2008 CORDELL BANK NATIONAL MARINE SANCTUARY CONDITION REPORT

REVIEWERS AND AFFILIATIONS

William J Sydeman, Ph.D.
President/Senior Scientist
Farallon Institute for Advanced Ecosystem Research
www.faralloninstitute.org
PO Box 750756
Petaluma, CA 94975
(707) 478-1381 (mobile)
wsydeman@comcast.net

Lance Morgan, Ph.D.
Vice President for Science
Marine Conservation Biology Institute
14301 Arnold Dr
Suite 25
Glen Ellen CA 95442/
Phone:/ 707.938.3214/
Fax:/ 707.996.4842
lance@mcbi.org

Chris Caldow
Contractor to NOAA's Biogeography Branch
National Oceanic and Atmospheric Administration
1305 East West Highway, (SSMC4/9247), N/SCI-1
Silver Spring, MD 20910
Phone: (301)713-3028 x164 Fax: (301)713-4384

The document that follows is a copy of the draft Cordell Bank National Marine Sanctuary Condition Report. Reviewer comments are embedded.

Cordell Bank National Marine Sanctuary

Condition Report

U.S. Department of Commerce
Carlos M. Gutierrez, Secretary

National Oceanic and Atmospheric Administration
VADM Conrad C. Lautenbacher, Jr. (USN-ret.)
Under Secretary of Commerce for Oceans and Atmosphere

National Ocean Service
John H. Dunnigan, Assistant Administrator

National Marine Sanctuary Program
Daniel J. Basta, Director

National Oceanic and Atmospheric Administration
Office of National Marine Sanctuaries
SSMC4, N/ORM62
1305 East-West Highway
Silver Spring, MD 20910
301-713-3125
http://sanctuaries.noaa.gov/

Cordell Bank National Marine Sanctuary
1 Bear Valley Road
Point Reyes Station, CA 94956
415-663-0314
http://cordellbank.noaa.gov/

Report Preparers:

Cordell Bank National Marine Sanctuary:
Lisa Etherington, Daniel Howard

National Marine Sanctuary Program:
Kathy Broughton, Stephen R. Gittings

Clancy Environmental Consultants, Inc.:
Karen Fox, Jeffrey Rosen
http://clancyenv.com

Comment [kb1]: Thank you for the opportunity to review this report. I am very interested in the Cordell Bank NMS, and the issue of how to report ecosystem conditions in general, so this request has been very stimulating and timely. I am working on a CA Current-wide IEA, which has elements of condition reporting, so reading this has been important for coordinating with that effort as well.

I have spoken with Dan Howard and Lisa Etherington about my comments, so hopefully none of this comes will come as a surprise. I think the report is excellent, overall, and I thoroughly enjoyed reading it. Clearly, the authors have done a tremendous amount of work, and have invented something new and very informative. I do have some suggestions which I hope will be taken in the spirit of constructive criticism, as that is how it is intended.

Comment [kb2]: Over all I felt the condition report read quite well. There is a lot of worthwhile information presented in a clear and understandable manner.

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

Credits for inside cover:

Suggested Citation:
Office of National Marine Sanctuaries 2008. Cordell Bank National Marine Sanctuary Condition Report 2008. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Sanctuary Program, Silver Spring, MD. ** pp.

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<<<Insert Atlas map of CBNMS: Cordell_Bank_final_map.jpg>>>
Figure 1. Cordell Bank National Marine Sanctuary is located entirely offshore about 50 miles (80 km) north of San Francisco.

About this Report

This "condition report" provides a summary of resources in the National Oceanic and Atmospheric Administration's Cordell Bank National Marine Sanctuary (sanctuary), pressures on those resources, current condition and trends, and management responses to the pressures that threaten the integrity of the marine environment. Specifically, the document includes information on the status and trends of water quality, habitat, living resources and maritime archaeological resources and the human activities that affect them. It presents responses to a set of questions posed to all sanctuaries (Appendix). Resource status of Cordell Bank is rated on a scale from good to poor, and the timelines used for comparison vary from topic to topic. Trends in the status of resources are also reported, and are generally based on observed changes in status over the past five years, unless otherwise specified. Sanctuary staff consulted with outside experts familiar with the resources and with knowledge of previous and current scientific investigations. Evaluations of status and trends are based on interpretation of quantitative and, when necessary, non-quantitative assessments, and the observations of scientists, managers and users. The ratings reflect the collective interpretation of the status of local issues of concern among sanctuary program staff and outside experts based on their knowledge and perceptions 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 first attempt to describe comprehensively the status, pressures and trends of resources at Cordell Bank National Marine Sanctuary. Additionally, the report helps identify gaps in current monitoring efforts and highlights areas where additional information is needed. The data discussed will enable us to not only acknowledge prior changes in resource status, but will provide guidance for future management as we face challenges imposed by issues such as increasing coastal populations, developing alternative energy sources, artificial reefs, and climate change.

Summary and Findings

Cordell Bank National Marine Sanctuary is an extremely productive marine area off the west coast of United States in northern California. Located about 50 miles (80 km) north of San Francisco, the sanctuary is entirely offshore, with the eastern boundary six miles from shore and the western boundary 30 miles (48 km) offshore at the 1000 fathom (1829 m) depth contour. The centerpiece of the sanctuary is Cordell Bank, a four-and-a-half mile (7.2 km) by nine-and-a-half mile (15.2 km) rocky undersea feature located 18 miles (29 km) west of the Point Reyes headlands. The bank sits at the edge of the continental shelf and rises abruptly from the soft sediments of the shelf to within 115 feet (35 m) of the ocean surface (Figure 2). Cordell Bank is located in the California Current upwelling system, which is associated with one of the four major eastern boundary currents of the world. Coastal upwelling associated with the eastern boundary current initiates an annual productivity cycle that supports a rich local biological community as well as migratory populations of sea turtles, fishes, seabirds and whales that travel thousands of miles to feed around the bank. The combination of a healthy benthic community on the bank in close proximity to offshore, open water species contributes to the unique biological diversity in a relatively confined area around Cordell Bank.

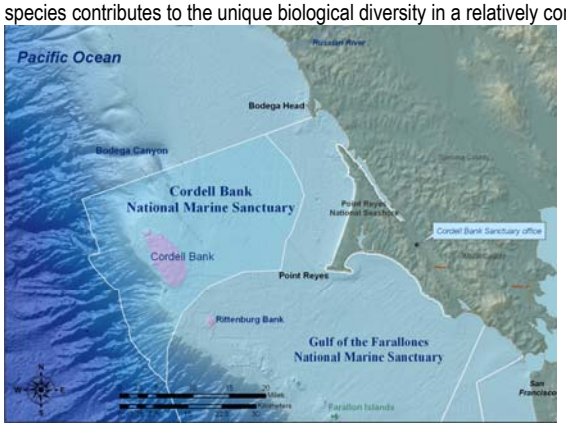

Figure 2. *Map of the Cordell Bank National Marine Sanctuary and surrounding area. This image depicts the seafloor features from the continental shelf to the continental slope, including the prominent feature of Cordell Bank. Image created by Pam van der Leeden.*

Activities that put pressure on sanctuary resources are diverse. Fishing activity has been conducted at Cordell Bank since the late 1800's and commercial and recreational fishing are still major activities. Restrictions implemented by the Pacific Fisheries

Comment [kb3]: The region discussed here is sometimes referred to as central and sometimes northern CA

The word "sanctuary" after Cordell Bank is inconsistently capitalized.

Comment [kb4]: Refer to the Sanctuary, instead of the sanctuary, throughout document.

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Comment [kb5]: it is unclear to me what time period(s) is/are being evaluated. The text states the last 5 years, but relative to what? Certainly, trends over as many years as possible should be considered, but also what happened this year or last is probably pretty important too (though not that important in the variable CA Current system). To me, these evaluations should be multi-scale, so that is something for the NMSP to consider as it moves forward with all of these condition reports.

Comment [kb6]: The report is a good current snap-shot of the Sanctuary though I think some consideration to the appropriate ecological baseline for the site needs to be further addressed. A partial recovery of a species from recent very low numbers should be understood over a longer time frame than just the past 5 years otherwise we might lead ourselves to believe that current abundance is improved from 5 years although well below abundance from 20 years ago. This lack of an appropriate baseline is also potentially a problem when addressing a species such as Humboldt squid that might be a regular but very infrequent visitor to northern California waters based on changes in oceanographic conditions that cycle at intervals longer than 5 years.

Comment [kb7]: Marine debris appears frequently in the report as a concern but is not mentioned in the "Summary and Findings"

Comment [kb8]: Many of the figures were not included so I am unable to comment on them. Some of the figures as they print in the pdf are so small as to be very hard to see, and as such will add little to the overall report. I have indicated which ones these are, if they are large enough in final format to be easily understandable I would keep them but not at current size.

Management Council to help rebuild depleted rockfish stocks limit current fishing activity within the sanctuary. The southeast corner of Cordell Bank National Marine Sanctuary is located approximately six miles from the terminus of the northern shipping lanes that funnel commercial vessels into and out of San Francisco Bay. On average, 2,000 large commercial ships transit through the sanctuary each year. There have been several large oil spills just south of the sanctuary in the last decade. Wildlife viewing trips are becoming increasingly popular in the sanctuary as opportunities to see humpback and blue whales and a diverse assemblage of pelagic seabirds draw enthusiasts from around the greater bay area. Charter trips leave from the closest coastal port of Bodega Bay.

Because of the offshore nature of the Cordell Bank sanctuary and the distance from major urban population centers, most water quality parameters suggest relatively good conditions. Benthic habitat quality has been impacted over the years as a result of bottom contact fishing gear on the rocky reef and on the soft bottom habitats of the sanctuary. Spatial fishing gear restrictions that are currently in place in some areas will help protect sanctuary habitats, and conditions should improve. Living resource conditions within Cordell Bank National Marine Sanctuary are considered to be diminished, because of depleted populations of rockfish, leatherback sea turtles and some species of seabirds. It might be expected that conditions for living resources will improve, due to fishery closures that are helping to rebuild depleted fish stocks. To date, no maritime archaeological resources have been identified in the sanctuary.

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The new management plan for Cordell Bank is scheduled for release in 2008, and contains a number of management actions that will address current issues and concerns. The plan stresses an ecosystem-based approach to management, which requires consideration of ecological interrelationships not only within the sanctuary, but within the larger context of the California Current ecosystem. It also makes essential an increased level of cooperation with other management agencies in the region. Specific management actions are called for in the plan, including: a new regulation prohibiting the introduction/release of non-indigenous species into the sanctuary, actions to reduce discharges and develop spill contingency plans, monitoring of sanctuary waters, habitats, and pelagic and benthic communities, and actions to track human use activities and their impacts.

National Marine Sanctuary System and System-Wide Monitoring

The National Marine Sanctuary System manages marine areas in both nearshore and open ocean waters that range in size from less than one to almost 140,000 square miles. Each area has its own concerns and requirements for environmental monitoring, but ecosystem structure and function in all these areas have similarities and are influenced by common factors that interact in comparable ways. Furthermore, the human influences that affect the structure and function of these sites are similar in a number of ways. For these reasons, in 2001 the program began to implement System-Wide Monitoring (SWiM). The monitoring framework (National Marine Sanctuary Program 2004) facilitates the development of effective, ecosystem-based monitoring programs that address management information needs using a design process that can be applied in a consistent way at multiple spatial scales and to multiple resource types. It identifies four primary components common among marine ecosystems: water, habitats, living resources and maritime archaeological resources.

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

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

Cordell Bank National Marine Sanctuary

- *529 square miles (1370 km^2)*
- *The main feature is an offshore rocky bank 4.5 miles (7.2 km) wide by 9.5 miles (15.2 km) long*
- *First located in 1853 by George Davidson, a hydrographer with the U.S. Coastal Survey*
- *Congressionally designated in 1989 as a National Marine Sanctuary*
- *Submerged offshore bank that is home to dense and diverse temperate benthic and pelagic flora and fauna*
- *Upwelling driven productivity supports a rich biological community that includes a combination of resident and migratory invertebrates, fishes, sea birds, turtles, and marine mammals. The Sanctuary is a feeding area for humpback and blue whales.*
- *Supports marine fisheries and wildlife viewing opportunities*

Cordell Bank National Marine Sanctuary Condition Summary

The following table is a compilation of findings from the "State of Sanctuary Resources" section of this report. (For further clarification of the questions posed in this table, please see the Appendix.)

Status:

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

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

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?	?	Offshore location may limit impacts, but data are sparse (page 22)	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.	New sanctuary regulations prohibiting the discharging or depositing into the sanctuary any material from a cruise ship (other than engine or generator cooling water and anchor wash) and narrowing the wastewater discharge exemptions for food wastes and sewage (no raw sewage). Monitoring conditions of sanctuary waters.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	—	Results of monthly monitoring of productivity and biotoxins (page 22)	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.	
3	Do sanctuary waters pose risks to human health and how are they changing?	—	Offshore location and oceanic conditions may limit impacts; no known risks identified during monthly monitoring (page 22)	Conditions do not appear to have the potential to negatively affect human health.	
4	What are the levels of human activities that may influence water quality and how are they changing?	?	Vessel discharges (page 22)	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?	?	Prior fishing gear impacts; activities now prohibited, but sparse data (page 24)	Selected habitat loss or alteration has taken place, precluding full development of living resources assemblages, but it is unlikely to cause substantial or persistent degradation in living resources or water quality.	New sanctuary regulations proh the disturbance of the seabed w Cordell Bank sanctuary. Trawling closures and seabed protection measures implemented by Pacific Fishery Management Council (in consultation with Cordell Bank NMS). Monitoring the benthic habitats associated with Cordell Bank. Outreach, education and monito programs increase awareness o impacts of marine debris.
6	What is the condition of biologically-structured habitats and how is it changing?	?	Prior fishing gear impacts; activities now prohibited, but sparse data (page 25)	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.	
7	What are the contaminant concentrations in sanctuary habitats and how are they changing?	?	Sparse data available (page 25)		
8	What are the levels of human activities that may influence habitat quality and how are they changing?	▲	Prior fishing impacts; some activities now prohibited (page 25)	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.	
LIVING RESOURCES					

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Comment [kb9]: not clear if the description of vessel discharges comes from opinion or data (or lack of data). 2,000 vessels a year is a significant number and it should not be considered to have no impact if there is not data to support this.

Comment [kb10]: if the habitat loss is to deep water corals and sponges many of these can live for very long periods of time (decades to much longer). Thus a lack of persistent degradation appears to need a time- scale associated with it. In this case, vis-à-vis the comment on living seafloor habitats, it would appear to be an incorrect rating since protection for the bank is not permanent (under PFMC regulations) and these species may take a much longer time to recover.

Comment [kb11]: Is the wording in "Description of Findings" Q. 5 & 6 consistent with Q. 8? – Habitat loss/alteration has taken place vs. no negative effect on habitat

Comment [kb12]: In general there is no comment on marine mammals, seabirds or turtles in the section on Living Resources, but there is concern for some of these species which come to Cordell Bank to forage (especially leatherbacks, blue whales and some seabirds – Cassin's Auklets).

