical) in bathing waters or fish intended for consumption. They also emerge when harmful algal blooms are reported or when cases of respiratory distress or other disorders attributable to harmful algal blooms increase dramatically. Any of these conditions should be considered in the course of judging the risk to humans posed by waters in a marine sanctuary.

Some sites may have access to specific information on beach and shellfish conditions. In particular, beaches may be closed when criteria for safe water body contact are exceeded, or shellfish harvesting may be prohibited when contaminant loads or infection rates exceed certain levels. These conditions can be evaluated in the context of the descriptions below.

Good	Conditions do not appear to have the potential to negatively affect human health.
Good/Fair	Selected conditions that have the potential to affect human health may exist but human impacts have not been reported.
Fair	Selected conditions have resulted in isolated human impacts, but evidence does not justify widespread or persistent concern.
Fair/Poor	Selected conditions have caused or are likely to cause severe impacts, but cases to date have not suggested a pervasive problem.
Poor	Selected conditions warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts are likely or have occurred.

Water
Human Activities

4. What are the levels of human activities that may influence water quality and how are they changing?

Among the human activities in or near sanctuaries that affect water quality are those involving direct discharges (transiting vessels, visiting vessels, onshore and offshore industrial facilities, public wastewater facilities), those that contribute contaminants to stream, river, and water control discharges (agriculture, runoff from impermeable surfaces through storm drains, conversion of land use), and those releasing airborne chemicals that subsequently deposit via particulates at sea (vessels, land-based traffic, power plants, manufacturing facilities, refineries). In addition, dredging and trawling can cause resuspension of contaminants in sediments.

Good	Few or no activities occur that are likely to negatively affect water quality.
Good/Fair	Some potentially harmful activities exist, but they do not appear to have had a negative effect on water quality.
Fair	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.
Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent, and/or repeated severe impacts have occurred or are likely to occur.

Habitat
Abundance & Distribution

5. What are the abundance and distribution of major habitat types and how are they changing?

Habitat loss is of paramount concern when it comes to protecting marine and terrestrial ecosystems. Of greatest concern to sanctuaries are changes caused, either directly or indirectly, by human activities. The loss of shoreline is recognized as a problem indirectly caused by human activities. Habitats with submerged aquatic vegetation are often altered by changes in water conditions in estuaries, bays, and nearshore waters. Intertidal zones can be affected for long periods by spills or by chronic pollutant exposure. Beaches and haul-out areas can be littered with dangerous marine debris, as can the water column or benthic habitats. Sandy subtidal areas and hard bottoms are frequently disturbed or destroyed by trawling. Even rocky areas several hundred meters deep are increasingly affected by certain types of trawls, bottom longlines and fish traps. Groundings, anchors and divers damage submerged reefs. Cables and pipelines disturb corridors across numerous habitat types and can be destructive if they become mobile. Shellfish dredging removes, alters and fragments habitats.

The result of these activities is the gradual reduction of the extent and quality of marine habitats. Losses can often be quantified through visual surveys and to some extent using high-resolution mapping. This question asks about the quality of habitats compared to those that would be expected without human impacts. The status depends on comparison to a baseline that existed in the past - one toward which restoration efforts might aim.

Good	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
Good/Fair	Selected habitat loss or alteration has taken place, precluding full development of living resource assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.
Fair	Selected habitat loss or alteration may inhibit the development of assemblages, and may cause measurable but not severe declines in living resources or water quality.
Fair/Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in some but not all living resources or water quality.
Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in most if not all living resources or water quality.

Habitat Structure

6. What is the condition of biologically structured habitats and how is it changing?

Many organisms depend on the integrity of their habitats and that integrity is largely determined by the condition of particular living organisms. Coral reefs may be the best known examples of such biologically-structured habitats. Not only is the substrate itself biogenic, but the diverse assemblages residing within and on the reefs depend on and interact with each other in tightly linked food webs. They also depend on each other for the recycling of wastes, hygiene and the maintenance of water quality, among other requirements.

