2009 MONTEREY BAY NATIONAL MARINE SANCTUARY CONDITION REPORT

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The document that follows is a copy of the DRAFT Monterey Bay National Marine Sanctuary Condition Report that was disseminated to three individuals who served as peer reviewers. In December 2004, 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. Among other information, these standards apply to Influential Scientific Information (ISI), 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 report they are reviewed by a minimum of three individuals who are considered to be experts in the field, were not involved in the development of the report, and are not Office of National Marine Sanctuaries employees. 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 comments and suggested edits that were received from the reviewers are embedded in the below draft. The final Monterey Bay NMS Condition Report may be downloaded from: http://sanctuaries.noaa.gov/.

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Monterey Bay National Marine Sanctuary
Condition Report

Comment [kb1]: Once report is finalized all figures will be renumbered.

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Cover photo credits left to right:
Map: Bathymetric grids provided by: National Marine Sanctuary Program. 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

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Abstract

Abstract to be inserted once report is complete. The SBNMS abstract can be used as an example.

Monterey Bay National Marine Sanctuary

- *13,780 square kilometers*
- *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 and 94 species of seabirds*
- *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*

Deleted: *<#>Continued use for commerce, such as shipping, fishing and whale watching¶*

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.

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Monterey Bay National Marine Sanctuary Condition Summary Table

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.
- N/A Question not applicable.

Offshore Category

Condition Summary: The results in the following table are a compilation of findings from the "State of Sanctuary Resources" section of this report. (For further clarification of the questions posed in the table, please see Appendix A.) Because of the considerable differences within the sanctuary between the pressures, states and responses affecting estuarine, nearshore, and offshore environments this document breaks down status and trends to represent these three categories. The offshore category is defined as extending from the 30 meter isobath out to the offshore boundary of the Monterey Bay National Marine Sanctuary and including the seafloor and water column.

#	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?	—	PCBs and dieldrin have exceeded water quality standards, but insufficient data to document negative impacts.	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.	Vessel routing patterns reduce the risk of collisions and spills. Active water quality protection program is in place and involves planning, research, monitoring, education, and outreach. Proposed regulations limit discharges from cruise ships.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	—	Evidence for nutrient enrichment in selected areas potentially affecting phytoplankton communities.	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?	—	No known risks.	Conditions do not appear to have the potential to negatively affect human health.	
4	What are the levels of human activities that may influence water quality and how are they changing?	▲	Reduced risk due to regulations and contaminants removal from sunken ships.	Few or no activities occur that are likely to negatively affect water quality.	
HABITAT					
5	What is the abundance and distribution of major habitat types and how is it changing?	▲	Habitat loss and modification due to trawl fishing, but recent increases in total area closed to trawl fishing.	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 offshore areas are expected to reduce damage to bottom habitats. Installation of submerged cables is regulated and monitored. Proposed regulations to incorporate the Davidson Seamount into the sanctuary will increase protection of fragile structure-forming organisms, such as deep sea corals.
6	What is the condition of biologically-structured habitats and how is it changing?	▲	Loss of structure-forming and structure-building taxa due to trawl fishing, but recent increases in total area closed to trawl fishing	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 ecosystem level effects, but no attenuation of persistent pesticide levels.	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.	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.	
LIVING RESOURCES					

Comment [kb2]: Consider reformatting State section so it follows the same outlines as the table.

Comment [kb3]: See comment in text that an Ocean Plan violation is an indication of an impact to water quality. Ocean acidification is mentioned elsewhere (p 56) in the text as a rapidly changing condition of concern but is not considered in the Tables.

Comment [kb4]: Despite prohibitions on dumping, we regularly see oil slicks in offshore waters during our aerial surveys within MBNMS.

Comment [JB5]: Of concern to many us is the fact that the closures were gerrymandered to excluded the heavily trawled areas and include areas that the trawlers don't use. Thus the claim and prediction that these closures will improve conditions are weak ones.

Huff/Paul comments on trend in Question 5 and 6: because areas closed to trawling are not areas with historically high levels of trawling it seems that the arrows should be no trend – why would you expect an increasing trend?

Comment [kb6]: Closures will be in areas that are mostly currently not troubled. Existing trawl area will remain open, if I understand correctly.

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9	What is the status of biodiversity and how is it changing?	▼	Changes in relative abundance, particularly in targeted fish and by-catch species.	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.	Numerous areas are closed to trawl fishing. Research and monitoring programs supported by SIMoN focus heavily on addressing causes of impacts to living resources and evaluating the effectiveness of management actions.
10	What is the status of environmentally sustainable fishing and how is it changing?	▲	Most groundfish species are above management targets. Some groundfish species have been severely reduced. Improvements due to increased restrictions.	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?	—	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?	▼	Domoic acid and contaminants can cause acute and/or chronic impacts in higher trophic level species.	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?	▲	Extraction and habitat disturbance from fishing. Improving because of increased restrictions.	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?	?	To date, only one of potentially hundreds of archaeological site inventories has been conducted.		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.	

Comment [JB7]: Andrew: "With increased fishing regs, I thought it would be an upward trend" Huff/Paul: Considering impacts of take/habitat disturbance from fishing –FAIR condition may be more accurate.

Comment [kb8]: Truth is, we don't know. It's hard to imagine that 50-80% of unfished biomass can be removed without some degradation of ecosystem integrity. Best to say "unknown effect on ecosystem integrity."

Paul/Huff: need to consider the impacts to ecosystem structure and function of removal of 60% of biomass of many fished species. Seems this condition rating may be too generous.

Comment [kb9]: This is a tricky one, but in the CA current, climate variation has a tremendous effect on the habitat quality for pelagic animals such as seabirds and marine mammals. We are not presently able to tease out natural vs. anthropogenic climate variation, but human-caused climate change is likely to contribute to changes in habitat quality in the future. In recent years 'anomalous' patterns of upwelling have lead to seabird breading failures and a decrease in local abundance of planktivorous marine mammals such as blue whales (See Peterson et al 2005 State of the California Current, CalCOFI report). I am not sure that the table'/s statement that 'effects are localized, not widespread' is true, nor that the up arrow (indicating improvements) is necessarily true for the offshore category.

Comment [kb10]: Since both Steve and Chris H were confused by "hundred of inventories".

Comment [JB11]: "How can this be yellow here but dark green in the nearshore? If we are talking oil in sunken ships, then I think the rank in the nearshore is a mistake.

Comment [kb12]: Inconsistent with green rating.

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Monterey Bay National Marine Sanctuary Condition Summary Table

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.
- N/A Question not applicable.

Nearshore Category

Condition Summary: The results in the following table are a compilation of findings from the "State of Sanctuary Resources" section of this report. (For further clarification of the questions posed in the table, please see Appendix A.) Because of the considerable differences within the sanctuary between the pressures, state and responses affecting estuarine, nearshore, and offshore environments this document breaks down status and trends to represent these three categories. The nearshore category is defined as extending from the shoreline boundary of the Monterey Bay National Marine Sanctuary (mean high water) to the 30 meter isobath and including the seafloor and water column.

#	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 numerous contaminants in localized areas, especially near river mouths and outflows.	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. Draft 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?	—	Clear evidence for localized nutrient enrichment; isolated incidents of fish kills and 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?	—	Unpredictable, periodic beach closures due to *E. coli;* consumption of contaminated shellfish at some locations.	Selected conditions have resulted in isolated human impacts, but evidence does not justify widespread or persistent concern.	
4	What are the levels of human activities that may influence water quality and how are they changing?	▼	Increasing pressures from urbanization and changing agricultural 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?	—	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 resources 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. Draft management plan increases focus on coastal development through the coastal armoring, desalination, dredging action plans. Provides support for 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?	—	No evidence of ecosystem level effects; but no attenuation of persistent pesticide levels.	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?	—	Trampling, all forms of extraction, and sediment disposal can have measurable, localized impacts.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.	
LIVING RESOURCES					

Comment [JB13]: I think MBARI has documented a trend in the nearshore phytoplankton community away from diatoms and towards dinoflagelates. I believe there is some evidence that urea may play a role in this species composition change. Raphael Kudela or Mary Silver at UCSC could provide some info on the connections between nitrogen loading and nearshore phytoplankton community composition. The last three years have been characterized by exceptionally persistent summer red tides, especially in the nearshore areas at the north end of the bay. It's not known, to my knowledge, whether the dinoflagelate blooms are related to human health, but there's plenty of anecdotal information of ear aches and stomach aches related to the recent red tides. Maybe the Santa Cruz Surfrider Foundation could provide a statement. I would downgrade the rating for nearshore eutrophic conditions to good/fair and getting worse, primarily because of the increasing red tides.

Comment [kb14]: We have no information on many currently applied pesticides (e.g. the pyrethroid group) in marine waters; little data on emerging contaminants (e.g. PBDE found recently in sea otter tissue.)

Comment [kb15]: Two marine mammal species, bottlenose dolphins and (transient) killer whales, have very high tissue loads of persistent contaminants such as PCBs and DDT. Bottlenose dolphins inhabit the nearshore region, transient killer whales roam widely in offshore waters. Sea otters, in the nearshore zone, also have high exposure to contaminants, which is thought to contribute to their high mortality rates.

Comment [kb16]: Trampling can cause significant localized effects on intertidal habitat quality. Perhaps qualify this statement? "they appear to have had only localized negative effects on habitat quality…."

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9	What is the status of biodiversity and how is it changing?	▼	Fishing and collecting have reduced overall biodiversity; continued declines at some locations on rocky shores	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.	Research and monitoring programs supported by SIMoN focus heavily on addressing causes of impacts to living resources and evaluating the effectiveness of management actions. On-water and on-shore interpreters help visitors reduce impacts to wildlife. Draft management plan increases focus on conservation of living resources through the Marine Protect Area, Introduced Species, and Wildlife Disturbance action plans.
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.	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?	▼	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. Draft 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.	

Comment [JB17]: concern about fishery management targets potentially leading to ecosystem impacts applies here as well.

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Monterey Bay National Marine Sanctuary Condition Summary Table

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.
- N/A Question not applicable.

Estuarine Category

Condition Summary: The results in the following table are a compilation of findings from the "State of Sanctuary Resources" section of this report. (For further clarification of the questions posed in the table, please see Appendix A.) Because of the considerable differences within the sanctuary between the pressures, states and responses affecting estuarine, nearshore, and offshore environments this document breaks down status and trends to represent these three categories. Though many small estuaries occur along the central California coastline, Elkhorn Slough is the only estuary into which the boundaries of the Monterey Bay National Marine Sanctuary extend.

#	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?	—	Agricultural inputs (freshwater, sediments, associated pollutants) have been documented at high levels; few studies of impacts but sensitive species are likely to be affected.	Selected conditions may inhibit the development of assemblages, and may cause measurable but not severe declines in 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?	—	Very high nutrient concentrations are observed but strong tidal flushing dilutes concentrations; hypoxia is sometimes observed.	Selected conditions may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources or habitats.	
3	Do sanctuary waters pose risks to human health?	—	Shellfish and fish that are harvested may contain levels of contaminants that pose risks to humans.	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?	—	The Sanctuary waters receive substantial agricultural inputs. Implementation of best management practices has been increasing, but no evidence yet of improving water quality conditions.	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?	▼	Habitat loss due to ongoing tidal erosion.	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?	▼	Native structure-forming organisms reduced 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?	—	High localized levels of contaminants; limited evidence of community level impacts.	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?	—	Creation of harbor mouth, diking and river diversion.	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.	
LIVING RESOURCES					

Comment [JB18]: questions a number of the water quality assessments for elkhorn slough – see text in State section for details

Comment [kb19]: Your text implies conditions may be expected to get worse given increasing population pressures.

Comment [kb20]: Is the Old Salinas River drainage and Harbor considered part of the area of interest? If so, there is documented significant toxicity here and at locations in Harbor. Nitrate levels are as high as anywhere in the world. That entire arm entering the Harbor is in very poor condition. I would say water quality there is severely impacted and has a significant influence on the rest of the estuary.

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9	What is the status of biodiversity and how is it changing?	—	Loss of eelgrass and some replacement of native species by non-native species, but overall high biodiversity.	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.	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 take of shellfish and mudflat invertebrates in the lower Slough as well as fishing and hunting. The impacts have not been documented.	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, but 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?	▼	Oyster and eelgrass declines.	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.		
14	What are the levels of human activities that may influence living resource quality and how are they changing?	—	Agricultural inputs, changes in land use, entrainment in power plant intakes.	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?	?	Very little is known for this area		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.	

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About This Report

This report provides a summary of resources in the National Oceanic and Atmospheric Administration's Monterey Bay National Marine Sanctuary, pressures on those resources, the current condition and trends, and management responses to the pressures that threaten the integrity of the marine environment. Specifically, this 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 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. Evaluations of status and trends were made by sanctuary staff in consultation with outside experts familiar with the resources and with knowledge of previous and current scientific investigations. The ratings reflect the collective interpretation of the status of local issues of concern among sanctuary program staff and outside experts based on their knowledge and perceptions of local problems. Similar reports summarizing resource status and trends will be prepared for each marine sanctuary approximately every five years and updated as new information allows. This information is intended to help set the stage for management plan reviews at each site and to help sanctuary staff identify monitoring, characterization and research priorities to address gaps, day-to-day information needs and new threats. 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.

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Introduction

The National Marine Sanctuary Program manages marine areas in both nearshore and open ocean waters that range in size from less than one to almost 362,600 square kilometers. Each area has its own concerns and requirements for environmental monitoring. Nevertheless, 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 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 (National Marine Sanctuary Program 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.

Assuming that a common marine ecosystem framework can be applied to all places, it follows that there may be a number of questions that can be posed at all sites and used as evaluation criteria to assess resource condition and trends. The questions, which are shown on page iii and explained in Appendix A are derived from both a generalized ecosystem framework and from the National Marine Sanctuary Program mission. They are widely applicable across the system of areas managed by the sanctuary program and are posed to all sanctuaries in order to provide a tool by which the program can measure its progress toward maintaining or improving natural and archaeological resource quality throughout the system.

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Site History and Resources

Overview

The Monterey Bay National Marine Sanctuary (reference to map) is the largest national marine sanctuary and second largest marine protected area in the United States (the recently designated Papahanaumokuakea Marine National Monument is the largest). The sanctuary includes nearly 450 kilometers of shoreline from Marin County in the north to Cambria in the south (about one-fourth of the California coast). It encompasses 13,780 square kilometers of ocean extending an average distance of 32 kilometers from shore. At its deepest point the sanctuary reaches a depth of 3,220 meters (two miles).

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 tiny microscopic plants 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.

Monterey Bay sanctuary is located along the coast of central California and extends an average of 32 km offshore. It shares its northern boundary with the Gulf of the Farallones National Marine Sanctuary. Map: T. Reid, NOAA/GFNMS

Maritime archaeological resources abound as well. Records indicate that 445 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, 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.
http://www.montereybay.noaa.gov/resourcepro/resmanissues/culturalres.html#SCR

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. 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. They subsisted through collection of acorns and shellfish, and hunting of birds, fish, small mammals, seals, and sea lions. In 1603 the Spanish briefly explored and named Monterey Bay, but settlement of the area did not begin until 1770. The Spanish built missions at Santa Cruz, Monterey and Carmel. (Terrell 2007)

Within decades of Spanish settlement, Monterey had became 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. 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. 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 trade commodity in the region, a pattern that continued well into the 20th century. (Terrell 2007)

Designation of the Sanctuary

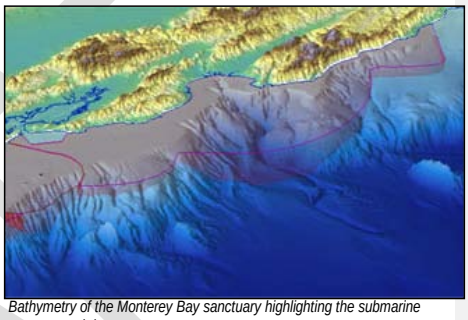
In 1977 the State of California nominated Monterey Bay and nine other locations along the Pacific Coast for consideration as national marine sanctuaries. Based on favorable public response, three of these sites were declared active candidates for designation - Monterey Bay, Channel Islands, and Point 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.

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, the Monterey Bay National Marine Sanctuary was officially designated on September 18, 1992. (NMSP 2002)

Geology

The Monterey Bay sanctuary contains one of the world's most geologically diverse and complex seafloors and continental margins (reference to map). 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.



Bathymetry of the Monterey Bay sanctuary highlighting the submarine canyons and deep sea.

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 and Gabilan mountain ranges dominate 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 km. The broad, extensive Salinas Valley and the Santa Lucia Range 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 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.

Comment [kb21]: Do you mean Big Sur River? It is a much larger watershed than the Little Sur

The Monterey Bay sanctuary seafloor can be divided into three segments based on geology. 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 km wide, and contains a very narrow, moderately dissected continental shelf.
http://www.montereybay.noaa.gov/sitechar/geol.html

The beaches of the Monterey Bay sanctuary are popular destination for sun bathers and swimmers. Photo: B. Damitz, NOAA/MBNMS

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, abundance of 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 fisheries are all contributors to regional economy with direct links to the sanctuary.

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. 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. More than 600 commercial vessels annually fish within the Monterey Bay National Marine Sanctuary boundaries. Most fishes caught within the sanctuary are landed at the five main ports: Princeton/Half Moon Bay, Santa Cruz, Moss Landing, Monterey, or Morro Bay. In 2003, ex-vessel revenues for landings at these five ports totaled almost $16.6 million paid to commercial fishers. Additional revenue is generated from the businesses associated with fishing operations, including marinas, maintenance operations, and equipment. (JMPR)

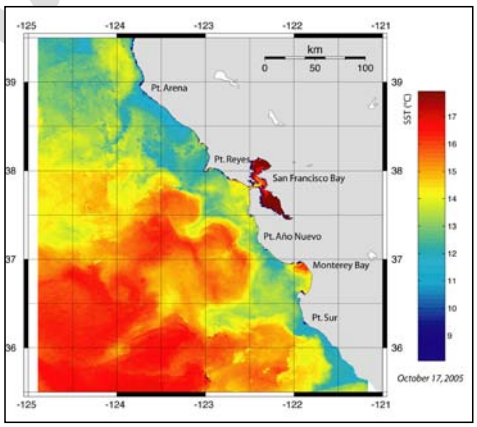
Container ships traveling between major shipping ports in southern California and San Francisco transit through the offshore waters of the Monterey Bay National Marine Sanctuary. Image: N. Capps, NOAA/MBNMS.

Other sanctuary-related industries include aquaculture, kelp harvesting, sand mining, and commercial shipping. The rich biodiversity and close proximity of the deep sea also provide unparalleled research opportunities for approximately twenty-five marine science facilities that, in 2004, employed almost 2,000 people (staff and researchers) with a combined budget of over $200 million. This includes government agencies, public and private university research institutions, and private facilities such as the Monterey Bay Aquarium. (NMSP 2002)

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 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 between mid-March and 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. Two upwelling centers are located in the Monterey Bay sanctuary: one near Point Año Nuevo and one near Point Sur.



A satellite image of sea surface temperature (°C) along the central California Coast from October 2005. Image: R. Kudela, UCSC.

The oceanic season generally occurs between mid-August and 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 between late November and 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.

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. We are currently in the cool phase.
http://www.montereybay.noaa.gov/sitechar/phys2.htm

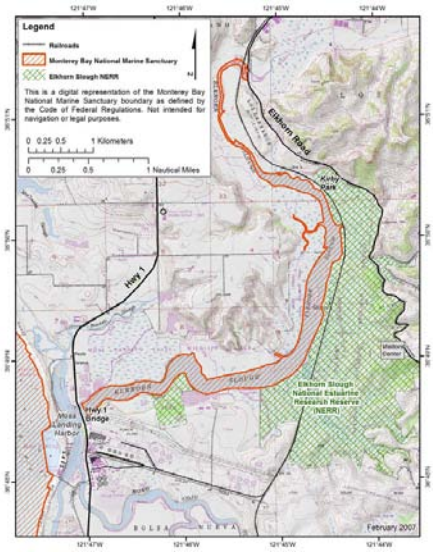
Habitats

The 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.



