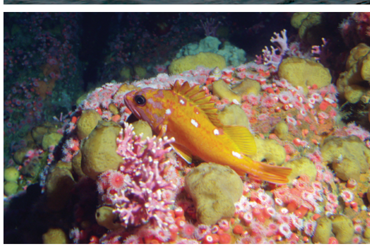
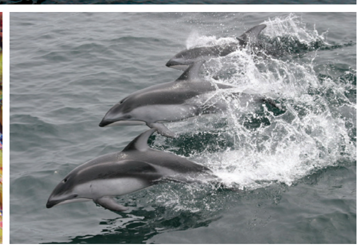
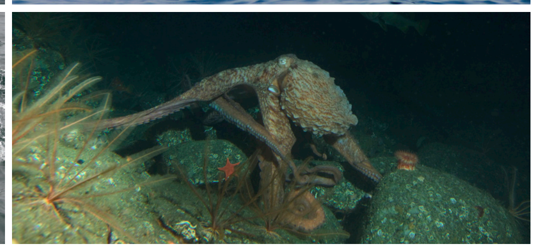
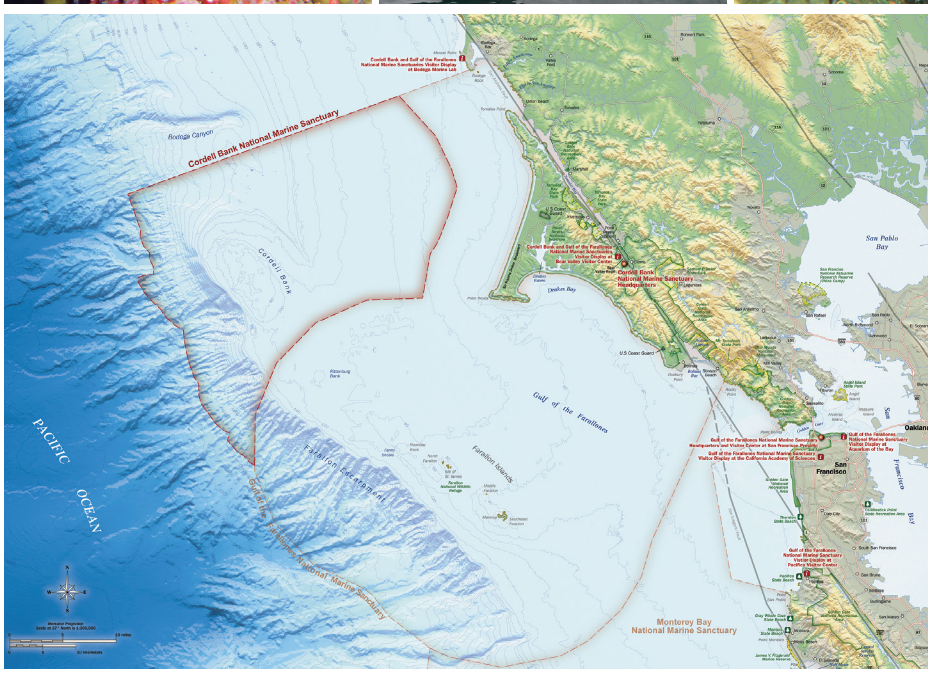
Cordell Bank
National Marine Sanctuary

CONDITION REPORT 2009









June 2009

NATIONAL MARINE SANCTUARIES

Cover credits:

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

Photos:
Humpback whale tail: Jennifer Stock; Black-footed albatross: Cornelia Oedekoven, SWFSC, NOAA; North Pacific giant octopus: Kip Evans; Krill: Benjamin Saenz; Dungeness crab: Richard Starr; rosy rockfish: Jodi Pirtle; Pacific white-sided dolphins: Holly Fearnbach, SWFSC, NOAA

Suggested Citation:
Office of National Marine Sanctuaries 2009. Cordell Bank National Marine Sanctuary Condition Report 2009. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 58 pp.