Kelp beds may not be biogenic habitats to the extent of coral reefs, but kelp provides essential habitat for assemblages that would not reside or function together without it. There are other communities of organisms that are also similarly co-dependent, such as hard-bottom communities, which may be structured by bivalves, octocorals, coralline algae, or other groups that generate essential habitat for other species. Intertidal assemblages structured by mussels, barnacles, algae and seagrass beds are other examples. This question is intended to address these types of places where organisms form structures (habitats) on which other organisms depend.

Good	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
Good/Fair	Selected habitat loss or alteration has taken place, precluding full development of living resources, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.
Fair	Selected habitat loss or alteration may inhibit the development of living resources and may cause measurable but not severe declines in living resources or water quality.
Fair/Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in some but not all living resources or water quality.
Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in most if not all living resources or water quality.

Habitat Contaminants

7. What are the contaminant concentrations in sanctuary habitats and how are they changing?

This question addresses the need to understand the risk posed by contaminants within benthic formations, such as soft sediments, hard bottoms, or biogenic organisms. In the first two cases, the contaminants can become available when released via disturbance. They can also pass upwards through the food chain after being ingested by bottom dwelling prey species. The contaminants of concern generally include pesticides, hydrocarbons and heavy metals, but the specific concerns of individual sanctuaries may differ substantially.

Good	Contaminants do not appear to have the potential to negatively affect living resources or water quality.
Good/Fair	Selected contaminants may preclude full development of living resource assemblages, but are not likely to cause substantial or persistent degradation.
Fair	Selected contaminants may inhibit the development of assemblages and may cause measurable but not severe declines in living resources or water quality.
Fair/Poor	Selected contaminants have caused or are likely to cause severe declines in some but not all living resources or water quality.
Poor	Selected contaminants have caused or are likely to cause severe declines in most if not all living resources or water quality.

Habitat
Human Activities

8. What are the levels of human activities that may influence habitat quality and how are they changing?

Human activities that degrade habitat quality do so by affecting structural (geological), biological, oceanographic, acoustic or chemical characteristics. Structural impacts include removal or mechanical alteration, including various fishing techniques (trawls, traps, dredges, longlines and even hook-and-line in some habitats), dredging channels and harbors and dumping spoil, vessel groundings, anchoring, laying pipelines and cables, installing offshore structures, discharging drill cuttings, dragging tow cables, and placing artificial reefs. Removal or alteration of critical biological components of habitats can occur along with several of the above activities, most notably trawling, groundings and cable drags. Marine debris, particularly in large quantities (e.g., lost gill nets and other types of fishing gear), can affect both biological and structural habitat components. Changes in water circulation often occur when channels are dredged, fill is added, coastal areas are reinforced, or other construction takes place. These activities affect habitat by changing food delivery, waste removal, water quality (e.g., salinity, clarity and sedimentation), recruitment patterns and a host of other factors. Acoustic impacts can occur to water column habitats and organisms from acute and chronic sources of anthropogenic noise (e.g., shipping, boating, construction). Chemical alterations most commonly occur following spills and can have both acute and chronic impacts.

Good	Few or no activities occur that are likely to negatively affect habitat quality.
Good/Fair	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.
Fair	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.
Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts have occurred or are likely to occur.

Living Resources
Biodiversity

9. What is the status of biodiversity and how is it changing?

This is intended to elicit thought and assessment of the condition of living resources based on expected biodiversity levels and the interactions between species. Intact ecosystems require that all parts not only exist, but that they function together, resulting in natural symbioses, competition and predator-prey relationships. Community integrity, resistance and resilience all depend on these relationships. Abundance, relative abundance, trophic structure, richness, H' diversity, evenness and other measures are often used to assess these attributes.

Good	Biodiversity appears to reflect pristine or near-pristine conditions and promotes ecosystem integrity (full community development and function).
Good/Fair	Selected biodiversity loss has taken place, precluding full community development and function, but it is unlikely to cause substantial or persistent degradation of ecosystem integrity.
Fair	Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
Fair/Poor	Selected biodiversity loss has caused or is likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity.
Poor	Selected biodiversity loss has caused or is likely to cause severe declines in ecosystem integrity.

