Monterey Bay

National Marine Sanctuary

CONDITION REPORT PARTIAL UPDATE:

A New Assessment of the State of Sanctuary Resources 2015

December 2015

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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All cover photos courtesy of Steve Lonhart, NOAA MBNMS

Clockwise: Southern sea otter (*Enhydra lutris nereis*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), Tube-dwelling anenome (*Pachycerianthus fimbriatus*), Great Blue Heron (*Ardea herodias*), Giant kelp (*Macrocystis pyrifera*), Juvenile vermilion rockfish (*Sebastes miniatus*), Juvenile purple sea urchin (*Strongylocentrotus purpuratus*) on a red volcano sponge (*Acarnus erithacus*) and Humpback whale (*Megaptera novaeangliae*)

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Monterey Bay National Marine Sanctuary

- *6,094 square miles (15,783 square kilometers).*
- *Congressionally designated in 1992 as a National Marine Sanctuary for the purpose of resource protection, research, education, and public use*
- *High diversity of flora and fauna including 34 species of marine mammals, more than 180 species of seabirds and shorebirds, at least 525 species of fishes, and an abundance of invertebrates and algae*
- *Includes bays, estuaries, coastal and oceanic waters*
- *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*
- *The Davidson Seamount is an undersea mountain habitat and is the first seamount to be protected within a United States national marine sanctuary*

About this Update

This document provides a partial update to Monterey Bay National Marine Sanctuary's 2009 Condition Report. The 2009 report provided a summary of resources in the National Oceanic and Atmospheric Administration's Monterey Bay National Marine Sanctuary (MBNMS or sanctuary), pressures on those resources, current conditions and trends, and management responses to reduce or mitigate human pressures. Specifically, the State of Sanctuary Resources section of the 2009 Condition Report presented responses to a set of 17 questions posed to all sanctuaries (see Appendix A). These responses provided information on the status and trends of water quality, habitat, living resources and maritime archaeological resources, and the human activities that affect them. These 17 questions were completed for three marine environments: (1.) estuarine, (2.) nearshore and (3.) offshore. The 2009 report can be downloaded from the Office of National Marine Sanctuaries website[1].

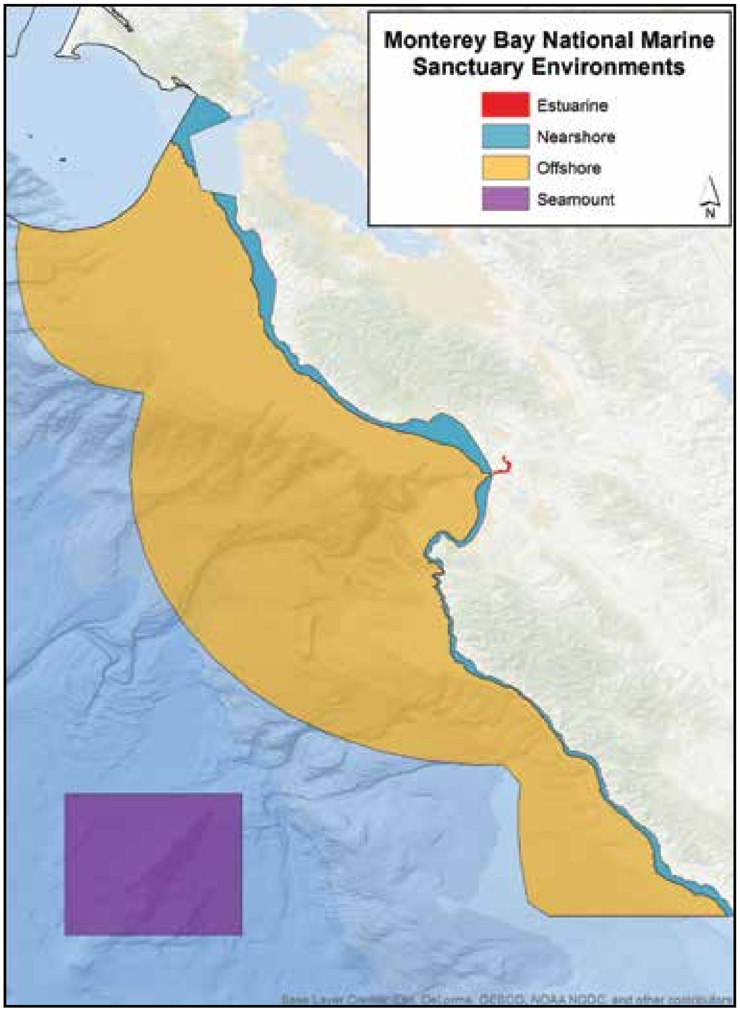
This report provides an updated assessment of the health of the sanctuary in the State of Sanctuary Resources section. Sanctuary staff, with input from regional scientific experts, re-evaluated status and trend ratings for 16[2] of the questions. Each question was re-evaluated for accuracy and completeness, given new data sets, published literature and expert opinion that have become available since 2009. In most cases, new information and updated narratives are provided for each question, and many include new status and trend ratings. Trend ratings are generally based on trends since 2009. This re-evaluation was completed for the three aforementioned marine environments: (1.) estuarine, (2.) nearshore and (3.) offshore. Furthermore, a fourth marine environment, seamount, was evaluated for the first time in this update due to the addition of Davidson Seamount Management Zone to the sanctuary in November 2008 (Figure 1).

In order to address the set of 16 questions, sanctuary staff consulted with outside experts familiar with the resources and with knowledge of previous and current scientific investigations in the sanctuary. Evaluations of status and trends are based on interpretation of quantitative and, when necessary, qualitative assessments, and the observations of scientists, managers and users. The ratings reflect the collective interpretation of the status of local issues of concern among sanctuary system staff and outside experts based on their knowledge and perception of local problems. The final ratings were determined by sanctuary staff. This report has been peer reviewed and complies with the White House Office of Management and Budget's peer review standards, as outlined in the Final Information Quality Bulletin for Peer Review.

This is the second effort to comprehensively describe the status and trends of resources at Monterey Bay National Marine Sanctuary. The report helps identify gaps in current monitoring efforts, as well as causal factors that may require monitoring and potential remediation in the years to come. The data discussed will not only enable resource managers and stakeholders to acknowledge prior changes in resource status, but will also provide guidance for future management challenges imposed by issues such as increasing coastal populations and climate change. This updated condition report also serves as a supporting document for the revision of the Monterey Bay National Marine Sanctuary Management Plan and will help inform constituents who wish to participate in that process.

[1] Office of National Marine Sanctuaries. (last updated Sept. 29, 2015). Condition Reports. National Marine Sanctuaries. http://sanctuaries.noaa.gov/science/condition.

[2] In 2012, the Office of National Marine Sanctuaries led an effort to review and revise the set of questions and their possible responses posed in the condition reports. As part of this effort, some questions were combined, new questions were added and other questions were removed. Question 10, "What is the status of environmentally sustainable fishing and how is it changing?" was removed from the set of questions. This decision was made because of all the questions, it was the only one that focused on a single human activity. The issue of fishing is sufficiently addressed in other questions found in the report, including those related to biodiversity, the status and health of key species, and the status of human activities. For a complete list of the new, revised set of questions, see ONMS 2015. Note that the revised questions are not reflected in the 2015 Monterey Bay National Marine Sanctuary Condition Report Update; however, because of the aforementioned reasons, question 10 was not answered. The new set of questions will be addressed when the condition report is revised in its entirety in the future.



S. De Beukelaer, MBNMS

Figure 1. Monterey Bay National Marine Sanctuary was subdivided into estuarine, nearshore (shoreline to 30 meters depth) and offshore (30 meters depth to seaward boundary) environments for the purpose of assessment in the 2009 MBNMS Condition Report due to the considerable differences in these environments. All 17 standardized questions were assessed separately for each of these environments. In the 2015 Condition Report, a fourth environment, seamount, has been assessed for the first time. The seamount environment is defined by the boundaries of the Davidson Seamount Management Zone, which was added to Monterey Bay National Marine Sanctuary in November 2008.

Summary and Findings

Monterey Bay National Marine Sanctuary is a federal marine protected area encompassing over 6,000 square miles in the United States. Within the boundaries of the sanctuary is a rich array of habitats, from rugged rocky shores and lush kelp forests to an underwater mountain, and 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.

The purpose of a condition report is to use the best available science and most recent data to assess the status of various parts of the sanctuary's ecosystem. Because of the considerable differences within the sanctuary between the estuarine, nearshore, offshore and seamount environments (Figure 1), each question found in the State of the Sanctuary Resources section of this report was answered separately for each environment. Though many estuaries occur along the central California coastline, they are not within the sanctuary's boundaries. Elkhorn Slough is the only estuary located inside MBNMS's boundaries, and thus, is the focus of the estuarine environment section in this report. The nearshore environment is defined as extending from the shoreline boundary of the sanctuary (mean high water) to the 30 meter isobaths, and includes the seafloor and water column. The offshore environment is defined as extending from the 30 meter isobath out to the offshore boundary of the sanctuary, and includes the seafloor and water column. The seamount environment includes the seamount and surrounding seafloor and water column within the Davidson Seamount Management Zone (DSMZ). The DSMZ was added to MBNMS in November 2008 and has been assessed for the first time in this update.

The 2015 assessment of the estuarine environment of Elkhorn Slough reinforces our 2009 assessment that this is an area of concern within the sanctuary. Elkhorn Slough has a history of extensive alteration of physical structures and natural processes that strongly impacts water quality, habitat quality and abundance, and the structure and health of the faunal assemblage. Continued inputs of nutrients and contaminants, especially in areas of muted tidal influence, are contributing to events, such as frequent hypoxia, algal blooms and impacts to sensitive species. Historic human modifications to this system have led to substantial changes in hydrology, erosion and sedimentation that continue to impact the abundance and quality of habitats and living resources. There is a high percentage of non-native species competing with native species and impacting ecosystem health. Some key species, such as eelgrass, native oysters and sea otters, are showing signs of improvement. The slough is the focus of new and on-going conservation and restoration efforts. In the coming years, restoration projects and improvements in land management practices should result in some measurable improvements in water and habitat quality in portions of the slough.

The nearshore environment, which includes the shoreline out to 30 meters depth, is the main zone of interaction between humans and the sanctuary. This is the zone where most residents and visitors interact with sanctuary resources, and where most human activities have the strongest influence. As such, this environment receives a lot of research and resource management attention. Habitats in less impacted areas are in good condition (e.g., Big Sur), but there are concerns about localized on-going activities, including sand mining, coastal armoring, inputs of contaminants and marine debris. A high percentage of the sanctuary's beaches regularly monitored for safety of swimming, received good grades in the last five years, likely due to improvements in sanitary sewer infrastructure in coastal cities. The nearshore waters continue to receive nutrient enrichments from land-based activity, which can intensify the effects of harmful algal blooms (HABs) on sensitive species. Decreases in persistent organic pollutants (dieldrin, dichlorodiphenyltrichloroethane [DDT], polybrominated diphenyl ethers [PBDEs]) were observed in mussels at five locations, but there is limited information available on new pollutants, such as current-use pesticides and pharmaceuticals. Recent drastic declines in sea stars, a key species in nearshore habitats, are a concern, but potential impacts on ecological function and biodiversity will take time to understand.

In the offshore environment, which extends from 30 meters depth to the seaward boundary, most of the regularly monitored key species and species assemblages appear to be stable. Pollutants (e.g., polychlorinated biphenyls [PCBs]), marine debris and toxins from Harmful Algal Blooms (HABs) were detected in some key species. There are concerns about impacts to sensitive species from human-caused noise, vessel traffic and entanglement in lines from buoys, and lost and active fishing gear. Bottom trawl fishing has decreased in intensity and spatial extent, as well as changed to less damaging gear and moved to less sensitive habitats. Recovery of formerly impacted habitats and structure-forming species is expected. The recent prevalence of unusually warm water along the U.S. West Coast has altered the distribution and abundance of some temperature-sensitive species and led to stranding events for a couple key species; however, more time is needed to determine if this phenomenon will have any persistent impacts on key species or the structure and function of the offshore ecosystem. Impacts from climate change, including acidification, warming and shoaling of the oxygen minimum zone, are starting to be detected, but much more research and monitoring is required to better understand and predict current and future impacts.

This first assessment of the seamount environment found benthic habitats and living resources on or near Davidson Seamount appear to be in good condition. Due to its depth, distance from shore and regulatory protections, the seamount area has not been impacted by human activities to the extent of other sanctuary offshore areas. Corals, sponges and other benthic fauna appear to be in pristine or near-pristine condition. Some threats exist, such as vessel traffic and changes in climate change, especially ocean acidification. More research and monitoring of water quality, habitat and living-resources associated with the seamount are needed to better understand the current status and predict potential impacts of human activities and changing climate.

Overall, this updated assessment of the state of sanctuary resources indicates that the sanctuary is doing quite well in comparison to other parts of the world's ocean. The abundance and diversity of wildlife seen in Monterey Bay is remarkable compared to many parts of the world, and many sanctuary resources are showing relative stability or improvement. Long-term monitoring along rocky shores and in kelp forests shows that biogenic habitat, including canopy-forming kelp, understory algae and many structure-forming invertebrates, have been generally abundant and stable. The number of native species in sanctuary habitats, one measure of biodiversity, appears to be stable with no known losses of native species. Though some non-native species are present in the sanctuary, no new introductions are known to have occurred in any of the sanctuary's environments. Most of the sanctuary's regularly monitored key species and species assemblages appear to be stable or slightly improving in status.

Nonetheless, a main purpose of this condition assessment is to identify problems with sanctuary health, so that management can focus on finding opportunities to improve conditions. We have identified some localized problems and some declining trends. Pressures on sanctuary resources are diverse. Some of the most prominent pressures include marine debris, vessel traffic, commercial and recreational fishing, agricultural and urban runoff, harmful algal blooms, coastal development, and disturbances to wildlife. In addition, larger, more global issues, such as climate change and ocean acidification, are significant areas of concern, where some impacts are being detected, but long-term effects are not well understood.

The findings in this update, along with information from the 2009 Monterey Bay National Marine Sanctuary Condition Report, will be used as a tool to support the process to review and update Monterey Bay National Marine Sanctuary's Management Plan. The new management plan will build on the 2008 Management Plan, which contained a number of management actions to address issues and concerns. The plan stressed an ecosystem-based approach to management, which requires consideration of ecological interrelationships not only within the sanctuary, but also within the larger context of the California Current ecosystem. In addition, the plan emphasized an increased level of cooperation with other management agencies in the region. The Management Plan Review process began in September 2015.

Monterey Bay National Marine Sanctuary Condition Summary Table

Estuarine Environment

The following table summarizes the "State of Sanctuary Resources" section of this report for the estuarine environment. The estuarine environment is focused on Elkhorn Slough because it is the only estuary located inside the boundaries of Monterey Bay National Marine Sanctuary. In each table, the first two columns list questions used to rate the condition and trends for qualities of water, habitat, living resources, and maritime archaeological resources. The Rating column consists of a color, indicating resource condition, and a symbol, indicating trend (see key for definitions). The Confidence column shows a rating by experts of their confidence in the status and trend for each questions. Confidence was based on the amount of available information and the level of agreement of experts (see Appendix B for additional information). The Basis for Judgment column provides a short statement or list of criteria used to support the rating. The Description of Findings column presents the statement that best characterizes resource status, and corresponds to the assigned color rating. The Description of Findings statements are customized for all possible ratings for each question (see Appendix A for further clarification of the questions and the Description of Findings statements). The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report.

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

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

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	Fair/Poor ▼	Status: N/A (not updated) Trend: N/A (not updated)	Major alterations to tidal, freshwater and sediment processes have increased the level of pollution and eutrophication; inputs of pollutants from agricultural and urbanized land sources.	Selected conditions have caused or are likely to cause severe declines in some, but not all living resources and habitats.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	Fair/Poor ▼	Status: Very High Trend: Very High	General trend of increasing nitrate in Elkhorn Slough. Frequent occurrence of depressed DO and hypoxic events. High percent cover of algal mats in summer.	Selected conditions have caused or are likely to cause severe declines in some, but not all living resources and habitats.
3	Do sanctuary waters pose risks to human health?	Fair/Poor ?	Status: N/A (not updated) Trend: N/A (not updated)	Elkhorn Slough and connected water bodies are impaired by pesticides and pathogens. High levels of contaminants in harvested crustaceans and bivalves could pose a risk to human health. SWAMP BOG fish results.	Selected conditions have caused or are likely to cause severe impacts, but cases to date have not suggested a pervasive problem.
4	What are the levels of human activities that may influence water quality and how are they changing?	Fair ▲	Status: High Trend: High	Substantial inputs of pollutants from non-point sources, especially agriculture. Less agriculture around Elkhorn Slough due to land acquisition by ESF thereby reducing nutrient loading from agriculture. No evidence yet of improving water quality due to changes in land management practices.	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.

Table is continued on the following page.

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

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
HABITAT					
5	What is the abundance and distribution of major habitat types and how is it changing?	–	Status: Very High Trend: Low	Over 150 years of hydrologic alteration has resulted in substantial erosion and habitat conversion. Recent stability with little change in relative abundance of habitat types.	Selected habitat loss or alteration has caused or is likely to cause severe declines in some, but not all living resources or water quality.
6	What is the condition of biologically-structured habitats and how is it changing?	▲	Status: Very High Trend: High	Severe reductions in the abundance of native structure-forming organisms from historic levels. Recent slight increases in eelgrass and native oysters.	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?	▼	Status: Very Low Trend: Very Low	Numerous contaminants present and at high levels at localized areas with some evidence of accumulation in top predators (sea otters).	Selected contaminants have caused or are likely to cause severe declines in some, but not all living resources or water quality.
8	What are the levels of human activities that may influence habitat quality and how are they changing?	▲	Status: Medium Trend: Low	Past hydrologic changes and maintenance of water diversion structures, and continued input of nutrients from agriculture. Management activities have the potential to reduce agricultural runoff and reduce erosion in some areas.	Selected activities warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts have occurred or are likely to occur.
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	–	Status: Medium Trend: Low	Changes in the relative abundance of some species associated with specific estuarine habitats. No significant recent changes in species richness or relative abundance.	Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
11	What is the status of non-indigenous species and how is it changing?	—	Status: Medium Trend: Medium	High percentage of non-native species, no known recent introductions or significant changes in abundance.	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?	▲	Status: Very High Trend: Very High	Abundance of native oyster, eelgrass and salt marsh are substantially reduced compared to historic levels. Salt marsh appears to be stable and slight increases in eelgrass and native oysters.	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?	?	Status: Low Trend: Low	Limited information on health or condition suggests eelgrass, oysters and sea otters are fairly healthy.	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?	?	Status: Medium Trend: Low	Many human activities that impact living resources (e.g., hydrologic modifications, inputs of pollutants from agriculture and development, introduction of non-indigenous species). Overall trend in human activities difficult to determine.	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.
MARITIME ARCHAEOLOGICAL RESOURCES					
15	What is the integrity of known maritime archaeological resources and how is it changing?	?	Status: N/A (not updated) Trend: N/A (not updated)	Very little is known about the integrity of the few known maritime archaeological resources in Elkhorn Slough.	Not enough information to make a determination.
16	Do known maritime archaeological resources pose an environmental hazard and is this threat changing?	–	Status: N/A (not updated) Trend: N/A (not updated)	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?	–	Status: N/A (not updated) Trend: N/A (not updated)	Existing human activities do not influence known maritime archaeological resources.	Few or no activities occur that are likely to negatively affect maritime archaeological resource integrity.

Monterey Bay National Marine Sanctuary Condition Summary Table

Nearshore Environment

The following table summarizes the "State of Sanctuary Resources" section of this report for the nearshore environment. The nearshore environment is defined as extending from the shoreline boundary of Monterey Bay National Marine Sanctuary (mean high water) to the 30-meter isobath and includes the seafloor and water column. In each table, the first two columns list questions used to rate the condition and trends for qualities of water, habitat, living resources, and maritime archaeological resources. The Rating column consists of a color, indicating resource condition, and a symbol, indicating trend (see key for definitions). The Confidence column shows a rating by experts of their confidence in the status and trend for each questions. Confidence was based on the amount of available information and the level of agreement of experts (see Appendix B for additional information). The Basis for Judgment column provides a short statement or list of criteria used to support the rating. The Description of Findings column presents the statement that best characterizes resource status, and corresponds to the assigned color rating. The Description of Findings statements are customized for all possible ratings for each question (see Appendix A for further clarification of the questions and the Description of Findings statements). The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report.

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

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

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	▼	Status: N/A (not updated) Trend: N/A (not updated)	Elevated levels of contaminants (e.g., POPs, heavy metals), nutrients, sediments, pathogens in some locations; on-going input of established and emerging pollutants. Acidification and hypoxia conditions increasing.	Selected conditions may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources and habitats.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	▼	Status: High Trend: High	Increasing nutrient enrichment and occurrence of HABs. New information regarding prevalence of microcystis in major river systems and coastal waters. HABs directly impacting fish, birds and mammals.	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?	?	Status: Very High Trend: Very High	Continue to have warnings at some beaches and lagoons due to high fecal indicator bacteria; declining dieldrin levels in mussels, contaminated shellfish at some locations and during some seasons. Contaminants in fish exceed seafood standards at a few 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?	▲	Status: Medium Trend: Medium	Human activities result in measurable, localized impacts. Reductions in urban and agricultural runoff anticipated in response to increased regulations for agriculture and stormwater pollution prevention.	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?	▼	Status: Very High Trend: Very High	Localized modification of coastal habitat and reduced habitat quality, primarily through armoring, erosion, landslide and accumulation of marine debris and contaminants.	Selected habitat loss or alteration may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources or water quality.
6	What is the condition of biologically-structured habitats and how is it changing?	–	Status: Very High Trend: Very High	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?	▼	Status: High Trend: High	Declines in some persistent contaminants (dieldrin), but new contaminants being added to the system; some evidence showing contaminants are accumulating in shellfish and resident fish and are impacting health of living resources (e.g., mammals)	Selected contaminants have caused or are likely to cause severe declines in some, but not all living resources or water quality.
8	What are the levels of human activities that may influence habitat quality and how are they changing?	?	Status: Medium Trend: Medium	Trampling, visitation and coastal armoring can have measurable, localized impacts; trash and contaminants present and accumulating slowly despite management efforts.	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.

Table is continued on the following page.

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

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	—	Status: Very High Trend: Very High	Fishing, collecting and poaching have altered biodiversity from what would be expected in a natural state. Most assemblages appear to be fairly stable except for sea stars and urchins.	Selected biodiversity loss may inhibit full community development and function and may cause measurable, but not severe degradation of ecosystem integrity.
11	What is the status of non-indigenous species and how is it changing?	▼	Status: Very High Trend: Very High	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?	▼	Status: Very High Trend: Very High	Abundance of some key species in each habitat type is lower than would be expected in a natural state. Many key species stable or slowly increasing, but recent dramatic declines for many sea star species.	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.
13	What is the condition or health of key species and how is it changing?	▼	Status: Very High Trend: Very High	Continuing health problems in sea otters and black abalone. New severe health issue for sea stars.	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?	▼	Status: Very High Trend: Very High	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?	?	Status: N/A (not updated) Trend: N/A (not updated)	Divers have looted sites, but few sites have been studied to determine trend.	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, scientific or educational value and may affect the eligibility of some sites for listing in the National Register of Historic Places.
16	Do known maritime archaeological resources pose an environmental hazard and is this threat changing?	▼	Status: Medium Trend: Medium	Known resources containing hazardous material continue to deteriorate.	Selected maritime archaeological resources may cause measurable, but not severe, impacts to certain sanctuary resources or areas, but recovery is possible.
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	?	Status: N/A (not updated) Trend: N/A (not updated)	Activities, such as recreational, diving occurs on wreck sites, but activity level is unknown.	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.

Monterey Bay National Marine Sanctuary Condition Summary Table

Offshore Environment

The following table summarizes the "State of Sanctuary Resources" section of this report for the offshore environment. The offshore environment is defined as extending from the 30-meter isobath out to the offshore boundary of Monterey Bay National Marine Sanctuary and includes the seafloor and water column. In each table, the first two columns list questions used to rate the condition and trends for qualities of water, habitat, living resources, and maritime archaeological resources. The Rating column consists of a color, indicating resource condition, and a symbol, indicating trend (see key for definitions). The Confidence column shows a rating by experts of their confidence in the status and trend for each questions. Confidence was based on the amount of available information and the level of agreement of experts (see Appendix B for additional information). The Basis for Judgment column provides a short statement or list of criteria used to support the rating. The Description of Findings column presents the statement that best characterizes resource status, and corresponds to the assigned color rating. The Description of Findings statements are customized for all possible ratings for each question (see Appendix A for further clarification of the questions and the Description of Findings statements). The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report.

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

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

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	Fair ▼	Status: High Trend: Very High	Elevated levels of contaminants (e.g., persistent organic pollutants), and ocean temperature and chemistry changes, some of which have been linked to changes in the offshore ecosystem.	Selected conditions may inhibit the development of assemblages and may cause measurable, but not severe declines in living resources and habitats.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	Good/Fair ▼	Status: Very High Trend: Medium	Nutrient enrichment in selected areas, continued nutrient loading and increased frequency and intensity of harmful algal blooms.	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.
3	Do sanctuary waters pose risks to human health?	Good/Fair ?	Status: N/A (not updated) Trend: N/A (not updated)	Measurable levels of biotoxins and contaminants in some locations that have the potential to affect human health; no reports of human impacts.	Selected conditions that have the potential to affect human health may exist, but human impacts have not been reported.
4	What are the levels of human activities that may influence water quality and how are they changing?	Fair ▲	Status: N/A (not updated) Trend: N/A (not updated)	Inputs of pollutants from agriculture and urban development; reduced risk of impacts from vessels due to regulation of traffic patterns and discharges, removal of oil from sunken ships.	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.
HABITAT					
5	What is the abundance and distribution of major habitat types and how is it changing?	Fair ▲	Status: High Trend: Medium	Benthic habitat loss and modification due to fishing with bottom-contact gear; recovery of seafloor habitats likely occurring in some locations following reductions in this activity.	Selected habitat loss or alteration may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources or water quality.
6	What is the condition of biologically-structured habitats and how is it changing?	Fair/Poor ?	Status: High Trend: Medium	Damage to and loss of structure-forming and structure-building taxa due to trawl fishing. Recovery likely occurring in some locations and for some taxa following reductions in this activity; however, concerns that ocean acidification is negatively impacting these species.	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?	Fair ▼	Status: High Trend: High	Exponential increase in amount of PCBs in water samples from two sites. Marine mammals are contaminated by PCBs. No evidence of strong ecosystem level effects. No additional information on contaminant levels in ocean sediments.	Selected contaminants may inhibit the development of assemblages and may cause measurable, but not severe declines of living resources or water quality.
8	What are the levels of human activities that may influence habitat quality and how are they changing?	Fair ▲	Status: High Trend: High	Decreases in both overall effort and spatial extent of fishing with bottom trawl gear. Inputs of marine debris and contaminants continues. Impacts of submerged cables and marine debris appear to be localized.	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.

Table is continued on the following page.

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

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	—	Status: Medium Trend: Low	Reduced relative abundance of targeted, by-catch, and sensitive species. Overall biodiversity does not appear to have increased or decreased during this time.	Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
11	What is the status of non-indigenous species and how is it changing?	—	Status: N/A (not updated) Trend: N/A (not updated)	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?	—	Status: Medium Trend: Low	Some key species at reduced abundance levels due to past or on-going harvest. Some monitored key species slowly increasing, but most appear to be fluctuating within the range expected based on long-term time series.	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?	▼	Status: Medium Trend: Low	Compromised health due to exposure to neurotoxins produced by HABs, entanglement in active and lost fishing gear, ingestion of marine debris and accumulation of persistent contaminants.	The condition of selected key resources is not optimal, perhaps precluding full ecological function, but substantial or persistent declines are not expected.
14	What are the levels of human activities that may influence living resource quality and how are they changing?	—	Status: Medium Trend: Medium	Recent management actions helping recover overfished stocks and impacted habitats, but inputs of marine debris and contaminants have measurable impacts; ocean acidification and hypoxia increasing.	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?	?	Status: N/A (not updated) Trend: N/A (not updated)	To date, only one of potentially hundreds of archaeological site inventories has been conducted.	Not enough information to make a determination.
16	Do known maritime archaeological resources pose an environmental hazard and is this threat changing?	▼	Status: Medium Trend: Medium	Known resources containing hazardous material located inside and immediately adjacent to the sanctuary continue to deteriorate.	Selected maritime archaeological resources may cause measurable, but not severe, impacts to certain sanctuary resources or areas, but recovery is possible.
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	?	Status: N/A (not updated) Trend: N/A (not updated)	Archaeological resources, particularly those that are undocumented, are vulnerable to degradation from trawling and looting.	Some potentially relevant activities exist, but they do not appear to have had a negative effect on maritime archaeological resource integrity.

Monterey Bay National Marine Sanctuary Condition Summary Table

Seamount Environment

The following table summarizes the "State of Sanctuary Resources" section of this report for the seamount environment. The seamount environment includes the Davidson Seamount Management Zone. In each table, the first two columns list questions used to rate the condition and trends for qualities of water, habitat, living resources, and maritime archaeological resources. The Rating column consists of a color, indicating resource condition, and a symbol, indicating trend (see key for definitions). The Confidence column shows a rating by experts of their confidence in the status and trend for each questions. Confidence was based on the amount of available information and the level of agreement of experts (see Appendix B for additional information). The Basis for Judgment column provides a short statement or list of criteria used to support the rating. The Description of Findings column presents the statement that best characterizes resource status, and corresponds to the assigned color rating. The Description of Findings statements are customized for all possible ratings for each question (see Appendix A for further clarification of the questions and the Description of Findings statements).

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

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

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	?	Status: N/A Trend: N/A	No information available specific to DSMZ; however, see the open ocean section of this report.	Not enough information to make a determination.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	?	Status: N/A Trend: N/A	No information available specific to DSMZ.	Not enough information to make a determination.
3	Do sanctuary waters pose risks to human health?	?	Status: N/A Trend: N/A	No information available specific to DSMZ.	Not enough information to make a determination.
4	What are the levels of human activities that may influence water quality and how are they changing?	?	Status: Medium Trend: Medium	Large vessels, particularly tankers, transiting through DSMZ pose a threat to water quality, but no known impacts from this activity. More information needed on levels and trends of other potential threats.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on water quality.
HABITAT					
5	What is the abundance and distribution of major habitat types and how is it changing?	—	Status: Very High Trend: High	Offshore location, existing level of protections and limited access to the seafloor may limit impacts.	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
6	What is the condition of biologically-structured habitats and how is it changing?	?	Status: Very High Trend: Medium	Biogenic species appear abundant; organisms larger, more robust than coastal canyon areas. Trend information unavailable.	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?	?	Status: N/A Trend: N/A	Contaminant concentrations in DSMZ are poorly understood. There have been very few sediment samples collected within DSMZ for the purpose of contaminant studies.	Not enough information to make a determination.
8	What are the levels of human activities that may influence habitat quality and how are they changing?	?	Status: High Trend: Medium	Harmful activities exist, but offshore location, existing level of protections and limited access to the seafloor may limit impacts.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.

Table is continued on the following page.

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

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	?	Status: Very High Trend: Medium	Relatively pristine area with few removals; but data are sparse.	Biodiversity appears to reflect pristine or near-pristine conditions and promotes ecosystem integrity (full community development and function).
11	What is the status of non-indigenous species and how is it changing?	—	Status: Medium Trend: Medium	No known non-indigenous species; but data are sparse.	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?	▲	Status: High Trend: High	Abundance and diversity of corals, stable fish stocks and existing protections. Federally endangered marine mammal populations (e.g., Fin whale), appear to be increasing.	Key and keystone species appear to reflect pristine or near-pristine conditions and many promote ecosystem integrity (full community development and function).
13	What is the condition or health of key species and how is it changing?	—	Status: High Trend: Medium	Key species appear healthy, and are protected or otherwise regulated.	The condition of key resources appears to reflect pristine or near-pristine conditions.
14	What are the levels of human activities that may influence living resource quality and how are they changing?	?	Status: High Trend: Medium	Offshore location, existing level of protections and few existing threats may limit impacts to living resources.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.
MARITIME ARCHAEOLOGICAL RESOURCES					
15	What is the integrity of known maritime archaeological resources and how is it changing?	N/A	Status: N/A Trend: N/A	No known maritime archaeological resources.	N/A
16	Do known maritime archaeological resources pose an environmental hazard and is this threat changing?	N/A	Status: N/A Trend: N/A	No known maritime archaeological resources.	N/A
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	N/A	Status: N/A Trend: N/A	No known maritime archaeological resources.	N/A

State of Sanctuary Resources

This section provides summaries of the condition and trends within four resource areas: (1.) water, (2.) habitat, (3.) living resources and (4.) maritime archaeological resources. Sanctuary staff, together with local subject experts, considered a series of questions about each resource area. The set of questions derive from the Office of National Marine Sanctuaries' mission, and a system-wide monitoring framework (NMSP 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on and study the ecosystems encompassed by the sanctuaries. 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.

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

Trends:

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

The purpose of this section of the report is to provide updated answers to 16 standardized questions.[3] For many questions, new data, published literature and expert opinions have become available since the 2009 report's publication (ONMS 2009). This new information is summarized and evaluated relative to the 2009 ratings. Moreover, it resulted in a change in status or trends for some of the questions (Estuarine Questions: 2, 4, 5, 6, 7, 8, 9, 12 and 13; Nearshore Questions: 2, 3, 4, 5, 7, 8, 9, 12, 13 and 16; Offshore Questions: 2, 5, 6, 7, 8, 9 and 14). 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.

For the 16 questions, the temporal reference frame is 2009 through the end of 2014. For example, when addressing question 1, "Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?," the 2015 MBNMS Condition Report Update examines potential stressors affecting water quality since 2009. Specifically, are there new stressors or have existing stressors changed (disappeared, diminished or increased) and have these differences since 2009 altered either the rating status or trend? If there is no change in the rating status, then the color will remain the same. If new information suggests the status has changed, then the color will change to reflect the new status. Similarly, if the trend remains the same (i.e. still improving, stable, declining or unknown), the symbol will not change. If new information suggests the trend has changed, then the trend symbol will be changed to reflect the new trend.

Some of the questions refer to the term "ecosystem integrity." When responding to these questions, subject experts and sanctuary staff judged an ecosystem's integrity by the relative wholeness of ecosystem structure, function and associated complexity, and the spatial and temporal variability inherent in these characteristics, as determined by its natural evolutionary history. Ecosystem integrity is reflected in a system's "ability to generate and maintain adaptive biotic elements through natural evolutionary processes" (Angermeier and Karr 1994). It also implies the natural fluctuations of a system's native characteristics, including abiotic drivers, biotic composition, symbiotic relationships and functional processes are not substantively altered and are either likely to persist or be regained following natural disturbance.

Questions 4, 8, 14 and 17 examine the levels of human activities that may influence the sanctuary's resources. While each question received a status and trend rating and an associated basis for judgment explanation, it should be noted that trend data are lacking for many of the human activities considered. In addition, it was difficult to assess the relationship between the impacts of an increasing human population and the effectiveness of management efforts designed to mitigate these anthropogenic pressures.

[3] In 2012, the Office of National Marine Sanctuaries led an effort to review and revise the set of questions and their possible responses posed in the condition reports. As part of this effort, some questions were combined, new questions were added and other questions were removed. Question 10, "What is the status of environmentally sustainable fishing and how is it changing?" was removed from the set of questions. This decision was made because of all the questions, it was the only one that focused on a single human activity. The issue of fishing is sufficiently addressed in other questions found in the report, including those related to biodiversity, the status and health of key species, and the status of human activities. For a complete list of the new, revised set of questions, see ONMS 2015. Note that the revised questions are not reflected in the 2015 Monterey Bay National Marine Sanctuary Condition Report Update; however, because of the aforementioned reasons, question 10 was not answered. The new set of questions will be addressed when the condition report is revised in its entirety in the future.

State of Sanctuary Resources

Because of the considerable differences within the sanctuary between seamount, offshore, nearshore and estuarine environments, each question was answered separately for each of these environments (see Figure 1). Though many estuaries occur along the central California coastline, Elkhorn Slough is the only estuary located inside the boundaries of Monterey Bay National Marine Sanctuary. The nearshore environment is defined as extending from the shoreline boundary of Monterey Bay National Marine Sanctuary (the mean high water line) to the 30 meter isobath and includes the seafloor and water column. The offshore environment is defined as extending from the 30 meter isobath out to the offshore boundary of Monterey Bay National Marine Sanctuary and includes the seafloor and water column. The seamount environment includes Davidson Seamount Management Zone.

The following sections update the 2009 State of Sanctuary Resources for estuarine, nearshore and offshore environments, as well as expands on the 2009 report by including the seamount environment for the first time. The goal of this update is to use the best available science and most recent data to re-evaluate the status and trends of the various components of the sanctuary's ecosystem. These ratings are relative to the highest standard of resource condition and ecosystem health possible in an area with multiple, sustainable uses. It is important to note that overall, MBNMS is doing quite well in comparison to other parts of the world's ocean. The sanctuary's abundance and diversity of wildlife is remarkable compared to much of the world. However, the purpose of this report is to characterize sanctuary health, so sanctuary managers can focus on finding solutions that continue to improve the health and resilience of the sanctuary ecosystem.

Photo: NOAA

State of Sanctuary Resources: Estuarine Environment

There are a few large and many small estuaries along the central California coast; however Elkhorn Slough is the only estuary located within the boundaries of Monterey Bay National Marine Sanctuary and, thus, it is the focus of our assessment of conditions in the estuarine environment of the sanctuary (see Figure 1). The estuaries adjacent to the sanctuary influence its conditions; this information, when available, will be covered in the Nearshore Environment section of this report.

Estuaries represent the confluence of terrestrial, freshwater and marine ecosystems, creating multiple, unique habitats supporting highly diverse communities and providing important ecosystem services. Unfortunately, these rare, but highly productive areas are also very fragile, and human alterations and impacts can diminish their ability to provide biological services (e.g., nursery and feeding grounds for fishes and birds) and to act as environmental filters.

The 2015 assessment of the estuarine environment of Elkhorn Slough uses newly available data, published studies and expert opinions to build on the 2009 assessment. This new information reinforces the conclusions in our 2009 assessment that this is an area of concern within the sanctuary. Elkhorn Slough has a history of extensive alteration of physical structures and natural processes that strongly impacts water quality, habitat quality and abundance, and the structure and health of the faunal assemblage. Continued inputs of nutrients and contaminants, especially in areas of muted tidal influence, contribute to events, such as frequent hypoxia, algal blooms and impacts to sensitive species. Historic human modifications to this system have led to substantial changes in hydrology, erosion and sedimentation that continue to affect the abundance and quality of habitats and living resources. There is a high percentage of non-native species competing with natives and impacting ecosystem health. Some key species, such as eelgrass, native oysters and sea otters, show signs of improvement. The slough is the focus of new and on-going conservation and restoration efforts. In the next several years, these restoration projects and improvements in land management practices should result in measurable improvements in water and habitat quality in portions of the slough.

Elkhorn Slough Volunteer Water Quality Monitoring

Since 1988, Elkhorn Slough National Estuarine Research Reserve (ESNERR), the Elkhorn Slough Foundation (ESF), and the Monterey County Water Resources Agency have been supporting a volunteer water monitoring program.[4] *Twenty-six stations in and around Elkhorn Slough, Moro Cojo Slough and the mouth of the Salinas River are sampled monthly for temperature, salinity, dissolved oxygen, pH, turbidity, nitrate, ammonium and dissolved inorganic phosphate.*

Estuarine Environment: Water Quality

1. ***Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?*** Stressors on water quality continue to be measured and documented in Elkhorn Slough, with particularly high levels of agricultural inputs, such as nutrients and sediment. These pollutants may inhibit the development of assemblages and may cause measurable, but not severe declines in living resources and habitats. For this reason, the question remains rated "fair/poor" with a "declining" trend.

A main cause of water and sediment quality degradation is agricultural non-point source pollution (Caffrey 2002, Phillips et al. 2002, ESNERR et al. 2009). Relatively high levels of nutrients and legacy agricultural pesticides, such as DDT (dichlorodiphenyltrichloroethane), have been documented within the Elkhorn Slough wetlands complex, with the highest concentrations measured in areas that receive the most freshwater runoff (Phillips et al. 2002, ESNERR et al. 2009). Pathogens, pesticides, sediments, low dissolved oxygen levels and ammonia have impaired sections of Elkhorn Slough and water bodies adjacent to the slough, including Moro Cojo Slough and Moss Landing Harbor. Since 1988, the Elkhorn Slough National Estuarine Research Reserve's (ESNERR) researchers and volunteers have been monitoring water quality at 26 sites in and around the reserve (see text box). Data collected from 2004-2009 determined if nutrient loading causes negative impacts to particular areas of the Elkhorn Slough estuarine complex. Of the 26 sites monitored, more than half far exceeded the thresholds for nitrate, phosphate and ammonia as established by the CCRWQCB, sometimes by two orders of magnitude, thus indicating that the Elkohrn Slough is highly impacted by nutrient loading (Hughes et al. 2010).

[4] (n.d.) Elkhorn slough research: Volunteer water quality monitoring. *ElkhornSlough.org*. Retrieved from http://elkhornslough.org/research/waterquality_volunteer.htm. (the official website of the Elkhorn Slough Foundation and Elkhorn Slough National Estuarine Research Reserve)

2. ***What is the eutrophic condition of sanctuary waters and how is it changing?*** In 2009, the eutrophic condition of the sanctuary's estuarine environment was rated as "fair" and "not changing" based on impaired conditions in Elkhorn Slough and the adjacent water bodies that drain into the slough (see 2009 MBNMS Condition Report for specifics). The 2015 rating has been changed to "fair/poor" with a "declining" trend based on increased nitrate concentrations, frequent occurrence of depressed dissolved oxygen and hypoxia events, and a high percent cover of algal mats in the summer at some monitoring stations.

Over recent years, Elkhorn Slough researchers have detected high phytoplankton concentrations, abundant and persistent macroalgal mats, and hypoxia events that they believe are due to high dissolved nutrient concentrations (Hughes et al. 2010). The goal of the 2010 Elkhorn Slough eutrophication report card was to provide an assessment of the eutrophic condition of the 26 sites that have been monitored since 1988 (Hughes et al. 2010). The report card used nutrient data collected from 2004-2009. Other indicators of eutrophic condition included percent cover of algal mats, dissolved oxygen readings at 15 minute intervals over two week periods, unionized ammonia and sediment surface to anoxia layer depth. The results indicate that just over half of the estuary (57.1%) is moderately eutrophic (most of the area within the sanctuary), and 41.4% is highly or hyper eutrophic (Figure 2). Most of the sites were characterized as hyper (62%) or high (27%) for freshwater nutrient inputs. Hypoxia and anoxia conditions are also widespread throughout Elkhorn Slough, but primarily occur behind water control structures where there is little flushing of water and organic matter. More than half of the estuarine complex is behind water control structures making hypoxia problematic in Elkhorn Slough (Hughes et al. 2010).

The majority of Elkhorn Slough's main channel, the part within MBNMS, shows moderate eutrophication mostly because there is unrestricted tidal exchange allowing for the regular mixing of relatively clean ocean water with relatively older estuarine water and the replenishment of dissolved oxygen. Even with the mixing, the Monterey Bay Aquarium Research Institute's (MBARI) Land/Ocean Biogeochemical Observatory (LOBO[5]) network shows that nutrient concentrations are increasing in the lower estuary (Hughes et al. 2010).

Low dissolved oxygen in Elkhorn Slough can cause reduced abundance and diversity of some species of fish and benthic invertebrates (Oliver et al. 2009, Hughes et al. 2015).

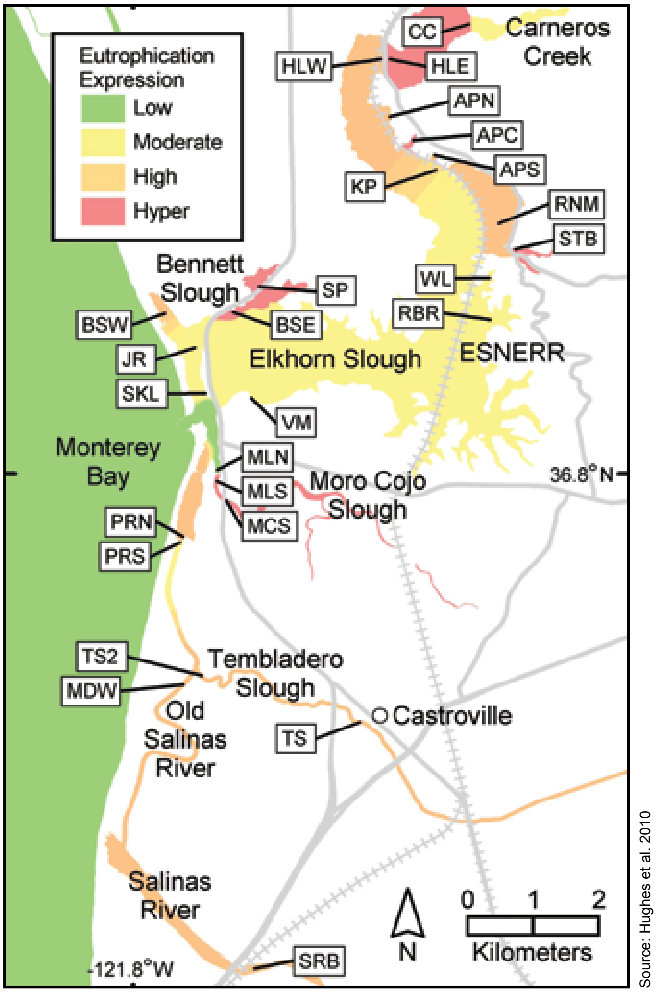


Figure 2. Water quality monitoring stations with eutrophication expression score results (2004-2009) in the Elkhorn Slough watershed.

Hughes et al. (2015) found that reductions in species diversity during hypoxic periods were driven by a complete loss of 12 rare species and declines in several species of flatfish. Populations of the two most common flatfish species, English sole and speckled sanddab, are reduced during hypoxic conditions along with the amount of suitable habitat. Elkhorn Slough is an important nursery habitat for English sole in Monterey Bay; therefore, reductions in the nursery function of this estuary could have consequences to the offshore adult population (Brown 2006, Hughes et al. 2014, Hughes et al. 2015).

Hughes et al. (2010) recommends continued efforts to reduce nutrient inputs into Elkhorn Slough. The Elkhorn Slough Foundation (ESF), as well as other partners through the Agriculture

[5] (last updated July 20, 2012). Land/ocean biogeochemical observatory (LOBO) in Elkhorn Slough. *Monterey Bay Aquarium Research Institute (MBARI)*. Retrieved from http://www.mbari.org/lobo/.

Land/Ocean Biogeochemical Observatory in Elkhorn Slough (LOBO)

The Land/Ocean Biogeochemical Observatory (LOBO) observing system is designed to monitor the flux of nutrients (nitrate, phosphate and inorganic carbon) in the Elkhorn Slough ecosystem. The environmental sensor network, developed by the Monterey Bay Aquarium Research Institute (MBARI), is capable of continuous, autonomous monitoring of key processes that regulate primary production, eutrophication and hypoxia in coastal environments.[6]

Surface Water Ambient Monitoring Program (SWAMP)

California's Surface Water Ambient Monitoring Program (SWAMP) assesses water quality in all of California's surface waters and coordinates all water quality monitoring conducted by the state and regional water boards. The program conducts monitoring directly and through collaborative partnerships, and provides numerous information products designed to support water resource management in California. SWAMP funds the Stream Pollution Trends (SPoT) and the Bioaccumulation Monitoring programs.[8]

Water Quality Alliance (AWQA) coordinated by the MBNMS Water Quality Protection Program, work to identify opportunities for more conservation easements and encourage more sustainable agriculture practices throughout central coast watersheds. Researchers at the Central Coast Wetlands Group also support water quality monitoring of these resources and have documented similar loading and eutrophication issues. Each of these are long-term efforts and it will take time to produce results. ESF believes that more rapid improvements are possible in the slough's upper reaches by improving management of the water control structures to increase tidal exchanges and reduce water stagnation.

3. ***Do sanctuary waters pose risks to human health?*** The human health risks posed by the sanctuary's estuarine waters, rated "fair/poor," with an "undetermined" trend, did not change from the 2009 Condition Report. Elkhorn Slough and adjacent water bodies, including Moro Cojo Slough, Moss Landing Harbor, Salinas River Lagoon and Old Salinas River Estuary, are impaired by pesticides, sediment, pathogens and other pollutants (SWRCB 2010[7]).

New information supports the previous rating of "fair/poor." The California Surface Water Ambient Monitoring Program documented elevated concentrations of persistent organic pollutants in fish tissue over a two year period (Davis et al. 2012) (see Table 1 on page 35). All four of the fish types collected in Elkhorn Slough exceeded at least one of the Environmental Protection Agency's (EPA) subsistence fisher screening values for PCBs (polychlorinated biphenyls), DDTs and dieldrin (USEPA 2000). The trend remains undetermined because of the persistent nature of contaminants that are found in the fish tissue and sediments within the Elkhorn Slough, which will take many years to change even with the implementation of significant management strategies (refer to the 2009 MBNMS Condition Report for more information).

4. ***What are the levels of human activities that may influence water quality and how are they changing?*** In 2009, human activities that can influence water quality were rated "fair" and the trend was "undetermined" based on poorly understood sources of non-point source pollution that threaten water quality in Elkhorn Slough from multiple sources, including substantial agricultural runoff from inputs along the Salinas River, Tembladero Slough and the Elkhorn Slough watershed (see 2009 MBNMS Condition Report for specifics).

The 2015 rating remains "fair," because there is no evidence of improved water quality, but the trend has been upgraded to "improving" based on the stricter regulation of agricultural land management and conservation activities in the watershed (refer to the response to Nearshore Question 4 for more information on increased state regulatory requirements). The Elkhorn Slough Foundation (ESF) has active farming operations totaling 113.5 acres and one grazing area totaling 290 acres. The present farmed area represents a reduction of approximately 90% of what had been farmed in the watershed prior to ESF[9] ownership. As of 2005, all of the farmed areas

[6] *Id.*
[7] State Water Resources Control Board (SWRCB). (Oct. 11, 2011). Final 2010 integrated report (clean water act section 303(d) list / 305(b) report: Category 5, 2010 California 303(d) list of water quality limited segments. Retrieved from http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/category5_report.shtml.
[8] (last updated Sept. 29, 2015). Surface water ambient monitoring program (SWAMP). California Environmental Protection Agency: State Water Resources Control Board (SWRCB). Retrieved from http://www.waterboards.ca.gov/water_issues/programs/swamp/.

in the watershed were certified as organic farmland. The grazing area has been managed using a Holistic Rangeland Management (HRM) approach since 1998. HRM is an approach to manage cattle that never allows a pasture to be overgrazed or to a point that might leave a pasture with a significant amount of bare soil and/or little vegetative cover. There are currently 17 sediment basins and eight grassed waterways or swales used as on-farm practices to slow water and remove suspended sediment, nutrients and other contaminants that might otherwise flow into the Elkhorn Slough.

Over the past fifteen years, management agencies have worked with local stakeholders to create regulatory, monitoring, education and training programs and to implement better agricultural and urban management practices aimed at reducing or eliminating pollution sources. Since 2008, a total of 50 acres of wetland and upland habitat at 12 sites throughout the Moro Cojo watershed were restored and enhanced. The restoration helped to mitigate anthropogenic impacts on wetland resources, particularly those that affect water quality, sedimentation and loss of habitat. Nonetheless, there continues to be a poor understanding of the relationships between the cumulative effects of behavioral changes within this region and changes in water quality conditions. Gee et al. (2010), as well as O'Connor et al. (2013), showed improved water quality on a micro watershed scale after restorations occurred, especially for nitrate. The Moro Cojo Slough Management and Enhancement Plan is a good start to measure the effectiveness of land-based management practices, along with a commitment to analyze and report the results.

Estuarine Environment: Habitat

The following information provides an assessment of the status and trends pertaining to the current state of estuarine habitat since 2009.

5. ***What is the abundance and distribution of major habitat types and how is it changing?*** The 2009 status and trend for the abundance and distribution of major habitat types in the estuarine environment of the sanctuary was "fair/poor" and "declining," respectively. This rating was based on an analysis of a chronological series of maps and aerial photos by the Elkhorn Slough

Estuarine Environment
Water Quality Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
HABITAT					
1	Stressors	▼	Status: N/A (not updated) Trend: N/A (not updated)	Major alterations to tidal, freshwater, and sediment processes have increased the level of pollution and eutrophication; inputs of pollutants from agricultural and urbanized land sources.	Selected conditions have caused or are likely to cause severe declines in some, but not all living resources and habitats.
2	Eutrophic Condition	▼	Status: Very High Trend: Very High	General trend of increasing nitrate in Elkhorn Slough. Frequent occurrence of depressed DO and hypoxic events. High percent cover of algal mats in summer.	Selected conditions have caused or are likely to cause severe declines in some, but not all living resources and habitats.
3	Human Health	?	Status: N/A (not updated) Trend: N/A (not updated)	Elkhorn Slough and connected water bodies are impaired by pesticides and pathogens. High levels of contaminants in harvested crustaceans and bivalves could pose a risk to human health. SWAMP BOG fish results.	Selected conditions have caused or are likely to cause severe impacts, but cases to date have not suggested a pervasive problem.
4	Human Activities	▲	Status: High Trend: High	Substantial inputs of pollutants from non-point sources, especially agriculture. Less agriculture around Elkhorn Slough due to land acquisition by ESF thereby reducing nutrient loading from agriculture. No evidence yet of improving water quality due to changes in land management practices.	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.

The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report (ONMS 2009).

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

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

[9] (n.d.) Land management. *ElkhornSlough.org*. Retrieved from http://www.elkhornslough.org/landmanagement/index.htm.

National Estuarine Research Reserve that revealed dramatic changes in the relative abundance of estuarine habitats over 130 years. In 1870, approximately 65% of Elkhorn Slough habitat was dense salt marsh, with less than 5% mud and sparse salt marsh habitat. By 2000, the amount of estuarine habitat composed of dense salt marsh had decreased to less than 20% and the amount of mud or sparse salt marsh habitat had increased to approximately 50%.

The analyses in the 2009 Condition Report used data collected through 2000 (ONMS 2009). Data are now available through 2009, which shows relative stability in the system between 2000 and 2009 with very little change in the relative abundance of estuarine habitats (Figure 3). Recent analyses (Wasson et al. 2013) show that salt marsh extent has remained stable since 2009, with minor losses balanced by gains; therefore, the 2015 status remains "fair/poor" and the trend is "not changing."