U.S. Department of Commerce
Gary Locke, Secretary

National Oceanic and Atmospheric Administration
Jane Lubchenco, Ph.D.
Under Secretary of Commerce for Oceans and Atmosphere

National Ocean Service
John H. Dunnigan, Assistant Administrator

Office of National Marine Sanctuaries
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:

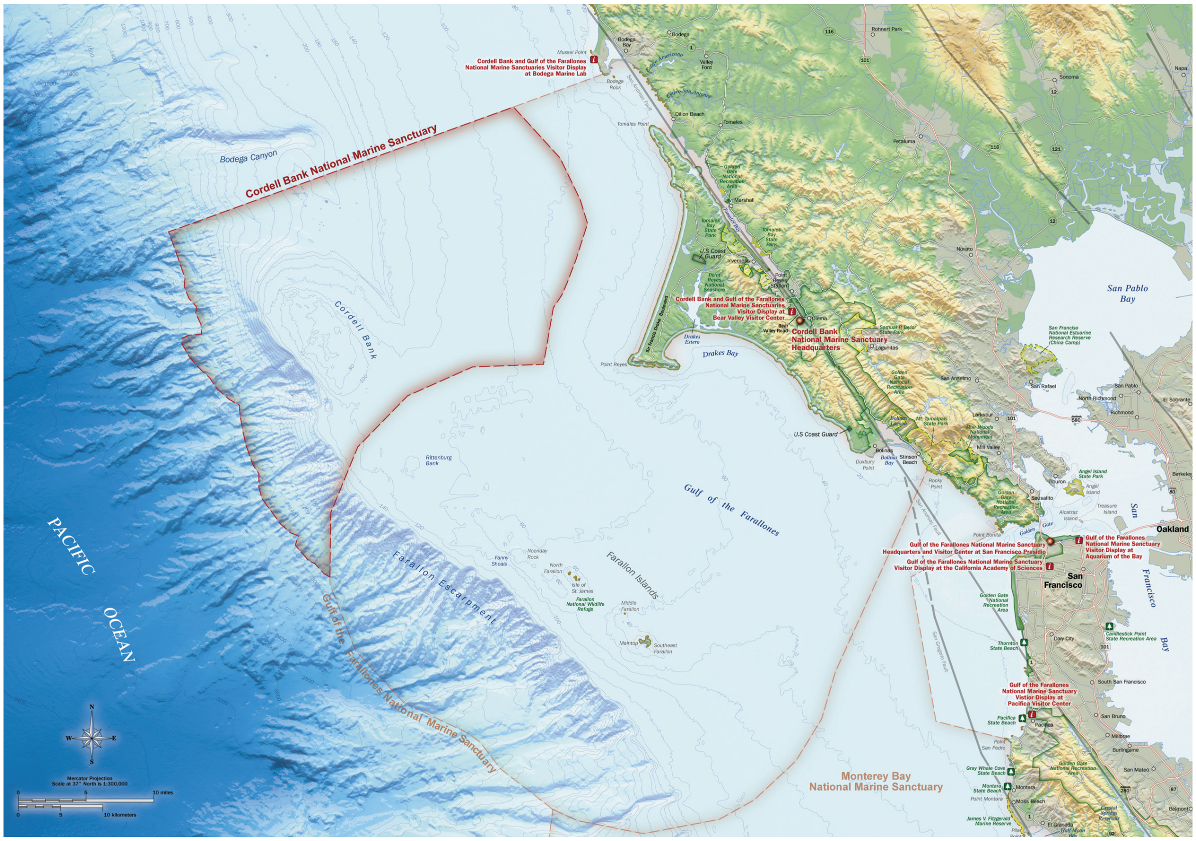
Cordell Bank National Marine Sanctuary:
Dr. Lisa Etherington, Daniel Howard

Office of National Marine Sanctuaries:
Kathy Broughton, Dr. Stephen R. Gittings

Copy Editor: Celeste Leroux

Layout: Matt McIntosh

Table of Contents



Credit: National Marine Sanctuaries

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, pressures on those resources, current condition and trends, and management responses to the pressures that threaten the integrity of the marine environment. Specifically, the document includes information on the status and trends of water quality, habitat, living resources and maritime archaeological resources and the human activities that affect them. It presents responses to a set of questions posed to all sanctuaries (Appendix A). Resource status of 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. In some cases, it was necessary to consider a longer time series to provide context for describing a current condition or trend. Sanctuary staff consulted with 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, 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. With its southern-most boundary located 42 miles (68 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. In total, the sanctuary protects an area of 529 square miles (1369 square km). 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 22 miles (35 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 falls within the California Current ecosystem, one of four major eastern boundary currents in the world. Coastal upwelling, a process associated with eastern boundary currents, initiates an annual productivity cycle at Cordell Bank that supports a rich biological community that includes local species as well as migratory sea turtles, fishes, seabirds and marine mammals that travel up to thousands of miles to feed around the bank. The combination of a healthy benthic community on the bank and its close proximity to offshore, open water species contributes to the unique biological diversity in a relatively confined area around Cordell Bank.