9	What is the status of biodiversity and how is it changing?	▲	Reduced rockfish populations; changing oceanic conditions (page 26)	Selected biodiversity loss has caused or is likely to cause severe declines in some, but not all ecosystem components, and reduce ecosystem integrity.	Rockfish conservation areas and seabed protection measures implemented by Pacific Fishery Management Council (in consultation with Cordell Bank NMS). New sanctuary regulation prohibiting the introduction or release of non-indigenous species into the sanctuary. Monitoring the ecological condition of pelagic community within the sanctuary. Monitoring the ecological condition of benthic community and habitats the sanctuary. Recent stock assessments indic rockfish populations are increas
10	What is the status of environmentally sustainable fishing and how is it changing?	▲	Overfishing and prior fishing impacts; closures and gear restrictions appear to be effective (page 27)	Extraction has caused or is likely to cause severe declines in some, but not all ecosystem components, and reduce ecosystem integrity.	
11	What is the status of non-indigenous species and how is it changing?	?	No known non-indigenous species; sparse data available (page 27)	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).	
12	What is the status of key species and how is it changing?	▲	Reduced rockfish, krill, and seabird populations; changing oceanic conditions (page 27)	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?	—	Water quality; offshore location; oceanographic conditions (page 28)	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?	▲	Overfishing and habitat disturbance, restrictions appear to be effective; Vessel traffic; marine debris (page 28)	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?	**N/A**	No documented underwater archeological sites	N/A	N/A
16	Do known maritime archaeological resources pose an environmental hazard and how is this threat changing?	**N/A**	No documented underwater archeological sites	N/A	
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	**N/A**	No documented underwater archeological sites	N/A	

Comment [kb14]: A recent study by Halpern et al. 2008 (Science) suggests that no portion of the ocean is pristine. Thus it is difficult to justify the term pristine or near-pristine.

Comment [kb13]: This statement probably belongs under "Basis for judgment in Q. 12 & 14.

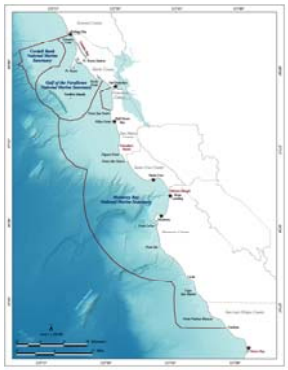
Comment [kb15]: The issues associated with Q. 14 potentially should include oil.

Site History and Resources

Overview

Located 18 miles (29 km) off the California coast and 50 miles (80 km) northwest of the Golden Gate Bridge (Figure 3), Cordell Bank, like many of the nation's 13 marine sanctuaries and one marine national monument, was recognized for its biodiversity and ecological integrity. Due to its unique combination of bathymetry and ocean conditions, the bank is an extremely productive marine environment. As a result of its national significance as an area of exceptional natural beauty and resources Cordell Bank National Marine Sanctuary was designated in 1989; it is administered by the National Oceanic and Atmospheric Administration (NOAA), within the Department of Commerce.

Cordell Bank sanctuary protects an area of 529 square miles of open water and the seafloor below. The dominant feature of the sanctuary is an offshore bank 4.5 miles (7.2 km) wide by 9.5 miles (15.2 km) long. The rocky submerged feature emerges from the soft sediments of the continental shelf, with the upper pinnacles reaching to within 115 feet (35 m) of the ocean's surface. The continental shelf depth at the base of the bank is roughly 300 to 400 feet (91-122 m).



Sharing Boundaries

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

Figure 3. *Cordell Bank National Marine Sanctuary is one of three contiguous National Marine Sanctuaries located along California's northern and central coast.*

Discovery of the Bank

<<<Insert old nautical chart of Cordell Bank: 1869Chart661CordellBank.jpg>>>
Figure 4. A nautical chart from 1869 showing the feature of Cordell Bank offshore of Point Reyes.

Cordell Bank was first discovered in 1853 by George Davidson, a hydrographer with the U.S. Coastal Survey, when his ship became lost in the fog while sailing for San Francisco Bay (Figure 4). When he lowered the lead line, a depth measuring device, Davidson expected a reading of approximately 400 feet (122 m), but was surprised to find it registered only 180 feet (55m). Sixteen years later, Edward Cordell, a surveyor with the U.S. Coastal Survey, conducted additional surveys when he was sent to relocate a "shoal west of Point Reyes." The numerous birds and marine mammals helped Cordell to locate the bank.

Several years prior to his surveys on the west coast, Cordell accompanied Henry Stellwagen on his surveying vessel to map Stellwagen Bank, which is in the Gulf of Maine and now also among the significant marine areas designated as national marine sanctuaries.

Cordell Bank was first explored underwater in 1977 by Cordell Expeditions, a non-profit research association (Figure 5). Over the next 10 years, divers documented the organisms living on and above the bank. Through these efforts, images of the biological diversity of Cordell Bank were available to the public for the first time. This effort was instrumental in designating the site in 1989 as a National Marine Sanctuary.

<<<Insert image of newspaper clippings of Cordell Expeditions: resizedcordellexpeditionclippings.jpg>>>
Figure 5. Through the efforts of Cordell Expeditions, images of the biological diversity of Cordell Bank were available to the public for the first time.

Comment [kb16]: Over all I felt the condition report read quite well. There is a lot of worthwhile information presented in a clear and understandable manner. The only concern I have is with respect to the section Site History and Resources. This was not what I was expecting to find in a Condition Report. It more appropriately belongs in a brochure for the public about the Cordell Bank sanctuary. The relevant information introduced here including species and pressures is mostly replicated in the other sections. Perhaps this section could focus more on historical pressures the resources within the sanctuary or region have faced?

Comment [kb17]: Nearly identical sentences have numbers inconsistently spelled out or not.

Comment [kb18]: Only some measures are accompanied by metric conversions.

Geology

The Sanctuary lies completely within the Pacific Plate, but its eastern boundary is located 7.5 miles (12 km) west of the convergence zone of two of the Earth's major tectonic plates: the Pacific and North American (Figure 6). The Pacific Plate is slowly moving northward relative to the North American Plate at an average rate of about 2 inches (5 cm) per year. Most of this motion occurs in catastrophic bursts of movement—earthquakes—along the San Andreas Fault system, which is hundreds of miles long and in places up to a mile (1.6 km) wide.

The topography of western California is strongly influenced by the San Andreas Fault, which has been active since its origin. About 10 percent of the present plate motion is compressional, shortening and wrinkling the crust to create the parallel coastal northwest-southeast mountain ranges.

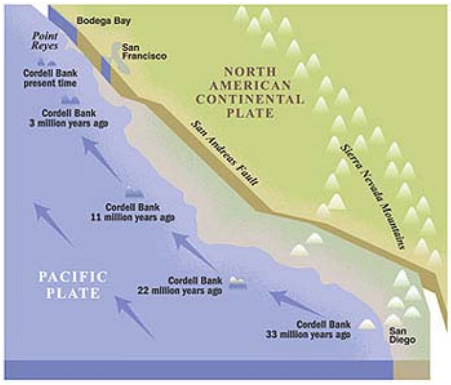


Figure 6. *Cordell Bank continues to move a few centimeters per year.*

Cordell Bank is the most prominent geological feature of the Sanctuary. The Salinian bedrock of Cordell Bank was originally created about 100 million years ago as part of the Sierra Nevada range. When the San Andreas fault formed ~20-30 million years ago, it sheared off part of the range, including the granitic feature of Cordell Bank, and carried it north to its present location. Cordell Bank and the Farallon Islands are part of the same Farallon Ridge structural high. Sediments surrounding the base of the Bank on the continental shelf are mostly composed of younger silt and sand deposits that originated from rivers and coastal erosion. These sediments continue to be moved around and further broken down by energetic seafloor ocean currents.

Commerce

The history of California's north coast is predominantly a maritime one. From the days of the early coastal Miwok inhabitants to the present, coastal waterways remain a main route of travel and supply. Ocean-based commerce and industries (e.g., fisheries, export and import, and coastal shipping) are important to the maritime history, the modern economy, and the social character of this region.

By 1935, San Francisco was the home port of twenty large American steamship lines, with more than forty foreign lines maintaining offices and agents in the city. More than five hundred ships called every month of the year, and a large majority of those ships purchased a major portion of their supplies from San Francisco merchants. The population around San Francisco Bay has grown rapidly and now exceeds 8 million people. The bay area's economy ranks as one of the largest in the world, larger than that of many countries. More than 10 million tourists are estimated to visit the bay region each year.

Cordell Bank is a productive area and has historically supported important commercial and recreational fisheries. The Pacific Fishery Management Council, working with NOAA's National Marine Fisheries Service and the California Department of Fish and Game, regulates fishing activity. Commercial fisheries generally target rockfish (*Sebastes* spp.) and other groundfish species, flatfish, Chinook salmon (*Oncorhynchus tshawytscha*), Dungeness crab (*Cancer magister*) and albacore tuna (*Thunnus alalunga*) (Ecotrust 2006).

Because of the abundance of food, the Cordell Bank area is a feeding ground for seabirds, turtles, and a variety of marine mammals, including blue and humpback whales (Figure 7). Beginning in early summer and continuing through fall, foraging wildlife frequent sanctuary waters. This coincides with the calmest weather of the year, and as a result, many charter vessels

from Bodega Bay and San Francisco make regular wildlife viewing trips to the bank at this time. Recreational fishing charters originating from Bodega Bay also frequent the waters surrounding Cordell Bank, targeting salmon, lingcod and rockfish and more recently, jumbo squid (*Dosidicus gigas*).

Figure. 7. Cordell Bank sanctuary is entirely offshore and contains an abundance of marine life, including humpback whales. Photo: Cornelia Oedekoven.

Water: Ocean Seasons

The calendar year at Cordell Bank can be separated into three oceanographic seasons: upwelling season in the spring and early summer, relaxation or oceanic in the late summer and fall, and the storm season in winter. This annual cycle of upwelling and relaxation and the resulting high primary productivity is one of the reasons that the Cordell Bank ecosystem supports such a rich and diverse marine community.

Upwelling Season: Cordell Bank National Marine Sanctuary is located in one of the world's four major coastal upwelling systems; the other three systems are located along the west coast of South America, southwest Africa, and northwest Africa. The upwelling of nutrient-rich, deep ocean water supports a food-rich environment and promotes the growth of organisms at all levels of the marine food web.

Figure 8. *Spring/summer upwelling in Cordell Bank region.*

During the upwelling season (March-July), strong northwest winds and the south flowing California Current combine with the earth's rotation to drive surface waters away from the shore (Figure 8). These surface waters are replaced by an upwelling of deeper water from offshore that is enriched with nutrients. The nutrients become available for photosynthesis by surface dwelling phytoplankton (microscopic marine algae) within the upper sunlit layer of the ocean. Phytoplankton form the foundation of the ocean food web and the infusion of nutrients and increased sunlight in spring initiates a bloom of life that radiates through the food web. An abundance of phytoplankton, zooplankton, and young fish are food for animals at higher levels of the marine food web. Productivity within the nearshore region is a balance between the positive influence of upwelling bringing enhanced nutrients to the surface, which stimulates phytoplankton growth, and the negative influence of mixing and advection, which transports phytoplankton below surface-lit layers as well as offshore. Thus, higher productivity within this region results from a combination of upwelling and relaxation events (Figure 9).

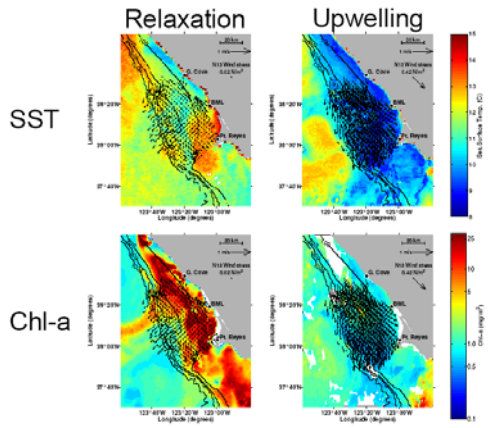


Figure 9. *Contrasting surface current (HF radar) patterns, oceanographic conditions, and chlorophyll-a levels during upwelling and relaxation events during the upwelling season (June 2003) within the California Current in the region of Cordell Bank National Marine Sanctuary (Largier et al. 2006).*

Relaxation or Oceanic Season: During the late summer and fall (August to early November), persistent coastal winds weaken and the sea surface becomes calmer. Surface currents during this time period are mostly northward and water temperatures increase. During this time, coastal waters are rich with the products of upwelling, and many migratory animals are in the area feeding on an abundance of prey.

Winter Storm or Davidson Current Season: The winter storm season (mid-November through February) is dominated by rough seas and greater mixing of ocean water. Strong winter storms originating in the Gulf of Alaska cause turbulent conditions that break down stratified ocean layers so that temperature, salinity, and nutrients are similar throughout the upper water column.

Habitat

The main feature of Cordell Bank sanctuary is an offshore rocky bank 4.5 miles (7.2 km) wide by 9.5 miles (15.2 km) long covering an area of approximately 26 square miles (41.8 km^2). The bank emerges from the soft sediments of the continental shelf, with the upper pinnacles reaching to within 115 feet (35 m) of the ocean's surface (Figure 10). Shelf depths at the base of the bank are roughly 300 to 400 feet (91-122 m).

Figure 10. The pinnacles of Cordell Bank harbor an abundance of life in both the benthic and pelagic habitats. Photo: Kip Evans.

Comment [kb19]: Consider improving the quality and interpretation of some of the figures (i.e. Fig. 9).

Comment [kb20]: This is too small - I doubt anyone will understand this figure, recommend removing this figure, and inserting something more stylized (or make it a lot bigger and explain it a bit more).

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Comment [kb21]: Under Habitat and/or Living Resources, there could be a sentence or two on importance of nursery habitats for young fishes (rockfishes). And the link of young rockfishes as an important prey source for birds, fishes, and some mammals could be discussed (besides krill, young rockfishes are a major source of prey for some species...what about small pelagics?)

Comment [kb22]: no mention is made of the rocky outcroppings which are mentioned later as a component of the shelf and slope. These areas while minimal in terms of area typically concentrate high abundance/biomass of marine life.

Comment [kb23]: This is the 3rd time in 11 pages that Cordell Bank is described (Summary, Box and here in text). A little repetitive.

The bank has a diversity of benthic habitats that includes high relief rock pinnacles, flat rock, boulders, cobble, sand, and mud (Figure 11). Distinct biological assemblages are associated with the different habitat types. The rugosity of the bank and the diversity of habitats are important contributors to the diversity of fishes and benthic invertebrates observed in the sanctuary.

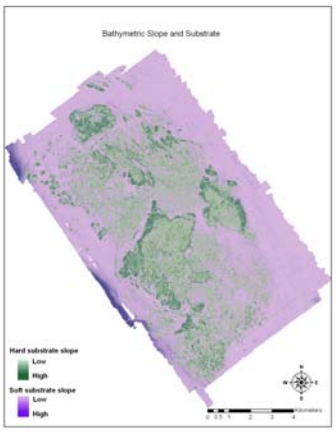

Figure 11. *Image of bathymetric slope and substrate type (hard versus soft bottom) of Cordell Bank, based on high resolution multibeam echosounder data. Source: Seafloor Mapping Laboratory at California State University Monterey Bay. Image created by Lisa Etherington*

Comment [kb24]: too small, can the angle be rotated to see bottom topography a bit ? Figure 16 is a better image, maybe delete this figure.

The vertical relief and hard substrate of the bank provide habitats with nearshore characteristics in an open ocean environment about 20 miles (32 km) offshore. The resident reef community associated with the bank is ecologically linked with the open ocean (pelagic) community, which includes animals that travel thousands of miles each year to feed around the bank. The result is a fascinating array of resident and transient animals, and tremendous biological diversity in the vicinity of Cordell Bank National Marine Sanctuary.