The various stressors and threats to habitat that were discussed in detail in the 2009 Condition Report continue to be a concern, including modified hydrology, high erosion rates and reduced sediment supply from rivers. A 2009 report analyzing sediment budgets for Elkhorn Slough projected continued erosion and degradation of subtidal and intertidal habitats under current conditions (PWA 2009). Projected sea level rise will create an additional sediment demand that should be factored into current management and restoration planning (PWA 2009).

Since its launch in 2009, the Tidal Marsh Restoration Project developed plans to restore salt marsh at the Minhoto site,[10] a site which subsided during a diked period. This project, slated for 2016, will likely increase suitable habitat through soil addition. It is expected that salt marsh plants will be added to these areas, survive and thereby increase the overall population within Elkhorn Slough. According to ESNERR staff, a comprehensive monitoring plan will be developed and implemented as part of the project to verify achievement of project goals and to increase understanding of ecosystem processes, including monitoring via aerial photography. Ecotone establishment will be assessed using quantitative field methods and the displacement of tidal prism will be assessed using LiDAR topographic measurements. These efforts will be critical to assess the achievement of goals and whether the restoration project has the intended effect of increasing tidal marsh and associated species in Elkhorn Slough.

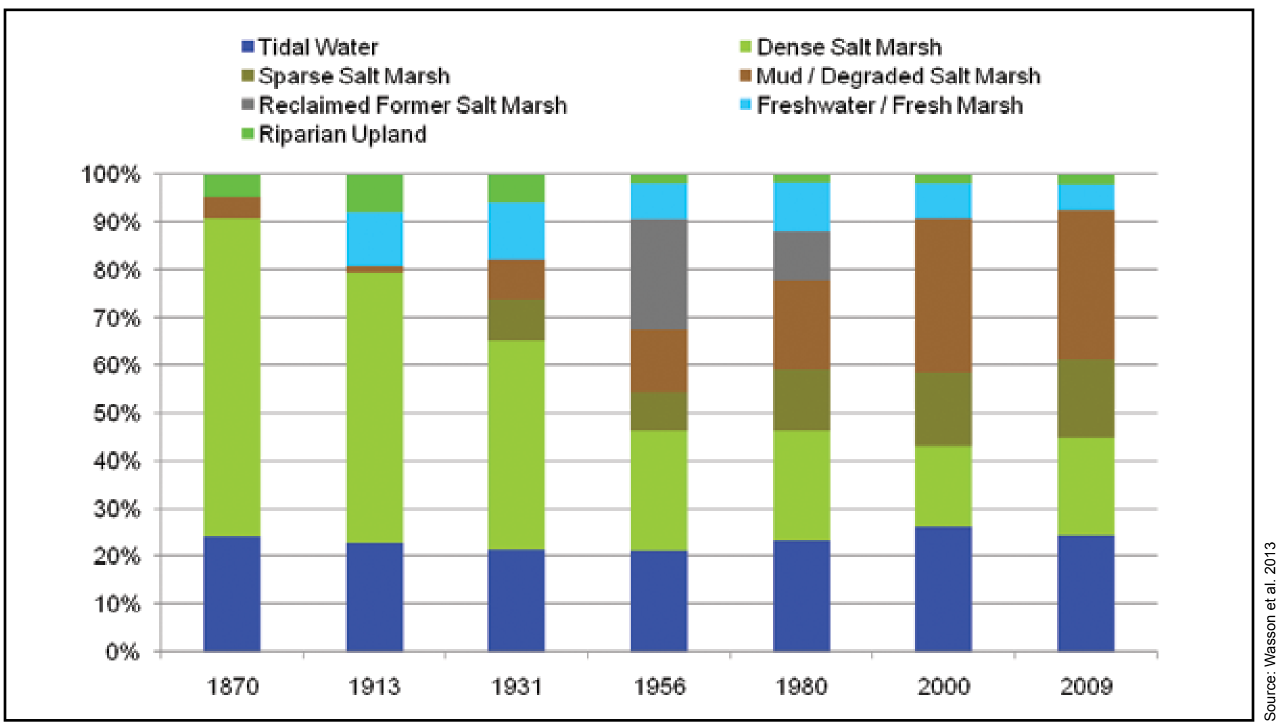


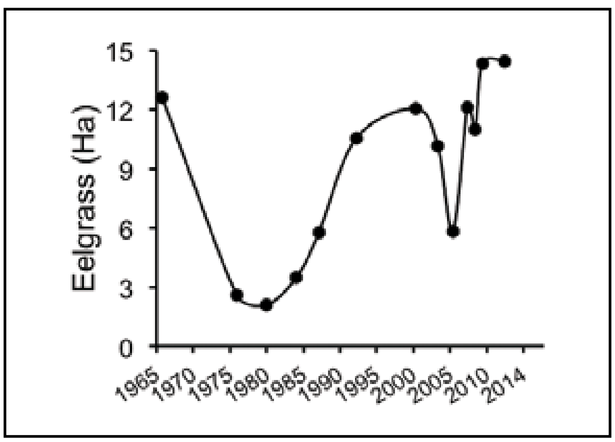
Figure 3. The relative abundance of seven different habitat types in Elkhorn Slough from analysis of a chronological series of maps and aerial photographs. Between 2000 and 2009, the trend in the system was relatively stable, with very little change in the relative abundance of estuarine habitats (the 2009 data was not available for use in the 2009 Condition Report).

6. ***What is the condition of biologically-structured habitats and how is it changing?*** The rating status for biologically-structured habitats in 2009 was "poor" with a "declining" trend. This was based on two native species that form biogenic habitat in the main channel of Elkhorn Slough: eelgrass (*Zostera marina*) and native oyster (*Ostrea lurida*, also referred to as *Ostreola conchaphila*). Both species have undergone severe reductions in abundance within the slough as compared to their historic levels. Additionally, there were concerns that a non-native reef-forming tubeworm (*Ficopomatus enigmaticus*) from Australia, which was initially identified in Elkhorn Slough in 1994 (Wasson et al. 2001), was spreading and possibly competing with native oysters for attachment sites. The 2015 rating status for biologically-structured habitats remains "poor," but the trend has been changed to "improving" due to recent increases in eelgrass abundance, restoration efforts associated with native oysters and new information on the condition of salt marsh habitat based on California Rapid Assessment Methods.

    New information on the aerial extent of eelgrass beds in Elkhorn Slough's main channel shows a slight increase in size since 2009 (Figure 4). Hughes et al. (2013) present evidence indicating "complex top-down effects of sea otter predation have resulted in positive benefits to eelgrass beds … in Elkhorn Slough." A recent study of the abundance of native oysters at nine sites in Elkhorn Slough reveals that oyster populations in Elkhorn Slough are smaller and have more frequent recruitment failure than populations in San Francisco Bay (Wasson et al. 2014). Oysters in the Slough remain very rare and have frequent years of zero recruitment estuary-wide, but very slight gains have been made due to restoration efforts on the Elkhorn Slough National Estuarine Research Reserve (ESNERR). Continued monitoring has not detected any major changes in the spread and spatial coverage of *Ficopomatus* or other invasive species (K. Wasson, ESNERR, pers. com.).

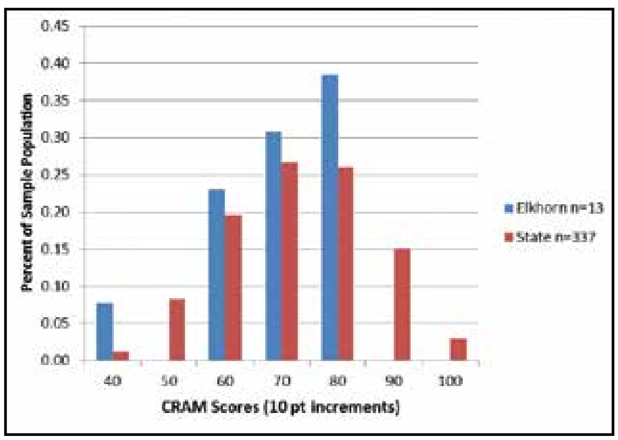
    Based on maps and photos, the 2009 abundance of Elkhorn Slough's dense salt marsh habitat is very low compared to historic levels documented in the late 1800s (Figure 3). Since 2006, the Central Coast Wetlands group has conducted probabilistic and opportunistic surveys to assess the condition of Elkhorn Slough's marsh habitat. The condition of 13 areas of Elkhorn Slough was assessed using the California Rapid Assessment Method (CRAM) for wetlands.

    Figure 5 depicts the distribution of CRAM condition scores for sites within Elkhorn Slough compared to the distribution of CRAM scores for the entire California coast. Seven percent of sites assessed within Elkhorn Slough received a CRAM assessment score of less than 40 points, representing a poor condition. The other sites within Elkhorn Slough scored between 50 and 80 points, representing fair/good condition of marsh habitat. No areas within Elkhorn Slough were documented with an excellent condition.



Source: Hughes et al. 2013

Figure 4. Historical analysis of eelgrass in Elkhorn Slough. Eelgrass cover and change through time were interpreted using low altitude vertical aerial imagery acquired between 1966 and 2012. Only years through which eelgrass cover could be determined with high confidence based on historical descriptions and recent ground surveys of distribution were used (N = 13).



Graph: R. Clark, Central Coast Wetlands Group
Data Source: http://www.cramwetlands.org

Figure 5. Distribution of estuarine California Rapid Assessment Method (CRAM) condition scores for 13 sites sampled within Elkhorn Slough compared with the distribution of CRAM condition scores for estuaries throughout California.

[10] Elkhorn Slough National Estuarine Research Reserve. (2012, May 13). Tidal marsh restoration using sediment addition. Retrieved from http://www.elkhornslough.org/tidalwetland/downloads/Tidal_Marsh_Restoration_Project_Overview_and_FAQ.pdf.

Repeated surveys of these sites using the same method could provide information on how marsh condition is changing in response to continued stressors, as well as restoration efforts in Elkhorn Slough.

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7. ***What are the contaminant concentrations in sanctuary habitats and how are they changing?*** Based on the available information on contaminant concentration in estuarine habitats of the Elkhorn Slough watershed the 2009 rating was "fair" because numerous contaminants from a variety of sources were identified, sometimes appearing at high levels in localized areas (ONMS 2009). In this largely rural watershed, the main source of water and sediment quality degradation appeared to be agricultural non-point source pollution (Caffrey et al. 2002). Significant concentrations of legacy agricultural pesticides, such as DDT, were documented in some watershed wetlands, with the highest levels in the areas receiving the most freshwater runoff (Caffrey et al. 2002). Moreover, the trend in contaminants in Elkhorn Slough habitats was "declining" because of the lack of attenuation of legacy pesticides and the continued input of currently applied pesticides (refer to the 2009 MBNMS Condition Report for more information).

The 2015 ratings for contaminants in Elkhorn Slough's estuarine habitats have been changed to "fair/poor" and "declining" due to the fact (1.) that legacy pesticides and newer pesticides are found in the water bodies that drain to Elkhorn Slough and (2.) that limited studies indicate that these contaminants are detected, sometimes at high concentrations, in animals in these systems.

Historically, organochlorines such as DDT, were applied on farms. Although said chemicals are now banned in the U.S., these compounds are long-lived because they adhere to soil particles. These legacy contaminated soils can enter Elkhorn Slough habitats through runoff from agricultural lands. Legacy pesticides can accumulate in habitat and associated benthic organisms and ultimately accumulate in higher trophic level marine organisms. Jessup et al. (2010) compared contaminants loads in sea otters from around the Monterey Bay area. They found high levels of legacy compounds in male sea otters from Elkhorn slough, especially DDT. The sea otters likely consume contaminants from benthic invertebrates.

Photo: Gabi Estill, Elkhorn Slough Foundation

Figure 6. Aerial photo of a sill that was installed at the mouth of Parson's Slough in 2011. The purpose of this restoration project was to reduce erosion and wetland loss in Elkhorn Slough.

In addition to legacy pesticides, newer pesticides have been found in the water column and sediment in many locations in the Salinas Valley watershed and Salinas River, which drain to Elkhorn Slough (TNC 2015) (see response to Nearshore Question 2 and 7 for more details). Toxicity and persistence of newer compounds vary, but their effects can be additive and concentrations at many sample sites in the Salinas River watershed are found in doses lethal to test organisms (TNC 2015). Studies of the effects of these compounds on estuarine species and on higher trophic level organisms are needed, but based on the studies in the watershed, these compounds could be impacting the health of lower and high trophic levels species in Elkhorn Slough. A study of contaminant levels, both legacy and some newer use compounds, in sea otters in Elkhorn Slough is currently underway (T. Tinker, USGS, pers. comm.). The results of this study should help determine the types of contaminants that are accumulating in sea otters and are likely present in the benthic invertebrates they eat.

8. ***What are the levels of human activities that may influence habitat quality and how are they changing?*** In 2009, the rating status and trend for the levels of human activities that may influence habitat quality was "poor" and "not changing" based on past hydrologic changes, continued dredging, maintenance of water diversion structures and input of agricultural non-point source pollution. The 2015 status remains "poor" because, although most of the aforementioned structural changes were made decades ago, the slough's habitat quality is still severely degraded by those changes. In addition, on-going maintenance of water control structures and dredging of the harbor mouth continue to alter Elkhorn Slough's habitat quantity and quality. Extremely high levels of nitrate continue to be added to the system.

Although the status remains "poor," the trend in human activities that influence habitat quality has been changed from "not changing" to "improving" due to newly implemented restoration efforts by the Elkhorn Slough Foundation (ESF), ESNERR, Central Coast Wetlands Group and others. More property in the Elkhorn watershed has been acquired by the ESF and ESNERR, and agricultural runoff has presumably declined as a result (see response to Estuarine Question 4 for more details).

The Parsons Slough Sill (Figure 6), a restoration project that was completed in February 2011, is an apparent success according to early monitoring.[11] This project, managed by the Tidal Wetland Project in a joint effort with ESNERR, was identified as the most efficient and lowest risk approach to reducing erosion and wetland loss in Elkhorn Slough. The sill is expected to significantly reduce erosive tides in Elkhorn Slough and prevent thousands of cubic yards of sediment from washing into the bay each year. The project is anticipated to restore an additional seven acres of tidal marsh around the perimeter of the Parsons Slough Complex.

Data gaps continue to exist. Data on human activities that may influence habitat quality are sparse. Purchasing land surrounding the estuary and either changing or reducing farming practices can have a positive impact on habitat quality (Gee et al. 2010).

While positive changes have occurred due to restoration activities, there has been no reduction of nutrient concentrations entering the estuary via the old Salinas River channel. There has been a decrease in nitrate loading, possibly because of the drought (see text box), but also potentially because of increased use of water efficient agriculture practices. Agricultural pollution leading to eutrophication in the estuary has enormous ecological impacts on sanctuary habitats in the estuary, and there has been no change in this trend (see response to Estuarine Question 2 for more details on nutrients and eutrophication). However, because water quality is covered in other questions, and to highlight the positive human activities due to restoration, which have had small beneficial impacts in selected areas, we have chosen a positive trend for this question.

Estuarine Environment Habitat Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
HABITAT					
5	Abundance/Distribution	— (Fair/Poor)	Status: Very High Trend: Low	Over 150 years of hydrologic alteration has resulted in substantial erosion and habitat conversion. Recent stability with little change in relative abundance of habitat types.	Selected habitat loss or alteration has caused or is likely to cause severe declines in some, but not all living resources or water quality.
6	Biologically-Structured	▲ (Poor)	Status: Very High Trend: High	Severe reductions in the abundance of native structure-forming organisms from historic levels. Recent slight increases in eelgrass and native oysters.	Selected habitat loss or alteration has caused or is likely to cause severe declines in most, if not all living resources or water quality.
7	Contaminants	▼ (Fair/Poor)	Status: Low Trend: Low	Numerous contaminants present and at high levels at localized areas with some evidence of accumulation in top predators (sea otters).	Selected contaminants have caused or are likely to cause severe declines in some, but not all living resources or water quality.
8	Human Impacts	▲ (Poor)	Status: Medium Trend: Low	Past hydrologic changes and maintenance of water diversion structures, and continued input of nutrients from agriculture. Management activities have the potential to reduce agricultural runoff and reduce erosion in some areas.	Selected activities warrant widespread concern and action, as large-scale, persistent and/or repeated severe impacts have occurred or are likely to occur.

The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report (ONMS 2009).

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

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

Photo: Becky Stamski / NOAA MBNMS

[11] (n.d.) Elkhorn Slough tidal wetland project restoration projects: Parsons Slough. *ElkhornSlough.org*. Retrieved from http://www.elkhornslough.org/tidalwetland/parsons.htm.

Droughts in California

The three-year period of 2012-2014 ranked as the driest consecutive three-year period on record for California's statewide precipitation. In particular, water year 2014 (October 1, 2013-September 30, 2014) ranked as the third driest on record for California's statewide precipitation. In 2014, a statewide emergency drought proclamation was triggered due to the cumulative impacts of multiple dry years and the record or near-record low precipitation in 2014.

Drought is a normal part of the water cycle in California and dry years happen periodically; however, sustained multi-year dry periods have been relatively infrequent in the historical record. Generally, drought in California results from an absence of winter precipitation. Notably, the 2012-2014 drought was further exacerbated by high air temperatures, with new climate records set in 2014 for statewide average temperatures. Warmer temperatures affect the percentage of precipitation that falls as rain or snow, and the spatial and temporal extent of mountain snowpack.

Impacts of drought are typically felt first by those most dependent on annual rainfall, such as ranchers or rural residents that rely on wells. Impacts increase with the length of a drought, as carry-over storage in reservoirs is depleted and levels in groundwater basins decline. California's extensive water supply infrastructure greatly mitigates the effects of short term (single year) dry periods to users of managed supplies (e.g., generally users in urban areas), although impacts related to unmanaged systems (e.g., stress on wildlife) remain (CDWR 2015).

Estuarine Environment: Living Resources

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

Key species, such as keystone species, indicators species, sensitive species and those targeted for special protection, are discussed in the responses to questions 12 and 13. Status of key species will be addressed in question 12 and refers primarily to population numbers. Condition or health of key species will be addressed in question 13. The sanctuary's key species are numerous and cannot all be covered here. Instead, in this report, we emphasize various examples from the sanctuary's primary habitats that have data available on status and/or condition.

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

9. ***What is the status of biodiversity and how is it changing?*** The 2015 rating status for biodiversity remains "fair" and the trend is "not changing" because there is no evidence of significant increases or decreases since 2009. Elkhorn Slough contains several estuarine habitats that support a diverse species assemblage. Though species richness in the estuary is high, the status of native biodiversity in Elkhorn Slough is rated fair based on changes in the relative abundance of some species associated with specific estuarine habitats. Human actions (e.g., altered tidal flow by dikes and channels) have altered the tidal, freshwater and sediment inputs, which has led to substantial changes in the extent and distribution of estuarine habitat types.

   We are not aware of any new stressors or threats to biodiversity that have emerged since 2009. Furthermore, we are not aware of any new data that indicates species additions or losses since 2009. Relative abundances of several species are likely to vary from 2009 to 2014, but we do not know of any particular drivers for such changes.

   There are multiple indices for species biodiversity (e.g., species richness and evenness) that can easily be calculated for Elkhorn Slough from monitoring data collected by ESNERR; however, knowing the appropriate target can be challenging. For instance, marine richness is always higher than estuarine richness, so increases in richness may not be a good indicator of estuarine health.

ESNERR Early Detection for Aquatic Invaders

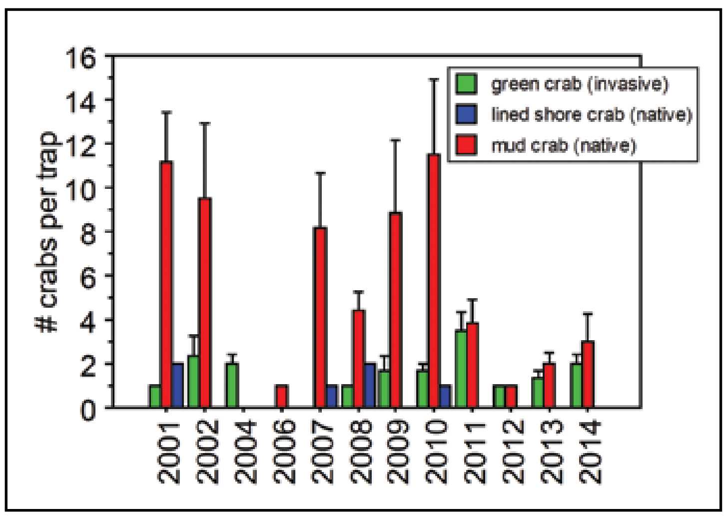
The Elkhorn Slough National Estuarine Research Reserve, in partnership with the Elkhorn Slough Foundation and Monterey Bay National Marine Sanctuary, and with funding from California Sea Grant, established an early detection program for aquatic alien invaders.[12] The goal of this program is to detect new invasions of problematic non-native aquatic organisms early enough to allow for successful eradication.

10. What is the status of environmentally sustainable fishing and how is it changing? We no longer assess this question in ONMS condition reports; therefore, content for this question was not updated.

11. What is the status of non-indigenous species and how is it changing? The rating status for non-indigenous species (NIS) remains "poor" and the trend remains "not changing." Elkhorn Slough is highly invaded, with 11% known NIS among invertebrates, as compared to the open coast which has 1% known NIS (Wasson et al. 2005). ESNERR updates surveys for NIS every two years in internal reports. Recent surveys have seen minor increases and decreases in abundance of some NIS species. For example, *Caulacanthus* (an invasive red turf alga) increased in 2011, but decreased somewhat by the time of the next survey in 2013. In the past years, the Japanese mud snail (*Batillaria attramentaria*) appears to have decreased in abundance at some sites (K. Wasson, ESNERR, pers. comm.). European green crab (*Carcinus maenas*) abundance is highly variable over time with no clear trend (Figure 7). Overall, given the high richness and abundance of NIS in Elkhorn Slough, we consider that the changes observed have probably not had a significant net change on impacts of NIS in the estuary, and thus, conclude that the trend is not changing.

12. What is the status of key species and how is it changing? The status of key species in the estuarine environment remains "fair/poor," but the trend has been changed from "declining" to "improving." Key species include native oysters, eelgrass, sea otters and salt marsh plants. Since 2009, native oyster populations increased in ESNERR due to restoration efforts,[13] but remain challenged by frequent years with zero oyster recruitment in the estuary (K. Wasson, ESNERR, pers. comm.). During the same period, eelgrass beds expanded slightly (see Figure 4). Conversely, the overall extent of salt marsh habitat did not undergo any significant changes (see Figure 3). There are no new stressors or threats to these key species since 2009.

Since 2009, the number of sea otters in Elkhorn Slough increased (Figure 8). Sea otters were first observed in Elkhorn Slough in 1984, and until recently, the slough was mostly populated by transient, non-territorial male sea otters. However, starting in about 2008, the predominantly transient male population was joined by reproducing females (T. Tinker, USGS-WERC, pers. comm.). The number of resident sea otters has grown due to this influx of females and the birth of their pups, as well as the presence of territorial males who are year-round residents (T. Tinker, USGS-WERC, pers. comm.). It is unknown exactly how many resident and transient sea otters can be sustained by the Elkhorn Slough's resources. It appears that sea otters increasingly use salt



Source: Wasson et al. 2015

Figure 7. Abundance of the European green crab (*Carcinus maenas*) (a non-indigenous species) compared to two native crab species, the lined shore crab (*Pachygrapsus crassipes*) and the mud crab (*Hemigrapsus oregonensis*), in Elkhorn Slough based on monitoring using baited crab pots. The invasion of the European green crab into Elkhorn Slough continues, with high variability in both native and invasive crab numbers over time.

[12] (n.d.) Elkhorn Slough research: Early detection for aquatic invaders. *ElkhornSlough.org*. Retrieved from http://elkhornslough.org/research/biomonitor_invasion.htm.

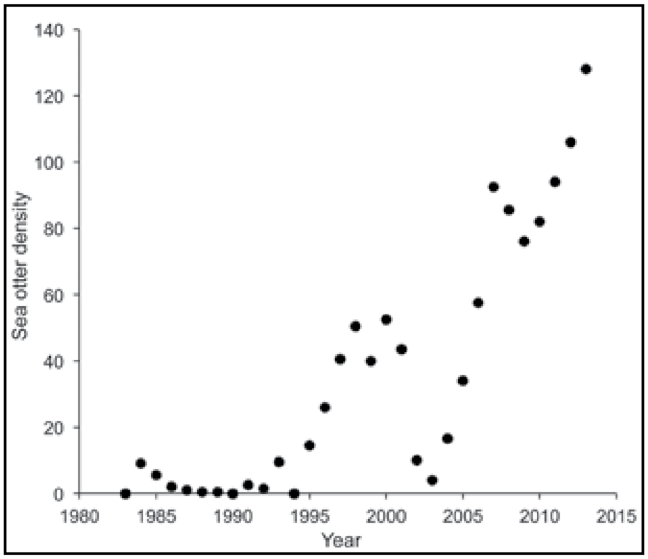


Figure 8. Long-term trend in sea otter density in Elkhorn Slough. Annual density calculated from the standardized biannual census counts from the US Geological Survey (USGS) (www.werc.usgs.gov) in which sea otter abundance in Elkhorn Slough is estimated from 1 day surveys in the spring and fall from 1985 to 2014. Sea otters first entered Elkhorn Slough in 1984, so, for this year, Kvitek et al. (1988) was used to estimate the number of otter arrivals in the estuary.

marsh habitats, with a greater number of otters spending more time further up the estuary (USGS, unpubl. data).

This growing population appears to influence the abundance of other species in Elkhorn Slough through complex ecological interactions. Recently, Hughes et al. (2013) found that complex top-down effects of sea otter predation on crabs in Elkhorn Slough have resulted in positive benefits to eelgrass. Sea otter predation has led to a decrease in crabs, which has allowed for an increase in the system's number of herbivore grazers. These grazers, such as the sea slug (*Phyllaplysia taylori*) and isopod (*Idotea resecata*), remove algae from the surface of seagrass blades, which, in the absence of herbivory, can harm eelgrass through shading and smothering. Recent increases in this top predator appear to mediate species interactions at the base of the food web and counteract the negative effects of anthropogenic nutrient loading in this highly impacted system (Hughes et al. 2013).

Looking forward, there are plans to restore salt marsh at the Minhoto site via the Tidal Marsh Restoration Project.[14] The project's planned addition of sediment to restore the marsh as the Minhoto site, a site that subsided during a diked period, is designed to increase tidal marsh habitat, reduce tidal scour and improve water quality. Slated to begin in 2016, the marsh restoration will be thoroughly monitored. These monitoring efforts will be critical to assess the achievement of goals and whether the restoration project has increased the extent of salt marsh habitat and other associated key species in Elkhorn Slough as intended.

13. What is the condition or health of key species and how is it changing? In 2009, the status of the condition or health of key species was designated as "undetermined;" today, however, based on our recent studies, that status is now considered "fair/good." Conversely, the trend, "undetermined," has not changed. The key species in Elkhorn Slough are eelgrass, native oysters, sea otters and salt marsh plants. The condition of eelgrass in the estuary is generally better in terms of having lower epiphyte cover on the blades than in other comparable estuaries, as a result of a sea otter-induced trophic cascade (Hughes et al. 2013). Native oysters' health or condition is not monitored, but the survivorship of adults is high, which suggests no major issues with disease (Wasson et al. 2014). Salt marsh plants appear to have been stressed by the 2012-2014 drought (K. Wasson, ESNERR, pers. comm.), but quantitative information on changes in their condition over time is not available. Low marsh plants appear stressed by excessive inundation, but high marsh plants appear healthy.

Veterinary assessments of 25 radio-tagged sea otters in 2013-2015 revealed that the body condition of slough animals is significantly better than in some other areas of the central coast, including Monterey and Big Sur. These results likely reflect the relatively abundant prey resources (particularly crabs and bivalve mollusks) available to otters in Elkhorn Slough. This hypothesis is supported by the preliminary results of foraging observations of tagged sea otters that show a high biomass intake rate in Elkhorn Slough (USGS, MBA and ESNERR, unpubl. data). However, foraging success is somewhat lower in the areas of the slough that have been used by otters for the longest amount of time. Continued use of Elkhorn Slough habitats by sea otters may eventually result in decreased prey abundance to this population.

A recent study of microcystin intoxication in sea otters in Monterey Bay indicates that some of these animals used habitats in or adjacent to Elkhorn Slough (Miller et al. 2010; also see Figure 11). Domoic acid toxicity is another contributing source of mortality for sea otters in Elkhorn Slough. Two sea otters that were part of a recent monitoring study in the slough, died, and were determined to have high domoic acid levels that probably contributed to their

[13] (n.d.) Elkhorn Slough research: Native oysters at Elkhorn Slough. *ElkhornSlough.org*. Retrieved from http://www.elkhornslough.org/research/conserv_oysters.htm.
[14] (n.d.) Tidal wetland project: Elkhorn Slough tidal marsh restoration. *ElkhornSlough.org*. Retrieved from http://www.elkhornslough.org/tidalwetland/tidal_marsh_restoration.htm.

mortality (USGS, unpublished data). An assessment of contaminant-loading in sea otters that reside in Elkhorn Slough is currently underway, and the results will provide insight into the condition and health of this key member of the estuarine community.

14. ***What are the levels of human activities that may influence living resource quality and how are they changing?*** The status of the levels of human activities that may influence living resource quality remains "fair/poor" and the trend remains "undetermined." A wide variety of human activities occur in and around the Elkhorn Slough (e.g., ecotourism, research, restoration, agriculture, fishing), but few data are available to quantify the level of these activities and how they have changed over time. Because many human activities, especially agricultural pollution and maintenance of dikes to reclaim wetlands for human uses, exert negative pressures on living resources in the slough, the level of human activities is rated fair/poor. Different human influences show contrasting trends. For instance, agricultural pollution has not diminished, but restoration activities are increasing. At the time of this assessment, it was unclear how to combine this information into a cumulative trend; however, efforts are underway, to better document the cumulative effect of conservation practices in the watersheds and their effects on water quality and habitat quality.

Addressing this question requires a concerted effort to list past and current activities that may influence living resource quality, assign a relative importance to each and then attempt to combine them in an analytical framework to generate an overall status. In 2014, the Central Coast Conservation Action Tracker,[15] an online web portal, was developed to gain a better understanding of the type and location of conservation practices in the watersheds draining to the sanctuary. The goal is to identify and better understand the linkage of improved management to water quality condition. In addition, researchers at Moss Landing Marine Labs (MLML) have also populated the California EcoAtlas website[16] with information on the implementation of wetland restoration projects throughout the central coast. MLML is developing a nutrient transport model to better quantify the cumulative effects of improved agricultural practices. In the future, these efforts will provide valuable information to better respond to this question.

Estuarine Environment
Living Resources Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
HABITAT					
9	Biodiversity	—	Status: Medium Trend: Low	Changes in the relative abundance of some species associated with specific estuarine habitats. No significant recent changes in species richness or relative abundance.	Selected biodiversity loss may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
11	Non-Indigenous Species	—	Status: Medium Trend: Medium	High percentage of non-native species, no known recent introductions or significant changes in abundance.	Non-indigenous species have caused or are likely to cause severe declines in ecosystem integrity.
12	Key Species Status	▲	Status: Very High Trend: Very High	Abundance of native oyster, eelgrass, and salt marsh are substantially reduced compared to historic levels. Salt marsh appears to be stable and slight increases in eelgrass and native oysters.	The reduced abundance of selected keystone species has caused or is likely to cause severe declines in some but not all ecosystem components, and reduce ecosystem integrity; or selected key species are at substantially reduced levels, and prospects for recovery are uncertain.
13	Key Species Condition	?	Status: Low Trend: Low	Limited information on health or condition suggests eelgrass, oysters and sea otters are fairly healthy.	The condition of selected key resources is not optimal, perhaps precluding full ecological function, but substantial or persistent declines are not expected.
14	Human Activities	?	Status: Medium Trend: Low	Many human activities that impact living resources (e.g., hydrologic modifications, inputs of pollutants from agriculture and development, introduction of non-indigenous species). Overall trend in human activities difficult to determine.	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.

The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report (ONMS 2009).

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

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

Estuarine Environment: Maritime Archaeological Resources

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

15. What is the integrity of known maritime archaeological resources and how is it changing? In the 2009 MBNMS Condition Report, the status and trend were both rated "undetermined" for this question because little was known about the integrity of the few maritime archaeological resources (e.g., Native American midden sites, historic pier) located in Elkhorn Slough (ONMS 2009). Since there is no new information on the integrity of maritime archaeological resources in Elkhorn Slough, the 2015 status and trend rating remain "undetermined."

16. Do known maritime archaeological resources pose an environmental hazard and is this threat changing? Determined in the 2009 MBNMS Condition Report (ONMS 2009), this question is rated "good" and "not changing" because there are no known maritime archaeological resources in Elkhorn Slough that pose an environmental hazard.

17. What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing? Our 2015 assessment remains the same as in the 2009 MBNMS Condition Report (ONMS 2009). This question is rated "good" and "not changing" because existing human activities do not pose a threat to the quality of Elkhorn Slough's known maritime archaeological resources. Nonetheless, as the main channel in Elkhorn Slough widens and deepens due to erosion, the risk of impact to the Native American midden sites will increase and likely become an issue in the future.

Estuarine Environment
Maritime Archaeological Resources Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
HABITAT					
15	Integrity	?	Status: N/A (not updated) Trend: N/A (not updated)	Very little is known about the integrity of the few known maritime archaeological resources in Elkhorn Slough.	Not enough information to make a determination.
16	Threat to Environment	—	Status: N/A (not updated) Trend: N/A (not updated)	No known environmental hazards.	Known maritime archaeological resources pose few or no environmental threats.
17	Human Activities	—	Status: N/A (not updated) Trend: N/A (not updated)	Existing human activities do not influence known maritime archaeological resources.	Few or no activities occur that are likely to negatively affect maritime archaeological resource integrity.

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

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

[15] (n.d.) *Conservation Action Tracker*. Retrieved from www.ccactiontracker.org. (The website was designed and built through a partnership of Central Coast Resource Conservation Districts (RCDs) and the Greater Monterey County Integrated Regional Water Management Plan (IRWMP) to measure conservation progress on California's central coast.)
[16] California Wetlands Monitoring Workgroup (CWMW). (n.d.) Existing aquatic resources — California aquatic resource inventory (CARI). *EcoAtlas*. Retrieved from http://ecoatlas.org/regions/ecoregion/central-coast.

State of Sanctuary Resources: Nearshore Environment

The nearshore environment, which includes the shoreline out to a depth of 30 meters (see Figure 1), is the main zone of interaction between humans and the sanctuary. This is the zone where most residents and visitors interact with sanctuary resources and where most human activities have the strongest influence. As such, this environment is the focus of substantial research and resource management attention.

Long-term monitoring along rocky shores and in kelp forests shows that biogenic habitat, including canopy-forming kelp, understory algae and many structure-forming invertebrates, have been generally abundant and stable. The number of native species in sanctuary habitats, one measure of biodiversity, appears to be stable with no known losses of native species. Though some non-native species are present in the sanctuary, no new introductions are known to have occurred in any of the sanctuary's environments. Most regularly monitored key species and species assemblages in the sanctuary appear to be stable or slightly improving in status. Recent drastic declines in sea stars, a key species in nearshore habitats, are a concern, but potential impacts on ecological function and biodiversity will take time to understand.

Habitats along less developed portions of the coast (e.g., Big Sur) are in good condition, but there are concerns about localized on-going activities, including sand mining, coastal armoring, inputs of contaminants and marine debris. In the past five years, a high percentage of the sanctuary's beaches regularly monitored for swimming safety have received good grades, likely due to improvements in sanitary sewer infrastructure in coastal cities. The nearshore waters continue to receive nutrient enrichments from land-based activities, which can intensify the effects of harmful algal blooms (HABs) on sensitive species. Decreases in persistent organic pollutants (dieldrin, DDT, PBDEs [polybrominated diphenyl ethers]) were observed in mussels at five locations, but there is limited information available on new pollutants, such as current-use pesticides and pharmaceuticals. Larger, more global issues, such as climate change and an ocean acidification, are significant areas of concern and detecting and predicting impacts is a focus of long-term monitoring efforts.

Nearshore Environment: Water Quality

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

1. ***Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?*** Information regarding stressors on water quality in the nearshore environment, particularly inputs of contaminants (e.g., POPs, heavy metals), nutrients, sediments and pathogens has not changed this question's rating in the last five years. Their presence may inhibit the development of assemblages and may cause measurable, but not severe declines in living resources and habitats. For this reason, the question's rating remains "fair" and the trend remains "declining." Measurements of ambient toxicity due to pesticides (e.g., toxaphene, DDT, diazinon, chlorpyrifos, pyrethroids, neonicotinoids) in waterways that drain to the sanctuary indicate a potential problem in the adjacent nearshore environment (Anderson et al. 2003, Hunt et al. 1999, Phillips et al. 2014, Starner and Goh 2012). Please see the 2009 MBNMS Condition Report for additional information.

   Current monitoring is insufficient to allow an accurate determination of sanctuary water quality and its effects on biological resources. Only a small fraction of known contaminants are measured, and even these are measured infrequently. Whole contaminant categories are essentially unmeasured, including endocrine disrupters, personal care products and most current-use pesticides. There is a critical need for a coordinated regional water quality monitoring program to provide an integrated assessment across the range of stressors, jurisdictions and information needs.

   In regards to changing oceanographic and atmospheric conditions, Booth et al. (2012) shows an increasing frequency of decreased pH and decreased dissolved oxygen conditions at the Monterey Bay Aquarium seawater intake at a depth of 17 meters. Ocean acidification and decreasing dissolved oxygen is discussed in more detail in Offshore Question 1. In the future, more directed study on the effects of climate driven changes in pH, temperature and dissolved oxygen on nearshore water quality will become increasingly important for understanding and tracking the status and condition of living resources in the sanctuary.

   California is invested in a coastwide effort, the West Coast Ocean Acidification and Hypoxia Science Panel,[17] which is scheduled to release a suite of products throughout 2015. These products, which are intended to help inform decision makers and managers, include a synthesis of the drivers of ocean and coastal acidification and hypoxia and a monitoring framework to track changing ocean chemistry.

2. ***What is the eutrophic condition of sanctuary waters and how is it changing?*** In 2009, the status, "good/fair," and the trend, "declining," were based off of clear evidence of frequent, localized and enhanced nutrient enrichment from both point and non-point sources in the sanctuary's nearshore environment. These conditions may preclude full development of living resource assemblages and habitats, but are not likely to

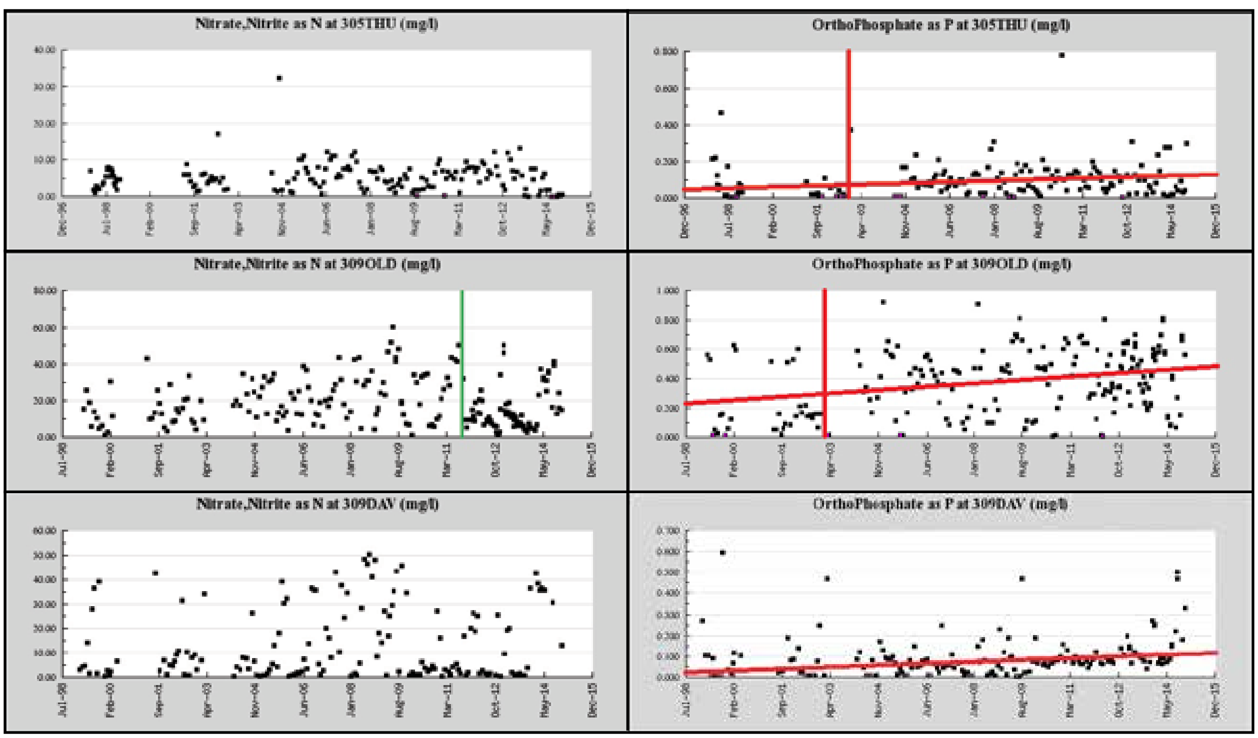
[17] (n.d.) West coast ocean acidification and hypoxia science panel. *California Ocean Science Trust*. Retrieved from http://www.oceansciencetrust.org/project/west-coast-ocean-acidification-and-hypoxia-science-panel/. ("A multi-state, bi-national effort providing scientific guidance to decision makers grappling with the rapidly shifting chemistry of coastal oceans.")

cause substantial or persistent declines (see 2009 MBNMS Condition Report for specifics). The 2015 rating has been changed to "fair" with a "declining" trend due to continued nutrient enrichment; the increased frequency of blooms of *Pseudo-nitzschia*, in addition to recent new species; and harmful algal blooms' (HABs) negative effects on fish, birds and mammals. New data indicates that HABs have measurable impacts on nearshore water quality and living resources. Additional information on HABs is presented below and in the offshore environment response to this question.

While upwelling is believed to initiate macro-scale algal blooms, the Monterey Bay's northeast corner seems to have a bloom incubator "hot spot" in an upwelling shadow that is influenced by runoff from nearby rivers with significant nutrient loads (Ryan et al. 2008). This phenomenon is also described in other areas of the central coast, such as the Santa Maria River to the south (Frolov et al. 2013).

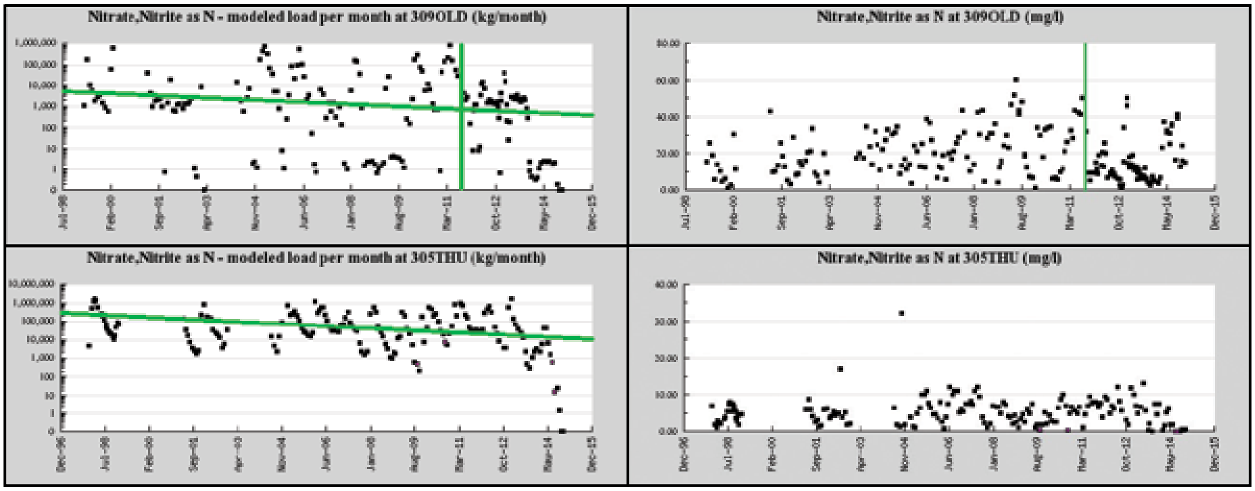
In recent years, orthophosphate concentrations have increased significantly in the Pajaro and Salinas watersheds. Figure 9 shows concentrations of nitrate and orthophosphate at the lower ends of the Pajaro (305THU), Old Salinas (309OLD) and Salinas (309DAV) rivers (CCAMP 2015). Inputs to the sanctuary, from the Salinas and Pajaro rivers, do not show increasing trends in nitrogen compounds. Nitrate concentrations increased in the Old Salinas River through approximately 2011, but have shown recent signs of decline. Regardless of trend, the nitrate concentrations remain high.

The primary land-based loading of nutrients to Monterey Bay comes from the Pajaro and Salinas River watersheds. Annual loads from the rivers are highly variable and influenced by flow. Because of relatively high flows and concentrations, the Pajaro River contributes the largest loads of nutrients to the sanctuary. San Lorenzo River and Carmel River contribute nutrient loads that are typically an order of magnitude lower. For example, in 2004-2005, the Central Coast Long-Term Environmental Assessment Network (CCLEAN) estimated average annual loads of nitrate from the Pajaro, Salinas, San Lorenzo and Carmel rivers as 271,000 kilogram per year, 214,000



Source: Central Coast Ambient Monitoring Program (CCAMP 2015)

Figure 9. Change analysis graph for Nitrate-Nitrite as N (NO3NO2_ N) and Orthophosphate as P (OP_ P) concentrations at Central Coast Ambient Monitoring Program (CCAMP) sites at Pajaro River at Thurwatcher Road (305THU), Old Salinas River Channel at Monterey Dunes Way (309OLD) and Salinas River at Davis Road (309DAV). Bayesian change point analysis, shown as vertical lines, shows specific points in time when there is a high probability that measurements taken before a certain date are different from measurements taken after that date. Statistically significant change points are identified as green (for decreasing data values) or red (for increasing data values) vertical lines, when comparing data collected before and after the change point. Sloped lines indicate significant linear regression relationships based on Mann Kendall analysis; red indicates significantly increasing trends.



Source: CCAMP 2015

Figure 10. Change analysis graph for Old Salinas River (309OLD) and Pajaro River (305THU) for Nitrate-N concentration (milligrams per liter) and modeled monthly load (kilograms per month). Load estimates are derived from modeled daily flows and monthly concentration data, applying a watershed specific dilution model to estimate concentrations where appropriate. Statistically significant change points identifying decreasing group means are identified as green vertical lines, when comparing data collected before and after the change point. Sloped lines indicate significant linear regression relationships based on Mann Kendall analysis; green indicates significantly decreasing trends.

kilogram per year, 28,300 kilogram per year and 34,000 kilogram per year, respectively (CCLEAN 2005). The Pajaro River total maximum daily load (TMDL) estimates that 1.3 million kilogram per year of total nitrogen on average is loaded to streams of the Pajaro River Basin (RWQCB 2015, in draft).

Loading of nutrients may be more important than concentration when considering potential impacts of freshwater inputs on the marine environment, and especially when considering the extended period of recent drought. The CCAMP program has estimated loads using a model that calculates daily river flows with monthly pollutant concentration data (CCAMP 2015). Since 2011, the mouth of the Old Salinas River has shown significant decreases in both the concentration and load of nitrate, and the Pajaro River also has decreasing nitrate loads (Figure 10). In some locations, data from recent years indicate there may be declines in loads of total ammonia, Kjeldahl nitrogen, total suspended solids and turbidity. Again, low flows in 2013 and 2014 may influence these observations.

Harmful algal bloom events have been linked with freshwater runoff events (Kudela and Chavez 2004) and may be associated with nutrient loading from coastal watersheds in the Monterey Bay (Kudela et al. 2008a, Kudela et al. 2008b). Another anthropogenic source of nitrogen comes from publicly owned treatment works (POTW). In a special CCLEAN study, it was determined that wastewater discharges from Monterey Bay area POTWs can contribute up to 80% of the total nitrogen available to phytoplankton during non-upwelling seasons (CCLEAN 2015). However, most studies indicate that the primary trigger for phytoplankton blooms is upwelling. In a 2012 study, the effects of upwelling events, storm water discharge and local circulation on phytoplankton blooms in southern and central California were analyzed using 10 years (1997-2007) of sea surface chlorophyll concentration, sea surface temperature and modeled freshwater discharges (Nezlin et al. 2012). Along the central coast, blooms persisted from spring to autumn during the seasonal intensification of upwelling. As described in Offshore Question 2, Nezlin et al. (2012) concluded that nutrient contributions from terrestrial sources could be negligible at a large scale, but could have a pronounced effect at a local scale in regard to duration and size of bloom, especially near river mouths and areas characterized by extended residence time.

In 2007, the microcystin toxin was determined to affect wildlife in the marine environment. Specifically, 11 southern sea otters were poisoned by microcystin, a toxin produced by the toxic form of *Microcystis aeruginosa*, which is a freshwater cyanobacterium. Historically, this particular cyanobacterium has been a problem in freshwater systems affecting wildlife on land. As of 2010, at least 21 sea otters have died, most found near embayments, harbors or river mouths (Figure 11). Microcystin was detected in three nutrient-impaired rivers that flow into Monterey Bay: (1.) San Lorenzo, (2.) Salinas and (3.) Pajaro rivers; however, the source of the toxin was ultimately traced to a freshwater lake, Pinto Lake, that connects to the Pajaro River. Results within this land-sea interface had microcystin concentrations as high as 2,900 parts per million (Miller et al. 2010). The suggested action level to reduce potential adverse health effects for microcystin is 0.0008 parts per million (OEHHA 2012). Miller et al. (2010) demonstrated that marine invertebrates, consumed by humans and sea otters, are capable of uptake and retention of microcystin. Even with continual flushing of sea water beginning at 96 hours post-exposure, gastrointestinal microcystin concentrations remained 30.5 parts per billion wet weight 21 days after initial exposure in mussels.

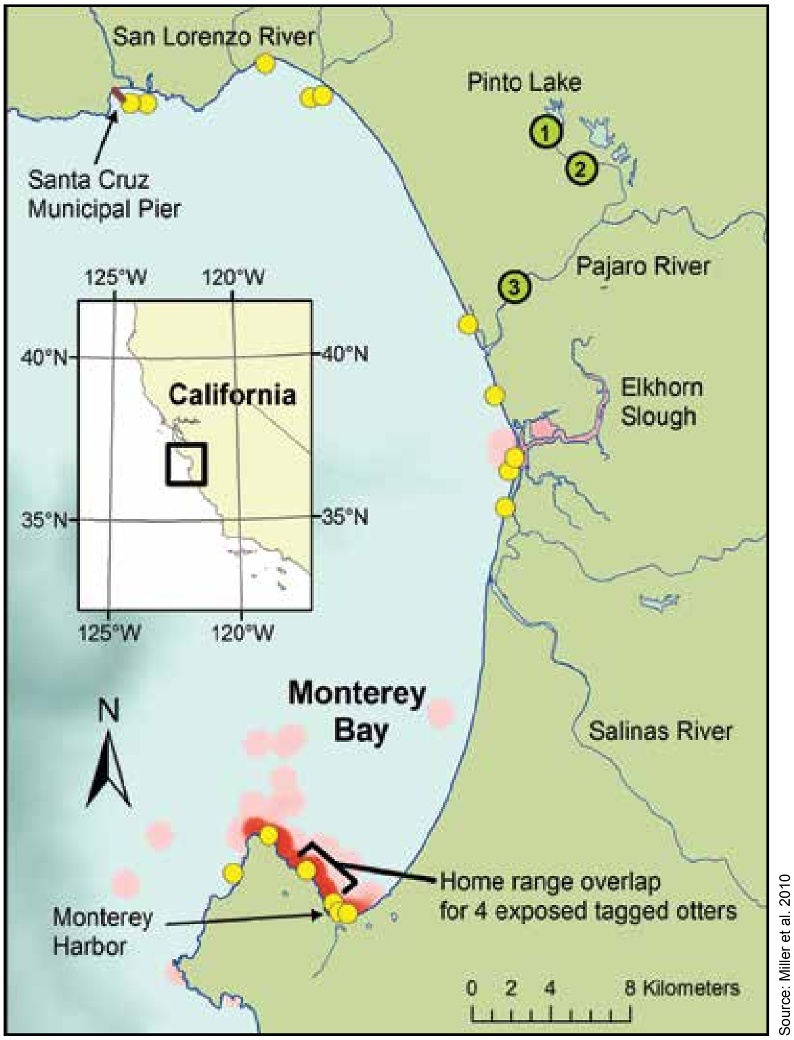


Figure 11. Map of Monterey Bay showing the distribution of sea otters dying due to microcystin intoxication (yellow circles). Note spatial association of sea otter strandings with coastal locations of river mouths, harbors, coastal ponds and embayments. Habitat utilization distributions for four radio-tagged, microcystin-poisoned otters are plotted as kernel density distributions fit to daily re-sighting locations (red shading, with regions of most intense shading corresponding to the habitats most frequently utilized by affected animals). Locations of freshwater samples collected during a "superbloom" of *Microcystis* in 2007 are indicated by green circles.

In 2010, 21 freshwater, estuarine and marine locations in California were surveyed using Solid Phase Adsorption Toxin Tracking (SPATT) samplers (Gibble and Kudela 2014) at the land-sea interface to determine the presence and concentration of microcystin. During this initial study, 15 of 21 sites were positive for microcystin toxin. Four watersheds were identified to have persistent concentrations of microcystin toxin (Big Basin, Pajaro, Salinas and Carmel) and further studied for two more years to determine a correlation between other environmental factors. Results indicated that coastal nutrient loading was a statistically significant predictor of microcystin concentrations and those concentrations appeared to have large peaks, especially in the spring and fall. The patterns of microcystin presence and concentration observed during this study suggest that microcystins are likely present throughout the year (Gibble and Kudela 2014) in the nearshore environment.

In 2007, a surfactant producing bloom occurred in Monterey Bay, but it was not documented in the 2009 Condition Report. It affected 14 species of seabirds by coating their feathers with a slimy yellow-green material that caused them to be severely hypothermic. The algal bloom, made up of the dinoflagellate (*Akashiwo sanguinea*), produced foam made of surfactant-like proteins that coated the birds' feathers, with effects similar to an oil spill; this was the first documented case of its kind. A total of 550 stranded, live birds were rescued and 207 fresh, dead birds were collected over a two month period (Jessup et al. 2009). While there is no evidence that this event was linked to terrestrial sources of nutrient loading, it does illustrate that new species of HABs are occurring in MBNMS and have negative impacts on living resources.