Activities that put pressure on sanctuary resources are diverse. Fishing activity has been conducted at Cordell Bank since the late 1800s and commercial and recreational fishing are still major activities. Restrictions implemented by the Pacific Fisheries 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 San Francisco Bay Area. Charter trips leave from the 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 soft bottom habitats of the sanctuary. Many derelict long lines and gill nets remain entangled on rocky areas of the bank. Spatial fishing gear restrictions that are currently in place in some areas will help protect sanctuary habitats and conditions are expected to improve. Living resource conditions

Cordell Bank National Marine Sanctuary

- *529 square miles (1369 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*

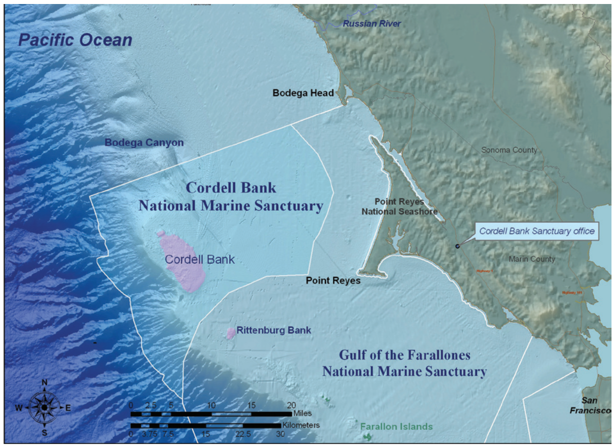


Image: Pam van der Leeden, CBNMS

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.

within Cordell Bank National Marine Sanctuary are considered to be diminished, because of depleted populations of rockfish, salmon, 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, but uncertainty remains due to global changes that are currently affecting our oceans. To date, no maritime archaeological resources have been identified in the sanctuary.

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

By assuming that a common marine ecosystem framework can be applied to all sites, the 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 Appendix A, are derived from both a generalized ecosystem framework and 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.

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 Cordell Bank sanctuary management plan, the information presented here is intended to help set the stage for management plan reviews at each site. The report also helps sanctuary staff identify monitoring, characterization and research priorities to address gaps, day-to-day information needs and new threats.

Cordell Bank National Marine Sanctuary Condition Summary Table

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

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

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

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?	? (Good)	Offshore location may limit impacts, but data are sparse (page 25)	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 using moored oceanographic instruments, vessel-based surveys, and net sampling for detection of harmful algal blooms.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	– (Good)	Absence of harmful algal blooms and low chlorophyll levels do not indicate eutrophication (page 25)	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?	– (Good)	Offshore location and oceanic conditions may limit impacts; no known risks identified during monthly monitoring (pages 25-26)	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?	? (Good/Fair)	Minimal human activities, but uncertainty of the levels of vessel discharges (page 26)	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?	? (Fair)	Prior fishing gear impacts, some activities now prohibited; sparse data (pages 26-27)	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.	New sanctuary regulations prohibiting the disturbance of the seabed within Cordell Bank sanctuary. Trawling closures and seabed protection measures implemented by Pacific Fishery Management Council (in consultation with Cordell Bank sanctuary). Monitoring the benthic habitats associated with Cordell Bank. Outreach, education and monitoring programs increase awareness of the impacts of marine debris.
6	What is the condition of biologically-structured habitats and how is it changing?	? (Fair)	Prior fishing gear impacts, some activities now prohibited; sparse data (pages 27-28)	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.	
7	What are the contaminant concentrations in sanctuary habitats and how are they changing?	? (Undet.)	Sparse data available (page 28)	N/A	
8	What are the levels of human activities that may influence habitat quality and how are they changing?	▲ (Fair)	Prior fishing impacts; some activities now prohibited (page 28)	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.	