Monterey Bay National Marine Sanctuary (orange hatched area) includes Elkhorn Slough east of the Hwy 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 (green hatching). Map: NOAA/MBNMS/SIMoN

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 vascular algae and plant species, over 100 fishes, more than 340 bird species, and over 550 invertebrate species that inhabit the slough. 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 leopard sharks and California halibut. The main channel of Elkhorn Slough, which snakes more than 10 km inland, is the only estuarine habitat located inside the boundaries of the Monterey Bay sanctuary (reference to map). (Caffrey et al. 2002)

Comment [kb22]: Why isn't SF Bay covered in this description? The mouth of SF Bay may not be adjacent to the MBNMS boundary, but SF Bay certainly influences MBNMS resources.

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 deep, marine lagoon with strong daily tidal currents and substantially altered distribution of estuarine habitat types. 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)

Three Mile Beach at Wilder Ranch State Park. Photo: J. Pederson, NOAA/MBNMS/SIMoN

Nearshore

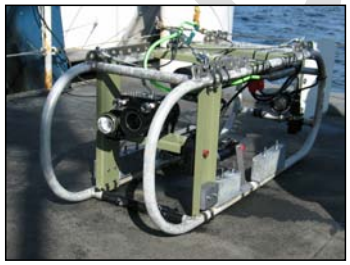
Beaches are one of the most visible and popular sanctuary habitats. Every year travelers from around the world come to enjoy the natural scenery, wildlife, and recreation that our beaches offer. Sand beaches represent half the intertidal habitat in the sanctuary. Included are long exposed beaches, protected 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. http://www.montereybay.noaa.gov/sitechar/sandy.html

Rocky shoreline comprises the other half of the coastline. 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 biology they developed has 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 phenomena. 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. http://www.montereybay.noaa.gov/sitechar/rocky.html

Coastal area south of Rocky Point on the Big Sur coast. Giant kelp can be seen on the surface of the water. Photo: J. Pederson, NOAA/MBNMS./SIMoN

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 at depths of two to more than thirty meters. 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. http://www.montereybay.noaa.gov/sitechar/kelp.html

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 kelps 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. http://www.montereybay.noaa.gov/sitechar/kelp.html



Technology, such as camera sleds, are used to study the distribution and abundance of habitats and species in the sanctuary. Photo: T. Anderson. NOAA

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 http://www.mbnms-simon.org/sections/sandyFloor/overview.php?sec=sf

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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 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 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.
http://www.mbnms-simon.org/sections/deepSea/overview.php?sec=ds

*Big Red Jelly (*Tiburonia granrojo*), a newly named and described species, was found slightly above the Davidson Seamount crest at 1,363 meters. Photo: NOAA/MBARI*

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 sometimes congregate in the canyon head or along canyon edges. http://www.mbnms-simon.org/sections/submarineCanyons/overview.php?sec=sc

The ROV Tiberon *is a remotely operated vehicle used to explore the midwater and deep sea habitats in the Monterey Bay region. Photo: R. Schwemmer, NOAA*

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 zone. 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.
http://www.mbnms-simon.org/sections/deepSea/overview.php?sec=ds

The midwater habitat and its inhabitants are currently being studied with remotely operated vehicles (ROVs) to develop a dynamic model of the community. 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.

Surfgrass and algae covered rocks at Pt. Pinos. Photo: C. King, NOAA/MBNMS/SIMoN

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 lettuce and sea hair, grow in the high intertidal flat, especially in tidal pools. Eelgrass 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 river mouths and estuaries. A variety of herbaceous plants, including pickleweed, saltgrass, cattails, sedges, and rushes, grow in salt marshes.

Along the rocky coast, certain types of algae tend to be found in different tidal height zones. Rockweed, a type of brown algae, and low growing, bushy red algae are the most common indicators of the high intertidal zone. Dense patches upright, calcified forms of red algae, called coralline algae, typically dominate the middle intertidal zone. The presence of surfgrass and brown algae, such as the southern sea palm and smaller kelps, are indicators of the low intertidal zone.

In the subtidal zone, a rich algal assemblage is associated with the kelp forest. Beneath the surface canopies formed by the giant and bull kelps there are many species of understory kelps. 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. http://montereybay.noaa.gov/sitechar/kelp2.html

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 (John Pearse, pers. comm.) and 204 species of invertebrates were found living in one kelp forest along the exposed coastline south of Carmel (http://www.montereybay.noaa.gov/sitechar/kelp3.html#3a). 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 are found primarily attached to hard structure (e.g., mussels, barnacles, sponges, tunicates, corals) or in soft sediments (e.g., sea pens, sea whips, clams). Invertebrates that are more mobile, such as snails, sea stars, sea urchins, octopus, and crabs, tend to prefer either rocky or soft bottom, 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 and Davidson Seamount (J. Connor, MBARI, pers. comm.).

Hopkin's Marine Life Refuge in Monterey Bay. Photo: S. Lonhart, NOAA/MBNMS?SIMoN

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 specialized fishes, such as gunnels, pricklebacks, and tidepool sculpins, are found in tide pools along the rocky coast. Rockfishes (of the genus *Sebastes*) compose a very diverse group found in many subtidal habitats in the sanctuary, but they are especially common on rocky reefs. Flatfish (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).

A copper rockfish on the rocky reef at Whaler's Cove, Point Lobos . *Photo: C. King, NOAA/MBNMS/SIMoN*

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 m. 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.
http://montereybay.noaa.gov/resourcepro/resmanissues/wildlife.html

Seabirds and Shorebirds

Sanctuary waters are among the most heavily used by seabirds worldwide. Ninety-four species of seabird are known to occur regularly within and in the vicinity of the sanctuary, and approximately 90 species of tidal and wetland birds occur on the shores, marshes, and estuaries bordering sanctuary waters (http://www.montereybay.noaa.gov/sitechar/bird1.html). 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 support highly productive food webs, which provide abundant seabird 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.
http://montereybay.noaa.gov/resourcepro/resmanissues/wildlife.html

Adult and juvenile brown pelicans roost at Natural Bridges State Beach. Photo: J. Pederson, NOAA/MBNMS/SIMoN

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), twenty-seven species of cetaceans (whales, dolphins, and porpoises), and one species of fissipeds (sea otter). Presently, approximately 82% of the southern sea otter population occurs within the sanctuary (Tinker et al. 2006).

A harbor seal hauls out onto a rock along Cannery Row. Photo: S. Lonhart, NOAA/MBNMS/SIMoN

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 - 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 twenty-seven 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 to feed during the summer and fall (e.g., blue and humpback whales). Movements of smaller cetaceans probably are 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. Relatively little is known about most of the other cetacean populations.

Endangered and Threatened Species

Twenty-five species that use resources in the sanctuary are listed by the U.S. federal government as endangered or threatened. Ten 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 newly listed species are the Western Snowy Plover, the Marbled Murrelet, winter and spring runs of Chinook salmon, central coast and south central coast steelhead, and the tidewater goby. 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 under review for downlisting or delisting.

Maritime Archaeological Resources

Submerged archaeological resources include shipwrecks, aircraft, wharfs 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.
http://montereybay.noaa.gov/resourcepro/resmanissues/culturalres.html

USS Macon *(ZRS-5) Airship 1933-1935. Photo: U.S. Naval Historical Center/National Archives.*

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*. 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 MBNMS. The remains of the *Macon* provide an opportunity to study the relatively undisturbed archeological remnants of a unique period in aviation history. http://montereybay.noaa.gov/research/macon/welcome.html

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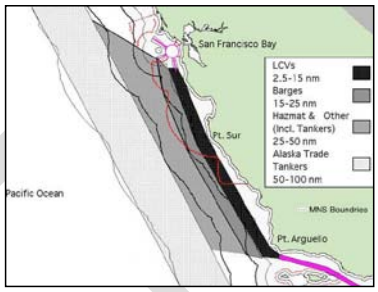
Pressures on the Sanctuary

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 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% of these transits are crude oil tankers. The majority of the remainder are 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 (reference map) 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 potential impacts can be enormous given the number and volume of these vessels and the potential size of a spill.
http://montereybay.noaa.gov/resourcepro/resmanissues/vessels.html



The pattern of vessel traffic transiting the Monterey Bay sanctuary at the time of sanctuary designation. Vessels are separated into four groups: Large commercial vessels (black), barges (dark grey), hazmat and other (grey), and Alaska Trade Tankers (light grey).

Military Use

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.
http://montereybay.noaa.gov/resourcepro/resmanissues/military.html

Squid fishing boat in Moss Landing Harbor. Photo: R. Stamski, NOAA/MBNMS/SIMoN

Commercial and Recreational Fishing

Fishing is a critical part of the culture and economy of the sanctuary, with more than 600 commercial vessels fishing in the region annually, along with substantial recreational fishing. About 200 species are typically caught in the commercial and recreational fisheries, with the bulk of the commercial landings composed of squid, rockfishes, salmon, albacore, Dover sole, sablefish, mackerel, anchovy, and sardines. The five primary gear types used are pots and traps, trawl nets, hook-and-line gear, purse seines, and gill nets. Although some local stocks appear healthy, resource managers are concerned about declines of certain stocks, habitat threats from some fishing gears, bycatch of non-target species, and ecosystem-level impacts of removal of important members of the food chain, such as forage species or top predators.
http://montereybay.noaa.gov/resourcepro/resmanissues/fishing.html

Water Quality

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. These areas receive rainfall and irrigation water, picking up a variety of pollutants, ultimately delivering them to streams, rivers, wetlands, and the sanctuary. Potential problems include: elevated nutrient levels (e.g., nitrate, urea), sedimentation, persistent pesticides (e.g., DDT and toxaphene), currently applied pesticides, oil and grease, metals, detergents, suspended solids, and bacterial and protozoan contamination. These contaminants can have a variety of biological impacts including bioaccumulation, toxicity, reproductive anomalies, reduced recruitment of anadromous species, algal blooms, morbidity and mortality to marine mammals, transfer of human pathogens and interference with recreational uses of the sanctuary due to beach closures.

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. http://montereybay.noaa.gov/resourcepro/resmanissues/beach.html

Beach closure sign warning of high bacteria levels at Cowell's Beach in Santa Cruz. Photo: R. Stamski, NOAA/MBNMS/SIMoN

Harmful Algal Blooms:
Populations of naturally occurring toxic algae occasionally grow to very high concentrations (blooms) in the sanctuary and produce extremely potent biotoxins. These events, termed harmful algal blooms, have led to mortalities in marine mammal and seabird populations, including forty-seven sea lion deaths in 1998.

Marinas and Boats:
Water pollution from activities associated with marinas and boating within the sanctuary is also a threat to 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.

A cruise ship anchored inside of Monterey Bay. This anchoring site is one of two designated by MBNMS that avoid sensitive habitat. Passengers are ferried to the streets of Monterey via a boat tender. Photo: C. King, NOAA/MBNMS/SIMoN

Cruise Ships:
Large cruise ships began visiting Monterey in 2002. 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. http://montereybay.noaa.gov/resourcepro/resmanissues/cruiseships.html

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. http://montereybay.noaa.gov/resourcepro/resmanissues/emergency.html

Coastal Development

The power plant in Moss Landing contains a seawater distillation plant that produces fresh water for use in the power production process. Photo: NOAA/MBNMS

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; 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. http://montereybay.noaa.gov/resourcepro/resmanissues/desalination.html

Dredging and Dredge Disposal
Periodic dredging of the local harbors is necessary to continue to allow access for vessels. There are four major harbors within the Monterey Bay National Marine Sanctuary, three of which conduct regular dredging activity. The Santa Cruz Harbor has a

permit to dispose of 350,000 cubic yards of clean, sandy material on an annual basis. The harbor disposes of this dredged material in the subtidal area adjacent to Twin Lakes State Beach, above mean high water at Twin Lakes State Beach, as well as the Marina landfill. Moss Landing Harbor has typically disposed of 50,000 to 150,000 cubic yards of dredge material per year at approved dredge sites as well as the Marina landfill, for material that was not suitable for aquatic disposal. The Monterey Harbor has dredged 4000 cubic yards of material on a sporadic basis in recent years. Monterey Harbor has occasionally made use of the historic dredge disposal area adjacent to Wharf 2, the area above mean high tide for beach replenishment, as well as the Marina landfill. Pillar Point Harbor has historically had little need for dredging, though that status may change in the future.

Dredging, which is used to improve access to harbors for vessels, poses some threats to benthic communities. Photo: NOAA/MBNMS

Dredging can pose a threat to 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. The disposal of dredge material can smother organisms at the disposal site. Disposal of dredge material can also 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. http://montereybay.noaa.gov/resourcepro/resmanissues/dredge.html

Erosion and Coastal Armoring

About 85% of the California coast experiences active erosion due to natural and anthropogenic causes. Ongoing erosion, which is largely a natural occurrence, presents a threat to coastal development that has occurred in areas vulnerable to these processes. Shoreline protective structures have been used extensively in the sanctuary to protect infrastructure and other development from wave action, or to retain soil to avoid erosion. This practice is commonly known as coastal armoring. The trends in Santa Cruz and Monterey counties are typical of the state. By 1998, coastal armoring had been installed to protect about twelve percent (or almost one-eighth) of the coastline statewide. With increases in development and continued natural erosion of coastal bluffs, 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.

Exposed cliffs are reinforced to slow erosion caused by wave action. Photo: NOAA/MBNMS

http://montereybay.noaa.gov/resourcepro/resmanissues/coastal.html

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. http://montereybay.noaa.gov/resourcepro/resmanissues/landslide.html

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 upon them directly, or by out-competing them for food or habitat space. Once established, non-indigenous species can be difficult to eradicate. Non-indigenous species

The Asian kelp Undaria pinnatifida *is a non-indigenous species that occurs on floating docks in Monterey harbor. Photo: S. Lonhart, NOAA/MBNMS/SIMoN*

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)

Probably the most important mechanism for the introduction of aquatic species world-wide is transport in ship ballast tanks, though other mechanisms such as introduction through improper disposal of aquarium materials, bait and seafood packing materials, aquaculture operations, and research activities can 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.

Terrestrial non-indigenous species, though they do not occur within the boundaries of the sanctuary, 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 seabirds colonies. The feces of the non-indigenous opossum is the main sources of the parasite *Sarcocystis neurona*, one of the most important infectious diseases affecting sea otters.
http://montereybay.noaa.gov/resourcepro/resmanissues/invasive.html

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 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.
http://montereybay.noaa.gov/resourcepro/resmanissues/wildlife.html

Kayaking is a popular way to enjoy the costal habitats of the sanctuary. Here kayakers explore Elkhorn Slough. Photo: R. Stamski. NOAA/MBNMS/SIMoN

Motorized and Non-motorized Vessels:

The use of motorized or non-motorized vessels (outboard or inboard 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 include 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. Also, 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 pilot's lack of understanding and acknowledgement of the zones.

Kelp is harvested in the Sanctuary at a variety of locations, to sustain aquaculture operations and to be turned into a variety of products. Photo: NOAA/MBNMS

Commercial Harvesting and Aquaculture Activities:

Commercial harvesting of certain fish 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 the entire filament of all lights used to attract squid to be shielded in order to reduce light scatter and decrease potential wildlife disturbance. Kelp harvesting may involve potential disturbance of various fauna associated with the kelp ecosystem. Certain

species such as sea otters could be prone to harassment by harvesting operations in the kelp beds. [http://montereybay.noaa.gov/resourcepro/resmanissues/kelp.html]

Acoustic Impacts:
Noise levels in the marine environment have been increasing. Anthropogenic sources of noise include large commercial shipping traffic (e.g., container ships, freighters, barges and tankers), recreational and commercial vessels, military low frequency testing, and research activities. A number of studies document impacts to living marine resources, including behavioral changes and physical effects due to exposure to anthropogenic noise and pressure waves in the marine environment. Projects like the Navy's Low Frequency Acoustics and the expansion of a Navy bombing range in Big Sur have elevated concerns. [http://montereybay.noaa.gov/resourcepro/resmanissues/acoustic.html]

A collection of fishing floats and beverage containers were collected on San Luis Obispo coast beaches in late March and early April 2006. Photo: San Luis Obispo Tribune News http://www.mbnms-simon.org/other/moreLinks/sporadic_asian_floats.php

Marine Debris:
Levels of debris in both the ocean and at the land-sea interface are of growing concern. Various types of debris are known to have adverse effects on marine species. Plastics in the marine environment never fully degrade and recent studies show plastic is consumed by organisms at all levels of the marine food web. DDT and other hydrophobic compounds are known to adhere to plastics. Ingestion and entanglement are two of the many problems associated with marine debris, and may lead to death for many organisms. Types of marine debris of particular concern include balloons, abandoned/ discarded fishing gear, plastics and Styrofoam, and consumer goods (e.g., 6-pack rings, plastic shopping bags, beverage bottles).

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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. For each, sanctuary staff and selected outside experts considered a series of questions about each resource area. The set of questions derive from the National Marine Sanctuary Program mission, and a system-wide monitoring framework (National Marine Sanctuary Program, 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. The questions are meant to set the limits of judgments so that responses can be confined to certain reporting categories that will later be compared among all sanctuary sites, and combined. 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.

Because of the considerable differences within the sanctuary between the environmental pressures, states and responses affecting estuarine, nearshore, and offshore environments, each question was answered separately for each of these categories. The nearshore category was defined as extending from the shoreline boundary of the Monterey Bay National Marine Sanctuary (mean high water) to the 30 meter isobath and the offshore category as extending from the 30 meter isobath out to the offshore boundary of the sanctuary. The only estuarine habitat within the boundaries of the sanctuary is the main channel and some larger side channels in Elkhorn Slough.

Water Quality
Offshore Category

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

Comment [kb23]: suggest that we add a sentence to the beginning of each section explaining that explanatory text follows each table.

Offshore Water Quality Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Stressors	—	PCBs and dieldrin have exceeded water quality standards, but insufficient data to document negative impacts.
Eutrophic Condition	—	Evidence for nutrient enrichment in selected areas potentially affecting phytoplankton communities.
Human Health	—	No known risks.
Human Activities	▲	Reduced risk due to regulations and contaminant removal from sunken ships.

Comment [kb24]: ▼?

Comment [kb25]: The text seems to support that conditions are getting worse.

- *Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?*

Stressors on the water quality in the offshore environment are considered to be good/fair and not changing. Some contaminants and pathogens are detected at elevated levels in offshore waters and sediments. For example, water samples collected by the CCLEAN program show that sites about five miles offshore in northern and southern Monterey Bay exceed the water quality

Comment [kb26]: pH is falling (rise in acidity) has been reported for deep waters. May have been reported for Monterey Bay. Check MBARI scientists/web site. If no, could have significant impact on marine life, from primary producers such as phytoplankton to large, active carnivores such as tuna.

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standards for PCBs (reference figure) and dieldrin (a persistent, bioaccumulative, toxic insecticide that was used from 1950 to 1974) set forth by the California Ocean Plan (CCLEAN Program Overview, in prep). However, there is insufficient data to evaluate the potential negative impacts these contaminants have on the living resources in the sanctuary. In general, ecological effects are more difficult to measure because they are the result of complex interactions among biological and environmental factors and may not manifest themselves as simple changes in organism abundances (CCLEAN Program Overview, in prep.). Fluctuations in nutrient levels in the sanctuary's offshore environment are natural and have substantial influence on living resources. However, there is insufficient data to determine if human activities are amplifying these natural fluctuations.

Comment [kb27]: The stated question is, is there an effect on water quality (not specifically on living resources). Violation of Ocean Plan standards should be considered an effect on water quality. Those standards are set with living resources in mind. These chemicals are showing up in sea otter tissues, mussel tissue, offshore sediments, etc. Finding them at levels exceeding standards in offshore waters is significant.

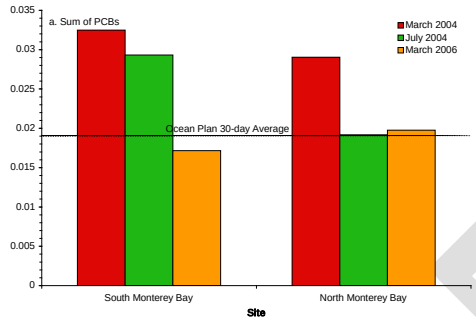

Figure 1. Concentrations of PCBs during the 2004 and 2006 wet and dry season at two marine background sites located 5 miles offshore in Monterey Bay (CCLEAN Program Overview, in prep.). Some samples exceed the water quality standards for PCBs set forth in the California Ocean Plan.