Soft bottom habitat constitutes the remaining continental shelf (313 square miles, or 800 km^2) and slope (190 square miles, or 486 km^2) protected within Cordell Bank sanctuary. This habitat lacks the physical structure or rugosity apparent on the rocky bank and the lack of hard substratum for attachment prevents algae and some invertebrates from colonizing soft-bottom habitats. Soft-bottom associated species live either on the surface of, or buried in, the sediments (Figure 12). Sand and mud are the two primary soft bottom habitat types within the sanctuary. The majority of sand habitat is located on the eastern edge of the bank on the continental shelf or in areas between the hard substrates on the bank. Mud bottom makes up most of the remaining habitat on the continental shelf and slope. The shallowest depths in the sanctuary, excluding Cordell Bank, are approximately 230 feet (70 m), and are found within the continental shelf region in the eastern part of the sanctuary.

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<<<Insert figure of skate in sandy habitat: SNOOK 053 LNGNSEDSKATE.jpg>>>

Figure 12. Long-nosed skates are commonly found in soft bottom habitats along the continental shelf and slope. Photo: Linda Snook.

In addition to the benthic habitats of Cordell Bank sanctuary, the open ocean water column is another important habitat. The water column is subjected to seasonal and annual variations in physical parameters like turbidity, temperature, and salinity, as well as stratification. Larger scale oceanographic events, combined with local conditions, make the water column a very dynamic habitat.

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Living Resources

Comment [kb25]: In general this section (Living Resources) would make more sense if it went from Benthos to inverts (krill and squid) to fish to turtles, birds and mammals – in order of taxonomic progression. The order appears rather random.

Benthos

A dense cover of benthic organisms carpets the shallower rock surfaces of Cordell Bank. The high light penetration in this offshore environment allows for algal photosynthesis in far deeper water than in similar habitats nearshore along the mainland coast. The abundant food supply drifting over the bank, combined with a hard substrate for larval settlement and attachment, provide ideal conditions that support a rich assemblage of benthic invertebrates (Figure 13). Ridges are thickly covered with

sponges, anemones, hard hydrocorals, soft gorgonian corals, hydroids, tunicates, harbor scattered crabs, holothurians, and gastropods. Giant Pacific octopus (*Octopus dofleini*) is a resident species found on the bank.

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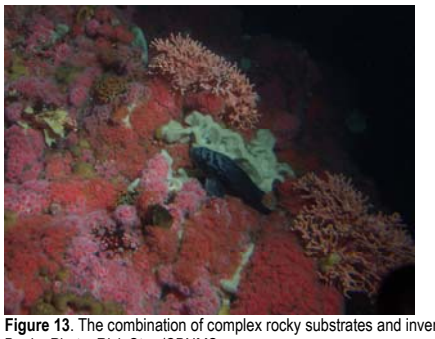

Figure 13. The combination of complex rocky substrates and invertebrates, such as hydrocorals, sponges, and sea anemones, provide habitat for fish on Cordell Bank. Photo: Rick Starr/CBNMS.

Soft bottom habitats also support a thriving community of benthic invertebrates. Adapted to life in and on a shifting substrate, these animals are either buried in the sediment, like polychaete worms and clams, or are mobile on the surface, such as sea stars and Dungeness crabs (*C. magister*) (Figure 14). The sea whip (*Halipteris sp*) is one common soft bottom resident that anchors in the mud with an inflatable bulb and extends into the water column providing structure and relief for fishes and other invertebrates on the flat, mostly featureless, bottom of the continental shelf.

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Figure 14. Dungeness crabs occupy continental shelf habitats and are an important commercial species in the region. Photo: Richard Starr/CBNMS.

Comment [kb26]: caption for Dungeness crab is awkward.

Krill

Two species of krill (*Thysanoessa spinifera* and *Euphausia pacifica*) are important trophic links in the Cordell Bank ecosystem (Figure 15). These small, shrimp-like crustaceans are referred to as "keystone" species because they are critical prey for so many other species on and around the bank. At Cordell Bank, krill are the primary reason that the area is a destination feeding ground for many migratory animals such as Chinook salmon (*Oncorhynchus tshawytscha*), humpback whales (*Megaptera novaeangliae*) and blue whales (*Balaenoptera musculus*). In addition, krill are prey for resident species like yellowtail rockfish (*Sebastes flavidus*) and Cassin's Auklets (*Ptychoramphus aleuticus*) that nest on the nearby Farallon Islands.

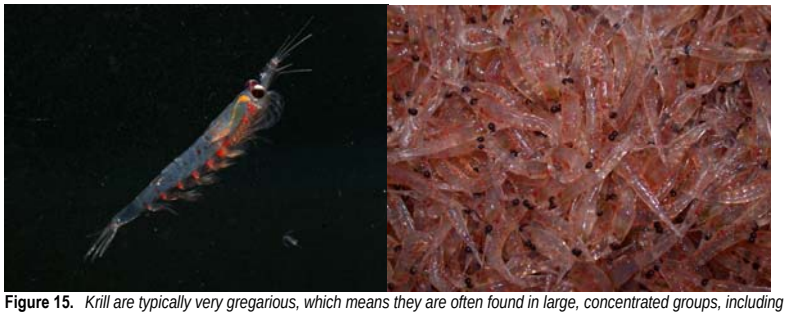

Figure 15. *Krill are typically very gregarious, which means they are often found in large, concentrated groups, including dense swarms with as many as 100,000 krill per cubic meter of ocean water. Photo credit: Benjamin Saenz*

Each spring and summer massive swarms of krill provide food for critical components of the Cordell Bank ecosystem including seabirds, fishes and whales. Krill exhibit unique behaviors that play an important role in affecting the distribution and abundance of predators. With the onset of darkness each night, krill migrate from near the ocean floor into the upper water column. In response, many species of fish move up in the water column at night to feed on the krill. These spectacular vertical migrations from seafloor to surface layers can cover almost 600 feet (over 180 m) in an hour. *T. spinifera* occasionally form dense swarms at the ocean surface during daylight hours. Fishes, seabirds and whales all feed actively on the krill when they aggregate on the surface. Seasoned fishermen key in on flocks of feeding seabirds, knowing that salmon are also feeding on the krill.

Comment [kb27]: Schools?

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Zooplankton

Myriad gelatinous zooplankters are a bizarre and little known component of the open ocean ecosystem at Cordell Bank. This ephemeral water column community floats by the bank on the currents. In addition to the common jellyfish, like moon jellies (*Aurelia aurita*) and sea nettles (*Chrysaora fuscescens*), more obscure invertebrate creatures such as hydromedusae, ctenophores, siphonophores, pteropods, and heteropods eat and are eaten in the water column around the bank. The ocean sunfish (*Mola mola*) and leatherback sea turtle (*Dermochelys coriacea*), which visit the sanctuary in the late summer and fall, exclusively eat these gelatinous creatures and depend on them to survive. Other animals such as the blue rockfish (*Sebastes mystinus*) and the yellowtail rockfish are opportunistic and gorge themselves when gelatinous zooplankton are abundant. In addition to zooplankters, planktonic fish and invertebrate larvae make up a large seasonal component of the plankton community.

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Fish

More than 180 species of fish have been documented in the Cordell Bank National Marine Sanctuary (Eldridge 1994, NMFS triennial surveys, Cordell Bank surveys), with rockfish dominating the fish community in both numbers and biomass (Figure 16). Since 2002, sanctuary staff and partners have conducted quantitative visual surveys from the manned 'Delta' submersible focusing on characterizing the bank's fishes and their preferred habitats (Anderson et al. 2007). During the fall of 2002, 70 fish species (or species-groups) representing 21 families were enumerated. Rockfishes (*Sebastes* spp.) were the dominant group, accounting for 27 species and 95% of all individuals. Of these, young-of-year (YOY) rockfishes were the most numerous, accounting for 64% of all rockfishes. The distribution and abundance of fishes were related to habitat type, depth, and location. Cordell Bank is a significant locus for the recruitment of juvenile rockfishes. It also appears that the deep boulder habitat provides a natural refuge for some overfished species, such as bocaccio (*Sebastes paucispinis*), yelloweye rockfish (*S. ruberrimus*), cowcod (*S. levis*) and canary rockfish (*S. pinniger*). Lingcod (*Ophiodon elongatus*) are especially conspicuous in the wintertime, when they move up onto the bank to lay their eggs.

Comment [kb28]: missing discussion of mid-water and coastal pelagic species (sardine / anchovy) ?

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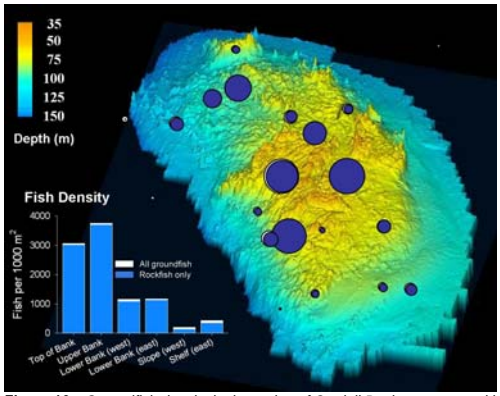

Figure 16. *Groundfish density in the region of Cordell Bank as measured by Delta submersible transects to assess the benthic community and habitat affinities. Rockfish account for 95% of fishes observed, with their abundance decreasing markedly as you move off the bank. Size of circles indicates comparative abundance in different locations on the bank. Image created by Tara Anderson.*

Limited scientific study has been directly focused on the ichthyofauna of the sanctuary's soft-bottom habitat, however, considerable information has been gathered and analyzed on the fish assemblages that inhabit the continental shelf and slope habitats of the Northeastern Pacific Ocean. While soft-bottom areas are the domain of flatfishes, skates and rays, a number of fusiform (spindle-shaped) fishes such as croakers, rockfishes, sculpins and surfperches also thrive in this habitat. Ecologically significant fishes most commonly found in the middle shelf include big skate (*Raja binoculata*), longspine combfish (*Zaniolepis latipinnis*), shortbelly rockfish (*Sebastes jordani*) and pacific sand dab (*Citharichthys sordidus*). On the outer shelf, fishes more commonly seen in research collections included the stripetail rockfish (Sebastes saxicola), greenstriped rockfish (*Sebastes elongatus*) and slender sole (*Lyopsetta exilis*). Beyond the shelf break in the mesobenthal slope region, fishes most commonly found include poachers, splitnose rockfish (*Sebastes diploproa*) and sablefish (*Anoplopoma fimbria*). Among the fishes that inhabit all three depth zones are lingcod (Figure 17), spotted cusk eel (*Chilara taylori*), plainfin midshipman (*Porichthys notatus*) and Dover sole (*Microstomus pacificus*).

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Albacore tuna (*Thunnus alalunga*) and salmon (*Oncorhynchus tshawytscha, O. kisutch*) frequent the sanctuary on a seasonal basis. Other pelagic species of interest that are observed in the surface waters surrounding Cordell Bank include the ocean sunfish and the blue shark (*Prionace glauca*).

<<<Insert figure of lingcod by Kip Evans: Lingcod.jpg>>>

Figure 17. Boulder habitats at the edge of the bank have high densities of large commercially important species including lingcod. Photo: Kip Evans.

Squid

The nominal range of jumbo squid (*Dosidicus gigas*) is from southern California to northern Chile, but recently, these large oceanic squid have become a regular occurrence in northern California (Zeidberg and Robison 2007), particularly in the region of Cordell Bank. The appearance of this species in this region occurred after the strong 1997/98 El Niño event (Zeidberg and Robison 2007, Field et al. 2007). Stomach samples of squid collected in 2005-2006 from waters of the California Current have shown that jumbo squid in this region preyed on a wide variety of sizes and types of prey, particularly larger fishes (Field et al. 2007). Some of the most frequently occurring prey items were species of commercial importance, including: Pacific hake (*Merluccius productus*), northern anchovy (*Engraulis mordax*), Pacific sardine (*Sardinops sagax*), rockfish, and market squid (*Loligo opalescens*) (Field et al. 2007). Jumbo squid were also found to feed on myctophids, mesopelagic fishes, and small crustaceans (Field et al. 2007). It is unknown what kind of changes the presence of these large predators will have on the ecosystem in the region of the sanctuary.

Comment [kb29]: No mention of *Loligo opalescens* (market squid) under the section on Squid. Are they not relevant to Cordell Bank (just asking)?

Comment [kb30]: now that oceanographic conditions are changed to cold water jumbo squid have disappeared – perhaps a little more about how this species interacts with year to year changes in seawater temp?

Marine Mammals

Twenty-six species of marine mammals (a combination of resident and migratory species) have been observed within the sanctuary. Monthly monitoring of the Cordell Bank pelagic environment indicates that Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) are the most frequently sighted marine mammal in the sanctuary (Figure 18). Other numerous

cetaceans include Dall's porpoises (*Phocoenoides dalli*) and northern right-whale dolphins (*Lissodelphis borealis*). Humpback and blue whales are regularly seen in the summer and fall when they visit the sanctuary to feed. In addition, gray whales (*Eschrichtius robustus*) pass the bank on their annual migrations between Arctic feeding grounds and Mexican breeding areas. Other mammals seen around the bank include Risso's dolphins (*Grampus griseus*), killer whales (*Orcinus orca*), California sea lions (*Zalophus californianus*) northern fur seals (*Callorhinus ursinus*), northern elephant seals (*Mirounga angustirostris*) and Steller sea lions (*Eumetopias jubatus*).

Figure 18. *Pacific white-sided dolphins are one of the most abundant marine mammals in the Cordell Bank sanctuary. Photo: Cornelia Oedekoven*

Seabirds

The waters around Cordell Bank provide critical foraging habitat for many species of seabirds. During the upwelling season, the highest levels of seabird biomass in central California waters are found at Cordell Bank, Monterey Bay and the Farallon ridge (Ford et al. 2004). Fifty-nine seabird species have been identified feeding in or near the sanctuary. Like the fishes and marine mammals, the composition of seabirds found at Cordell Bank is a mix of local breeding birds and highly migratory open-ocean species. For example, it is possible to see one-half of the world's population of Ashy Storm-Petrels (*Oceanodroma homochroa*), which nest on the Farallon Islands, on the water around Cordell Bank at one time. More than 20,000 Cassin's Auklets, which are also local breeders, have been counted around the bank in a single day (Stallcup 2004). Local representative species use the nearby Farallon Islands and Point Reyes areas to nest, while some migrant birds nest thousands of miles away. A recent study using satellite tags documented that Black-footed Albatross (*Diomedea nigripes*) nesting in the northwestern Hawaiian Islands are "commuting" to Cordell Bank waters to gather food for their chicks before returning to their nests (Hyrenbach et al. 2006) (Figure 19). Other migratory species use the productive waters around the bank as a stopover on their annual migration route. For example, tens of thousands of Sooty Shearwaters (*Puffinus griseus*) pass through the sanctuary annually as part of their migration between the west coast of North America and New Zealand.

Comment [LA31]: Capitalize?

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Figure 19. *Black-footed albatrosses travel thousands of miles from the northwestern Hawaiian Islands to feed in the waters of Cordell Bank sanctuary. Photo: Sophie Webb*

Sea turtles

The sanctuary is the seasonal home for the endangered leatherback sea turtle. The leatherback is a regular summer visitor and is the only species of sea turtle that journeys to cold waters to feed. Leatherbacks feed on the seasonal abundance of jellyfish in the Cordell Bank area.