Table is continued on the following page.

Cordell Bank National Marine Sanctuary Condition Summary Table (Continued)

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	▲	Overharvest of some rockfish populations, but recent stock assessments suggest some over-fished populations are increasing. Changes in abundance and distribution of many taxa linked to changing ocean conditions (pages 29-31)	Selected biodiversity loss has caused or is likely to cause severe declines in some, but not all ecosystem compo-nents, and reduce ecosystem integrity.	Rockfish conservation areas and seabed protection measures implemented by Pacific Fishery Management Council (in consultation with Cordell Bank sanctuary). New sanctuary regulation prohibit-ing the introduction or release of non-indigenous species into the sanctuary. Monitoring the ecological condition of pelagic community and habitats within the sanctuary. Monitoring the ecological condition of benthic community and habitats within the sanctuary.
10	What is the status of environ-mentally sustainable fishing and how is it changing?	▲	Overfishing of some rockfish and prior fishing impacts; closures and gear restrictions appear to be effective (pages 31-32)	Extraction may inhibit full community development and funtion and may cause measurable but not severe degradation of ecosystem integrity.	
11	What is the status of non-indigenous species and how is it changing?	?	No known non-indigenous species; but data are sparse (page 32)	N/A	
12	What is the status of key species and how is it changing?	▲	Overharvest of some rockfish populations, but recent stock assessments suggest some over-fished populations are increasing. Changes in abundance and distribution of many taxa linked to changing ocean conditions (pages 32-34)	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?	–	Changes in condition appear to be caused by natural events (page 34).	The condition of key resources ap-pears to reflect pristine or near-pristine conditions.	
14	What are the levels of human activities that may influence liv-ing resource quality and how are they changing?	▲	Influences on living resources include fishing and associated habitat disturbance, vessel traffic (discharge, noise, collision), and marine debris (derelict gear and plastics) (pages 34-35)	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 re-sources and how is it changing?	?	No documented underwater archaeological sites (page 35)	N/A	N/A
16	Do known maritime archaeo-logical resources pose an environmental hazard and how is this threat changing?	?	No documented underwater archaeological sites (page 35)	N/A	
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	?	No documented underwater archaeological sites (page 35)	N/A	