Living Resources
Extracted Species

10. What is the status of environmentally sustainable fishing and how is it changing?

Commercial and recreational harvesting are highly selective activities, for which fishers and collectors target a limited number of species, and often remove high proportions of populations. In addition to removing significant amounts of biomass from the ecosystem, reducing its availability to other consumers, these activities tend to disrupt specific and often critical food web links. When too much extraction occurs (i.e. ecologically unsustainable harvesting), trophic cascades ensue, resulting in changes in the abundance of non-targeted species as well. It also reduces the ability of the targeted species to replenish populations at a rate that supports continued ecosystem integrity.

It is essential to understand whether removals are occurring at ecologically sustainable levels. Knowing extraction levels and determining the impacts of removal are both ways that help gain this understanding. Measures for target species of abundance, catch amounts or rates (e.g., catch per unit effort), trophic structure and changes in non-target species abundance are all generally used to assess these conditions.

Other issues related to this question include whether fishers are using gear that is compatible with the habitats being fished and whether that gear minimizes by-catch and incidental take of marine mammals. For example, bottom-tending gear often destroys or alters both benthic structure and non-targeted animal and plant communities. "Ghost fishing" occurs when lost traps continue to capture organisms. Lost or active nets, as well as lines used to mark and tend traps and other fishing gear, can entangle marine mammals. Any of these could be considered indications of environmentally unsustainable fishing techniques.

Good	Extraction does not appear to affect ecosystem integrity (full community development and function).
Good/Fair	Extraction takes place, precluding full community development and function, but it is unlikely to cause substantial or persistent degradation of ecosystem integrity.
Fair	Extraction may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
Fair/Poor	Extraction has caused or is likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity.
Poor	Extraction has caused or is likely to cause severe declines in ecosystem integrity.

Living Resources
Non-Indigenous Species

11. What is the status of non-indigenous species and how is it changing?

Non-indigenous species are generally considered problematic and candidates for rapid response, if found, soon after invasion. For those that become established, their impacts can sometimes be assessed by quantifying changes in the affected native species. This question allows sanctuaries to report on the threat posed by non-indigenous species. In some cases, the presence of a species alone constitutes a significant threat (certain invasive algae). In other cases, impacts have been measured and may or may not significantly affect ecosystem integrity.

Good	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).
Good/Fair	Non-indigenous species exist, precluding full community development and function, but are unlikely to cause substantial or persistent degradation of ecosystem integrity.
Fair	Non-indigenous species may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
Fair/Poor	Non-indigenous species have caused or are likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity.
Poor	Non-indigenous species have caused or are likely to cause severe declines in ecosystem integrity.

Living Resources
Key Species

12. What is the status of key species and how is it changing?

Certain species can be defined as "key" within a marine sanctuary. Some might be keystone species, that is, species on which the persistence of a large number of other species in the ecosystem depends - the pillar of community stability. Their functional contribution to ecosystem function is disproportionate to their numerical abundance or biomass and their impact is therefore important at the community or ecosystem level. Their removal initiates changes in ecosystem structure and sometimes the disappearance of or dramatic increase in the abundance of dependent species. Keystone species may include certain habitat modifiers, predators, herbivores and those involved in critical symbiotic relationships (e.g. cleaning or co-habitating species).

Other key species may include those that are indicators of ecosystem condition or change (e.g., particularly sensitive species), those targeted for special protection efforts, or charismatic species that are identified with certain areas or ecosystems. These may or may not meet the definition of keystone, but do require assessments of status and trends.