Harmful algal blooms are the result of rapid growth of toxin-producing unicellular algae found in surface waters. On-going monitoring in the sanctuary is tracking the seasonal abundance and distribution of harmful algal species and trying to identify the conditions under which blooms occur. In May 1998, a bloom of the diatom *Pseudo-nitzschia australis* was monitored in Monterey Bay. This species produces domoic acid, a neurotoxin, that subsequently was found in high levels in anchovy, sardines and California sea lions in central California. Monitoring also tracks dinoflagellates that cause paralytic shellfish poisoning, dinoflagellates that cause diarrhetic shellfish poisoning, and *Cochlodinium catenatum,* a species first detected in Monterey Bay in July 2004. Dense blooms of *C. catenatum* can produce a foul-smelling slime and have been associated with fish kills and other damage off Mexico and Central America. http://www.mbnms-simon.org/sections/openOcean/project_info.php?pid=100173&sec=oo; http://calpreempt.ucsc.edu/; http://currents.ucsc.edu/04-05/03-07/algae.asp

Comment [kb28]: pseudo-nitzschia can bloom without producing harmful levels of toxin.

- *What is the eutrophic condition of sanctuary waters and how is it changing?*

The eutrophic condition in the sanctuary's offshore environment is considered to be good/fair and not changing. Algal blooms are naturally occurring events, but they appear to be increasing in intensity and frequency (CIMT 2006). There is growing evidence that humans are causing algal blooms to occur more frequently, be larger, and last longer. Humans could be influencing phytoplankton blooms by increasing nutrient availability via runoff, climate change, or by assisting in the transport of new species into an area (Kudela et al. 2005, Glibert 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 blooms.

Comment [kb29]: These two sentences almost seem to contradict one another. The first says that eutrophication is not changing, the second says that blooms are occurring more frequently and lasting longer. Perhaps clarify by saying there is no evidence of resulting dissolved oxygen depletion, if that is the case

Comment [kb30]: Seems like the rating should be "getting worse"?

Comment [kb31]: these two statements are inconsistent "not changing"…"appear to be increasing".

The mission of the Center for Integrated Marine Technologies (CIMT) is to create a coastal ocean observing and forecasting system that provides a scientific basis for the management and conservation of Monterey Bay, and serves as a model for all of California 's coastal marine resources and the U.S. Integrated Ocean Observing System (IOOS). http://cimt.ucsc.edu/index.htm

The linkages between nitrogen sources (e.g., urea) and iron and how they influence harmful algal blooms is an area of active research in Monterey Bay, primarily lead by researchers at the Center for Integrated Marine Technologies (CIMT) (reference figure). Blooms occur when environmental conditions are favorable to phytoplankton growth. Although domoic acid is a naturally occurring chemical in the ocean, recent work has shown that inputs of urea and copper may promote the growth of domoic acid producing phytoplankton and may increase the production of domoic acid (Armstrong et al. 2007). Urea is a waste product of mammals and is found in agricultural fertilizers and near leaky septic tanks and sewage discharge systems. Copper is often found in higher concentrations at urban outfalls to the ocean. Once in the nearshore environment, these contaminants may be transported offshore and affect offshore ecosystems.

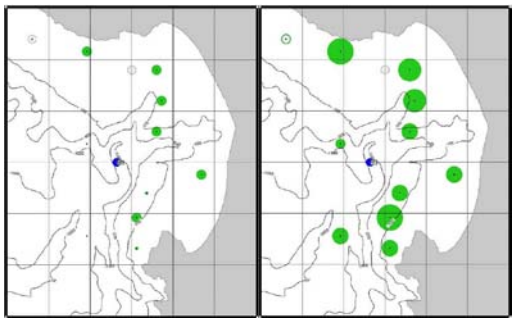

Figure 2. Spatial distribution and relative density (circle diameter) of *Pseudo-nitzschia* blooms in November 2002 (left panel) and in March 2003 (right panel) (CIMT 2006).

- *Do sanctuary waters pose risks to human health?*

There is no known evidence to suggest that offshore sanctuary waters pose a risk to human health or that the level of risk is changing. 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. in press). Such contamination, however, has not been linked to the water quality in the offshore environment of the sanctuary.

Similarly, elevated concentrations of some trace metals, such as mercury, are a health concern for humans consuming 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.

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

The level of human activities that influence offshore water quality is considered to be minimal. Remediation efforts have reduced the risk that human activities affect water quality in the sanctuary's offshore environment.

The 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. http://www.mbnms-simon.org/sections/beachCombers/index.php?l=n

Comment [JB32]: This section should probably mention human activities responsible for nutrient loading and contaminants in offshore waters

The most notable impact of human activities on offshore water quality it the release of oil into the environment from vessels. On average, when more than 2% of seabirds surveyed on beaches are oiled, a significant oiling event is occurring; such was the case in the winter of 1997-98, 2001-2002, and 2004-05 (reference to figure). These events were subsequently attributed to oil leaking from the *S.S. 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 decreased releases of oil into the offshore waters of the sanctuary. However, chronic oiling continues to be a problem affecting seabirds in the Monterey Bay National Marine Sanctuary (reference figure), despite efforts to mitigate illegal dumping of bilge water during the years of the study. http://www.mbnms-simon.org/sections/birds/project_info.php?pid=100143&sec=ss

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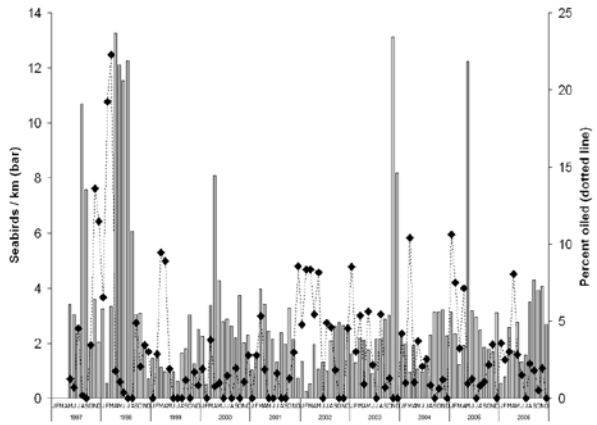

Figure 3. Since 1997, the BeachCOMBERS monitoring program has documented trends in oiled relative to total seabirds recorded during surveys of stranded seabirds and mammals on beaches in the Monterey Bay sanctuary. The percent of birds recorded that have externally visible oil are plotted (dotted) over the total number of seabirds per km of beach recorded during each monthly survey (gray bars). On average, when more than 2% of birds are oiled, a significant oiling event is occurring.

Nearshore Category

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

Nearshore Water Quality Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Stressors	—	Elevated levels of numerous contaminants in localized areas, especially near river mouths and outflows.
Eutrophic Condition	—	Clear evidence for localized nutrient enrichment; isolated incidents of fish kills and algal blooms.
Human Health	—	Unpredictable, periodic beach closures due to *E. coli;* consumption of contaminated shellfish at some locations.
Human Activities	▼	Increasing pressures from urbanization and changing agricultural practices.

- *Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?*

Stressors on water quality in the nearshore environment are considered to be fair and not changing. Elevated levels of numerous contaminants, such as nutrients and persistent organic pollutants (e.g., PCBs, PAHs, dieldrin, DDT), have been detected in the nearshore environment, with some of the highest levels in localized areas, such as near river mouths and sewage outflows. The nearshore waters of the sanctuary exceed the

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. http://www.ccamp.org/

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. Begun in 2001, CCLEAN is determining the sources, amounts and effects of contaminants reaching nearshore waters.

Comment [kb33]: I believe this should say "with an undetermined trend". I think that is more accurate unless there are reports I've not seen that indicate the contrary.

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California Ocean Plan for PCBs (CCLEAN 2006). Primarily urban-derived stressors to the nearshore environment include heavy metals, detergents, nutrients, sediments, PAHs, and bacteria. Although it is known that there are toxic conditions in streams and outfalls, the impact on the nearshore ocean is generally unknown.

River mouths contribute higher loads of persistent organic pollutants (POPs), nitrates, and urea to the nearshore environment, while wastewater contributes higher loads of ammonia and orthophosphate. For example, the four large rivers (Carmel, Salinas, Pajaro, and San Lorenzo) that drain to Monterey Bay are the source of most of the PCBs measured by the CCLEAN program, with the Salinas River being the largest source (CCLEAN Program Overview, in prep).

Sources of nitrates and urea in the nearshore environment are waste products from mammals and agriculture fields, septic tanks, and sewage discharge systems. High loads of urea have been found in rivers and streams during the last 5 years of sampling by the CCLEAN Program, with Pajaro River and Tembladero Slough being the largest sources (reference figure). Big Sur, Carmel and San Lorenzo River also typically have high loads of urea (CCLEAN Program Overview, in prep).

Comment [kb34]: Is this proven for these waterbodies?

Comment [kb35]: How do you determine what constitutes a "high" load of urea? There are no water quality standards for this pollutant. What we do know is that loads are significantly higher than those coming from effluent discharges.

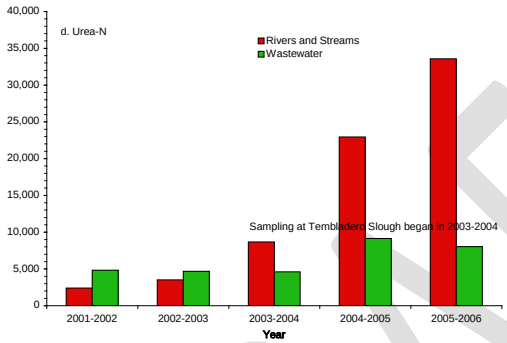

Figure 5. Comparisons of combined annuals loads in kilograms of urea from gaged rivers and wastewater 2001-2006 (CCLEAN Program Overview, in prep.). Gaged rivers: Scott Creek (added in 2003-2004), San Lorenzo River, Soquel Creek, Pajaro River, Salinas River, Carmel River and Big Sur River. Wastewater: 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.

The Central Coast Ambient Monitoring Program (CCAMP) conducted a study between 2001 and 2006 to asses the quality of water, tissue, and sediment samples from six central coast harbors, including three that are within the sanctuary (reference figure). An EPA Water Quality Index was calculated for samples based on levels of dissolved oxygen, dissolved inorganic nitrogen, ortho-phosphate, chlorophyll, and water clarity. Most of the sampling sites within the sanctuary were either good or fair, but two sites in Moss Landing Harbor were categorized as poor (Sigala et al. 2007).

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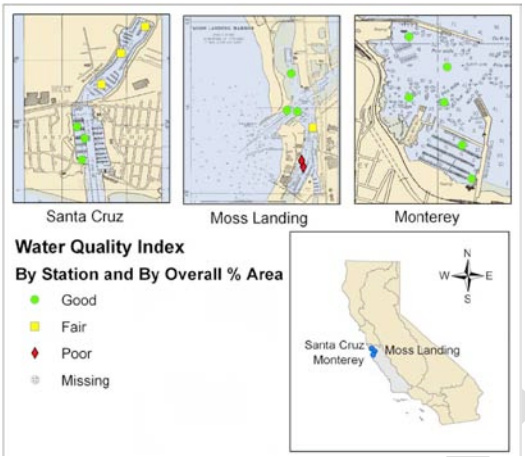

Figure 6.Water Quality Index values by station in Santa Cruz, Moss Landing and Monterey harbors. Overall rankings (good, fair, poor) were based on individual rankings for total dissolved inorganic nitrogen (DIN), orthophosphate as P, chlorophyll a, and water clarity (% light transmission). (modified from Sigala et al. 2007)

Occasionally along the California coast the diatom *Pseudonitzschia* blooms and produces a neurotoxin called domoic acid. This toxin can cause seizures and even death in sea otters that eat contaminated shellfish. A recent study shows that certain POPs including some chlorinated pesticides, some polybrominated biphenyl ethers, and some PCBs are important risk factors for sea otters that die of infectious diseases (Miller et al. 2007), in addition to particular bacterial pathogens (Melissa Miller, pers. com.). Toxoplasmosis, caused by the parasite *Toxoplasma gondii*, is a major cause of mortality and a contributor to the slow rate of population recovery for southern sea otters in California. The most likely source of this pathogen is from the environmentally resistant oocysts that are shed in the feces of domesticated cats and transported via freshwater runoff into the marine ecosystem (Conrad et al. 2005).

Comment [kb36]: these aren't necessarily coupled.

- *What is the eutrophic condition of sanctuary waters and how is it changing?*

The eutrophic condition of nearshore waters is considered to be good/fair with no evidence for an upward or downward trend over time. There is, however, very clear evidence for localized, enhanced nutrient loads due to point and non-point sources, mostly originating in the large rivers. There is evidence of isolated incidents of fish and mussel kills and algal blooms, but there is no evidence linking nutrient loading to these incidents. While nutrients are essential for algal blooms, including harmful algae, harmful bloom events are only weakly associated with direct nutrient loading (Kudela et al. 2004).

Comment [kb37]: If plankton blooms are increasing in frequency and duration, is that not evidence of a potential trend related to eutrophication?

The most abundant sources of nitrate and urea are river discharges and the most abundant sources of orthophosphate and ammonia are wastewater. In general, nutrient enhancements to the nearshore environment are greatest during winter months. Rivers vary in their load contributions relative to different nutrients. Nitrates from the Pajaro and Salinas Rivers and Tembladero Slough are far greater that for other major rivers that drain to the sanctuary (reference figure) (CCLEAN Program Overview, in prep).

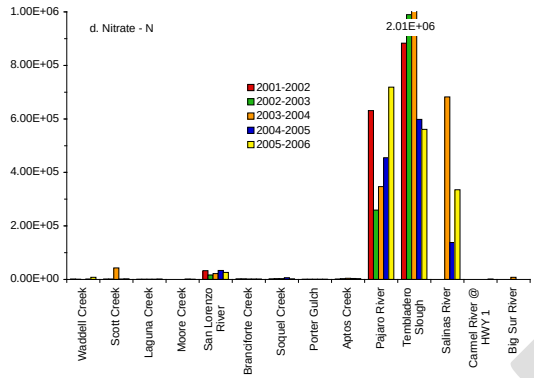

Figure 8. Annual nitrate load into near shore waters from 14 streams and rivers sampled by the CCLEAN program during the period 2001-2006 (CCLEAN Program Overview, in prep). Sampling locations are listed from north (Waddell Creek) to south (Big Sur River).

Comment [JB38]: Note to Graphic designer: Remove "d. Nitrate – N" from graph. Label X-axis "Sampling sites"; Y-axis label "Annual Nitrate Load (units?)"

- *Do sanctuary waters pose risks to human health?*

The condition of nearshore waters is considered to be fair and not changing. Although the majority of the sanctuary coastline does not pose a risk to human health, there are localized and isolated impacts along the sanctuary's shoreline that potentially pose a risk to human health. Unpredictable, periodic beach warnings and closures due to pathogen indicators (*E. coli*, fecal coliform, total coliform, *Enterococcus*) are common (reference figure).

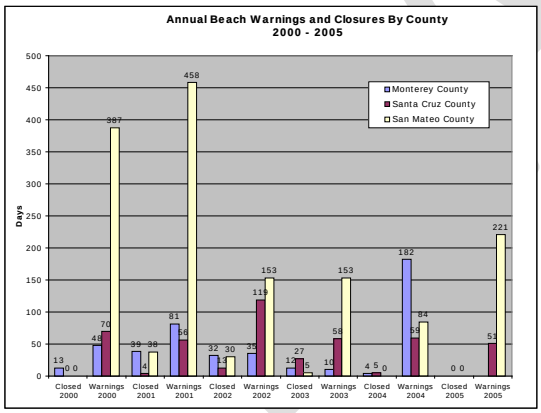

Figure 9.Number of days per year that beaches in Monterey, Santa Cruz, and San Mateo counties have been closed or had warnings posted. Weekly bacterial testing is conducted by local health officers between April 1 and October 31 in waters adjacent to public beaches having more than 50,000 visitors annually (Source: JMPR).

The primary Santa Cruz County beaches experienced elevated levels of *Enterococcus*, *E. coli*, fecal coliform and/or total coliform that exceeded State standards 5-20% of the time from 2000-2004. 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%. Such illness (earaches, gastrointestinal distress, etc.) is typically the result of swimming near an outfall or other impacted areas, such as a river mouth, following a runoff event. The primary sources of bacterial contamination at beaches within 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 (County of Santa Cruz 2006).

CCLEAN observations indicate that the greatest loads of *E. coli* (reference figure) 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 is the only site that seems to have generally increasing bacterial loads over the five years of the CCLEAN program (CCLEAN Program Overview, in prep).

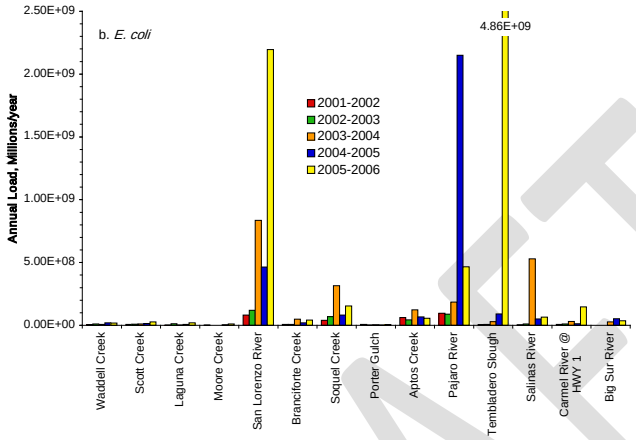

Figure 10. Comparisons of estimated loading of *E. coli* bacteria into near shore waters during 2001-2006 for CCLEAN sites (CCLEAN Program Overview, in prep.) Sampling locations are listed from north (Waddell Creek) to south (Big Sur River).

Contaminants such as PCBs and dieldrin are present in the nearshore waters of the sanctuary and exceed standards outlined in the California Ocean Plan. Mussels at most sites around Monterey Bay sampled by CCLEAN, National Status and Trends, and State Mussel Watch exceeded the California Office of Environmental Health Hazard Assessment human health screening for dieldrin. Evidence shows that contaminants are present, persistent and exceed allowances set forth in the California Ocean Plan; therefore a consideration should be made for issuing a health advisory for mussels (CCLEAN, Program Overview, in prep.).

- *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 fair and probably getting worse overall. The pollutants associated with urban development and agricultural cultivation increase pressure on the nearshore water quality conditions in the sanctuary. The greatest loads of persistent contaminants in the sanctuary are delivered from non-point sources and agricultural cultivation of the landscape. Regulation of these sources has increased , and the technology, education, and implementation of better rural and urban management practices have improved in recent years. However, more water quality data and improved tracking of management practice implementation are required to understand the degree of change in water quality conditions that may be associated with management practice improvement.

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 (County of Santa Cruz 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. The level of implementation and spatial extent of such practices that currently exists is very likely to be offset by intensification of human activities in coastal watersheds that introduce pollutants to the nearshore environment.

Comment [kb39]: this is way too uncertain. Anyone could say this. Need an authoritative statement, based on some sort of data or assessment.

Comment [kb40]: New regulatory programs have been implemented in the last five years that also have the potential to improve water quality, including Phase 2 stormwater programs and the Irrigated Agricultural Waiver Program. The latter program includes a management practice tracking component.

Comment [kb41]: the conclusions for this section feel completely unsubstantiated.

DRAFT

Estuarine Category

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

Estuarine Water Quality Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Stressors	—	Agricultural inputs (freshwater, sediments, associated pollutants) have been documented at high levels; few studies of impacts but sensitive species are likely to be affected.
Eutrophic Condition	—	Very high nutrient concentrations are observed but strong tidal flushing dilutes concentrations; hypoxia is sometimes observed.
Human Health	—	Shellfish and fish that are harvested may contain levels of contaminants that pose risks to humans.
Human Activities	—	The sanctuary waters receive substantial agricultural inputs. Implementation of best management practices has been increasing, but no evidence yet of improving water quality conditions.