Comment [kb33]: I believe LB turtles are mostly here in the fall ?? (not summer)

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Maritime Archaeological Resources

It is unknown how many shipwrecks, if any, rest on the seafloor of the Cordell Bank sanctuary. Prehistoric use of the island, when the bank was exposed during the last ice age, may also have occurred. Until recently, Cordell Bank and the surrounding seabed have been inaccessible due to location, depth, and currents. Improving technology, such as sonar, remotely operated vehicles, and manned submersibles, has reduced some constraints to exploration. High resolution multibeam echosounder surveys of the entire bank, as well as limited side-scan sonar surveys of the soft bottom continental shelf area, have not detected any maritime archaeological resources in the sanctuary. However, only 18% of the sanctuary seafloor has been mapped with these remote sensing techniques.

Pressures on the Sanctuary

Numerous human activities, natural events, and processes affect the condition of natural and archaeological resources in marine sanctuaries. This section describes the nature and extent of the most prominent pressures in Cordell Bank sanctuary.

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Harvesting

The Cordell Bank area supports an active commercial and recreational fishery (Figure 20). Commercial and recreational fishing, combined with habitat destruction, poor recruitment and anomalous oceanographic conditions, have contributed to declines of many marine species in central and northern California waters. Several runs of Chinook salmon, Coho salmon (*O. kisutch*), and steelhead (*O. mykiss*) in central California have been listed as federally endangered and threatened since 1994. The complex life histories of these species, spanning fresh water rivers and ocean environments, subject them to negative impacts from many different sources at all stages of their lives. Many rockfish populations have declined under fishing pressure and years of recruitment failure due to unfavorable oceanographic conditions, and several species are currently considered overfished, including cowcod (*S. levis*), canary (*S. pinniger*), yelloweye (*S. ruberrimus*) and darkblotched rockfish *(S. crameri*).

Comment [kb34]: Some of the information has been presented unevenly. For instance, there is quite a bit of detail on marine debris (much of which is not relevant to Cordell Bank but is taken from elsewhere around the world), while important details on fishing have not been included. It would be useful to report some data on fishing effort and gear types, and how efforts and types have changed over the years.

Commercial and sport fisheries in Cordell Bank sanctuary have generally targeted rockfish, lingcod, flatfish, salmon, Dungeness crab and albacore tuna. Commercial boats will travel from out of the area to fish for groundfish, salmon and crab. Most of the private boats and charter vessels that fish Cordell Bank sanctuary are from Bodega Bay or San Francisco Bay. Rough ocean conditions often prevent smaller boats from accessing the bank. Gear types used in the sanctuary have included bottom trawl, mid-water trawl, hook and line, gill nets, crab traps, pots and long lines (including troll long line, vertical long line, and fixed gear long line). Observations from submersibles have documented the presence of lost fishing gear entangled in rocky areas of the bank. These bottom-tending gear types can damage sensitive habitats that provide food and shelter for invertebrates and fishes.

Comment [kb35]: A map of fishing pressures in the Sanctuary would be informative, along with recent fishery management rules (Essential fish habitat, rockfish conservation areas) as well as a discussion of the role or the Sanctuary in working with the regional FMC to address sanctuary resources.

Comment [LA36]: citation available?

Comment [LA37]: citation

Figure 20. *For many years, the productivity around Cordell Bank has attracted commercial fishermen.*

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Hunting of marine mammals for meat and fur in the 1800s and early 1900s contributed to declines of many species, including northern elephant seals (*Mirounga angustirostris*), harbor seals (*Phoca vitulina*), California and Steller sea lions, and northern fur seals. Hunting of large whales during the last two centuries nearly extirpated several species, including gray, blue, humpback and fin (*Balaenoptera physalus*) whales. One of the last active whaling stations in America operated in San Francisco Bay until 1971. Selected open ocean fisheries have significantly reduced some populations of sea turtles and seabirds that are taken as bycatch in these fisheries.

Comment [LA38]: List of species with high bycatch mortality at Cordell Bank?

Vessel Traffic

The southeast corner of Cordell Bank National Marine Sanctuary is located approximately five nautical miles (8.9 km) from the terminus of the northern shipping lanes that funnel commercial vessels into and out of San Francisco Bay. This traffic corridor, which was designated by the U.S. Coast Guard, is used by large commercial vessels entering San Francisco Bay from the north or leaving San Francisco Bay and transiting to the north. Because the terminus of the northern lane is adjacent to the sanctuary, all inbound and outbound traffic using the northern lanes passes through the sanctuary on their approach to or departure from San Francisco Bay. In 2004, 2,608 commercial vessels were reported transiting the northbound shipping lanes into and out of the Bay (United States Coast Guard, Automatic Identification System, unpubl. data).

Vessel spills are a major concern when considering potential threats to Cordell Bank's resources. Historically, the total number of oil spills from transiting vessels has been small, but the potential impacts may be enormous given the number and volume of vessels and the sensitivity of resources in the area. Large commercial vessels are of particular concern because in addition to their cargo they can carry up to one million gallons of bunker fuel, a heavy, viscous fuel similar to crude oil. In late 1984, on-board explosions, about eight miles seaward of the Golden Gate Bridge, disabled the tanker Puerto Rican. The vessel eventually broke apart and discharged refined oil products within the boundary of the Gulf of the Farallones National Marine Sanctuary. Thousands of seabirds were oiled and died. In November 2007, the container ship *Cosco Busan* collided with the Bay Bridge within San Francisco Bay, spilling 58,000 gallons of bunker fuel that spread throughout the Bay and into the coastal waters (Figure 21). Oil from the spill traveled over 25 miles (40 km) and reached beaches adjacent to Gulf of the Farallones sanctuary waters, northwest of the Bay mouth. Wildlife impacted from the spill included thousands of seabirds that were oiled and killed (Oiled Wildlife Care Network, January 2008). The impacts of these incidents demonstrate the seriousness of the potential hazards to Cordell Bank sanctuary from vessel spills, including vessel traffic occurring outside the sanctuary boundary.

<<<Insert photo of aerial view of oil from Cosco Busan spill: 20071110_CBOS_DH_ 006.jpg

Figure 21. The detrimental impacts of the Cosco Busan oil spill of November 2007 reached far beyond the spill location in San Francisco Bay, including offshore waters.

California ports handled an estimated 650 cruise ship port calls in 2004. In 2003, the cruise industry predicted a 25 percent increase in the number of vessels operating in the waters of California over the next 10 years (California Environmental Protection Agency 2003). Cruise ships make port calls to at least six locations in California, including San Francisco and Monterey Bay. Many of these ships have over 3000 people on board and have the potential to severely impact water quality in localized areas if they are not responsibly operated. Cruise ships are capable of generating massive volumes of waste. The main pollutants generated by a cruise ship are: sewage (also referred to as black water), gray water, oily bilge water, hazardous wastes, and solid wastes. Cruise ships are the equivalent of small cities in regard to waste production, and though these vessels generally incinerate the majority of waste produced, they are not subject to the strict environmental regulations and monitoring requirements imposed on land based facilities, such as obtaining discharge permits, meeting numerous permit conditions, and monitoring discharges.

Within sanctuary waters, disposal of bilge water with any concentration of oil, and disposal or discharge of any harmful substance is prohibited. However, discharge of water and other biodegradable effluents incidental to vessel use, including treated effluent from a Type 1 or Type 2 marine sanitation devices, deck wash down, and engine exhaust, is currently allowed.

In addition to the threats of materials being deposited from vessels into the sanctuary, the vessels themselves could directly affect various sanctuary resources. Vessels can potentially alter the behavior of marine mammals and seabirds, changing the distribution of the animals or the amount of time that they spend feeding and/or resting. More drastically, vessels can injure or kill marine mammals and seabirds through collisions (Figure 22). In the Eastern North Pacific, the average number of humpback whale and blue whale deaths due to ship strikes was at least 0.2 per year from 1999-2003 and 1998-2002, for humpback and blue whales, respectively (Carretta et al. 2007).

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Comment [LA39]: Citation? Because of vessel size, decibels emitted, combination…

Comment [kb40]: insert the unusually high number of whale strikes in 2007 – 3 blue whales hit in southern California.

Figure 22. *Large vessels such as cruise ships and cargo vessels have the potential to directly impact marine mammals. Photo: Bob Wilson.*

Noise

The level of noise pollution in the oceans has increased dramatically during the last 50 years, with much of this due to commercial shipping (National Research Council 2003). Another source of noise pollution that has the potential to impact sanctuary resources is exploration for oil and gas. Although oil exploration/production is currently prohibited within Cordell Bank sanctuary boundaries, activity adjacent to the sanctuary boundary would have the potential to affect the integrity of sanctuary resources. An additional source of noise pollution is from sonar activities, including human-generated mid-frequency sonar from military vessels.

The effects of noise on marine mammals, seabirds, fishes, and turtles are not entirely known, though active sonar has been conclusively linked to the deaths of whales in other areas. Many marine mammals respond to noise by altering their breathing rates, increasing or reducing their time underwater, changing the depths or speeds of their dives, shielding their young, changing their song durations, and swimming away from the affected area. Extreme noise pollution may cause temporary or permanent hearing loss in marine mammals and other organisms. Disorientation and hearing loss may account, in part, for cases in which ships collide with marine mammals that are apparently unaware of the approaching vessel. As ships get bigger and noisier, this could become a larger issue within sanctuaries. Oil exploration-related seismic surveys may cause fish to disperse from the acoustic pulse with possible disruption to their feeding patterns. Available data on fish indicates potential effects on sensitive egg and larval stages within a few meters of the sound source. These surveys may also disrupt prey location and communication among marine mammals and in severe cases cause internal injuries.

Comment [LA41]: cite

Comment [kb42]: a reference should be included to substantiate the comment that "active sonar was conclusively linked to the deaths of whales"

Climate

The calendar year at Cordell Bank sanctuary is comprised of three distinct oceanographic periods. These periods, described by upwelling, wind relaxation (oceanic), and winter storms (Davidson Current), are associated with different oceanographic conditions. The amount of production in surface waters and the extent to which organisms disperse is directly affected by these different conditions. In response to oceanographic drivers (as well as seasonal migration patterns), the abundance and diversity of organisms present in a given region change dramatically throughout the year and from one year to the next.

In addition to seasonal and annual climatic variations that influence productivity of the sanctuary, longer-term climatic phenomena influencing the region include El Niño-Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), and global climate change, processes that operate on different spatial and temporal scales. Off the coast of California, El Niño events are characterized by increases in ocean temperature and sea level, enhanced onshore and northward flow, and reduced productivity. During this period, survivorship and reproductive success of some seabirds and fishes decreases with reduced plankton abundance. The disruption of the food web also impacts higher level predators like marine mammals that depend on krill and fish for food, leading to widespread starvation and decreased reproductive success. In addition, changes in current patterns and increased water temperature affect immigration of warm-water species and emigration of cold-water species.

Pacific Decadal Oscillations are periods of sustained climate conditions associated with shifts in ecosystem production regimes in cycles of about 50 years duration. Associated with these cycles, the surface waters of the central and northern Pacific Ocean shift several degrees from the mean temperature. Such shifts in mean surface water temperature have been detected five times during the past century, with the most recent shift in 1998. Biological patterns are related to these climate 'regime shifts'. The Pacific Decadal Oscillation affects production in the eastern Pacific Ocean and, consequently, affects organism abundance and distribution throughout the food web. For example, the alternating 20 to 30 year cool and warm periods in the Pacific cause the abundances of anchovies (cool periods) and sardines (warm periods) to alternate (Chavez et al. 2003).

As evidence has mounted in recent decades for accelerated warming of the world's oceans (Levitus et al. 2000), increased attention has been focused on the potential impacts of this change on marine organisms. Researchers predict that a monotonic gradual increase in ocean water temperature will cause a northward shift in the ranges of at least some species. It is also possible that some fishes will move to deeper cooler water. Of course, not all species will shift their ranges in response. If their rate of northward migration is too slow to keep pace with the changes, they will either adapt, live under suboptimal conditions, or perhaps vanish locally. Regardless, the composition of local assemblages is expected to change (Allen et al. 2006).

The increase in the amount of CO_2 in the atmosphere has lead not only to increased temperatures on Earth, but also to higher levels of dissolved CO_2 in the world's oceans. Since CO_2 reacts with seawater to form carbonic acid, the addition of increased amounts of CO_2 has lowered the pH of the oceans (a condition termed ocean acidification) and has reduced the amount of freely available carbonate ions. These conditions could be detrimental to many marine organisms, including mollusks and corals, which rely on carbonate from seawater to build their shells and other hard parts, and certain shell-producing plankton. The magnitude of the impact of increased ocean acidification on marine ecosystems is unknown.

Comment [kb43]: report out this week in Science Express documents the increase in OA from upwelling in Northern California (Ref, Feely et al 2008. Evidence for Upwelling of Corrosive "Acidified" Water onto the Continental Shelf. Science Express / www.sciencexpress.org / 22 May 2008 / 10.1126/science.1155676).

Marine Debris

Levels of debris in both the ocean and at the land-sea interface are of growing concern. Marine debris poses a growing threat to marine life and biological diversity. Various types of debris are known to have adverse effects on marine species. Ingestion and entanglement are two of the largest problems associated with marine debris, which may cause injury and death to selected marine wildlife, including some endangered and protected species that are found in Cordell Bank sanctuary. Marine debris originates from both land-based and ocean-based sources, although the majority of marine debris (approximately 80%) appears to come from land-based sources (U.S. Dept. of Commerce and U.S. Navy 1999). Land-based sources include: littering, storm water runoff, coastal municipal landfills, loss during garbage transport, open trash collection containers, industrial facilities, and beach-goers. Ocean-based sources include: commercial and recreational fishing, overboard disposal of passenger and commercial shipboard waste, and cargo containers falling off ships in high seas. Types of marine debris include cigarette butts, balloons, abandoned or discarded fishing gear, plastics and styrofoam, and consumer goods including 6-pack rings and plastic shopping bags. The potential impact of marine debris on living resources in Cordell Bank sanctuary was highlighted by high rainfall in 2006, which flooded inland areas in the San Francisco Bay watershed and resulted in large amounts of debris washing 50 miles (80 km) to the northwest to Cordell Bank (Cordell Bank sanctuary, unpubl. data).

Comment [kb44]: Given the research of the "ACES" program and that Cordell Bank staff contribute to it , there should mention of it here as well as the evidence of albatross foraging in the "Garbage patch" in the north Pacific gyre.

Deleted: These

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Plastics in the marine environment never fully degrade and recent studies show plastic is consumed by organisms at all levels of the marine food web. In addition, dichlorodiphenyltrichloroethane (DDT) and other hydrophobic compounds are known to adhere to plastics. Given the quantities of plastic debris floating in the ocean, the potential for ingestion is enormous. For example, survival of endangered sea turtles is threatened by ingestion of plastic; studies have found that as many as 75% of sampled sea turtles have plastic debris in their digestive tracks (Tomas et al. 2002). Leatherback sea turtles frequent the Cordell Bank area in summer and fall, hunting for gelatinous zooplankton that can be abundant in the sanctuary. Plastic marine debris also impacts many seabird species. Surface feeding seabirds, including albatrosses, shearwaters, fulmars, and storm-petrels, are most susceptible to plastic ingestion, with frequency of individuals with plastic in the stomach ranging from 50 to 80% (Nevins et al. 2005) (Figure 23). For example, adult Black-footed Albatross often mistake floating plastic debris as food and ingest huge quantities of plastic bottle caps, plastic fragments, discarded cigarette lighters, and plastic toys, which unfortunately, they also feed to their chicks on remote islands. Tagging studies have documented Black-footed Albatross crossing the eastern Pacific to feed in and around Cordell Bank sanctuary. When these adults return to their nests on the Northwestern Hawaiian Islands to feed their chicks, a high percentage of the meal is composed of plastic.