Site History and Resources

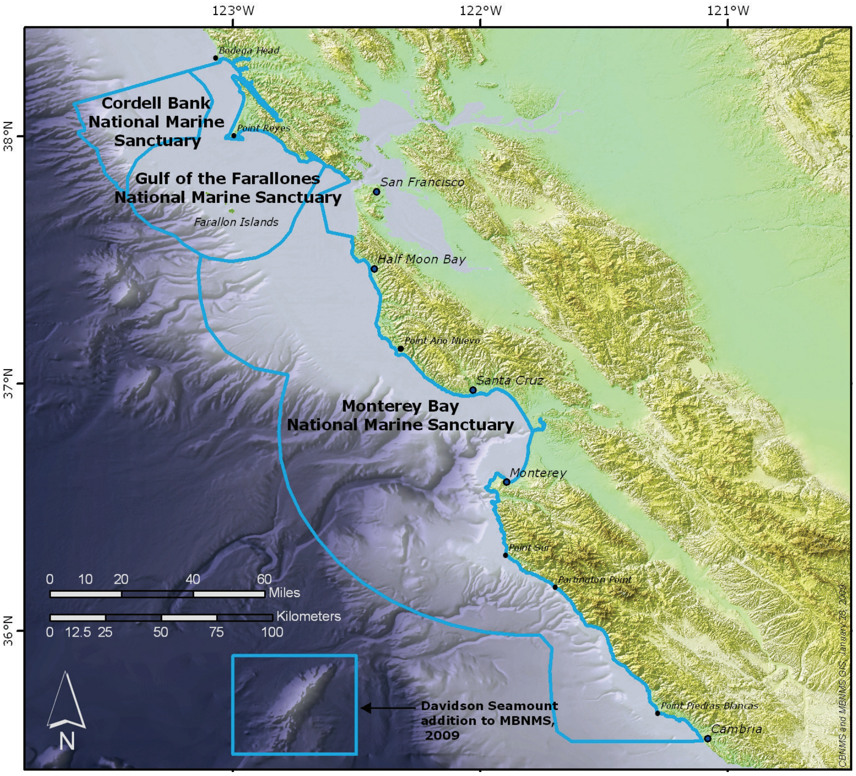


Image: Pam van der Leeden, CBNMS

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

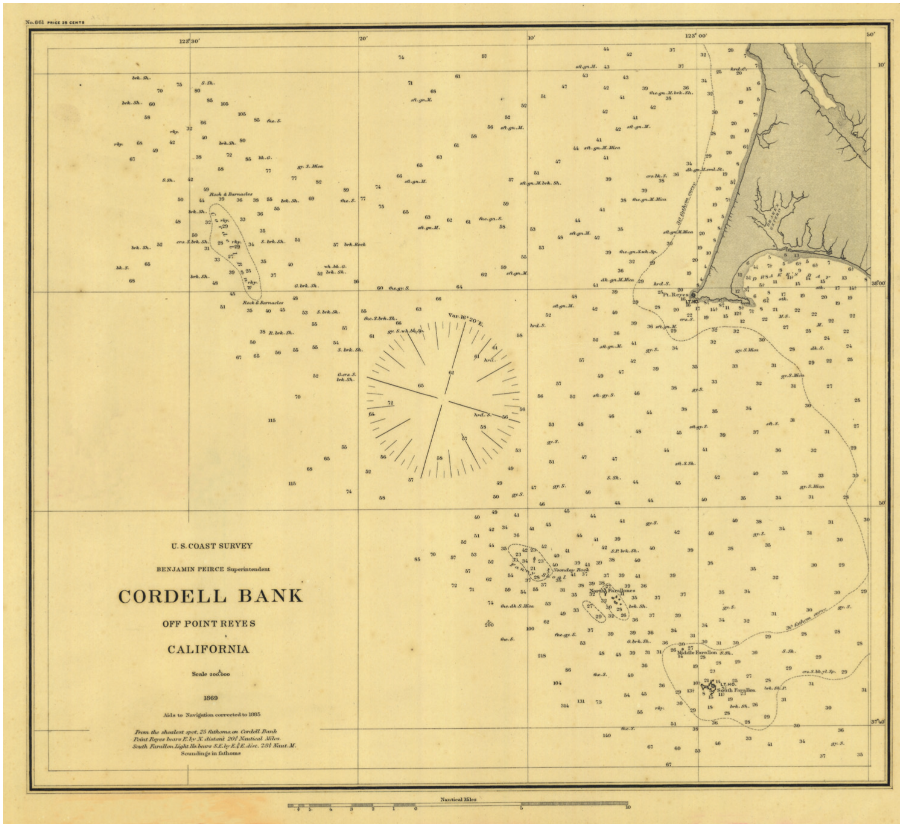
Overview

Located off the California coast, 42 miles (68 km) northwest of San Francisco (Figure 3), Cordell Bank sanctuary, like many of the nation's 13 marine sanctuaries and one marine national monument, has been recognized for its biodiversity and ecological integrity. Due to its unique combination of bathymetry and ocean conditions, the Cordell Bank sanctuary 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.

The Cordell Bank sanctuary protects an area of 529 square miles (1369 km²) 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. This rocky submerged feature emerges from the soft sediments of the continental shelf, with the upper pinnacles reaching

Sharing Boundaries

Three of the 14 areas managed by the Office of National 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.



Map: NOAA

Figure 4. A nautical chart from 1869 showing the feature of Cordell Bank offshore of Point Reyes.

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).

Discovery of the Bank

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 (Schmieder 1991).

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 a national marine sanctuary.

Cordell Bank was first explored underwater in 1978 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 made available to the public for the first time. These efforts were instrumental in the process of designating the site as a National Marine Sanctuary in 1989.