Elkhorn Slough is the only estuary on the central California coast located within the boundaries of the Monterey Bay National Marine Sanctuary. Over the past 150 years, human actions have altered the tidal, freshwater, and sediment processes in Elkhorn Slough. Such impacts have substantially altered the water quality conditions and have increased the levels of pollution and eutrophication in the slough (ESTWPT 2007).

- *Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?*

Stressors in the estuarine environment of the sanctuary are considered to be fair and not changing. The rating of fair and not changing for stressors is based on high levels of agricultural inputs, such as freshwater, sediments, and associated pollutants, which have been historically documented in Elkhorn Slough. 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.

Estuarine habitats often have particularly high levels of pollution relative to other coastal habitats because human uses such as industry, agriculture, residential development, and harbors are often densely concentrated around them (Kennish 2002). Virtually all such human uses of the estuary and adjacent land potentially supply some contaminants to the water column – for instance industrial chemicals, agricultural fertilizers and pesticides, residential sewage, and boat paints. In estuarine habitats of the Elkhorn Slough watershed, pollutants such as nutrients and pesticides from a variety of sources have been identified. In this largely rural watershed, the main cause of water and sediment quality degradation appears to be agricultural non-point source pollution (Caffrey 2002, Phillips et al. 2002, ESNERR Management Plan 2007).

Approximately two dozen wetlands comprising approximately 637 acres of estuarine habitats in the Elkhorn watershed are currently behind water control structures and levees. Such construction has 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 (e.g., algae and decaying matter). Studies of Azevedo Pond demonstrate that the site regularly experiences anoxia during the night (Beck and Bruland 2000, Chapin et al. 2004). Also, many tidal wetland sites experience muted tidal conditions and receive less than five percent of the full tidal range, which can contribute to poor water quality conditions (ESTWPT 2007).

- *What is the eutrophic condition of sanctuary waters and how is it changing?*

The eutrophic condition of estuarine environments within the sanctuary is characterized as fair and not changing. Based on a survey in 1999, Elkhorn Slough is classified as a highly eutrophic environment due to the occurrence of low dissolved oxygen levels, high chlorophyll-a, and high nitrate concentrations (NOAA 1998). Eutrophication can lead to an array of harmful effects

Comment [kb42]: Estuarine category for water quality lacks any figures or tables of quantitative data.

Comment [kb43]: Elkhorn Slough is undergoing steady and rapid erosion resulting from constriction of the Moss Landing Harbor mouth. This may be one of the most significant human impacts, yet it's not mentioned in this section. It would lead to a down arrow.

Comment [kb44]: If Elkhorn Slough is classified as a highly eutrophic environment (see text), wouldn't Fair/Poor be more appropriate?

Comment [kb45]: Do we know that more implementation is occurring? In fact, with new food safety guidelines in place, many riparian buffers and vegetated treatment systems are being removed.

Comment [kb46]: I would be inclined to grade this as "poor", not fair.

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including reduction in water quality, fish death, 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 at 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 Management Plan 2007).

In recent decades the increased supply of nutrients has been an important contributor to eutrophication in estuaries. Remarkably high nutrient and pesticide concentrations have been historically documented in Elkhorn Slough. Although there is no evidence of recent increases of nitrate levels in Elkhorn watershed wetlands, current concentrations are two orders of magnitude higher than in the 1920s (Caffrey 2002). Up to 2,000 μM (125 mg/L as nitrate, 28 mg/L as N) concentrations of nitrate have been recorded in the Old Salinas River Channel (Johnson et al. in press), which is almost three times higher than the water quality standard for municipal and domestic water supply use (ESTWPT 2007). Peak values at monitoring sites within the slough are among the highest ever reported for estuarine ecosystems (Caffrey 2002).

Comment [kb47]: cite refs – this is a big statement, needs backing up.

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 NERR's System-wide water quality monitoring program has detected higher levels of nutrients in reserve wetlands on outgoing tides, attributable to local sources, than on incoming tides. An array of *in-situ* nitrate monitoring instruments has recently documented nitrate from Salinas River channel / Tembladero Slough sources traveling up the slough, into and well past the reserve (ESNERR Management Plan 2007; K. Johnson in prep; http://www.mbari.org/lobo).

- *Do sanctuary waters pose risks to human health?*

The estuarine waters of the sanctuary are considered to be fair/poor and not changing in terms of their level of risk to human health. 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). 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 (ESNERR Management Plan 2007, Hunt et al. 2003, Anderson et al. 2004) High levels of contaminants in harvested crustaceans and bivalves could pose a risk to human health.

- *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 characterized as fair and stable. An important and relatively poorly understood threat to estuarine habitats in Elkhorn Slough is non-point source pollution from multiple sources, including substantial agricultural runoff from inputs along the Salinas River, Tembladero Slough, and Elkhorn Slough watershed. Nutrients and significant concentrations of legacy agricultural pesticides, such as DDT and fecal coliform bacteria have been documented in some watershed wetlands, with highest levels in the areas receiving the most freshwater runoff (ESNERR Management Plan 2007; Phillips et al. 2002). 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 Management Plan 2007). 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).

Comment [kb48]: not a "legacy ag. pesticide"

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. The construction of levees restricts tidal exchange and can reduce water quality due to hypersalinity (ESTWPT 2007, ESNERR Management Plan 2007).

Recent changes in human activities may improve water quality conditions within the slough. 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. Presently, there is no evidence to suggest a causal relationship between these changes in behavior and changes in water quality conditions within the slough.

Comment [kb49]: Do we know that behavior has changed? Some are changing in the wrong direction as a result of new food safety guidelines. We do know that programs are being implemented. I would rephrase to something like "there is no evidence to suggest implementation of practices has yet improved water quality conditions in the Slough".

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Habitat

Comment [kb50]: My main overall comment on the report is that 'habitat' is generally biased towards benthic or near-bottom habitats. The pelagic habitats are harder to define but are nonetheless a key part of the sanctuary system, and they support a great diversity and abundance of seabirds & marine mammals (and fishes). It is probably too late in the process to expand on pelagic habitats, but it may be worth noting in our comments that these have not been considered as thoroughly, likely because they are harder to assess using the criteria provided.

Offshore Category

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

Offshore Habitat Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Abundance/Distribution	▲	Habitat loss and modification due to trawl fishing, but recent increases in total area closed to trawl fishing.
Structure	▲	Loss of structure-forming and structure-building taxa due to trawl fishing, but recent increases in total area closed to trawl fishing.
Contaminants	—	No evidence of strong ecosystem level effects, but no attenuation of persistent pesticide levels.
Human Impacts	▲	High levels of previous trawl fishing, but recent reductions in trawling activity.

Comment [kb51]: Perhaps "Fair"? Many CCLEAN samples exceeded Effects Levels for toxicity from DDT and dieldrin at 80 m depth.

- *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 considered to be fair and improving. The majority of the physical habitat in the offshore zone 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. This structure is in turn used by fishes (reference image) and other taxa as refugia from predation and currents. There is no doubt that mobile, bottom-contact fishing gear (such as otter trawls) alters seafloor structure and communities (see reviews by Auster and Langton 1999, Kaiser and Jennings 2002). Considerably less is known about the recovery of seafloor habitats following that alteration. A study of the impacts of trawling in the Monterey Bay National Marine Sanctuary found that an area with high levels of trawling had significantly more trawl tracks, exposed sediment, and shell fragments and significantly fewer rocks and mounds and less flocculent material than a lightly trawled area (Engel and Kvitek 1998). New Essential Fish Habitat trawling closures along the Central Coast have provided the opportunity to study habitat recovery by comparing an area that has not been fished for 3+ years to an area that continues to be fished today. Results to-date show significant differences exist in microhabitat structure (biogenic mounds and depressions) between recovering and fished areas (J. Lindholm, pers. comm.). Additional sampling to track this recovery is planned to continue in 2007 and 2008.

Figure 11. Mounds and depressions create habitat heterogeneity on the soft seafloor that can be lost when an area is fished using bottom-contacting gear, such

as otter trawls. This photos shows a greenstriped rockfish sitting in a depression on the seafloor. *(Photo: NOAA/MBNMS).*

Based on the known impacts of bottom trawling on the physical habitat, and the extent of trawling effort in the sanctuary over the past 10 years (reference figure), the condition of offshore habitats is considered to be fair. Certain trawl-induced impacts are long-term (e.g., boulder and rocks removed by trawl nets), while many impacts to subtidal soft-sediments (e.g., homogenization of sediment structure and loss of microhabitat structure) may be less persistent. Though habitat modification has been substantial in the sanctuary, the condition of offshore habitat is likely improving due to recovery of areas recently closed to trawling (reference map of trawling closures page 74).

Comment [kb52]: Isn't this the answer to the next question? How does this differ for the first sentence of the next question?

Comment [JB53]: questions the validity of this statement because EFH closures are not in highly trawled areas.

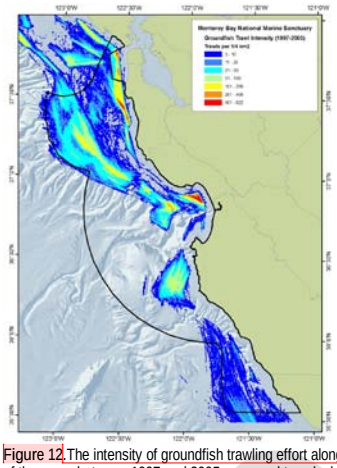


Figure 12 The intensity of groundfish trawling effort along the central California coast. Intensity was calculated as the number of trawls per ¼ km². Data from all of the years between 1997 and 2005 was used to calculate intensity. Based on PacFin trawl logbook data provided by NMFS (Map: S. De Beukelaer, NOAA/MBNMS).

Comment [kb54]: there is no map showing the new closure areas that are credited with the potential for helping habitat recovery. (There is a map in the unnumbered figure on page 74 that should be referenced here.) Of concern to many of us is the fact that the closures were gerrymandered to excluded the heavily trawled areas and include areas that the trawlers don't use. Thus the claim and prediction that these closures will improve conditions are weak ones.

- *What is the condition of biologically-structured habitats and how is it changing?*

Based on the known impacts of bottom trawling on biologically-structured habitats and the large portions of the offshore habitats that have been trawled in the past, the condition of offshore biologically-structured habitats is considered to be fair/poor. Again, given the closure of portions of the sanctuary to bottom-contact gear, the status of these resources is improving. In addition to reducing heterogeneity of the physical habitat, bottom-contact gear can injure or remove both structure-forming and structure-building taxa. These biogenic structures, some of which are long-lived and take a long time to regenerate, are used by mobile fish and invertebrate species. In addition, rocks and concretions that serve as hard substrate for attachment by some structure-forming organisms are collected by trawl nets and permanently removed from an area. Injury and removal of structure-forming invertebrates and associated hard substrates results in loss of habitat that supports the offshore living resource assemblage.

Comment [kb55]: how does this differ from the judgment on pg 38?

Cold seep communities and whale falls are two other types of biologically-structured habitats found in the offshore zone of the sanctuary that support very diverse and unique biological communities. Cold seep communities are long-lived, deep-sea communities characterized by bacterial mats and chemosynthetic clams and tubeworms (reference map) (Barry 1996). 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). Many cold seeps have probably not been impacted by trawling because currently trawling does not occur on the steep slopes or at the depths where these communities are often found (Paull 2005). However, the shallowest cold seeps located in low-relief areas and some whale falls have been impacted by bottom-contact gear, for example trawlers have pulled up whale bones in their nets. However, studies of these deep-sea communities are very limited and the impact of trawling and other human activities have not been assessed.

Comment [kb56]: Many cold seeps are found on flat, low-relief bathymetry.

DRAFT

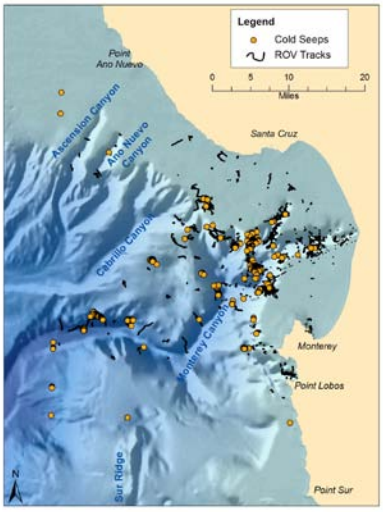
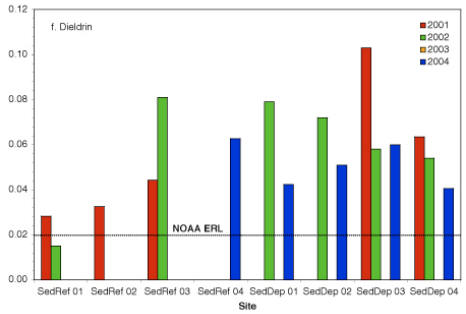


Figure 13.The location where cold seeps (orange circles) have been observed in the Monterey Bay region. Black lines show the locations where the Monterey Bay Aquarium Research Institute (MBARI) conducted remotely operated vehicle (ROV) surveys from April 1989 to June 2002. Data provided by Charlie Paull, MBARI (Map: S. De Beukelaer, NOAA/MBNMS).

- *What are the contaminant concentrations in sanctuary habitats and how are they changing?*

The contaminant concentrations in the offshore zone is considered to be good/fair because there are elevated levels of pesticides in shelf and canyon sediments at sites offshore of urban and agricultural pollution sources. The trend in contaminant concentrations in offshore habitats has not been well studied, but there is some evidence suggesting that there is little change in levels of persistent pesticides over time.

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. Concentrations of DDTs in every sediment sample exceeded the NOAA Effect Range Low guideline at which amphipod toxicity is typically measured in 10% of laboratory bioassays, and also exceeded the average concentration of DDTs in San Francisco Bay sediments in 2002 (reference figure). Concentrations of dieldrin exceeded the Effect Range Low in 16 out of 32 samples (reference figure).. This study also found that persistent organic pollutants and river discharges of suspended sediments could be negatively affecting several infaunal taxa. Analysis of historic data for sediment DDT concentrations near four of the current sampling sites indicated that only one site has experienced a significant decline in DDTs since 1969–1970. (CCLEAN 2006)



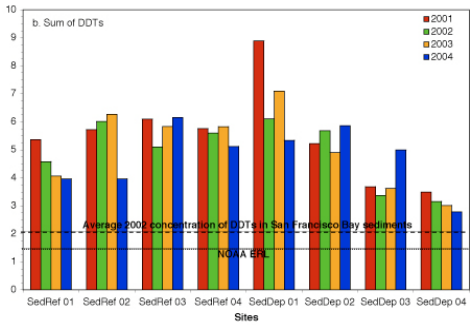


Figure 14.Concentration of DDT and dieldrin, two types of POPs, in sediments collected from eight CCLEAN sites in 2001, 2002, 2003 and 2004. NOAA ERL (Effects Range Low) refers to sediment guidelines developed by the U.S. National Oceanic and Atmospheric Administration based upon the incidence of acute toxicity to amphipods in laboratory tests. (CCLEAN 2006).

Paull and colleagues (2002) found that a distinct trail of residues of the pesticide DDT marks the axis of Monterey Canyon as the pathway for recent material transport from the continental shelf into the deep sea. Dilution of the pesticides occurs primarily at the coastline, with little further dilution occurring as the sediments move downslope into >3 km water depths. 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.

- *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 zone is fair/poor because of previously high levels of trawling in a large portion of the offshore zone. However, the levels of this activity have been reduced by recent area closures which should allow recovery of many of the impacted habitats. Two other activities that can negatively influence the quality of the offshore habitat are installation of submerged cables and abandonment or loss of fishing gear. The laying of submerged cables is strictly regulated by the sanctuary. Four new cables, with a combined total length of 114 km within sanctuary boundaries, have been permitted since the sanctuary was designated in 1992. Derelict fishing gear (including nets, monofilament line, crab pots, and buoys) can directly degrade the physical habitat through deposition on the seafloor and biologically structured habitat. In addition, derelict gear in the water column poses an entanglement risk to pelagic animals, especially large fishes, sea turtles, and mammals. The abundance of derelict fishing gear in the sanctuary has not been studied and the cumulative impacts to offshore habitats and organisms are not well understood.

Comment [kb57]: obvious question: have these cables caused problems? Should say something – yes, no, no data.

Nearshore Category

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

Nearshore Habitat Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Abundance/Distribution	—	Localized modification or loss of habitat coastal habitat, primarily through armoring of coastal bluff, erosion of sandy shoreline, and landslide disposal on rocky reef.
Biologically-Structured	—	Monitoring programs indicate healthy populations and no major perturbations.
Contaminants	—	No evidence of ecosystem level effects, but no attenuation of persistent pesticide levels.
Human Activities	—	Trampling, all forms of extraction, and sediment disposal can have measurable, localized impacts.

Comment [kb58]: See sea otter comment above.

Comment [kb59]: ▼? Based on population growth?

- *What is the abundance and distribution of major habitat types and how is it changing?*

The abundance and distribution of nearshore habitats are 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.

In California, shorelines are eroding primarily because of an increase in storm intensity, sea-level rise, climatic changes, and as a consequence of human activities that disrupt the natural sediment supply (. 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. Within the central region, short-term rates of change were calculated to be -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, which cover most of the coastline of the entire Monterey Bay National Marine Sanctuary. In the Monterey Bay region, the net average change rate more than doubled from the long-term to short-term. The general area where erosion became more predominant corresponded to the portion of coast where sand mining practices throughout the 20th century removed large volumes of sand from the beach and dunes (Griggs et al. 2005 and Thornton et al. 2006, as cited in Hapke et al. 2006).

Comment [kb60]: cite reference

Armoring of coastal bluff 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. Armoring also alters the type of habitat in a given location, converting soft-sediment habitats (e.g., sandy beaches) to hard substrates such as rock, cement, or 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 km, or approximately 7%, of the sanctuary's coastline have been armored (reference map) (California Coastal Commission 2005).
http://www.montereybay.noaa.gov/resourcepro/resmanissues/coastal.html

Figure 15. Location of coastal armoring structures in the MBNMS (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. (Map: S. De Beukelaer, NOAA/MBNMS)

The abundance and distribution of rocky intertidal and subtidal habitats have not been altered substantially in the sanctuary. 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, on-going erosion of the head of the Monterey Canyon (located in the nearshore zone) 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. http://www.mbnms-simon.org/sections/rockyShores/project_info.php?pid=100280&sec=

- *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 zone over the last five years indicate that this resource is good and stable. A number of on-going monitoring studies in the nearshore subtidal habitats (e.g., PISCO subtidal monitoring, CRANE, MBNMS subtidal monitoring) 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, canopy-forming kelps have been abundant and healthy over the last five years (reference Figure). Prohibition of bottom trawling in California state waters beginning in the 1990s effectively stopped the perturbation of structure-forming invertebrates in subtidal sandflats and formerly impacted areas should be recovering from this disturbance.

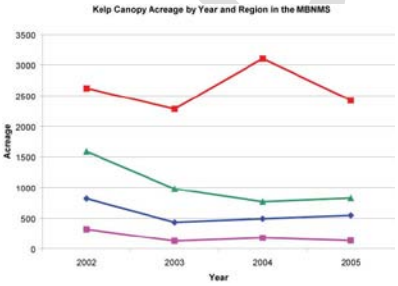


Figure 16. The annual trend in aerial extent of kelp canopy (in acres) as determined from aerial surveys by the California Department of Fish and Game using Digital Multi-Spectral Video (California Department of fish and Game, 2002-2005). Data from four regions are plotted separately: North - Northern 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.