Comment [LA45]: cite

Comment [LA46]: make connection between hunting gelatinous zooplanton and plastic debris.

<<<Insert image of Black-footed albatross picking at balloon: bfarichstallcup.jpg>>>
Figure 23. Black-footed albatross picking at marine debris at Cordell Bank sanctuary. Photo: Rich Stallcup.

Entanglement in marine debris is another serious problem, and it has been linked to measurable population declines for a variety of marine mammals. Scientists have estimated that 100,000 marine mammals are killed by entanglement in debris each year in the North Pacific (Wallace 1985). Recent stock assessments indicate that annual mortality and injury due to entanglement is 1.2 individuals per year and 0 individuals per year for the Eastern North Pacific stocks of humpback (data from 1999-2003) and blue whales (data from 1998-2002), respectively (Carretta et al. 2007). In 1997, a Take Reduction Plan, which included skipper education workshops and the required use of pingers, was put into place to reduce injury and mortality of whales due to interactions with drift gillnet fisheries (Carretta et al. 2007). Using data from 1997-2001, minimum total annual take of California sea lions is 1476 per year, a mortality rate that cannot be considered as insignificant when assessing the status of this stock (Caretta et al. 2007).

Significant amounts of derelict fishing gear have been documented in Cordell Bank National Marine Sanctuary (Figure 24). This includes long lines, gill nets, crab gear, and trawl warps entangled on and around the bank. One concern is that the abandoned fishing gear on Cordell Bank may be harming sanctuary resources, creating artificial habitat for marine life, and potentially impacting the physical structure of the bank. This derelict gear also poses a danger to personnel and equipment involved in sanctuary research and monitoring activities.

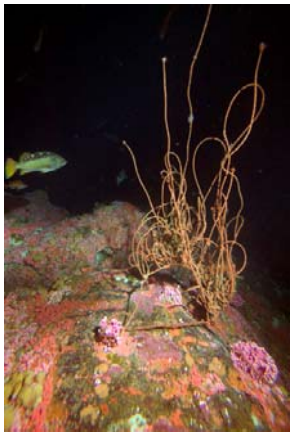

Figure 24. *Derelict gear entangled on rocky substrate of Cordell Bank. The benthic community in the vicinity of the gear includes hydrocorals, anemones, sponges, and rockfish. (Photo credit: Kip Evans)*

Non-indigenous Species

Comment [kb47]: Potential for invasion by pelagic hydroids or medusa or tunicates would appear to be very high given nearby location to SF Bay and its high rate of invasion. High risk.

Non-indigenous species can alter species composition, threaten the abundance and diversity of native species and interfere with healthy ecosystem function. Once established, non-indigenous species can be extremely difficult to remove, especially in deep water habitats like Cordell Bank.

A number of non-native species are present in the marine environment near Cordell Bank, but none are known to currently exist in the Cordell Bank sanctuary. Non-native species are still considered to be a potential major threat to living resources and habitats in the sanctuary. Numerous non-indigenous species have been found in the adjacent Gulf of the Farallones sanctuary (deRivera et al. 2005, Byrnes et al. 2007), and a list of non-native species that have a high probability of being found in the sanctuary has been compiled (J. Byrnes, unpubl. data). The list was obtained by comparing lists of species within and around sanctuary waters to lists of known invaders within California, Bodega Harbor, Tomales Bay, and Elkhorn Slough. The list should therefore be regarded as conservative, including some species that may not yet be within sanctuary waters, but given their geographic proximity, have a high probability of invading in the near future. For example, there is concern regarding an invasive tunicate *Didemnum* sp. that has been observed in nearby coastal areas (Tomales Bay and Bodega Bay, CA) and has the potential to cause great ecological and economic damage (Bullard et al. 2007). This invasive species is known to spread rapidly, alter benthic habitats, and overgrow sessile organisms such as sponges, anemones, bryozoans, hydroids, macroalgae and tunicates (Bullard et al. 2007) (Figure 25).

Figure 25. *Anemones are prominent organisms on Cordell Bank and could be sensitive to non-native species invasions. Photo: Michael Carver/CBNMS*

State of Sanctuary Resources

This section provides summaries of the condition and trends within four resource areas: water, habitat, living resources, and maritime archaeological resources. For each, sanctuary staff and selected outside experts considered a series of questions about each resource area. The set of questions derive from the National Marine Sanctuary System's mission, and a system-wide monitoring framework (National Marine Sanctuary Program 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on, and study the ecosystems encompassed by the sanctuaries. The questions are meant to set the limits of judgments so that responses can be confined to certain reporting categories that will later be compared among all sanctuary sites and combined. The Appendix (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 "?" – the trend is undetermined.

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

Water

Cordell Bank is far enough offshore to be relatively free of direct impacts associated with terrestrial inputs. The eastern edge of the sanctuary is located six miles (10 km) from shore, and is adjacent to western Marin and Sonoma counties, which are sparsely populated and rural in character. Due to depth, resuspension of bottom sediments is not thought to substantially affect water quality (Figure 26).

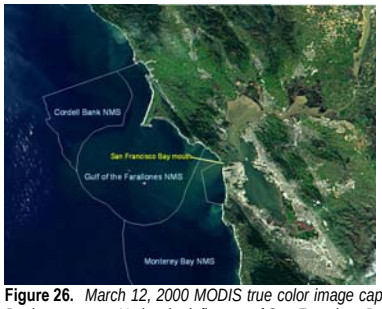

Figure 26. *March 12, 2000 MODIS true color image capturing the San Francisco-Oakland metropolitan area, Point Reyes and the offshore location of Cordell Bank sanctuary. Notice the influence of San Francisco Bay outflow on the offshore environment. Image created by Pam van der Leeden.*

The following information summarizes an assessment by experts in the field and sanctuary staff of the status and trends pertaining to water quality and its effects on the environment in Cordell Bank National Marine Sanctuary:

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

Oceanic water quality off northern California is generally good, except in areas adjacent to population centers, such as San Francisco Bay. The distance and location of Cordell Bank 50 miles (80 km) to the northwest of the San Francisco Bay generally buffers the sanctuary from any direct outflow effects. The prevailing winds and currents flow from the north, so the flow out of the Bay is driven to the south, away from Cordell Bank for most of the year. This is not the case in winter, when storm conditions are characterized by heavy rainfall, strong southerly winds and a coastal current that flows northward. In January 2006, impacts from severe flooding of coastal counties in northern California, caused by heavy rainfall, were observed at Cordell Bank during a

Comment [kb48]: As I said above the document is excellent, but it needs some teeth, and by this I mean...data. Certainly, time series of key measurements (indicators) should be reported, and for those extending over decades, averages over 5y periods could be made, with a sliding window of averages if possible (LOWESS curves are particularly useful in this context).

The document is also more of a description/inventory of CBNMS and its biological resources, than an assessment or condition report. I think is fine for this introductory stage, but basic oceanography and species accounts do not provide information with which to make "condition" assessments, whereas time series do. Then there is the question of how to illustrate change. I have found that plotting annual values for those that are available, plus/minus 1 S.D. (roughly equivalent to the 80% CI) is a pretty good way of showing variability, and what is outside the norm.

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Comment [LA49]: Up and down arrows do not appear in this draft (on a Mac).

Comment [kb50]: water quality, I agree that water quality is probably *good*, but I also think that there are some things that deserve further consideration. For example, is the water column more stratified by general ocean warming? I would think so, which would have an effect on primary productivity. Certainly, some time series of temperature should be shown, possibly even the one from the Farallon Islands (Bodega buoy is very different, being near shore). There is also a tremendous dataset from the NMFS rockfish surveys from 1983-2007 that could be analyzed for changes in hydrographic conditions. Until this work is done, I would code Water 1 as *Undetermined* – since this is one included ocean climate and oceanographic conditions and no analysis has been done. Stating it is *good* is a guess, and is probably incorrect. Better yet would be some assessment of nutrients (nitrates) or CHL-a, possible by analyzing SeaWIFS. I agree with the other assessments for water quality, and would also note that oil from the *Cosco Busan* apparently reached Cordell Bank; this could be mentioned. The fact that the shipping lanes are right there also means there is a constant threat of discharge or accidents.

winter monitoring cruise (Cordell Bank sanctuary, unpubl. data). Debris such as large logs, dock pilings, floats, bottles, balloons, plastic sheets and bags littered the surface waters over Cordell Bank, likely originating from San Francisco Bay. This event was an indicator that extended El Niño conditions with heavy rains could affect water quality at Cordell Bank sanctuary as water and debris from San Francisco Bay intrudes into the sanctuary. The plume from the Russian River (located 13 miles, or 21 km north of the sanctuary's northeast corner) may enter the sanctuary in winter and spring, but typically this flow is inshore of the bank.

Anomalous atmospheric conditions in 2005 and 2006 delayed the onset and intensity of coastal upwelling along the northern California coast (Peterson et al. 2006). If these atmospheric conditions become a persistent feature in this area, then the potential would exist for negative impacts caused by the decoupling of life history patterns and early season oceanographic productivity.

Stressors on water quality from changing oceanographic and atmospheric conditions are currently not producing long-term negative effects. However, this could change if weather patterns shift. Current water quality conditions are reported to be good, but at present the trend is unknown due to a paucity of data.

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

There is no evidence of eutrophication within Cordell Bank sanctuary or the surrounding waters. Chlorophyll levels spanning seven years (1997-2004) were summarized and chlorophyll in the sanctuary never approached values that would indicate eutrophication (Stumpf et al. 2005). Monthly estimates of chlorophyll-a in recent years (2004-present) demonstrate similar patterns (Cordell Bank sanctuary, unpubl. data). Levels of chlorophyll-a concentrations and the absence of harmful algal blooms (HABs), as measured from samples taken within the sanctuary (California Department of Health Services, monthly reports), lead us to believe that eutrophication is not a problem within Cordell Bank sanctuary, and conditions appear stable.

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

Water samples are taken from Cordell Bank sanctuary during the sanctuary's monthly monitoring cruises for the California Department of Health Services (CDHS). The purpose of the sampling is to identify early warning signs of harmful algal blooms, focusing on the dinoflagellate *Alexandrium catenella* (paralytic shellfish poisoning), and the diatom *Pseudonitzschia* spp (domoic acid carriers) (Figure 27). To date, there have been no indications of elevated levels of either species (California Department of Health Services, monthly reports). Although these data are insufficient to identify the effects of specific stressors, there are currently no data to suggest that water quality is compromised.

<<<Insert photo of phytoplankton sampling: 20050516_CMA_MCC4.JPG>>>

Figure 27. Monthly water sampling is conducted to identify early warning signs of harmful algal blooms. Photo: Michael Carver

A report investigating the current state of knowledge of water quality in west coast sanctuaries concluded that Cordell Bank sanctuary is the least likely of the west coast sanctuaries to be impacted by sources of water pollution due to its offshore location and oceanic conditions (Meyers 2005). During monthly monitoring at the site, sanctuary staff have not detected any risks to human health. At this time, it is assumed that water quality is good in this regard and does not pose any risks to human health. Conditions appear to be stable.

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

Since 1970, there have been regular reports of oil-soaked birds at the Farallon Islands, suggesting frequent offshore releases of hydrocarbons. Vessels that clean tanks and pump bilges prior to entering San Francisco Bay are potential sources for this pollution. Discharges from deteriorating sunken vessels, however, have recently been identified as an additional and perhaps substantial source of hydrocarbons. Samples collected by the Gulf of the Farallones National Marine Sanctuary Beach Watch program and analysis by the California Department of Fish and Game's Office of Spill Prevention and Response have identified a sunken vessel, *SS Jacob Luchenbach*, as the source for many recent oiling events (Hampton 2003).

In recent years, attention has been focused on various compounds that are found in treated wastewater and their potential impacts on aquatic environments. These compounds include pharmaceuticals, personal care products, and household chemicals. It is unknown to what degree such inputs from terrestrial sources may impact the offshore environment and sanctuary resources.

Other threats to water quality exist, including large vessel spills and discharges from cruise ships. Based on previous releases 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. Yet, while vessel numbers transiting the sanctuary do not

appear to be increasing (1999-2005, United States Coast Guard, Automatic Identification System, Unpubl. data), it is unknown what the levels of discharge are from these vessels and how this has changed through time.

Water Quality Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

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

#	Status	Rating	Basis for Judgment
1	Stressors	?	Offshore location may limit impacts, but data are sparse
2	Eutrophic Condition	—	Results of monthly monitoring of productivity and biotoxins
3	Human Health	—	Offshore location and oceanic conditions may limit impacts; no known risks identified during monthly monitoring
4	Human Activities	?	Vessel discharges

Habitat

Habitat loss and fragmentation are perhaps the most serious threats confronting all species of wildlife today. Many of the activities and conditions that indirectly affect marine life are first experienced as an alteration or disturbance to their habitat.

Activities that currently have the greatest potential impact on the sanctuary's benthic habitats are the use of bottom-tending fishing gears, the deposition of lost fishing gear and other marine debris (Figure 28), the introduction of non-native species and the construction and placement of cables and pipelines.

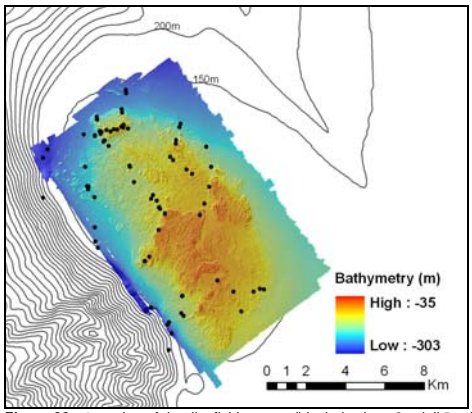

Figure 28. *Location of derelict fishing gear (black dots) on Cordell Bank detected during submersible monitoring surveys of the bank community. Gear locations are overlaid on high resolution bathymetry, which was generated from multibeam echosounder data (source: Seafloor Mapping Laboratory at California State University Monterey Bay). Contour lines are drawn every 50m and illustrate the location of the bank on the continental shelf in close proximity to the shelf break and steep continental slope. Image created by Lisa Etherington.*

From 2001-2005, Cordell Bank sanctuary conducted submersible surveys on and around the bank. During these surveys, fishing gear was consistently observed on the bottom. In 2002, derelict gear was observed entangled on the seafloor on 18 of the 20 transects (90%) conducted over rocky habitat. The most common gear types observed were long-lines and occasional gill nets. Most are entangled among boulders or on high relief rock. Many of the high relief areas are covered with hydrocorals and other encrusting invertebrates.

Trawl activity in the sanctuary is currently restricted by depth closures associated with the Rockfish Conservation Area. Additional areas of the sanctuary have recently been closed to bottom trawl activity through regulations applied under the Essential Fish Habitat designation issued by the National Marine Fisheries Service in June of 2006 (Federal Register 2006).

Comment [kb51]: I agree with these assessments. Habitat is probably not pristine, but is also not badly affected by previous human activities. I don't think contaminants are completely unknown though. A study funded by GFNMS in 1993 resulted in numerous publications on contaminants (Sydeman, Jarman) and these could be reviewed. My take on this is that contaminants (the typical ones at least) are not at zero, but are not that bad either, so I would rate it as *fair*, and improving (assuming hydrocarbons don't get worse from oil spills). I'm not convinced that biogenic habitat quality is actually improving, but it probably isn't getting any worse.