3. Do sanctuary waters pose risks to human health? In 2009, the status and trend of risks to human health were "fair/poor" and "undetermined," respectively. As reported in 2009, selected conditions caused or were likely to cause severe impacts to human health; however, these cases did not suggest a pervasive problem in the nearshore environment. Therefore, although there were localized areas and

Central Coast Ambient Monitoring Program (CCAMP)

The Central Coast Ambient Monitoring Program (CCAMP)[18] is the Central Coast Regional Water Quality Control Board's regionally scaled water quality monitoring and evaluation 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. More information is available on the Sanctuary Integrated Monitoring Network (SIMoN) website.[19]

Central Coast Long-Term Environmental Assessment Network (CCLEAN)

The Central Coast Long-term Environmental Assessment Network (CCLEAN) is a long-term monitoring program designed to help municipal agencies and resource managers protect the quality of nearshore marine waters in the Monterey Bay area. CCLEAN, which began in 2001, determines the sources, amounts and effects of contaminants in nearshore waters. More information is available on the Sanctuary Integrated Monitoring Network (SIMoN) website.[20]

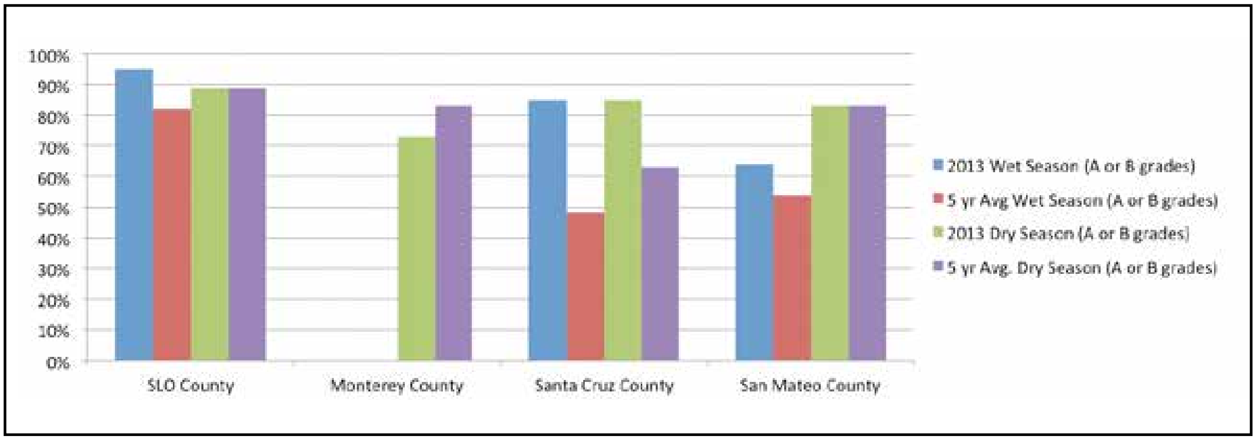
serious isolated impacts to human health, the majority of the sanctuary's nearshore waters did not pose risks to humans (see 2009 MBNMS Condition Report for specifics). In 2015, the rating has been changed to "fair" because of declines in persistent organic pollutants measured in mussels and improvements to sanitary sewer infrastructure in coastal cities, as documented by a high percentage of A and B grades in the Heal the Bay Beach report card. An "undetermined" trend was based on a risk of consuming contaminated seafood and the high variability of water quality monitoring results. Again, evidence of specific human impacts did not justify widespread or persistent concern.

Indicator bacteria, such as fecal coliform, *Escherichia coli* (*E. coli*), and *Enterococcus*, do not usually cause illness in humans. Instead, their presence indicates the potential for water contamination with other pathogenic microorganisms, such as bacteria, viruses and protozoa, that do pose a health risk to humans (see Atwill and Carabez 2011). Figure 12 shows that three of the four counties with beaches in the sanctuary have an A or B grade at least 80% of the time when sampled during the dry weather averaged over the last five years. Please see the full report to understand the grading system (HTB 2014).

Pathogenic bacteria are of major concern for their effects on human and marine mammals. According to a report produced by FoodNet and the Centers for Disease Control and Prevention (CDC 2009), 41% of reported human bacterial infections are caused from *Salmonella* and 4% are caused by a strain of *E. coli* called *E. coli* 0157:H7 (note that this particular strain of *E. coli* is known to cause harm to humans). Over a twelve month period from April 2009 through April 2010, a study of 23 rivers, creeks and estuaries along the central coast of California were sampled 56 times to determine if *Salmonella* and *E.coli* 0157:H7 were present in those water bodies and sediment. Included in the study was an investigation to determine if there were seasonal trends and/or a correlation with fecal coliform (or *E.coli*) concentrations. *Salmonella* was detected in 31% of the water samples and 20 of the 23 sampling sites had at least one sample test positive for *Salmonella*. Scott Creek Lagoon, Soquel Creek and the Salinas River consistently tested negative. *Salmonella* in the water column was strongly associated with *Salmonella* in the sediment. In addition, the concentration of fecal coliform was significantly associated with the concentration of *Salmonella*. Approximately 2.4% of the samples tested positive for *E. coli* 0157:H7. Four sites tested positive one time and one site tested positive two times (Atwill and Carabez 2011). This study confirmed that human pathogens are common in central coast streams, and fecal indicator bacteria are a reasonable proxy for detecting these pathogens.

In 2007, CCLEAN reduced its mussels sampling from wet and dry seasons to just wet seasons because that was historically when the greatest concentration of persistent organic pollutants (POPs) were detected. While concentrations of some POPs continue to exceed or nearly exceed various alert levels for the protection of human health, several POPs have declined over recent years (CCLEAN 2014). Since 2008, dieldrin has remained below

[18] (n.d.) Central coast ambient monitoring program. *California Environmental Protection Agency: Central Coast Regional Water Quality Control Board*. Retrieved from http://www.ccamp.us/ccamp_org/.
[19] (n.d.) Central coast ambient monitoring program. *Sanctuary Integrated Monitoring Network (SIMoN)*. Retrieved from http://www.sanctuarysimon.org/projects/project_info.php?projectID=100205&site=true.
[20] (n.d.) Central coast long-term environmental assessment network (CLEAN). *Sanctuary Integrated Monitoring Network (SIMoN)*. Retrieved from http://sanctuarymonitoring.org/projects/project_info.php?projectID=100147.



Source: Heal the Bay Beach Report Card 2014

Figure 12. Data from the 2014 Heal the Bay Beach Report Card showing percentage of A and B grades for 2013 and the past five year average for dry and wet weather monitoring. Monterey County did not report sufficient wet weather data to be included.

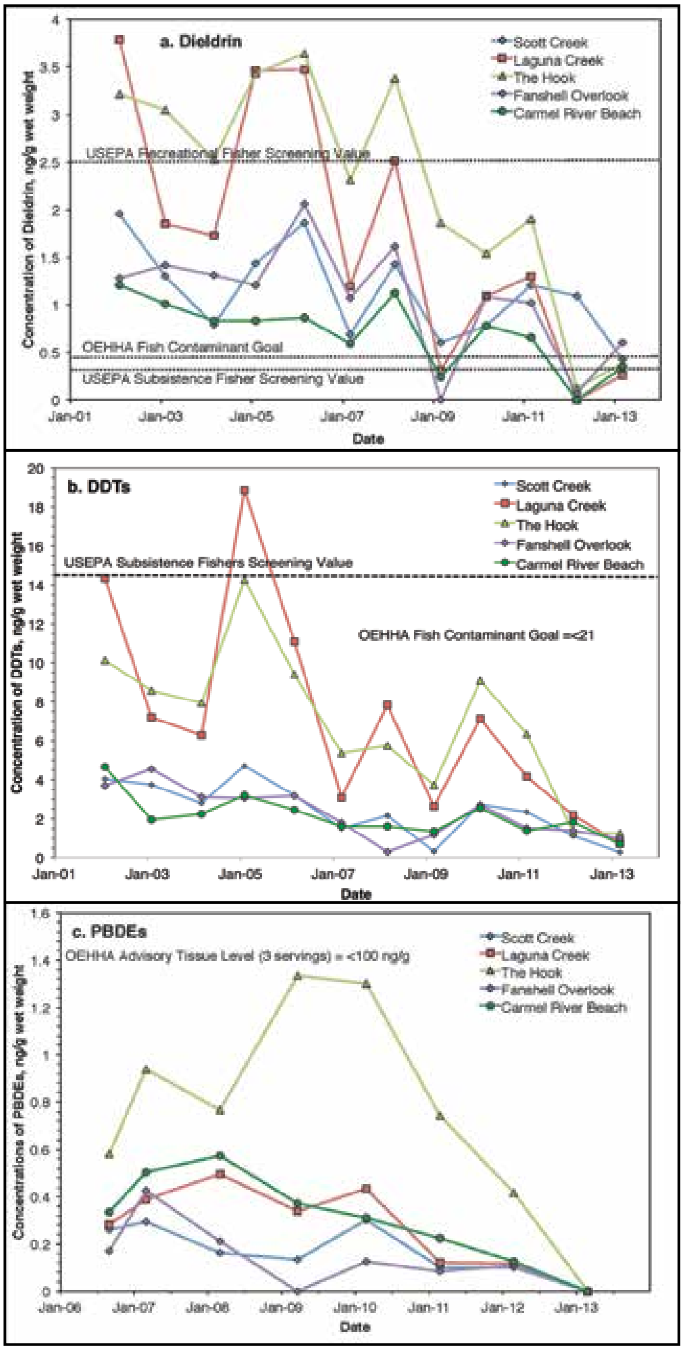
the U.S. EPA's recreational fisher screening value at most sites, but concentrations remain above the U.S. EPA's subsistence fisher screening level (Figure 13a). Significant dieldrin declines were observed at Laguna Creek, the Hook and Carmel River Beach. DDT has also declined over the past 11 years with downward trends being significant at all sites (Figure 13b). Since 2008, PBDE concentrations have generally declined in mussels, with significant declines detected at Carmel River Beach (Figure 13c) (Figure 14).

Methylmercury is the pollutant that poses the most widespread potential health concerns to consumers of fish caught in California coastal waters (Figure 15). The California Office of Environmental Health Hazard Assessment (OEHHA) No Consumption Advisory Tissue Level (ATL) of 0.44 parts per million provides an upper bound threshold for assessment of methylmercury in California sport fish. This value represents a relatively high concentration above which frequent consumption might not be safe for the most sensitive fish consumers (children and women of childbearing age). In a two year study conducted by the California Surface Water Ambient Monitoring Program, 3,483 fish representing 46 species were collected from 68 locations on the California coast. On California's central coast near Carmel, average concentrations >0.44 parts per million methylmercury were found in gopher, rockfish (n=7) and lingcod (n=1). Similar findings were reported for lingcod (n=1) off the Cambria /Northern San Luis Obispo coast and leopard shark (n=8) in Elkhorn Slough. Eleven types of fish caught on the central coast fell within the moderate range of contamination <0.44 and >0.07 parts per million for methylmercury including black (n=12), blue (n=16), brown (n=11), gopher (n=16) and China rockfish (n=1) and cabezon (n=9) and five shark species (Davis et al. 2012). Table 1 provides POP results for central coast samples collected during this study (CCLEAN 2014). While several species from Elkhorn Slough had exceedances of subsistence fisher screening values for more than one contaminant, most species caught along the central coast did not reflect the exceedances of the Ocean Plan observed in the CCLEAN monitoring.

4. ***What are the levels of human activities that may influence water quality and how are they changing?*** In 2009, human activities detrimental to water quality conditions in the nearshore environment were rated "fair" with an "undetermined" trend, based on activities that had resulted in measurable resource impacts; however, evidence suggested these effects were localized and not widespread (see 2009 MBNMS Condition Report for specifics). The 2015 rating remains "fair," but with an "improving" trend, based on anticipated reductions in urban and agricultural runoff in response to state regulations. In addition, Special Protections for Areas of Special Biological Significance (ASBS) are being enforced. Efforts to change human behaviors that cause pollution have strong potential to lead to an improvement in water quality. Some improvements in water quality have been observed; however, we lack data on the specific levels of human activities. Below we describe the current landscape related to population increases, reduced water availability and regulatory changes.

From April 2010- June 2013, the population in Monterey and Santa Cruz counties has increased by 3.3% (13,769 people) and 2.7% (7,043 people), respectively.[22] This is consistent with the state of California's population increase of 2.9% and the national increase of 2.4% over the same time period. While the

[22] (n.d.) *U.S. Census Bureau*. Retrieved from http://census.gov.

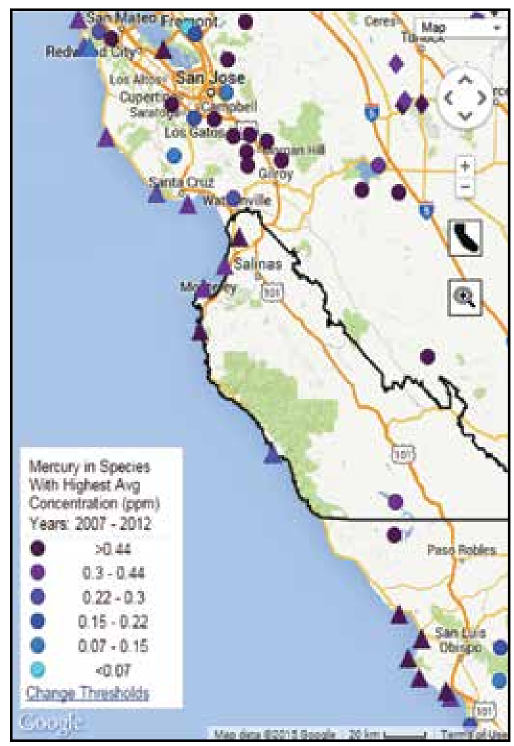


Source: CCLEAN 2014

Figure 13a, b, c. Wet-weight concentrations of (a.) Dieldrin, (b.) DDTs and (c.) PBDEs measured in mussels during the wet season from five CCLEAN sites in the Monterey Bay area.

Source: CCLEAN 2014

Figure 14. Locations of CCLEAN sampling sites for municipal wastewater effluent, receiving water, sediment, mussels and rivers.



Source: SWRCB My Water Quality Portal[21] accessed on April 18, 2015

Figure 15. Map from My Water Quality Portal on SWRCB website showing mercury concentrations in fish caught along the central coast from 2007-2012.

[21] (last updated May 20, 2013). What are the levels and long-term trends in my lake, stream or ocean location? *California Environmental Protection Agency: California Water Quality Monitoring Council.* Retrieved from http://www.mywaterquality.ca.gov/safe_to_eat/data_and_trends/index.shtml?county=Monterey.

Table 1. In 2010, POP concentrations (nanogram per gram, wet weight) in fish collected along California's central coast. Each sample consisted of a composite of filets from 4-6 fish. Values in red exceeded EPA subsistence fisher screening values (USEPA 2000).

Station Name	Species	Sum of PCBs	Sum of DDTs	Dieldrin
Santa Cruz Coast Area	Black Rockfish	0.0	0.92	0.00
Santa Cruz Coast Area	Blue Rockfish	0.0	1.14	0.00
Santa Cruz Coast Area	Cabezon	0.0	0.87	0.00
Santa Cruz Coast Area	Gopher Rockfish	0.0	2.29	.
Santa Cruz Coast Area	Kelp Greenling	0.3	3.84	.
Santa Cruz Coast Area	Lingcod	0.7	5.7	0.00
Santa Cruz Coast Area	White Croaker	0.3	3	0.00
Santa Cruz Area Wharfs/Beaches	Cabezon	0.0	1.3	.
Santa Cruz Area Wharfs/Beaches	Gopher Rockfish	0.2	1.67	0.00
Santa Cruz Area Wharfs/Beaches	Kelp Greenling	0.0	4.77	0.00
Santa Cruz Area Wharfs/Beaches	Lingcod	2.0	10.98	.
Santa Cruz Area Wharfs/Beaches	White Croaker	0.0	1	0.00
Elkhorn Slough	Bat Ray	0.5	3.54	**0.89**
Elkhorn Slough	Leopard Shark	**3.0**	3.87	**0.59**
Elkhorn Slough	Shiner Surfperch	**4.9**	**34.37**	**0.80**
Elkhorn Slough	Top Smelt	**2.5**	**18.05**	**1.29**
Moss Landing/Marina Coast	Black and Yellow Rockfish	0.0	2.4	.
Moss Landing/Marina Coast	Black Rockfish	0.0	0.87	0.00
Moss Landing/Marina Coast	Brown Rockfish	**3.9**	2.53	0.00
Moss Landing/Marina Coast	China Rockfish	**2.8**	1.04	.
Moss Landing/Marina Coast	Gopher Rockfish	0.5	2.23	0.00
Monterey/Pacific Grove Coast	Black Rockfish	**2.7**	4.05	0.00
Monterey/Pacific Grove Coast	Blue Rockfish	0.0	1.28	0.00
Monterey/Pacific Grove Coast	Gopher Rockfish	0.0	0.76	0.00
Monterey/Pacific Grove Coast	Kelp Rockfish	0.9	1.86	.
Monterey/Pacific Grove Coast	Rainbow Surfperch	0.2	3.1	0.00
Carmel Coast	Blue Rockfish	0.0	1.02	0.00
Carmel Coast	Cabezon	0.3	0	.
Carmel Coast	Gopher Rockfish	0.2	1.31	0.00
Carmel Coast	Lingcod	**8.2**	**22**	.
Carmel Coast	Olive Rockfish	**2.5**	3.02	0.00
Carmel Coast	Rainbow Surfperch	0.3	2.49	0.00
Carmel Coast	Vermillion Rockfish	0.0	2.07	0.00

Source: Davis et al. 2012

population increases, construction and new development have slowed because of the limits on water availability.

On March 15, 2012, the Central Coast Regional Water Quality Control Board (CCRWQCB) adopted a Conditional Waiver of Waste Discharge Requirements (Agricultural Order No. R3-2012-0011) that applies to owners and operators of irrigated land used for commercial crop production. The CCRWQCB regulates discharges from irrigated agricultural lands to protect surface water and groundwater. The CCRWQCB is targeting priority water quality contaminants, such as pesticides, nutrients and sediments – especially nitrate impacts to drinking water sources.[23]

The CCRWQCB also oversees a stormwater program to prevent stormwater runoff from conveying pollutants to surface waters. The stormwater program is a National Pollutant Discharge Elimination System (NPDES) program implemented in two phases based on the size of a jurisdiction (Phase I and Phase II). The City of Salinas (population greater than 155,000 in 2013) holds the only individual Phase I municipal stormwater permit in the central coast region. On March 10, 2003, coastal cities that met the definition of Phase II Regulated Small Municipal Separate Storm Sewer Systems (MS4s) were required to obtain permit coverage. It was not until February 5, 2013, that a proposed final draft of the Phase II Small MS4 General Permit was adopted; it became effective on July 1, 2013 (Order No. 2013-0001).[24]

In addition to the agriculture and stormwater regulations, the State Water Resource Control Board (SWRCB) also took action regarding implementation of Special Protections for Areas of Special Biological Significance (ASBS). The California Ocean Plan states that: "Waste shall not be discharged to areas designated as being of special

[23] (n.d.) Irrigated land regulatory program. *California Environmental Protection Agency: Central Coast Regional Water Quality Control Board*. Retrieved from http://www.waterboards.ca.gov/centralcoast/water_issues/programs/ag_waivers/index.shtml.

[24] (last updated June 24, 2013). Storm water program: Municipal program. *California Environmental Protection Agency: State Water Resources Control Board (SWRCB)*. Retrieved from http://www.waterboards.ca.gov/water_issues/programs/stormwater/municipal.shtml.

biological significance. Discharges shall be located a sufficient distance from such designated areas to assure maintenance of natural water quality conditions in these areas." This Ocean Plan's absolute discharge prohibition applies unless an exception is granted. On March 20, 2012, the State Water Resources Control Board adopted Resolution 2012-0012 approving exceptions to the CA Ocean Plan for selected discharges into Areas of Special Biological Significance, including special protections for beneficial uses. Currently, dischargers are developing ASBS Compliance Plans that addresses stormwater discharges (wet weather flows) and how pollutant reductions in stormwater runoff will be achieved through best management practices. At the time of this report's publication, no monitoring results have been released, and thus, it is too soon to determine effectiveness the Special Protections' effectiveness.

The ASBS Special Protections required reference site monitoring to establish conditions that would set natural water quality numeric values for each of the parameters measured at 28 sites along the entire California coast. All 11 of the central coast reference sites are located within the sanctuary. In 2013, preliminary results indicated that there was no toxicity at any of the sites; however, one reference site within the sanctuary reported detectable levels of anthropogenic constituents (i.e., synthetic pesticides). On average, the ocean receiving water concentrations at reference sites were comparable in pre to post-storm samples indicating that the stormwater runoff was not contributing anthropogenic pollutants to the receiving water at the reference sites. These were the first year results of the required two years of monitoring reference sites. More information is needed to confirm these results (Schiff et al. 2015).

On the central coast, multiple cities from Santa Cruz to Carmel have received state funding to build dry weather diversions, which collect urban runoff from April through November and pump it to a wastewater treatment plant. These facilities reuse the water, usually for landscape watering or groundwater replenishment, and reduce the amount of untreated water flowing to the ocean. Other examples of human activities that reduce pollutant runoff include use of drip irrigation, retention ponds/swales, nutrient management, integrated pest management and erosion control measures.

Boat marinas also do their part to reduce vessel pollution. Most marinas adjacent to MBNMS have bilge pumpouts to remove oily water from vessels. They also have sewage pumpouts that are used on a daily basis to pump sewage from vessel holding tanks to the wastewater treatment plant (ML Asst. Harbormaster, per. comm.), thereby reducing the amount of nutrients, pathogens and chemicals that enter the sanctuary. In a two year period, Moss Landing Harbor District recycled over 5,000 gallons of oily water and crankcase oil from vessels in that harbor.

With the adoption of ASBS Special Protections, the Agricultural Order and the MS4 Storm Water permits, there is much more regulatory oversight to reduce pollutant loads from these sources into the state's surface waters. Now, the challenge is to develop a regional monitoring program designed to measure changes in nearshore water quality as a result of these regulatory requirements and management practices. Currently, each program has its own specific monitoring requirements. The limited number of samples, analytes and geographic scope reduces the confidence and statistical rigor that is needed to determine if efforts implemented are effective in improving water quality.

Photo: Becky Stamski / NOAA MBNMS

Nearshore Environment Water Quality Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
1	Stressors	▼	Status: N/A (not updated) Status: N/A (not updated)	Elevated levels of contaminants (e.g., POPs, heavy metals), nutrients, sediments, pathogens in some locations; on-going input of established and emerging pollutants. Acidification and hypoxia conditions increasing.	Selected conditions may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources and habitats.
2	Eutrophic Condition	▼	Status: High Trend: High	Increasing nutrient enrichment and occurrence of HABs. New information regarding prevalence of microcystis in major river systems and coastal waters. HABs directly impacting fish, birds and mammals.	Selected conditions may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources or habitats.
3	Human Health	?	Status: Very High Trend: Very High	Continue to have warnings at some beaches and lagoons due to high fecal indicator bacteria; declining dieldrin levels in mussels, contaminated shellfish at some locations and during some seasons. Contaminants in fish exceed seafood standards at a few locations.	Selected conditions have resulted in isolated human impacts, but evidence does not justify widespread or persistent concern.
4	Human Activities	▲	Status: Medium Trend: Medium	Human activities result in measurable, localized impacts. Reductions in urban and agricultural run-off anticipated in response to increased regulations for agriculture and stormwater pollution prevention.	Selected activities have resulted in measurable resource impacts, but evidence suggests effects are localized, not widespread.

The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report (ONMS 2009).

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

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

Nearshore Environment: Habitat

The following information provides an assessment of the current status and trends of nearshore marine habitats since 2009, which include beaches, rocky intertidal, the sandy seafloor and subtidal rocky reefs and kelp forests. The bulk of current long-term monitoring occurs in rocky intertidal and subtidal rocky reefs and kelp forests; therefore, the assessments rely heavily on the status of those two habitats. More long-term monitoring is needed on the status of beaches and sandy seafloor habitats.

5. What is the abundance and distribution of major habitat types and how is it changing? In 2009, the abundance and distribution of nearshore habitats was rated "good/fair" based on localized modification and degradation of coastal habitat, primarily through armoring of coastal bluffs and beaches, erosion of sandy shoreline and landslide disposal on rocky reefs. The trend in habitat modification was "not changing" because coastal armoring occurred at a slow pace while dams were removed in some locations. In 2015, the status has been changed to "fair" because of localized modification and loss of coastal habitat (mostly along shoreline) through landslide disposal, armoring and erosion. New information provides additional details on subtidal benthic habitat complexity, but does not change status. Also, the trend has changed to "declining" due to the continued impacts of human activities (e.g., marine debris, coastal development, sand mining) that are altering and degrading habitat, albeit at a very slow pace. The impacts of marine debris on habitat is further discussed in response to Nearshore Question 8.

New seafloor habitat maps indicate more structural complexity and variability than previously understood. The California Seafloor Mapping Program (CSMP),[25] a collaborative program funded in 2007, has since mapped California's state waters, including most of the nearshore environment inside the sanctuary using remote sensing, GIS and video technologies coupled with field sampling. In portions of the nearshore environment previously believed to contain fairly uniform soft bottom habitat, CSMP has found that depressed deposits of coarse-grained sediment, also called rippled scour depressions (RSDs), are more abundant and widespread than previously understood, comprising a total of 4.6% of seafloor type on the shelf in central California (Davis et al. 2013, CSMP 2012). RSDs add complexity and patchiness to relatively

[25] (last modified Oct. 1, 2015). California seafloor mapping program. *U.S. Geological Survey (USGS): Pacific Coastal and Marine Science Center.* Retrieved from http://walrus.wr.usgs.gov/mapping/csmp/index.html.

homogeneous, unconsolidated sedimentary substrates on the inner continental shelf. Moreover, differences have been observed in the faunal communities found inside and outside of RSDs. Hallenbeck et al. (2012) found that the densities of suspension feeders, invertebrate predators, and fishes, as well as the richness of suspension feeders and invertebrate predators, were significantly greater outside. However, young-of-the-year rockfish (*Sebastes* spp.) and smaller flatfish were more abundant inside RSDs, and this habitat may function as a nursery habitat for these groups.

Finescale benthic habitat mapping information is not yet available in most of the white zone in MBNMS. The white zone is the area along the immediate coastline where obstacles such as fog, high surf, rocky shoals, cloudy water and floating kelp have prevented it from being mapped with traditional technology. Currently, researchers are developing new techniques for mapping this zone and hopefully habitat data will be available in the coming years (CSMP 2012, OST and CDFW 2013).

Armoring of coastal bluffs and cliffs can alter the natural processes of erosion, sediment transport and deposition.[26] Armoring changes the type of habitat in a given location, converting soft-sediment habitats (e.g., sandy beaches) to hard substrates (e.g., rock, cement, steel), which support very different biological communities. In 2009, we reported that an estimated 32.43 kilometers, or approximately 7%, of the sanctuary's coastline, was armored (California Coastal Commission 2005). Since 2009, there have been ten authorizations issued by the sanctuary for new armoring and the maintenance of existing structures, primarily in Santa Cruz county (MBNMS permit database). This number of authorizations is similar to the 13 issued by the sanctuary over the previous six year period (2003-2008) which suggests that the rate of armoring has not changed substantially. However, the exact location and coastal extent of new armoring projects was not available, so we could not update our 2009 estimates of the extent of coastal armoring in the sanctuary.

Coastal sand mining in the city of Marina is the main cause of high erosion rates of beaches and adjacent dune habitat in the southern Monterey Bay (SMB) region (ESA PWA 2012). The USGS identified the SMB region as the most erosive shore on average in California (Hapke et al. 2006). The Coastal Regional Sediment Monitoring Plan (CRSMP) for southern Monterey Bay concluded that the sand mine in Marina operated by CEMEX, which bought the mine is 2000, was a primary cause of high erosion rates in SMB (PWA et al. 2008). CEMEX mines approximately 200,000 cubic yards of sand per year. It was recently estimated that cessation of this sand mining activity would reduce erosion rates by at least 60% across the entire SMB region (ESA PWA 2012). Such a cessation would slow erosion rates to natural levels, and the adverse impacts caused by mining will not continue to accumulate. Cessation of sand mining was identified as the most significant erosion mitigation measure, and thus, it should be the highest priority for all jurisdictions in the southern Monterey Bay region (ESA PWA 2012). However, a mechanism for cessation of the CEMEX commercial sand mining operation has not been identified.

Occasionally, rocky intertidal and subtidal habitat along the Big Sur coast is buried by sediment from landslide disposal; however, this activity has decreased in recent years, likely due to fewer significant winter storms.[27] In 2011, the only new landslide disposal occurred at Alder Creek. This area was monitored for three years to evaluate any impacts to the subtidal and intertidal habitats.[28] A full summary of the results of this study is not yet available, but preliminary results indicate that some localized impacts, such as sand accumulation and lower biodiversity, were observed in the rocky intertidal habitat just south of the slide area (Bell et al. 2015). Past study of impacts from landslide disposal activities along the central coast found impacts

Long-term Monitoring Program and Experiential Training for Students (LiMPETS)

LiMPETS (Long-term Monitoring Program and Experiential Training for Students) is an environmental monitoring and education program for students, educators and volunteer groups. This hands-on program was developed to monitor the coastal ecosystems of California's national marine sanctuaries to increase awareness and stewardship of these important areas. Two distinct monitoring programs make up the core of the network: (1.) the Rocky Intertidal Monitoring Program and (2.) the Sandy Beach Monitoring Program. Approximately 5,500 teachers and students are involved with the collection of data as part of the LiMPETS network.

[26] (reviewed May 20, 2014). Resource issues: Coastal armoring and erosion. *Monterey Bay National Marine Sanctuary (MBNMS)*. Retrieved from http://www.montereybay.noaa.gov/resourcepro/resmanissues/coastal.html.
[27] (reviewed Mar. 15, 2014). Resource issues: Landslide and debris. *Monterey Bay National Marine Sanctuary (MBNMS)*. Retrieved from http://montereybay.noaa.gov/resourcepro/resmanissues/landslide.html.
[28] (n.d.) Big Sur nearshore characterization (BSNC). *Sanctuary Integrated Monitoring Network (SIMoN)*. Retrieved from http://sanctuarysimon.org/projects/project_info.php?projectID=100312.

to be localized, and strongly dependent on the type of nearshore habitats (rocky vs. sandy) present at, and immediately adjacent to, the site of the slide (Oliver et al. 1998).

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

Data from the last five years on the condition of biologically-structured habitats in the nearshore environment indicates that, similar to the assessment in 2009, these resources are in "good" condition with a "not changing" trend. A number of on-going monitoring studies in the rocky intertidal and kelp forest habitats indicate that a variety of ecologically important structure-forming species appear to be healthy and no major perturbations have been observed. No data is available on the condition and recent trend for biogenic species on the sandy seafloor.

In the rocky intertidal habitat, mussels (*Mytilus californianus*) are an important structure-forming species in the mid zone. The on-going monitoring by LiMPETS (Long-term Monitoring Program and Experiential Training for Students) of mussels abundance on intertidal platforms at Davenport Landing, Natural Bridges and Almar Avenue shows quite a bit of stability over the last 40 years with recent mussel abundances (2009-present) being similar to the long-term average (Figure16) (J. Pearse, unpubl. data[29]). The abundance of mussels has been reduced at some locations due to repeated harvests for human consumption (P. Raimondi, PISCO/MARINe, pers. comm.). Locations with higher levels of recreational tidepooling activity can have lower coverage of some types of algae in the upper intertidal zone and around the margins of tidepools due to chronic trampling (Tenera Environmental 2003). Nonetheless, the sites with reduced abundance from trampling and harvest comprise a small percentage of habitat in the entire nearshore environment.

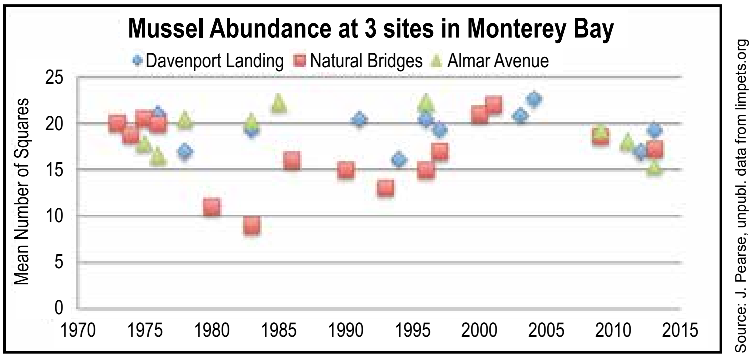


Figure 16. Estimates of abundance of mussels (*Mytilus californianus*) from counts made in quarter-meter square quadrats randomly placed within plots on mussel-dominated mid-zone, intertidal platforms at Davenport Landing (blue diamond), Natural Bridges (red square) and Almar Avenue (green triangles).

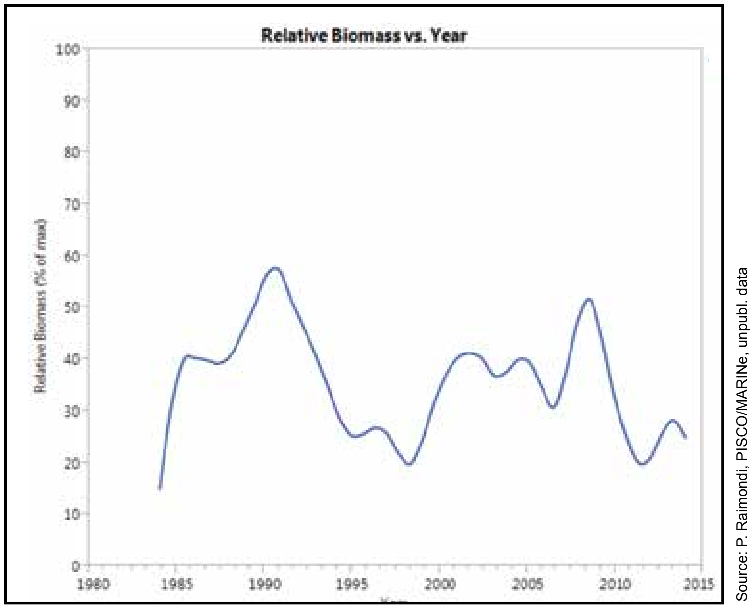


Figure 17. Relative abundance of giant kelp (*Macrocystis pyrifera*) canopy along the central California coast (from Point Año Nuevo to Point Conception) since 1984. Aerial extent of the kelp canopy was calculated from Landsat satellite images and the mean annual relative biomass was calculated as a percentage of the maximum extent observed during the study period.

Kelp beds persist from year to year, but the extent of kelp beds does exhibit seasonal and annual variation. For instance, the extent of giant kelp (*Macrocystis pyrifera*) off central California ranges from a low of 6.5 square kilometers to a high of 47 square kilometers (OST and CDFW 2013). The amount of giant kelp canopy along the central California coast, calculated from Landsat satellite images, shows that, since 2009, kelp canopy has fluctuated within the range that is expected based on a longer time series that started in 1984 (Figure 17) (P. Raimondi, PISCO/MARINe, unpubl. data). The abundance of two other important structure-forming groups in kelp forests, the understory kelp (*Pterygophora californica*) and erect red algae, also

[29] Pearse, J. (11 Mar. 2014). [Long-term Monitoring Program and Experiential Training for Students (LiMPETS) goals for the rocky intertidal]. Unpublished raw data. Retrieved from limpets.org/.

Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)

PISCO is a long-term monitoring and research program designed to understand the dynamics of the West Coast's ocean ecosystem. In 1999, PISCO began a large-scale, long-term study of the patterns of species diversity in rocky shore and kelp forest habitats and the physical and ecological processes responsible for structuring these communities. PISCO is led by scientists from core campuses: Oregon State University (OSU); Stanford University's Hopkins Marine Station, University of California, Santa Cruz (UCSC) and University of California, Santa Barbara (UCSB).

Reef Check California (RCCA)

Reef Check California (RCCA) is a network of trained volunteers who carry out surveys of nearshore reefs that provide data on the status of key indicator species. RCCA's goal is to support the sustainable use and conservation of our nearshore marine resources.

appears to be in good and stable condition based on long-term monitoring by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) (Figure 18) (M. Carr, PISCO, unpubl. data). Reef Check California (RCCA) observed similar trends in the density of giant kelp and *Pterygophora* (J. Freiwald, RCCA, unpubl. data). RCCA is a citizen science group composed of SCUBA divers that have been monitoring kelp forests at 17 sites in MBNMS since 2006.

Looking forward, some recent events could result in substantial changes in the abundance of nearshore structure-forming species. Starting in 2014, sea surface temperatures have been anomalously high all along the U.S. West Coast. Moreover, some indicators suggest that the Pacific Decadal Oscillation shifted from conditions that promote high primary productivity (observed in 2008-2013) to less productive conditions in 2014 (see response to Offshore Question 1 for more details). If these less productive conditions, or anomalously high temperatures, persist in the region, they could result in declines in abundance of canopy-forming kelp and understory algae. Also, abundance of kelp and understory algae may be negatively impacted by the recently observed increase in abundance of red and purple sea urchins, which consume kelp and understory algae (see Figure 31 on page 54). In 2014, this increase in sea urchins began concurrently with a dramatic reduction in the abundance of some sea star species, such as the ochre star (see Figure 29 on page 53). Ochre stars' predation of mussels limits the mussels' abundance in the lower intertidal zone. The absence of ochre star predation may allow mussel beds to expand their lower limit, which could result in an increase their overall abundance at some locations (S. Lonhart, MBNMS, pers. comm.). On-going monitoring efforts in the sanctuary, including Multi-Agency Rocky Intertidal Network (MARINe), PISCO, RCCA and LiMPETS, will be the key to track these potential changes in the status and condition of structure-forming species in nearshore habitats.

7. ***What are the contaminant concentrations in sanctuary habitats and how are they changing?*** In 2009, the condition of nearshore habitats was rated "fair" and "declining" due to elevated contaminants at locations near urban, maritime or agricultural activities and the continued input of contaminants into coastal waters from point and non-point sources (see 2009 report for specifics). The 2015 rating has been downgraded to "fair/poor" with a "declining" trend based on new contaminants detected, contaminants that exceed regulatory objectives and evidence of the accumulation of contaminants in sea otters, shellfish and resident fish that have caused or are likely to cause severe declines in some but not all living resources or water quality.

Throughout the nearshore environment water quality section, we have provided examples of land-based contaminants detected in the water column, sediment, flora and fauna. While some of the contaminants that were a concern in 2009 have decreasing concentrations, such as dieldrin, DDT and PBDEs found in mussels at five sites around Monterey Bay (see Figures 13 a, b and c) and a detailed discussion in response to Nearshore Question 3), other legacy POPs, such as PCBs and polycyclic aromatic hydrocarbons (PAHs), remain in the water and sediment at levels of concern for marine organisms. A recently published study found that sea otters from three sites in Monterey Bay (Santa Cruz, Elkhorn Slough and Monterey) had mean POP levels 5-20 times higher than sea otters from locations in Alaska (Jessup et al. 2010). In particular, sea otters from Santa Cruz had high levels of both PCBs and DDT (see Offshore Question 7 for more information on PCBs in marine mammals).

New current-use pesticides have been detected in the tissues of marine and estuarine organisms in central California. In a study by Smalling et al. (2013), current use pesticides (CUPs) and legacy pesticides (DDT) were studied to determine their presence in water, sediment and the tissues of sand crabs

(*Emerita analoga*), starry flounder (*Platichthys stellatus*) and staghorn sculpin (*Leptocottus armatus*) in a coastal estuary. This was the first study to document the occurrence of CUPs in the tissues of marine organisms. Water samples were analyzed for a suite of 68 CUPs; 24 were detected including six fungicides, eight herbicides, five insecticides and five pesticide degradates. Sediment was analyzed for 34 fungicides and 57 CUPs; 22 were detected, including four fungicides, seven herbicides, seven insecticides and four pesticide degradates. Fish and crab tissue samples were analyzed for 98 CUPs; 13 CUPs and DDT were detected in the fish tissue. Total DDT concentrations were an order of magnitude higher than individual CUPs in the fish tissue. Ten contaminants, including three fungicides, four insecticides and DDT, DDD and DDE were detected in the sand crab tissue. Many of the most frequently detected compounds in the fish and crab tissues were typically observed in the water and sediment samples, with the exception of pyrethroids, which were present in both sediment and tissue but at non-correlated concentrations (Smalling et al. 2013).

As described in the response to Nearshore Question 2, microcystin toxicity has become a serious threat in the last five years. A 2010 study surveyed 21 freshwater, estuarine and marine locations using Solid Phase Adsorption Toxin Tracking (SPATT) samplers (Kudela 2011) at the land-sea interface to determine the presence and concentration of microcystin. Fifteen of 21 sites were positive for microcystin toxin. These blooms are common in freshwater systems throughout California; however, it was not until recently that we now understand the widespread occurrence of toxic blooms at low to moderate levels in the marine environment throughout the year. Coastal nutrient loadings were statistically significant predictors of the microcystin concentrations with clear evidence for seasonality at some sites (Gibble and Kudela 2014). As described in the nearshore water quality section, microcystin was determined to have poisoned 11 southern sea otters in 2007.

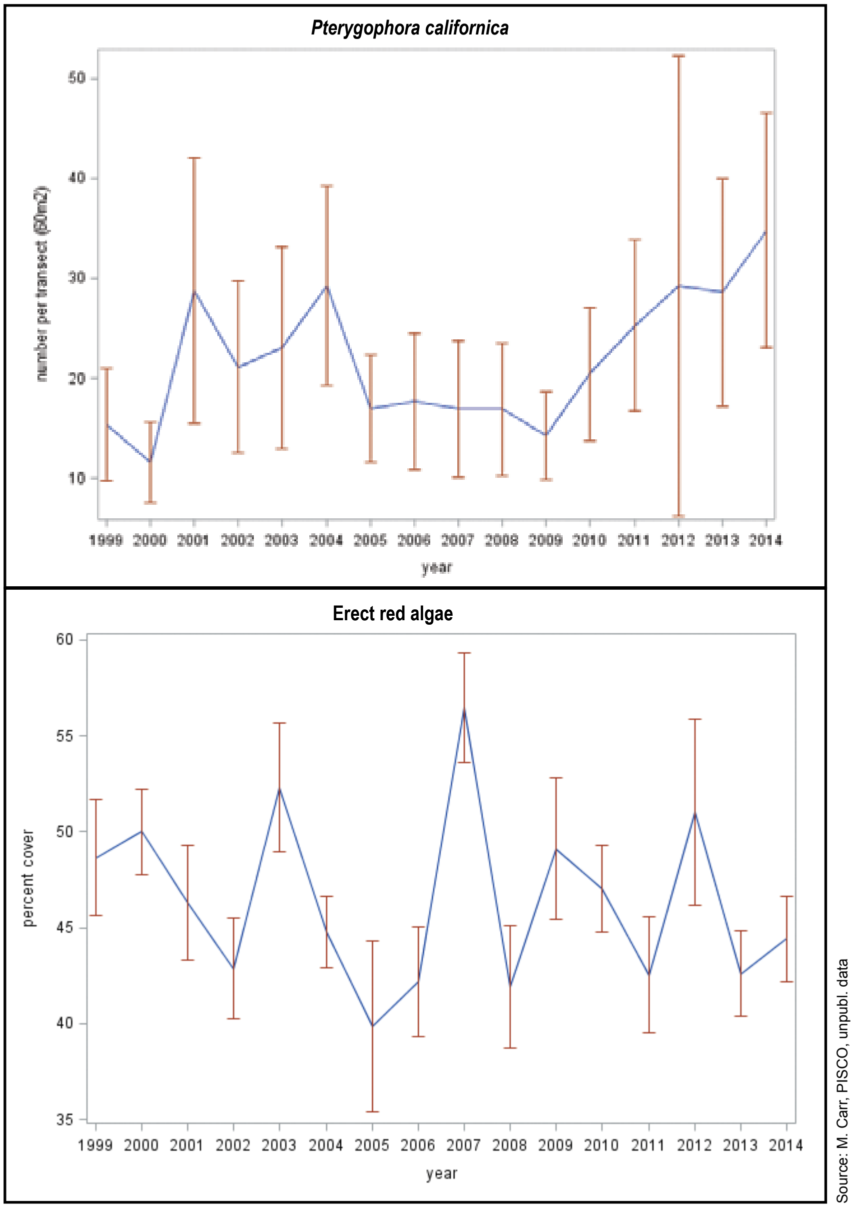
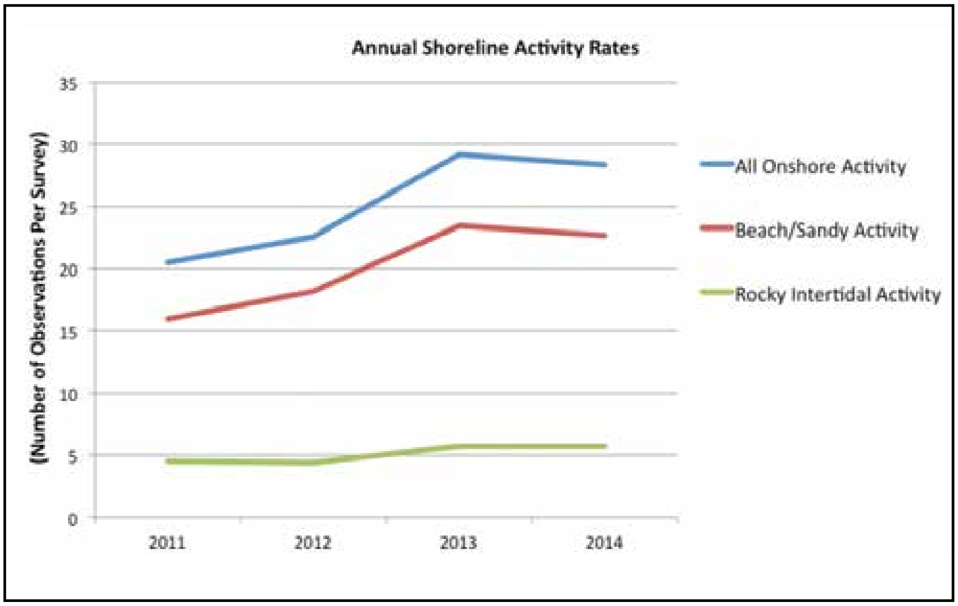


Figure 18. Mean annual abundance (and standard error) estimates of the understory kelp (*Pterygophora californica*) (top) and the erect red algae complex (bottom) from 12 long-term monitoring sites in kelp forests around Monterey and Point Lobos. At each site, SCUBA divers swam along transects to record the number of *Pterygophora* encountered and used point contact along a transect tape to calculate percent cover of erect red algae.



Source: MPA Watch, unpubl. data

Figure 19. Average number of people engaged in shoreline-based activity during multiple surveys each month by MPA Watch Volunteers at ten sites in central California from March 2011 through mid-2014. Activities levels are shown for all shoreline activity (blue) as well as the proportion engaged in activities on beaches (red) versus rocky shores (green). In all cases, the general level of human activity at these shoreline sites has increased over the study period.

8. What are the levels of human activities that may influence habitat quality and how are they changing? In 2009 the level of human activities that influence habitat quality in the nearshore environment was rated"good/fair" because some human activities had substantial, localized negative impacts on habitat quality. The trend was "undetermined" due to a lack of information for many of the activities and uncertainty regarding how to combine the available information into a cumulative trend. Based on new information, the status was changed to "fair" because some on-going activities have substantial, localized negative impacts on habitat quality (e.g., coastal armoring, coastal development, sand mining) and some activities (e.g., release of contaminants and marine debris) are more widespread, although there are efforts to reduce said impacts (beach clean-ups, management of contaminant sources).

The 2015 trend remains "undetermined" due to uncertainty in how to combine the available information into a cumulative trend. Some activities with negative impacts, like sand mining, coastal armoring, dredging and landslide disposal, continue at rates similar to the last assessment period (see Nearshore Question 5 for more details). Human visits to the shoreline are increasing, which could lead to increasing impacts to the intertidal habitat. Contaminants and marine debris are present and likely accumulating, but at an unknown rate. Conversely, some activities may offset negative impacts (coastal clean-ups, management of contaminant sources and implementation of best management practices).

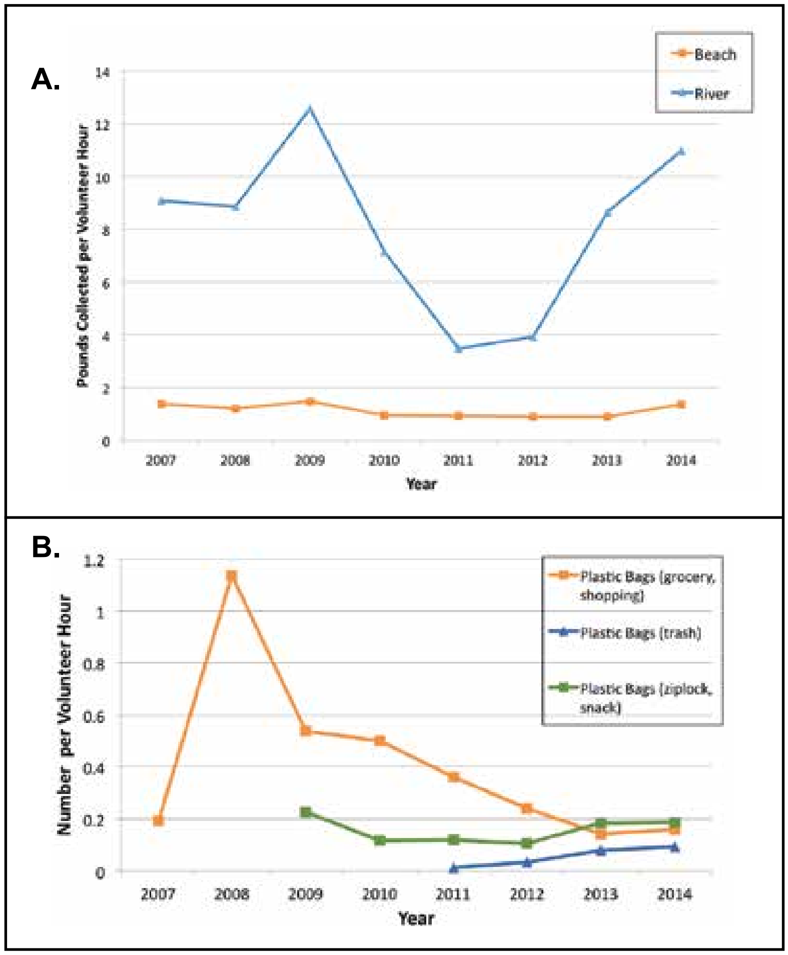
Beaches and rocky shores with roads and parking lots can receive a high level of visitors, especially at sites near population centers. In the rocky intertidal zone, people may negatively impact the habitat by trampling animals or algae, or by collecting structure-forming organisms and turning over rocks and boulders. At beaches, visitors may negatively impact habitat quality by littering or causing disturbance of critical habitat for sensitive species, such as the western snowy plover. In 2011, the Otter Project began training volunteers to survey human activities along the central California coast at beaches and accessible rocky shores in a citizen science program called MPA Watch (marine protected area).[30] The types of activities they record include both extractive (hand collection, line-fishing) and non-extractive (tidepooling, wildlife watching, playing) activities. Based on the first four years of survey data, the average amount of shoreline activities observed increased from 2011 to 2013, and then remained similar between 2013 and 2014 (Figure 19). The increase in shoreline activity rates occurred at both beaches and rocky shores (J. Natov, Otter Project, unpubl. data).

A variety of land-based and water-based human activities result in the introduction of contaminants, including pesticides, microbial contaminants and plastic debris, into the nearshore habitats. The leading sources of contamination in the sanctuary are agricultural and urban runoff (see response to Nearshore Question 7 for detailed information). A recent study of the types of litter on Monterey Bay's beaches found that small pieces of styrofoam (5 –millimeters- 5 centimeters in size) and fragmented

[30] (n.d.) Marine protected areas (MPAs). *The Otter Project*. Retrieved from http://www.otterproject.org/what-we-do/programs/habitat/marine-protected-areas/.

plastics (2 millimeters -2 centimeters) were the two most common types of litter (Rosevelt et al. 2013). Both items are persistent in the environment and a hazard for animals foraging in nearshore habitats (Arthur et al. 2009, Donnelly-Greenane et al. 2014, Nevins et al. 2014, NOAA-MDP 2014). The deposition of styrofoam, fertilizer pellets and fragmented plastics was highest in winter and central bay locations, especially after storm events, which may indicate transport of debris by rivers. The fertilizer pellet casings are the remains of time-release fertilizer applications on land uses, such as agriculture or nurseries.

Since 2007, Save Our Shores (SOS), a non-profit marine conservation organization in Santa Cruz, has led 1,886 beach and river clean-ups in Santa Cruz and Monterey counties. Currently, they host monthly clean-ups at 53 beaches on Monterey Bay and less frequent clean-ups on the San Lorenzo River, Elkhorn Slough and several other creeks in Santa Cruz County. Despite SOS's efforts, trash continues to be found and removed from both beaches and rivers. Volunteers at beaches collect smaller loads of trash per hour than volunteers in rivers (Figure 20a), which may be due to the fact that volunteers at the less frequent river clean-ups encounter more and larger trash. It appears that more river clean-up could substantially reduce inputs of trash to the sanctuary (B. Patterson, SOS, unpubl. data). The number of plastic grocery bags found per hour has declined every year since 2008, while the number of other types of plastic bags has not declined (Figure 20b). This decline may be due in part to plastic grocery bag bans in local communities, including Santa Cruz (2011) and Monterey (2014) counties.



Source: Save our Shores, unpubl. data

Figure 20. (A.) Average pounds of trash collected per hour by volunteers at clean-up events at beaches (orange) and rivers (blue) in Santa Cruz and Monterey counties since 2007. (B.) Number of plastic grocery (orange), plastic trash (blue) and plastic snack/ziplock (green) bags collected per hour by volunteers.