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 (Pete Raimondi, pers. comm.). In general, the abundance of structural algae (e.g., rockweek) and surfgrass appears to be good and not changing, except in locations with high levels of human visitation (Pete Raimondi, 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. However, this study also found that for the most part, areas with high visitation did not differ substantially from areas with low levels of visitation in the abundance and diversity of structure-forming organisms. (Tenera Environmental 2003)

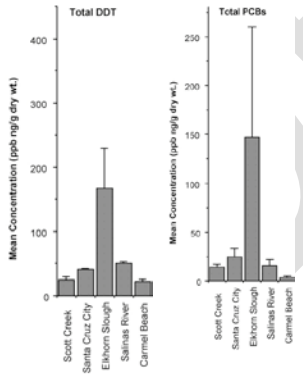
- *What are the contaminant concentrations in sanctuary habitats and how are they changing?*

From limited studies of the levels of contaminants in the habitats in the Monterey Bay National Marine Sanctuary, it appears that the condition of nearshore habitats is good/fair and stable, with contaminants at low levels in most areas and elevated contaminants at a few locations near urban or agricultural activities.

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. 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 are 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. (Sigala et al. 2007)

A study to detect contaminants in sand crabs collected in the surf zone at five beaches in the sanctuary – Scott Creek Beach, Santa Cruz Main Beach, Elkhorn Slough Mouth, Salinas River Mouth, and Carmel Beach – was conducted in 2000 (Dugan et al. 2005). Oxychlordane, DDT, and PCBs were found to be elevated at the beaches near the mouth of Elkhorn Slough, while they were fairly low at the other sites (reference figure).

Comment [kb61]: too vague – relative to what?



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 19 beaches in August-September 2000 (modified from Dugan et al. 2005).

Mussels at five sites (Scott Creek, Laguna Creek, The Hook, Fanshell Overlook, Carmel River Beach) in the Monterey Bay region have been monitored twice per year since 2001 for persistent organic pollutants (POPs) (CCLEAN 2006) (reference figure). At Laguna Creek and the Hook there were high concentrations of DDTs and chlordanes as well as dieldrin in the wet

season samples. 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. There is no evidence that these contaminant levels are having significant negative impacts on mussels or the organisms that prey on them, however, there has not been much research to examine potential higher trophic level impacts of organic contaminants.

Comment [kb62]: A Proposition 13 grant on bioaccumulation in sea otter tissues was recently completed and is available (see M Miller comments earlier in this document (p. 32) stating that contaminants are risk factors for infectious disease).

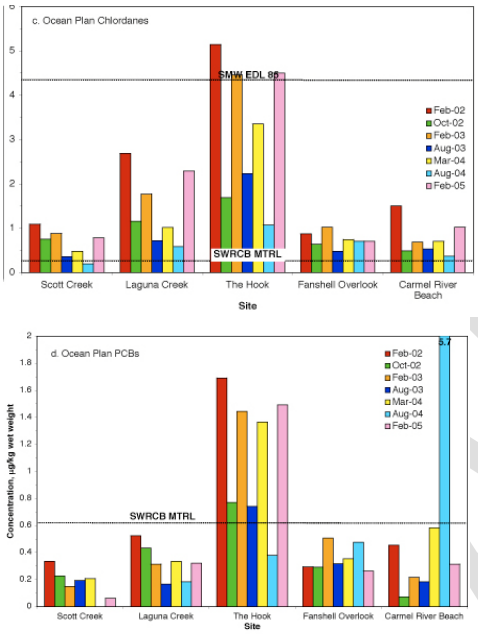


Figure 17.Wet-weight tissues concentrations of chlordanes and PCBs in mussels from five CCLEAN sites compared with various screening values and guidelines. Mussels were collected in February 2002, October 2002, February 2003, August 2003, March 2004, August 2004 and February 2005. (CCLEAN 2006)

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)

- *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 zone is considered to be good/fair because some human activities can have substantial, localized negative impacts on habitat quality. The levels of human activity appear to be stable over the last five years because most of these human activities are not new, but instead are on-going at specific sites.

Comment [kb63]: Increasing urban populations (like upcoming 3000+ home development in Salinas) will increase the pressures described in this section, esp. intertidal visitation.

Rocky intertidal areas with easy access to the public receive a high level of human visitation, especially sites near the cities of Santa Cruz, Monterey, Half Moon Bay and San Francisco. A recent study found that approximately 50,000 people visit the Point Piños intertidal zone annually, representing a small percentage of the total visitors to the rocky shores of the Monterey peninsula (reference figure) (Tenera Environmental 2003). Visitor attendance 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, compared to approximately 5,000 at Point Pinos (Tenera Environmental 2003). Visitors to the intertidal habitat may negatively impact the

Comment [kb64]: But CA population is growing and tourist trends could be changing. Need more authoritative basis for this statement.

Jenn: we could instead say that there is no evidence for increasing or decreasing trend

habitat by trampling or 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.

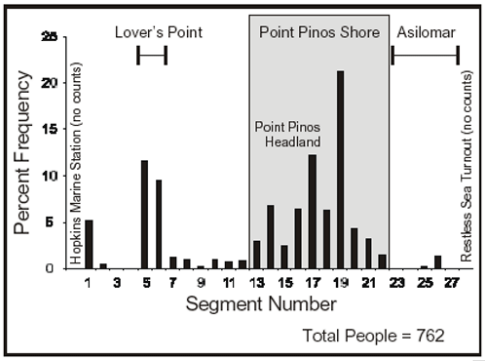


Figure 18a.Levels of visitor use along the coast in the rocky intertidal zone (excludes beaches) along the Monterey peninsula. A total of 762 people were observed in 28 visitor surveys. Segments included a range of potentially affected locations in high use areas and reference stations with lower visitor use. Hopkins Marine Life Refuge and Restless Sea were assumed to experience only minor visitor use because of restricted access [from Tenera environmental 2003; http://www.mbnms-simon.org/sections/rockyShores/project_info.php?pid=100183&sec=]

Armoring of the coastline is an activity that tends to be clustered near population centers and along sections of the coastal highway. Maintenance of current armoring structures and development of new structures may influence habitat quality - this activity is occurring in the sanctuary, but has not recently increased in intensity or frequency.

Two activities that impact the subtidal habitat are fishing using bottom-contact gear and harvesting of kelp for aquaculture. The use of trawling gear was prohibited in state waters in the 1990s which has significantly reduced the use of bottom-contact gear in nearshore habitats. Kelp harvesting occurs at a few locations near aquaculture facilities, but this activity has been decreasing over the last five years.

Estuarine Category

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

Estuarine Habitat Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Abundance/Distribution	▼	Habitat loss due to ongoing tidal erosion.
Biologically-Structured	▼	Native structure-forming organisms reduced from historic levels.
Contaminants	—	High localized levels of contaminants; limited evidence of community level impacts.
Human Activities	—	Creation of harbor mouth, diking and river diversion.

- *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 considered to be fair/poor

and declining because of habitat loss resulting from erosion and conversion. In 1947, 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 erosion 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, increased wave action, sea-level rise, and levee breaching (ESTWP 2007).

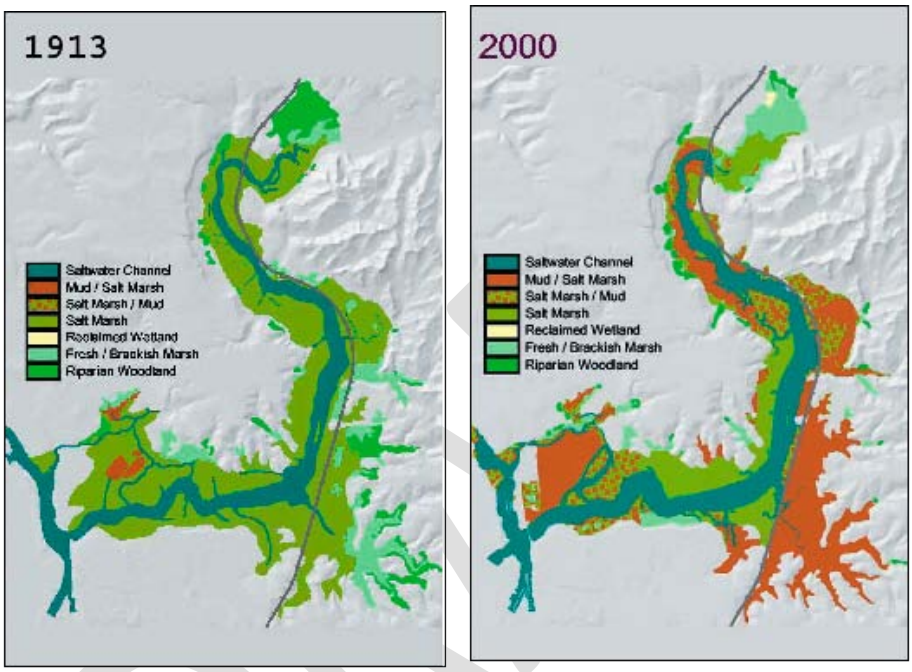


Figure 18b. Aerial photograph interpretations of changes in estuarine habitat composition from 1913 to 2000. [from Elkhorn Slough Tidal Wetland Strategic Plan -Chapter 3: Major Impacts to Elkhorn Slough Estuarine Habitats]

Deleted: 12

Since 1870, approximately 50% of the salt marsh habitat in Elkhorn Slough has been lost (reference figure) due to marsh drowning and bank erosion, which causes the edges of the marsh to collapse into the channel (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). Bank erosion rates along the main channel of Elkhorn slough are 0.4-0.6 meters per year in the upper slough and average 0.3 meters per year in the lower slough. Erosion of bank and channel habitat is deepening and widening 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). 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). The likely loss of significant inputs of riverine sediment from the Salinas River (diverted in the early 1900s) and/or Pajaro River and sediment entering Elkhorn Slough from Monterey Bay due to the jetties are also considered to be significant in the imbalance of high erosion rates compared with low depositional rates (ESTWP 2007).

- *What is the condition of biologically-structured habitats and how is it changing?*

The two native species that form biogenic habitat in the main channel of Elkhorn Slough, eelgrass (*Zostera marina*) and native oyster (*Ostreola conchaphila*) are considered to be in poor and declining condition because of a severe reduction in abundance from historic levels.

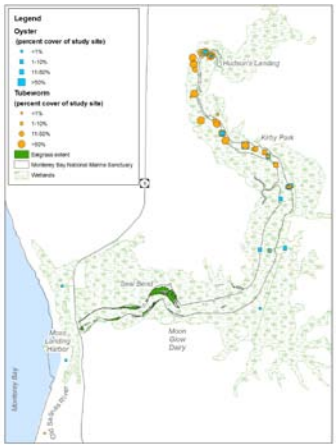


Figure 19. Distribution of eelgrass (*Zostera marina*), native oyster (*Ostreola conchaphilia*), and non-indigenous tubeworm (*Ficopomatus enigmaticus*), three species that form biogenic habitat in Elkhorn Slough, California. The widest apparent extent of visible submerged eelgrass (green area) was identified from aerial imagery taken in April 2003 (ESNERR/CDFG 2003) 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. (Map: S. De Beukelaer, NOAA/MBNMS)

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.). 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 and by 1980 eelgrass was reduced to a few small patches near the Highway 1 bridge (Zimmerman and Caffrey 2002). In the late 1980s and early 1990s, broadening and shallowing of the main channel in some locations allowed the establishment of a large eelgrass bed at Seal Bend and other smaller beds scattered throughout the main channel (reference figure) (Zimmerman and Caffrey 2002, E. van Dyke, pers. comm.). Although the current abundance of eelgrass is higher than it was in the middle of last century, it is still much reduced compared to historic levels. Aerial photos have been taken of eelgrass beds in Elkhorn Slough over the past six years, but these images have not been ground-truthed or analyzed to quantify changes in the distribution and abundance of eelgrass over time (E. van Dyke, pers. comm.).

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) and they were commercially harvested from Elkhorn Slough through at least the early 1960s (Barrett 1963). Currently, native oyster populations in Elkhorn Slough are limited to a few locations in the upper slough and the total population size is estimated to be a few thousand individuals (reference figure) (K. Wasson and K. Heiman, pers. comm.). Dead oyster shells are far more numerous than live individuals. Recruitment of new juveniles appears to be very low (K. Heiman, unpublished data) and there are very few small individuals in the population.

New biogenic habitat is being created by a non-native reef-forming tubeworm (*Ficopomatus enigmaticus*), which was initially identified in Elkhorn Slough in 1994. Colonies of tubeworms in Elkhorn Slough can form calcium carbonate reefs up to one meter high and over five meters in diameter. Although they require a piece of hard substrate to start colony formation, adult tubes can act as hard substrate for subsequent generations, making the potential spread and impacts of this species within a system dramatic. 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 (reference figure). 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 (Heiman 2006).

- *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 considered to be in fair condition and not changing 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 cause of water and sediment quality degradation appears 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 highest levels in the areas receiving the most freshwater runoff (Caffrey et al. 2002).

An analysis of the data available from various long-term monitoring programs has shown the highest concentrations of many of the contaminants in the database (e.g, butyltins, chlordane, DDT, dieldrin, PAHs, PCBs) have occurred in the Elkhorn Slough and Salinas Valley areas and are probably associated with legacy agricultural applications. 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 as 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 due directly to sensitivity to high contaminant concentrations (ESNERR Draft Management Plan).

- *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 severely degrade the estuarine portion of the sanctuary, thereby resulting in a fair/poor rating. Though the majority of human activities that have altered hydrology occurred many decades ago, the negative impacts of these activities on estuarine habitats continue (ESNERR Draft Management Plan).

Agriculture activities in the Elkhorn watershed are the main source of non-point source pollution to habitats in Elkhorn Slough. The fundamental approach required to reduce inputs of pollutants to estuarine habitats is to decrease the amount of agricultural runoff and sediments leaving farms, and/or to decrease the concentration of contaminants in them. A number of organizations have and continue to encourage, teach, and assist growers and landowners in improving land-use practices in the Elkhorn watershed, or by owning land and managing it directly. With on-going training efforts, voluntary improvements, land acquisitions, and increasingly strict regulations, agricultural pollution is likely to decrease in the coming decades, but these management activities have yet to show measurable decreases in contaminants in Elkhorn Slough habitats (ESNERR Draft Management Plan Chapter 8).

Living Resources

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,

Comment [kb65]: Legacy pesticide concentrations are not changing. However, given recent sediment toxicity studies in drainages to the Slough, there is evidence that sediment toxicity is associated with newly applied pesticides (pyrethroids). These are more persistent than OP pesticides and are increasing in use as OPs are phased out. So, pesticide contaminants in sediment are likely increasing. Ag waiver monitoring has shown widespread sediment toxicity in the lower Salinas agricultural areas.

Comment [kb66]: Butyltins are from anti-fouling paint, no? (not agricultural applications).

Comment [kb67]: Everything in Estuarine section points to "poor", not "fair/poor" (see page 95 in Appendix A).

Comment [kb68]: I would also recommend that in your reports, where you are discussing the status/trends of protected species or fish, that you consider include links to some NMFS web sites, like you do with references to other Sanctuary resources. For example, we annually publish Stock Assessment Reports for marine mammals, which are available at http://www.nmfs.noaa.gov/pr/sars/. The most updated info about ESA species (including turtles) is available at http://www.nmfs.noaa.gov/pr/species/esa/. Each of the Science Centers public stock assessment reports and such on line, although they can be difficult to find sometimes, and not as nicely summarized in once place like with the marine mammal stock assessment reports.

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.

Offshore Category

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.

Offshore Living Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Biodiversity	▼	Changes in relative abundance, particularly in targeted fish and by-catch species.
Environmentally Sustainable Fishing	▲	Most groundfish species are above management targets. Some groundfish species have been severely reduced. Improvements due to increased restrictions.
Non-Indigenous Species	—	Very few non-indigenous species identified in offshore waters.
Key Species Status	—	Reduced abundance of a number of key pelagic species; some reductions caused by activities outside the sanctuary.
Key Species Condition	▼	Domoic acid and contaminants can cause acute and/or chronic impacts in higher trophic level species.
Human Activities	▲	Extraction and habitat disturbance from fishing. Improving because of increased restrictions.

- *What is the status of biodiversity and how is it changing?*

The status of native biodiversity in the offshore habitats of the sanctuary is considered to be good/fair and the trend is declining because of changes in relative abundance, particularly in targeted fish and by-catch species. Species richness remains unchanged, as no species have become locally extinct. There is some evidence of declining biodiversity of some large mobile species (e.g., sea bird population declines), but these are more likely related to large-scale environmental shifts driven by climate change or human activities occurring outside the boundaries of the Monterey Bay National Marine Sanctuary.

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

The abundance of some large mobile species, such as Sooty Shearwaters and leatherback turtles, have recently declined in the sanctuary, but these declines appear to be caused by factors, such as fishing by-catch and breeding failures, occurring outside the sanctuary. Climate change and ocean basin-scale environmental shifts may also influence the relative abundance of these species in the sanctuary.

The abundance of jumbo squid (*Dosidicus gigas*) has increased recently in the sanctuary (reference figure) (Field et al. in press, Zeidberg and Robison 2007) and may be having impacts on local biodiversity. Observations from remotely operated vehicle surveys in the Monterey Bay region show that jumbo squid have been present and sporadically abundant since the 1997-98 El Niño, particularly between 2003 and 2006 (Robison and Zeidberg 2006). 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. in press). 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). 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.

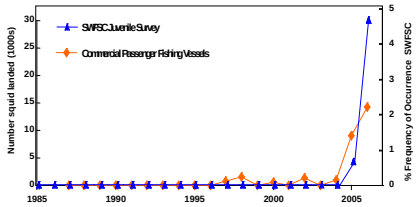


Figure 20. Indices of relative jumbo squid abundance over time. The number of squid caught by California commercial passenger fishing vessels north of Point Conception (orange diamond) and the frequency of occurrence of jumbo squid in pelagic midwater trawl surveys conducted in May and June off of the Central California coast by the Southwest Fisheries Science Center (SWFSC) since 1985 (blue triangle) are shown (modified from Field et al. in press).

- *What is the status of environmentally sustainable fishing and how is it changing?*

The status of environmentally sustainable fishing is considered to be good/fair because the abundance of many harvested species is reduced below unfished population levels, and some targeted and non-targeted species have been drastically reduced by past fishing activity. However, the trend of sustainable fishing is considered to be improving because the management strategies used by NOAA's National Marine Fisheries Service (NMFS) and the Pacific Fisheries Management Council (PFMC) have become much more restrictive since the Sustainable Fisheries Act was passed in 1998. Many of the species are responding positively to management changes and are showing clear evidence of recovery based on stock assessments. Contributing to these recoveries are gear changes to reduce by-catch, limits on the number of permitted vessels in the fishery, and several closures and restricted areas (e.g., Essential Fish Habitat trawl closures and the Rockfish Conservation Area). For depleted rockfish species with stock assessment data, all are showing increasing trends in spawning biomass over the past 10 years. Of the 80 species of groundfish managed by PFMC only six rockfish are currently considered overfished (i.e., bocaccio, cowcod, canary rockfish, yelloweye rockfish, darkblotched rockfish, and widow rockfish). Moreover, 11 out of 18 rockfish species show evidence of increasing average body size since 1999 (reference figure)(Steve Ralston, unpublished data). The recent increase in size of these fishes is consistent with reduced fishing. Pacific hake are declining due to low recruitment, which may be linked to predation by the increasing population of jumbo squid in central California. Although landings for many of these species have declined in recent years, this is due to harvesting restrictions, and should not be used as an indication of population health.

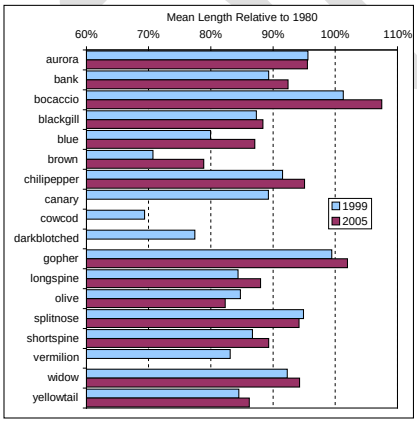


Figure 21. Average lengths of Monterey Bay sanctuary rockfishes in 1999 and 2005 relative to their mean lengths in 1980. Data summarized for the 18 rockfish stocks with the highest landings by commercial gears from Avila, Morro Bay, Monterey, Moss Landing and Santa Cruz habors between 1978 and 2006. Data for

2005 were not available for canary, cowcod, darkblotched and vermillion because those species were not landed by commercial gears in that year (Steve Ralston, unpublished data).