Comment [kb52]: this is another opportunity to show a map of fishing effort or management areas

Comment [kb53]: When mentioning the submersible surveys, add the word 'demersal' or 'benthic' before fish species; that tool is not necessarily the best for surveying pelagic fishes.

The following information provides an assessment by sanctuary staff of the status and trends pertaining to the current state of benthic habitats in Cordell Bank National Marine Sanctuary:

5. What is the abundance and distribution of major habitat types and how is it changing?

Cordell Bank National Marine Sanctuary encompasses an area of 529 square miles (1370 km^2). The sanctuary can be partitioned into three benthic habitat types: 1) the continental shelf covers 313 square miles (810 km^2) and is primarily mud bottom ranging from 230-656 feet (70-200m) deep, 2) the continental slope covers 190 square miles (492 km^2) and is primarily mud bottom with some rock outcrops and ranges between 656 feet (200 m) at the shelf break down to 6955 feet (2120 m) at the western boundary of the sanctuary, 3) Cordell Bank is roughly 4.5 miles wide by 9.5 miles long (7.2 x 15.2 km) covering an area of approximately 26 square miles (68 km^2). The rocky bank emerges from the soft sediments of the continental shelf, with the upper pinnacles reaching to within 115 feet (35 m) of the ocean's surface. Shelf depths at the base of the bank are between 300 and 400 feet (91-122 m). The bank has a diversity of habitats that include high relief rock pinnacles, flat rock, boulders (Figure 29), cobble, sand, and mud. High resolution backscatter and bathymetry data were recently collected on Cordell Bank and the surrounding soft bottom areas and habitat characteristics such as slope, rugosity, depth, and substrate type are being used to quantitatively describe the physical habitats that make up the bank. (For more information on mapping Cordell Bank, see the Seafloor Mapping Lab at CSUMB Web site: http://seafloor.csumb.edu/index.html).

<<<Insert photo of boccacio in deep boulder habitat by Linda Snook: CBNMS DELTA 6248 SNOOK 013.jpg>>>
Figure 29. Cordell Bank provides deep water refugia of boulder habitats for overfished species such as Boccacio.

The abundance and distribution of major habitat types is ranked as good/fair, reflecting impacts from past long line and bottom trawling activities. As some areas in the sanctuary are now off limits to the use of bottom contact gear and bottom trawling, habitat conditions on hard and soft bottom habitats should improve; however, there is not enough data to determine a trend.

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

Biologically-structured habitats, identified as invertebrate communities on the upper bank (including hydrocorals and sponges) (Figure 30) and sea whip (*Halipteris sp.)* fields on the soft mud of the continental shelf, appear for the most part to be healthy and stable. These biologically structured habitats have, however, been impacted in the past by long lines, gill nets and bottom trawls. As some areas in the sanctuary are now off limits to the use of bottom contact gear and bottom trawling, condition of biologically structured habitats should improve; however, we do not have enough data to determine a trend. Furthermore, it is not known how scouring from storm events and subsequent larval settlement affect the condition of the biologically structured habitat. It is also unclear how a long-term warming trend in the ocean would affect the condition of the lush invertebrate community carpeting the upper reaches of the bank.

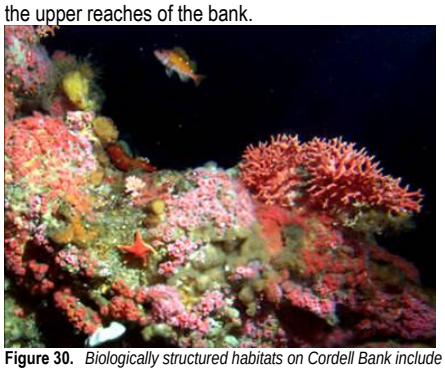

Figure 30. *Biologically structured habitats on Cordell Bank include hydrocorals, sponges, and anemones. (Photo credit: Jodi Pirtle).*

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

Contaminant concentrations in sanctuary benthic habitats are poorly understood. There have been very few sediment samples collected on the shelf and slope and preliminary analysis of several samples indicates levels of Dichloro-Diphenyl-Trichloroethane (DDT), polychlorinated biphenyls (PCB), and polycyclic aromatic hydrocarbons (PAH) are low (I. Hartwell, unpubl. data). Nevertheless, it does appear that these compounds are accumulating at depth in Bodega Canyon (I. Hartwell, unpubl. data), a feature just north of Cordell Bank Sanctuary, a pattern that holds true for other canyons as well. 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?

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Comment [kb54]: Suggest ranking the biologically-structured habitats as fair rather than good/fair because of the significant evidence of derelict gear, the long-lived nature of these organisms, and the lack of a good baseline but known collection of corals that dates back to the 1800s in this area.

Comment [kb55]: is there any work to determine the significance of levels of contaminants?

Comment [kb56]: This should read "…samples indicate **low concentrations** of…" – ref. either I. Hartwell unpubl. data or if this is just a general statement about the contaminants along that region of the coastline can reference - Hartwell, S.I. 2007. Distribution of Persistent Organic Contaminants in Canyons and on the Continental Shelf off Central California. NOAA Technical Memorandum NOS NCCOS CCMA 58. 67pp.

Deleted: is true for most canyons

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In the past, bottom contact fishing gear within Cordell Bank sanctuary has affected habitat quality. Gear restrictions and area closures associated with the Rockfish Conservation Areas (RCAs) and Essential Fish Habitat (EFH) have reduced human activity in the sanctuary, decreasing habitat impacts. It is not clear, however, if or when closures associated with the RCAs and EFH may be lifted, an eventuality that could reverse current trends in human activity levels.

Habitat Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

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

#	Status	Rating	Basis for Judgment
5	Abundance/Distribution	?	Prior fishing gear impacts; activities now prohibited, but sparse data
6	Structure	?	Prior fishing gear impacts; activities now prohibited, but sparse data
7	Contaminants	?	Sparse data available
8	Human Impacts	▲	Prior fishing impacts; some activities now prohibited

Living Resources

The current state of living resources in the sanctuary is a snapshot in an evolving relationship between biological populations, physical processes and outside pressures. These pressures can be natural or human induced, and in many cases where populations fall to critically low levels, it is a combination of both. Many populations of fishes, marine mammals and seabirds are still recovering from historic population declines caused by pollution, over-harvest, destruction of habitat, and recruitment failure. Several species, like gray whales, brown pelicans and elephant seals, have recovered to what are believed to be historic levels. Other populations, like leatherback sea turtles and some species of rockfish, are at all time lows. And in recent years jumbo squid populations have expanded to Cordell Bank from the south and have persisted in the area. Squid being a voracious, top-level predator could have significant impacts on the biodiversity and community composition within the sanctuary.

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

The conditions of the following groups were used to assess the overall status of biodiversity:

- Seabirds: Seabird populations within central California have generally suffered long term declines, with a few species showing recent increases in population size. Migratory species are also experiencing population declines caused by human impacts in remote locations. Some local breeding species have experienced high mortality and reduced reproductive success in recent years due to poor feeding conditions in the coastal ocean.

- Marine mammals: Stock assessments suggest that many of the populations of marine mammals that use sanctuary habitats are stable or increasing. For example, there is evidence suggesting an increasing population for the eastern North Pacific humpback whale stock (Carretta et al. 2007). Nevertheless, the distribution and use of sanctuary habitats by some marine mammals (e.g., blue whale) in recent years (i.e., 2005-06) appears to have been altered due to a decrease in the overall abundance of krill in the area.

- Fishes: Overharvest of some rockfish populations (i.e. yelloweye, canary, and cowcod), combined with poor recruitment, has severely impacted their populations along the west coast and has resulted in the closure of some groundfish fisheries in an attempt to rebuild depleted populations. There is also some indication that the removal of large predators (e.g., yelloweye rockfish) can alter the species composition, allowing populations of smaller fishes (e.g., the pygmy rockfish (*Sebastes wilsoni*) and squarespot rockfish (*S. hopkinsi)* to expand (Baskett et al. 2006). This process may help explain data from recent submersible observations on Cordell Bank, in which pygmy rockfish were the most abundant rockfish observed on Cordell Bank (Anderson et al. 2007, In Prep.). Closures associated with Rockfish Conservation Areas and Essential Fish Habitat have been established and these protected areas will reduce fishing pressure and help rebuild depleted rockfish populations. Population metrics from recent stock assessments indicate an increase in population abundance over the last five years for many overfished species, while populations of other species

Comment [kb57]: This is where I have knowledge, but my comments are primarily about the pelagic environment rather than benthos. My overall comment here pertains to question 12 of Appendix A. I do not disagree that we don't know about invasive species (Q11), but I think for all the others the boxes should be rated as *fair/poor* (orange, not yellow). The reason here is that the likelihood of recovery is *uncertain*, not *possible*. To me, p*ossible* recovery would have to be something that we fully understand; for example, if humans were to stop fishing, the resource would recover. That is not the case with many of the biodiversity losses and trends of poor productivity we have observed for this system, including losses in seabirds, rockfishes, krill, whales, hake and SALMON, etc. The food web for the OCS appears to have collapsed and is not, to any great extent, recovering…despite the slight improvement in 2007. And, if we look at the period in question, 2003-2007, clearly the situation is dismal at best. Cordell Bank used to be a fishing ground for salmon, but this is gone because the salmon aren't there. Blue whales that used to come to Cordell to eat are going elsewhere due to lack of food. Locally breeding seabirds showed unprecedented breeding failures in 2005 and 2006…with minimal increases in 2007. Rockfish productivity is way down when compared to 2001 and 2002, when there was a blip upwards, and some of the species showing these trends are *unfished*. This means that something else is causing it. The last very productive years for most rockfish species were 1987 and 1988…and only some of them did better during the increase of 2001 and 2002. My point here is that there are dozens of signals, all pointing to a food web in severe distress, and we don't know why….our best guess is climate change (since there are no fisheries for krill, auklets, blue whales, etc.), and since climate change is not going to end anytime soon, the likelihood of recovery is *uncertain. I could even convince myself that the likelihood of recovery is unlikely*

Comment [LA58]: Cite

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Comment [kb59]: order make more sense as fishes, birds, marine mammals.

Comment [kb60]: what are your key indicators? Auklets, whales, krill, rockfish – would seem like a good list.

considered overfished appear to be stable. Lingcod are a top predator and their population is rebounding from overfished status after consecutive years with very good recruitment.

Comment [kb61]: Perhaps change wording to 'Lingcod are a top predator and their population has been declared rebuilt after consecutive years of expected good recruitment.'"?

- Benthic invertebrates: Overall biodiversity of benthic invertebrates on soft and hard substrates on the continental shelf appears healthy, based on limited observations. Further, photographs of the invertebrate assemblage on the reef top of Cordell Bank over time suggest that current biodiversity is also healthy and stable. The condition of slope invertebrates is virtually unknown.
- Pelagic invertebrates: Annual fluctuations in pelagic invertebrates are related to oceanic conditions; a warming trend in coastal oceans could affect population structure and species composition. The recent persistent residence of the jumbo squid within the region of the sanctuary suggests the possibility that the marine ecosystem has been altered by the addition of a top level predator, resulting in shifts in community composition.

Species have probably not been lost from the marine ecosystem within Cordell Bank sanctuary in recent history and it is likely that species richness has not declined. However, changes in the abundance of several key groups suggest that relative abundance of different species (species evenness) has changed, and thus altered community composition. Changes in oceanic conditions in recent years has likely altered productivity within the sanctuary, with consequent changes in abundance and distribution of many taxa, including krill, marine mammals, and seabirds. Further, depletion of rockfish stocks due to overharvesting, as well as poor recruitment, has likely both affected species composition and reduced rockfish biomass on Cordell Bank; however, recent stock assessments suggest that many populations of overfished species are increasing. In addition, the range expansion and recent addition of jumbo squid to the marine ecosystem in this area could have a large impact on community structure. In combination, these natural and human-induced alterations have diminished, to some extent, ecosystem integrity in both benthic and pelagic systems.

Comment [LA62]: cite

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

The negative impacts of long lines, gillnets and bottom trawls on seafloor habitats and benthic organisms in the sanctuary have been well documented in recent years. Prohibitions associated with the Rockfish Conservation Area closures and regulations implemented in 2006 under Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) are encouraging sustainable fishing practices by prohibiting the use of destructive gear types on selected benthic habitats.

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

Currently, there are no non-native species documented in the sanctuary. Of note, however, is that there has not been a comprehensive inventory of species within the sanctuary. There is some concern regarding an invasive tunicate, *Didemnum* sp. that has been observed in nearby coastal areas and has covered large areas of Georges' Bank on the east coast (Bullard et al. 2007). The invasive tunicate is similar to a native *Didemnum*, and sampling will be necessary to determine which species is present on Cordell Bank.

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

Key species were selected for several groups of animals inhabiting Cordell Bank National Marine Sanctuary. In some cases, local and migratory representatives were selected from one group to capture population changes that may be associated with pressures on different temporal and spatial scales.

The following provides a summary for selected indicator species or groups:

- Cassin's Auklet: Cassin's Auklets nest on the Farallon Islands and use local sanctuary waters to feed, foraging primarily on krill. Populations have been declining slightly, and reproductive failure in 2005 and 2006 related to anomalous oceanic conditions and poor early season productivity (Sydeman et al. 2006) may have long term impacts.
- Black-footed Albatross: Black-footed Albatrosses nest on the northwestern Hawaiian Islands and are seasonally common and can be locally abundant within the sanctuary in the summer. The population on Midway Island appears to be stable. Populations are impacted, however, by long-line mortality in other areas and these impacts could eventually be observed at Cordell Bank sanctuary. These albatrosses are also known to ingest and feed plastic to chicks, which can as a result die of starvation. However, because albatrosses live up to 50 years, the influence of these impacts on population trends and the abundance of birds in the sanctuary are slow to emerge.
- Sooty Shearwater: Sooty Shearwaters are one of the most abundant seabirds in the sanctuary as well as in the California Current System during summer (Figure 31). Flocks with thousands of individuals pass through the sanctuary in summer and fall, feeding in the productive waters of the northeast Pacific while away from their nesting islands in Chile

and New Zealand. Worldwide populations are currently in decline, with high mortality due to bycatch in various fisheries (U.S. Fish and Wildlife Service 2006).

<<<Insert photo of Sooty Shearwater: 20070712_CMA_SNGH_SOSH_1.jpg>>>
Figure 31. Sooty Shearwaters are one of the most abundant seabirds in the sanctuary.