The pressures discussed are likely to increase with continued coastal development and population growth. Management programs at the local, regional and state levels attempt to reduce negative impacts, but it is unknown whether these programs will be able to offset the increasing pressure of development and population growth on sanctuary habitats. In particular, production of desalinated water has the potential to increase substantially over the next few years, especially given the severe drought in California (see Droughts in California text box).[31] There are a variety of concerns associated with desalination facilities, including additional coastal development, significant volumes of greenhouse gas emissions from the energy intensive desalination process and construction of new pipelines that can disturb the seafloor, surf zone and dunes, and potentially change coastal hydrology (NOAA 2010). As of early 2015, there are multiple desalination facilities being considered within the sanctuary, with all but one located in Monterey Bay. In March 2015, the first new project completed a test well to study the effectiveness of a sub-surface well intake to minimize negative impacts on sanctuary resources.

[31] (reviewed Nov. 26, 2014). Resource issues: desalination. *Monterey Bay National Marine Sanctuary (MBNMS)*. Retrieved from http://montereybay.noaa.gov/resourcepro/resmanissues/desalination.html.

Nearshore Environment
Habitat Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
5	Abundance/ Distribution	▼ (Fair)	Status: Very High Trend: Very High	Localized modification of coastal habitat and reduced habitat quality, primarily through armoring, erosion, landslide and accumulation of marine debris and contaminants.	Selected habitat loss or alteration may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources or water quality.
6	Biologically-Structured	— (Good)	Status: Very High Trend: Very High	Monitoring programs indicate healthy populations and no major perturbations.	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
7	Contaminants	▼ (Fair/Poor)	Status: High Trend: High	Declines in some persistent contaminants (dieldrin), but new contaminants being added to the system; some evidence showing contaminants are accumulating in shellfish and resident fish and are impacting health of living resources (e.g., mammals).	Selected contaminants have caused or are likely to cause severe declines in some, but not all living resources or water quality.
8	Human Impacts	? (Fair)	Status: Medium Trend: Medium	Trampling, visitation and coastal armoring can have measurable, localized impacts; trash and contaminants present and accumulating slowly despite management efforts.	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.

The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report (ONMS 2009).

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

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

Photo: Chad King / NOAA MBNMS

Nearshore Environment: Living Resources

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

Key species, such as keystone species, indicators species, sensitive species and those targeted for special protection, are discussed in the responses to questions 12 and 13. Status of key species will be addressed in question 12 and refers primarily to population numbers. Condition or health of key species will be addressed in question 13. The sanctuary's key species are numerous and all cannot be covered here. Instead, in this report, we emphasize examples from the sanctuary's primary habitats with data available on status and/or condition.

The following information provides an assessment of the status and trends since 2009 that pertain to the current state of the sanctuary's living resources in the nearshore environment, This section is based on studies of faunal communities in the sandy and rocky intertidal and the sandy and rocky subtidal habitats. Much more research occurs in rocky intertidal and subtidal rocky reef and kelp forests; therefore, the assessments are primarily based on the status of living resources in these two habitats. More research and long-term monitoring is needed on the status and trends of faunal communities associated with beaches and sandy seafloor habitats.

Multi-Agency Rocky Intertidal Network (MARINe)

The Multi-Agency Rocky Intertidal Network (MARINe)[32] is a partnership of agencies, universities and private groups committed to determine the health of the rocky intertidal habitat along North America's west coast and providie this information to the public. MARINe monitors over 100 coastal sites and many of the sites have been monitored for periods of 15 to over 25 years. MARINe represents the largest program of its kind.

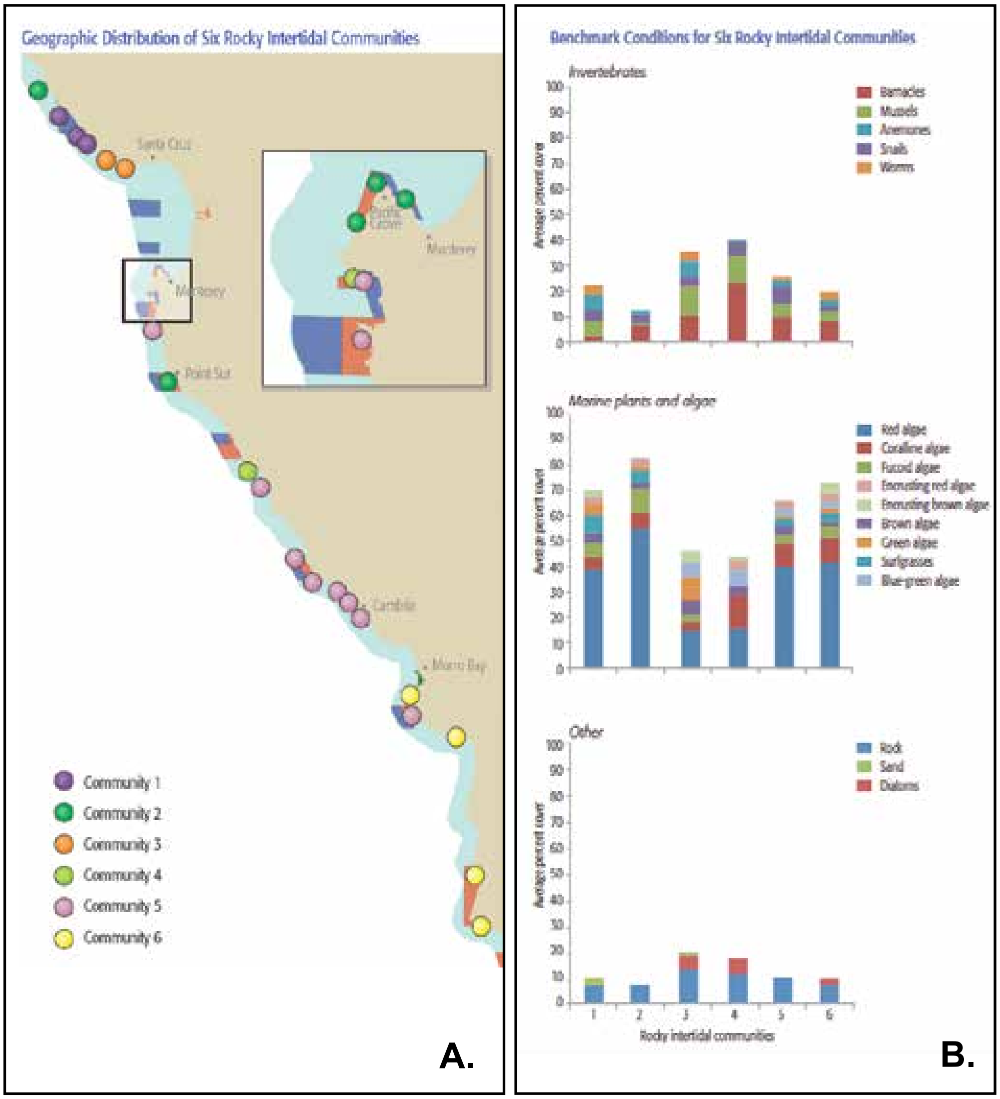
9. ***What is the status of biodiversity and how is it changing?*** Native species richness in the sanctuary's nearshore habitats has been unchanged over the last few decades with no known local extinctions of native species. Nonetheless, the relative abundance of native species in the intertidal and nearshore subtidal zones has been altered by a variety of factors, including human activities, such as trampling and harvest. The recent implementation of many marine reserves and conservation areas in California's state waters may facilitate recovery of reduced populations in those locations. Based on these patterns in 2009, the status of native biodiversity in the nearshore environment of the sanctuary was rated "fair," but the overall trend in biodiversity was "undetermined."

On-going monitoring in rocky intertidal and subtidal reef habitats provides new information to further characterize patterns in community composition in nearshore habitats and examine trends in abundance of key species and assemblages. We are only aware of one substantial change to nearshore biodiversity: a recent dramatic decline in sea stars and concurrent increase in sea urchins (see response to Nearshore Questions 12 and 13 for details). This occurred very recently and we need more time to determine whether it will persist and cause, or be likely to cause, severe declines in other ecosystem components (which would be consistent with a fair/poor rating). Therefore, the status for 2015 remains "fair." The trend is "not changing" due to the apparent stability of most components of the rocky shore and kelp forest assemblages.

The sanctuary's rocky intertidal community is biologically rich, with 567 native species documented in surveys of the more conspicuous species (Wasson et al. 2005). The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) and Multi-Agency Rocky Intertidal Network (MARINe) collect long-term monitoring data from 26 sites in the central California's rocky intertidal habitat. An analysis of the percent of available space occupied by certain types of invertebrates, marine plants and algae, and physical substrate, identified six distinct communities (Figure 21) (summarized in OST and CDFW 2013). These patterns of relative abundance and diversity

[32] (n.d.) *Multi-Agency Rocky Intertidal Network (MARINe)*. Retrieved from http://www.marine.gov/index.htm.

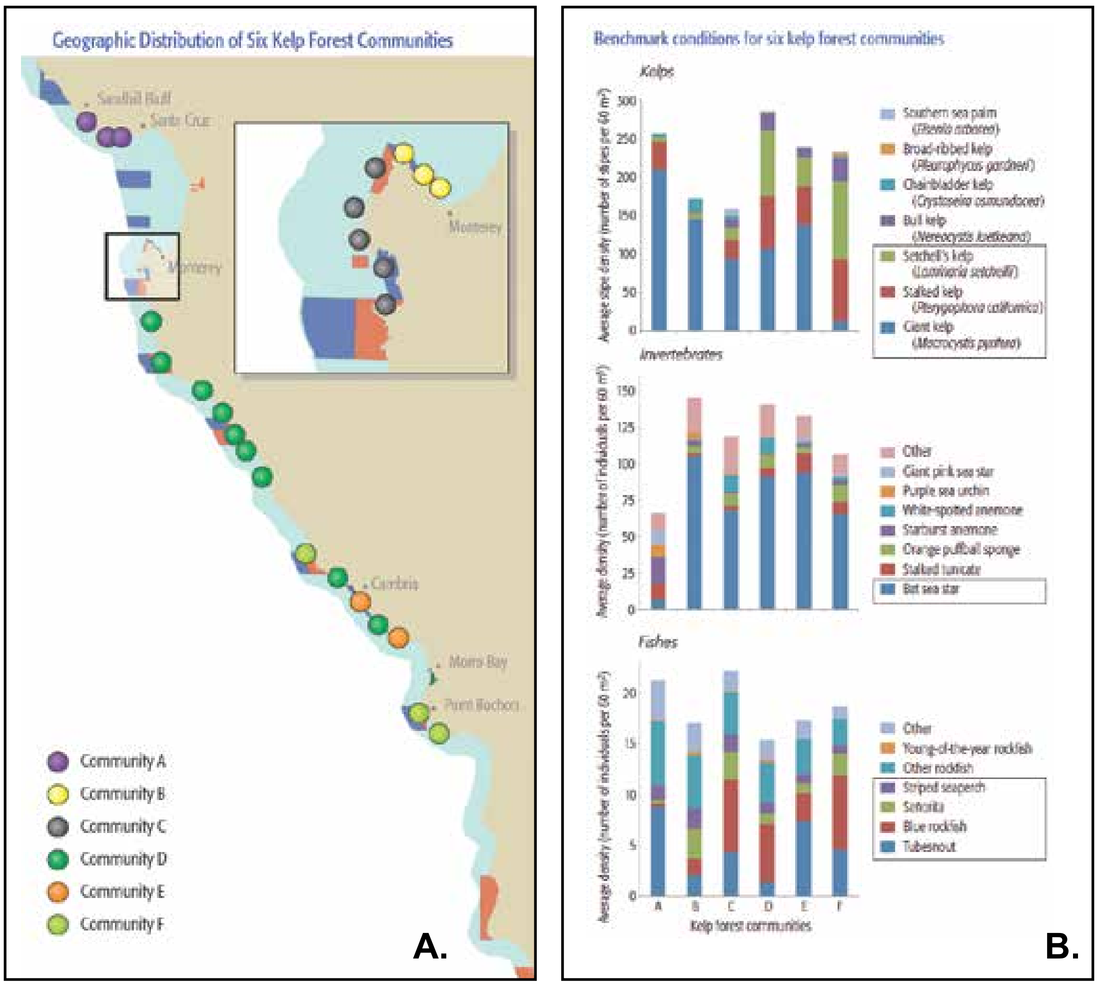
of species in the rocky intertidal habitat appear to be strongly influenced by physical features, including swell and wave exposure, rock roughness, substrate slope, and water temperature. For example, sites with communities 3 and 4 experience higher swell and wave exposure than sites with communities 1, 2, 5 and 6 (OST and CDFW 2013). Although community 6 was not observed inside MBNMS, it may occur in the sanctuary at sites with similar physical attributes. The level of human activities, such as harvest or trampling, can also affect the relative abundance and diversity at a given location; however, specific information on trends in biodiversity and the relative importance of changes in physical factors and human use patterns are not currently available.



Source:PISCO/MARINe/UCSC. Figures from OST and CDFW 2013.

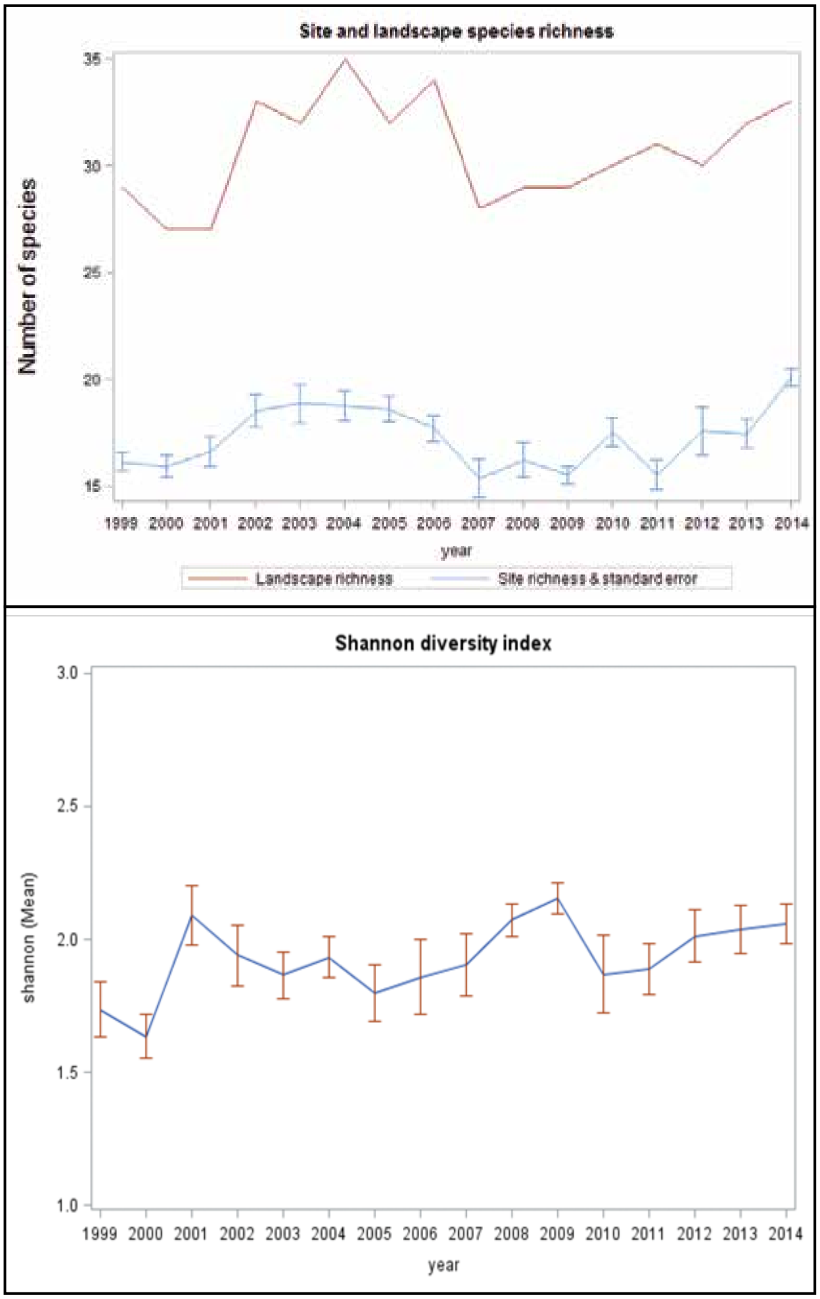
Figure 21. (A.) Analysis of long-term monitoring data from 26 sites in the rocky intertidal habitat in central California, identified six distinct communities that can be differentiated based on the percent of the available space occupied by invertebrates, marine plants and algae, and the physical substrate. (B.) Species included in the graphs (right) are those that characterize the community groups (i.e., have the highest density), rather than those that distinguish among the community groups. Physical features, such as swell and wave exposure, rock roughness, substrate slope and water temperature, are found to influence the abundance and diversity of species in the rocky intertidal.

PISCO also collected long-term monitoring data from 25 kelp forests in central California. PISCO identified six distinct communities that can be differentiated based on the relative density of canopy and understory kelps and certain species of invertebrates and fishes (Figure 22) (summarized in OST and CDFW 2013). The type and relief of the substrate was found to strongly influence abundance and diversity of kelp forest communities. For example, community A was found in areas dominated by bedrock with flat relief, community C was associated with habitats with more moderate and high relief than the others and community E was found in habitats with the most boulder and cobble substrates (OST and CDFW 2013). Though Community E was not observed inside MBNMS, it may occur in the sanctuary at sites with similar physical attributes.



Source: PISCO/UCSC. Figures from OST and CDFW 2013.

Figure 22. (A.) Analysis of long-term monitoring data from 25 sites in the kelp forests along the central California coast, identified six distinct communities that can be differentiated based on the relative density of canopy and understory kelps, invertebrates and fishes. (B.) All species included in the graphs are those that characterize the communities. The black boxes surround the species that were identified through the clustering analyses to distinguish among the communities. Physical features, such as rock type and relief, were found to have a strong influence on abundance and diversity of kelp forest communities.



Source: PISCO, unpubl. data

Figure 23. Landscape and mean site species richness (number of species) and mean site diversity (Shannon Diversity Index) of the kelp forest fish assemblage was calculated using long-term monitoring data of the adult fish assemblage at 12 sites in MBNMS. All non-cryptic fish species that are commonly observed along transects were included in the analysis. Landscape richness includes all the species that were used to calculate site species richness in a given year. The Shannon Diversity Index (H') takes into account the species richness and relative abundance of those species (evenness). The value of H' increases both when the number of species increases and when evenness increases, and is maximized when all species are equally abundant. Red bars=standard error.

Lastly, PISCO's long-term monitoring data for kelp forest fishes at 12 sites in the sanctuary provides some information on trends in diversity of the nearshore fish assemblage (Figure 23). Species richness and diversity of the kelp forest fish assemblage in the sanctuary varies over time, likely influenced by multiple factors, including changing ocean conditions. However, there were no obviously strong influences of ocean conditions on kelp forest fish diversity, and diversity appears to be fairly stable from 1999-2014.

Less is known about biodiversity patterns in the sanctuary's sandy bottom habitats. Some observed changes in biodiversity in the soft bottom habitats of the nearshore environment are likely in response to large-scale, long-term climatic shifts (e.g., Pacific Decadal Oscillation), but data detecting this pattern are limited to a small area (MLML 2006). Additional long-term monitoring data would be useful to further explore status and trends in this faunal community.

As discussed above, patterns in biodiversity in rocky shore and kelp forest communities are strongly influenced by physical factors. Changes in physical factors driven by global climate change will influence the sanctuary's patterns of biodiversity. Warming of air temperature should lead to ocean warming, which will lead to changes in species distribution along the north-south coastline of MBNMS. A subset of the species that occur in the sanctuary are "southern" species, whose range extends only into the southern or central portions of MBNMS. Some other species are "northern" species, whose range only extends into the northern or central portions of the sanctuary. As ocean temperatures warm, we would expect to see the range of some southern species expand northward while the range of some northern species contracts. Sagarin et al. (1999) found some evidence that the ranges of some southern species were expanding northward along the California coast. We are not aware of any new examples of range expansions and contractions of nearshore species in the sanctuary due to climate warming, but we expect this to be a future driver of change in nearshore biodiversity.

10. *What is the status of environmentally sustainable fishing and how is it changing?* We no longer assess this question in ONMS condition reports; therefore, content for this question was not updated.

11. *What is the status of non-indigenous species and how is it changing?* In the 2009 report, the status of non-indigenous species (NIS) was rated "good" with a "declining trend" because some NIS were identified in the sanctuary's nearshore habitat and a few of those species appeared to have spread. Surveys in sandy and rocky intertidal habitats detected NIS in all habitat types, but the percentage of NIS was low (1-2%) (Wasson et al. 2005, Maloney et al. 2006). The 2015 status remains "good" with a "declining" trend because new information on NIS in the sanctuary's nearshore habitats is consistent with 2009's basis for judgment.

NIS (e.g., *Caulacanthus ustulatus, Endocladia muricata. Sargassum muticum, Colpomenia spp. Hymeniacidon, Sargassum muticum*) continue to be observed at low abundance levels by monitoring programs in the sanctuary's nearshore habitats and we are not aware of evidence of strong ecological impacts from these species (P. Raimondi, PISCO/MARINe, pers. comm., Zabin et al. unpubl. data[33]). Recent surveys in Moss Landing and Monterey Harbors by California's Marine Invasive Species Program found that the percentage of NIS was low (<2%) (CDFW 2014), which is consistent with the past studies noted above. One species of concern, the Asian kelp (*Undaria pinnatifida*), continues to be abundant in Monterey Harbor, but has not spread outside the harbor (S. Lonhart, MBNMS, pers. comm.)[34] A second species of concern, the Japanese bryozoan (*Watersipora subtorquata*), shows patterns of slowly spreading away from Monterey Harbor along the rocky intertidal and subtidal habitats of the Monterey peninsula.

In 2009, we reported that surveys had documented the spread of *Watersipora* from Monterey Harbor to the open coast at the Hopkins Marine Life Refuge. (S. Lonhart, MBNMS, unpubl. data). Surveys in October 2014 recorded *Watersipora* from four subtidal sites (Breakwater Cove, McAbee Beach, Hopkins Marine Station and Lovers Point) and from three intertidal sites (Breakwater Cove, McAbee Beach, and Hopkins Marine Station) along the Monterey peninsula, but it was not found at the survey sites furthest away from the harbor on the peninsula (Coral Street) or in Carmel Bay.[35] The colonies observed were typically small, representing between 0.1-2.5% cover across study transects, but were widely distributed within transects in some locations (i.e., found in 23% of quadrats at Breakwater Cove and 10% of quadrats at McAbee Beach). The bryozoan was attached to a wide variety of substrates, including rock, barnacles, algae and crabs. It was found on both horizontal and vertical surfaces subtidally, but appears to be limited to vertical surfaces in the intertidal zone.

12. *What is the status of key species and how is it changing?* In 2009, the status of key species in the nearshore environment was rated "good/fair" and the trend was "not changing" because of the reduced abundance of a limited number of key species in each habitat type. Although monitoring data indicates that many key species are stable or increasing, the 2015 status is changed to "fair" and "declining" because of the recent, significant changes in the abundance of sea stars and sea urchins. Both sea stars and sea urchins can influence ecological structure and function of rocky reef and kelp forest habitats, and this dramatic change in their relative abundance may have measurable impacts to ecosystem integrity in the nearshore environment.

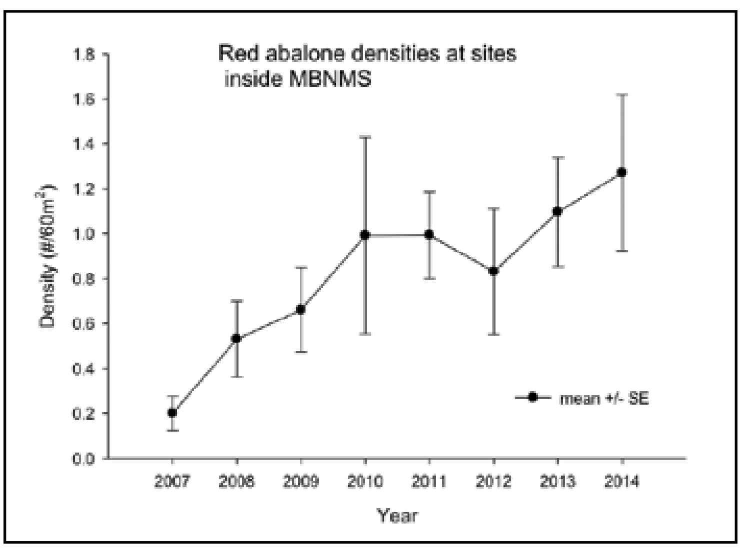
Below we briefly provide updated information on the status of a number of key species that play important ecological roles in the nearshore ecosystem.

Key species in the rocky intertidal habitat include sea stars, black abalone, owl limpets, surf grass, mussels, algae and black oystercatchers. In the response to Nearshore Question 6, we reported that the status of the habitat-forming species (e.g., mussels, surf grass, algae) is generally good and stable sanctuary-wide, but show reduced abundance at some sites because of high levels of human impacts (trampling, harvest) (PISCO/MARINe, unpubl. monitoring data). As was reported in 2009, disease (i.e., withering syndrome) severely reduced black abalone abundance in the southern portion of the sanctuary (i.e., south of Pt. Sierra Nevada); over-harvesting and predation reduced abundance in the rest of the sanctuary, but disease was not prevalent (ONMS 2009). Since 2009, abundance has not changed substantially at any sites in the sanctuary (P.

[33] (n.d.) Detecting non-native species in kelp forests and on rocky shores. *Sanctuary Integrated Monitoring Network (SIMoN)*. Retrieved from http://www.sanctuarysimon.org/projects/project_info.php?projectID=100419&site=true.
[34] For background information on *Undaria* in MBNMS see http://www.sanctuarysimon.org/projects/project_info.php?projectID=100184.
[35] (n.d.) Detecting non-native species in kelp forests and on rocky shores. *Sanctuary Integrated Monitoring Network (SIMoN)*. Retrieved from http://www.sanctuarysimon.org/projects/project_info.php?projectID=100419&site=true.

Source: Weinstein et al. 2014

Figure 24. Distribution of black oystercatchers (*Haematopus bachmani*) observed during a state-wide population assessment in 2011 in the early breeding season. The number of birds observed at a location is represented by the size of the purple circle on the map. Observers surveyed approximately 9% of the mainland California coast, equaling approximately 18% of the state's mainland suitable habitat. The black oystercatcher is a special status species because of a small global population size, low overall reproductive success and complete dependence on rocky intertidal shorelines, which are easily disturbed by humans and vulnerable to rising sea level.



Source: Reef Check California monitoring data

Figure 25. Annual mean density (and standard error) estimates for red abalone (*Haliotis rufescens*) from 16 long-term monitoring sites in Monterey Bay National Marine Sanctuary (MBNMS). Since 2007, average density has slowly increased from 0.2 to 1.3 abalone per transect (60 square meters).

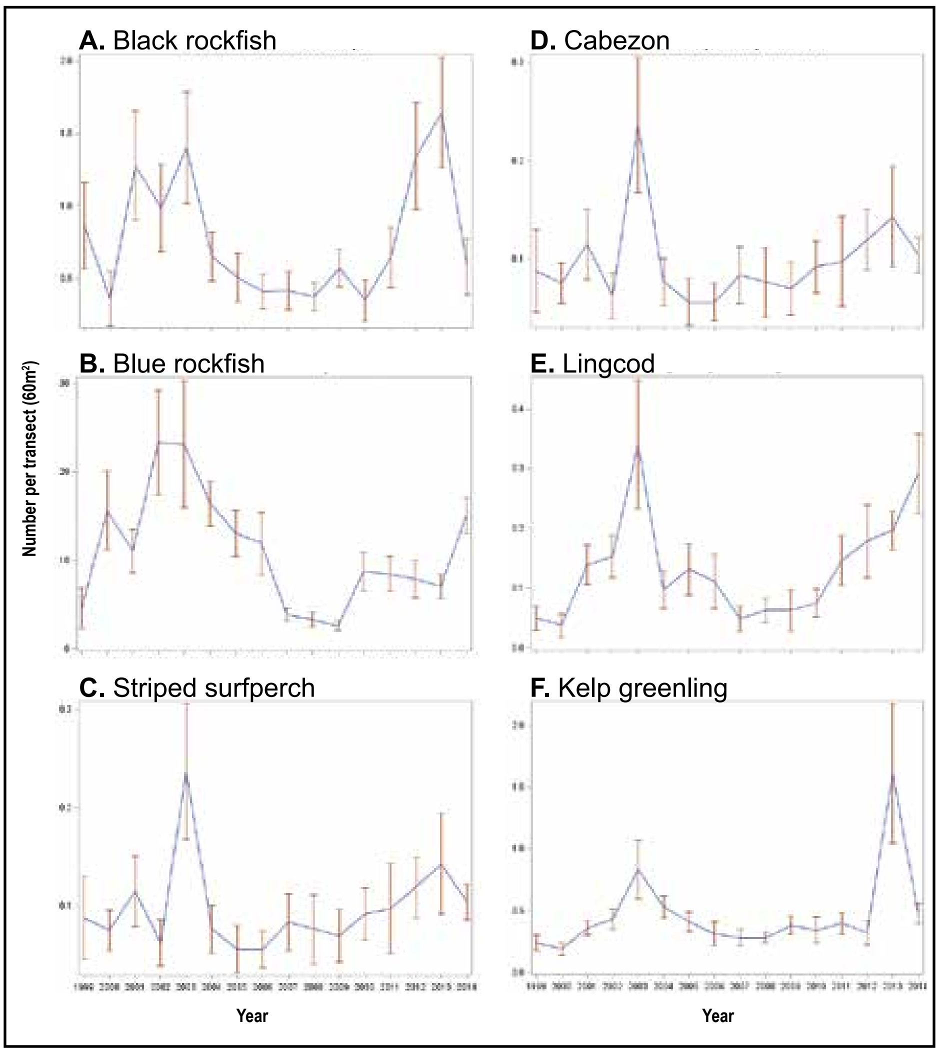
Raimondi, PISCO/MARINe, pers. comm.).

In 2011, the California population of black oystercatcher (*Haematopus bachmani*) was assessed for the first time during the early breeding season when observers surveyed approximately 18% of the state's mainland suitable habitat (Weinstein et. al. 2014). Density of individuals in mainland survey areas averaged 3.14 birds per kilometer, but were quite variable across survey sites with high densities observed at some locations in MBNMS (Figure 24). Analysis of Audubon's Christmas Bird Count (CBC) data suggests that the California population has been increasing slightly in recent years (2007–2011) (Weinstein et al. 2014).

PISCO, Reef Check California (RCCA) and sanctuary staff monitor the kelp forest community at many sites in MBNMS. In the response to Nearshore Question 6, we reported that the status of some key structure-forming species (e.g., canopy-forming kelp and understory algae) is generally good and stable sanctuary-wide. Another key kelp forest species, the red abalone (*Haliotis rufescens*), appears to be increasing in abundance (Jan Freiwald, RCCA, unpubl. data). Since 2007, when RCCA began monitoring red abalone density at 16 sites in the sanctuary, average density has slowly increased from 0.2 to 1.3 abalone per transect (60 square meters) (Figure 25).

Rockfishes, cabezon, lingcod, kelp greenling and surfperches are important residents on nearshore subtidal reefs. Recreational and commercial harvest of these targeted species has reduced the overall abundance of these fish stocks compared to unfished levels (to varying extents depending on the species). Some nearshore fish stocks that were previously overfished, such as canary rockfish, bocaccio and lingcod, are rebuilding or fully recovered (P. Reilly, CDFW, pers. comm., Wallace and Cope 2013, Field 2014). Monitoring by both PISCO and RCCA at multiple sites in the sanctuary indicates that generally fish populations appear to have stable or increasing trends in abundance (for example see Figure 26) (PISCO, unpubl. data). In addition, strong recruitment of young-of-the-year rockfish has been observed in kelp forests in the sanctuary in both 2013 and 2014 (Figure 27).

Sea otters are considered a keystone species of the kelp forest ecosystem because they are highly effective predators capable of limiting herbivorous invertebrate (e.g., sea urchins) populations, that if otherwise left unchecked, can decimate kelp beds and the associated community of fish and invertebrates. Since the 1980s, USGS scientists have calculated a population index each year for the southern sea otter (*Enhydra lutris nereis*). In 2014, the population index was 2,944, which continues the gradual increase observed since 2010 (Figure 28). The population of sea otters in the sanctuary is composed of three regions with different demographic patterns: (1.) the north coast region (extending from Santa Cruz northward) is stable or slowly growing, with further growth and range expansion limited primarily by deaths attributable to non-consumptive shark bites, which have increased sharply in the last five years; (2.) the Monterey Bay region (Santa Cruz to Monterey, but excluding Elkhorn Slough) is growing slowly because it is comprised of mostly non-reproducing individuals (transient males and subadult females) and has higher rates of mortality due to water quality issues, and more recently by increased rate of shark bites; and (3.) the central coast region (extending from Monterey south to Cambria) has shown variable growth rates from year to year, but over the last decade has been more or less stable because it is at or near carrying capacity, and in the last 5-10 years, there has also been a significant increase in shark bite mortality near Cambria (T. Tinker, USGS-WERC, pers. comm.). Although the demographics in the three regions are quite different, the population trend of otters in all three



Source: PISCO monitoring data

Figure 26. Annual mean abundance (and standard error) estimates from 12 long-term monitoring sites around Monterey and Pt. Lobos for six species of kelp forest fish: (A.) black rockfish (*Sebastes melanops*), (B.) blue rockfish (*S. mystinus*), (C.) striped surfperch (*Embiotoca lateralis*), (D.) cabezon (*Scorpaenichthys marmoratus*), (E.) lingcod (*Ophiodon elongatus*) and (F.) kelp greenling (*Hexagrammos decagrammus*). Fish are measured by counting the number of fish observed as SCUBA divers swim along a transect.

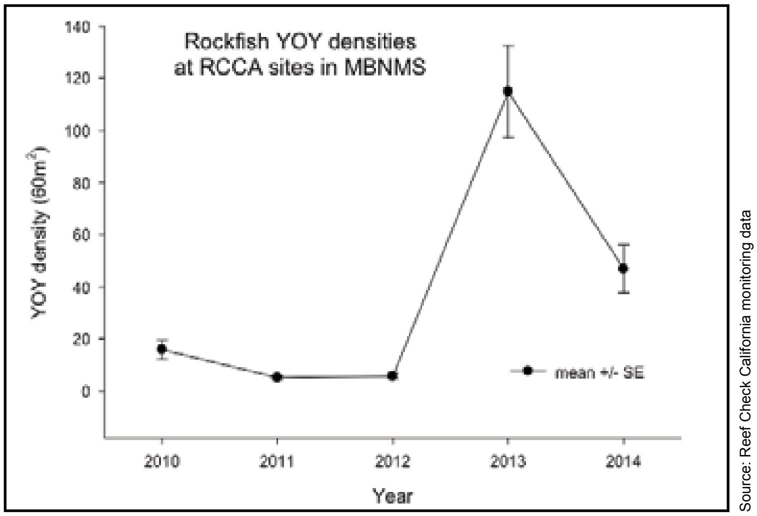


Figure 27. Annual mean density (and standard error) estimates for young-of-the-year (YOY) rockfish (*Sebastes* spp.) from 16 long-term monitoring sites in Monterey Bay National Marine Sanctuary (MBNMS). Number of YOY are counted as SCUBA divers swim along a transect.

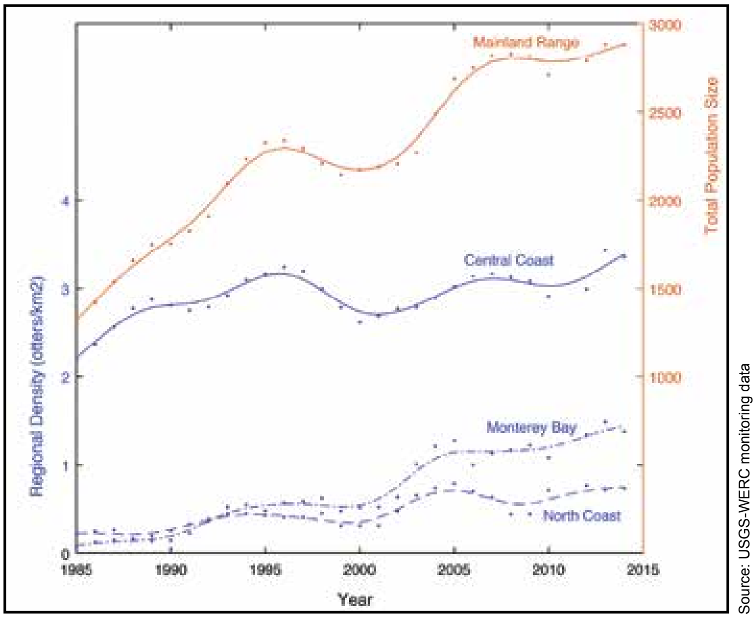


Figure 28. Since the 1980s, USGS scientists have calculated a population index each year for the mainland range of the southern sea otter (*Enhydra lutris nereis*). In 2014, the population index is 2,944, which continues the gradual increase that has been seen since 2010 (red line). The population of sea otters in the sanctuary can be divided into three regions with different demographic patterns: (1.) the north coast region extending from Santa Cruz northward (dashed blue line); (2.) the Monterey Bay region extending Santa Cruz to Monterey (dash-dot blue line); and (3.) the central coast region extending from Monterey southward to Cambria (solid blue line). Although the demographics in these three regions are quite different, the regional density of sea otters has been stable or increasing very slowly in all three regions in recent years.

regions is stable or weakly positive (Figure 28).

A major concern for the status of key species in both rocky intertidal and subtidal habitats is the drastic decline of sea star populations along the Northeast Pacific coast due to an extensive outbreak of sea star wasting syndrome. Similar die-offs have occurred in the past, but never before at this magnitude and over such a wide geographic area.[36] Twenty affected species have been documented, including the ochre star (*Pisaster ochraceus*) (Figure 29), the giant star (*Pisaster giganteus*) and the sunflower star (*Pycnopodia helianthoides*) (Figure 30). Ochre and sunflower stars are considered to be keystone species in the nearshore environment because they have a disproportionately large influence on other species in their ecosystem. Declines in sea star populations in nearshore habitats may lead to changes in biodiversity at affected sites, for example through release of prey species that are commonly eaten by sea stars. However, it is too soon to understand the severity or persistence of any such changes. Substantial recruitment of baby sea stars has been observed in a few areas severely affected by wasting disease.[36] This could indicate that replenishment of affected populations will be more rapid than expected; however, for recovery to occur, the new sea stars must be relatively unaffected by wasting disease and they must arrive at many of the locations that have been affected by wasting disease.[36] This is and will continue to be a topic of intense study along the West Coast and the ecological implications will be better understood in a few years.

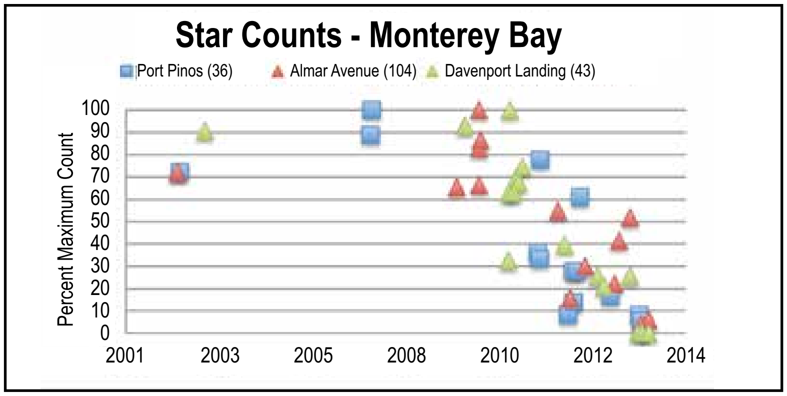
A second concern for the status of key species is the recent dramatic increase in the observed abundance of sea urchins in kelp forests. RCCA divers have observed a dramatic increase in the number of purple sea urchins (*Strongylocentrotus purpuratus*) and red sea urchins (Mesocentrotus franciscanus) that are visible during SCUBA surveys (Figure 31). It is unlikely that their abundance in the kelp forest system has increased this quickly, but instead that sea urchins have emerged from hiding in cracks and crevices in the reef now that one of their predators, the sunflower star, is absent or at very low abundance. Sea urchins consume

[36] (2015). Pacific rocky intertidal monitoring: Trends and synthesis: Sea star wasting syndrome updates. *University of California, Santa Cruz: Ecology and Evolutionary Biology.* Retrieved from http://www.eeb.ucsc.edu/pacificrockyintertidal/data-products/sea-star-wasting/updates.html

canopy-forming kelp and understory algae and are capable of quickly removing most fleshy algal biomass from a site (Estes and Palmisano 1974). The ecological impacts of this recent change in sea urchin abundance and behavior could be substantial in kelp forest habitats, but will require more time and monitoring to understand.

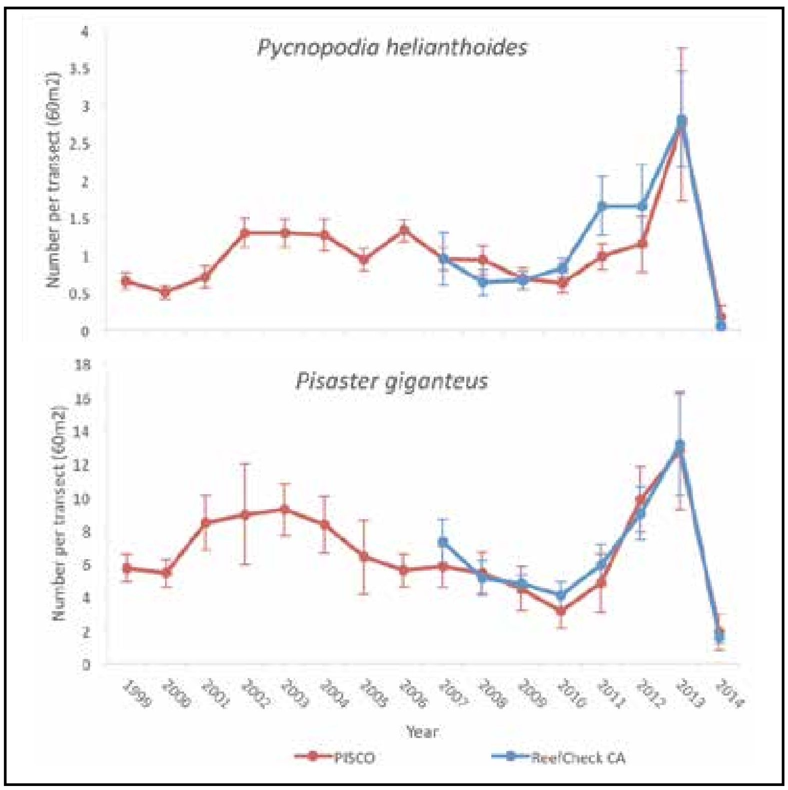
Very little monitoring occurs for key species in beach and sandy seafloor habitats. The exception is the western snowy plover (*Charadrius nivosus nivosus*) for which monitoring is required due to its status as a threatened species under the Endangered Species Act. The estimated number of nesting birds observed each year from 2010 to 2014 ranged from 382 to 431, which significantly exceeded the target of 338 breeders recommended for the Monterey Bay area in the USFWS Recovery Plan (Page et al. 2015). While the number of nesting snowy plovers in the Monterey Bay area currently meets the USFWS Recovery Goal target, predator pressure is increasing in frequency and magnitude and continues to be one of the greatest management challenges. The status of snowy plovers in the Monterey Bay region is good but "management reliant" (C. Esyter, Point Blue Conservation Science, pers. comm.).

13. What is the condition or health of key species and how is it changing? In 2009, the health of key species in the nearshore environment was rated "fair." The 2015 status will remain "fair" due to the health of some key species being negatively impacted by disease or contamination, which may cause measurable reductions in ecological function of those species. In 2009, the trend was rated "not changing" because the sanctuary's impacted populations did not decline in number, but health appeared to be one reason they did not recover from depressed levels. The recent outbreak of a wasting syndrome resulted in significant population declines in many species of sea stars in both intertidal and subtidal habitats.



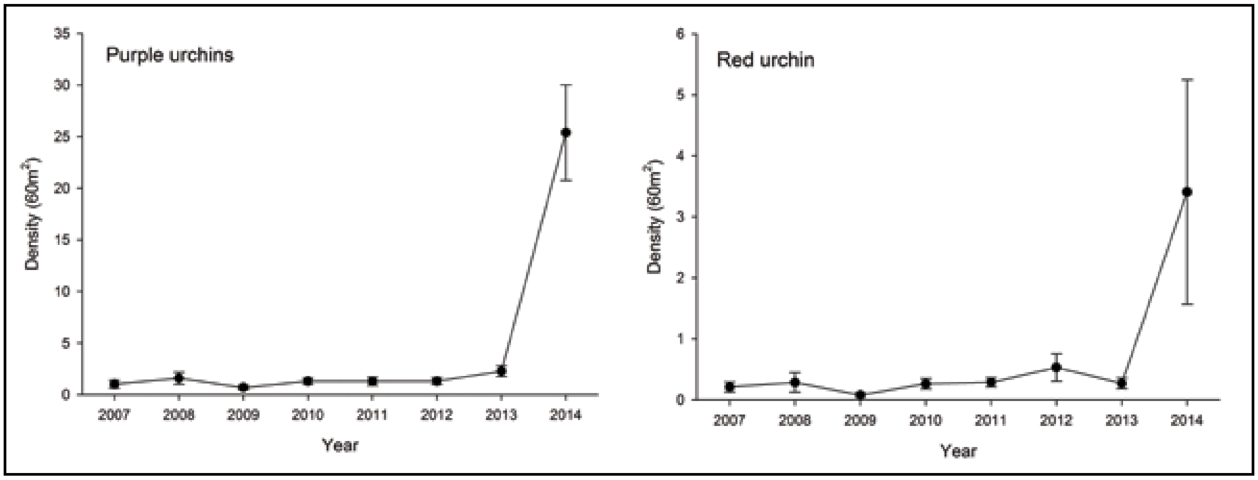
Source: J. Pearse, unpubl. data from limpets.org

Figure 29. Abundance of ochre star (*Pisaster ochraceus*) is shown as percent of maximum number counted at three rocky intertidal sites in MBNMS (number in parentheses is the maximum number counted at that site): Point Pinos (blue square), Almar Avenue (red triangle) and Davenport Landing (green triangle). Monitoring data collected by the LiMPETS citizen science program suggest that the decline in ochre stars at these sites occurred over a period of 3-5 years before the mass mortality event that began in late 2013 (J. Pearse, pers. comm.).



Source: PISCO monitoring data and RCCA monitoring data

Figure 30. Annual mean abundance (and standard error) estimates for the sunflower star (*Pycnopodia helianthoides*) (top) and giant stars (*Pisaster giganteus*) (bottom) from 12 PISCO (red) and 16 RCCA (blue) long-term subtidal monitoring sites around Monterey and Point Lobos. Abundance is measured by counting the number of stars observed as SCUBA divers swim along a transect. Annual abundance peaked in summer 2013 and then dropped to very low abundance by summer 2014.



Source: RCCA monitoring data

Figure 31. Annual mean abundance (and standard error) estimates for the purple sea urchin (*Strongylocentrotus purpuratus*) and red sea urchin (*Mesocentrotus franciscanus*) at 16 RCCA long-term subtidal monitoring sites around Monterey and Point Lobos. Annual abundance of sea urchins has increased dramatically in 2014, the same time that sea star abundance declined dramatically.

Therefore, a new serious health issue for key species, wasting syndrome, downgraded the trend to “declining” in 2015.

Sea stars inhabiting the U.S. West Coast, both in rocky intertidal and subtidal habitats, started showing signs of wasting syndrome in mid-2013; by the end of 2014, an extensive outbreak had severely reduced sea star numbers at many sites up and down the coast (see Figures 29 and 30). Wasting syndrome has been documented in sea stars along the West Coast in the past, but this is the largest event ever observed.[37] Wasting syndrome typically causes lesions to appear in the ectoderm, followed by decay of tissue surrounding the lesions, which leads to eventual fragmentation of the body and death. Scientists with the MARINe monitoring program documented[38] 20 affected species including the giant star (*Pisaster giganteus*), the bat star (*Patiria miniata*) and the rainbow star (*Orthasterias koehleri*) (Figure 32). Hewson et al. (2014) provided evidence for a link between a densovirus and sea star wasting syndrome; however, there are likely to be additional contributing factors, such as warm water events.

This densovirus is also found in other echinoderms (e.g., sea urchins). Scientist are closely monitoring sea urchin populations due to observations in 2014 of urchins with signs of wasting at some locations in southern California.[39] However, wasting has been observed in sea urchins in the past and it is unclear whether these recent observations are due to a spread of the current outbreak to other echinoderm species or due to increased efforts to monitor and report any signs of wasting syndrome (S. Lonhart, MBNMS-SIMoN, pers. comm.).

In 2009, black abalone (*Haliotis cracherodii*)[40] was listed as endangered under the Endangered Species Act (74 FR 1937). This species is ecologically extinct in the southern portion of the sanctuary (south of Point Sierra Nevada), where the population was reduced dramatically in the mid-2000s by withering syndrome (summarized in ONMS 2009); it has not shown any recent signs of recovery (P. Raimondi, PISCO/MARINe, pers. comm.). The disease has not caused populations north of Point Sierra Nevada to decline; however, the current reduced densities in this region hinder reproduction and population growth (P. Raimondi, PISCO/MARINe, pers. comm.).

Over the last six years, the number of stranded sea otters has increased, with the highest numbers ever observed in 2012 (both for the entire range and for the portion of the population in MBNMS).[41] The leading causes of sea otter mortality is different for the sanctuary’s three regions. In the north coast region, there is high mortality from shark attacks, which is likely associated with

[37] *Id.*
[38] (last updated July 8, 2014). Sea star species affected by wasting syndrome. *University of California, Santa Cruz: Ecology and Evolutionary Biology*. Retrieved from http://www.eeb.ucsc.edu/pacificrockyintertidal/data-products/sea-star-wasting/species_affected_2014_0708.pdf.
[39] (last updated Sept. 25, 2015). Pacific rocky intertidal monitoring: Trends and synthesis: Sea star wasting syndrome. *University of California, Santa Cruz: Ecology and Evolutionary Biology*. Retrieved from http://www.eeb.ucsc.edu/pacificrockyintertidal/data-products/sea-star-wasting/.
[40] (last updated Feb. 27, 2013). Black abalone (Haliotis cracherodii). *National Oceanic and Atmospheric Administration (NOAA) Fisheries: Office of Protected Resources*. Retrieved from http://www.nmfs.noaa.gov/pr/species/invertebrates/blackabalone.htm.
[41] (last updated Sept. 22, 2014). California sea otter standing network: 2013 Stranding summary. *U.S. Geological Survey (USGS): Western Ecological Research Center*. Retrieved from http://www.werc.usgs.gov/ProjectSubWebPage.aspx?SubWebPageID=7&ProjectID=232.

Photo A: S. Lonhart, NOAA/MBNMS/SIMoN
Photo B: C. King, NOAA/MBNMS/SIMoN
Photo C: S. Lonhart, NOAA/MBNMS/SIMoN

Figure 32. Twenty species of sea star have been observed to suffer from sea star wasting syndrome (SSWS) including (A.) the giant star (Pisaster giganteus), (B.) the bat star (Patiria miniata) and (C.) the rainbow star (Orthasterias koehleri). Wasting syndrome typically causes lesions to appear on the body surface, followed by the decay of tissue surrounding the lesions, which leads to eventual fragmentation of the body and death. Curling of the arms (A.) is one early sign of SSWS.

the region's close proximity to pinniped rookeries. In the central coast region, there is high mortality in breeding-age females likely due to food resource limitation because the population is likely at or near carrying capacity, the maximum population size that can be sustained by the resources available in the area. In the Monterey Bay region, disease and water quality issues impact sea otter health including high pollutant loads, protozoal infections (including *Toxoplasma gondii* and *Sarcocystis neurona*), bacterial infections, the microbial toxin microcystin and domoic acid intoxication from harmful algal blooms (Tinker et al. 2006, Miller et al. 2007, Miller et al. 2010, Tinker et al. 2013). Sea otters appear to be a very good indicator species for water quality issues (T. Tinker, USGS-WERC, pers. comm). For more details on water quality impacts to sea otters, see the response to Nearshore Question 2.

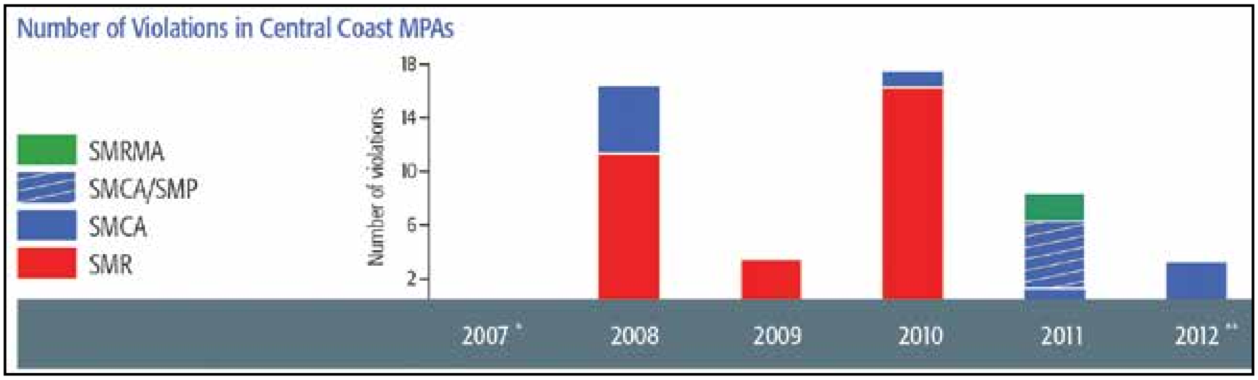
14. What are the levels of human activities that may influence living resource quality and how are they changing? The status of human activities that may influence living resource quality in the nearshore environment remains "fair" with a "declining" trend. Consistent with our findings in 2009, a number of human activities have localized, negative impacts on living resources in the nearshore environment, and most of these activities are continuing at current levels or are increasing in intensity. Human activities, such as agriculture and urban development, can increase levels of contaminants in the nearshore environment and negatively impact the health of nearshore species, including mussels, some fish and sea otters, as was discussed in Nearshore Questions 2, 3 and 7.