Good	Key and keystone species appear to reflect pristine or near-pristine conditions and may promote ecosystem integrity (full community development and function).
Good/Fair	Selected key or keystone species are at reduced levels, perhaps precluding full community development and function, but substantial or persistent declines are not expected.
Fair	The reduced abundance of selected keystone species may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity; or selected key species are at reduced levels, but recovery is possible.
Fair/Poor	The reduced abundance of selected keystone species has caused or is likely to cause severe declines in some but not all ecosystem components, and reduce ecosystem integrity; or selected key species are at substantially reduced levels, and prospects for recovery are uncertain.
Poor	The reduced abundance of selected keystone species has caused or is likely to cause severe declines in ecosystem integrity; or selected key species are a severely reduced levels, and recovery is unlikely.

Living Resources
Health of Key Species

13. What is the condition or health of key species and how is it changing?

For those species considered essential to ecosystem integrity, measures of their condition can be important to determining the likelihood that they will persist and continue to provide vital ecosystem functions. Measures of condition may include growth rates, fecundity, recruitment, age-specific survival, tissue contaminant levels, pathologies (disease incidence tumors, deformities), the presence and abundance of critical symbionts or parasite loads. Similar measures of condition may also be appropriate for other key species (indicator, protected or charismatic species). In contrast to the question about keystone species (#12 above), the impact of changes in the abundance or condition of key species is more likely to be observed at the population or individual level and less likely to result in ecosystem or community effects.

Good	The condition of key resources appears to reflect pristine or near-pristine conditions.
Good/Fair	The condition of selected key resources is not optimal, perhaps precluding full ecological function, but substantial or persistent declines are not expected.
Fair	The diminished condition of selected key resources may cause a measurable but not severe reduction in ecological function, but recovery is possible.
Fair/Poor	The comparatively poor condition of selected key resources makes prospects for recovery uncertain.
Poor	The poor condition of selected key resources makes recovery unlikely.

Living Resources
Human Activities

14. What are the levels of human activities that may influence living resource quality and how are they changing?

Human activities that degrade living resource quality do so by causing a loss or reduction of one or more species, by disrupting critical life stages, by impairing various physiological processes, or by promoting the introduction of non-indigenous species or pathogens. (Note: Activities that impact habitat and water quality may also affect living resources. These activities are dealt with in Questions 4 and 8, and many are repeated here as they also have direct effect on living resources).

Fishing and collecting are the primary means of removing resources. Bottom trawling, seine-fishing and the collection of ornamental species for the aquarium trade are all common examples, some being more selective than others. Chronic mortality can be caused by marine debris derived from commercial or recreational vessel traffic, lost fishing gear and excess visitation, resulting in the gradual loss of some species.

Critical life stages can be affected in various ways. Mortality to adult stages is often caused by trawling and other fishing techniques, cable drags, dumping spoil or drill cuttings, vessel groundings or persistent anchoring. Contamination of areas by acute or chronic spills, discharges by vessels, or municipal and industrial facilities can make them unsuitable for recruitment; the same activities can make nursery habitats unsuitable. Although coastal armoring and construction can increase the availability of surfaces suitable for the recruitment and growth of hard bottom species, the activity may disrupt recruitment patterns for other species (e.g., intertidal soft bottom animals) and habitat may be lost.

Spills, discharges, and contaminants released from sediments (e.g., by dredging and dumping) can all cause physiological impairment and tissue contamination. Such activities can affect all life stages by reducing fecundity, increasing larval, juvenile, and adult mortality, reducing disease resistance, and increasing susceptibility to predation. Bioaccumulation allows some contaminants to move upward through the food chain, disproportionately affecting certain species.

Activities that promote introductions include bilge discharges and ballast water exchange, commercial shipping and vessel transportation. Releases of aquarium fish can also lead to species introductions.

Good	Few or no activities occur that are likely to negatively affect living resource quality.
Good/Fair	Some potentially harmful activities exist, but they do not appear to have had a negative effect on living resource quality.
Fair	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.
Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts have occurred or are likely to occur.