- Humpback whale: Cordell Bank and the other west coast sanctuaries provide important foraging grounds for humpback whales, which are seasonally abundant, migrating into the sanctuary during late spring, summer and fall to feed in its productive waters. They are generalist feeders, but prey heavily on small schooling fish and krill. The eastern north Pacific stock is listed as federally endangered, and there is evidence to suggest a positive population trend (Carretta et al. 2007).
- California sea lion: California sea lions are one of the most abundant pinnipeds found in the sanctuary, with highest abundance from summer through early spring when animals are not on the breeding grounds on the Channel Islands and Año Nuevo. Data suggest that El Niño events (depending on severity, timing, length, and frequency) influence the population growth rate (Caretta et al. 2007) as well as their distribution and abundance within the area (Lowry and Forney 2005). In recent years, the population has been growing at 5.4% to 6.1% per year (Carretta et al. 2007).
- Blue whale: Cordell Bank and the other west coast sanctuaries provide important foraging grounds for migrating blue whales in summer and fall. These whales feed primarily on krill; thus, their use of sanctuary habitats is expected to vary with krill abundance. A change in the distribution of blue whales in 2005 and 2006 is probably a response to changing oceanic conditions and reduced krill abundance in the region during these years. The population of the eastern north Pacific stock of blue whales appears to be growing (Carretta et al. 2007).
- Rockfish: Rockfish are the dominant group of fishes on Cordell Bank, and status varies by species. Yellowtail and widow rockfish are commonly observed in mid-water over pinnacles and high reef areas. Canary rockfish have been identified as overfished by the Pacific Fishery Management Council and are seen in the deeper reef areas (Figure 32). There is also some indication that the removal of large predators (e.g., yelloweye rockfish) can alter species composition, allowing populations of smaller fishes such as pygmy and squarespot rockfish to increase (Baskett et al. 2006). In recent submersible surveys, pygmy rockfish were the most abundant rockfish observed (Anderson et al. 2007, In Prep.). Nevertheless, population metrics from recent stock assessments indicate an increase in abundance over the last five years for many overfished species, while populations of other species considered overfished appear to be stable.

Comment [kb63]: When mentioning the submersible surveys, add the word 'demersal' or 'benthic' before fish species; that tool is not necessarily the best for surveying pelagic fishes.

<<< Insert photo of canary rockfish by Tara Anderson: CBDELTA 6246 ANDERSON 016.jpg>>>
Figure 32. Canary rockfish are seen in deeper reef areas of the sanctuary.

- Krill: Krill are keystone species and large changes in population size are related to changing oceanic conditions. Reduced primary productivity in 2005 and 2006, which was associated with anomalous atmospheric conditions that delayed upwelling, limited krill population growth and impacted the condition of higher trophic levels dependent on krill. There is no commercial harvest of krill in California, so human impacts on patterns of krill abundance are not suspected.
- Reef-top Invertebrates: The upper reef areas of Cordell Bank shallower than 60 meters are covered with a rich and diverse assemblage of benthic invertebrates. Sponges, strawberry anemones, hydrocorals, and tunicates encrust rock surfaces, while more mobile sea stars, sea urchins and crabs move over the surface of this reef. Photographs taken by Cordell Expeditions in the late 1970s appear similar to the biological assemblage observed by sanctuary staff in 2005.
- Sea Turtles: The world population of leatherback sea turtles has declined by over 90% since 1980 and the population status is currently endangered. Much of the mortality occurs when eggs are harvested from beaches and adults are taken as by-catch in high seas fisheries. The Cordell Bank area is an important foraging area for adult leatherbacks in late summer and fall. The occurrence of leatherbacks within the sanctuary is likely tied to changes in oceanic conditions and the availability of jellyfish.

Comment [kb64]: the mention of krill take in CA is not an issue in federal waters where Cordell Bank Sanctuary is, but the FMC is proposing to prohibit all take of krill in federal waters which is. Even if there is not direct take by humans the statement that there is not human impact overlooks impacts on water quality and climate change so this statement should be revised appropriately.

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Changes in oceanic conditions in recent years has likely altered productivity within the sanctuary, with expected changes in abundance and distribution of many taxa, including indicator species such as krill, blue whales and Cassin's Auklet (Figure 33). Further, depletion of rockfish stocks due to overharvesting, and poor recruitment is suspected to have caused an overall decline

in the rockfish biomass and altered species composition on Cordell Bank; however, stock assessments suggest that many populations of overfished species are increasing. Several of the indicator species appear to have been negatively impacted by the combination of natural and human-induced forces. Substantial or persistent declines, however, are not expected for these species and several of the indicator species that feed within the sanctuary exhibit healthy populations that are increasing.

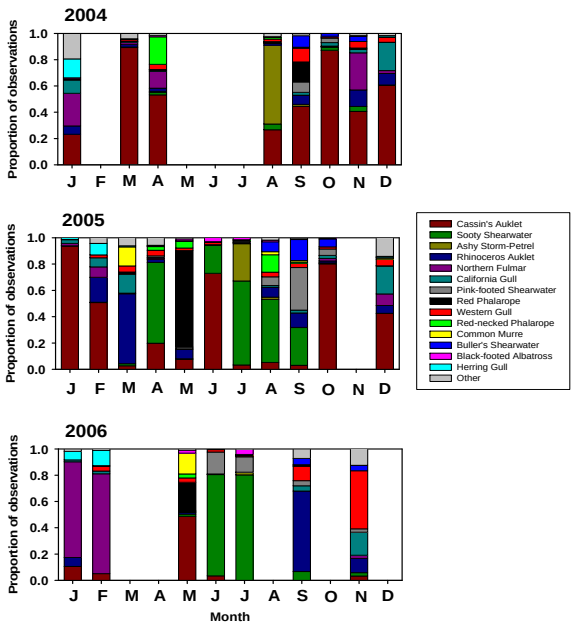

Figure 33. *Seabird species composition, as measured by monthly monitoring of the Cordell Bank pelagic ecosystem, illustrating seasonal and inter-annual variation in the species most abundant within sanctuary waters. A decrease in the proportion of observations made up of Cassin's Auklets is noted in 2005 and 2006, presumably in response to changing oceanographic conditions and food availability in the region. Image created by Lisa Etherington.*

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

Some work at Cordell Bank in the 1980s (Okihiro et al. 1992) documented the occurrence and frequency of lesions on several species of rockfish, but the cause was not determined. Mortality events for some marine mammals and seabirds are related to domoic acid poisoning associated with "red tides" or phytoplankton blooms. These events are often discovered when organisms wash up on coastal beaches and therefore have not been linked to the Cordell Bank sanctuary. The occurrence of domoic acid poisoning appears to be more prevalent in southern California. Natural fluctuations in body condition and health of key species are caused by changing oceanic conditions that affect food supplies. Reduced ocean productivity resulting from anomalous conditions has been related to poor condition of seabirds, marine mammals and fishes. Ocean warming and reduced productivity associated with long term climate change could impact the condition and health of key species.

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

Fishing and associated habitat disturbance, vessel traffic (discharge, noise, collision) and marine debris (derelict gear and plastics) are human activities that may influence living resource quality on Cordell Bank. Fishing activity has been severely restricted to protect habitat and overfished rockfish populations. Shipping activity remains constant, averaging about 2000 commercial vessels a year passing through the sanctuary. Human activity related to marine debris continues to increase as the human population continues to grow, especially in coastal areas.

Comment [kb65]: need a magnifying glass to read it and make sense. You might consider paraphrasing the information in the text and making the figure much larger.

Comment [LA66]: replace with research?

Comment [LA67]: Several different health issues are mentioned in one paragraph. Maybe an opening sentence stating there are a variety of health issues and go on to describe them would make this more clear.

Comment [kb68]: Citation?

Comment [kb69]: Domoic acid outbreaks also occure with some frequency in Monterey Bay, much closer to Cordell Bank, than southern CA.

Living Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

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

#	Status	Rating	Basis for Judgment
9	Biodiversity	▲	Reduced rockfish populations; changing oceanic conditions
10	Sustainable Fishing	▲	Overfishing and prior fishing impacts; closures and gear restrictions appear to be effective
11	Non-indigenous Species	?	No known non-indigenous species; sparse data available
12	Key Species	▲	Reduced rockfish, krill, and seabird populations; changing oceanic conditions
13	Health of Key Species	—	Water quality; offshore location; oceanographic conditions
14	Human Activities	▲	Overfishing and habitat disturbance, restrictions appear to be effective; vessel traffic; marine debris

Comment [LA70]: Key and chart does not render up/down arrows when viewed on a Mac.

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Maritime Archaeological Resources

Comment [kb71]: It is not clear whether Cordell Bank has been determined to not have any cultural/ maritime resources or whether this is just unknown. I know the Bank has been well surveyed, but if the remaining area has only been partially surveyed then it would be better to reference questions 15-17 as unknown rather than N/A.

To date, there are no documented shipwrecks on the seafloor of Cordell Bank sanctuary. However, the Farallon Islands and the mainland coast north of the Golden Gate have historically provided hazardous navigational obstacles to shipping. Year-round fogs and dangerous winds and storms often led ships to rocks and beaches, to be pounded by the Pacific swells. Fierce currents sweep into and out of the entrance to the Golden Gate. Many known shipwrecks litter the floor of the nearby Gulf of the Farallones sanctuary. Therefore, it is possible that shipwrecks exist within the boundaries of Cordell Bank National Marine Sanctuary and will eventually be identified.

Records indicate that 430 vessel and aircraft losses were documented between 1595 and 1950 along California's Central Coast from Cambria north to Bodega Head: 173 in the Gulf of the Farallones sanctuary and 257 in the Monterey Bay sanctuary. To date, none have been documented within the Cordell Bank National Marine Sanctuary.

The abundance of shipwrecks along the California coast warrants future underwater exploration of these resources. Cordell Bank sanctuary is working with the Gulf of the Farallones and Monterey Bay sanctuaries to design efforts to ensure public awareness, understanding, appreciation, and sustainable use of the historical, cultural, and archaeological resources. In a team effort, the three sanctuaries are working toward identification and assessment of documented shipwrecks, some of which may pose significant environmental hazards; to protect sites from unauthorized disturbance; and to develop heritage partnerships and programs.

Maritime Archaeological Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

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

#	Status	Rating	Basis for Judgment
15	Integrity	**N/A**	No documented underwater archaeology sites
16	Threat to Environment	**N/A**	No documented underwater archaeology sites
17	Human Activities	**N/A**	No documented underwater archaeology sites

Response to Pressures

This section describes current or proposed responses to pressures on the Cordell Bank National Marine Sanctuary. The National Oceanic and Atmospheric Administration is responsible for protecting sanctuary resources and facilitating multiple uses within

the sanctuary that are compatible with resource protection. Prohibitions are established through federal and state laws, authority granted in the National Marine Sanctuary Act, and each site's designation document and site specific regulations.

Harvesting

Management of commercial and recreational fisheries in California state waters (0-3 nautical miles from shore) is primarily the responsibility of the California Department of Fish and Game (Figure 34). The Pacific Fishery Management Council and NOAA's National Marine Fisheries manage fisheries in federal waters (3 to 200 nautical miles from shore). Although Cordell Bank Sanctuary is located entirely in federal waters, the authority for management of some commercial and recreational species found within the sanctuary is shared between the state and federal agencies. The National Marine Sanctuary Program does not manage specific fisheries, but it does have a mandate to protect the sanctuary ecosystem and the authority to manage human uses that may affect sanctuary resources.

The Pacific Fishery Management Council is one of regional councils established by Congress, and ma fisheries in federal waters off California, Oregon, a Washington. The council is composed of federal a fishery management officials and industry represe has oversight on developing, monitoring, and revis management plans for each fishery within the U. S Economic Zone.

<<<Insert photo of boats heading out of Bodega Harbor by Steve Howell: 20070712_CMA_SNGH_FIPF.jpg>>>
Figure 34. Bodega Harbor is the closest port to Cordell Bank sanctuary, and is used by both commercial and recreational fishermen.

The Cordell Bank Draft Management Plan includes five action plans that, once finalized, will guide sanctuary management for the next five years. "Ecosystem Protection" is one of the action plans. This action plan was developed jointly with a variety of stakeholders including, local fishermen, biologists, enforcement personnel and conservation partners, and addresses the potential impacts from human activities. To better understand and allow for fishing activities that are compatible with sanctuary goals and ecosystem health, the action plan includes, but is not limited to, the following strategies:

- Improve communication between sanctuary staff and the Pacific Fishery Management Council and the California Fish and Game Commission by establishing consistent and coordinated region-wide sanctuary representation at the Pacific Fisheries Management Council and Fish and Game Commission meetings.
- Establish an ongoing process to track and evaluate activities and their impacts in and around sanctuary waters.
- Develop policy recommendations or management action(s) to address impacts from activities on sanctuary resources.
- Work with Gulf of the Farallones and Monterey Bay national marine sanctuaries to support the Pacific Fisheries Management Council and NOAA Fisheries action to prohibit the commercial harvest of krill.
- Profile fishing activities and communities in and around the sanctuary to better understand levels of impacts specific to Cordell Bank sanctuary.

The Cordell Bank Draft Management Plan is a revision of the original management plan, developed when the sanctuary was designated in 1989, and is focused on how best to understand and protect the sanctuary's resources. The National Marine Sanctuary Program updated the management plans for Cordell Bank, Gulf of the Farallones, and Monterey Bay national marine sanctuaries in what is known as the Joint Management Plan Review. Management plans are sanctuary-specific planning and management documents required by law for all national marine sanctuaries. These p describe regulations, boundaries, resource research, and education programs to guide management activities. They specify how s can continue to conserve, protect, and enha nationally significant living and cultural reso

West Coast groundfish fisheries, and fisheries that may take groundfish incidentally, are managed with a variety of closed areas intended to either minimize the bycatch of overfished groundfish species, or to protect groundfish habitat. Currently, there is no commercial or recreational fishing for groundfish permitted on Cordell Bank because the bank falls within the Rockfish Conservation Area established in 2002 by the Pacific Fishery Management Council to protect several species of overfished rockfish. The establishment of Rockfish Conservation Areas has improved the status and recovery of depleted fish stocks, including several rockfish populations. It is unclear when this closure will be lifted.

In 2002, sanctuary staff observed fishing gear, primarily long lines, entangled on the bottom, during 18 of 20 dives over rocky habitat on Cordell Bank. Based on these findings, staff worked with their advisory council, NOAA Fisheries and the Pacific Fisheries Management Council to recommend protection for this critical habitat (Figure 35). In 2006, Cordell Bank was identified as a Habitat Area of Particular Concern under NOAA Fisheries Essential Fish Habitat designation. Under this designation, the use of bottom contact gear was prohibited in water shallower than 50 fathoms on Cordell Bank. Additionally, the use of bottom trawls was prohibited on some of the soft bottom habitat in the sanctuary.

Cordell Bank and the Gulf of the Farallones national marine sanctuaries contracted Ecotrust, a nonprofit organization, to collect, compile and analyze socioeconomic information pertaining to commercial and recreational fisheries in the area in support of the

Comment [kb72]: This another opportunity to map fishing closures and activities, in one of these areas this should be included. Also I think it could be more explicitly stated that current fishing closures to help recover rockfish could be removed and that these are not part of the sanctuary regulations, thus outside of sanctuary control. Once lifted sanctuary living resources will be subject to increased fishing pressure. The idea that bottom trawling is a compatible activity with sanctuary resources is tough to accept. There is widespread scientific evidence of impacts from trawling on both soft and hard bottom habitats and good consensus it is a destructive from of fishing. As long as the sanctuary allows trawling it would be hard to rate any impact on seafloor habitat as improving. (references include NRC report on Trawling and Dredging 2002; AFS volume on Benthic Habitats and the Effects of Fishing AFS Symposium 41, 2005 eds Barnes and Thomas; Chuenpagdee et al. 2003 Shifting gears: Assessing collateral impacts of fishing methods in the U.S. waters Frontiers in Ecology and the Environment 1(10): 517–524).

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Comment [kb73]: Regarding the new regulations (RCAs and EFH-closures), it would be very useful to include a figure with the boundaries of the closed areas relevant to Cordell Bank and relevant to the types of gear that are prohibited. Also, the dates that those closures were implemented would be good to include when discussing those regs. It seems that the report uses the words "restricted", "limited", and "prohibited" when referring to the new regs for trawl activities and closures to groundfishing. Perhaps they could clarify and use just one term (for instance on p. 31 they state that 'there is no commercial or recreational fishing for groundfish permitted on CB..." It seems prohibited' would be the correct term to use).

management plan review process. The report, "Socioeconomic Profile of Fishing Activities and Communities Associated with the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries" has been completed and is available to the public at on the Ecotrust Web site (http://www.ecotrust.org/jmpr/).