Recent data on human activity levels along the coastline show that more people visit both beaches and the rocky shore (see Figure 19). Increased access and activity along the shore can increase damage from non-extractive activities, such as trampling, turning over rocks, flushing birds and marine mammals (Tenera Environmental 2003). In 2012, surveys of breeding pairs of black oystercatchers in Monterey County found that breeding success is reduced directly by humans and pinnipeds trampling nests, and indirectly by humans flushing adults, which leaves eggs and hatchlings vulnerable to predation from gulls.[42]

The increased recreational use of beaches can have negative impacts on beach organisms as well. For example, kite flying, horseback riding and dogs off leash can disturb birds (as was noted for western snowy plovers in Nearshore Question 12), while picnicking can increase trash. Small pieces of trash in nearshore habitats may be ingested by foraging animals, or animals may become entangled in larger debris, such as lost fishing gear, ropes and packing straps (see response to Offshore Questions 8 and 14 for additional information). Litter clean-up activities on popular beaches and in rivers, as discussed in the response to Nearshore Question 8, helps to reduce the amount of debris that enters the nearshore environment.

Poaching (illegal harvest) continues to be a problem in MBNMS, both inside and outside of the marine protected areas (MPAs) implemented by California in state water in 2007 (north of Pigeon Point) and 2010 (South of Pigeon Point) (OST and CDFW 2013). While only a small number of people knowingly violate regulations, even a single poaching event can have a significant impact on a sensitive local population. For example, in 2009, wardens caught a poacher who took 60 black abalone from a central coast MPA (OST and CDFW 2013); this was a major impact to the endangered species at that site. Of the violations in central California MPAs (Figure 33), 94% occurred within 65 kilometers of Morro Bay, the base port for one of the large patrol vessels in the region, which suggests that an increased rate of patrol results

[42] Roberson, D. (2012, Oct.). Black oystercatcher (*Haematopus bachmani*): 2012 Reproductive success survey. *Monterey Bay: Monterey Birds.* Retrieved from http://creagrus.home.montereybay.com/MTYbirdsBLOY2012.html.



Source: OST and CDFW 2013

Figure 33. Number of violations of marine protected area (MPA) regulations in the central coast region recorded by California Department of Fish and Wildlife wardens from September 2007-March 2012. MPA types: State Marine Reserve (SMR-red); State Marine Conservation Area (SMCA-blue); SMCA/State Marine Park (SMP-blue hatch); and State Marine Recreational Management Area (SMRMA-green)

in a higher detection of violations (OST and CDFW 2014). More funding and personnel are needed to increase enforcement and public education efforts. Additional restrictive measures on fishing in nearshore habitats, including seasonal closures, bag limits and area closures, may result in decreases in the overall fishing effort, but could also lead to redistribution of fishing effort and increased pressure in areas open to fishing. More monitoring of distribution and intensity of extractive human activities is needed to better understand the impacts of recent area closures.

A recent analysis of fishing effort in the sanctuary through 2012 looked at trends in shore fishing, private/rental boat and commercial passenger fishing vessels (CPFV) activities (Leeworthy and Schwarzmann 2015). Shore fishing in the sanctuary shows no obvious trend from 2004-2012, but there is more variability in recent years (2010 was lowest and 2011 was highest in the time series). Private/rental boat activity declined, then increased from 2005 through 2012, with the minimum number of person-days having occurred in 2008 and the highest number in 2012. The number of CPFV fishing person-days declined from 2004 through 2008, but from 2008 through 2012, the number of person-days increased. It is likely that the decline in private boat and CPFV fishing effort to a low in 2008 was strongly influenced by the absence of a salmon fishery due to low abundance of salmon in ocean waters (P. Reilly, CDFW, pers. comm.). However, the total number of person-days in 2012 was roughly two-thirds of the level in 2004. Overall, fishing effort appears to have remained the same or slightly increased since the 2009 report.

Organisms living in sandy beach and subtidal habitats are impacted by several types of human activities. These include coastal armoring to reduce bluff erosion and protect buildings, coastal development, 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. Most of these activities are at levels similar to those reported in the 2009 Condition Report; however, given the extreme drought facing California (see Droughts in California text box), it is likely that desalination activity will increase in the next few years.

Photo: MBNMS

Nearshore Environment
Living Resources Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
9	Biodiversity	—	Status: Very High Trend: Very High	Fishing, collecting and poaching have altered biodiversity from what would be expected in a natural state. Most assemblages appear to be fairly stable except for sea stars and urchins.	Selected biodiversity loss may inhibit full community development and function and may cause measurable, but not severe degradation of ecosystem integrity.
11	Non-Indigenous Species	▼	Status: Very High Trend: Very High	A few non-indigenous species have been identified, and some appear to be spreading.	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).
12	Key Species Status	▼	Status: Very High Trend: Very High	Abundance of some key species in each habitat type is lower than would be expected in a natural state. Many key species stable or slowly increasing, but recent dramatic declines for many sea star species.	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.
13	Key Species Condition	▼	Status: Very High Trend: Very High	Continuing health problems in sea otters and black abalone. New severe health issue for sea stars.	The diminished condition of selected key resources may cause a measurable, but not severe reduction in ecological function, but recovery is possible.
14	Human Activities	▼	Status: Very High Trend: Very High	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.

The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report (ONMS 2009).

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

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

Nearshore Environment: Maritime Archaeological Resources

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

15. What is the integrity of known maritime archaeological resources and how is it changing? The integrity of the known maritime archaeological resources in nearshore habitats was rated "fair" with an "undetermined" trend in the 2009 Condition Report (ONMS 2009). This status assessment was based on limited information because only one nearshore archaeological site location inventory has been conducted in MBNMS's nearshore environment (In 1979-1981, the National Park Service inventoried the California Gold Rush passenger steamship *Tennessee* lost in 1853) (Schwemmer 2006a). However, anecdotal information indicated that recreational divers and beachcombers had removed artifacts from shipwrecks, and that sites were reported in various stages of degradation due to their exposure to waves, shifting sands and strong currents.

In 2015, there is no new information on the integrity of known maritime archaeological resources in the nearshore environment; therefore, this question continues to be rated "fair." There is no baseline monitoring information available to detect a change or impact to the resources; hence, the trend in their integrity remains "undetermined." It is assumed that less relic hunting occurs today due to education, and the fact that 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 the information exchanged among enthusiasts.

16. Do known maritime archaeological resources pose an environmental hazard and is this threat changing? In 2009, this question was rated "good" and the trend was "not changing" because the known maritime archaeological resources in the nearshore environment were believed to pose few or no environmental threats. Monterey Bay National Marine Sanctuary's inventory of known maritime archaeological resources in shallow water (50 feet or 15 meters, or less) suggested an unlikelihood that the remains of shipwrecks inside the sanctuary boundary hold hazardous cargos and/or bunker fuels; this was also true for most shipwrecks located near the entrance to San Francisco Bay (just beyond the sanctuary boundary).

New information gathered since 2009 indicates that at least one nearshore shipwreck located just outside the sanctuary boundary, the freighter *Fernstream* lost in 1952 (Figure 34;

Vessel 2 on Figure 35), has the potential to pose an environmental hazard to sanctuary resources. Specifically, the ship's deterioration could result in the release of hazardous cargo and/or bunker fuel that prevailing currents have a high likelihood of carrying from this source into MBNMS. Due to the fact that the *Fernstream* is the highest ranked potentially polluting wreck that occurs in U.S. Coast Guard District 11, and the structural integrity of the vessel is reduced, this question is now rated "fair" with a "declining" trend.

In 2013, NOAA completed a risk assessment of the *Fernstream* (NOAA 2013b), and followed with three surveys which allowed for a more detailed assessment of the wreck (NOAA 2014). The *Fernstream* is the highest ranked potentially polluting wreck in U.S. Coast Guard District 11, which includes the coastal and offshore waters off California to South America (NOAA 2013b). For the worst case discharge scenario, the *Fernstream* scored high; for the most probable discharge scenario, the *Fernstream* scored medium (NOAA 2013b). Surveys in 2013 suggest the structural integrity of the vessel is reduced (Figure 36) and the vessel most likely contains some diesel bunker fuel and oil lubricants, although it is likely trapped beneath sediments (NOAA 2014). Under the National Contingency Plan, the U.S. Coast Guard and the regional response team have the primary authority and responsibility to plan, prepare for and respond to oil spills in U.S. waters. NOAA recommended that this site be included within the Area Contingency Plan, and active monitoring programs should be implemented, based on the results of the three surveys of opportunity in 2013. Outreach efforts with the technical and recreational dive community, as well as commercial and recreational fishermen who frequent the area, would be helpful to gain awareness of changes at the site. The final determination of what type of action, if any, rests with the U.S. Coast Guard.

17. What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing? Several human activities that occur in the sanctuary may influence the quality of maritime archaeological resources in the nearshore environment, including the removal of artifacts from archaeological sites, diving, anchoring and fishing activities (e.g., historic trawling, other gear impacts). For the known archaeological sites in the nearshore environment, human activities did not appear to have a significant negative impact on the integrity of these resources so this question was rated "good/fair" in the 2009 Condition Report (ONMS 2009). Given that these potential impacts had not been measured, the trend in 2009 was "undetermined." There is no new information available on the levels of human activities that influence maritime archaeological resources; therefore, the 2015 ratings remain "good/fair" with an "undetermined" trend.

Photo: Robert Schwemmer, Maritime Library
Source: http://sanctuaries.noaa.gov/shipwrecks/fernstream/fernstream_sinking_robert-schwemmer-maritime-library.jpg

Figure 34. M/V *Fernstream*'s bow still visible above the water just before sinking in 1952 off Lime Point Lighthouse in San Francisco Bay after the collision with the SS *Hawaiian Rancher*.

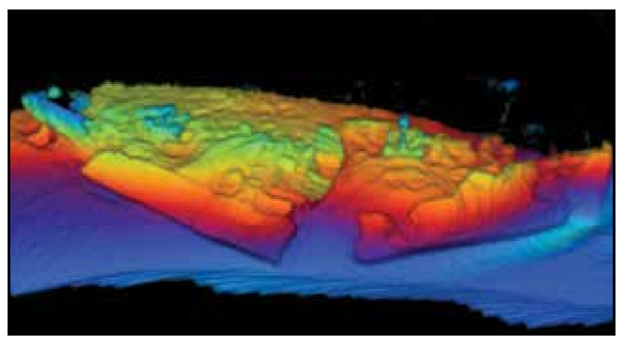
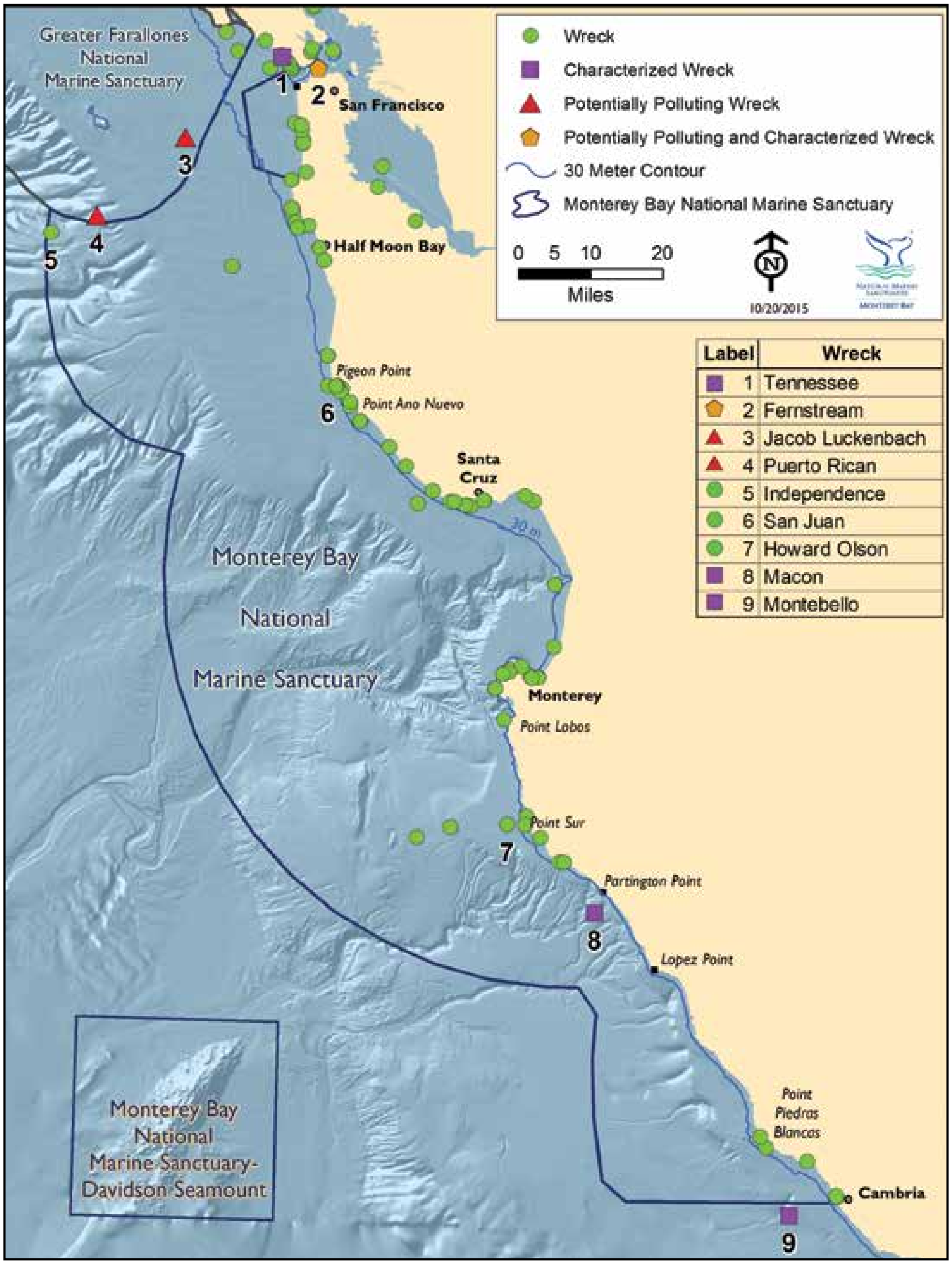


Photo: Coda Octopus
Source: http://sanctuaries.noaa.gov/shipwrecks/fernstream/fernstream-coda-octopus-03.jpg

Figure 36. Coda Octopus 3-D Echoscope sonar image of the shipwreck M/V *Fernstream*, looking south. The bow is located to the right in red, with the stern to the left in dark blue. A severe breach in the starboard hull forward of the bridge-house is visible.



Data Source: MBNMS inventory of known vessel losses; Map: S. De Beukelaer, NOAA/MBNMS

Figure 35. Approximate locations of known vessel losses in and adjacent to Monterey Bay National Marine Sanctuary from the sanctuary's inventory of submerged cultural resources. Three vessels have been characterized (purple square), two are considered to be "potentially polluting wrecks" (red triangle) and one vessel has been both characterized and determined to be a "potentially polluting wreck" (orange pentagon). For the rest of the vessels in the inventory, there is little to no verified location information (green circles).

Nearshore Environment
Maritime Archaeological Resources Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
15	Integrity	?	Status: N/A (not updated) Trend: N/A (not updated)	Divers have looted sites, but few sites have been studied to determine trend.	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, scientific or educational value and may affect the eligibility of some sites for listing in the National Register of Historic Places.
16	Threat to Environment	▼	Status: Medium Trend: Medium	Known resources containing hazardous material continue to deteriorate	Selected maritime archaeological resources may cause measurable, but not severe, impacts to certain sanctuary resources or areas, but recovery is possible.
17	Human Activities	?	Status: N/A (not updated) Trend: N/A (not updated)	Activities, such as 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.

The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report (ONMS 2009).

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

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

Photo: NOAA

State of Sanctuary Resources: Offshore Environment

The offshore environment, which extends from a depth of 30 meters to the seaward boundary, contains the majority of the seafloor and open water habitat in MBNMS (see Figure 1). The seafloor in this environment ranges in depth from 30 meters down to over 3,000 meters at its deepest point in the sanctuary, and includes the outer continental shelf, slope, rise and submarine canyons. The open water — three-dimensional habitats not associated with the seafloor — has a total volume of 12.026 trillion cubic meters or approximately 4.8 billion Olympic-sized swimming pools. Open water can be subdivided into three zones by depth. First, the epipelagic zone, which includes the upper 200 meters of the water column, comprises 18% of the open water habitat. Second, the mesopelagic zone, from 200 to 1,000 meters, makes up nearly half of the open water. Third, the remaining 35% of the open water's volume is deeper than 1,000 meters and is called the bathypelagic zone.

Generally, less information is available for the offshore environment than the nearshore environment. This is due in part to the fact the offshore environment covers a much larger area of seafloor and possesses a greater volume of water than the nearshore environment. Moreover, we must overcome more logistical and economic hurdles to study the offshore environment. Offshore research often requires large vessels to deploy nets, remotely operated vehicles or submersibles to sample and explore the vast volume of water and deep seafloor habitats. Nevertheless, it is widely recognized that the offshore ecosystem's productivity supports a great diversity and abundance of invertebrates, fishes, seabirds and marine mammals. Although often limited in spatial coverage or frequency of sampling, we have used the most recent data and best available local information to summarize the status of the sanctuary's offshore environment.

Most of the regularly monitored key species and species assemblages in the offshore environment appear to be stable. The number of native species in offshore habitats, one measure of biodiversity, appears to be stable with no known losses of native species, and no species introductions are known to have occurred. Bottom trawl fishing – the most extensive impact to offshore benthic habitat – has decreased in intensity and spatial extent. Furthermore, bottom trawlers have switched to less damaging gear and moved to less sensitive habitats therefore, we expect the recovery of formerly impacted habitats and structure-forming species.

Pollutants (e.g., PCBs), marine debris and toxins from Harmful Algal Blooms (HABs) are detected in some key offshore species. There are concerns about impacts to sensitive species from human-caused noise, vessel traffic, and entanglements in buoy lines and lost and active fishing gear. The recent prevalence of unusually warm water along the U.S. West Coast has altered the distribution and abundance of some temperature-sensitive species and led to stranding events for a couple of key species; however, we need more time to determine if this phenomenon will have any persistent impacts on the structure and function of the offshore ecosystem or key species. Impacts from climate change, including acidification, warming and shoaling of the oxygen minimum zone, are starting to be detected, but we require additional research and monitoring to better understand and predict current and future impacts.

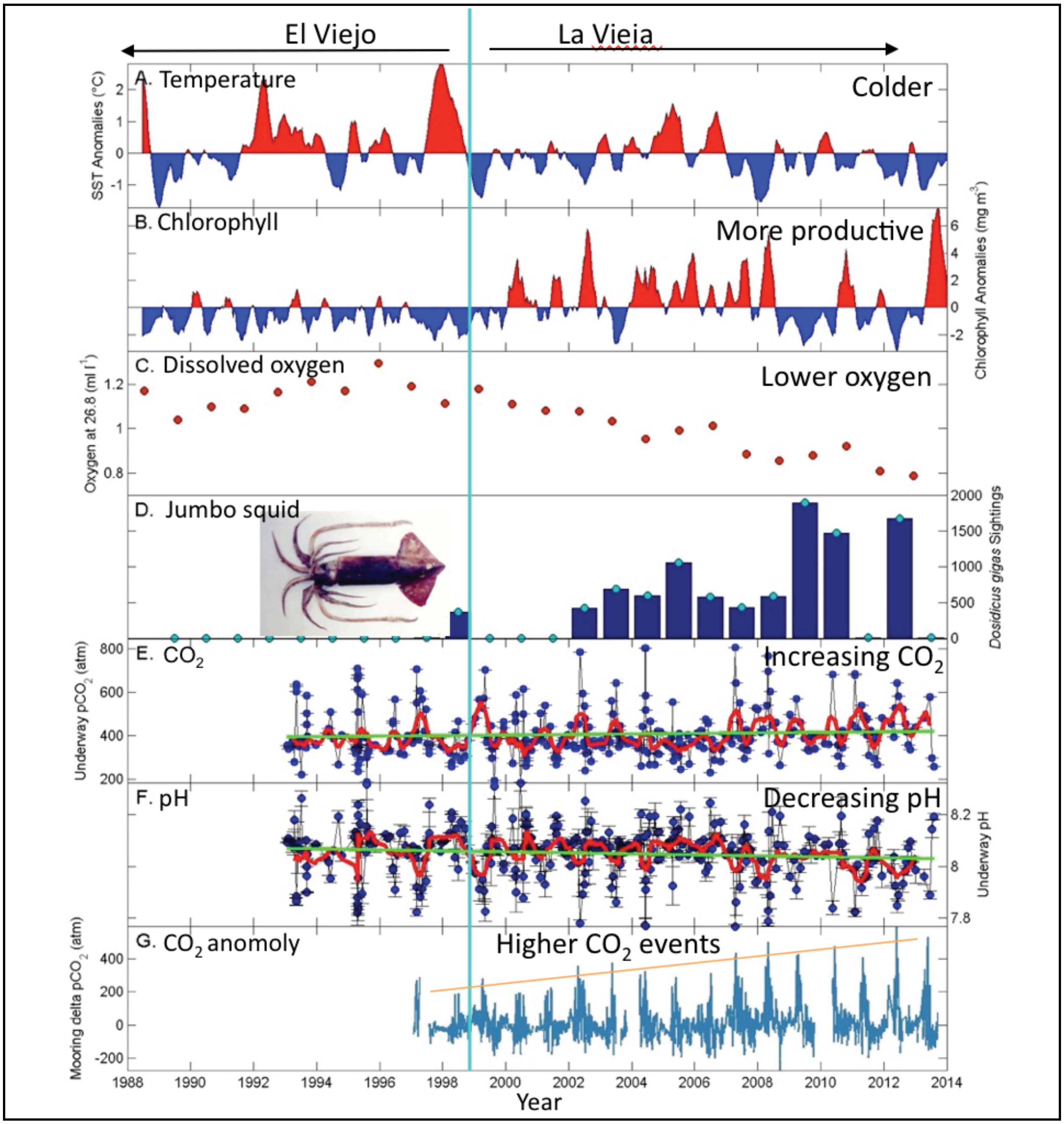
Offshore Environment: Water Quality

The focus of the offshore water quality section of this report is the change in the quality of open water habitats. The quality of these open water habitats is influenced by natural and anthropogenic factors. The recent patterns in natural cycles (e.g., El Niño Southern Oscillation) are reviewed in our response to question 1 below. The timing of the 2015 Condition Report Update, and how it aligns with these natural cycles, may have some influence on the apparent health of sanctuary resources, especially water quality and living resources. When long-term monitoring information is available, we have tried to account for whether the current conditions of sanctuary resources are within the range expected due to the natural fluctuations in climate and ocean conditions.

The following information provides an assessment of the current status and trends of offshore water quality and its effects on habitat and living resources in that environment.

1. ***Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?*** Stressors on the offshore environment's water quality, specifically changing ocean conditions, pollutants and toxin-producing harmful algal blooms (HABs), may inhibit the development of assemblages and may cause measurable declines in some living resources and habitats. For this reason, the rating in the 2009 condition report was "fair" with a "declining" trend. The 2015 status for stressors in offshore waters remains "fair" and "declining" based on changing ocean chemistry, increasing levels of pollutants (detailed in Offshore Questions 3 and 7) and continued occurrence of toxin-producing HABs (details in Offshore Question 2), all of which have measurable impacts to offshore water quality and appear to influence the health and composition of pelagic faunal communities.

   Over the last few decades, extensive research has improved our understanding of the natural cycles in oceanographic and atmospheric conditions that occur in the eastern Pacific Ocean, such as the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). Time



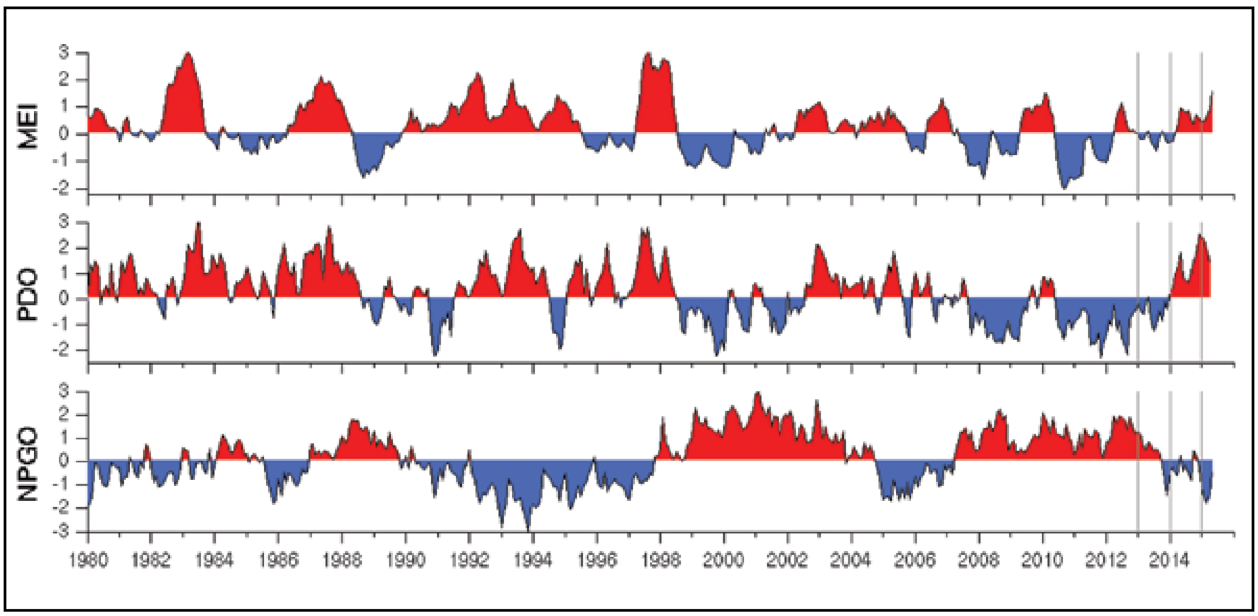
Credit: F. Chavez, MBARI

Figure 37. Monitoring data collected by the Monterey Bay Aquarium Research Institute (MBARI) were used to create a time series of ocean conditions observed in Monterey Bay since 1988 which includes a warm phase (i.e., "El Viejo") and cool phase (i.e., "La Vieja") of the Pacific Decadal Oscillation. Anomalies in surface temperature (A.) and productivity (B.) with higher (or lower) than average values in red (or blue) indicate the recent phase is generally cooler and more productive. (C.) Dissolved oxygen levels have declined and (D.) sightings of jumbo squid have increased. Long-term trends of increasing CO_2 (E.) and decreasing pH (F.) are consistent with changes expected due to global climate change. The magnitude of high CO_2 events is also increasing (G.). Panels A, B andC show averages from three MBARI stations: C1, M1 and M2. Panel D shows data collected during MBARI ROV dives in Monterey Bay. Panels E and F show data collected along an onshore-offshore transect line between stations C1 and M2. Panel G shows data collected at mooring M1.

series data describe recent conditions relative to these natural cycles; however, fluctuations in offshore conditions relative to natural cycles are not the basis for the fair and declining trend. Instead, the ratings are based on stressors linked to human activities which are not part of the system's natural cycling, such as inputs of pollutants and global climate change. We discuss these stressors after a brief summary of natural variation in climate and ocean conditions.

Oceanographic monitoring data collected by the Monterey Bay Aquarium Research Institute (MBARI) shows that the period from 2009-2013 was mostly productive during a cool phase of the Pacific Decadal Oscillation (PDO), which is associated with strong upwelling, cooler sea surface temperatures and some very high chlorophyll anomalies (Figure 37) (F. Chavez, MBARI monitoring data). These cooler productive conditions are linked to a high abundance of many forage groups, including krill and young-of-the-year fishes (see Offshore Questions 9 and 12 for additional detail), and can help support higher reproductive success of locally breeding seabirds and pinnipeds, higher seasonal abundance of foraging baleen whales and migratory seabirds and higher productivity of juvenile and adult salmon (Santora et al. 2012, Wells et al. 2012).

Starting in 2014, sea surface temperatures were anomalously high all along the U.S. West Coast. At the M1 buoy in Monterey Bay, unusually high sea surface temperatures (2-4ºC higher than usual) began in August 2014 and persisted into 2015. The Multivariate ENSO Index (MEI), PDO index and North Pacific Gyre Oscillation (NPGO) (Figure 38), all of which can be used to track climate and ocean conditions in the North Pacific Basin, shifted from conditions that generally promote high primary productivity in 2008-2013 to less productive conditions in 2014 (Harvey et al. 2014, Hazen et al. 2014). Decreased upwelling, warm temperatures and decreased productivity in 2014 and early 2015 have likely affected the abundance and distribution of some types of forage fish and invertebrates and resulted in mass strandings of emaciated Cassin's auklets and California sea lions (see Offshore Question 13 for more information). The unusually warm water also coincided with increased sightings of warmer water species (e.g., tropical sea butterflies [pteropods], blue buoy barnacles, a green sea turtle and common dolphins) not usually observed in MBNMS, except during El Niño events.[43] If the warming persists far into 2015, some of the species that do well in a colder, more productive ocean could experience reduced growth, poor



Data Credit: NPGO data from http://www.o3d.org/npgo/; PDO data from http://jisao.washington.edu/pdo/; MEI data from http://www.esrl.noaa.gov/psd/enso/mei/
Graph: I. Schroeder, NMFS-SWFSC

Figure 38. Three indices of climate and ocean conditions in the North Pacific Basin shifted in 2014 from conditions promoting high primary productivity to less productive conditions. The Multivariate ENSO Index (MEI) indicates the intensity of an ENSO event with positive anomaly values (red) denoting El Niño conditions and negative values denoting La Niña conditions. The Pacific Decadal Oscillation (PDO) index is related to North Pacific sea surface temperature with cold regimes (blue) associated with higher productivity and warmer regimes (red) associated with lower productivity. The North Pacific Gyre Oscillation (NPGO) is influenced by sea level and circulation patterns. Positive values of the NPGO (red) are linked to stronger currents and higher productivity while negative values (blue) are linked to weaker currents and lower productivity. The graphs show the long-term mean (0) ± 3.0 standard deviations based on the full time series.

Credit: NOAA (downloaded from http://www.noaanews.noaa.gov/stories2014/20140430_oceanacidification.html)

Figure 29. (Left) A healthy pteropod (planktonic marine snail) collected during the U.S. West Coast survey cruise. (Right) Many of the pteropods, such as this one, collected during the study had signs of dissolving shells.

reproductive success and population declines. At the same time, species that do well in warmer conditions may experience increased growth, survival and abundance. We will need a few more years of observation to determine if this is a short-term anomaly (possibly due to El Niño) or the beginning of a longer-term shift to a warm phase of the PDO.

Despite the fact that most of the period from 2009-2014 has been productive for the sanctuary, continuing shifts in ocean chemistry due to global climate change are leading to increasingly stressful conditions for many species in the offshore environment (reviewed in Doney et al. 2012). Oceanographic monitoring data collected by MBARI in Monterey Bay's offshore waters (Figure 37) show that ocean CO_2 is increasing while pH and dissolved oxygen are decreasing (F. Chavez, MBARI monitoring data). Ocean acidification describes a decrease in ocean pH levels caused by an increase in dissolved CO_2. The natural process of upwelling that occurs along the central California coast already results in a high amount of dissolved CO_2 in this area because upwelling brings CO_2-rich waters from the deep ocean to the shelf environment. Human-caused CO_2 adds to the overall level of dissolved CO_2 in these waters and could exacerbate ocean acidification in the offshore environment (Doney et al. 2012).

Ocean acidification is a stressor on marine organisms, particularly those with body parts made of calcium carbonate. Phytoplankton and zooplankton are the base of the pelagic food web, and many types of phytoplankton and zooplankton have calcium carbonate shells that are vulnerable to dissolution from increasing acidity. For example, a recent study of pteropods' shell thickness (planktonic snails) (Figure 39) along the U.S. West Coast found the incidence of severe shell dissolution has more than doubled relative to pre-industrial conditions (Bednarsek et al. 2014). The authors project that severe shell dissolution could increase to as much as 70% by 2050 in the central onshore region of the California Current Ecosystem, which includes MBNMS's entire coast out to the 200 meter isobath. Pteropods are important prey for a number of pelagic species including salmon, mackerel and herring, and reductions in this food source could affect other components of the pelagic food web.

Another potential stressor to inhabitants of deep shelf and slope habitats is a shoaling of the oxygen minimum zone (Gilly et al. 2013). The oxygen minimum zone (OMZ) is a midwater depth range where the oxygen concentration is less than 20 micromole per kilogram in the Pacific. In the sanctuary, the OMZ typically occurs at depths from 600 to 1000 meters. Oxygen concentration in the water column rapidly decrease approaching the OMZ's upper boundary, continues to decline until a minimum is reached in the middle of the OMZ and then gradually increases with depth to the OMZ's lower boundary and beyond. The OMZ influences both the vertical distribution of pelagic fauna, and where the OMZ intersects the seafloor, the depth distribution

[43] Rogers, P. (2014, Nov. 2). Unusual warm ocean conditions off California, west coast bringing odd species. *San Jose Mercury News.* Retrieved from http://www.mercurynews.com/science/ci_26851300/unusual-warm-ocean-conditions-off-california-west-coast?source=infinite.

of benthic fauna (Gilly et al. 2013). Shoaling of the upper OMZ boundary has been observed over the past several decades in the eastern Pacific (Bograd et al. 2008). Shoaling of the OMZ is causing vertical habitat compression for those species that occur in waters above the upper OMZ boundary and cannot tolerate reduced oxygen levels. These species may respond to shoaling of the OMZ with a shift in vertical distribution to shallower depths, while those species that reside within the OMZ will experience a vertical expansion of their habitat (Gilly et al. 2013). For example, the shoaling of the OMZ has been associated with a reduction in abundance of mesopelagic fish larvae possibly due to mesopelagic fishes having to move to shallower depths which makes them more vulnerable to visually oriented predators (Koslow et al. 2011). OMZ shoaling may also restrict usable habitat for high trophic level, migratory fishes (e.g., swordfish, sharks and tunas) and make them more vulnerable to surface fishing gear, as has been observed in the tropical northeast Atlantic Ocean (Stramma et al. 2012). The northern expansion of the jumbo squid's range along the west coast of North America also appears to be facilitated by shoaling of the OMZ (Stewart et al. 2014).

2. ***What is the eutrophic condition of sanctuary waters and how is it changing?*** Experts agree that the eutrophic condition in the offshore environment rating remains "good/fair" because monitoring data suggests that selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines. The 2009 "declining" trend continues to be supported by additional evidence of nutrient enrichment and increasing frequency and intensity of harmful algal blooms in selected areas.

Two types of marine HABs pose the most significant threats to California's coastal ecosystem. First, dinoflagellates of the genus *Alexandrium* cause paralytic shellfish poisoning (PSP). Second, diatoms of the genus *Pseudo-nitzschia* produce domoic acid (DA), which causes amnesic shellfish poisoning (ASP) in humans. Other less common HABs, which may occur more frequently in the future, include: *Cochlodinium, Akashiwo sanguinea* and *Dinophysis* (Lewitus et al. 2012).

In most areas along the West Coast, there is little evidence to support anthropogenic factors as the primary cause of *Alexandrium* blooms. In California, blooms are strongest in the drier seasons, and typically appear offshore, and move onshore when upwelling relaxes (Langois and Smith 2001, Anderson et al. 2008). Research on phytoplankton productivity in ammonium-rich discharges from San Francisco Bay indicate there is a possibility that elevated ammonium levels prevent nitrate uptake by diatoms, which then allows dinoflagellates to bloom (Glibert et al. 2011); however, Kudela et al. (2010) showed that ammonium is a nutrient source for *Pseudo-nitzschia*. Specifically, Kudela et al. looked at nutrient use by harmful algae in upwelling systems and determined that chain forming HABs (including *Alexandrium*) are well adapted to use upwelling derived nitrate.

After many domoic acid (DA) events caused harm to humans, monitoring efforts and regulations were increased and have successfully prevented the harvest of toxin-contaminated shellfish. However, there continue to be many cases of documented DA toxicity in finfish, marine mammals and birds (Bargu et al. 2012). During fall 2010 in Monterey Bay, DA levels were exceptionally high in California mussels. Lewitus et al. (2012) concluded that the two primary types of HABs, those causing paralytic shellfish poisoning (PSP) and amnesic shellfish poisoning (ASP), originate in offshore waters and are carried inshore. Then, as HABs move closer to the shoreline, under certain conditions described below, it is then possible that nutrients flowing from the land can affect these blooms, either by increased magnitude and/or prolonged duration.

The Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) program was established to better understand the dynamics of HABs. One of its core research projects is to better understand highly stratified systems, such as in northeastern Monterey Bay. The northeastern bight of Monterey Bay was identified as a study site and there is significant documentation of recurring blooms of toxic *Pseudo-nitzschia*. DA is of particular concern in Monterey Bay during upwelling because of the high productivity; food chains are short, which allows DA to be rapidly transferred to higher trophic levels (Kvitek et al. 2008). In 2010, a study was conducted to better understand the interrelationships between nutrients and HAB dynamics. Timmerman et al. (2014) used profilers and towed instruments to describe the physical and biogeochemical conditions of the site and characterize the bloom. Discrete water samples were collected above, within and below a sub-surface layer of *Pseudo-nitzschia*. It was determined that a high total nitrogen to total phosphorus ratio drives the formation of toxic blooms. They concluded that, if additional studies indicate that phosphate stress (or nitrogen enrichment) is found to be critical in bloom toxicity, there could be more toxic blooms from anthropogenic nutrient inputs (Timmerman et al. 2014).

Please see the 2009 MBNMS Condition Report for additional information.

3. ***Do sanctuary waters pose risks to human health?*** The rating of "good/fair" with an "undetermined" trend and the accompanying explanation have not changed since the 2009 report. Selected conditions in offshore waters, including low levels

of a number of toxic pollutants and toxins produced by HABs, have the potential to affect human health. While there is some evidence of increasing loads of biotoxins and contaminants, a clear trend in the risk to human health could not be determined. Please refer to Offshore Question 2 for updated information on harmful algal blooms and Offshore Question 7 for more information on contaminant concentrations in offshore habitats.

4. What are the levels of human activities that may influence water quality and how are they changing? We have no new information to change the status rating or trend for this question. The level of human activities that directly influence offshore water quality are considered to be "fair," in that they result in measurable local impacts to the ocean, and "improving" due to increased regulation and remediation efforts since the sanctuary's establishment. In some instances, it can be difficult or impossible to directly measure the impacts of human activity on offshore water quality conditions, but select activities have notable impacts. For instance, the primary contributor from land-based activities is inputs of contaminants and nutrients linked to urban development and agriculture. Vessel traffic is the main activity that occurs in the sanctuary's offshore waters, which can result in acoustic impacts and discharge of ballast water, bilge oil and trash (see 2009 MBNMS Condition Report for more details).

Offshore Environment Water Quality Status and Trends

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

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

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

Offshore Environment: Habitat

The sanctuary's offshore environment of the sanctuary can be divided into open water habitats (i.e., the water column) and benthic habitats (i.e., the seafloor). Because the physical and chemical oceanography of open water habitats was covered in the water quality section (questions 1-4), the offshore habitat status and trends are focused primarily on benthic habitats, except for question 7, in which we discuss contaminants in both seafloor and open water habitats.

The following information provides an assessment of the current status and trends of offshore benthic habitats.

5. What is the abundance and distribution of major habitat types and how is it changing? In the 2009 report, the abundance and distribution of major benthic habitat types in the offshore environment of the sanctuary was rated "fair" based on past and on-going levels of human activities, in particular fishing with mobile bottom-contact gear, that influenced the distribution, abundance and quality of benthic habitats and associated living resources (ONMS 2009). There is limited new information available to directly assess offshore habitat condition in the sanctuary. Hence, the status remains "fair" based on the known physical impacts that bottom trawling can have on habitats (Engel and Kvitek 1998, Auster and Langton 1999, NRC 2002, Lindholm et al. 2004, de Marignac et al. 2009) and that fishing with bottom trawl gear continues inside the sanctuary.

In 2009, the trend was "undetermined" for two reasons: (1.) a lack of information on both the rate and degree of recovery of habitat and associated living resources inside areas recently closed to bottom-contact fishing gear; and (2.) the associated changes in the distribution and intensity of fishing activities in the remaining open areas. New information suggests that trawling activity has decreased in intensity and spatial extent, moved to areas likely to have less sensitive habitats and now uses less destructive gear types (e.g., small footrope gear [see Offshore Question 8 for specific details on this human activity]). In addition, given some new information that unconsolidated habitats may be able to recover relatively quickly from physical modifications, we can infer that recovery from trawling impacts is likely occurring in the portion of the sanctuary no longer subject to this activity. Though the magnitude and speed at which condition may be improving is unknown, the likelihood that habitat condition has improved and will continue to improve in areas where trawling effort has been reduced or prohibited is the basis for an "improving" trend in 2015.

Credit: Chad King, NOAA/MBARI

Figure 40. Image of the lost shipping container located on a sediment-covered seabed at a depth of 1,281 meters in MBNMS. A recent study found that the container has conferred a mild, local disturbance to the sediments and infauna in a 10 meter halo around the container (Taylor et al. 2014). The surface of the container has been colonized by many organisms including many types of structure-forming invertebrates, such as crinoids, sponges and anemones.

The majority of MBNMS has not received the detailed characterization and monitoring necessary to quantify the impact of human activities on habitat condition. Since 2009, the amount of the offshore benthic environment that has received finescale characterization increased by a small amount based on research and characterization by USGS, California State University, Monterey Bay (CSUMB), Monterey Bay Aquarium Research Institute (MBARI) and MBNMS (see IfAME and MBNMS 2011, USGS/CSUMB Seafloor Mapping Program). This new information is consistent with the 2009 summary that most of the benthic seafloor is composed of soft sediments (various mixtures of sand, mud and silt), with hard substrates, such as deep reef, rock and gravel, occurring in patches of various sizes (ONMS 2009).

Recently, Lindholm et al. (2015) examined impacts of high and low intensity bottom trawling with small-footrope gear on soft-bottom habitats at a depth of 160-170 meters off Morro Bay, an area just south of MBNMS. They found that trawling had measurable local impacts on soft sediments, such as leaving scour marks (measuring up to 20 centimeters wide and 10 centimeters deep), that can persist for at least a year. However, they found minimal reductions in bioturbated sediments in trawled plots, and they did not detect significant change in micro-topographic structure or the composition of the infaunal invertebrates assemblage between trawled and control plots. Most of the invertebrate groups had relatively low densities in the study area, but showed very high spatio-temporal variability. Overall, this study indicated that bottom trawling with small-footrope gear may have limited impacts in some soft-bottom habitats.

Another concern for habitat quality is the accumulation of marine debris in deep-sea habitats. Marine debris on the seafloor can impact both physical habitat and community composition, but impacts appear to be localized. In 2011, researchers measured the impacts of a shipping container that was lost at sea in early 2004 and came to rest on a sediment-covered seabed at a depth of 1,281 meters in MBNMS (Taylor et al. 2014). They found higher sediment grain-size near the container, which is very likely related to the hydrodynamic effects of the container on local flow patterns leading to net removal of fine sediments. These changes in sediments may be the cause of a drop in diversity and richness of the benthic infaunal community near the container site. Additionally, the surface of the container provides hard substrate for colonization by taxa usually found in association with rocky habitat, not sediment-covered seabed (Figure 40).

Conversely, some key taxa that dominate rocky habitat at this depth were absent or rare on the container, perhaps related to potential toxicity of the paint or limited time for colonization and growth. Overall, results indicate that the container has conferred a mild disturbance in a 10 meter halo around the 30 square meter container (an area of 600 square meters), which has led to increased abundance for some species and lower abundance for others. Future study of the container and other debris on the seafloor is needed to determine the cumulative impact of debris on habitat quality and whether debris is a significant source of contaminants to sediments or local fauna.

6. What is the condition of biologically-structured habitats and how is it changing? In 2009, the condition of offshore, biologically-structured habitats, including soft-corals, gorgonians, sponges and brachiopods was rated as "fair/poor" based on the known negative impacts of bottom-contact fishing gear on biologically-structured habitats and the extensive use of these gears in the offshore environment in the past where these sensitive resources were likely to occur. As of 2009, there was very limited study of structure-forming species and the impact of trawling and other human activities had not been assessed broadly. The 2015 status rating remains "fair/poor" because new information provides mostly initial characterization of previously unexplored locations and there has been little repeated observation of sites to assess temporal changes in the status of biologically-structured habitats.

In 2009, the trend was "undetermined" because it was unclear if resources had begun to recover in the portions of the sanctuary that had been recently closed to trawling. The trend in 2015 remains "undetermined" because there has been little additional information on the status of structure-forming species that may be improving in the areas closed to trawl gear. Certainly, the condition of structure-forming species may be improving in the sanctuary because bottom trawling effort has declined, moved to areas with less sensitive habitat and switched to less destructive gear. Nonetheless, there are emerging concerns in regards to ocean acidification and the declining condition of corals and other species with calcified body parts. We need more information on both the recovery from trawling and impacts of ocean acidification to better assess these questions.

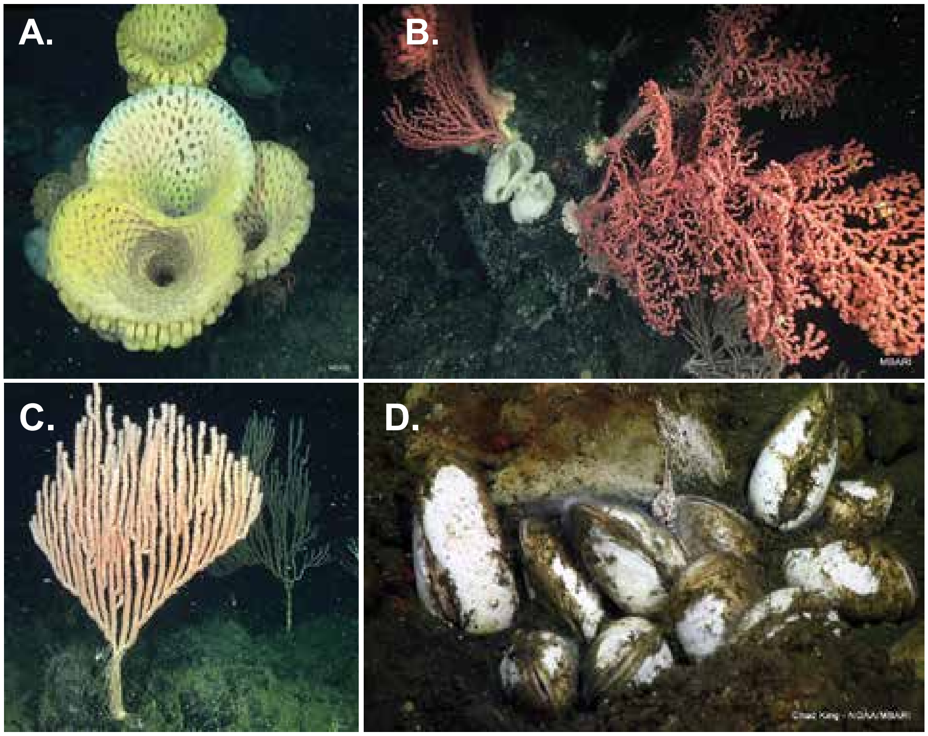


Photo: A-C: MBARI; D: C. King NOAA/MBARI

Figure 41. Two recent expeditions, which used video cameras on remotely operated vehicles to explore the surface of Sur Ridge, found an abundance of structuring-forming invertebrates at this previously unexplored site, including (A.) goiter sponges, (B.) bubblegum corals, (C.) bamboo corals and (D.) and vesicomyid clams half-buried within a cold seep.

[44] King, C. (2014, June). Sur ridge and lost shipping container cruise log (June 5-9, 2014). *Sanctuary Integrated Monitoring Network (SIMoN)*. Retrieved from http://sanctuarysimon.org/news/2014/06/sur-ridge-and-lost-shipping-container-cruise-log-june-5-9-2014/.

Information on the distribution and condition of these organisms is limited, especially in more remote areas and in comparison to historic abundance and distribution patterns. The existing data was augmented by recent towed camera sled and ROV video surveys in limited areas of the outer shelf, upper slope, submarine canyons and at Sur Ridge. For example, the sanctuary, in collaboration with MBARI, was able to explore Sur Ridge for the first time in 2013, and again in 2014.[44] The first views of this large submerged rocky ridge revealed areas covered in extensive beds of deep-sea corals and sponges (Figure 41) and the unexpected discovery, on the south side, of some chemosynthetic biological communities.

Structure-forming species generally grow slow and are patchily distributed organisms sensitive to human activities that contact the seafloor. Lindholm et al. (2008) studied patterns in the distribution of the sea whip in an area off the central California coast impacted by mobile fishing gear. Lindholm et al. found that the marked difference in the occurrence of upright sea whips among video transects may be attributable to water depth and/or impacts from otter trawling. In a recent study of trawling impacts and recovery of soft bottom habitat at a depth of approximately 170 meters off central California (Morro Bay area), Lindholm et al. (2015) found little to no detectable impact of trawling on the physical topography and biological community, except for persistent scour marks from trawling gear. In addition, the invertebrate assemblage in the study area was found to be highly variable in both space and time, suggesting that aspects of this habitat can be dynamic, making it difficult to understand and predict the impacts of trawling on the benthic community. These, and additional recent publications on the impacts of bottom trawling on soft bottom habitat, have noted that little has been written about recovery of seafloor habitat from the effects of fishing, and that there is a lack of long-term studies to fully evaluate impacts.

Given that fisheries management actions now prohibit trawling in some previously trawled areas (e.g., Trawl Rockfish Conservation Areas, Essential Fish Habitat closures, California state waters), it is likely that structure-forming invertebrates have been recovering and recolonizing these areas. In addition, structure-forming species are likely receiving less impacts now that fishing effort with bottom trawl gear has declined overall in the sanctuary and the gear being used (i.e., small-footrope trawl gear) is less damaging to benthic resources. Bottom trawling also appears to have shifted to less sensitive habitat types and locations (see Offshore Question 8 for additional detail). Though it is likely that some recovery has and will continue to occur, these biologically-structured habitats may recover slowly or may never re-establish to their original abundance or composition, even in the absence of future pressures.

The addition of hard structure to the seafloor, such as unburied submerged cables or marine debris composed of plastic, metal and glass, is a disturbance to the physical habitat and local abundance and distribution of benthic invertebrates. Recent studies of a lost shipping container (see Figure 40) and the unburied section of a submerged cable found an increase over time of the number of structure-forming species that require physical structure for attachment, such as crinoids and anemones, on and immediately adjacent to the structures (Kuhnz et al. 2011, Taylor et al. 2014).

One topic of increasing concern is the potential impacts of changing ocean conditions on biogenic species, many of which have calcified structures. We are not aware of specific studies of impacts of acidification on biogenic species in the sanctuary, but a recent meta-analysis shows that acidification has a strong negative effect on calcification rates and abundance of corals (Kroeker et al. 2013). Directed study of the effects of climate driven changes in pH, temperature and dissolved oxygen on structure-forming species will become increasingly important for understanding and tracking the status and condition of the sanctuary's structure-forming species in the future.

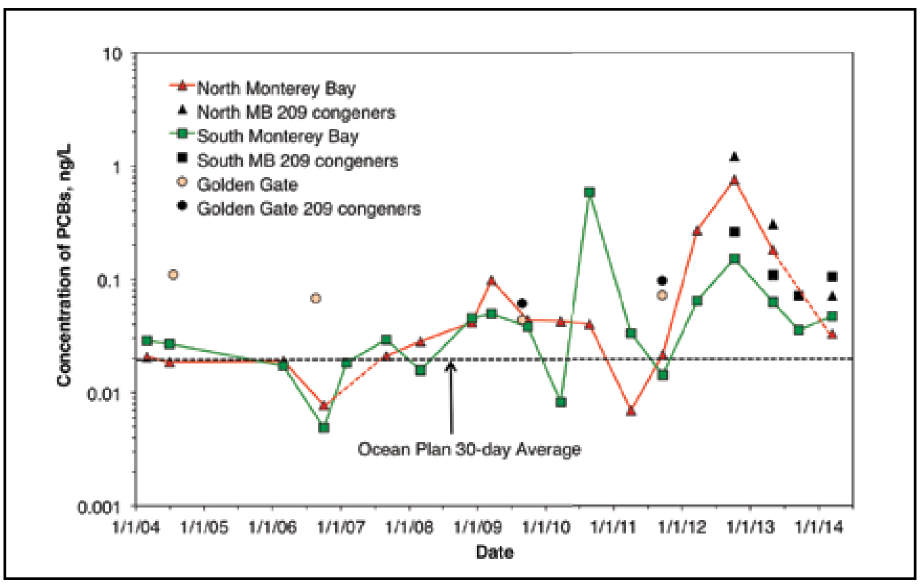
7. ***What are the contaminant concentrations in sanctuary habitats and how are they changing?*** Based on elevated levels of pesticides in shelf and canyon sediments at sites off the shore of urban and agricultural pollution sources, the condition of offshore habitats was rated as "good/fair" in the 2009 report. The basis for this judgment was that trends in contaminant concentrations in offshore habitats had not been well studied. There was, however, limited research to suggest little to no attenuation in the concentration of some persistent contaminants in sediments on the continental shelf and continued inputs and delivery of some contaminants to deep-sea habitats, such as submarine canyons (see 2009 MBNMS Condition Report for specifics). This limited information suggested an overall "declining" trend for this question.

There is no new information on contaminants in sediments, but given the rationale from the 2009 rating, there is no reason to believe that there has been a substantial decrease in the contaminant levels in sediments. New information does suggest that PCBs may be an even bigger problem than previously realized given new data that indicates an exponential increase in the amount of PCBs measured in the water column at two CCLEAN monitoring sites. For this reason, the new rating has been changed to "fair" with the same "declining" trend as in 2009.

In 2012-2013, the analysis of PCBs in water and wastewater treatment plant effluent was expanded from 70 congeners historically measured by CCLEAN to all 209 PCB congeners in order to better determine the source of the elevated PCBs. Measurement of all 209 congeners resulted in 60-70% higher total PCB concentrations compared to the 70 previously measured. This new information indicates that the historical total PCB concentrations could have been substantially higher. The Monterey Bay results were then compared to a site monitored just outside of San Francisco Bay by the Regional Monitoring Program (RMP),[45] and the results were similar; however, the highest Monterey Bay results exceeded those at the Golden Gate (CCLEAN 2014, Figure 42). Even though total concentrations of PCBs were similar at the two sites, results for all 209 congeners were very different. There were much higher percentages of low-chlorine homologs in the Monterey Bay samples compared to the Golden Gate samples. Monterey Bay congeners were also more consistent than what was measured at the Golden Gate site, which were highly variable. This suggests different sources of PCBs at the two sites (CCLEAN 2014).