Maritime Archaeological Resources Integrity

15. What is the integrity of known maritime archaeological resources and how is it changing?

The condition of archaeological resources in a marine sanctuary significantly affects their value for science and education, as well as the resource's eligibility for listing in the National Register of Historic Places. Assessments of archaeological sites include evaluation of the apparent levels of site integrity, which are based on levels of previous human disturbance and the level of natural deterioration. The historical, scientific and educational values of sites are also evaluated and are substantially determined and affected by site condition.

Good	Known archaeological resources appear to reflect little or no unexpected disturbance.
Good/Fair	Selected archaeological resources exhibit indications of disturbance, but there appears to have been little or no reduction in historical, scientific or educational value.
Fair	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, scientific or educational value and may affect the eligibility of some sites for listing in the National Register of Historic Places.
Fair/Poor	The diminished condition of selected archaeological resources has substantially reduced their historical, scientific or educational value and is likely to affect their eligibility for listing in the National Register of Historic Places.
Poor	The degraded condition of known archaeological resources in general makes them ineffective in terms of historical, scientific or educational value and precludes their listing in the National Register of Historic Places.

Maritime Archaeological Resources Threat to Environment

16. Do known maritime archaeological resources pose an environmental hazard and how is this threat changing?

The sinking of a ship potentially introduces hazardous materials into the marine environment. This danger is true for historic shipwrecks as well. The issue is complicated by the fact that shipwrecks older than 50 years may be considered historical resources and must, by federal mandate, be protected. Many historic shipwrecks, particularly early to mid-20th century, still have the potential to retain oil and fuel in tanks and bunkers. As shipwrecks age and deteriorate, the potential for release of these materials into the environment increases.

Good	Known maritime archaeological resources pose few or no environmental threats.
Good/Fair	Selected maritime archaeological resources may pose isolated or limited environmental threats, but substantial or persistent impacts are not expected.
Fair	Selected maritime archaeological resources may cause measurable, but not severe, impacts to certain sanctuary resources or areas, but recovery is possible.
Fair/Poor	Selected maritime archaeological resources pose substantial threats to certain sanctuary resources or areas, and prospects for recovery are uncertain.
Poor	Selected maritime archaeological resources pose serious threats to sanctuary resources, and recovery is unlikely.

Maritime Archaeological Resources
Human Activities

17. What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?

Some human maritime activities threaten the physical integrity of submerged archaeological resources. Archaeological site integrity is compromised when elements are moved, removed or otherwise damaged. Threats come from looting by divers, inadvertent damage by scuba diving visitors, improperly conducted archaeology that does not fully document site disturbance, anchoring, groundings, and commercial and recreational fishing activities, among others.

Good	Few or no activities occur that are likely to negatively affect maritime archaeological resource integrity.
Good/Fair	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.
Fair	Selected activities have resulted in measurable impacts to maritime archaeological resources, but evidence suggests effects are localized, not widespread.
Fair/Poor	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
Poor	Selected activities warrant widespread concern and action, as large-scale, persistent, and/or repeated severe impacts have occurred or are likely to occur.

Appendix B: Consultation with Experts and Document Review

The process for preparing condition reports involves a combination of accepted techniques for collecting and interpreting information gathered from subject matter experts. The approach varies somewhat from sanctuary to sanctuary, in order to accommodate differing styles for working with partners. The Monterey Bay National Marine Sanctuary approach was closely related to the Delphi Method, a technique designed to organize group communication among a panel of geographically dispersed experts by using questionnaires, ultimately facilitating the formation of a group judgment (Linstone and Turoff 1975). This method can be applied when it is necessary for decision-makers to combine the testimony of a group of experts, whether in the form of facts or informed opinion, or both, into a single useful statement.

The Delphi Method relies on repeated interactions with experts who respond to questions with a limited number of choices to arrive at the best supported answers. Feedback to the experts allows them to refine their views, gradually moving the group toward the most agreeable judgment. For condition reports, the Office of National Marine Sanctuaries uses 17 questions related to the status and trends of sanctuary resources, with accompanying descriptions and five possible choices that describe resource condition (Appendix A).