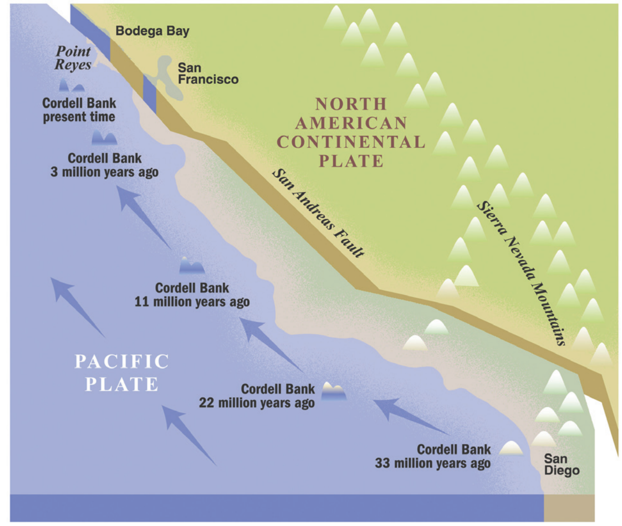
Geology

The Cordell Bank sanctuary is situated on the Pacific Plate, with its eastern boundary 7.5 miles (12 km) west of the convergence zone of two of the Earth's major tectonic plates: the Pacific and North American Plates (Figure 6). The Pacific Plate is slowly moving northward relative to the North American Plate at an average rate of about two inches (five cm) per year. Most of this motion occurs in catastrophic bursts of movement—recognized as earthquakes—along the San Andreas Fault system, which is hundreds of miles long and in places many miles wide.


Scientists to study 'lost island'
Cordell Bank off Point Reyes
The many riches
An amazing island underneath the sea
Cordell Bank divers find
Visit to a long-lost island
EMPHASIS
lore undersea mountain
Cordell Bank surprises explorers
Mystery sea mount
lore Cordell Bank
Lush Sea World Rises From Obscurity
Undersea mountain reveals ancient clues
mysterious island beneath Pacific
Cordell Bank Dive Was Well Wort

Credit: Cordell Expeditions

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.



Credit: CBNMS

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

The topography of western California is strongly influenced by the San Andreas Fault, which has been active for millions of years. Although the majority of the plate motion is "strike-slip" resulting in hundreds of miles of lateral displacement of the earth's crust, a small percentage of the plate motion is "compressional", or displaying a shortening and wrinkling of the earth's crust that creates northwest-southeast mountain ranges.

Cordell Bank is the most prominent geological feature of the sanctuary. The Salinian bedrock of Cordell Bank formed about 100 million years ago as part of the Sierra Nevada range. When the San Andreas fault was created ~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 (Figure 6). Cordell Bank and the Farallon Islands are part of the same Farallon Ridge structural high. Sediments surrounding the base of Cordell Bank on the continental shelf are composed predominantly 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 to this port 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 San Francisco Bay Area region each year.

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 (*Zalophus californianus*) and Steller sea lions (*Eumetopias jubatus*), and northern fur seals (*Callorhinus ursinus*). Hunting of large whales during the last two centuries nearly extirpated several species, including gray (*Eschrichtius robustus*), blue (*Balaenoptera musculus*), humpback (*Megaptera novaeangliae*) and fin (*Balaenoptera physalus*) whales. One of the last active whaling stations in America operated in San Francisco Bay until 1971.

Cordell Bank is a productive area and has historically supported important commercial and recreational fisheries. The Pacific Fishery

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

Management Council, working with NOAA Fisheries and the California Department of Fish and Game, regulates fishing activity. Commercial fisheries generally target rockfish (*Sebastes spp.*) and other groundfish species, Chinook salmon (*Oncorhynchus tshawytscha*), Dungeness crab (*Cancer magister*) and albacore tuna (*Thunnus alalunga*) (Scholz et al. 2005).

Because of the abundance of food, the Cordell Bank area is a feeding ground for fishes, 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 (*Ophiodon elongatus*) and rockfish and more recently, jumbo squid (*Dosidicus gigas*).

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.

Upwelling Season: The 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.

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 nutrient-rich deeper water from offshore. Rising into the sunlit layer of the ocean, these nutrients become available for incorporation into living systems through photosynthesis by phytoplankton (microscopic marine algae). Phytoplankton form the foundation of this oceanic food web; 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 upwelling which stimulates phytoplankton growth, and mixing and advection, which transport phytoplankton below surface-lit layers as well as offshore.