Several studies were reviewed to determine if there was a connection between PCBs found in sanctuary waters with PCB contamination in killer whales (*Orcinus orca*) and the marine mammals on which they feed. Ross et al. (2000a) divided the eastern North Pacific killer whales into three populations: (1.) northern resident, (2.) southern resident and (3.) transient. Whales seen on the central coast that primarily consume other marine mammals are generally from the transient population. The total PCB concentrations were surprisingly high in all three populations, but especially high in the transients. Even with the contrasting diets of the resident and transient killer whales, the mean congener-specific PCB profiles were similar among the three populations. The profiles were dominated by higher chlorinated congeners, with most of the lower congeners being absent or present at very low levels. The role of age, sex and dietary preference is strongly related to contaminant accumulation, and it is unclear how and if the lower PCBs congeners are metabolized or are absent. Adult females showed lower PCB concentrations during reproductive years beginning at 15 years old and showed increases again at 50 years old. Females transfer approximately 60% of organochlorines to their offspring through reproduction and lactation (Ross et al. 2000a).

After better understanding the PCB signature in transient killer whales, an attempt was made to research the PCB signature in their food and its effects. Persistent organic pollutants (POPs) are found in lipid rich blubber layers of marine mammals around the world (O'Shea 1999). PCB levels have been associated with a high prevalence of cancer in California sea lions (*Zalophus californianus*), including immunotoxic and reproductive impacts (Ross et al. 2000b, Ylitalo et al. 2005). In a study by Hall et al. (2008), they measured changes in blubber contaminant concentrations in California sea lions associated with weight loss and weight gain during rehabilitation. They found that total DDTs dominated the contaminant profiles, followed by total PCBs and total PBDEs. During mass loss, the lower chlorinated PCB congeners, chlordanes and hexachlorocyclohexanes were lost at a higher rate than the other contaminant classes, such as PBDEs. The preferential mobilization of the lesser chlorinated PCBs has also been reported in gray seals (*Halichoerus grypus*) during lactation fasting (Debier et al. 2003)



Source: CCLEAN 2014

Figure 42. Concentrations of PCBs historically measured in nearshore waters at two CCLEAN sites in Monterey Bay, compared with results from measurement of 209 congeners in program year 2012–2013 and two samples collected off the Golden Gate Bridge.

[45] (n.d.) *San Francisco Estuary Institute (SFEI) and the Aquatic Science Center*. Retrieved from http://www.sfei.org.

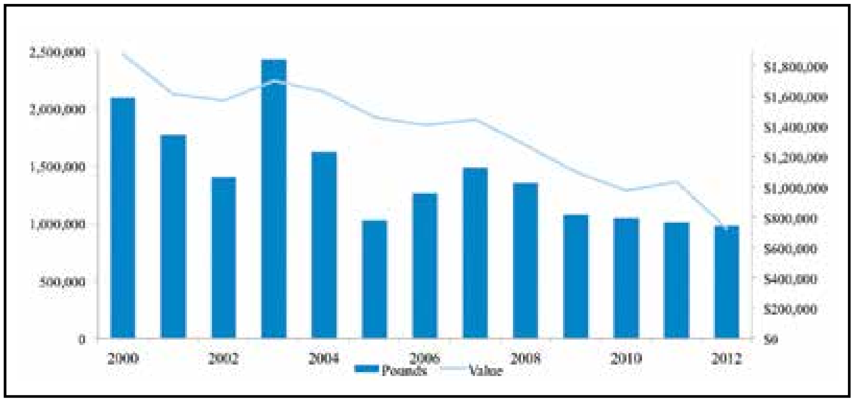
and in gray and Northern elephant seals (*Mirounga angustirostris*) during post-weaning fast (Debier et al. 2006).

Because of the different PCB profiles between water and sediment samples, as well as natural degradation and physiological processes, it is difficult to make a direct connection between sources of PCBs and their uptake and effects on marine organisms. A Stream Pollution Trends (SPoT) program report measured PCBs and found low concentrations and no acute invertebrate toxicity due to PCBs in sediments from central coast watersheds (Phillips et al. 2014). The negative effects occur as the PCBs begin to bioaccumulate in the food web, as demonstrated above. While concentrations in fish do not often exceed thresholds of concern (Davis et al. 2012), numerous fish consumption advisories have been issued for lakes, rivers, bays and coastal areas within California due to these contaminants. While we cannot make a definitive link between PCBs coming off the land, measured in sanctuary waters and sediment, and found in killer whale tissues, we can state that: (1.) PCBs are elevated in the offshore waters of Monterey Bay; (2.) PCBs are elevated in marine mammal tissues; (3.) the congener profiles are different in water and mammal tissues, with lesser chlorinated congeners in water and more highly chlorinated congeners in mammals; (4.) lower chlorinated congeners appear to be excreted or metabolized in smaller mammals preyed upon by killer whales; and (5.) marine mammals in Monterey Bay are highly contaminated by persistent organic pollutants, including PCBs.

8. What are the levels of human activities that may influence habitat quality and how are they changing? In 2009, the level of human activities that influence habitat quality in the offshore environment was rated as "fair/poor" primarily because bottom-contact fishing gear had been employed widely for many decades, and additionally because of the accumulation over decades of marine debris in offshore habitats. The 2015 status rating is changed to "fair" based on decreases in both overall effort and spatial extent of fishing with bottom trawl gear as compared to the past when it was more widespread and occurred in areas with more sensitive habitats.

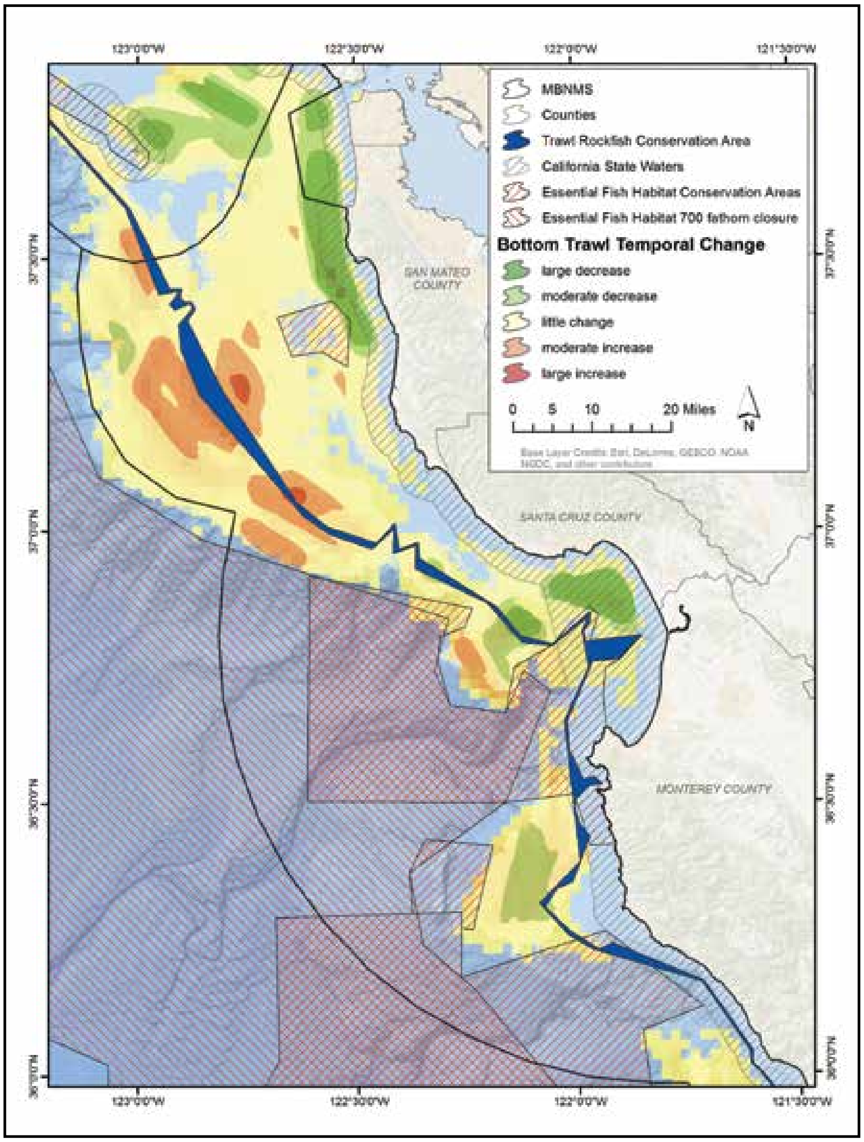
In addition, new studies indicate that impacts of bottom trawling gear, submerged cables and marine debris on soft bottom habitats are localized. The trend in 2009 was "improving" because the level of fishing with bottom contact fishing gear had been reduced by landing restrictions, gear restrictions and area closures. The trend in 2015 remains "improving" because bottom trawling, which is the most damaging human activity in the offshore environment, has decreased in spatial distribution and intensity, especially in areas with the most sensitive resources. Inputs of marine debris and contaminants continues, but it is unclear if there has been an increase in the rate of these activities.

Overall trawling effort, as evidenced by catch records from bottom trawl fishing inside the sanctuary, appears to be much lower recently, as compared to the higher levels that occurred from 2000-2003 and appears to have stabilized between 2009-2012 at around 1 million pounds (Figure 43) (Leeworthy et al. 2014). These decreases in the overall bottom trawl fishing effort are likely due in part to changes in fisheries management. In the 2009 condition report, there were concerns that area closures might lead to redistribution of fishing effort and increased fishing pressure in areas open to bottom trawl fishing. New information on the general distribution of change in fishing effort using bottom trawl gear along the U.S. West Coast before (2002-mid-2006) and after (mid-2006-2010) implementation of essential fish habitat area closures shows that effort has been redistributed inside the sanctuary (Figure 44) (NMFS 2013a, b). Decreases in effort occurred mostly in or adjacent to state waters off the San Mateo county coast and in northern Monterey Bay, and the outer shelf off Point Sur. The majority of large or moderate increases in effort occurred in soft-bottom habitat on the outer shelf and upper slope flanking the Trawl Rockfish Conservation Area in the northern half of MBNMS.



Credit: Leeworthy et al. 2014

Figure 43. Volume (bars) and value (line) of trawl catch from reporting blocks in MBNMS from 2000 to 2012. Recent catch volume is much lower than the 2003 high of 2.4 million pounds. Catch appears to have stabilized, hovering around 1 million pounds and $800,000 in value since 2009. Groundfish accounted for more than 97% of the trawling harvest volume and value in MBNMS in 2012.



Data source: NMFS 2013 a, b / Map: S. De Beukelaer, MBNMS

Figure 44. The generalized distribution of change in fishing effort using bottom trawl gear in MBNMS (black boundary) before and after implementation of essential fish habitat closures in mid-2006 (red hatched areas) that prohibit the use of bottom trawl gear. "Before" data is from January 2002 to mid-2006, and "after" data is from mid-2006 to December 2010. Additional areas closed to bottom trawling are shown: Trawl Rockfish Conservation Area (Trawl RCA) and California state waters (gray hatching). Prohibition of bottom trawling in state waters began in 1953, but this closure was not implemented in some locations (e.g., Monterey Bay) until 2006. The spatial extent of the Trawl RCA has fluctuated seasonally since implementation in late 2002; the minimum extent has been 100-150 fathoms (shown on map) and the maximum extent has been 0-200 fathoms. This data layer was created by the National Marine Fisheries Service using trawl logbook data. In order to ensure the confidentiality of discrete fishing locations, trawls were first represented by straight lines between recorded start and end points of the vessel, and then summarized within 500 x 500 meter contiguous grid cells. It is important to note that bottom trawls rarely follow straight-line paths, so the map only provides a general sense of changes in fishing effort between two time periods. In certain areas and time periods, particularly south of 36ºN latitude and in the more recent time period, trawling is so patchy that little data can be shown in map view. Furthermore, fishing effort is often concentrated around closed areas; therefore, caution should be used when interpreting spatial patterns.

In 2011, the National Marine Fisheries Service and the Pacific Fisheries Management Council implemented an individual fishing quota (IFQ) program in the federal Pacific coast groundfish fishery. Some goals of IFQ management include decreased bycatch and increased catch accountability, profitability and efficiency. Somers et al. (2015) summarized changes in distribution and intensity of bottom trawl effort along the U.S. West Coast since the implementation of the IFQ program. Broadly, it appears that the patterns shown in Figure 44 have continued with IFQ management (K. Somer, NMFS-NWFSC, pers. comm.). However, since most of the log book data on bottom trawl effort in MBNMS from the program's implementation is not publically available due to confidentiality limitations, a more detailed description of recent patterns in trawling effort was not possible at this time.

A recent study off central California of impacts to benthic habitat and living resources from high and low intensity trawling with small footrope gear found that, although there were some detectable impacts to seafloor sediment structure, changes in associated infauna, epifauna and structure-forming species were difficult to detect (Lindholm et al. 2015). The invertebrate assemblage in the study area was found to be highly variable in both space and time, suggesting that aspects of this habitat can be dynamic, making it difficult to understand and predict the impacts of trawling on the benthic community. Impacts of trawling appear to be specific to the time and location of the activity. The magnitude and duration of any impacts will likely be dependent on the faunal community and the physical and ecological processes that occur at the site at the time of impact.

Three other concerns about negative impacts of human activities on the quality of offshore benthic habitats are installation of submerged cables, accumulation of contaminants and marine debris (e.g., trash, lost fishing gear) on the seafloor. Studies of submerged cables in the sanctuary have shown little measurable impacts of the cable on physical habitat after the initial installation phase is complete, and some increases in local abundance of structure-forming invertebrates, such as anemones and crinoids, that use exposed segments of the cable as hard substrate for attachment (Kogan et al. 2006, Kuhnz et al. 2011). Contaminants in offshore habitats are still a concern, as we discussed in the 2009 MBNMS Condition Report (ONMS 2009). The limited new information on contaminants in habitats, with a focus on increasing PCB levels in the sanctuary's offshore waters, and possible impacts to living resources is discussed in Offshore Question 7.

Recent studies of marine debris in offshore habitats have found that marine debris can be surprisingly abundant on portions of the sanctuary's deep seafloor. Schlining et al. (2013) reviewed patterns in marine debris observed using 22 years of video footage from Monterey Bay covering depths from 25-3,971 meters. The majority of debris was plastic (33%) and metal (23%) and debris was relatively more abundant within Monterey Canyon; this result suggests that submarine canyons act as conduits for debris transport from coastal to deep-sea habitats (Figure 45). This study, as well as two others of marine debris in shallower (15-450 meters) (Aiken et al. 2014) and deeper (1,281 meters) (Taylor et al. 2014) habitats, suggest that impacts of marine debris on habitats and associated animals communities are fairly localized and may be negative for some faunal groups (e.g., some soft-bottom associated infauna and epifauna) and positive for others (increased abundance of fish and invertebrate taxa found in association with rocky habitat and structure-forming species).

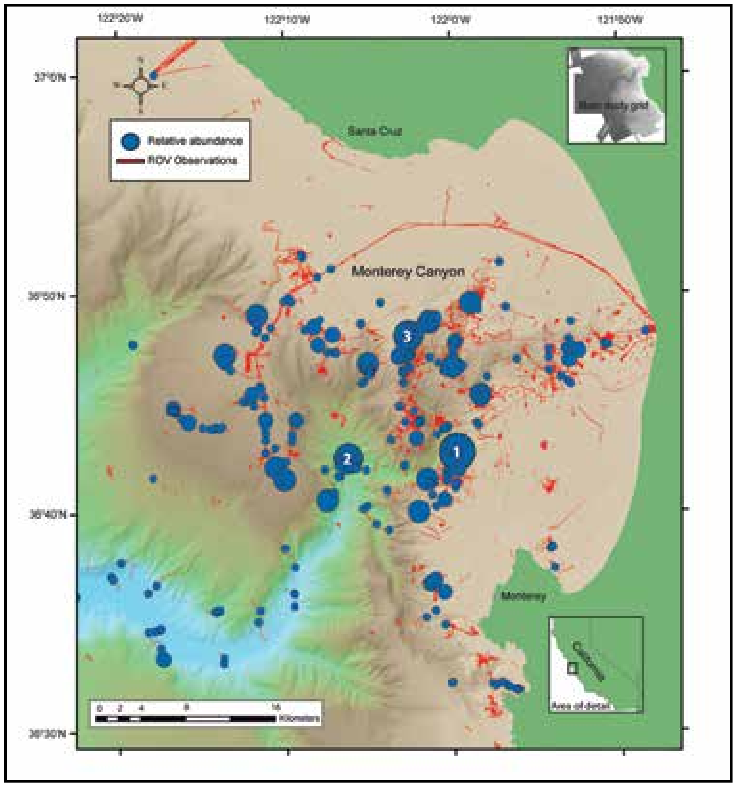


Figure 45. Distribution and relative abundance of marine debris observed in Monterey Bay. Tracks of Monterey Bay Aquarium Research Institute (MBARI) ROV surveys over the 22-year study period are shown in red. The relative abundance of trash was normalized by the amount of time spent searching the seafloor; the largest circles depict areas of trash accumulation which tend to occur on the outside walls of canyon meanders where high-energy water flow and erosion occur. The total study grid (upper inset) extended to the abyssal plain and included Davidson Seamount, about 130 kilometers to the southwest.

Credit: Monterey Bay Aquarium Research Institute & Schlining et al. 2013

There are some efforts to reduce inputs of debris into the sanctuary through litter clean-ups on beaches and in watersheds (see Nearshore Question 8 for more detailed information). In addition, over three years (2009-2011), MBNMS staff and partners removed more than 1,000 pounds of lost fishing gear from the offshore habitats in the sanctuary that posed hazards to benthic and pelagic marine organisms (De Beukelaer and Grimmer 2014).[46]

[46] (2014, April 16). Resource issues: lost fishing gear project. Monterey Bay National Marine Sanctuary. http://montereybay.noaa.gov/resourcepro/resmanissues/lostgear.html.

Offshore Environment
Habitat Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
5	Abundance/ Distribution	▲	Status: High Trend: Medium	Benthic habitat loss and modification due to fishing with bottom-contact gear; recovery of seafloor habitats likely occurring in some locations following reductions in this activity.	Selected habitat loss or alteration may inhibit the development of assemblages, and may cause measurable, but not severe declines in living resources or water quality.
6	Biologically- Structured	?	Status: High Trend: Medium	Damage to and loss of structure-forming and structure-building taxa due to trawl fishing. Recovery likely occurring in some locations and for some taxa following reductions in this activity; however concerns that ocean acidification is negatively impacting these species.	Selected habitat loss or alteration has caused or is likely to cause severe declines in some, but not all living resources or water quality.
7	Contaminants	▼	Status: High Trend: High	Exponential increase in amount of PCBs in water samples from two sites. Marine mammals are contaminated by PCBs. No evidence of strong ecosystem level effects. No additional information on contaminant levels in ocean sediments.	Selected contaminants may inhibit the development of assemblages and may cause measurable, but not severe declines of living resources or water quality.
8	Human Impacts	▲	Status: High Trend: High	Decreases in both overall effort and spatial extent of fishing with bottom trawl gear. Inputs of marine debris and contaminants continues. Impacts of submerged cables and marine debris appear to be localized.	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.

The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report (ONMS 2009).

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

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

Photo: Chad King / NOAA MBARI

Offshore Environment: Living Resources

Biodiversity is variation of life at all levels of biological organization, and commonly encompasses diversity within a species (genetic diversity) and among species (species diversity), and comparative diversity among ecosystems (ecosystem diversity). Biodiversity can be measured in many ways. The simplest measure is to count the number of species found in a certain area at a specified time; this is termed species richness. Other indices of biodiversity couple species richness with a relative abundance to provide a measure of evenness and heterogeneity. When discussing biodiversity, we primarily refer species richness and to diversity indices that include relative abundance of different species and taxonomic groups. To our knowledge, no species have become extinct within the sanctuary; therefore, native species richness remains unchanged since sanctuary designation in 1992. Researchers have described previously unknown species (i.e., new to science) in deeper waters, but these species existed within the sanctuary prior to their discovery. We do not include non-indigenous species in our estimates of native biodiversity; the status of non-indigenous species in the sanctuary is addressed in Question 11.

Key species, such as keystone species, indicators species, sensitive species and those targeted for special protection, are discussed in the responses to questions 12 and 13. Status of key species will be addressed in question 12 and refers primarily to population numbers. Condition or health of key species will be addressed in question 13. The sanctuary's key species are numerous and cannot all be covered here. Instead, in this report, we emphasize various examples from the sanctuary's primary habitats that have data available on status and/or condition.

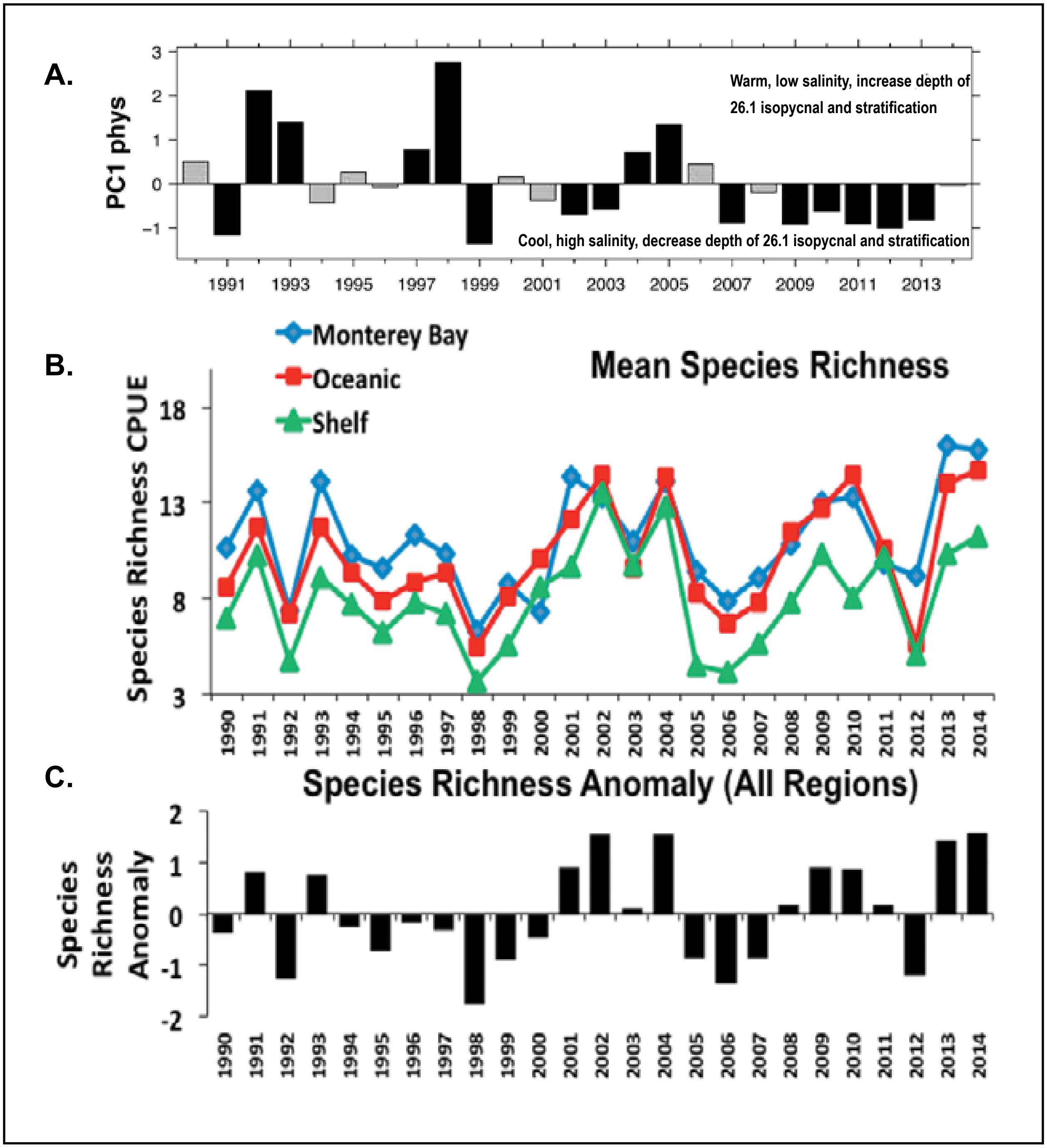
The following information provides an assessment of the current status and trends of the sanctuary's living resources in the offshore environment.

9. ***What is the status of biodiversity and how is it changing?*** Thorough historic and current inventories are not available to fully measure biodiversity status and trends in the sanctuary. Based on the best available information, the status of native biodiversity in the sanctuary's offshore habitats was rated "fair" in the 2009 MBNMS Condition Report because, although native species richness remained unchanged, the relative abundance of many species and taxonomic groups had been substantially altered by both natural and anthropogenic pressures. Shifts in the relative abundance of multiple species, especially those at higher trophic levels, are indicators of compromised native biodiversity in the system and impact community and ecosystem structure and function. However, the cumulative trend in biodiversity was "undetermined" due to a lack of information on the changes in relative abundance of many deep-sea species, and uncertainty about how to combine the individual trends in species abundance into a cumulative trend in biodiversity.

Recent trends in abundance are available for a number of key species and is summarized in more detail in Offshore Question 12. Additionally, some new information on biodiversity of pelagic forage and soft-bottom infaunal groups will be discussed below. Based on said information, the 2015 status of biodiversity will remain "fair," with a trend of "not changing" because, though some species and faunal groups have increased or decreased in abundance since 2009, there is not strong evidence that overall biodiversity in the offshore environment has increased or decreased significantly during this time. Many of the species and faunal groups, for which we have time series data, appear to have fluctuated within the range that is expected, based on a longer time series.

A historical perspective suggests that many of the offshore environment's higher trophic level species, such as marine mammals, seabirds and predatory fishes, are at reduced abundances. The most recent stock assessments by the National Marine Fisheries Service finds that most mammal stocks in the sanctuary are stable or slowly increasing in abundance (Carretta et al. 2013). Some locally breeding seabirds have experienced average (e.g., common murre) to above average (e.g., Cassin's auklet) reproductive success in recent years, while reproductive success of others (e.g., Brandt's cormorant) has been below average (see Offshore Question 12 for more detailed information). Levin et al. (2006) found that decades of fishery extraction contributed to changes in the fish assemblage on the continental shelf and slope. Specifically, the species that dominated the shelf/slope assemblage had vastly different trophic roles and life-history strategies than the species they replaced. Though recent changes in fishery management have improved stock status for overfished species (NMFS-CCIEA 2014), it is unclear if the relative abundance of functional groups has started to change back to the conditions observed many decades ago.

A newly derived index of species richness of the epipelagic forage community, based on the presence of 68 taxa collected in mid-water trawl nets by the National Marine Fishery Service Southwest Fisheries Science Center's (NMFS-SWFSC) Rockfish Recruitment and Ecosystem Assessment Surveys, can be used to explore spatio-temporal patterns of diversity over the last 25 years and regional ocean conditions (Figure 46a) (Santora et al. 2014, J. Santora, 2011-2014 unpubl. data). The midwater trawl samples used to create this index have been collected each May and June since 1990, and include fixed sampling stations over the shelf and out to the 2,000 meter isobath between the Monterey peninsula and the Gulf of the Farallones (Santora et al. 2012). Interannual variability of species richness largely



Source: (A.) Santora et al. 2014, (B.) and (C.) J. Santora, unpubl. data

Figure 46. (A.) Multivariate index of regional ocean conditions off central California derived from National Marine Fishery Service Southwest Fisheries Science Center's Rockfish Recruitment and Ecosystem Assessment Surveys (RREAS) hydrographic sampling stations (values less than +0.5 and greater than -0.5 are shaded gray); (B.) interannual variability of mean species richness (mean number of species per trawl station; repeated sampling during May-June at a depth of 30 meters) catch-per-unit-effort (CPUE) among RREAS stations characterized as shelf, oceanic and Monterey Bay; and (C.) anomaly of species richness across all stations (mean removed and divided by long-term standard deviation; 1990-2014).

reflects production of juvenile rockfish (*Sebastes* spp.). Observed species richness of the epipelagic forage community is slightly higher in samples collected from the Monterey Bay and oceanic regions (offshore sites) as compared to the shelf region (Figure 46b). In addition, species richness was lower during warm water conditions and higher during cool water conditions; this pattern is coherent among all three ecological regions (shelf, oceanic and Monterey Bay). Relatively high forage species richness was observed from 2009-2014, a period with generally cool and productive conditions (Figure 46c).

The abundance of jumbo squid (*Dosidicus gigas*) observed during MBARI's midwater ROV surveys in Monterey Bay has increased recently in the sanctuary (Panel D in Figure 37), which may impact both regional and local biodiversity. This species may affect local biodiversity by driving changes in the pelagic food web because jumbo squid is both: (1.) a voracious predator of a variety of pelagic and semi-pelagic fishes (e.g., Pacific hake, Pacific herring, northern anchovy, sablefish, salmonids, various rockfishes, myctophid fishes, squids) (Field et al. 2007, Field et al. 2013) and (2.) an important forage item for many higher trophic level fishes and marine mammals, including toothed whales and tunas, billfishes and sharks (Field 2008). These animals are likely to play a major role in the structure of offshore ecosystems. The cause of the observed range expansion of jumbo squid has not been determined; possible contributing factors include the recent cool phase of the Pacific Decadal Oscillation, harvest of large pelagic predators and shoaling of the OMZ due to global climate change (Stewart et al. 2014).

Biodiversity in the sanctuary's deep-sea communities is not well understood because of the logistical challenges of conducting research in deep water. A recent study compared patterns of biodiversity of infaunal communities in sediments collected from various locations on the sanctuary's shelf and slope (Oliver et al. 2011). This study found 1,521 species of macrofaunal invertebrates in 32 square meters of bottom sampled, which is one of the highest species densities reported from soft-bottom habitats worldwide. Samples from the shelf (30-150 meters) had higher species density, larger number of animals and greater evenness of relative abundance compared to samples from the slope (250-2000 meters), which suggests that the complexity of biological interactions may be higher on the shelf than on the slope (Oliver et al. 2011). The highest number of species was observed at the shelf-slope break (100-150 meters) coincident with the location of breaking internal waves in the Monterey Bay and under an upwelling plume and production hot spot. Future repeated samplings of these or similar locations would be useful to track patterns in the diversity of infaunal communities over time.

There are indications that deep-sea sponge and coral communities in the sanctuary have been impacted by human activities before many aspects of their basic biology and ecology could be ascertained (J. Barry, MBARI, pers. comm.). There is little repeated monitoring of these benthic resources to track changes in condition and potential recovery from these past impacts. Overall, there is much to be learned about the species richness and evenness of several important communities within the sanctuary's offshore habitats.

10. *What is the status of environmentally sustainable fishing and how is it changing?* We no longer assess this question in ONMS condition reports; therefore, content for this question was not updated.

11. *What is the status of non-indigenous species and how is it changing?* In 2009, the status of non-indigenous species in offshore habitats was rated "good" and "not changing" because very few non-indigenous species had been identified in offshore habitats and those present did not appear to affect ecosystem integrity (ONMS 2009). In 2015, the rating remains "good" and "not changing" because we are not aware of substantial new information on the status of non-indigenous species in MBNMS's offshore habitats.

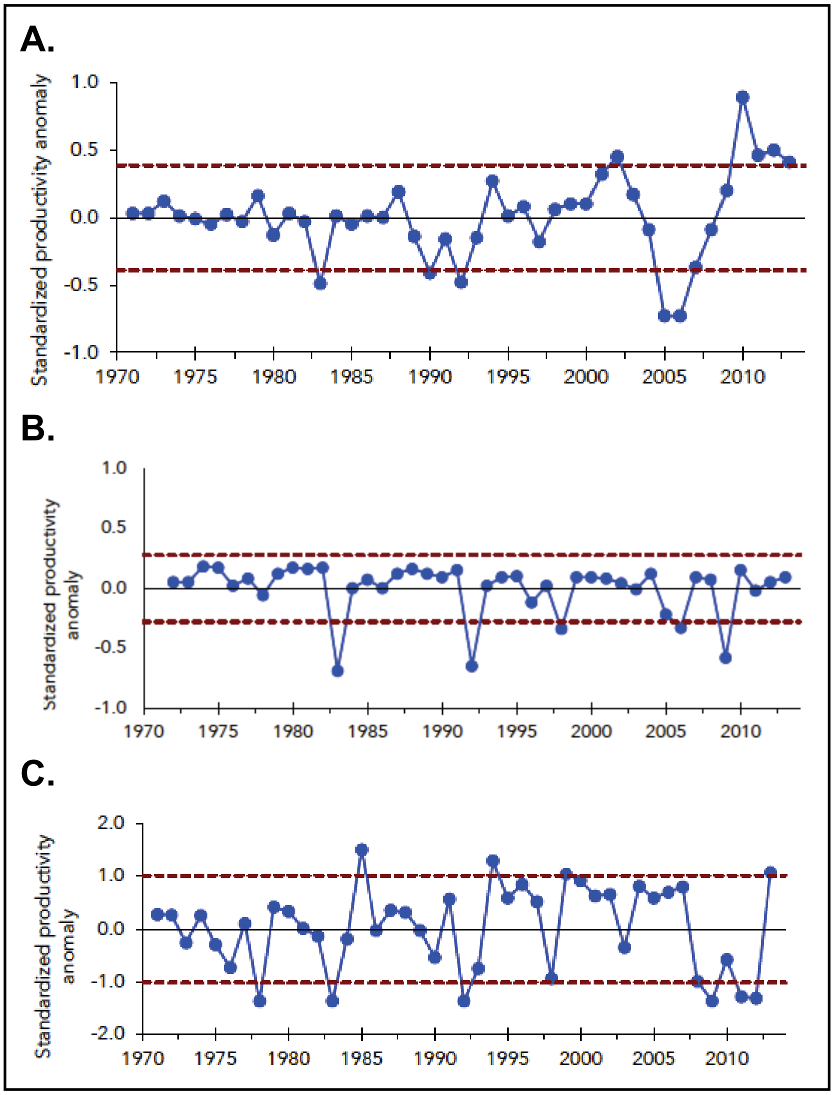
12. *What is the status of key species and how is it changing?* In 2009, the status of key species in the offshore environment was rated "good/fair" and the trend was "not changing" based on the known population sizes of many high-profile species in the offshore environment, including marine mammals, seabirds, pelagic fishes (e.g., salmon, tunas, sharks) and sea turtles. Many of these are apex predators and play important ecological roles in the sanctuary ecosystem. On-going monitoring of many of these species, along with new data on a few other key components of the offshore ecosystem, reveal that population sizes are changing, but mostly within the range that is expected based on long-term time series. Therefore, the 2015 rating for key species remains "good/fair" and "not changing."

Below we briefly provide updated information on the status of a number of key species that play important ecological roles in the sanctuary ecosystem as either predators or the forage base for the pelagic system.

Based on the latest stock assessments by the National Marine Fisheries Service, most marine mammals (e.g., whales, dolphins, seals, sea lions) that are residents or seasonal visitors to MBNMS are stable or increasing in abundance at the population level (Carretta et al. 2013). The local abundance of mammal species that migrate to the sanctuary to forage (e.g., humpback, blue and fin whales) is strongly influenced by the abundance and distribution of their prey, such as krill, sardine and anchovy. Breeding success of locally breeding seabirds has varied recently by species. For instance, Cassin's auklet has had higher than average breeding success, common murre breeding success has fluctuated around the long-term mean and Brandt's cormorant breeding success was very low until a very successful year in 2013 (Figure 47) (Warzybok et al. 2013, Elliott and Jahncke 2014).

Salmon and groundfish are key species in the sanctuary due to their important role in both the offshore food web and in commercial and recreational fisheries. Many of central California's salmon stocks have been listed under the federal Endangered Species Act.[47] As of 2013, the abundance of coho and Chinook salmon stocks that use MBNMS's offshore environment are at reduced abundance levels and many show declining trends (Wells et al. 2014a). Based on recent stock assessments by the National Marine Fisheries Service and Pacific Fisheries Management Council, the status of groundfishes (e.g., rockfishes, flatfishes) has improved compared to 2009.[48] As of 2013, three assessed stocks (canary rockfish, yelloweye rockfish, Pacific Ocean perch) are in an overfished state, but increasing in abundance (as compared to seven stocks in an overfished condition in 2009), and there is no recent indication of overfishing on any assessed groundfish stocks, which suggests increasing relative abundance of groundfish in the offshore environment (Cope and Haltuch 2014).

Forage species directly and indirectly support the tremendous abundances and species diversity of higher trophic levels. The annual abundance of seven key forage groups has been monitored each year (May-June) off central California since 1990 by the NMFS-SWFSC Rockfish Recruitment and Ecosystem Assessment Surveys (Figure 48) (Wells et al. 2014b). Notably, 2013 and 2014 had some of the



Data Source: Point Blue Conservation Science
Figure Source: Warzybok et al. 2013

Figure 47. Breeding success anomalies for (A.) Cassin's auklet, (B.) common murre and (C.) Brandt's cormorant on Southeast Farallon Island, 1971-2013. Solid black line represents long-term mean, and dotted red lines represent ± 80% confidence intervals.

[47] (last updated Oct. 8, 2015). Endangered and threatened marine species under NMFS's jurisdiction. *National Oceanic and Atmospheric Administration (NOAA) Fisheries*. Retrieved from http://www.nmfs.noaa.gov/pr/species/esa/listed.htm#fish.

[48] (n.d.) Groundfish: Stock assessments, STAR reports, STAT reports, rebuilding analyses, terms of reference. *Pacific Fishery Management Council*. Retrieved from http://www.pcouncil.org/groundfish/stock-assessments/.

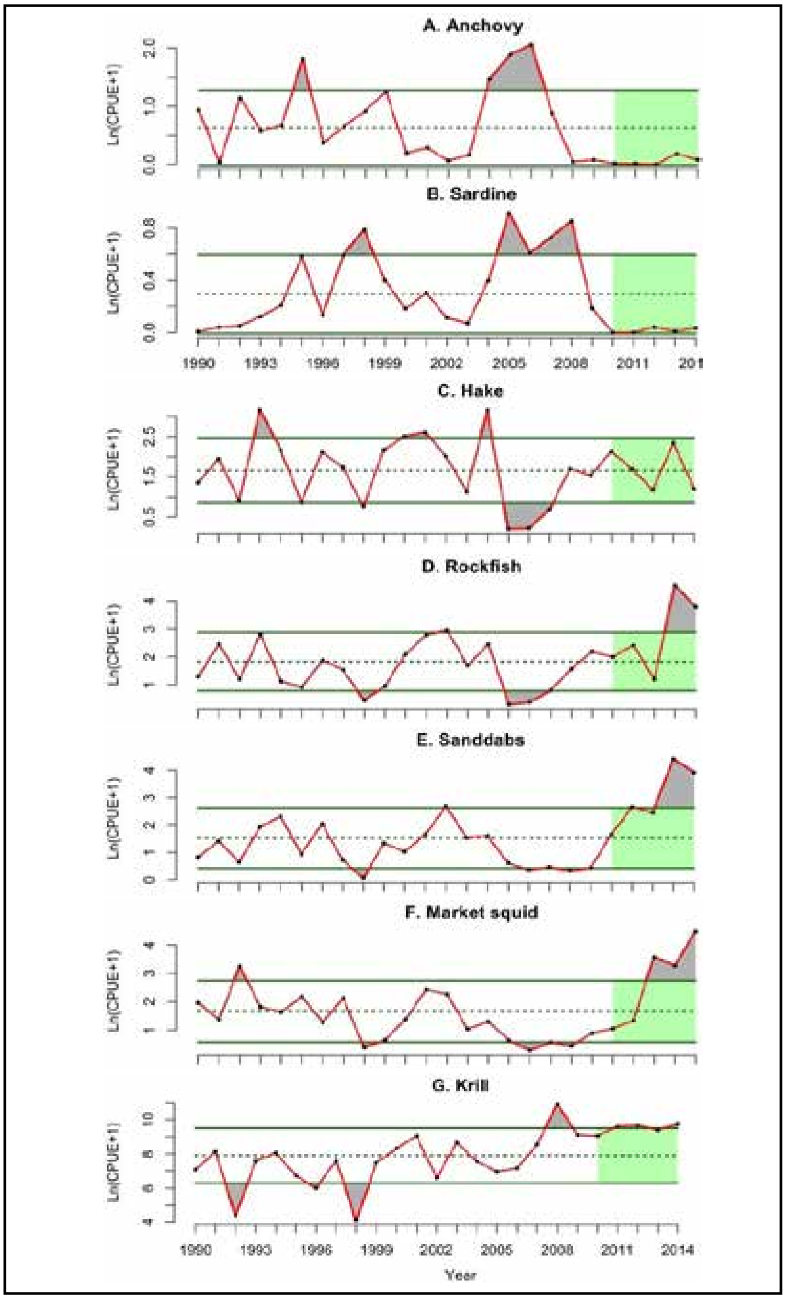


Figure: Wells et al. 2014b

Figure 48. The annual geometric means of catch-per-unit effort (CPUE) from NMFS-SWFSC Rockfish Recruitment and Ecosystem Assessment Surveys for seven key pelagic forage groups: (A.) adult northern anchovy, (B.) adult Pacific sardine, (C.) juvenile Pacific hake, (D.) young-of-the-year rockfish, (E.) juvenile sanddabs, (F.) market squid (multiple life stages) and (G.) adult krill. These fishery-independent midwater trawl surveys have occurred each year in May-June off central California since 1990. Horizontal lines show the mean (dashed line) ± 1.0 standard deviation (solid lines) of the full time series, gray shading = 95% confidence intervals. Light green shading highlights the most recent five years in the time series.

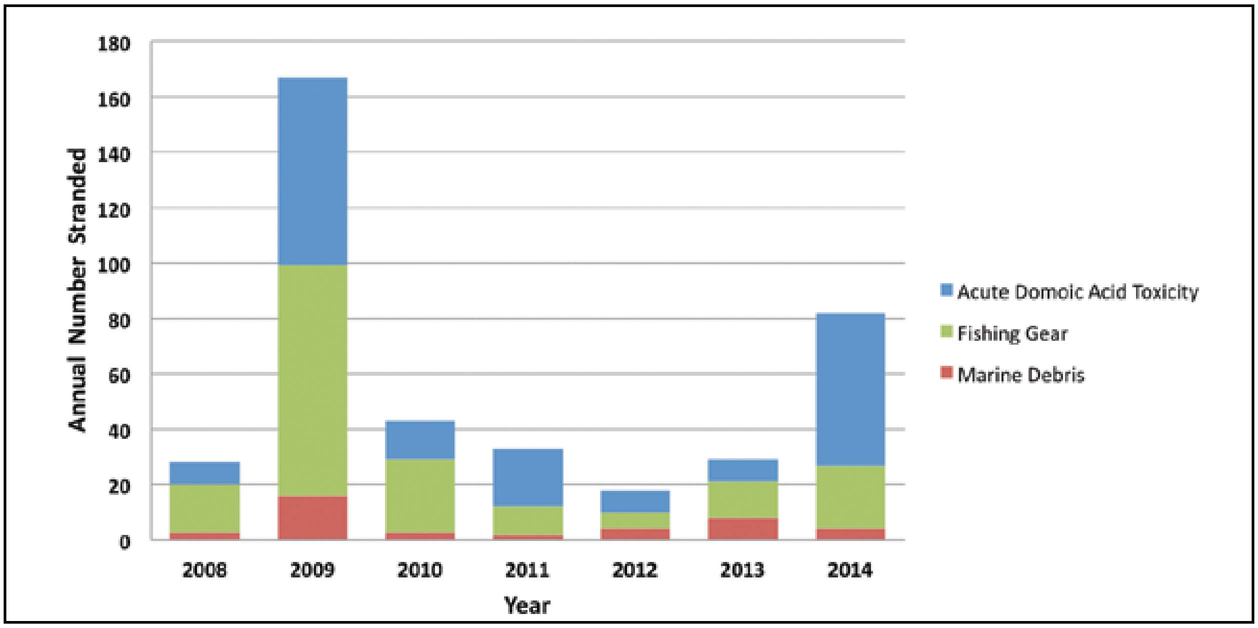
highest densities of young-of-the-year (YOY) rockfish, sanddab and market squid ever observed by this survey. Krill abundance has been high and unusually stable since 2009, and Pacific sardine and northern anchovy abundance has been low over the same period. Years with high numbers of YOY groundfish, market squid and krill are generally associated with cooler ocean conditions and high levels of upwelling and productivity, which in turn are associated with greater breeding success and productivity of many of the higher trophic level predators that forage on this assemblage, such as seabirds and salmon (Santora et al. 2012, Wells et al. 2012). The lower abundance of anchovy and sardine in such years may reflect localized availability (these stocks may be distributed further south and/or offshore during high upwelling conditions in the period this survey operates) (Wells et al. 2014b).

13. What is the condition or health of key species and how is it changing? The condition of key species in the offshore environment will continue to be rated "good/fair" and "declining" (ONMS 2009). The available new information, though limited, is consistent with the 2009 assessment that the health of several key species is impacted by exposure to neurotoxins produced by harmful algal blooms (HABs), entanglement in active and lost fishing gear, ingestion of marine debris and accumulation of persistent contaminants. The continued input of non-biodegradable marine debris and persistent contaminants into the offshore waters of the sanctuary, combined with the lack of attenuation of legacy contaminants, suggests that these threats to the condition of key species may have slowly increased over the past decades and are likely to continue to slowly increase in the future. Though the threats posed by persistent contaminants,[49] HABs[50] and marine debris (NRC 2008) are fairly pervasive in the world's ocean, highlighting these issues in MBNMS, and providing an update of available data, can help to inform future research and management efforts to reduce these impacts to key species in the sanctuary.

Below we will briefly summarize some new information on health impacts to key species, except for health impacts from contaminants, which is summarized in the response to Offshore Question 7, and increases in frequency of harmful algal blooms, which is summarized in the response to Nearshore Questions 2.

The Marine Mammals Center (MMC), a rehabilitation center on the central California coast, tracks the cause of strandings of marine mammals including animals stranding on MBNMS's beaches. Domoic acid, a neurotoxin produced by the diatom *Pseudo-nitzschia*, continues to impact the health of key species. The annual number of marine mammals that stranded on sanctuary beaches from 2008-2014 and were determined to have died from acute domoic acid toxicity ranged from a low of eight (in years 2008, 2012 and2013) to highs of 55 (2014) and 68 (2009) animals (blue bars in Figure 49) (MMC, unpubl. data). Each year marine mammals, mostly seals and sea lions, strand on beaches in the sanctuary due to interaction with active and lost fishing gear (e.g., fishing nets, crab pots, fishing hooks, monofilament line) or entanglement in other man-made debris (e.g., packing straps, plastic bags, rope) (Figure 49) (MMC, unpubl. data).

Currently, reports of large whale entanglement (primarily humpback whales and gray whales) in active or lost fishing gear and other man-made lines (e.g., buoy lines) is on the rise in California, including Monterey Bay.[51] For the period from 2014 to July 2015, there were 46 large whale entanglements confirmed along the U.S. West Coast, with 35 of those in California (14 of which were in Monterey County). In comparison, for the entire West Coast from 1990 to 2009, about 10 whale entanglements were reported each year (Figure 50). The cause of the recent spike in reports of entangled whales is not clear. Potential contributing factors include increasing whale populations, increasing overlap of whale activities (e.g., migrating, feeding) with human activities that have the



Source: MMC, unpubl. data

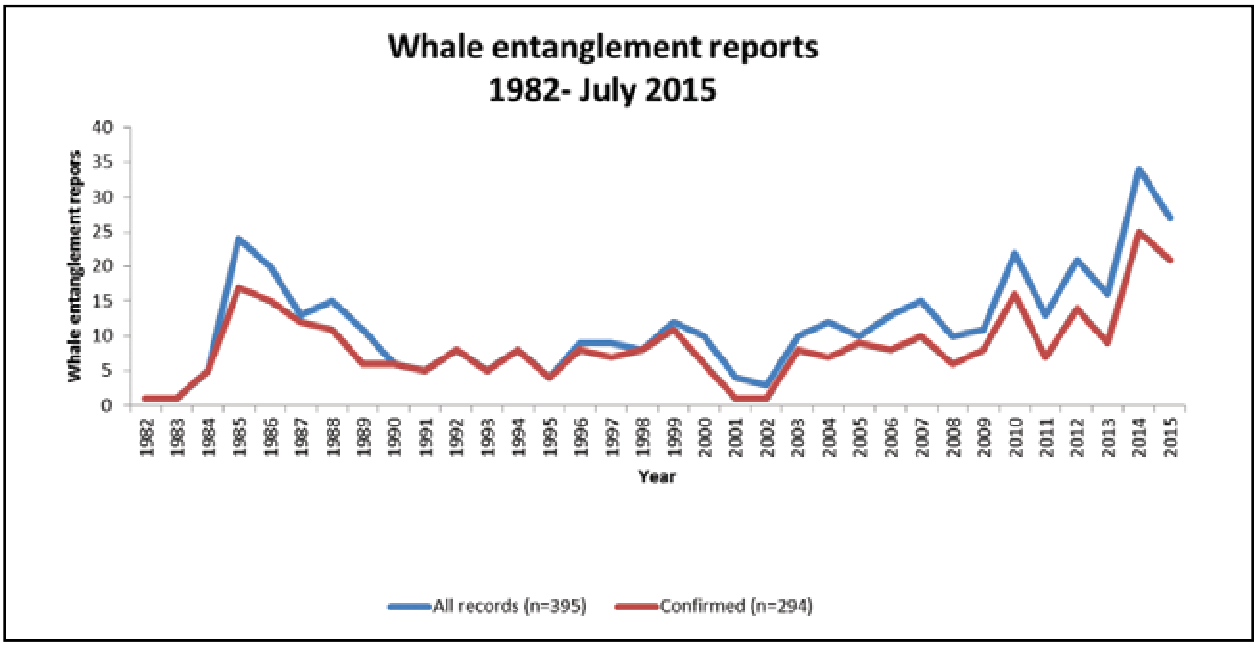
Figure 49. Annual number of marine mammals stranded on beaches in MBNMS and treated by the Marine Mammal Center (MMC) because of acute domoic acid toxicity (blue), entanglement in fishing gear (green) and (marine debris). The Marine Mammals Center, a rehabilitation center on the central California coast, tracks the cause of strandings of marine mammals, including animals stranding on the beaches in MBNMS.

[49] (last updated June 29, 2015). Persistent organic pollutants: A global issue, a global response. *U.S. Environmental Protection Agency (EPA)*. Retrieved from http://www2.epa.gov/international-cooperation/persistent-organic-pollutants-global-issue-global-response#resources. (see the resources section)
[50] (last updated July 31, 2012). Distribution of HABs throughout the world. *Harmful Algae*. Retrieved from http://www.whoi.edu/redtide/regions/world-distribution.
[51] (2015, Sept.) Whale entanglements: A summary as of August 2015. *Sanctuary Integrated Monitoring Network (SIMoN)*. Retrieved from http://sanctuarysimon.org/news/2015/09/whale-entanglements-a-summary-as-of-august-2015/.

potential to entangle whales (e.g., fishing, buoy installation) and an increase in on-the-water observers likely to report entangled animals (e.g., whale watching, recreational boating). Whales that migrate or feed close to shore enter a region prone to having more gear in the water. Humpback whales have been feeding close to shore in the Monterey Bay region in recent years, which may be contributing to an increase in whale-gear interactions. Another contributing component may be an increase in fishing effort by some sectors of the fishing industry in central California (largely Monterey County). This potential combination of more effort nearshore by both whales and humans may be a leading factor in the recent increase of entanglement events.

Marine mammals being injured or killed by boat strikes is an additional health concern for large whales, smaller cetaceans and pinnipeds. Each year, a couple of marine mammals are found stranded on sanctuary beaches with obvious signs of interactions with boats (MMC, unpubl. data; MBNMS, unpubl. data[52]). Between July and October 2010, two blue whales (one pregnant female that resulted in the loss of the fetus), one humpback and two fin whales were found dead in and around Monterey Bay, Greater Farallones and Cordell Bank national marine sanctuaries. Nonetheless, the exact number of marine mammals that are injured or killed each year from interactions with boats is very difficult to determine because many of these animals are unlikely to strand on beaches where they can be found, and it is hard to ascertain the specific cause of death (through necropsy) and link mortality to vessel strikes.

Entanglement in marine debris is also a health concern for seabirds. The sanctuary's Beach COMBERS monitoring program has documented seabird carcasses found on area beaches that are entangled in marine debris for the years 1997-2012 (Figure 51). Over the 15 year study period, a total of 279 entanglements were reported by surveyors affecting 24 seabird species (Nevins et al. 2014). The five species that comprised the highest percentage of entanglements were common murres (23%), sooty



Source: D. Lawson, NMFS-PRD, http://www.opc.ca.gov/webmaster/ftp/pdf/whale-entanglement/P1-Aug-20-Whale-Entanglement-Discussion-Management-of-Entanglement-and-Entanglement-Data.pdf

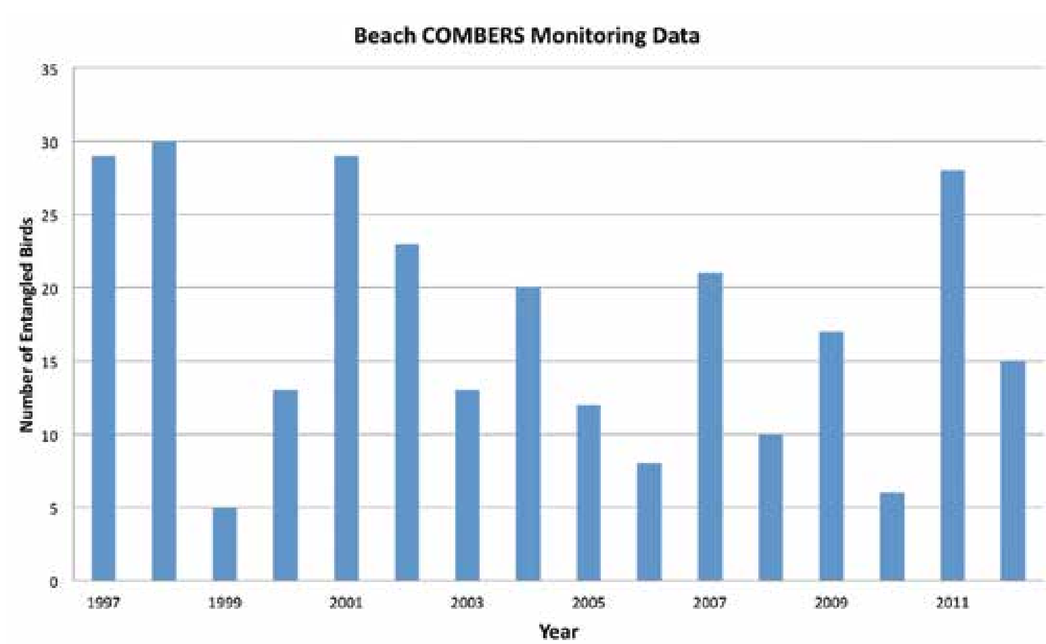
Figure 50. Annual number of large whale entanglements reported (blue) and confirmed (red) along the U.S. West Coast. Reports of entanglements have increased in recent years. Factors contributing to this trend likely include an increasing overlap of whale activities (e.g., migrating, feeding) with human activities that have the potential to entangle whales (e.g., fishing, buoy installation) and an increase in on-the-water observers likely to report entangled individuals (e.g., whale watching, recreational boating).