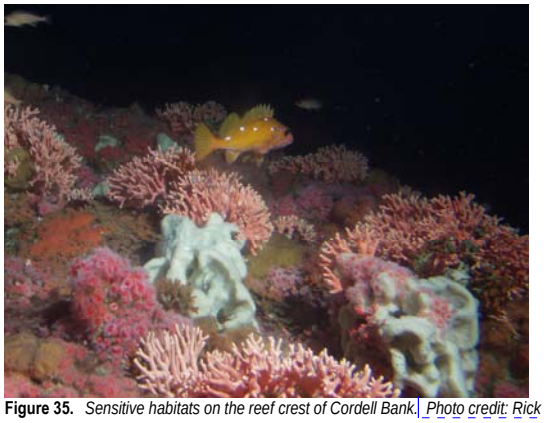

Figure 35. *Sensitive habitats on the reef crest of Cordell Bank. Photo credit: Rick Starr*

Comment [LA74]: Listing the common names for the coral, sponges, anemones and rockfish pictured would be of interest to the reader that has come across these species descriptions earlier.

Cordell Bank sanctuary staff will continue monitoring fish and invertebrate assemblages in relation to the fine-scale habitat on and adjacent to the bank portion of Cordell Bank sanctuary. Monitoring work will identify locations and quantity of anthropogenic impacts, including derelict gear and other marine debris. Specifically, submersible field surveys (one- to three- year intervals) will be conducted to monitor the distribution and abundance of fishes and invertebrates on and adjacent to the bank (Figure 36).

Figure 36. *Surveying the underwater ecosystem of Cordell Bank requires marine technology such as manned submersibles due to the extreme depths and strong currents within the offshore environment. Photo credit: Michael Carver*

Vessel Traffic

National Marine Sanctuary Program regulations prohibit discharge or deposits by vessels within the sanctuary or from beyond sanctuary boundaries if the substance or material discharged enters the sanctuary and injures a sanctuary resource (exceptions are: fish, chumming materials, or bait produced and discarded during routine fishing activities; engine exhaust; and water and biodegradable effluent incidental to vessel operations, e.g., deck wash down and gray water, but excluding oily bilge wastes). A new regulation specific to cruise ships prohibits discharge of any kind (except engine and generator cooling water and anchor wash).

In addition, a new partnership between the National Marine Sanctuary Program and the U.S. Coast Guard is helping sanctuary staff study potential impacts of vessel traffic in the Cordell Bank sanctuary. The U.S. Coast Guard provided software that is allowing staff to track real-time movements of all large ships carrying Automatic Identification Systems (AIS). The last six years of data reveal that an average of 200 ships per month pass through Cordell Bank sanctuary. Understanding vessel traffic patterns is important in documenting potential threats to sanctuary marine life. The information is already proving valuable as scientists used traffic data to determine the most appropriate placement of an oceanographic buoy that was installed in spring 2007.

The sanctuary has also responded to the threat of wildlife disturbance by establishing education programs aimed to reduce potential negative impacts from wildlife viewing activities. Outreach events include fairs, school presentations, evening lecture series, visitor centers, student summits, and teacher workshops.

Comment [kb75]: does the last sentence regarding the outreach events including fairs, evening lectures, etc. really belong there?

Noise

One of the priority activities identified in the Cordell Bank sanctuary management plan is to assess the impacts from acoustics on sanctuary resources. This effort would involve working with partners to develop programs to conduct passive acoustic monitoring to identify and quantify sources of anthropogenic noise to better understand the effects of sound in the marine environment. Another activity included in the revised management plan is the development of a compatibility index to rank and evaluate types and levels of impacts from human activities, including human generated noise.

Comment [kb76]: Do you mean noise from vessels?

Marine Debris

The Cordell Bank sanctuary draft management plan outlines activities to assess impacts from marine debris on sanctuary resources and conduct mitigation activities. One such activity is to develop protocols to monitor pelagic marine debris and incorporate those into monthly monitoring activities (Figure 37). With support from NOAA's Marine Debris Program, sanctuary staff have developed protocols for monitoring the presence of floating debris and have integrated this data collection as part of its monthly monitoring program that tracks the abundance of seabirds and mammals in the sanctuary. This new information is important to understand the source of debris observed in the sanctuary and to identify threats that exist for the animals living in the sanctuary. The monitoring program provides information that helps managers make decisions that safeguard sanctuary resources.

Figure 37. *Floating marine debris is surveyed monthly to determine patterns of type, abundance, and seasonality. Photo: Peter Pyle/CBNMS*

Another activity outlined as a priority in the management plan is to expand GIS databases to characterize benthic marine debris in the sanctuary. Cordell Bank sanctuary staff is planning to work with partners to expand databases to track and characterize the type, location and amounts of marine debris in the region. Data include observations collected during benthic monitoring using submersible transects and video footage as well as observations collected during habitat mapping and characterization research activities within the sanctuary.

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In 2006, researchers completed high-resolution, bathymetric mapping of Cordell Bank that will enhance future research, monitoring, and restoration efforts on Cordell Bank. This was a cooperative effort with the Seafloor Mapping Laboratory at California State University Monterey Bay. The benthic maps have already been used to help sanctuary staff plan the removal of derelict fishing gear on the bank and to understand the relationship between the occurrence of derelict gear and seafloor habitat characteristics. In 2007, staff will be testing methods to remove entangled fishing gear from deep water habitats, and survey areas of the bank never seen before to document the presence of marine debris in the region.

Comment [LA77]: 2008?

Cordell Bank sanctuary staff work on various outreach activities educating the public about the impacts of marine debris on the ocean environment, with emphasis on the ingestion of plastics by seabirds. The sanctuary provides teachers with resources to teach about the diets of seabirds and the unfortunate global problem of marine debris in the ocean. Staff members also collaborate with educators in the Northwestern Hawaiian Islands and local marine education organizations to provide albatross boluses for students to dissect and quantify plastic pieces versus organic prey items (Figure 38). In 2008, the sanctuary will be embarking on a new collaborative exhibit at the Oakland Museum of California, where environmental issues such as marine debris will be highlighted.

<<<Insert photo of students dissecting albatross bolus by Jennifer Stock: 20070806_EDU_JLS_036.jpg>>>
Figure 38. Students learning about marine debris through dissection of albatross boluses. Photo: Jennifer Stock.

Non-indigenous Species

Additional sampling is necessary to determine the status of non-indigenous species, particularly related to the concern regarding the invasive tunicate *Didemnum sp*. that has been observed in nearby coastal areas. Future surveys and collections of potential invasive species on the bank may be incorporated into current benthic community transect surveys. Scientists at Bodega Marine Laboratory have compiled a list of potential non-native species for the sanctuary based on data from nearshore areas north and south of Cordell Bank.

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In the revised Cordell Bank management plan, a new regulation was recommended that would prohibit the introduction or release of an introduced species from within or into the sanctuary. The exception to this regulation is the release of non-indigenous fishes caught while recreational or commercial fishing.

Concluding Remarks

Cordell Bank National Marine Sanctuary is an offshore location compared to some other marine sanctuaries, a fact that is reflected by fairly good water and habitat quality ratings. But, it is still susceptible to a number of human impacts including pollutants from land and ocean sources, overfishing and habitat disturbance, all of which have reduced, to some extent, the quality of some living resources. Management actions intended to protect the bank and its rich natural resources involve working cooperatively with other management authorities to implement and enforce regulations and conduct scientific investigations and assessments. Sanctuary resources under threat seem to be responding favorably to protective measures put in place over the last several years, particularly with regard to fishing impacts. Nevertheless, improvements in monitoring are needed in certain areas particularly contaminants and non-native species. Much remains to be understood at Cordell Bank and many impacts caused by human activities may be hidden by the extremely high levels of natural annual to multi-decadal variation in resources in the region. Thus, the approach to management will continue to involve focusing on assessments of specific areas of interest, based on perceived threats, and continued studies of fundamental ecosystem drivers and interactions among resources.

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Comment [kb78]: Perhaps restate "Sanctuary resources [previously thought to be] under threat seem to be responding favorably..."

Acknowledgements

Clancy Environmental Consultants, Inc. was instrumental in developing the template for this document and providing the initial material under contract to NOAA. We would particularly like to thank Karen Fox for drafting the initial content. We also thank the following subject matter experts for providing input on the various status and trends ratings: Ben Becker, Point Reyes National Seashore; John Largier, Bodega Marine Laboratory; Peter Pyle, Institute for Bird Populations; Dale Roberts, Cordell Bank National Marine Sanctuary and Point Reyes National Seashore.

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California Department of Fish and Game: Marine Region: http://www.dfg.ca.gov/mrd/

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

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Cordell Bank, Gulf of the Farallones and Monterey Bay Sanctuary Joint Management Plan Review: http://sanctuaries.noaa.gov/management/mpr/welcome.html

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National Park Service: Point Reyes National Seashore: http://www.nps.gov/pore/home.htm

NOAA's National Centers for Coastal Ocean Science: http://coastalscience.noaa.gov/

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U.S. Geological Survey: http://www.usgs.gov/

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Appendix:
Rating Scheme for System-Wide Monitoring Questions

Deleted: Appendix A

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

The questions derive from the National Marine Sanctuary Program mission, and a system-wide monitoring framework (National Marine Sanctuary Program, 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on, and study the ecosystems encompassed by the sanctuaries. They are being used to guide staff and partners at each of the 14 sites in the sanctuary system in the development of this first periodic sanctuary condition report. The questions are meant to set the limits of judgments so that responses can be confined to certain reporting categories that will later be compared among all sites, and combined. 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.

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

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

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

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

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

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

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

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

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

Question 3 (Water/Human Health): Do sanctuary waters pose risks to human health and how are they changing?

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

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

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

Question 4 (Water/Human Activities): What are the levels of human activities that may influence water quality and how are they changing?

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

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

problem.

Poor	Selected activities warrant widespread concern and action, as large-scale, persistent, and/or repeated severe impacts have occurred or are likely to occur.

Question 5 (Habitat/Abundance/Distribution): What are the abundance and distribution of major habitat types and how are they changing?

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

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

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

Question 6 (Habitat/Structure): What is the condition of biologically-structured habitats and how is it changing?

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

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

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

resources or water quality.

Poor	Selected habitat loss or alteration has caused or is likely to cause severe declines in most if not all living resources or water quality.

Question 7 (Habitat/Contaminants): What are the contaminant concentrations in sanctuary habitats and how are they changing?

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

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

Question 8 (Habitat/Human Activities): What are the levels of human activities that may influence habitat quality and how are they changing?

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

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

Question 9 (Living Resources/Biodiversity): What is the status of biodiversity and how is it changing?

This is intended to elicit thought and assessment of the condition of living resources based on expected biodiversity levels and the interactions between species. Intact ecosystems require that all parts not only exist, but that they function together, resulting in natural symbioses, competition, and predator-prey relationships. Community integrity, resistance and resilience all depend on

these relationships. Abundance, relative abundance, trophic structure, richness, H' diversity, evenness, and other measures are often used to assess these attributes.

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

Question 10 (Living Resources/Extracted Species): What is the status of environmentally sustainable fishing and how is it changing?

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

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

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

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

Question 11 (Living Resources/Non-indigenous Species): What is the status of non-indigenous species and how is it changing?

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

Good	Non-indigenous species are not suspected or do not appear to affect ecosystem integrity (full community development and function).

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

Question 12 (Living Resources/Key Species): What is the status of key species and how is it changing?

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

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

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

Question 13 (Living Resources/Health of Key Species): What is the condition or health of key species and how is it changing?

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

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

Question 14 (Living Resources/Human Activities): What are the levels of human activities that may influence living resource quality and how are they changing?

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

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

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

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

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

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

Question 15 (Maritime Archaeological Resources/Integrity): What is the integrity of known maritime archaeological resources and how is it changing?

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

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

	scientific, or educational value, and is likely to affect their eligibility for listing in the National Register of Historic Places.
Poor	The degraded condition of known archaeological resources in general makes them ineffective in terms of historical, scientific, or educational value, and precludes their listing in the National Register of Historic Places.

Question 16 (Maritime Archaeological Resources/Threat to Environment): Do known maritime archaeological resources pose an environmental hazard and how is this threat changing?

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

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

Question 17 (Maritime Archaeological Resources/Human Activities): What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?

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

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

Page 27: [1] Comment [kb57] **Kathy Broughton** **5/29/2008 11:40:00 AM**

This is where I have knowledge, but my comments are primarily about the pelagic environment rather than benthos. My overall comment here pertains to question 12 of Appendix A. I do not disagree that we don't know about invasive species (Q11), but I think for all the others the boxes should be rated as *fair/poor* (orange, not yellow). The reason here is that the likelihood of recovery is *uncertain,* not *possible*. To me, p*ossible* recovery would have to be something that we fully understand; for example, if humans were to stop fishing, the resource would recover. That is not the case with many of the biodiversity losses and trends of poor productivity we have observed for this system, including losses in seabirds, rockfishes, krill, whales, hake and SALMON, etc. The food web for the OCS appears to have collapsed and is not, to any great extent, recovering…despite the slight improvement in 2007. And, if we look at the period in question, 2003-2007, clearly the situation is dismal at best. Cordell Bank used to be a fishing ground for salmon, but this is gone because the salmon aren't there. Blue whales that used to come to Cordell to eat are going elsewhere due to lack of food. Locally breeding seabirds showed unprecedented breeding failures in 2005 and 2006…with minimal increases in 2007. Rockfish productivity is way down when compared to 2001 and 2002, when there was a blip upwards, and some of the species showing these trends are *unfished*. This means that something else is causing it. The last very productive years for most rockfish species were 1987 and 1988…and only some of them did better during the increase of 2001 and 2002. My point here is that there are dozens of signals, all pointing to a food web in severe distress, and we don't know why….our best guess is climate change (since there are no fisheries for krill, auklets, blue whales, etc.), and since climate change is not going to end anytime soon, the likelihood of recovery is *uncertain. I could even convince myself that the likelihood of recovery is unlikely given that we have some new predators in the system (Humboldt squid) that are increasing stressors on these diminished resources.* In any event, I think these scores should be *fair/poor* with unknown trends. There are many datasets available to confirm this. I have also observed recreational fishers switching to rockfish instead of salmon in the region, so the score of *improving trends* for human activities is questionable. In short, I think this section needs some additional consideration of the available data, and I would be happy to help with this effort. I don't think the news is very good about leatherback sea turtles either.

It was good to see the seabird survey time series Cordell Bank NMS has obtained, as seabirds could provide an index to ecosystem health. But, plotting the proportion of observations made up of species x, y, z, is not very informative. I would suggest selection of a few species (Cassin's auklets, Rhino auklets, western gulls and common murres, maybe) and plotting density (bird/km2) against time. Better yet would be some multivariate index. The change in Cassin's auklet in 2005 and 2006, for example, would be much more obvious in the species' density rather than its contribution to the community overall.

I understand that the stock assessments indicate some slight recovery/increases in some species of rockfish, but I'm not sure that really applies to Cordell Bank NMS as these are made for considerably larger spatial areas, e.g. California Current at large. The best data on rockfish is probably the juvenile pre-recruit surveys, and I think that would indicate continuing severe problems.