In order to address the 17 questions, sanctuary staff selected and consulted outside experts familiar with water quality, living resources, habitat, and maritime archaeological resources. A small workshop (23 participants) was convened where experts participated in facilitated discussions about each of the 17 questions. Experts represented various affiliations including Applied Marine Sciences, California Department of Fish and Game, California State University Monterey Bay, Center for Integrated Marine Technologies, Elkhorn Slough National Estuarine Research Reserve, Gulf of the Farallones National Marine Sanctuary, Monterey Bay Aquarium Research Institute, Monterey Bay National Marine Sanctuary, Monterey Maritime & History Museum, NOAA's Southwest Fisheries Science Center, Office of National Marine Sanctuaries, Partnership for Interdisciplinary Studies of Coastal Oceans, Regional Water Quality Control Board, Santa Cruz County Water Resources Program, The Nature Conservancy, U.S. Geological Survey, and University of California Santa Cruz.

At the workshop each expert was introduced to the questions, was then asked to provide recommendations and supporting arguments, and the group supplemented the input with further discussion. In order to ensure consistency with Delphic methods, a critical role of the facilitator was to minimize dominance of the discussion by a single individual or opinion (which often leads to "follow the leader" tendencies in group meetings) and to encourage the expression of honest differences of opinion. As discussions progressed, the group converged in their opinion of the rating that most accurately describes the current resource condition. After an appropriate amount of time, the facilitator asked whether the group could agree on a rating for the question, as defined by specific language linked to each rating (see Appendix A). If an agreement was reached, the result was recorded and the group moved on to consider the trend in the same manner. If agreement was not reached, the facilitator instructed sanctuary staff to consider all input and decide on a rating and trend at a future time, and to send their ratings back to workshop participants for individual comment.

The first draft of the document summarized the opinions and uncertainty expressed by the experts, who based their input on knowledge and perceptions of local conditions. Comments and citations received from the experts were included, as appropriate, in text supporting the ratings.

The first draft of the document was sent to the subject experts (including those who had been invited to the workshop but could not attend), the Monterey Bay National Marine Sanctuary Advisory Council and the Monterey Bay National Marine Sanctuary Research Activities Panel for what was called an Initial Review, a 21-day period that allows them to ensure that the report accurately reflected their input, identify information gaps, provide comments or suggest revisions to the ratings and text. Upon receiving those comments, the writing team revised the text and ratings as they deemed appropriate.