[52] (reviewed Oct. 15, 2014). Resource issues: Whale strikes. *Monterey Bay National Marine Sanctuary (MBNMS)*. Retrieved from http://montereybay.noaa.gov/resourcepro/resmanissues/whalestrikes.html.

shearwaters (12.5%), Brandt's cormorants (10%), western gulls (9%) and brown pelicans (7%). Alcids (24%), gulls (21.5%) and cormorants (15%) were the seabird groups most commonly affected. Monofilament fishing line was the dominant source of entanglement, and a hook or lure was often present on these lines. There were seven reports of net interactions (herring, gill and fishing nets). Three reports mentioned entanglement via a balloon string around the legs and/or wings, and two reports cited the ingestion of a balloon piece in the stomachs of a common murre and a fulmar.

Recent large stranding events of Cassin's auklets and California sea lions appear to be the result of the starvation of juvenile animals due to low prey availability and unusual oceanographic conditions. Beached-bird surveys recorded unusually high numbers of dead Cassin's auklets (*Ptychoramphus aleuticus*) on beaches from British Columbia through central California (Henkel et al. 2015). In central California, encounter rate peaked in November and December 2014, based on Beach COMBERS monitoring data. Most of the birds from central California were hatch-year birds with emaciated or poor body condition, and presumed to have died of starvation. A likely contributing cause of this mortality event is the unusually large cohort of hatch-year auklets that were apparently unable to find adequate prey resources to survive their first winter (Henkel et al. 2015). Prey shortages were likely influenced by anomalous ocean conditions (described in response to Offshore Question 1). Prey shortages also appear to be the cause of poor growth rates of California sea lion (*Zalophus californianus*) pups observed by the NMFS monitoring program at San Miguel Island (Harvey et al. 2014) and the unusually large number of stranded, malnourished pups that have been admitted to rehabilitation centers in southern and central California in the winter and spring of 2015.[53] Although these events have significant health impacts on animals in these populations, it is unknown if these mass stranding events will have any lasting impacts on the overall health of these populations.

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



Source: Nevins et al. 2014

Figure 51. Annual number of seabird carcasses reported as entangled in monthly Beach COMBER surveys from 1997-2012. The survey study area began with ten beaches (1997-1998), expanded to 11 beaches (1999), then to 17 beaches, including surveys in San Luis Obispo County (mid-2001-2002), and grew to 30 beaches by 2009 to the present. Note: The survey area has increased over time. The numbers reported are for total number of observations each year and have not been standardized by survey effort. Therefore, this data should not be used to examine trends in entanglement rates over time.

Beach COMBERS

The Beach Coastal Ocean Mammal and Bird Education and Research Surveys (Beach COMBERS) Program uses trained volunteers to survey beached marine birds and mammals monthly at selected sections of beaches throughout the Monterey Bay National Marine Sanctuary.[54]

changing? A number of human activities, including fishing, inputs of marine debris and vessel traffic, influence the quality of living resources in the offshore portion of the sanctuary. The level of these human activities was rated "fair" in 2009 and will continue to be rated "fair" in 2015 because most of these activities have resulted in measurable impacts to living resource quality. An "improving" trend was provided in 2009 because recent changes in fisheries management were likely to result in the improved status of fished species and reduced impacts to habitat and non-target species. The 2015 trend has been changed to "not changing" because, although fished stocks and habitats continue to recover from overfishing and impacts from bottom contact fishing, marine debris and contaminants are accumulating in offshore habitats and ocean acidification is increasing.

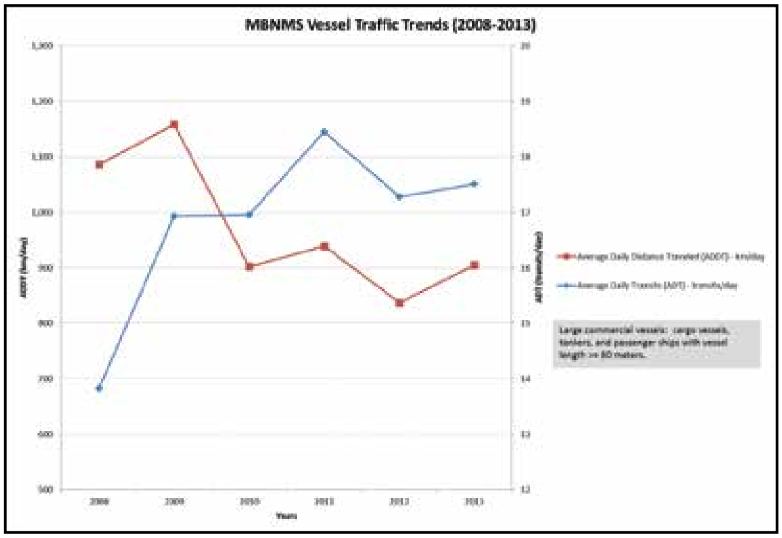
Fishing is a human activity that influences sanctuary habitats and living resources in a number of ways beyond the removal of targeted biomass. A number of changes in fisheries management implemented prior to 2007, including gear restrictions, area closures and landing reductions, appear to have resulted in overall better management of fished stocks (as evidence by recent stock assessments), decreased impacts to biogenic habitat and non-targeted species (summarized in response to Offshore Question 8), and a lower overall level of fishing effort in central California compared the 1990s and early 2000s. In 2011, NOAA Fisheries implemented the West Coast Groundfish Trawl Catch Share Program. The new program transitioned the fleets from a single, fleet wide quota that encouraged competition to catch as many fish as possible until the allocation was met to a catch or quota system controlled by individuals or groups of fishermen. This new catch shares system has allowed two important groundfish stocks, canary rockfish and petrale sole, to rebuild to a sustainable level over the last five years, and others are in the process of rebuilding. Available data on recent commercial fishing activity, including fishing for groundfish, salmon, market squid and Dungeness crab, in the sanctuary suggest that overall fishing activity has been steady, with some fishing activities increasing and others decreasing likely in response to environmental conditions and regulations (OST and CDFW 2013, Leeworthy et al. 2014).

Marine debris impacts marine life in many ways, most notably through entanglement (as discussed in the response to Offshore Question 13) and ingestion of plastic fragments that can clog the digestive tract. Although negative impacts to living resources from ingestion of plastics has been demonstrated in MBNMS in the past (e.g., Northern Fulmars in Monterey Bay from 2003-2007 in Donnelly-Greenan et al. 2014), we are not aware of any new studies in the sanctuary and thus, cannot determine if the problem is increasing in severity. However, the fact that many types of debris, in particular plastic debris, do not degrade raises concern that this problem will increase in severity in the future. The ability for plastics to attract and transport contaminants has been documented (Arthur et al. 2009) and this is an area that could use further study to determine potential impacts to the sanctuary's living resources.

While small-scale and acute impacts may be diminished due to the large size of the offshore ecosystem, there are large-scale phenomena that continue to impact this system. Large vessels transiting through the sanctuary can negatively impact living resources in a number of ways including pollution,[55] collision with animals,[56] and noise.[57] Two studies of ambient ocean noise levels along the California coast found that low-frequency background noise increased from the 1960s to the 2000s by about 3 decibels per decade at the two sites studied; Point Sur in MBNMS (Andrew et al. 2002) and San Nicolas Island in southern California (McDonald et al. 2008). Most of this increase in low-frequency ambient noise was attributed to an increase in shipping traffic during that time.

More recent measures of ambient low-frequency noise are not available inside MBNMS to determine if this increasing trend in vessel-generated noise has continued since the early 2000s; however, recent analysis of large vessel traffic inside

[53] (last updated Apr. 21, 2015). 2013-2015 California sea lion unusual mortality event in California. *National Oceanic and Atmospheric Administration (NOAA) Fisheries*. Retrieved from http://www.nmfs.noaa.gov/pr/health/mmume/californiasealions2013.htm.
[54] (n.d.) Coastal ocean mammal and bird education and research surveys (Beach COMBERS). *Sanctuary Integrated Monitoring Network (SIMoN)*. Retrieved from http://sanctuarysimon.org/monterey/sections/beachCombers/index.php?l=n.
[55] (reviewed Mar. 5, 2014) Resources issues: Lost shipping containers. *Monterey Bay National Marine Sanctuary (MBNMS)*. Retrieved from http://montereybay.noaa.gov/resourcepro/resmanissues/lostshippingcontainers.html.
[56] (reviewed Oct. 15, 2014). Resource issues: Whale strikes. *Monterey Bay National Marine Sanctuary (MBNMS)*. Retrieved from http://montereybay.noaa.gov/resourcepro/resmanissues/whalestrikes.html.
[57] (reviewed Sept. 25, 2015). Resource issues: Acoustic (noise) impacts. *Monterey Bay National Marine Sanctuary (MBNMS)*. Retrieved from http://montereybay.noaa.gov/resourcepro/resmanissues/acoustic.html.



Source: NMFS-SWFSC (research in progress)

Figure 52. Average Daily Distance Traveled (ADDT) (red) and Average Daily Transits (ADT) (blue) inside the boundaries of Monterey Bay National Marine Sanctuary down to 36ºN, but does not include the Davidson Seamount Management Zone. The annual vessel traffic trends are based on U. S. Coast Guard NAIS data for 2008-2014 for vessels greater than or equal to 80 meters. The data do include traffic near the San Francisco Traffic Separation Scheme.

and adjacent to MBNMS for the period 2008 to 2014 has found that there was an increase in the number of vessels transiting through MBNMS between 2008 and 2009, but no significant trend since 2009 (blue line in Figure 52). It is interesting to note that the overall distance traveled inside the sanctuary boundary decreased during this time because the vessels are transiting further to the west and spending less time overall in MBNMS (red line in Figure 52). This may mean an overall decrease in exposure of living resources inside MBNMS to some potential impacts from vessel traffic (e.g., collisions), but likely not a decrease in overall noise generated by this activity.

Large vessel traffic is one of a variety of human activities in and adjacent to MBNMS that generate underwater noise. Other potential sources of underwater noise in MBNMS include smaller recreational and commercial vessels, sonars used in military training, pile drivers and dredging used in marine construction, airguns and other seismic sources used in energy exploration, sonars and other active acoustic sources used in research activities, and aerial sources, such as overflights. Noise generated by these human activities can have a detrimental effect on a variety of marine animals including marine mammals, turtles, fish and invertebrates. Studies have documented behavioral responses, lost listening opportunities, and physical injuries in marine animals due to exposure to human-induced noise (NRC 2003, 2005). There is concern about the cumulative impacts of noise from a variety of sources on the natural "soundscape" of the sanctuary, and this is an active topic of research and management in MBNMS.[58] Efforts to monitor the acoustic environment in MBNMS are underway and this data should help improve our understanding of potential impacts of human-induced noise on marine mammals and other wildlife in the sanctuary.

A recent study examined the spatial overlap of human activities with the distribution of large marine predators to find areas along the U.S. West Coast with a high likelihood of impacts. Maxwell et al. (2013) combined tracking data for eight species of marine predators (seabirds, whales, turtles) with data on 24 human stressors (weighted to reflect expected impacts specific to those predators) to calculate cumulative utilization and impact (CUI) scores for the entire U.S. West Coast. High CUI scores were used to identify locations where important species habitat and high-risk activities are likely to coincide. MBNMS had many cells with moderate to high CUI scores, especially for marine mammals and leatherback sea turtles. Cumulative impacts were higher inshore than offshore for all species groups, and the majority of the highest cumulative impact cells were found over the continental shelf which is consistent with most human stressors being concentrated near human population centers (Figure 53).

Global climate change's effects on ocean chemistry is an increasing stressor to offshore living resources. As was discussed in the response to Offshore Question 1, waters in MBNMS are becoming more acidic, which is a stressor on living resources, especially those with calcified body parts. Some impacts to living resources from increasingly acid waters have already been observed (e.g., Bednarsek et al. 2014). Ocean acidification from climate change has also been predicted to have implications for ocean acoustics by allowing low frequency sound to travel farther (Ilyina et al. 2010). More study is needed on the impacts of acidification on both pelagic and benthic organisms to better understand the level of current impacts and predict future impacts of changing water chemistry on the conditions of living resources. Global climate change is causing shifts in other

[58] *Id.*

physical properties of ocean waters, including increasing water temperature, hypoxia and shoaling of the Oxygen Minimum Zone, which are likely to have significant local impacts to living resource in the sanctuary's offshore environment. Directed study of the effects of climate driven changes in pH, temperature and dissolved oxygen on a variety of species will become increasingly important to understand and track the status and condition of living resources in the sanctuary in the future.

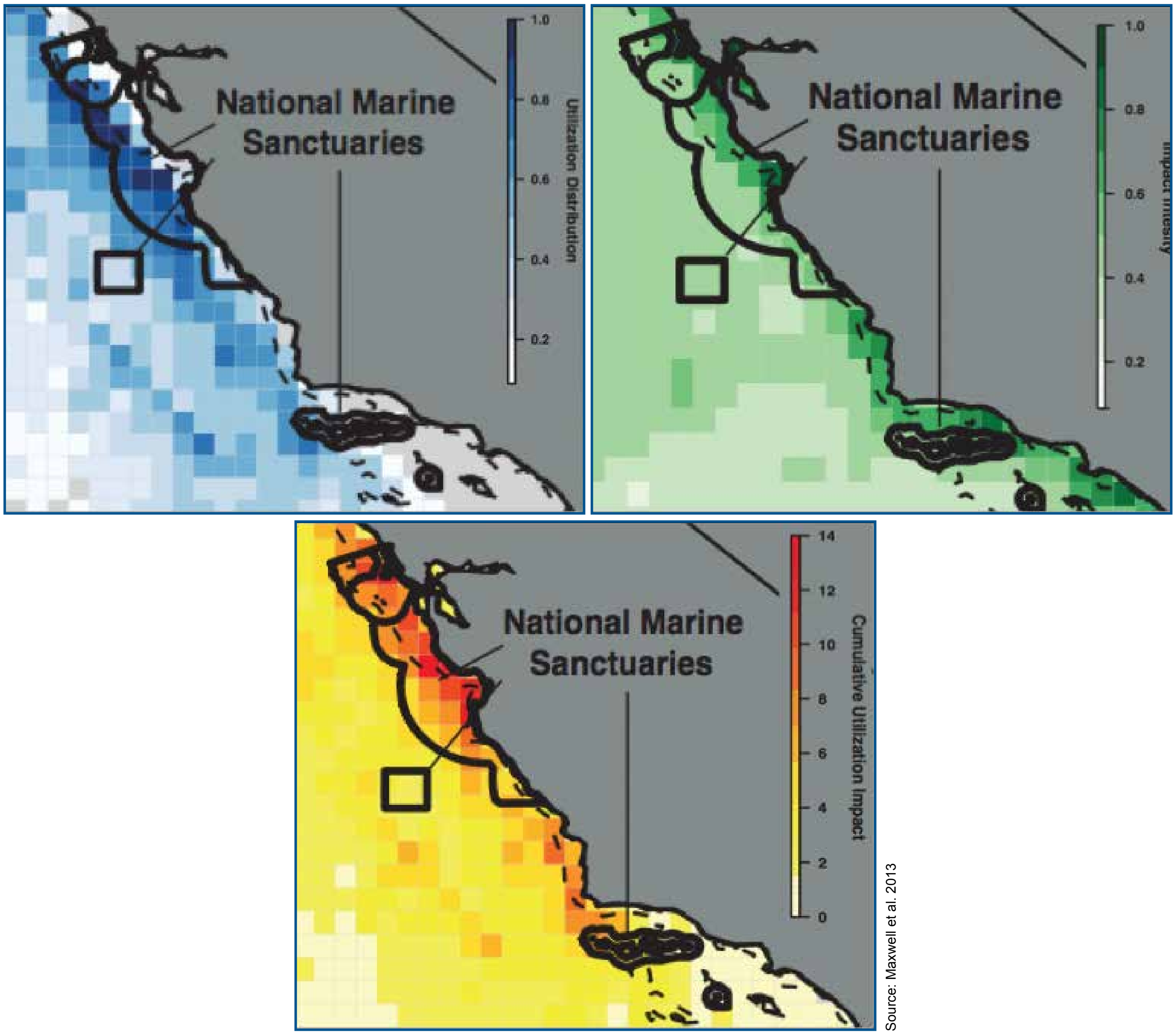


Figure 53. Maxwell et al. (2013) combined tracking data for eight species of marine predators (seabirds, whales, turtles) (top left panel) with data on 24 human stressors weighted to reflect expected impacts specific to those species (top right panel) to calculate cumulative utilization and impact scores (bottom panel) for the entire U.S. West Coast. Cumulative utilization and impact scores were used to determine where important species habitat and high-risk areas are likely to coincide (e.g., cells with high scores). The central coast of California had high scores, especially for marine mammals and leatherback sea turtles. Cumulative impacts were higher inshore than offshore for all species groups, and the majority of the highest cumulative impact cells are found over the continental shelf, which is consistent with most human stressors concentrated near human population centers.

Offshore Environment
Living Resources Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
9	Biodiversity	Fair –	Status: Medium Trend: Low	Reduced relative abundance of targeted, by-catch, and sensitive species. Overall biodiversity does not appear to have increased or decreased during this time	Selected biodiversity loss may inhibit full community development and function and may cause measurable, but not severe degradation of ecosystem integrity.
11	Non-Indigenous Species	Good –	Status: N/A (not updated) Trend: N/A (not updated)	Very few non-indigenous species identified in offshore waters.	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).
12	Key Species Status	Good/Fair –	Status: Medium Trend: Low	Some key species at reduced abundance levels due to past or on-going harvest. Some monitored key species slowly increasing, but most appear to be fluctuating within the range expected based on long-term time series	Selected key or keystone species are at reduced levels, perhaps precluding full community development and function, but substantial or persistent declines are not expected.
13	Key Species Condition	Good/Fair ▼	Status: Medium Trend: Low	Compromised health due to exposure to neurotoxins produced by HABs, entanglement in active and lost fishing gear, ingestion of marine debris and accumulation of persistent contaminants.	The condition of selected key resources is not optimal, perhaps precluding full ecological function, but substantial or persistent declines are not expected.
14	Human Activities	Fair –	Status: Medium Trend: Medium	Recent management actions helping recover overfished stocks and impacted habitats, but inputs of marine debris and contaminants have measurable impacts; ocean acidification and hypoxia increasing.	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.

The questions with red numbers have new ratings compared to the 2009 Monterey Bay National Marine Sanctuary Condition Report (ONMS 2009).

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

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

Offshore Environment: Maritime Archaeological Resources

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

15. What is the integrity of known maritime archaeological resources and how is it changing? As we reported in 2009, there is great uncertainty regarding the integrity of submerged maritime archaeological resources in the sanctuary's offshore environment; therefore, we delivered an "undetermined" rating for both status and trend. The sanctuary's inventory of submerged cultural resources contains information on known vessel losses (see Figure 35 on page 59); however, there is 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 (see Vessel 8 in Figure 35) (*Macon* Expedition 2006[59], Schwemmer 2006b) . No other site evaluations have been conducted by federal, state or private resource management agencies.

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-sea environment tends to have fewer biological processes that accelerate ship degradation. One probable cause of impacts in offshore waters is bottom trawling; however, because the majority of wreck locations are unknown, the impacts from historical and recent trawling are unknown as well.

[59] (reviewed Sept. 24, 2013). MBNMS ecosystem observations 2006. *Monterey Bay National Marine Sanctuary (MBNMS)*. Retrieved from http://montereybay.noaa.gov/reports/2006/eco/welcome.html.

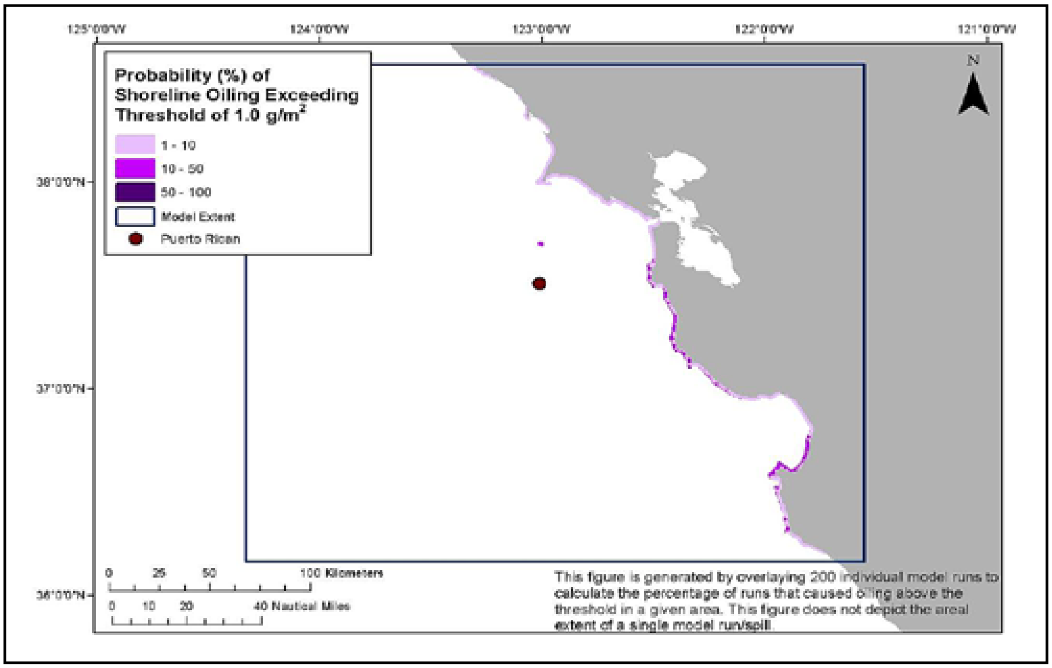


Figure 54. Probability of shoreline oiling (exceeding 1.0 gram per square meter) from the most probable discharge of 2,100 barrels (bbl) of heavy fuel oil from the *Puerto Rican*. The output of this model indicates that shoreline habitats in a large portion of Monterey Bay National Marine Sanctuary are at risk of oiling under this discharge scenario.

Credit: NOAA 2013d

16. Do known maritime archaeological resources pose an environmental hazard and is this threat changing? In 2009, this question was rated "fair" with a "declining" trend because Monterey Bay National Marine Sanctuary's inventory of known maritime archaeological resources suggested that offshore shipwrecks have the potential to pose an environmental hazard to sanctuary resources. Specifically, the deterioration of offshore wrecks could result in the release of hazardous cargo and/or bunker fuel (e.g., U.S. Navy aircraft carrier USS *Independence* scuttled in 1951; passenger steamship *San Juan* lost in 1929; lumber freighter *Howard Olson* lost in 1956) (Figure 35). Moreover, prevailing currents can carry hazardous materials from shipwrecks located outside the sanctuary into MBNMS (e.g., cargo freighter SS *Jacob Luckenbach* lost in 1953; tanker *Puerto Rican* lost in 1984; and other vessels scuttled by the military to dispose of weapons). New information on these previously identified threats provides further support to maintain the "fair" status with a "declining" trend.

From 1992 to 2001, extensive tarball deposits along the coast from north of Bodega to Point Lobos (in central MBNMS) were estimated to have killed over 51,000 seabirds (e.g., grebes, cormorants and common murres) and eight sea otters (Luckenbach Trustee Council 2006). The source of these tarballs was ultimately traced to the SS *Jacob Luckenbach* which sank off San Francisco in 1953 (located just north of MBNMS and inside Greater Farallones National Marine Sanctuary) (see Vessel 3 in Figure 35). The U.S. Coast Guard, California Department of Fish and Game, National Oceanic and Atmospheric Administration and others collaborated to identify the extent of impacts and to remove the fuel. In 2002, much of the oil was removed from the SS *Jacob Luckenbach*, and the remaining oil was sealed inside the vessel (NOAA 2013a, 2013c). The amount of oil left onboard is uncertain; estimates range from 11,500 gallons to 85,000 gallons (NOAA 2013c). The amount of oil released during the sinking and periodic mystery spills is estimated to be in excess of 300,000 gallons, suggesting that the amount still trapped in the hull would be less than 60,000 gallons. There is, however, general consensus that the remaining pockets of oil on the wreck cannot be safely removed.

Recently, NOAA completed risk assessments of the SS *Jacob Luckenbach* and *Puerto Rican*, shipwrecks located outside of, but adjacent to, the sanctuary boundary (see Vessels 3 and 4 in Figure 35) (NOAA 2013a, 2013c, 2013d). For the worst case discharge scenario, both wrecks scored high; for the most probable discharge scenario, both wrecks scored medium (Figure 54) (NOAA 2013a, 2013c, 2013d). Under the National Contingency Plan, the U.S. Coast Guard and the regional response team have the primary authority and responsibility to plan, prepare for and respond to oil spills in U.S. waters. NOAA recommended that these sites be reflected in the area contingency plans and active monitoring programs should be implemented. Outreach efforts with the technical and recreational dive community, as well as commercial and recreational fishermen who frequent the areas, would be helpful to gain awareness of changes at these sites. In addition, NOAA recommended the *Puerto Rican* wreck should be considered for further assessment to determine the vessel condition, amount of oil onboard and feasibility of oil removal action (NOAA 2013d). The final determination of what type of action, if any, rests with the U.S. Coast Guard.

The shipwreck *Montebello* had been a long-term concern due to the amount of oil on board when it sank (Figure 55). The vessel rests 900 feet below the surface of the Pacific Ocean, approximately seven miles off the shore of Cambria in San Luis Obispo County (see Vessel 9 in Figure 35). Archaeologists, historians and biologists have visited the site several times to inspect the vessel and surrounding area for oil and wildlife (Schwemmer 2005). In October 2011, a Unified Command, led by the U.S. Coast Guard and California Department of Fish and Game's Office of Spill Prevention and Response, assessed the SS *Montebello's* cargo and fuel tanks to determine if oil was present. The Unified Command found that the SS *Montebello* is not a substantial oil threat to California waters and shorelines.[60] What happened to the oil that was on board the vessel when it sank remains a mystery. NOAA scientists conducted computer trajectory models based on a number of hypothetical oil release scenarios and concluded that a long-term release model seemed most reasonable.

Photo: Unocal

Figure 55. Launch of the oil tanker *Montebello* on January 21, 1921, at Southwestern Shipbuilding Company in East San Pedro, California. The ship sank off Cambria during World War II. In 2011, it was determined that the *Montebello* is not a substantial oil threat to California waters and shorelines.

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

17. What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing? In 2009, this question was rated "good/fair" because a few human activities (e.g., fishing with bottom trawl gear, technical diving) were identified as probable sources of impacts to some offshore maritime archaeological resources. Archaeological resources are not able to recover when fishing gear destroys a site or divers remove artifacts. There was a concern that recent changes in regulation of bottom trawling may have shifted fishing effort and increased the risk to resources that have not been impacted in the past. In addition, continued development of underwater technologies increasingly affords the public the opportunity to locate and visit deep-sea archaeological resources, which may result in future impacts. However, because the majority of wreck locations are unknown, the trend in impacts from historical and recent human activities was "undetermined." There is no new information available on the levels of human activities that influence offshore maritime archaeological resources; therefore, the 2015 rating remains "good/fair" with an "undetermined" trend.

[60] (2011, Oct. 20). No visual evidence of oil found onboard SS *Montebello. Monterey Bay National Marine Sanctuary (MBNMS)*. Retrieved from http://montereybay.noaa.gov/maritime/111020montebello.pdf.

Offshore Environment
Maritime Archaeological Resources Status and Trends

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

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

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

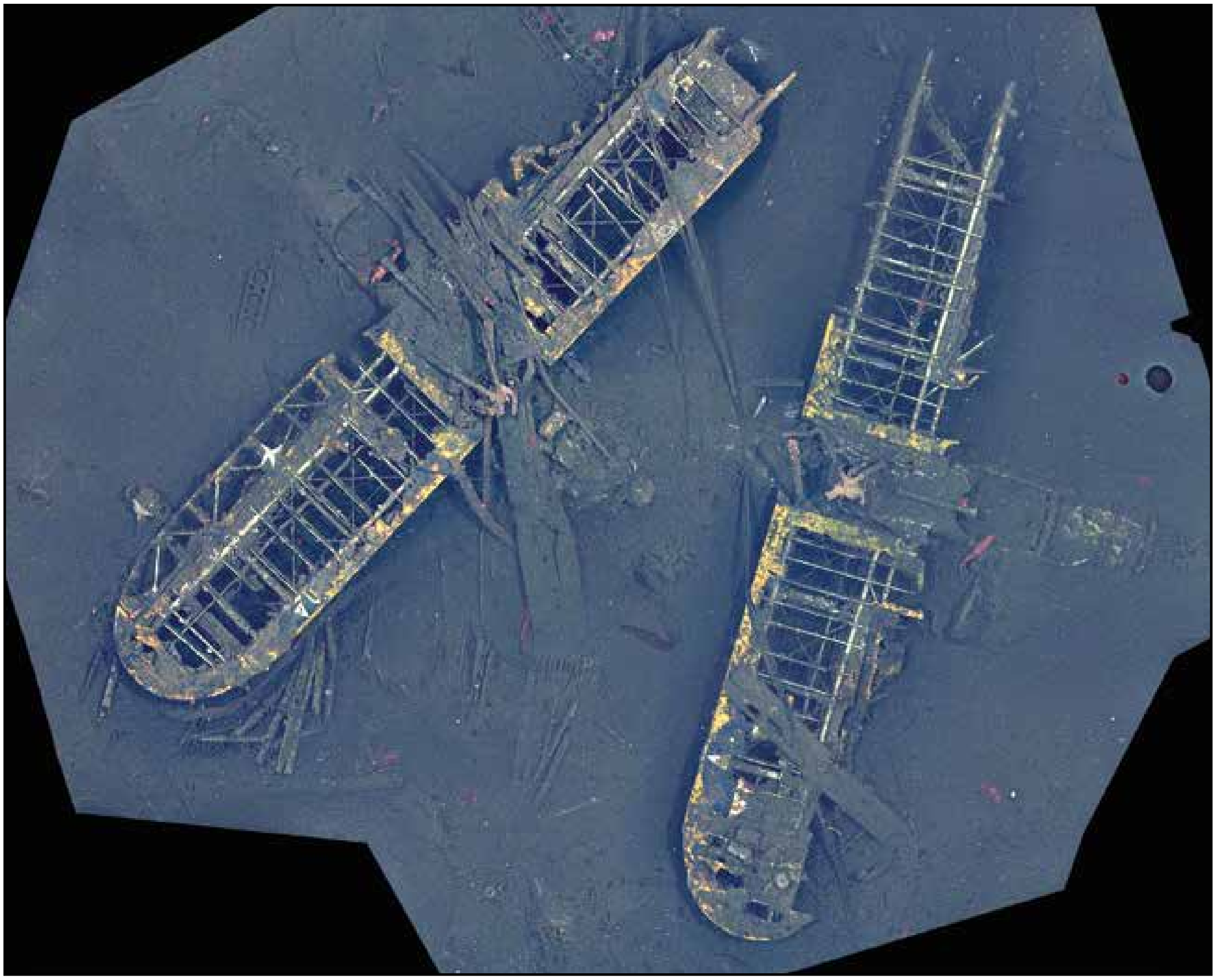


Photo: MBARI-NOAA/MBNMS-Ken Israel Integral Consulting Inc.

State of Sanctuary Resources: Seamount Environment

After the 2009 Condition Report was drafted, NOAA expanded Monterey Bay National Marine Sanctuary to include the Davidson Seamount. Davidson Seamount is the first seamount to be protected within a United States national marine sanctuary. The following information provides the first summary of conditions and trends for four resource areas in the seamount environment: (1.) water, (2.) habitat, (3.) living resources and (4.) maritime archaeological resources.

The Davidson Seamount is an undersea mountain habitat off the coast of central California, 75 miles (121 kilometers) due west of San Simeon. At 26 miles (42 kilometers) long and 8 miles (13 kilometers) wide, it is one of the largest known seamounts in U.S. waters. From base to crest, the seamount is 7,480 feet (2,280 meters) tall, yet its summit is still 4,101 feet (1,250 meters) below the sea surface.

In 1938, Davidson Seamount was the first to be characterized as a "seamount" by the United States Board on Geographic Names. Furthermore, it was named in honor of the United States Coast and Geodetic Survey scientist George Davidson, a leader in charting the waters of the West Coast.

New technology has only recently allowed scientists to bring back dramatic high resolution images from the deep-sea, offering researchers and the public an opportunity to witness the never before seen glimpses of rare marine species living in this largely cold, dark and mysterious habitat. The proximity of education and research institutions in the Monterey Bay region facilitate interdisciplinary collaborations that enhance research and education about this spectacular area.

The Office of National Marine Sanctuaries determined the Davidson Seamount requires protection from the take of or other injury to benthic organisms or those organisms living near the seafloor because of the seamount's special ecological and fragile qualities and potential future threats that could adversely affect these qualities.

As part of the 2008 Management Plan for MBNMS, a boundary change included the undersea mountain as Davidson Seamount Management Zone (DSMZ) (Figure 56). The boundary change added a 775 square mile (2,007 square kilometers) area to MBNMS, increasing MBNMS's area to 6,094 square miles (15,783 square kilometers).

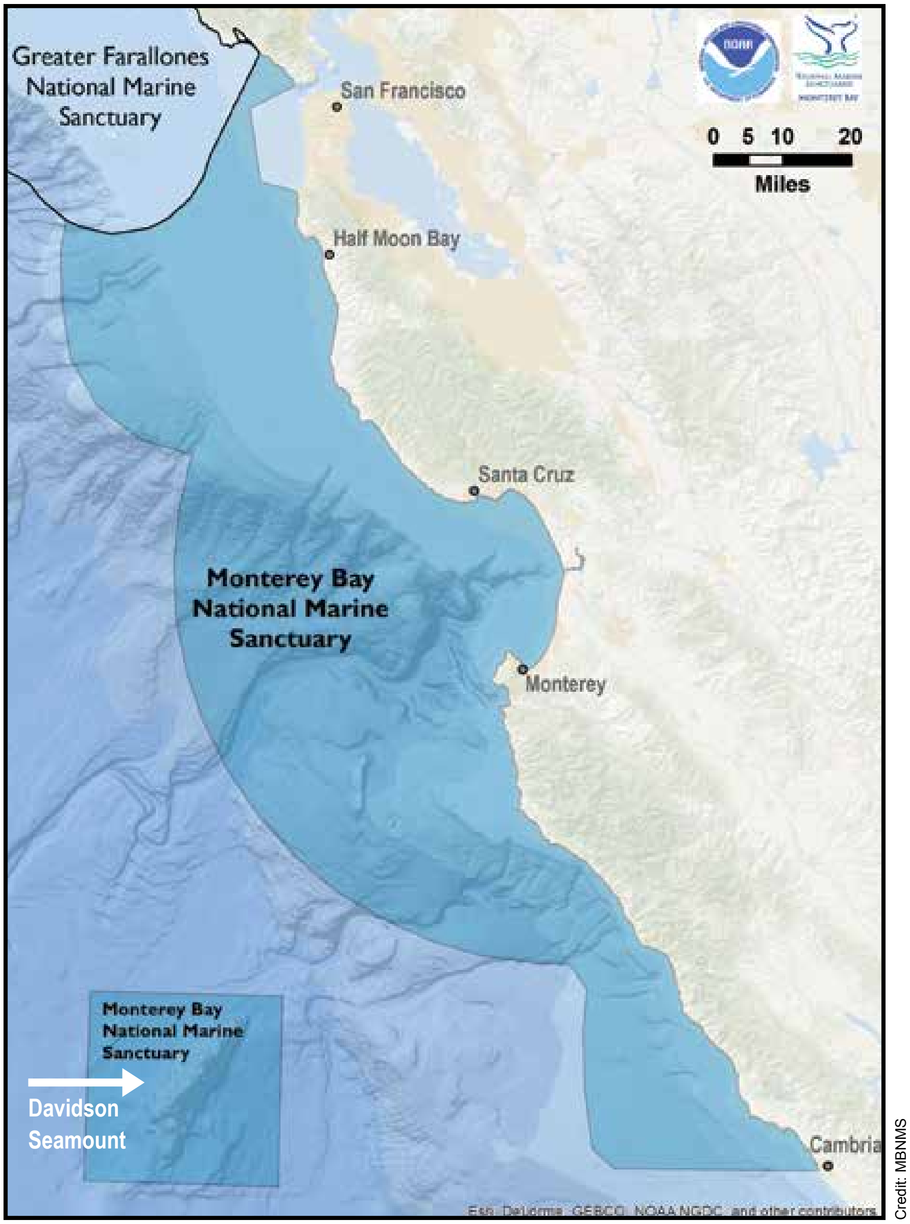


Figure 56. Monterey Bay National Marine Sanctuary, including Davidson Seamount Management Zone, which was added in November 2008.

Seamount Environment: Water Quality

Though relatively close to shore (70 nautical miles to the southwest of Monterey) and one of the largest known seamounts in U.S. waters, Davidson Seamount appears to be relatively pristine, based on observations of biological communities during sea surface and submersible explorations (2002-2010). No water quality monitoring occurs within Davidson Seamount Management Zone; however, an abundance of marine mammals and seabirds at the sea surface, and large, diverse, abundant cold-water corals and sponges on the seamount may indicate that the water quality is good and that there are few, if any, risks to human health.

Table 2. A recent threats assessment for Davidson Seamount Management Zone (DSMZ) describes the known existing and potential threats to DSMZ. Threat levels of low, medium and high were assigned to the various threats. To be assigned a threat level of low there must be (1.) existing regulations to protect against that threat, or (2.) it must be accepted that the activity associated with the threat is currently impossible or highly unlikely to occur. To be assigned a threat level of medium, there must be (1.) a possibility that the threat activity will occur (either legally through a permitting process or otherwise) despite existing regulations to protect against that threat, or (2.) there are no current protections against the threat, but also the threat activity is not known to occur. To be assigned a threat level of high, there must be no regulatory protections in place against the threat and the threat activity is known occur or is likely to occur. At present, vessel traffic, sea temperature rise and ocean acidification appear to be the most severe threats to DSMZ.

	Threat Level		
Threat	**Low**	**Medium**	**High**
Vessel Traffic			■ (red)
Submerged Vessels		■ (yellow)	
Military Activity		■ (yellow)	
Bio-Prospecting	■ (green)		
Cumulative Research Collection		■ (yellow)	
Commercial Harvesting: Waters Above Seamount		■ (yellow)	
Commercial Harvesting: Deep water Fisheries	■ (green)		
Commercial Harvesting: Coral Harvesting	■ (green)		
Oil and Gas Exploitation	■ (green)		
Deep-sea Mining	■ (green)		
Marine Debris/Dumping		■ (yellow)	
Underwater Cables		■ (yellow)	
Water Quality		■ (yellow)	
Sea Temperature Rise			■ (red)
Ocean Acidification			■ (red)

Credit: MBNMS 2012

1. ***Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?*** No information specific to DSMZ is available on specific stressors affecting water quality. For this reason, the rating for this question is "undetermined." A trend is "undetermined" due to a paucity of data. However, see the Offshore Environment section of this report for related information.

2. ***What is the eutrophic condition of sanctuary waters and how is it changing?*** No information specific to DSMZ is available on eutrophic conditions. For this reason, the rating for this question is "undetermined." A trend is "undetermined" due to a paucity of data. However, see the Offshore Environment section of this report for related information.

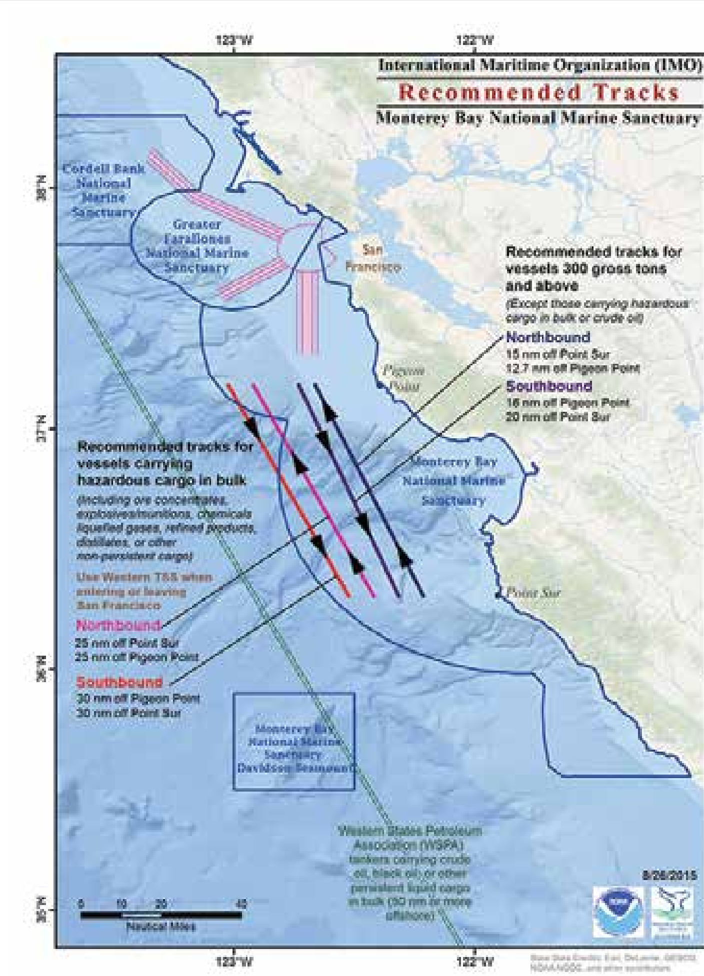
3. ***Do sanctuary waters pose risks to human health?*** No information specific to DSMZ is available on risks to human health. For this reason, the rating for this question is "undetermined." A trend is "undetermined" due to a paucity of data. However, see the Offshore Environment section of this report for related information.

4. ***What are the levels of human activities that may influence water quality and how are they changing?*** Threats exist to water quality in Davidson Seamount Management Zone, such as vessel traffic, marine debris/dumping and global climate change (see Table 2 for a full list of potential threats and their ratings). At present, vessel traffic, sea temperature rise and ocean acidification appear to be the most severe threats to DSMZ (MBNMS 2012). Recently, the levels of large vessel traffic in and around DSMZ were quantified; however, the activity level of other threats has not been quantified, and it is unknown if the cumulative activity level is changing. Concurrently, these activities' potential impacts to water quality and other resources in DSMZ have not been studied. Therefore, this question is rated "good/fair" with an "undetermined" trend.

Threats to water quality from vessel traffic include oil or chemical spills and discharges, loss of cargo and other marine debris, ship-based pollution (i.e., residues from tank cleaning), exchange of ballast water and noise pollution (MBNMS 2012). When compared to coastal waters, DSMZ's offshore location reduces the risk of impacts from accidents and spills caused by collisions and groundings. However, transiting vessels, in particular those carrying crude oil, bunker fuel or other hazardous materials, have the potential to impact water quality in DSMZ (MBNMS 2012).

DSMZ's northeast corner is bisected by the Western States Petroleum Association (WSPA) recommended shipping tracks for tankers that carry crude oil, black oil or other persistent liquid cargo in bulk (Figure 57). Miller (2011) found that the average number of vessel transits through DSMZ in 2010 was 159 per month. An analysis of vessel traffic (2009-2012) indicates that a great majority of the large vessels that transit in or near MBNMS comply with the WSPA and International Maritime Organization (IMO) recommended tracks shown in Figure 57 (De Beukelaer et al. 2014). For example, Automatic Identification Systems (AIS) data from 2011 show that the majority of tankers cross over DSMZ near the WSPA recommended track and the majority of cargo vessels transited between DSMZ and MBNMS on MBNMS's western boundary via the IMO recommended tracks (Figure 58).

It would be useful to further explore the AIS data for trends in the number of vessels that transit through DSMZ on a monthly or annual basis. Data on the contents of each vessel and the levels of discharge from these vessels would improve understanding of the threat posed by tanker traffic and how this has changed over time. However, based on known impacts of previous spills elsewhere and known levels of vessel traffic, these pressures are considered to have the potential to degrade water quality, and may preclude full function of living resource assemblages and habitats, should they occur.



Source: MBNMS(http://montereybay.noaa.gov/materials/maps/vessel_lanes1_lg.jpg)

Figure 57. International Maritime Organization (IMO) recommended tracks for large shipping vessels (greater than 300 gross tons), including container ships, bulk freighters, hazardous materials carriers and tankers. Western States Petroleum Association recommends tankers carrying crude oil, black oil or other persistent liquid cargo in bulk to transit 50 nautical miles or more offshore.

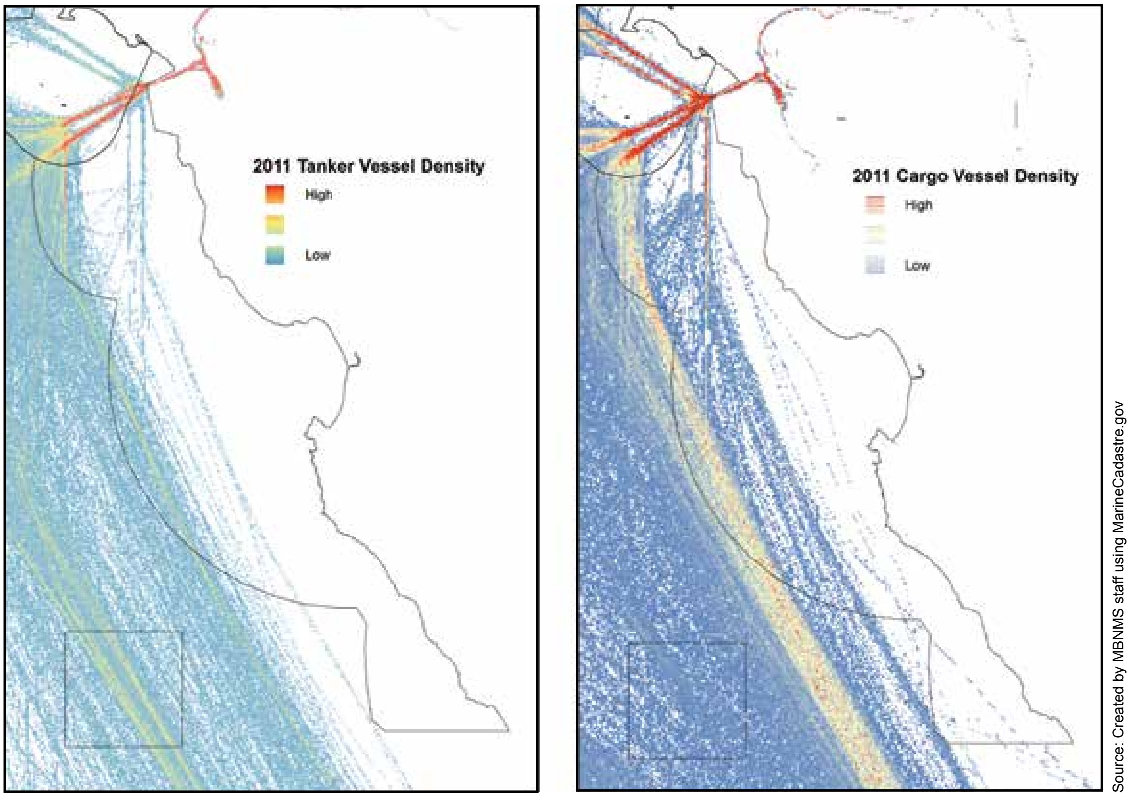


Figure 58. 2011 vessel density data for cargo vessels and tankers based on Automatic Identification Systems (AIS) data. AIS are navigation safety devices that transmit and monitor the location and characteristics of many vessels in U.S. and international waters in real-time. The map service from MarineCadastre.gov was used to represent the density of cargo and tanker vessel traffic in 2011 from vessels with AIS transponders in 100 meter grid cells. The data are best interpreted using high to low density. The map shows that the majority of the tankers cross over DSMZ, but that the majority of cargo vessels actually transit between DSMZ and MBNMS and on MBNMS's western boundary via the IMO recommended tracks for vessels that carry hazardous cargo in bulk.

Seamount Environment
Water Quality Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
1	Stressors	?	Status: N/A (not updated) Trend: N/A (not updated)	No information available specific to DSMZ; however, see the open ocean section of this report.	Not enough information to make a determination.
2	Eutrophic Condition	?	Status: N/A (not updated) Trend: N/A (not updated)	No information available specific to DSMZ.	Not enough information to make a determination.
3	Human Health	?	Status: N/A (not updated) Trend: N/A (not updated)	No information available specific to DSMZ.	Not enough information to make a determination.
4	Human Activities	?	Status: Medium Trend: Medium	Large vessel, particularly tankers, transiting through DSMZ poses a threat to water quality, but no known impacts from this activity. More information needed on levels and trends of other potential threats.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on water quality.

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

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

Seamount Environment: Habitat

5. ***What is the abundance and distribution of major habitat types and how is it changing?*** The abundance and distribution of major habitat types in the sanctuary's seamount environment is rated "good." Habitat quality is considered to be in pristine or near-pristine condition due to limited past and current levels of human activities that could influence the distribution, abundance, and quality of benthic habitats. The trend is rated "not changing" due to the seamount's remote nature, and current regulations by Monterey Bay National Marine Sanctuary and NOAA Fisheries that prohibit alteration of the seafloor and use of bottom-contact fishing gear, respectively.

The geological structure and origin of five central California seamounts (Davidson, Guide, Pioneer, Gumdrop and Rodriguez) have only recently been described as an atypical type of oceanic volcanism, having northeast-trending ridges that reflect the ridge-parallel structure of the underlying crust (Davis et al. 2002). The Davidson Seamount consists of about six subparallel linear volcanic ridges separated by narrow valleys that contain sediment. These ridges are aligned parallel to magnetic anomalies in the underlying ocean crust. The seamount is 12.2 ± 0.4 million years old and formed about eight million years after the underlying mid-ocean ridge was abandoned. Unlike most intraplate ocean island volcanoes, the seamounts are built on top of spreading center segments that were abandoned at the continental margin when the tectonic regime changed from subduction to a transform margin (Davis et al. 2007). Davidson Seamount is the largest of the five seamounts; it is ~42 kilometers long, ~13 kilometers wide and rises ~2,280 meters from the ocean floor to a water depth of ~1,250 meters (Davis et al. 2002). Its volume above the seafloor is~320 cubic kilometers (Davis et al. 2002).

DSMZ's benthic habitat (775 square miles) can be partitioned into three habitat types: (1.) summit, (2.) flanks (or slope) and (3.) base (McClain et al. 2010). In addition, the water column habitat (1,595 cubic miles) can be partitioned into three habitat types: (1.) sea surface, (2.) mid-water and (3.) bentho-pelagic. Structure-forming invertebrates, such as the many species of corals and sponges at Davidson Seamount, hold an important ecological role to create habitat structure, and are vulnerable to disturbance from human activities (MBNMS 2012).

Due to its deep, offshore location, few institutions have conducted research activities at the seamount (i.e., MBNMS, MBARI, USGS). Most of the research involves video surveys; however, rocks and biogenic habitat have been collected, as well as the occasional placement of anchored markers for repeated measurements (e.g., coral age and growth studies). Collectively, these activities have a small footprint and do not threaten the abundance and distribution of habitat types.

During a 2006 ROV dive survey, researchers discovered a telecommunications cable that runs along the side of the seamount (MBNMS 2012). The history and current status of the cable is unknown. Submarine cables could become destructive to biogenic habitats (e.g., corals and sponges) if they become mobile.

Recent regulatory actions were taken to protect the seafloor on and around Davidson Seamount. In June 2006, NMFS prohibited fishing with bottom contact gear (or any other gear) below 3,000 feet in the Davidson Seamount Essential Fish Habitat (EFH) Conservation Area (NMFS, DOC 2006). In November 2008, Monterey Bay National Marine Sanctuary expanded to include Davidson Seamount Management Zone. Standard sanctuary regulations apply (including the seabed alteration prohibition), and the "take"[61] of biological or non-biological resources below 3,000 feet is prohibited (DOC 2008). The Davidson Seamount EFH Conservation Area and DSMZ share the same boundaries and were created to address potential threats to the seamount and natural resources (MBNMS 2012). The seamount itself is too deep for most fish trawling methods, where fish density is very low, and the species seen to date are not commercially desirable.

6. ***What is the condition of biologically-structured habitats and how is it changing?*** Deep-sea corals and sponges are the seamount's primary structure-forming species. Based on recent surveys, they appear to be in pristine or near-pristine condition; however, historic information on the distribution and abundance of these resources is not available and information on current distribution, abundance and condition of these organisms is limited. In addition, it is unknown when global climate change (e.g., sea temperature rise, ocean acidification) will affect structure-forming species in the seamount environment. It is for these reasons that the condition of the seamount's biologically-structured habitats is rated "good" and the trend is "undetermined."

Most of the organisms found at seamounts are large, sessile organisms, such as corals and sponges (Figure 59). ROV surveys to Davidson Seamount have recorded a variety of corals and sponges, including black corals (Order Antipatharia), soft corals (Order Alcyonacea), sea fans (Order Gorgonacea) and sponges (Phylum Porifera); approximately 22 coral and 24 sponge taxa in

[61] "Take" defined as: "Moving, removing, taking, collecting, catching, harvesting, disturbing, breaking, cutting, or otherwise injuring, or attempting to move, remove, take, collect, catch, harvest, disturb, break, cut, or otherwise injure, any Sanctuary resource located more that [sic.] 3,000 feet below the sea surface within the Davidson Seamount Management Zone." 15 CFR § 922.132(11)(i)

total (Burton and Lundsten 2008). Davidson Seamount's invertebrate community at Davidson Seamount is dominated by passive suspension-feeding invertebrates (mostly corals) (Lundsten et al. 2009a). The hard rock substrate and elevated current velocities often found at the seamount appear to provide habitat favorable to sessile suspension and filter-feeding invertebrates.

Large, sessile corals and sponges are used as a habitat by other organisms. They serve as hard substrate for attachment by other sessile organisms (e.g., basket stars, sea stars, scale worms, other corals, other sponges) and as shelter or food by some mobile organisms (e.g., fishes, skate egg cases, crabs, shrimps). There is increasing evidence that many areas of deep-sea coral and sponge habitats function as ecologically important habitats for fishes and invertebrates (Hourigan et al. 2007).