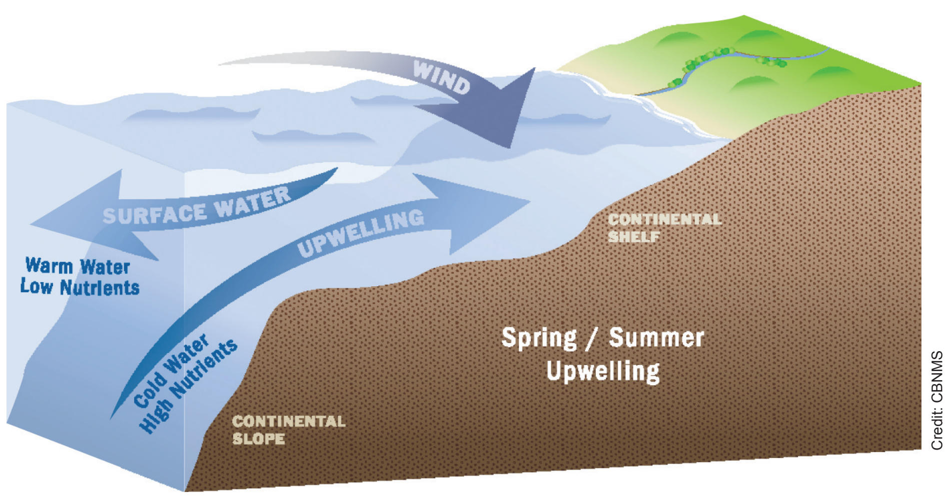


Figure 8. Spring/summer upwelling in Cordell Bank region.

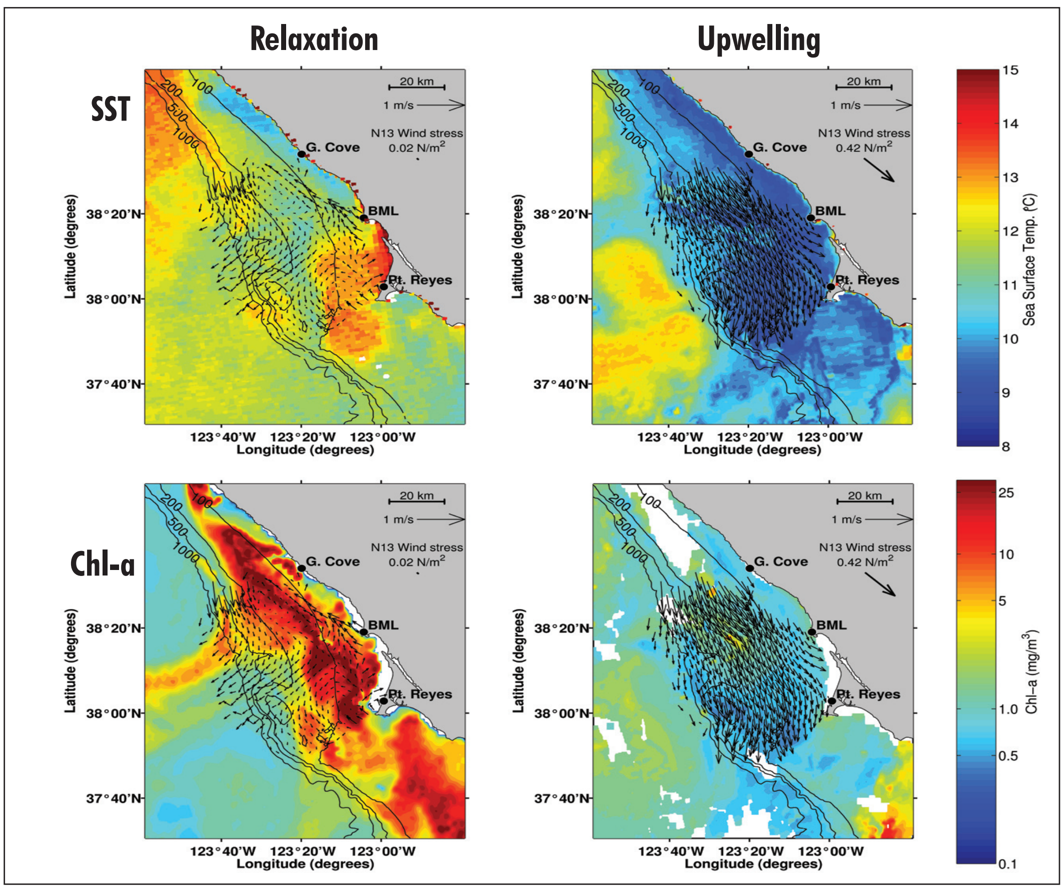
Thus, higher productivity within this region results from a combination of upwelling and relaxation events (Figure 9).