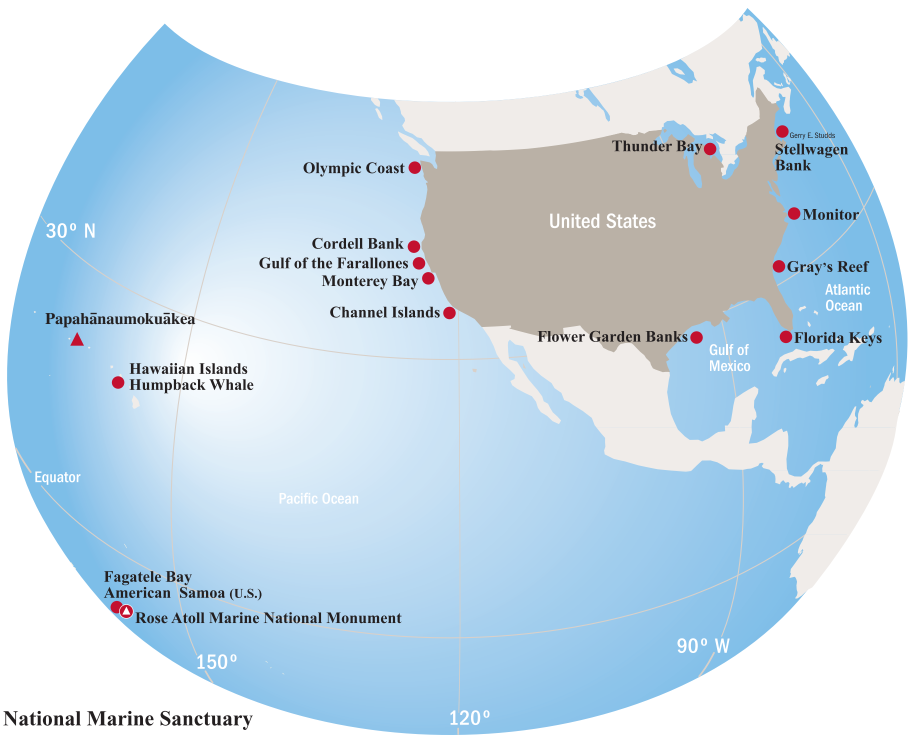
A draft final report was then sent to Dr. Chris Harrold (Monterey Bay Aquarium), Dr. Rikk Kvitek (California State University Monterey Bay), Ms. Karen Worcester (Central Coast Regional Water Quality Control Board). This External Peer Review is a requirement that started in December 2004, when the White House Office of Management and Budget (OMB) issued a Final Information Quality Bulletin for Peer Review (OMB Bulletin) establishing peer review standards that would enhance the quality and credibility of the federal government's scientific information. Along with other information, these standards apply to Influential Scientific Information, which is information that can reasonably be determined to have a "clear and substantial impact on important public policies or private sector decisions." The Condition Reports are considered Influential Scientific Information. For this reason, these reports are subject to the review requirements of both the Information Quality Act and the OMB Bulletin guidelines. Therefore, following the completion of every condition report, they are reviewed by a minimum of three individuals who are considered to be experts in their field, were not involved in the development of the report, and are not ONMS employees. Comments from these peer reviews were incorporated into the final text of the report. Furthermore, OMB Bulletin guidelines require that reviewer comments, names, and affiliations be posted on the agency website: http://www.cio.noaa.gov. Reviewer comments, however, are not attributed to specific individuals.

During the time period the report was being peer reviewed the document was also sent to particularly important partners in research and resource management, including NOAA's Marine Debris Program, the National Marine Sanctuary West Coast Regional Office and NOAA's National Marine Fisheries Service. These bodies were asked to review the technical merits of resource ratings and accompanying text, as well as to point out any omissions or factual errors. Following the External Peer Review the comments and recommendations of the reviewers were considered by sanctuary staff and incorporated, as appropriate, into a final draft document. In some cases sanctuary staff reevaluated the status and trend ratings and when appropriate, the accompanying text in the document was edited to reflect the new ratings. The final interpretation, ratings, and text in the draft condition report were the responsibility of sanctuary staff, with final approval by the sanctuary superintendent. To emphasize this important point, authorship of the report is attributed to the sanctuary alone. Subject experts were not authors, though their efforts and affiliations are acknowledged in the report.

Notes

THE NATIONAL MARINE SANCTUARY SYSTEM

The Office of National Marine Sanctuaries, part of the National Oceanic and Atmospheric Administration, serves as the trustee for a system of 14 marine protected areas encompassing more than 150,000 square miles of ocean and Great Lakes waters. The 13 national marine sanctuaries and one marine national monument within the National Marine Sanctuary System represent areas of America's ocean and Great Lakes environment that are of special national significance. Within their waters, giant humpback whales breed and calve their young, coral colonies flourish, and shipwrecks tell stories of our maritime history. Habitats include beautiful coral reefs, lush kelp forests, whale migrations corridors, spectacular deep-sea canyons, and underwater archaeological sites. These special places also provide homes to thousands of unique or endangered species and are important to America's cultural heritage. Sites range in size from less than one to almost 140,000 square miles and serve as natural classrooms, cherished recreational spots and are home to valuable commercial industries. The sanctuary system represents many things to many people and each place is unique and in need of special protections.



- National Marine Sanctuary
- Marine National Monument
- Proposed for sanctuary designation

Scale varies in this perspective.
Adapted from National Geographic maps.

NOAA — National Oceanic and Atmospheric Administration — U.S. Department of Commerce

National Marine Sanctuaries