An important component of the offshore ecosystem is krill, an abundant shrimp-like crustacean that directly or indirectly feeds much of the pelagic food web. Regulations prohibiting the harvest of krill were passed in 2000 by the State legislature and in 2006 by a Federal management agency, which protects this resource for the marine mammals, sea birds, and fishes that rely upon krill as a primary food source.

Sardine and mackerel stocks are assessed by the National Marine Fisheries Service, and squid and anchovy stocks are monitored by the California Department of Fish and Game and the PFMC. The status of these coastal pelagic fisheries is good and the trend appears to be stable, though the population size of coastal pelagic species tends to be influenced strongly by prevailing oceanographic conditions. The Dungeness crab and spot prawn fishery are trap-based fisheries with low by-catch and both appear to be environmentally sustainable.

Comment [kb69]: states that Dungeness crab fishery is stable and sustainable. I have recently noticed large numbers of sea otters (>60) north of Pescadero in areas that have traditionally been important Dungeness crab catch areas. Sea otters have had dramatic impacts on Dungeness crab catches in Kodiak and Southeast Alaska. Is there any evidence that the recent expansion of the California sea otter range into these important central coast crab fishery areas is having a similar impact yet? It seems as though it should certainly be identified as a threat.

The Monterey Bay Aquarium Research Institute (MBARI) has collected a great deal of information on the benthic faunal community. In areas where MBARI ROV surveys observe trawl marks on the soft bottom they tend to find areas relatively denuded of benthic invertebrate megafauna and associated species, whereas areas that lack trawling show much more advanced community development (Jim Barry, 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. Closures of some areas to trawling will lead to improvements over time, but other areas may receive higher pressure due to fishery displacement. Even nominal amounts of trawling in a pristine area can lead to significant damage. However, this is an area of research that is, in general, data poor.

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

The status of non-indigenous species in offshore habitats is considered good because very few non-indigenous species have been identified in these habitats. Maloney and colleagues 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. (Maloney et al. 2006)

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 rodents and other egg predators on coastal islands reduces the reproductive success of nesting sea birds that forage in sanctuary waters. In some cases, aggressive management strategies have removed these introduced predators from islands with rookeries, resulting in increased nesting success.

- *What is the status of key species and how is it changing?*

Comment [kb70]: How does "status" differ from "condition or health" Do you mean "population status"?

The status of key species in the offshore environment is considered to be good/fair and the trend is stable because of a reduction in the abundance of a number of pelagic species. There are many high-profile species in offshore habitats. These include cetaceans, sea birds, pelagic fishes (e.g., salmon, tunas and sharks), and sea turtles. Many of these are apex predators play important roles in the sanctuary ecosystem. Here we focus on a few examples from each of the major groups. Among sea birds Sooty Shearwaters are key because of the extremely high densities reached during the summer, when tens of thousands of adults forage for fishes and squid in sanctuary waters after migrating from the southern hemisphere. Numbers of Sooty Shearwaters are declining in the sanctuary, but this decline is primarily due to impacts in the southern hemisphere. Leatherback turtles are also declining, but again this is not due to impacts to adults foraging in the Monterey Bay sanctuary, but instead due to problems at nesting beaches in the Western Pacific and adult mortality on the high seas. Cetacean populations are generally in good condition and many are slowly increasing in size.

Comment [kb71]: Again, mixed message in judgment statement.

The salmon that are harvested in sanctuary waters are mostly fall-run Chinook. This run is largely supported by hatchery releases and most of the harvested fish are of hatchery origin. Other Chinook runs, such as those in the Klamath river, are not doing well due to habitat degradation and water use issues in their spawning streams. Ocean survival of salmon is now believed to 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) 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 (*Loligo opalescens*) are seasonally abundant and population growth appears to be influenced more by prevailing oceanographic conditions than recent fishing pressure. The current status of market squid is good and the trend is stable.

Phytoplankton is another key component in 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 (reference figure)(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. http://www.mbnms-simon.org/sections/openOcean/project_info.php?pid=100190&sec=oo

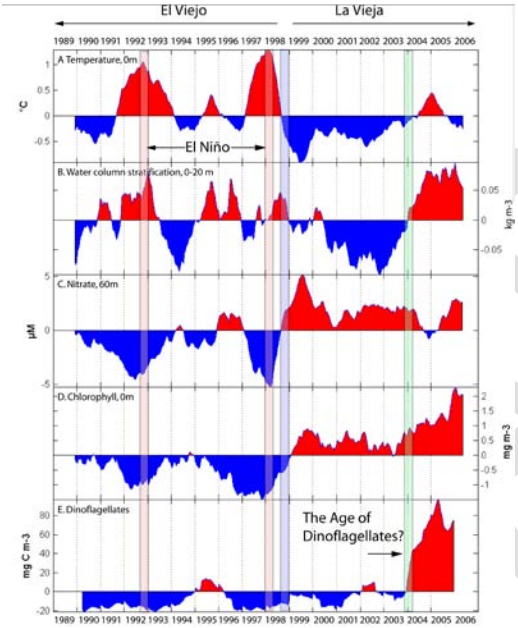


Figure 22. Time series of anomalies, with higher [or lower] than normal values in red [or blue]. (A) 0 m temperatures have in general remained cool since 1998, resulting in high (C) 60 m nitrate and (D) 0 m chlorophyll (overall phytoplankton biomass) values. However, centric diatoms decreased sharply 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 (light blue column) and one La Nina (pink column) are shown. (Pennington et al. 2007).

- *What is the condition or health of key species and how is it changing?*

Comment [kb72]: Table on pg 56 shows "good/fair" rating, but there is no reference or explanation in this text.

The health of offshore species is not well understood. We do know that some species of phytoplankton produce natural toxins that adversely affect several apex predators, including marine mammals and sea birds 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 on beaches in the Monterey Bay region.

Comment [JB73]: [Need more info on the number of stranded or dead birds and mammals attributed to domoic acid poisoning.

Unlike the populations of Steller sea lions off British Columbia and Southeast Alaska, which have been increasing in size for the past two decades, the population off California and Oregon has not grown. 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. Similar declines have been observed at South Farallon Island, a breeding colony just north of the Monterey Bay National Marine Sanctuary. The decline of the central California breeding population 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. http://www.mbnms-simon.org/projects/specialSpecies/stellar_sea_lion.php

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

The levels of human activities that may influence living resource quality in the offshore environment are considered to be fair and improving due to reduced extraction and habitat disturbance from fishing. The offshore sea floor has been negatively impacted by bottom-contact gear that disturbs bottom sediments and damages fragile biogenic habitat (e.g., long-lived sponges and corals). The recent closure of large portions of the offshore seafloor to bottom trawling should allow these areas to recover and the quality of benthic living resources to improve. Cable laying is another human activity that disturbs benthic communities because it requires digging a trench to bury the cable. This activity is strictly regulated inside the Monterey Bay sanctuary to minimize impacts to living resources.

The offshore ecosystem is more protected than the estuarine or nearshore ecosystem 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 and 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 pace 100 times faster than in the previous 650,000 years (http://www.latimes.com/news/local/oceans/la-oceans-series,0,7842752.special). 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.

Comment [kb74]: don't use newspaper references in a science-based report. This reduced the credibility of the document.

Nearshore Category

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.

Nearshore Living Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse

DRAFT

? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Biodiversity	▼	Fishing and collecting has reduced overall biodiversity; continued declines at some locations on rocky shores.
Environmentally Sustainable Fishing	—	Studies have found decreased abundance and size structure in fished areas compared to marine reserves.
Non-Indigenous Species	▼	A few non-indigenous species have been identified, and some appear to be spreading.
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.
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.
Human Activities	▼	Variety of visitation, extraction, and coastal development activities, some of which are increasing in frequency.

- *What is the status of biodiversity and how is it changing?*

The relative abundance of native species in the intertidal and nearshore subtidal has been altered to some extent throughout the sanctuary by human activities, such as trampling and harvesting for human consumption. Recent increases in human access to some rocky intertidal sites appear to be responsible for declining biodiversity in those areas (PISCO intertidal monitoring). Based on these patterns, the status of native biodiversity in the nearshore environment of the sanctuary is considered to be good/fair, but the trend is declining.

In the southern portion of the sanctuary, between Ragged Point and Cambria, biodiversity in the rocky intertidal is declining, according to the last two years of data collected by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO; Pete Raimondi, pers. comm.). Intertidal areas that were private land were recently opened to the public and the level of poaching in these areas has increased. The rocky intertidal habitats between Carmel and Año Nuevo are very accessible to the public, and given their proximity to large population centers, native biodiversity in these areas has been reduced relative to historic levels (pre-1900s). Rocky intertidal areas between Ragged Point and Big Sur are protected from most direct human impacts (e.g., poaching, trampling) due to limited or no public access. Increased human access can also impact the relative abundance of highly mobile species that forage in the rocky intertidal. For example, the Black Oystercatcher, an important avian predator in rocky intertidal communities, is easily flushed by humans and tends to be in lower abundance at sites with high human visitation levels.

In subtidal rocky reefs and kelp forests, past fishing practices have altered the relative abundance of targeted and non-targeted fishes (reference figure) and invertebrates (Starr et al. 2004, PISCO subtidal monitoring data). Because these impacts have been on-going for many decades, there is no expected change in 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, but the reason for this remains unknown. There has also been a shift in distribution of certain species along the coast, but the mechanism is also unknown. 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 is limited to a small area (MLML 2006).

Comment [kb75]: Cite ref – this is a big statement.

Comment [kb76]: Mixing documented biodiversity decline with potential. Keep separate. There are thousands of ways biodiversity can be negatively impacted.

Comment [kb77]: Cite ref. Why would we expect this?

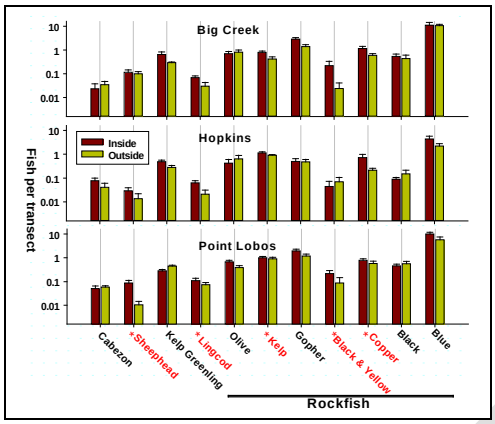


Figure 24. The abundance (number per transect) of fish inside of three marine reserves was compared to abundance outside of the reserves. Out of the eleven targeted species surveyed, abundance was significantly higher inside the reserve at all three sites for the five species highlighted in red (data from PISCO subtidal monitoring program).

- *What is the status of environmentally sustainable fishing and how is it changing?*

Comment [kb78]: What does this mean? Are you excluding from consideration fishing that is not environmentally sustainable? Isn't the question really "what is the status of commercially and recreationally fished stocks"?

The status of environmentally sustainable fishing in the nearshore environment of the sanctuary is considered to be good/fair and not changing. Based on the current management strategies for fishing implemented by State and Federal agencies, there is no evidence that fishing will lead to declines in species richness. Although there is evidence that local abundance and size-frequency structures for many targeted species are reduced in areas open to fishing (e.g., Mason 1998, Paddack and Estes 2000, Dorn 2002, Starr et al. 2004), there is no evidence of an ecosystem-level response to this pressure. It is difficult to assess the impacts that reduced abundance of fished stocks have on ecosystem function as very little research has explored this question.

Comment [kb79]: how about non-sustainable fisheries?

Sustainable fisheries in the rocky intertidal are 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-frequency structure of some large, mobile species, such as sea stars and limpets are lower in areas with easy access to the public when compared to areas where public access is difficult or prohibited (reference figure)(PISCO intertidal monitoring data). Poaching of protected species, such as black abalone, occurs at some sites in the Monterey Bay National Marine Sanctuary (Pete Raimondi, pers. comm.) and may negatively impact sustainable fisheries and the ecosystem.

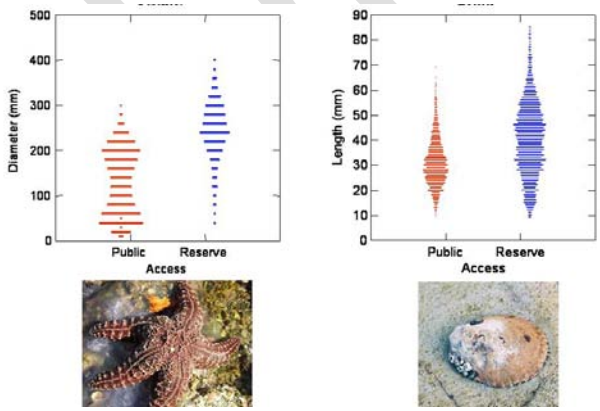


Figure 25. The size-frequency structure of the ochre star (*Pisaster*) and the owl limpet (*Lottia*) are reduced in areas where the public has easy access to the rocky shore compared to areas where public access is difficult or prohibited (data from PISCO intertidal monitoring program).

Comment [kb80]: At least 2 figures (Fig. 25 & 26) are included in the report but are not referred to in the body of the text. Don't include figures that aren't referenced in the text. And for every figure/chart/photo that is included in the report, make sure there's a reference to it.

The abundance levels of some nearshore fish stocks have been substantially reduced by recreational and commercial fishing and take of these species has been reduced (e.g., bocaccio, kelp greenling, lingcod, cabezon) or prohibited (e.g., abalone, canary rockfish) by fishery management regulations. Other stocks appear to be at levels that can sustain current levels of recreational and commercial harvest. 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 management target of 40% of unfished spawning biomass (reference figure). However, many of the harvested stocks in nearshore waters are not assessed regularly making it difficult to determine their current level of abundance and to evaluate stock status.

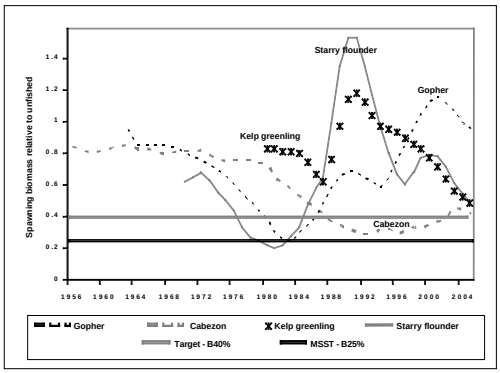


Figure 26. Trends in the estimated size of the spawning population relative to the estimated size the population would be if unfished. Data is shown for the four nearshore stocks - gopher rockfish, cabezon, kelp greenlilng, and starry flounder – that were assessed in 2006 by the PFMC (provided by Steve Ralston and John Field, NMFS-SWFSC). 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.

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. The squid fishery (the highest gross value fishery in the state) is in good condition but it is strongly influenced by oceanographic conditions, making the squid fishery highly variable. 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.

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

The status of non-indigenous species in nearshore habitats is good/fair and the trend is declining because non-indigenous species have been identified in the nearshore habitat of the sanctuary and a few of these species appear to be spreading. 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., possible native or possibly introduced) (Wasson et al. 2005).

Maloney and colleagues (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 between these habitats (1-2%), but the actual numbers of introduced species identified from each habitat type varied: 16 were found in the rocky intertidal, 12 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 expanded from bays or estuarine habitats onto the outer coast.

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Other surveys (S. Lonhart, MBNMS, unpublished data) have documented the spread of the introduced Japanese bryozoan, *Watersipora subtorquata*. 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 noted 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. The invasive Asian kelp, *Undaria pinnatifida* is slowly spreading out of the Monterey marina into the outer harbor area. It is only a matter of time before this two-meter long kelp reaches the breakwater and subtidal reefs in front of Cannery Row. 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.

Comment [kb81]: Need more authoritative statement and citation.

- *What is the status of key species and how is it changing?*

The status of key species in the nearshore environment is considered to be 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 include abalone, sea urchins, mussels, and habitat-forming algae. Abalone populations are severely depleted due to over-harvesting, sea otter predation, and disease. When they are at natural abundances, adult abalone act as major herbivores, altering 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, have been decimated in southern and south-central California by withering foot syndrome (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). Perhaps because of the decline in abalone, the status of habitat-forming algae is good. Black Oystercatchers are important avian predators of limpets (another important herbivore in the rocky intertidal), 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 important human impact (Tenera 2003).

Comment [kb82]: This implies that historical (when?) high abalone abundance is natural, and current abundances are low. This is wrong. Current red abalone abundances in central CA are limited by sea otter predation but are not low. Abalone are restricted to cryptic habitats and smaller size classes. This is not "severely depleted" and is closer to "natural" than previous high densities of the early-to-mid 1900s.

The status of subtidal kelp species and sea urchins appears to be good at monitoring sites in the Monterey Bay and Big Sur regions (PISCO / CRANE subtidal monitoring). Rockfishes are important residents of the nearshore subtidal and have been reduced (to varying extents 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). These two species of fish have strong community-level interactions and disproportionately affect the ecosystem.

Sea otter numbers in central California are well below pre-harvest levels, and it is not clear why the population has not rebounded quickly over the past 40 years. 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 trend towards increase over the whole range (reference figure). 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 2007 is 3,026, while the 3-year running average count for 2007 (the average of the 2005, 2006, and 2007 spring counts) is 2,818. http://www.werc.usgs.gov/otters/; http://www.mbnms-simon.org/projects/specialSpecies/sea_otter.php

Comment [kb83]: There are several papers documenting a relatively high level of mortality from infectious disease in sea otters. This sentence seems inconsistent with the paragraph following Figure 29.

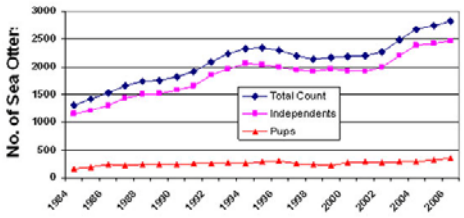

Figure 28. Number of southern sea otters counted during spring surveys, plotted as 3-year running averages. Total number (blue diamond), number of dependent pups (red triangle), and the number of independents (adults and subadultsl pink square) are shown. Surveys cover the central California coast between Half Moon Bay to Santa Barbara (data USGS-WERC; available from http://www.werc.usgs.gov/otters/ca-survey3yr.html)

Nearshore soft-bottom habitats in the shallow subtidal used to have high densities of Pismo clams, 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 currently being monitored.

- *What is the condition or health of key species and how is it changing?*

The health of key species in the nearshore environment is considered to be fair because the health of some key species is negatively impacted by disease or chemical contaminants. The impacted populations are generally not declining in the sanctuary, but decreased health appears to be one reason that the populations are not increasing 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 marched northward along the coast and appears poised to expand into central California (reference figure) (Raimondi et al. 2002). Although there is no evidence that this disease is directly a result of an anthropogenic mechanism, climate change may be indirectly exacerbating the northward spread of the disease. http://www.mbnms-simon.org/projects/specialSpecies/black_abalone.php

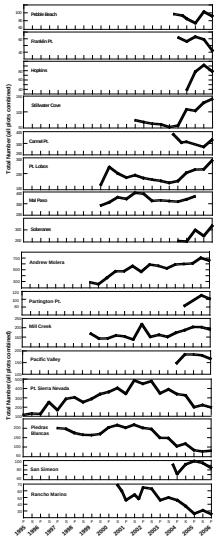

Figure 29. Trends in abundance of black abalone at monitoring sites in the sanctuary. Sites are listed from north to south. Abundance of black abalone has been unchanging or increasing at many northern and centrally located sites, but declining at sites near the south boundary of the sanctuary (PISCO/MARINE intertidal monitoring data).

The intermittent and sluggish recovery of the sea otter cannot be attributed to any single cause, but instead is the result of a combination of multiple threats to the health of the population. As a general category, disease was found to be the cause of death in 50% of fresh condition beach cast southern sea otters from 1998 through 2003. 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. PCB and DDT residues and tributyltin have been found at high concentrations in sea otter tissues. 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. In some cases, exposure to one threat may make an

animal more susceptible to the others (e.g., a diseased sea otter may be more susceptible to predation than a healthy sea otter). (Tinker et al. 2006) http://www.mbnms-simon.org/projects/specialSpecies/sea_otter.php

- *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 considered to be 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 increasing in intensity. The human activities that negatively impact rocky intertidal resources are all increasing.