DeVogelaere et al. (2005) found that all of the deep-sea corals observed at Davidson Seamount (with the exception of *Anthomastus*) had other obvious megafauna associated with them. Polychaete worms, isopods, shrimps, crabs, basket stars, crinoids, brittle stars and anemones lived on the corals. Fauna observed adjacent to corals were grenadier (*Coryphaenoides* spp.), thornyheads (*Sebastolobus* sp.), sponges, other corals, sea stars, clams, sea cucumbers and octopi (*Graneledone* sp.).

Species assemblages at Davidson Seamount's summit contain dense aggregations of corals and sponges (McClain et. 2009). These species also occur at similar depths along the rocky walls of Monterey Canyon, but at far lower densities or dominance, and they are smaller in size. These preliminary results suggest that the structure of seamount assemblages may differ from other deep benthic habitats and may prove to be source populations for many deep-sea species.

Bubble gum coral (*Paragorgia* spp.) are the most dramatic corals at Davidson Seamount due to their size (>2 x 2 meters in height and width) and dense aggregations ("forests") on local peaks and adjacent steep slopes (Figure 60) (DeVogelaere et al. 2005, Clague et al. 2010). *Paragorgia arborea* is considered to have a high rating of structural importance, due to its large size, branching morphology, many associations with other species and high relative abundance (Whitmire and Clarke 2007).

Age and growth studies of cold-water corals at Davidson Seamount indicate they are slow growing and long-lived

Credit: NOAA/MBARI

Figure 59. Primoid coral (*Narella* sp.), black coral (T*rissopathes pseudotristicha*) and feather stars (*Florometra serratissima*) on the Davidson Seamount (2,669 meters).

Figure 60. Bubble gum coral (*Paragorgia arborea*) on the Davidson Seamount (1,313 meters).

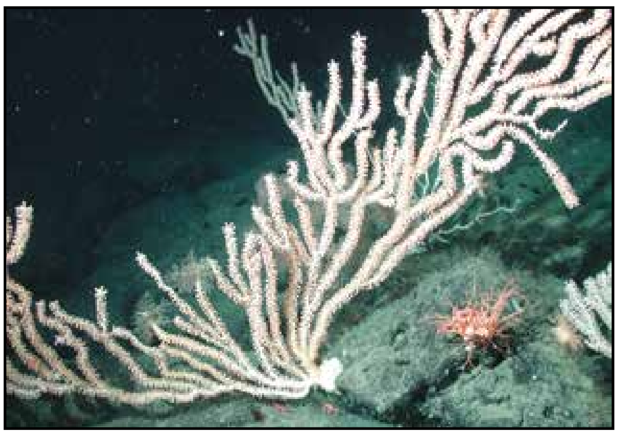


Figure 61. Bamboo coral (*Keratoisis* sp.) on the Davidson Seamount (1,455 meters). Coral colony age estimates exceed 200 years (Andrews et al. 2005).

Figure 62. Precious coral (*Corallium* sp.) and basket stars (*Gorgonocephalus* sp.) on the Davidson Seamount (1,692 meters).

(Andrews et al. 2005, 2007, 2009). Radiometric ageing results for two bamboo coral colonies (*Keratoisis* sp.) converged on a radial growth rate of ~0.055 millimeters per year (Figure 61). One colony was aged at 98 ± 9 years, with an average axial growth rate of ~0.7 centimeters per year. The age of a large colony was >145 years with an estimated axial growth rate of 0.14 to 0.28 centimeters per year. A linear (axial) growth rate of approximately 0.25 centimeters per year led to a colony age of about 115 years for the precious coral (*Corallium* sp.); however, based on the radial growth rate, an age of up to 200 years is possible (Figure 62). Due to the slow growth of these habitat-forming organisms, recovery from any damage could be slow (i.e., many decades to centuries).

These slow growing and long-lived structure-forming species are vulnerable to disturbances from human activities that impact the seafloor (see Table 2 for a summary of threats). Currently, the sanctuary's seamount environment is well-protected from many activities that could alter the seafloor, such as bottom-contact fishing (see Seamount Question 5). And, to date, few activities have occurred on the seamount seafloor due to its remote nature (i.e., offshore and deep).

DSMZ is bisected by the shipping tracks of tankers that carry crude oil, black oil or other persistent liquid cargo in bulk (see Figure 57); however, spills from these ships will not likely impact benthic habitat. Another class of threat related to vessel traffic is the possibility for cargo from container ships to be lost at sea (MBNMS 2012). Impacts of lost cargo can include the threat of habitat crushing or smothering habitat and the introduction of foreign habitat structures. Cargo vessels transit the waters immediately adjacent to DSMZ (see Figure 58), but there have been no known impacts to structure-forming species from lost cargo in DSMZ.

At present, sea temperature rise and ocean acidification appear to be two of the most severe threats to DSMZ (Table 2). Rogers et al. (2007) suggest changes in ocean chemistry resulting from climate change may result in large-scale changes in the faunal composition of seamount communities, especially where corals play a role in structuring the environment and providing habitats for other species. We are not aware of any temperature or pH impacts on the condition of structure-forming species at DSMZ, but there is very little information available. We need to monitor ocean temperature and chemistry, and the condition of structures-forming species.

7. ***What are the contaminant concentrations in sanctuary habitats and how are they changing?*** Contaminant concentrations in the seamount environment are poorly understood. There have been very few sediment samples collected within DSMZ for the purpose of contaminant studies. As a

result, the assessment of contaminant concentrations is "undetermined" with an "undetermined" trend.

It is known, however, that its depth and distance from land do not prevent the seamount environment from impacts from point and non-point water pollution (MBNMS 2012). For example, traces of the pesticide DDT, banned in the U.S. since 1972, but still present in watershed sediments, were detected in sediments near the base of the seamount and probably transported through Monterey Canyon sediment flow events (C. Paull, MBARI, unpub. data, Hartwell 2008). Further work is needed to understand contaminant concentrations, transport pathways and changes in contaminant concentrations over time.

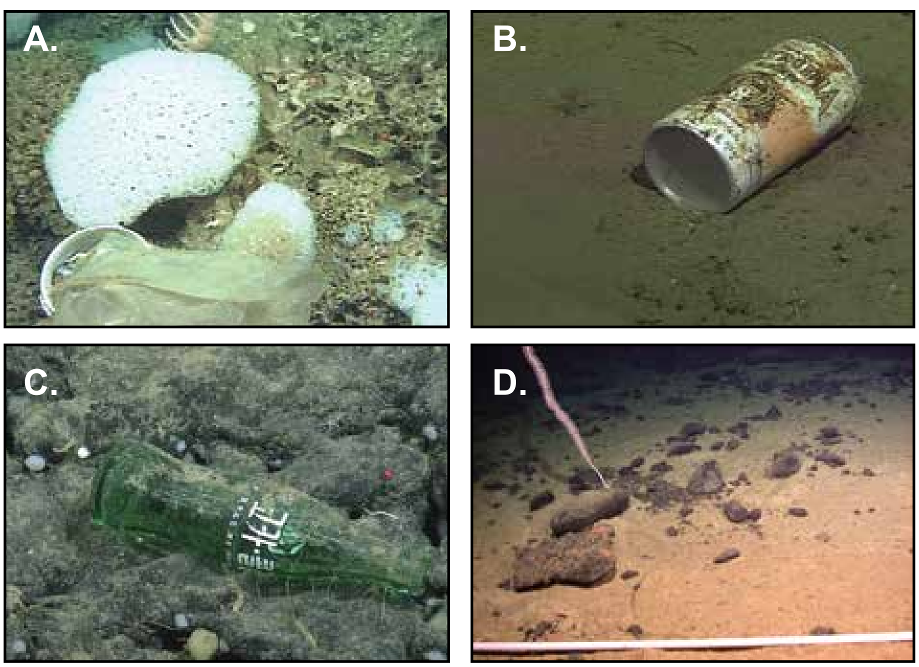
8. *What are the levels of human activities that may influence habitat quality and how are they changing?*

Various existing and potential threats to Davidson Seamount's habitat quality include: vessel traffic (e.g., loss of cargo, noise pollution); sunken vessels; military activity (e.g., dumping of dangerous waste, acoustic impacts to marine mammals); bioprospecting; cumulative research collection; commercial harvesting (e.g., deep-sea fisheries, coral harvesting); oil and gas exploitation; mining; marine debris/dumping; underwater cables; sea temperature rise; and ocean acidification (see Table 2 for a comprehensive list of threats). The activity levels of many of these threats have not been quantified, and it is unknown if the cumulative level of these threats is changing. Therefore, this question is rated "good/fair" with an "undetermined" trend.

Davidson Seamount is one of the world's few seamount areas to receive the level of protection afforded by Monterey Bay National Marine Sanctuary and NOAA Fisheries (see response to Seamount Question 5 for more details). Sanctuary regulations provide important – although not comprehensive – defenses against many of these identified threats to benthic habitat. Furthermore, the depth of Davidson Seamount's summit, flanks (or slope) and base habitats make some forms of exploitation impossible or highly unlikely (MBNMS 2012).

Benthic habitats within DSMZ exhibit evidence of cumulative intentional and accidental dumping (MBNMS 2012, Schlining et al. 2013, DeVogelaere et al. 2014). During ROV surveys in 2002 and 2006, 44 pieces of marine debris were observed and documented (41% metal and 25% plastic). Specific items included bottles, cans, brooms, newspaper, buckets, curtains and a train wheel (Figure 63). The effects of pressure, temperature, darkness and relatively calm waters deep within DSMZ can preserve debris. The debris discovered thus far is likely proportional to sampling effort, and future research expeditions are bound to uncover additional materials of anthropogenic origin (MBNMS 2012).

Some of the debris observed at the seamount was likely lost or dumped from large vessel transiting through DSMZ. The possibility of lost cargo containers is an additional threat to benthic



Credit: NOAA/MBARI (copied from DeVogelaere et al. 2014)

Figure 63. Examples of marine debris observed on Davidson Seamount: (a.) a plastic bag on top of a sponge limits the ability of the sponge to filter food from the water; (b.) an Olympia beer can was found at 8,589 feet; (c.) a Coca-Cola bottle, that originated in South Korea, was likely lost off an oil tanker or container ship; and (d.) a communications cable, of unknown origin, is visible in the lower part of this image.

habitat (MBNMS 2012). Impacts of lost cargo can include the threat of habitat crushing or smothering and the introduction of foreign habitat structures (see Offshore Question 5 and Figure 40). Cargo vessels transit the waters immediately adjacent to the DSMZ (see Figure 58), but there have been no known impacts to habitat from lost cargo in DSMZ.

During a 2006 ROV dive survey, researchers discovered a telecommunications cable that runs along the side of the seamount (Figure 63d) (MBNMS 2012). The history and current status of the cable is unknown. Submarine cables could become destructive to biogenic habitats (e.g., corals and sponges), if they become mobile.

At present, sea temperature rise and ocean acidification appear to be two of the most severe threats to DSMZ (Table 2). Rogers et al. (2007) suggest changes in ocean chemistry resulting from climate change may result in large-scale changes in the faunal composition of seamount communities, especially where corals play a role in structuring the environment and providing habitats for other species. We are not aware of temperature or pH impacts on the condition of structure-forming species at DSMZ, but there is very little information available. Sea temperature rise and ocean acidification are global phenomena and require regulation at larger geographical scales beyond the jurisdiction of sanctuary management (MBNMS 2012); however, making note of them here will allow managers within and beyond the sanctuary to anticipate and respond to these pressures.

Seamount Environment Habitat Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
5	Abundance/Distribution	– (Good)	Status: Very High Trend: High	Offshore location, existing level of protections and limited access to the seafloor may limit impacts.	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
6	Biologically-Structured	? (Good)	Status: Very High Trend: Medium	Biogenic species appear abundant; organisms larger, more robust than coastal canyon areas. Trend information unavailable.	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.
7	Contaminants	? (Undet.)	Status: N/A Trend: N/A	Contaminant concentrations in DSMZ are poorly understood. There have been very few sediment samples collected within DSMZ for the purpose of contaminant studies.	Not enough information to make a determination.
8	Human Impacts	? (Good/Fair)	Status: High Trend: Medium	Harmful activities exist, but offshore location, existing level of protections and limited access to the seafloor may limit impacts.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.

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

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

Seamount Environment: Living Resources

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

Key species, such as keystone species, indicators species, sensitive species and those targeted for special protection, are discussed in the responses to questions 12 and 13. Status of key species will be addressed in question 12 and refers primarily to population numbers. Condition or health of key species will be addressed in question 13. The sanctuary's key species are numerous and cannot all be covered here. Instead, in this report, we emphasize various examples from the sanctuary's primary habitats that have data available on status and/or condition.

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

9. ***What is the status of biodiversity and how is it changing?*** In recent history, it is unlikely that species have become locally extinct or that species richness has declined in the marine ecosystem within DSMZ. Some baseline information on local biodiversity has been collected by surveys of the seafloor and sea surface. For these reasons, the status of biodiversity in the seamount environment is rated as "good" with an "undetermined" trend.

Seamount Benthos

In 2002 and 2006, the sanctuary led two multi-institutional expeditions to characterize the geology and natural history of Davidson Seamount. Approximately 140 hours of video and samples were collected during 17 remotely operated vehicle (ROV) dives. Most dives were primarily on the seafloor, with opportunistic dives in the water column above the seamount. At least 237 taxa were observed, including 18 previously undescribed species (Burton and Lundsten 2008, E. Burton, MBNMS, unpubl. data).

The Davidson Seamount is a relatively pristine area populated by a diversity of cold-water corals, most of which have other species associated with them (see Seamount Environment Habitat Question 6) (DeVogelaere et al. 2005). While most of the corals were found on the seamount's highest peaks, others were found deeper, and still, almost exclusively on ridge formations.

Species assemblages at the seamount summit contain dense aggregations of corals and sponges (McClain et al. 2009). These species are encountered at similar depths along rocky walls of Monterey Canyon, but at far lower densities or dominance, and they are smaller in size. Preliminary results suggest that structure of seamount assemblages may differ from other deep-sea benthic habitats and prove to be source populations for many deep-sea species.

Species diversity and density at Davidson Seamount do not significantly change with depth, and can vary greatly on a single isobath (McClain et al. 2010). Authors suggest the lack of clear bathymetric pattern in diversity or density may reflect the proximity of Davidson Seamount to highly productive coastal waters fueled by coastal upwelling. However, changes of 50% in assemblage composition were observed over a ~1,500 meter depth interval down the flanks of the seamount (McClain et al. 2010).

Seamount Sea Surface

Several ship-based and aerial surveys have taken place at Davidson Seamount to determine the occurrence of marine mammals, seabirds or surface-swimming fishes (Figure 64) (Benson 2002, Forney 2002, King 2010, Newton and DeVogelaere 2013). The majority of these surveys were opportunistic, and limited in range or duration. In July 2010, sanctuary staff and regional experts conducted a dedicated, ship-based survey of the waters above and around the Davidson Seamount. Eight transect lines were surveyed for a total of 605 kilometers of "on-effort" observations. Seventeen species of seabirds and six marine mammal species were observed (Newton and DeVogelaere 2013). Overall, 200 sightings of 668 individual marine mammals were counted during the three day survey. Fin whales (*Balaenoptera physalus*) were the most commonly encountered marine mammal (51% of all marine mammal sightings) (Figure 65). Additionally, there were 316 sightings of 1,033 individual seabirds comprising 17 different species. Cook's Petrel (*Pterodroma cookii*) and Leach's Storm-Petrel (*Oceanodroma leucorhoa*) were the two most commonly encountered species (77% of seabird sightings and 82% of all seabirds observed). Including off effort sightings, observers recorded the greatest number of Cook's Petrel ever observed in California waters (5,125 total birds).

Credit: Steve Choy/NOAA MBNMS

Figure 64. Black-footed Albatross (*Phoebastria nigripes*).

Credit: Abe Borker/NOAA

Figure 65. Fin whale (*Balaenoptera physalus*) above Davidson Seamount.

10. What is the status of environmentally sustainable fishing and how is it changing? We no longer assess this question in ONMS condition reports; therefore, content for this question was not included.

11. What is the status of non-indigenous species and how is it changing? There are no known non-indigenous species within the seamount environment (Burton and Lundsten 2008, Lundsten et al. 2009a, 2009b). Non-indigenous species in offshore habitats are not suspected or do not appear to affect ecosystem integrity because very few non-indigenous species have been identified in these habitats. Hence, this question is rated "good" and the trend is "not changing."

12. What is the status of key species and how is it changing? The status of key species in the offshore environment is rated "good/fair" and the trend is "increasing." Key species include cold-water corals (biogenic species), marine mammals (i.e., fin whale) and fisheries-targeted pelagic fishes (i.e., albacore, swordfish, common thresher shark). Cold water corals (biogenic habitat) may represent indicators of ecosystem condition or change, marine mammals are considered charismatic species and pelagic fishes are key species due to their important role in commercial and recreational fisheries. While coral species appear to reflect near-pristine conditions, whale and fished species do not, leading to a good/fair rating.

Biogenic Species

Structure-forming invertebrates at Davidson Seamount, such as the many species of cold-water corals and sponges, hold an important ecological role to create habitat structure for other species (Figure 66). All of the deep-sea corals observed at Davidson Seamount (with the exception of *Anthomastus*) had other obvious megafauna associated with them (DeVogelaere et al. 2005). Polychaete worms, isopods, shrimps, crabs, basket stars, crinoids, brittle stars and anemones lived on the corals. Present adjacent to corals were grenadier (*Coryphaenoides* spp.), thornyhead (*Sebastolobus* sp.), sponges, other corals, seastars, clams, sea cucumbers and octopi (*Graneledone* sp.).

Credit: NOAA/MBARI

Figure 66. Yellow sponge (*Staurocalyptus* sp.), basket star (*Gorgonocephalus* sp.), white ruffle sponge (*Farrea occa)*, and white branched sponge (*Asbestopluma monticola*) on the Davidson Seamount (1,316 meters).

Observations from Davidson Seamount show that summit assemblages contain dense aggregations of corals and sponges (McClain et al. 2009). These species are encountered at similar depths along the rocky walls of Monterey Canyon, but at far lower densities or dominance than at Davidson Seamount. Lundsten et al. (2010) identified 25 coral species at Davidson Seamount. The Gorgonacea (e.g., bubble gum corals, *Paragorgia* spp.) were the most frequently observed coral group (73%) and encompassed the widest depth range. Other coral groups included Antipatharians (black corals, 21.8%), Alcyonacea (4.7%), Scleractinia (0.4%), Zoanthidea (0.09%) and Pennatulacea (0.07%).

Bubble gum corals (*Paragorgia* spp.) are the most dramatic corals observed at Davidson Seamount due to their size (>2 x 2 meters in height and width) and dense aggregations ("forests") on local peaks and adjacent steep slopes (DeVogelaere et al. 2005, Clague et al. 2010). These corals are thought to reach the largest size of any sedentary colonial animal (Hourigan et al. 2007). For example, colonies of *Paragorgia arborea* in New Zealand have been reported to reach 10 meters in height (Smith 2001, Hourigan et al. 2007).

Age and growth studies of cold-water corals at Davidson Seamount indicate they are slow growing and long-lived, with some colonies aged at over 100 years old (see Seamount Question 6 for more details) (Andrews et al. 2005, 2007, 2009). Due to their large size and slow growth, deep-sea corals and sponges are vulnerable to disturbance from human activities that contact the seafloor. Sanctuary regulations prohibit the take of corals, unless permitted for research purposes. In addition, the seamount is protected from bottom fishing gear through essential fish habitat designation. Therefore, coral removal is unlikely and closely regulated.

Marine Mammals

Several ship-based and aerial surveys have taken place at Davidson Seamount to determine the occurrence of marine mammals, seabirds or surface-swimming fishes (Benson 2002, Forney 2002, King 2010, Newton and DeVogelaere 2013). The majority of these surveys were opportunistic, and limited in range or duration. In July 2010, the first dedicated, multi-disciplinary survey of marine mammal, seabird and oceanographic conditions at the Davidson Seamount occurred (Newton and DeVogelaere 2013). During the three day ship-based survey, there were 200 sightings of 668 individual marine mammals (Newton and DeVogelaere 2013). Fin whales (*Balaenoptera physalus*) were the most commonly encountered marine mammal (51% of all marine mammal sightings). The California/Oregon/Washington fin whale stock is listed as federally endangered, and there is some indication that the population may be growing (Carretta et al. 2013). While we have less information on other marine mammals in the area, the following species have also been observed: Dall's porpoise (*Phocoenoides dalli*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) and Northern right whale dolphin (*Lissodelphis borealis*) (Newton and DeVogelaere 2013).

Fisheries-Targeted Species

In recent years, two commercial finfish fisheries have operated in the top 150 feet (46 meters) of water above Davidson Seamount to target highly migratory pelagic species: (1.) drift gillnetting for swordfish and sharks, and (2.) trolling for albacore (NOAA 2008, MBNMS 2012). Swordfish and pelagic sharks are primarily caught with drift gillnets. Albacore (*Thunnus alalunga*) are caught both commercially and recreationally by trolling lures or live bait. Fishermen have reported that the seamount may enhance albacore fishing in certain years (NOAA 2004, MBNMS 2012). The seamount itself is too deep for most fish trawling methods, where fish density is very low, and with the exception of thornyhead, the species seen to date are not commercially desirable.

The North Pacific albacore stock area consists of all waters in the Pacific Ocean north of the equator (ALBWG 2014). Estimates of total stock biomass (age-1 and older) show a long term decline from the early 1970s to 1990, followed by a recovery through the 1990s and subsequent fluctuations without trend in the 2000s. Based on the results of the stock assessment, the North Pacific albacore stock is not experiencing overfishing and probably not in an overfished condition. The Albacore Working Group (ALBWG) concludes that the North Pacific albacore stock is healthy and that current productivity is sufficient to sustain recent exploitation levels, assuming average historical recruitment in both the short and long-term.

The North Pacific common thresher shark (*Alopias vulpinus*) stock has not been fully assessed. The U.S. West Coast Exclusive Economic Zone (EEZ) regional catch and catch per unit effort (CPUE) suggests the population is increasing from estimated low levels in the early 1990s (PFMC 2014).

The northeast Pacific's swordfish (*Xiphias gladius*) stock is healthy, is not overfished, overfishing is not occurring and biomass is greater than the biomass at which maximum sustainable yield (MSY) is produced (Marsh and Stiles 2011, ISC 2014).

13. What is the condition or health of key species and how is it changing? The condition or health of key species in the offshore environment is rated "good" and the trend is "not changing." The health of coral and other biogenic species seems good. There are some concerns about impacts of ocean chemistry changes on these species, but further study is needed to determine if there have been any impacts to populations at Davidson Seamount. The response to Offshore Question 13 provides a general summary of health concerns for marine mammals in the offshore waters, including entanglement in and ingestion of marine debris and the bioaccumulation of contaminants. There are some DSMZ-specific threats to marine mammal health (e.g., vessel traffic, noise), but little data is available to assess impacts of those threats in DSMZ. Fisheries-targeted species (e.g., albacore, swordfish, thresher shark) have no known DSMZ-specific health issues. These long-lived fishes can have elevated levels of contaminants, such as mercury, but DSMZ is not a source of those contaminants.

Biogenic Species

Age and growth studies of cold-water corals at Davidson Seamount indicate they are slow growing and long-lived (Andrews et al. 2005, 2007, 2009). Radiometric ageing results for two bamboo coral colonies (*Keratoisis* sp.) converged on a radial growth rate of ~0.055 millimeters per year. One colony was aged at 98 ± 9 years, with an average axial growth rate of ~0.7 centimeters per year. The age of a large colony was >145 yearswith an estimated axial growth rate of 0.14 to 0.28 centimeters per year. A linear (axial) growth rate of approximately 0.25 centimeters per year led to a colony age of about 115 years for the precious coral (*Corallium* sp.); however, based on the radial growth rate, an age of up to 200 year is possible. Due to the slow growth of these habitat-forming organisms, recovery from any damage could be slow (i.e., many decades to centuries).

Bubblegum corals' growth rates are not well-defined (Hourigan et al. 2007). Age estimates using skeletal cross sections from one Davidson Seamount colony (*Paragorgia arborea*) (80 centimeters from base to tip along main axis) suggest 9 to 14 years (Andrews et al. 2005). When translated to a linear growth rate, the estimate is relatively high: 6-9 centimeters per year. However, counting of these growth zones was very subjective and should be interpreted with caution. Radiocarbon-dating of a very large New Zealand *Paragorgia arborea* colony resulted in preliminary age estimates ranging between 100-200 years for the tip of the colony, and between 300-500 years for the base of the colony (Tracey et al. 2003).

Sanctuary regulations prohibit the take of corals, unless permitted for research purposes. In addition, the seamount is protected from bottom fishing gear in essential fish habitat. Therefore, coral removal is unlikely and closely regulated.

Marine Mammals

Vessel traffic can cause health concerns for key marine mammal species. The northeast corner of DSMZ is bisected by shipping tracks of tankers that carry crude oil, black oil or other persistent liquid cargo in bulk (see Figure 57). Threats from vessel traffic include oil or chemical spills, loss of cargo, ship-based pollution (i.e., residues from tank cleaning), exchange of ballast water and noise pollution.

Additionally, low frequency sounds produced by vessels have acoustic impacts that are not confined to coastal waters, but penetrate deep waters (MBNMS 2012). Impacts from this type of pollution remain uncertain for cetaceans and other species that spend a large part of their life in deep waters and use sound to communicate, navigate, feed and sense their environment (UNEP 2007).

14. What are the levels of human activities that may influence living resource quality and how are they changing? Although there are some existing and potential threats to living resources, Davidson Seamount is one of the world's few seamount areas to receive the level of protection afforded by Monterey Bay National Marine Sanctuary and NOAA Fisheries. Sanctuary regulations provide important – although not comprehensive – defenses against various threats. Furthermore, the great depth of Davidson Seamount's summit, flanks (or slope) and base habitats make some forms of exploitation impossible or highly unlikely (MBNMS 2012). Nonetheless, as previously noted, there are various levels of existing and potential threats (see Table 2 for a full list of potential threats and their ratings). The activity levels of most of the existing threats have been qualitatively described in DSMZ. Conversely, some potentially harmful activities exist (i.e., vessel traffic, marine debris, sea temperature rise, ocean acidification), but they do not appear to have had a negative effect on living resource quality. Given all of these factors, we do not know if the cumulative activity level has changed. Therefore, this question is rated "good/fair" with an "undetermined" trend.

At present, vessel traffic, marine debris, sea temperature rise and ocean acidification appear to be the most severe threats to living resources in DSMZ (MBNMS 2012). Marine debris has been found on the seafloor in DSMZ and may negatively impact benthic organisms (see Seamount Question 8 for more details). Floating marine debris impacts pelagic animals in many ways, most notably through entanglement and ingestion of plastic fragments that can clog the digestive tract (see Offshore Questions 13 and 14 for more details). However, the amount of marine debris in DSMZ, particularly in the water column, is not well understood.

Threats to living resources from vessel traffic include oil or chemical spills and discharges, loss of cargo and other marine debris, ship-based pollution (i.e., residues from tank cleaning), exchange of ballast water, ships colliding with whales and other large animals and noise pollution (MBNMS 2012). The northeast corner of DSMZ is bisected by the Western States Petroleum Association (WSPA) recommended shipping tracks for tankers carrying crude oil, black oil or other persistent liquid cargo in bulk (see Figure 57). Miller (2011) found that the average number of vessel transits through DSMZ in 2010 was 159 per month. An analysis of vessel traffic (2009-2012) indicates a great majority of the large vessels that transit in or near MBNMS comply with the WSPA and International Maritime Organization (IMO) recommended tracks (see Figure 58) (De Beukelaer et al. 2014). It would be useful to look at the trends in AIS data for the number of vessels that transit through DSMZ on a monthly or annual basis. One emerging threat to the Davidson Seamount's living resources is the impacts of changing ocean chemistry on both plankton and benthic structure-forming species, many of which have calcified body parts. We are not aware of specific studies of impacts of acidification on living resources in DSMZ. Directed study of the effects of climate driven changes in pH, temperature and dissolved oxygen on key species in DSMZ will become increasingly important to understand and track the status and condition of living resources. Sea temperature rise and ocean acidification are global phenomena and require regulation at larger geographical scales beyond the jurisdiction of sanctuary management (MBNMS 2012); however, making note of them here will allow managers within and beyond the MBNMS to anticipate and respond to these pressures.

Seamount Environment: Maritime Archaeological Resources

The following information provides an assessment of the current status and trends of the maritime archaeological resources in the offshore environment.There are no known maritime archaeological resources within Davidson Seamount Management Zone; therefore, questions 15-17 are not applicable to this environment.

15. What is the integrity of known maritime archaeological resources and how is it changing? There are no known maritime archaeological resources within Davidson Seamount Management Zone.

16. Do known maritime archaeological resources pose an environmental hazard and is this threat changing? There are no known maritime archaeological resources within Davidson Seamount Management Zone.

17. What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing? There are no known maritime archaeological resources within Davidson Seamount Management Zone.

Seamount Environment
Living Resources Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
9	Biodiversity	?	Status: Very High Trend: Medium	Relatively pristine area with few removals; but data are sparse.	Biodiversity appears to reflect pristine or near-pristine conditions and promotes ecosystem integrity (full community development and function).
11	Non-Indigenous Species	–	Status: Medium Trend: Medium	No known non-indigenous species; but data are sparse.	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).
12	Key Species Status	▲	Status: High Trend: High	Abundance and diversity of corals, stable fish stocks and existing protections. Federally endangered marine mammal populations (e.g., Fin whale), appear to be increasing.	Key and keystone species appear to reflect pristine or near-pristine conditions and many promote ecosystem integrity (full community development and function).
13	Key Species Condition	–	Status: High Trend: Medium	Key species appear healthy, and are protected or otherwise regulated.	The condition of key resources appears to reflect pristine or near-pristine conditions.
14	Human Activities	?	Status: High Trend: Medium	Offshore location, existing level of protections and few existing threats may limit impacts to living resources.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.

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

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

Seamount Environment
Maritime Archaeological Resources Status and Trends

#	Issue	Rating	Confidence	Basis for Judgment	Description of Findings
15	Biodiversity	N/A	Status: N/A Trend: N/A	No known maritime archaeological resources.	N/A
16	Non-Indigenous Species	N/A	Status: N/A Trend: N/A	No known maritime archaeological resources.	N/A
17	Key Species Status	N/A	Status: N/A Trend: N/A	No known maritime archaeological resources.	N/A

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

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

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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 System's mission, and a system-wide monitoring framework (NMSP 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on and study the ecosystems encompassed by the sanctuaries.[62] They are used to guide staff and partners at each of the system's 14 sites in the development of this first periodic sanctuary condition report. Evaluations of status and trends may be based on interpretation of quantitative and, when necessary, non-quantitative assessments and observations of scientists, managers and users.

Ratings for a number of questions depend on judgments involving "ecological integrity," and an ecosystem's status with regard to it because one of the foundational principles behind the establishment of marine sanctuaries is to protect ocean ecosystems; however, this concept can be confusing, and interpreted in different ways, so it is important to clarify its application within this report. Ecological integrity implies the presence of naturally occurring species, populations and communities, and ecological processes functioning at appropriate rates, scales and levels of natural variation, as well as the environmental conditions that support these attributes (modified from National Park Service Vital Signs monitoring program).[63] Ecosystems have integrity when they have their native components intact, including abiotic components (the physical elements, such as water and habitats), biodiversity (the composition and abundance of species and communities in an ecosystem) and ecosystem processes (the engines that makes ecosystem work (e.g., space competition, predation, symbioses) (from Parks Canada).[64] For purposes of this report, the level of integrity that is judged to exist is based on the extent to which humans have altered key attributes, and the effect of that change on the ability of an ecosystem to resist continued change and recover from it. The statements for many questions are intended to reflect this judgment. Reference is made in the rating system to "near-pristine" conditions, which, for this report would imply a status as near to an unaltered ecosystem as we can reasonably presume to exist, recognizing that there are virtually no ecosystems on Earth completely free from human influence.

Not all questions, however, use ecological integrity as a basis for judgment. One focuses on the impacts of water quality factors on human health. Another rates the status of key species compared with that expected in an unaltered ecosystem. One rates maritime archaeological resources based on their historical, archaeological, scientific and educational value. Another considers the level and persistence of localized threats posed by degrading archaeological resources. Finally, four specifically ask about the levels of on-going human activity that could affect resource condition.

During workshops in which status and trends are rated, experts discuss each question, and relevant data, literature and experience associated with the topic. They then discuss statements that are presented as options for judgments about the status. These statements have been customized for each question. Once a particular statement is agreed upon, a color code and status rating (e.g., good, fair, poor) is assigned. Experts can also decide that the most appropriate rating " N/A" (the question does not apply) or "Undet." (resource status is undetermined).

A subsequent discussion is then held about the trend and whether conditions are improving, remaining the same or declining. 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.

[62] In 2012, the Office of National Marine Sanctuaries led an effort to review and revise the set of questions and their possible responses posed in condition reports. The revised questions are not reflected in the 2015 Monterey Bay National Marine Sanctuary Condition Report Update. The revised questions will be addressed when the condition report is revised in its entirety in the future.
[63] Monitoring the condition of natural resources. National Park Service. Retrieved from http://science.nature.nps.gov/im/monitor/.
[64] What is ecological integrity? National Parks Canada. Retrieved from http://www.pc.gc.ca/progs/np-pn/ie-ei.aspx.

Water Stressors

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

This is meant to capture shifts in condition that arise 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 all, living resources and habitats.

Water Eutrophic Condition

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

Nutrient enrichment often leads to planktonic and/or benthic algae blooms. Some affect benthic communities directly through space competition. Overgrowth and other competitive interactions (e.g., accumulation of algal-sediment mats) often lead to shifts in dominance in the benthic assemblage. Disease incidence and frequency can also be affected by algae competition and the resulting chemistry along competitive boundaries. Blooms can also influence 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 deplete oxygen.

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

Water
Human Health

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

Human health concerns are generally aroused by evidence of contamination (usually bacterial or chemical) in bathing waters or fish intended for consumption. They also emerge when harmful algal blooms are reported or when cases of respiratory distress or other disorders attributable to harmful algal blooms increase dramatically. All of these conditions should be considered for this question.

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

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

Water
Human Activities

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

Among the human activities in or near sanctuaries that affect water quality are those that involve 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 that release airborne chemicals that subsequently deposit via particulates at sea (vessels, land based traffic, power plants, manufacturing facilities, refineries). In addition, dredging and trawling can cause resuspension of contaminants in sediments.

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

Habitat Abundance & Distribution

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

Habitat loss is of paramount concern when it comes to protecting marine and terrestrial ecosystems. Of greatest concern to sanctuaries are changes caused, either directly or indirectly, by human activities. The loss of shoreline is recognized as a problem indirectly caused by human activities. Habitats with submerged aquatic vegetation are often altered by changes in water conditions in estuaries, bays and near-shore 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 well as 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 to which restoration efforts might aim.

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

Habitat Structure

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

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

Kelp beds may not be biogenic habitats to the same 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. Other examples include intertidal assemblages structured by mussels, barnacles, algae and seagrass beds. This question is intended to address these types of places, where organisms form structures (habitats) on which other organisms depend.

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

Habitat Contaminants

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

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

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

Habitat Human Activities

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

Human activities that degrade habitat quality affect 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 a habitat's critical biological components 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 gillnets 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 after spills, with both acute and chronic impacts.

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

Living Resources Biodiversity

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

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

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

Living Resources Extracted Species

10. What is the status of environmentally sustainable fishing and how is it changing?[65]

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 occur 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.

[65] In 2012, the Office of National Marine Sanctuaries led an effort to review and revise the set of questions and their possible responses posed in the condition reports. As part of this effort, some questions were combined, new questions were added and other questions were removed. Question 10, "What is the status of environmentally sustainable fishing and how is it changing?" was removed from the set of questions. This decision was made because of all the questions, it was the only one that focused on a single human activity. The issue of fishing is sufficiently addressed in other questions found in the report, including those related to biodiversity, the status and health of key species, and the status of human activities. For a complete list of the new, revised set of questions, see ONMS 2015. Note that the revised questions are not reflected in the 2015 Monterey Bay National Marine Sanctuary Condition Report Update; however, because of the aforementioned reasons, question 10 was not answered. The new set of questions will be addressed when the condition report is revised in its entirety in the future.

Living Resources Non-Indigenous Species

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

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

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

Living Resources Key Species

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

Certain species can be defined as "key" within a national 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 status and trend assessments.

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 severely reduced levels, and recovery is unlikely.

Living Resources
Health of Key Species

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

For those species considered essential to ecosystem integrity, measures of their condition can be important to determine 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 question 12 above), the impact of changes in the abundance or condition of key species is more likely to be observed at the population or individual level, and less likely to result in ecosystem or community effects.

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

Living Resources
Human Activities

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

Human activities that degrade living resource quality cause a loss or reduction of one or more species by disrupting critical life stages, impairing various physiological processes or 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 effects on living resources).

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

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

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

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

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

Maritime Archaeological Resources Integrity

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

The condition of archaeological resources in a marine sanctuary significantly affects their value for science and education, as well as the resource's eligibility for listing on 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 on 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 on 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 on the National Register of Historic Places.

Maritime Archaeological Resources Threat to Environment

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

A sinking ship could introduce 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 from the early to mid-twentieth century, can still retain oil and fuel in tanks and bunkers. As shipwrecks age and deteriorate, the potential increases for a release of these materials into the environment.

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

Maritime Archaeological Resources Human Activities

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

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

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

Appendix B:
Consultation with Experts and Document Review

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

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

In order to address the standardized questions, sanctuary staff selected and consulted outside experts familiar with water quality, living resources, habitat and maritime archaeological resources in the estuarine, nearshore, offshore and seamount environments. A few different approaches (e.g., small group meetings, conference calls, email and individual meetings) were used to get expert input on the questions, depending on the availability of experts (a list of experts who provided input is available in the Acknowledgement section of this report).

In these meetings and calls, experts were introduced to the questions and then asked to provide recommendations and supporting arguments. In small group settings and conference calls, the group converged in their opinion of the rating that most accurately described the current resource condition. In individual meetings and email correspondence, the sanctuary staff considered all input and decided on status and trend ratings. In all cases, draft status and trend ratings along with supporting narratives were made available to experts for individual comment.

Experts were also consulted to assign a level of confidence in status and trend ratings by: (1.) characterizing the sources of information they used to make judgments and (2.) their agreement that the available evidence supports the selected status and trend ratings. The evidence and agreement ratings were then combined to determine the overall confidence ratings, as described in the table here.

Step 1: Rate Evidence

Consider three categories of evidence typically used to make status or trend ratings: (1.) data, (2.) published information and (3.) personal experience.

Evidence Scores		
Limited	**Medium**	**Robust**
Limited data or published information, and little or no substantive personal experience.	Data available, some peer reviewed published information, or direct personal experience.	Considerable data, extensive record of publication, or extensive personal experience.

Step 2: Rate Agreement

Rate agreement among those participating in determining the status and trend rating, or if possible, within the broader scientific community. Levels of agreement can be characterized as *"low," "medium"* or *"high."*

Step 3: Rate Confidence

Using the matrix below, combine ratings for both evidence and agreement to identify a level of confidence. Levels of confidence can be characterized as *"very low," "low," "medium," "high"* or *"very high."*

Agreement ⟶

"Medium" High agreement Limited evidence	*"High"* High agreement Medium evidence	*"Very High"* High agreement Robust evidence
"Low" Medium Agreement Limited evidence	*"Medium"* Medium agreement Medium evidence	*"High"* Medium agreement Robust evidence
"Very Low" Low agreement Limited evidence	*"Low"* Low agreement Medium evidence	*"Medium"* Low agreement Robust evidence

Evidence (type, amount, quality, consistency) ⟶

An initial draft of the update, which was written by sanctuary staff, summarized the new information, expert opinions and level of confidence expressed by the experts (who based their input on knowledge and perceptions of local conditions). Comments, data and citations received from the experts were included, as appropriate, in text supporting the ratings. This initial draft of the update was made available to contributing experts and data providers which allowed them to review the content and determine if the report accurately reflected their input, identify information gaps, provide comments or suggest revisions to the ratings and text. Upon receiving those comments, the writing team revised the text and ratings as they deemed appropriate. In some cases, additional review of certain sections, by those with specific expertise, was requested after revision. Sometimes, additional input on confidence scores was requested if the status and trend changed after those ratings had first been established in a small group setting.

In July 2015, a draft final report was sent to regional scientists for final review (listed in the Acknowledgemen' section of this report). In December 2004, External Peer Review became a requirement when the White House Office of Management and Budget (OMB) issued a Final Information Quality Bulletin for Peer Review (OMB Bulletin) established peer review standards that would enhance the quality and credibility of the federal government's scientific information. Along with other information, these standards apply to Influential Scientific Information, which is information that can reasonably be determined to have a "clear and substantial impact on important public policies or private sector decisions." The condition reports are considered Influential Scientific Information. For this reason, these reports are subject to the review requirements of both the Information Quality Act and the OMB Bulletin guidelines. Therefore, following the completion of every condition report, they are reviewed by a minimum of three individuals who are considered to be experts in their field, were not involved in the development of the report and are not ONMS employees. Comments from these peer reviews were incorporated into the final text of this report. Furthermore, OMB Bulletin guidelines require that reviewer comments, names and affiliations be posted on the agency website, http://www.cio.noaa.gov/. Reviewer comments, however, are not attributed to specific individuals. Comments by the External Peer Reviewers are posted at the same time as the formatted final document.

The reviewers were asked to review the technical merits of resource ratings and accompanying text, as well as to point out any omissions or factual errors. Following the External Peer Review, the comments and recommendations of the reviewers were considered by sanctuary staff and incorporated, as appropriate, into a final draft document. The final interpretation, ratings and text in the draft condition report were the responsibility of sanctuary staff, with final approval by the sanctuary superintendent. To emphasize this important point, authorship of the report is attributed to the sanctuary alone. Subject experts were not authors, though their efforts and affiliations are acknowledged in the report.

Estuarine Environment - Confidence Scoring Table

Question	2015 Rating	Evidence (Limited, Medium or Robust)	Agreement (Low, Medium or High)	Confidence (Very Low, Low, Medium, High or Very High)
Water Quality				
Question 1: Multiple Stressors	Status: Fair/Poor	Not updated	Not updated	Not updated
	Trend: Declining	Not updated	Not updated	Not updated
Question 2: Eutrophic Condition	Status: Fair/Poor	Robust	High	Very High
	Trend: Declining	Robust	High	Very High
Question 3: Risks to Human Health	Status: Fair/Poor	Not updated	Not updated	Not updated
	Trend: Undetermined	Not updated	Not updated	Not updated
Question 4: Human activities and Water Quality	Status: Fair	Medium	High	High
	Trend: Improving	Medium	High	High
Habitat				
Question 5: Major Habitat	Status: Fair/Poor	Robust	High	Very High
	Trend: Not changing	Medium	Low	Low
Question 6: Biologically-Structured	Status: Poor	Robust	High	Very High
	Trend: Improving	Robust	Medium	High
Question 7: Contaminants	Status: Fair/Poor	Low	Low	Very Low
	Trend: Declining	Low	Low	Very Low
Question 8: Human Activities and Habitat	Status: Poor	Medium	Medium	Medium
	Trend: Improving	Medium	Low	Low
Living Resources				
Question 9: Biodiversity	Status: Fair	Medium	Medium	Medium
	Trend: Not changing	Medium	Low	Low
Question 11: Non-Indigenous Species	Status: Poor	Medium	Medium	Medium
	Trend: Not changing	Medium	Medium	Medium
Question 12: Status Key Species	Status: Fair/Poor	Robust	High	Very High
	Trend: Improving	Robust	High	Very High
Question 13: Condition Key Species	Status: Good/Fair	Limited	Medium	Low
	Trend: Undetermined	Limited	Medium	Low
Question 14: Human Activities and Living Resources	Status: Fair/Poor	Medium	Medium	Medium
	Trend: Undetermined	Limited	Medium	Low
Maritime Archaeological Resources				
Question 15: Integrity	Status: Undetermined	Not updated	Not updated	Not updated
	Trend: Undetermined	Not updated	Not updated	Not updated
Question 16: Threat to Environment	Status: Good	Not updated	Not updated	Not updated
	Trend: Not changing	Not updated	Not updated	Not updated
Question 17: Human Activities	Status: Good	Not updated	Not updated	Not updated
	Trend: Not changing	Not updated	Not updated	Not updated

Nearshore Environment - Confidence Scoring Table

Question	2015 Rating	Evidence *(Limited, Medium or Robust)*	Agreement *(Low, Medium or High)*	Confidence *(Very Low, Low, Medium, High or Very High)*
Water Quality				
Question 1: Multiple Stressors	Status: Fair	Not updated	Not updated	Not updated
	Trend: Declining	Not updated	Not updated	Not updated
Question 2: Eutrophic Condition	Status: Fair	Robust	Medium	High
	Trend: Declining	Robust	Medium	High
Question 3: Risks to Human Health	Status: Fair	Robust	High	Very High
	Trend: Undetermined	Robust	High	Very High
Question 4: Human activities and Water Quality	Status: Fair	Limited	High	Medium
	Trend: Improving	Limited	High	Medium
Habitat				
Question 5: Major Habitat	Status: Fair	Robust	High	Very High
	Trend: Declining	Robust	High	Very High
Question 6: Biologically-Structured	Status: Good	Robust	High	Very High
	Trend: Not changing	Robust	High	Very High
Question 7: Contaminants	Status: Fair/Poor	Medium	High	High
	Trend: Declining	Medium	High	High
Question 8: Human Activities and Habitat	Status: Fair	Robust	Low	Medium
	Trend: Undetermined	Robust	Low	Medium
Living Resources				
Question 9: Biodiversity	Status: Fair	Robust	High	Very High
	Trend: Not changing	Robust	High	Very High
Question 11: Non-Indigenous Species	Status: Good	Robust	High	Very High
	Trend: Declining	Robust	High	Very High
Question 12: Status Key Species	Status: Fair	Robust	High	Very High
	Trend: Declining	Robust	High	Very High
Question 13: Condition Key Species	Status: Fair	Robust	High	Very High
	Trend: Declining	Robust	High	Very High
Question 14: Human Activities and Living Resources	Status: Fair	Robust	High	Very High
	Trend: Declining	Robust	High	Very High
Maritime Archaeological Resources				
Question 15: Integrity	Status: Fair	Not updated	Not updated	Not updated
	Trend: Undetermined	Not updated	Not updated	Not updated
Question 16: Threat to Environment	Status: Fair	Medium	Medium	Medium
	Trend: Declining	Medium	Medium	Medium
Question 17: Human Activities	Status: Good/Fair	Not updated	Not updated	Not updated
	Trend: Undetermined	Not updated	Not updated	Not updated

Offshore Environment - Confidence Scoring Table

Question	2015 Rating	Evidence (Limited, Medium or Robust)	Agreement (Low, Medium or High)	Confidence (Very Low, Low, Medium, High or Very High)
Water Quality				
Question 1: Multiple Stressors	Status: Fair	Medium	High	High
	Trend: Declining	Robust	High	Very High
Question 2: Eutrophic Condition	Status: Good/Fair	Robust	High	Very High
	Trend: Declining	Medium	Medium	Medium
Question 3: Risks to Human Health	Status: Good/Fair	Not updated	Not updated	Not updated
	Trend: Undetermined	Not updated	Not updated	Not updated
Question 4: Human activities and Water Quality	Status: Fair	Not updated	Not updated	Not updated
	Trend: Improving	Not updated	Not updated	Not updated
Habitat				
Question 5: Major Habitat	Status: Fair	Medium	High	High
	Trend: Improving	Low	High	Medium
Question 6: Biologically-Structured	Status: Fair/Poor	Medium	High	High
	Trend: Undetermined	Low	High	Medium
Question 7: Contaminants	Status: Fair	Medium	High	High
	Trend: Declining	Medium	High	High
Question 8: Human Activities and Habitat	Status: Fair	Medium	High	High
	Trend: Improving	Medium	High	High
Living Resources				
Question 9: Biodiversity	Status: Fair	Medium	Medium	Medium
	Trend: Not changing	Low	Medium	Low
Question 11: Non-Indigenous Species	Status: Good	Not updated	Not updated	Not updated
	Trend: Not changing	Not updated	Not updated	Not updated
Question 12: Status Key Species	Status: Good/Fair	Medium	Medium	Medium
	Trend: Not changing	Medium	Low	Low
Question 13: Condition Key Species	Status: Good/Fair	Medium	Medium	Medium
	Trend: Declining	Medium	Low	Low
Question 14: Human Activities and Living Resources	Status: Fair	Medium	Medium	Medium
	Trend: Not changing	Medium	Medium	Medium
Maritime Archaeological Resources				
Question 15: Integrity	Status: Undetermined	Not updated	Not updated	Not updated
	Trend: Undetermined	Not updated	Not updated	Not updated
Question 16: Threat to Environment	Status: Fair	Medium	Medium	Medium
	Trend: Declining	Medium	Medium	Medium
Question 17: Human Activities	Status: Good/Fair	Not updated	Not updated	Not updated
	Trend: Undetermined	Not updated	Not updated	Not updated

Seamount Environment - Confidence Scoring Table

Question	2015 Rating	Evidence *(Limited, Medium or Robust)*	Agreement *(Low, Medium or High)*	Confidence *(Very Low, Low, Medium, High or Very High)*
Water Quality				
Question 1: Multiple Stressors	Status: Undetermined	N/A	N/A	N/A
	Trend: Undetermined	N/A	N/A	N/A
Question 2: Eutrophic Condition	Status: Undetermined	N/A	N/A	N/A
	Trend: Undetermined	N/A	N/A	N/A
Question 3: Risks to Human Health	Status: Undetermined	N/A	N/A	N/A
	Trend: Undetermined	N/A	N/A	N/A
Question 4: Human activities and Water Quality	Status: Good/Fair	Limited	High	Medium
	Trend: Undetermined	Limited	High	Medium
Habitat				
Question 5: Major Habitat	Status: Good	Robust	High	Very High
	Trend: Stable	Medium	High	High
Question 6: Biologically-Structured	Status: Good	Robust	High	Very High
	Trend: Undetermined	Limited	High	Medium
Question 7: Contaminants	Status: Undetermined	N/A	N/A	N/A
	Trend: Undetermined	N/A	N/A	N/A
Question 8: Human Activities and Habitat	Status: Good/Fair	Medium	High	High
	Trend: Undetermined	Limited	High	Medium
Living Resources				
Question 9: Biodiversity	Status: Good	Robust	High	Very High
	Trend: Undetermined	Medium	High	High
Question 11: Non-Indigenous Species	Status: Good	Limited	High	Medium
	Trend: Not changing	Limited	High	Medium
Question 12: Status Key Species	Status: Good/Fair	Robust	Medium	High
	Trend: Increasing	Medium	High	High
Question 13: Condition Key Species	Status: Good	Medium	High	High
	Trend: Not changing	Limited	High	Medium
Question 14: Human Activities and Living Resources	Status: Good/Fair	Medium	High	High
	Trend: Undetermined	Limited	High	Medium
Maritime Archaeological Resources				
Question 15: Integrity	Status: N/A	N/A	N/A	N/A
	Trend: N/A	N/A	N/A	N/A
Question 16: Threat to Environment	Status: N/A	N/A	N/A	N/A
	Trend: N/A	N/A	N/A	N/A
Question 17: Human Activities	Status: N/A	N/A	N/A	N/A
	Trend: N/A	N/A	N/A	N/A

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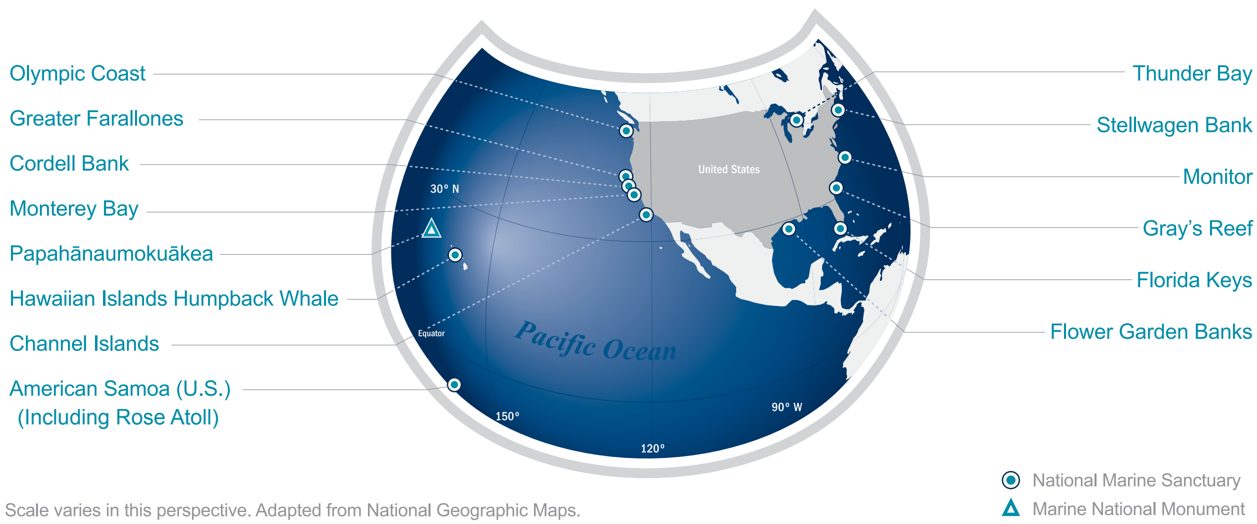
The National Marine Sanctuary System

The Office of National Marine Sanctuaries, part of the National Oceanic and Atmospheric Administration, serves as the trustee for a system of 14 marine protected areas encompassing more than 170,000 square miles of ocean and Great Lakes waters. The 13 national marine sanctuaries and one marine national monument within the National Marine Sanctuary System represent areas of America's ocean and Great Lakes environment that are of special national significance. Within their waters, giant humpback whales breed and calve their young, coral colonies flourish, and shipwrecks tell stories of our maritime history. Habitats include beautiful coral reefs, lush kelp forests, whale migrations corridors, spectacular deep-sea canyons, and underwater archaeological sites. These special places also provide homes to thousands of unique or endangered species and are important to America's cultural heritage. Sites range in size from one square mile to almost 170,000 square miles and serve as natural classrooms, cherished recreational spots, and are home to valuable commercial industries.



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

The Office of National Marine Sanctuaries is part of NOAA's National Ocean Service.

Vision – People value marine sanctuaries as treasured places protected for future generations.

Mission – To serve as the trustee for the nation's system of marine protected areas to conserve, protect and enhance their biodiversity, ecological integrity and cultural legacy.