As more private lands are opened to public access, extraction - both legal and illegal - has increased in the rocky intertidal zone. 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. Increased restrictive management of the nearshore subtidal fishery – including area closures, seasonal closures, and bag limits – have resulted in a decrease in subtidal fishing. However, these changes in fisheries management may also lead to redistribution of fishing effort and increased fishing pressure in some 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, birds can be disturbed by kite flying and a dog off leash, while picnicking increases trash.

DRAFT

Estuarine Category

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.

Estuarine Living Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Biodiversity	—	Loss of eelgrass and some replacement of native species by non-native species, but overall high biodiversity.
Environmentally Sustainable Fishing	—	There is take of shellfish and mudflat invertebrates in the lower Slough as well as fishing and hunting. The impacts have not been documented.
Non-Indigenous Species	—	High percentage of non-native species, but no known recent introductions.
Key Species Status	▼	Oyster and eelgrass declines.
Key Species Condition	?	No direct measurements of health or condition have been made for eelgrass and oysters.
Human Activities	—	Agricultural inputs, changes in land use, entrainment in power plant intakes.

- *What is the status of biodiversity and how is it changing?*

The status of native biodiversity in Elkhorn Slough is considered to be good/fair and the trend is declining based on alterations in the relative abundance of some species due to on-going changes in the distribution and abundance of estuarine habitats. Elkhorn Slough contains several estuarine habitats supporting a diverse species assemblage. Caffrey and colleagues documented dozens of vascular algae and plant species, over 100 fish species, over 300 bird species, and over 550 invertebrate species (Caffrey et al. 2002). However, there is strong evidence that local biodiversity is threatened, and has already changed significantly in the past 150 years (Caffrey et al. 2002). 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.

A comparison of benthic intertidal sediment cores collected in the mid-1970s and mid-1990s found a significant decline in total invertebrate species diversity over that time period (Wasson et al. 2002). Species that have declined in abundance between the 1970s and 1990s include the phoronid worm *Phoronopsis viridis*, the ghost shrimp *Callianassa californiensis*, the gaper clam *Tresus nuttallii*, and the cephalochordate *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 the 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 decrease in infaunal worms (Lindquist 1998).

Comment [kb84]: Species richness? Biodiversity? If no, what index?

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 the subsequent conversion of a few dominant habitat types into a patchwork of several habitat types. 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., unpublished data, as cited in ESNERR 2007). The increased abundance of sea otters in Elkhorn Slough, an important predator of clams, crabs and other large invertebrates, are also causing shifts in the species compositions of the benthic invertebrate fauna (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. Lower abundances of many fish species (<30 percent lower than 1970s levels) 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 assemblage in the lower channel and tidal creeks have become more similar since the 1970s. Fish

Comment [kb85]: What does this mean? Spell out.

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).

- *What is the status of environmentally sustainable fishing and how is it changing?*

The status of environmentally sustainable fishing in Elkhorn Slough is considered to be good/fair and not changing. There is limited take of shellfish (e.g., gaper clams) and mudflat invertebrates (e.g., ghost shrimp and worms for use as fishing bait in the lower Slough) (Wasson et al. 2002). Digging for clams and worms can be seen during very low tides, and the limits of take are set by the California Department of Fish and Game and require a sport fishing license. There is also some fishing and hunting (Wasson, pers. comm.). However, the impacts of these activities have not been documented.

Comment [kb86]: I was under the impression that Elkhorn Slough once supported a commercial oyster industry, that has since ceased to be because of elevated indicator bacteria and harvesting closures.

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

Although there have not been recent introductions of non-indigenous species, there is a very high percentage of non-native species in the estuarine environment of the sanctuary, therefore, the status of non-indigenous species in Elkhorn Slough is considered to be poor and not changing. Over 70 non-native species have been documented in the slough's estuarine habitats. The most commonly encountered invertebrates during low tide in Elkhorn Slough are invaders (e.g., the sponge *Hymeniacidon sinapium*, Japanese mud snail *Batillaria attramentaria*), some of which are having significant effects on native communities (Wasson et al. 2001). Wasson and colleagues documented 527 invertebrate species inhabiting Elkhorn Slough (Wasson et al. 2005). 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 8 were introduced, 13 cryptogenic, and 567 were native species (Wasson et al. 2005). Significantly higher numbers of introduced species were in Elkhorn Slough compared to the open coast. Non-indigenous species in the slough arrived mostly with non-native cultured oysters and on fouled boat hulls. Oyster culture is not currently occurring in the slough, but the potential for future introductions from fouled boat hulls is high.

- *What is the status of key species and how is it changing?*

The status of key species, such as oysters and eelgrass, in the estuarine environment is considered to be fair/poor and the trend is declining. In Elkhorn Slough, native oysters and eelgrass beds, the main biologically-structured habitats, are in poor condition compared to historical levels (see response to the second habitat question relating to 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 Low Low Water) and water flow (10-30 cm/s peak flow) is available (Zimmerman and Caffrey 2002).

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Other species that play an increasingly important role in structuring ecological communities in Elkhorn Slough are not native to the system. 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. The bright orange sponge, *Hymeniacidon sinapium,* forms massive aggregations in the upper slough channels with high flow and likely effect the plankton community and availability of this food source to other filter feeding species. The tubeworm *Ficopomatus enigmaticus* forms massive reefs in areas with freshwater input and has been show to influence the local invertebrate assemblage. (Wasson et al. 2002)

Comment [kb87]: Is there evidence/references for this? If so, cite them. Sponges feed on very small stuff (bacteria, algae)

Comment [kb88]: But do we have any evidence that legacy pesticides are impacting eelgrass, native oysters, or marsh plants health significantly? My guess would be that they are not. I would suspect presence of invasive species is a far greater impact on the health of oyster populations, although as a food item for higher trophic levels, oysters could be compromised by high levels of DDT (see your text, p. 46). I don't think algae and plants are impacted by organochlorine pesticides. However, turbid water is damaging to eelgrass, and so is nitrate at high concentrations. Currently applied herbicides could also represent a risk. We don't have data on any of this, but I think these are more reasonable risks than DDT.

- *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 marsh plants. Water quality and hydrological issues are negatively affecting these species. Contaminants are high in Elkhorn Slough due to the presence of legacy pesticides (e.g., DDT) and as a result of inputs of contaminants from watershed land use practices (Hardin et al. 2007). Estuaries have long served as ecosystem filters, but the present level of anthropogenic input overwhelms their capacity to clean the water. Currently there is no clear trend on the health of many of these species in Elkhorn Slough because they are not being monitored.

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

The levels of human activities that influence living resource quality in the estuarine environment are considered to be fair and the trend is not changing. Boating activities within Elkhorn Slough have facilitated the introduction of many non-indigenous species. Past aquaculture practices (e.g., the deliberate introduction of non-native oysters) also served as a pathway to introduce non-indigenous species. 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). In addition, the physical opening of the mouth of the slough has contributed to hydrological changes that alter hydrologic and sediment dynamics, which in turn affected the size and distribution of eelgrass beds. Sediment transportation from watersheds into the slough has also been severely altered by development and agricultural activities surrounding the slough. 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 (Wasson, pers. comm.). Most of these human activities have been occurring for decades and are anticipated to continue at similar levels in the future.

Comment [kb89]: Based on the definitions on pg. 98 of the appendix, "fair" seems too high. "Fair/Poor" seems most consistent with the content in this section.

Maritime Archaeological Resources

Offshore Category

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.

Offshore Maritime Archaeological Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Integrity	?	To date, only one of potentially hundreds of archaeological site inventories has been conducted.
Threat to Environment	▼	Known resources containing hazardous material continue to deteriorate.
Human Activities	?	Archaeological resources, particularly those that are undocumented, are vulnerable to degradation from trawling.

- *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 (*Macon* Expedition 2006; Schwemmer 2006b). No other site evaluations have been conducted by other Federal, State, or private resource management agencies. http://montereybay.noaa.gov/research/macon/

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Figure 30. 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

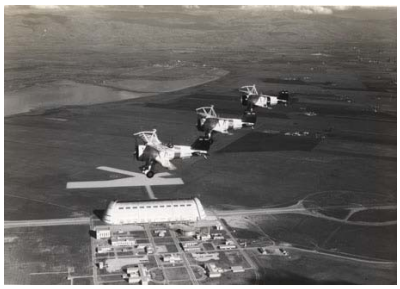

Figure 31. Sparrowhawk bi-planes flying in formation over Moffett Field. The Curtiss aircraft company adapted their F9C-2 Sparrowhawk bi-plane fighters to be used aboard the "flying aircraft carriers." When the USS *Macon* was lost off Point Sur on February 12, 1935, the airship went down with four bi-planes. Photo: Wiley Collection, Monterey Maritime & History Museum

Figure 32. 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 where a trapeze was lowered and the pilot would position the hook onto the trapeze. Sparrowhawk pilots were nicknamed the "men on the flying trapeze". Photo: NOAA/MBARI 2006

The USS *Macon*, a 785-foot dirigible (reference image), was lost offshore of Point Sur on February 12, 1935 when it foundered tail first into the chilly 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 USS *Macon*'s aluminum girder show signs of degradation after 71 years in the offshore marine environment (Schwemmer 2006b). 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, deep-water environment tends to have fewer biological processes accelerating ship degradation. One probable impact in 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.

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- *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 there are shipwrecks offshore that are currently in fair condition but 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). Additional threats to sanctuary resources are from shipwrecks located just outside the sanctuary boundary (e.g., tanker *Montebello* (reference image) sunk by Japanese submarine 1941, cargo freighter *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* and *Jacob Luckenbach* have been located and the structural integrity of the hull provides the capacity to hold bunker fuel and hazardous cargoes (Schwemmer 2005).

Comment [kb90]: didn't the MBNMS and Coast Guard trace oil in the sanctuary to one of these wrecks? If so, that should be mentioned here.

Figure 33. Launch of the Oil Tanker *Montebello* on January 21, 1921 at Southwestern Shipbuilding Company in East San Pedro, California. The ship was sunk off the Big Sur coast during World War II and may still contain large quantities of oil. Photo: Unocal

With the exception of the partial bunker fuel removal from the *Jacob Luckenbach* and monitoring of the *Montebello* (both outside the 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.

- *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 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 unknown.

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 non-renewable resources.

Archaeological resources in deeper and calmer offshore waters are generally in a more stable environment (limiting physical effects). Cold, deep-water environments tend to have fewer biological processes accelerating ship degradation compared to nearshore sites. Other emerging threats to offshore archaeological sites are the trenching of submerged communication cables that may impact submerged resources.

Nearshore Category

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.

Nearshore Maritime Archaeological Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Integrity	?	Divers have looted sites, but not all sites have been studied to determine trend.
Threat to Environment	—	MBNMS Resource Inventory indicates no known environmental hazards.
Human Activities	?	Recreational diving occurs on wreck sites, but activity level is unknown.

- *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 considered to be 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 2006a). No other site evaluations have been conducted by other Federal, State, or private resource management agencies in the nearshore environment.

Recreational divers have located at least 27 shipwrecks in the 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 higher 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 34), steam schooner *Gypsy* lost 1905, former sailing bark and later oil barge *Roderick Dhu* lost 1909, and Salinas River Barge (*Sauce Bros)* lost 1983 (Figure 35). 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.

Figure 34. 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: B. Yerena, NOAA

Figure 35. Barge (Sauce Brothers Ocean Towing) grounded near the Salinas River after a storm in December 1983. Photo: Copyright (C) 2002-2007 Kenneth & Gabrielle Adelman, California Coastal Records Project, www.Californiacoastline.org

- *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, therefore. 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.

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- *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 considered to be good/fair. Several human activities may influence the quality of maritime archeological resources in the nearshore, 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 the 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.

Comment [kb91]: "=" Good.

DRAFT

Estuarine Category

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.

Estuarine Maritime Archaeological Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Getting worse
? = Undetermined trend N/A = Question not applicable

Status	Rating	Basis for Judgment
Integrity	?	Very little is known for this area
Threat to Environment	—	No known environmental hazards.
Human Activities	—	Existing human activities do not influence archaeological resources.

- *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 36). 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.

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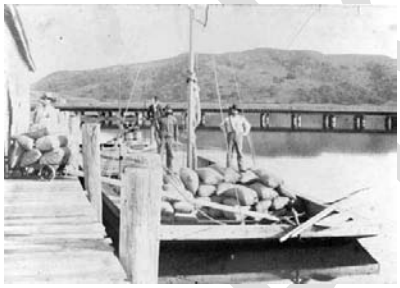


Figure 36. A view of Watsonville Landing (now remembered as Hudson's Landing) after the rail bridge was built across the north end of Elkhorn Slough. Credit: unknown

Comment [kb92]: (need to ask ESNERR for permission; if we have enough pictures we may eliminate this one)

- *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 the situation is considered to be good and not changing.

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

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

(http://www.elkhornslough.org/tidalwetlandproject/index.html) 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, the situation is considered to be good. Currently, the trend of impact to the maritime archeological sites is not changing.

DRAFT

Response to Pressures

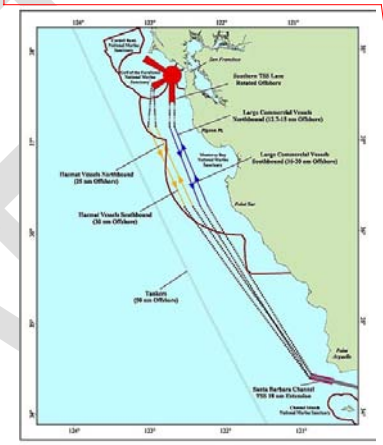
This section describes current or proposed responses to pressures. Current responses are based on implementation of the sanctuary's 1992 management plan. Proposed responses are those strategies outlined in the current Monterey Bay National Marine Sanctuary draft management plan.

The draft management plan was developed as part of a process known as the Joint Management Plan Review. The National Marine Sanctuary Program 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 providing numerous opportunities for public input, the National Marine Sanctuary Program 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 draft management plan includes twenty-five action plans that will guide the Sanctuary for the next five to ten years. The draft plan was released in fall 2006 and was open for comments until January 2007.

Vessel Traffic

In 1997, the United States Coast Guard (USCG) and the National Oceanic and Atmospheric Administration (NOAA) established a workgroup of key stakeholders, 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 16 kilometers farther offshore to reduce the risk of groundings, and organized into north-south lanes to reduce the risk of collision (reference map). These recommendations were ultimately approved by the International Maritime Organization, and implementation began in 2000. (http://montereybay.noaa.gov/vt/items.html)



New vessel traffic routes through the Monterey Bay National Marine Sanctuary. The LCV, Hazmat Vessel, and Tanker routes were moved to a minimum of 12.7 nm, 25 nm, and 50 nm offshore, respectively. Map: J. Kum, NOAA/MBNMS

In 2004 a container ship lost 15 large cargo containers overboard within the sanctuary. 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 discharging the shipping containers. The funds will be used to fund projects to protect and restore the seabed (Ecosystem Observations 2005, 2006).

Military Use

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 proposed 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. http://sanctuaries.noaa.gov/jointplan/fact/mb/MarineMammalsSeabirdsTurtles.pdf

Commercial and Recreational Fishing

The Monterey Bay National Marine Sanctuary does not directly manage any aspect of commercial or recreational fisheries. Fishing in state waters (orange zone in Figure X below) is managed by the California Department of Fish and Game. Fishing in federal waters (offshore of state waters) is managed by NOAA's National Marine Fisheries Service. Current involvement of the Monterey Bay sanctuary in issues related 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

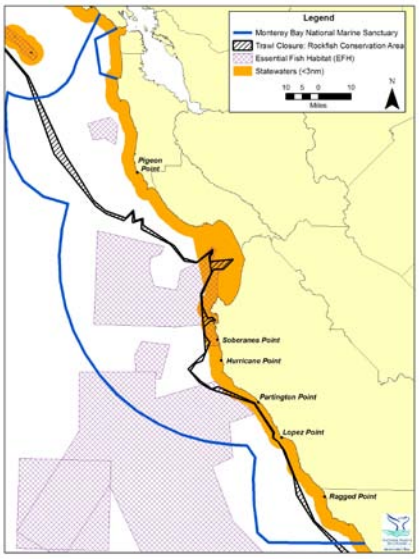
Comment [kb93]: Portions of the "Response to Pressures" section seem too "Sanctuary-centric". I think this section would benefit from taking a bigger picture view of what other agencies and organizations are doing related to these issues, in good part in response to Sanctuary input and pressure. Many agencies have undertaken new programs in part in response to Sanctuary management plans. For example, the Central Coast Water Board established a new regulatory program for irrigated agriculture, that includes requirements for education, management practice implementation and reporting, and monitoring. The Sanctuary set the stage for development of this program with its prior water quality activities. To mention the gathering of agricultural management practice data through SAM, or activities of the Sanctuary's Agriculture Water Quality Alliance, without reference to this important new program seems out of context. Similarly, to say that the citizen's monitoring network is gathering urea data, without also noting that that effort is also underway from creek and river mouths by the CCLEAN program is missing the bigger picture of cooperation and collaboration in monitoring. It may be that that is the intent of this section, to focus only on the activities of Sanctuary staff. But I think that underrepresents the impact the Sanctuary has had on other agency activities.

Comment [kb94]: Next steps…. [Still need to add some info here as we get closer to the release date for this report we can add the most current info on the status of the JMPR release.]

Comment [kb95]: what are they? Should briefly describe. E.g., are bombing practices low alt. flight submarine war games?

protection plans related to fishing such as Marine Protected Areas and The Effects of Trawling on Benthic Habitats.

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. One proposed action plan under review, called 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 proposed 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.
http://sanctuaries.noaa.gov/jointplan/fact/mb/FishingRelatedEdandRes.pdf



Areas that prohibit bottom trawling in the Monterey Bay sanctuary as of January 2007. Orange = state waters; black hatching = Rockfish Conservation Area; purple hatching = Essential Fish Habitat closure. Map: S. De Beukelaer, MBNMS/NOAA

Numerous scientific studies have found that bottom trawling adversely impacts 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 sustainable fisheries. By identifying the scope and severity of bottom trawling within the sanctuary, management will be able to determine the need for protective actions and identify solutions to potential problems.
http://sanctuaries.noaa.gov/jointplan/fact/mb/BottomTrawlingEffects.pdf

Over the last decade, bottom-trawling activities have been restricted in sanctuary waters. The California state legislature passed a bill in the 1990s prohibiting bottom-trawling out to 3 nautical miles (5.5 km) offshore (reference map). Revision of this legislation in 2006 extended the prohibition to all state waters, including the entire Monterey Bay. In 2003 the California Fish and Game Commission prohibited directed trawling for spot prawns in California. Since some of this trawling had occurred on hard bottom, this action resulted in protection of sensitive benthic habitat. The Pacific Fishery Management Council together with the National Marine Fisheries Service has prohibited bottom trawling in two types of zones – a Trawl Rockfish Conservation Area and Essential Fish Habitat (reference map). The Trawl Rockfish Conservation Area was closed, beginning in 2002, to prevent by-catch of depleted rockfish species. The upper and lower boundaries of this closure have changed slightly over time, but generally encompasses the seafloor between 100 and 150 fathoms (180 and 275 meters). The Essential Fish Habitat trawl closed areas were identified in consultation with the trawling industry and implemented in June of 2006.

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. http://montereybay.noaa.gov/resourcepro/resmanissues/fishing.html

Water Quality

The sanctuary's Water Quality Protection Program committee has developed multi-stakeholder plans for urban runoff, marinas and boating, agriculture and rural lands, and water quality monitoring. Implementation of all of these plans has begun with a variety of partners. (http://montereybay.noaa.gov/resourcepro/water-pro.html)

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. http://www.mbnms-simon.org/other/gen/imaps.php

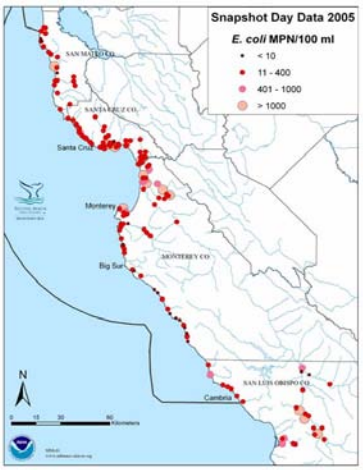
The Synthesis, Assessment, and Management project is implementing a watershed-based approach to address questions about non-point source pollution that facilitates a high level of coordination between monitoring organizations and uses water quality data in conjunction with information on land use practice changes. The objectives of the SAM project have been developed in close partnership with the Central Coast Regional Water Quality Control Board, the California Coastal Commission, and the California Environmental Protection Agency. These are: (1) integrate existing water quality and geographic data sets to address the sources, status, and trends of water pollutants; (2) gather, analyze, and map information on recently implemented agricultural best management practices within Central Coast watersheds; and (3) develop a model for ongoing data integration, analysis, and reporting with input from stakeholders.

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 Joint Management Plan Review Beach Closure and Microbial Contamination Action Plan. The goal of this action plan is to eliminate all beach closures in the sanctuary by 2010. Additionally, the sanctuary seeks a significant decreasing trend in beach water quality warnings. This action plan identifies the following needs:

- a program to identify sources of contamination;
- research on sources of pathogens;
- increased monitoring, education and enforcement;
- expand notification and emergency response;
- develop a database and a source control program to reduce beach closures and postings due to microbial contamination.

http://sanctuaries.noaa.gov/jointplan/fact/mb/BeachClosures.pdf



Concentrations of the bacteria E.coli recorded at Snapshot Day monitoring sites in 2005. Map: S. De Beukelaer, NOAA.MBNMS

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 identify sources. The Network coordinates two annual regional monitoring events, First Flush in the fall and Snapshot Day in the spring (reference map), and a summer-long water quality monitoring program called Urban Watch. http://montereybay.noaa.gov/monitoringnetwork/welcome.html

Harmful Algal Blooms:

The Monterey Bay sanctuary is a partner in the Center for Integrated Marine Technologies (http://cimt.ucsc.edu/; http://www.mbnms-simon.org/sections/waterQuality/project_info.php?pid=100173&sec=wq), which is tracking the seasonal abundance and distribution of harmful algal species and trying to identify the conditions under which blooms occur. Data from this monitoring program help inform the state health department of times and locations of potential health risks posed by harmful algal blooms. The sanctuary has also funded researchers at the University of California, Santa Cruz to investigate 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 (http://www.mbnms-simon.org/sections/beachCombers/index.php?l=n).

Actions of the sanctuary's water quality protection program may help to reduce the frequency or magnitude of harmful algal blooms. The Agriculture Water Quality Alliance (http://www.montereybay.noaa.gov/resourcepro/ag.html) 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

Comment [kb96]: The e. coli map should be shown or reference back in the section dealing with contamination (Fig. 10 page 34).

Comment [kb97]: cite reference.

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(http://www.montereybay.noaa.gov/monitoringnetwork/welcome.html) began collecting samples for urea in the First Flush program and is providing those data to researchers at the Center for Integrated Marine Technologies.

Marinas and Boats:
The Marinas and Boating section of the Water Quality Action Plan proposed 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:

- 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.

Joint Management Plan Review: http://sanctuaries.noaa.gov/jointplan/drafts/mb_mp.html

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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 a more comprehensive prohibition on cruise ship discharges within the sanctuary. These are being developed further as the main components of the Management Plan's Cruise Ship Action Plan. The sanctuary proposes to prohibit all discharges from cruise ships within Sanctuary waters except for cooling water (from engines and generators) and anchor wash down water. In addition, the proposed action plan outlines strategies to conduct outreach and coordination with the cruise ship industry, providing it with information about the sanctuary, and monitor and enforce potential cruise ship discharges. http://sanctuaries.noaa.gov/jointplan/fact/mb/CruiseShipDischarge.pdf

E/V Sharkcat is used by staff to monitor various activities in the sanctuary and enforce regulations. Photo: NOAA/MBNMS

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, a total of 57 reported 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 US 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 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 area 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 le by the National Oceanic and Atmospheric Administration in collaboration with the U.S. Coast Guard and the State of California. A series of drills over the summer offered training in evaluation of habitat and species impacts, oil-spill response protocols, communications, and field and command center operations. Ecosystem Observations 2006; http://sanctuaries.noaa.gov/safeseas/

Comment [kb98]: use proper literature citation format.

The Palo Alto*, also know 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. Photo: OSPR/DFG*

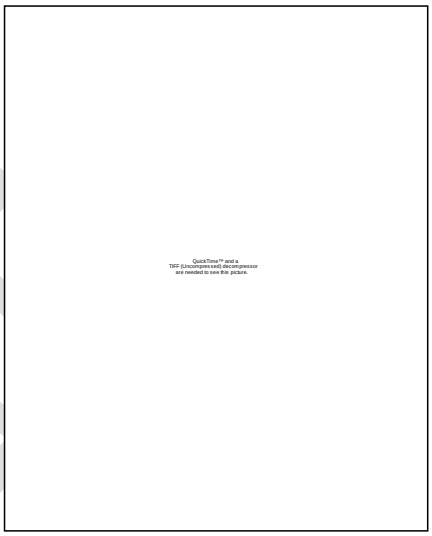
For smaller events and vessels, the sanctuary has often assumed a lead role in ensuring that fuel and oil, debris and where necessary, the vessel itself, is adequately removed to minimize damage. In addition, staff may conduct damage and recovery assessments, as well as, restoration effort if needed. 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* (reference

image). This oil had been linked to the death of more than 50 oiled seabirds since 2004. In addition, 173 seabird and 2 harbor seal carcasses were recovered from the bunker tank that contained all the fuel (Michaels 2006).

Coastal Development

Desalination

Three desalination facilities currently operate within the boundaries of the sanctuary and approximately ten facilities have recently been proposed (reference map). 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. The action plan also includes development of facility siting guidelines and a modeling and monitoring program for desalination discharges.
http://sanctuaries.noaa.gov/jointplan/fact/mb/Desalination.pdf



The location of existing and proposed desalination plants in the Monterey Bay National Marine Sanctuary. Map: J. Kum, NOAA/MBNMS

Dredging and Dredge Disposal

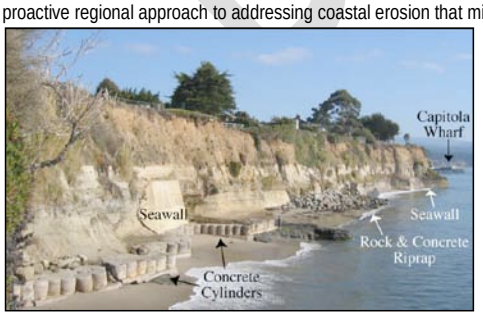
Sanctuary staff will continue to review the disposal of dredge material in approved locations at sea or along the shoreline. The sanctuary's Harbors and Dredge Disposal Action Plan was developed jointly with a variety of stakeholders and partners and includes the following components:

- Continuing to participate in and improve coordinated permit review with the California Coastal Commission, US Army Corps, and the US 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.

http://sanctuaries.noaa.gov/jointplan/fact/mb/HarborsandDredgeDisposal.pdf

Erosion and Coastal Armoring

The armoring of the coastline for protection of private and public structures continues to expand throughout the sanctuary. The sanctuary has recently begun to take a more active role in addressing coastal armoring, and has developed a Coastal Armoring Action Plan with the goal of developing and implementing a proactive regional approach to addressing 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:



An unplanned assemblage of coastal armoring structures at Opal Cliffs near the city of Capitola (on the north side of Monterey Bay). Photo: R. Stamski, MBNMS/NOAA/SIMoN

- 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;

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

http://sanctuaries.noaa.gov/jointplan/fact/mb/CoastalArmoring.pdf

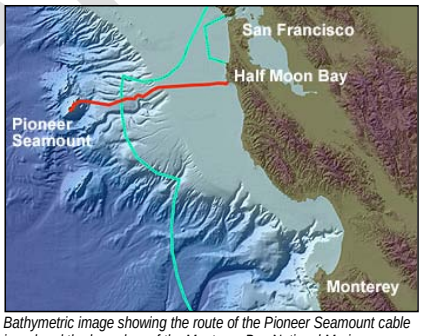
The staff of the Elkhorn Slough Estuarine Research Reserve are leading a large, collaborative effort - the Elkhorn Slough Tidal Wetland Project – to develop and implement specific recommendations to conserve and restore estuarine habitat lost due to due tidal erosion. This collaboration, initiated in 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. http://www.elkhornslough.org/tidalwetlandproject/index.html

Landslide Disposal

The Monterey Bay 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. A proposal has also been developed to evaluate the sensitivity of various marine habitats and locations along the coast to deposition, with the goal of identifying appropriate and inappropriate circumstances for disposal adjacent to the ocean.
http://www.montereybay.noaa.gov/resourcepro/resmanissues/landslide.html

Submerged Cables

The installation, operation, and removal of submerged cables may disturb sensitive habitats and negatively impact areas of the seafloor. In the Submerged Cables Action Plan, the sanctuary proposes administrative guidelines for applications and identifies the need to define sensitive sanctuary habitats that should be avoided. 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 National Marine Sanctuary System to develop nationwide guidelines on appropriate locations and restrictions for underwater fiber optic cables based on habitat sensitivity and other criteria (JMPR).
http://sanctuaries.nos.noaa.gov/jointplan/drafts/mb_mp.html



Bathymetric image showing the route of the Pioneer Seamount cable in red and the boundary of the Monterey Bay National Marine Sanctuary in turquoise. Image: NOAA/MBNMS

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 km between Pillar Point Air Force Station in Half Moon Bay and the Pioneer Seamount (reference map). 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 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. Sea anemones were found to 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. http://www.mbari.org/news/homepage/2006/cable.html

Comment [JB99]: Consider moving some of this text to State section to address comment by

Non-indigenous Species

Eradication of non-indigenous species is difficult and often impossible, and management practices focus largely on prevention of introductions. The goal of the proposed Introduced Species Action Plan is to maintain the biological communities and ecological processes of the sanctuary and to protect them from the potentially adverse impacts of non-indigenous species. This action plan, developed jointly with a multi-stakeholder working group, calls for the following actions:

- Develop a program to prevent the introduction of non-native species;

- Develop a research and monitoring program for existing introduced species;
- Develop an early detection and response program.

Sanctuary staff have conducted some research and education on this issue and occasionally have 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 Masters 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. Surveys in early 2007 found very low densities of this invasive kelp on harbor pilings. However, monitoring in the harbor has detected a recent increase in the abundance of the 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. http://www.mbnms-simon.org/other/moreLinks/invasives.php

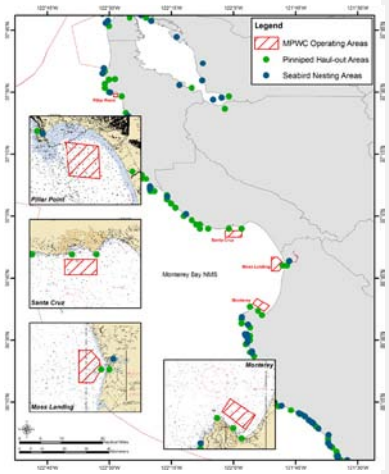
Wildlife Disturbance

Monterey Bay sanctuary addresses wildlife disturbance through a mix of educational outreach, regulations and enforcement. 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 proposed Marine Mammal, Seabird, and Turtle Disturbance Action Plan. http://sanctuaries.noaa.gov/jointplan/fact/mb/MarineMammalsSeabirdsTurtles.pdf

Volunteer docent with the TeamOCEAN kayaker outreach program. Photo: NOAA/MBNMS

One effort to reduce wildlife disturbance in the sanctuary is an education/outreach program called TeamOCEAN (Ocean Conservation Education Action Network). Started in 2000 the TeamOCEAN 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. 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 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. (http://montereybay.noaa.gov/educate/to/welcome.html)

Similarly, the sanctuary has assisted in reducing harassment of the 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 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 have also developed educational signage for several highly visited shoreline locations to reduce impacts of trampling and collecting of intertidal species. http://www.beachcalifornia.com/piedras.html



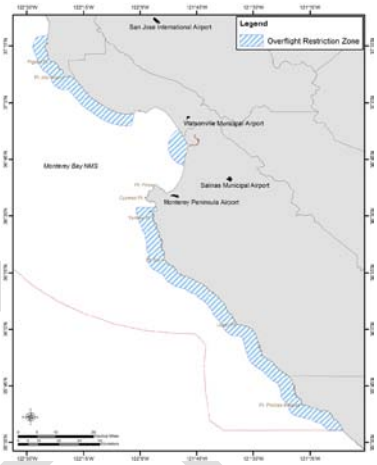
Location of four zones where the use of Motorized Personal Watercraft are allowed in the sanctuary (red hatching). The location of pinniped haul-outs (green) and seabird nesting sites (blue) also are shown. Map: Dave Lott, NMSP/NOAA

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 proposed Motorized Personal Watercraft Action Plan is to minimize disturbance of wildlife by motorized personal watercraft and to minimize user conflicts between watercraft operators and other recreational users while providing opportunities for watercraft use within the sanctuary. In this action plan, the sanctuary proposes 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 (reference

map). The action plan includes education and enforcement procedures and exploration of the need for certain exceptions. http://sanctuaries.noaa.gov/jointplan/fact/mb/MotorizedPersonalWatercraft.pdf

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 (reference map). Implementation of this sanctuary regulation has encountered some problems due to pilot's lack of understanding and acknowledgement of the zones 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, which may be conducting whale watching trips within the sanctuary overflight restriction zones.
http://www.montereybay.noaa.gov/resourcepro/resmanissues/wildlife.html



Aircraft are restricted from flying under 1,000 feet (300 meters) in zones with sensitive wildlife (blue hatching). Map: Dave Lott, NMSP/NOAA

Aquaculture Activities:
Kelp is harvested in the sanctuary at a variety of locations, to sustain aquaculture operations and to be turned into 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. http://montereybay.noaa.gov/research/techreports/kelpreportfinal/welcome.html

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 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 Fisheries and other partners to determine acceptable sound levels in the different frequency ranges affecting wildlife. http://montereybay.noaa.gov/resourcepro/reports/LFAreport/welcome.html

Marine Debris:
In the Marine Mammals, Seabirds, and Turtle Disturbance Action Plan, the sanctuary proposes to address the threat of marine debris to wildlife by developing a marine debris database, conducting education and outreach programs to Illustrate the impacts to wildlife caused by marine debris, and working in cooperation with other agencies and municipalities to develop a notification and recovery program for abandoned gear.

Comment [kb100]: Why this group? Do they generate marine debris?

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Tidepool Protection:
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 proposes to 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 on-going research at rocky intertidal sites is updated periodically in the Sanctuary Integrated Monitoring Network (SIMoN) inventory of research projects (http://www.mbnms-simon.org/sections/rockyShores/projects.php?sec=rs). Staff also collaborates with the Partnership for Interdisciplinary

Studies of Coastal Oceans (PISCO), a consortium of academic scientists that have been conducting extensive monitoring of rocky intertidal habitats (http://www.piscoweb.org). 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 Piños (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.

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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 occured and determin 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.

Blue whales feeding on surface swarms of krill. Photo: K. Newton Center for Integrated Marine Technologies

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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 proposed Ecosystem Monitoring Action Plan provides a framework for close coordination in ecosystem monitoring amongst the three sanctuaries, enabling the sanctuaries to more effectively address ecosystem monitoring issues. The goal of the Monterey Bay 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.

SIMoN - the Sanctuary Integrated Monitoring Network

SIMoN 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.
http://montereybay.noaa.gov/research/simon/welcome.html

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 (JMPR). http://sanctuaries.noaa.gov/jointplan/drafts/mb_mp.html

During the scoping period of the Joint Management Plan Review, the National Marine Sanctuary Program received approximately 7,000 public comments requesting greater ecosystem protection for the 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 proposed 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. (http://montereybay.noaa.gov/resourcepro/resmanissues/mpa.html)

Maritime Archaeological Resources

The draft Maritime Heritage Action Plan developed by working group members and National Marine Sanctuary Program staff, provides a framework for a Maritime Heritage Resources Program. The sanctuary is working with the National Marine Sanctuary Program, 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 the 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 region:

Oil tanker Montebello *propeller covered with white-plumed anemones (*Metridium farcimen*). Photo: R. Schwemmer, NOAA*

- Two contributions to the Monterey Bay National Marine Sanctuary Site Characterization: "A Recent History of the Monterey Bay National Marine Sanctuary Region" (http://montereybay.noaa.gov/sitechar/rechist.html) and "Early Uses of the Resources" (http://montereybay.noaa.gov/sitechar/early.html)

- Monterey Bay National Marine Sanctuary Shipwreck Database: The website 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. (http://www.cinms.nos.noaa.gov/shipwreck/mbnms.html)

- 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, the Monterey Bay National Marine Sanctuary http://montereybay.noaa.gov/research/techreports/smithhunter2003.html

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. (http://channelislands.noaa.gov/shipwreck/dbase/montebello_2.html); (http://www.mbnms-simon.org/sections/deepSea/project_info.php?pid=100145&sec=ds)

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 the Monterey Bay and west coast regional office of the National Marine Sanctuary Program, 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 National Marine Sanctuary Program 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. (http://montereybay.noaa.gov/research/macon/2005.html, http://montereybay.noaa.gov/research/macon/2006.html)

In Summary

The Monterey Bay National Marine Sanctuary faces many threats over an extremely large area of the California coast, and therefore sanctuary staff is actively involved in a wide variety of environmental protection activities. Some approaches to management rely on existing sanctuary regulations and staff actions, but most require continuous 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.

But while the sanctuary continues to build trust and progress by working with many partners, considerable challenges lie ahead. Increasing pressures and threats from ocean vessel traffic, international fishing, 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 that the sanctuary currently operates. But if the experiences of the sanctuary in the Monterey region are any indication, the site will be actively and effectively involved in addressing the problems, 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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External Reviewer: Chris Harrold, Rikk Kvitek, Karen Worcester

MBNMS staff help with text and maps: Erica Burton, Gary Conley, Sophie De Beukelaer, Chad King, Steve Lonhart

Comment [JB101]: address the comments by Forney and Worcester, in terms of recognizing other partnerships and information sources, by adding a section here called "Other Sources of Information from Sanctuary Collaborators." It can have a one line description of the program and a web link. You can add regional water board pages, nmfs stock assessments, etc.

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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 Program mission, and a system-wide monitoring framework (National Marine Sanctuary Program, 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. The questions are meant to set the limits of judgments so that responses can be confined to certain reporting categories that will later be compared among all sites, and combined.

Following a brief discussion about each question, statements are presented that were used to subjectively 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.

Comment [kb102]: Need to make clear that the judgments are subjective and not based on any accepted standards or quantitative scores or analyses.

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.

Question 1 (Water/Stressors): Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?

Comment [kb103]: Numbering the questions is confusing and serves no useful purpose, since question numbers do not appear in the body of the text.

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 non-point 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 al, living resources and habitats.

Question 2 (Water/Eutrophic Condition): What is the eutrophic condition of sanctuary waters and how is it changing?

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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.

Question 3 (Water/Human Health): 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.

Question 4 (Water/Human Activities): 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.

Question 5 (Habitat/Abundance/Distribution): 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 hardbottoms 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.

Question 6 (Habitat/Structure): 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, and algae are another example, seagrass beds another. 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.

Question 7 (Habitat/Contaminants): 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.

Question 8 (Habitat/Human Activities): 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.

Question 9 (Living Resources/Biodiversity): 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.

Question 10 (Living Resources/Extracted Species): 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.

Question 11 (Living Resources/Invasive Species): 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.

Question 12 (Living Resources/Key Species): 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.

Question 13 (Living Resources/Health of Key Species): 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.

Question 14 (Living Resources/Human Activities): 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.

Question 15 (Maritime Archaeological Resources/Integrity): 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.

Question 16 (Maritime Archaeological Resources/Threat to Environment): Do known maritime archaeological resources pose an environmental hazard and 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.

Question 17 (Maritime Archaeological Resources/Human Activities): 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.

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