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 in the upper water column, homogenizing temperature, salinity, and the distribution of nutrients. The northward-flowing Davidson Current has a stronger influence on circulation during this time period.

Habitat

Cordell Bank National Marine Sanctuary encompasses an area of 529 square miles (1,369 km^2). The sanctuary can be partitioned into three benthic habitat types. The continental shelf covers 313 square miles (810 km^2) and is primarily mud bottom ranging from 230-656 feet (70-200m) deep. 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 6,955 feet (2,120 m) at the Western boundary of the sanctuary. The main feature of the sanctuary is an offshore rocky bank roughly 4.5 miles



Credit: Largier et al. 2006

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). For sea surface temperature (SST), red indicates warmer waters and blue indicates cooler waters. For chlorophyll-a, blue indicates lower concentrations and red indicates higher concentrations. Black arrows show the direction and intensity of surface currents (notice the increase in surface current vectors during upwelling conditions).

Photo: Kip Evans

Figure 10. The pinnacles of Cordell Bank harbor an abundance of life and provide structure for schooling rockfishes.

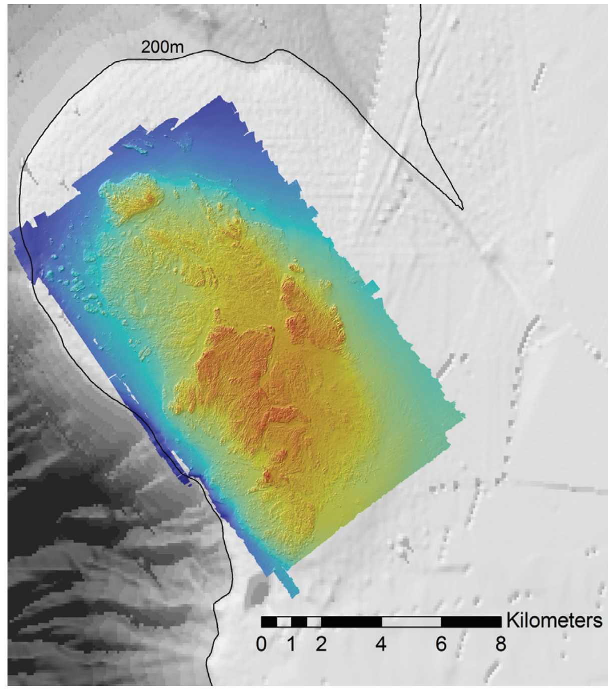


Image: Lisa Etherington, CBNMS

Figure 11. Bathymetry of Cordell Bank based on high resolution multibeam echosounder data. Red represents the shallowest depths (to 35 meters), blue represents the deepest depths. The 200 meter contour line illustrates the proximity of Cordell Bank to the continental shelf break. Data source: Seafloor Mapping Laboratory at California State University Monterey Bay.

wide by 9.5 miles long (7.2 x 15.2 km) covering an area of approximately 26 square miles (68 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 between 300 and 400 feet (91-122 m).

The bank has a diversity of benthic habitats that include high relief rock pinnacles, flat rock, boulders, cobble, sand, and mud (Figure 11). Distinct biological assemblages are associated with each habitat type. 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.

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 an array of resident and transient animals and tremendous biological diversity in the vicinity of the Cordell Bank National Marine Sanctuary.

Isolated rock piles and rock outcroppings are an important habitat component within the sanctuary. These areas, while nominal in terms of area, typically concentrate high abundance and biomass of marine life, particularly fishes. Submersible observations have documented hundreds of rockfish of several species and several lingcod in close proximity to a relatively small rock pile on the mud slope west of Cordell Bank (Cordell Bank sanctuary, unpubl. data). Fish observations diminished with distance from the feature (Cordell Bank sanctuary, unpubl. data).

Soft bottom habitat constitutes the remaining continental shelf and slope protected within the Cordell Bank sanctuary. The lack of hard substratum for attachment prevents algae and some invertebrates from colonizing these 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 depth in the sanctuary, excluding Cordell Bank, is approximately 230 feet (70 m), and is on the continental shelf area in the eastern part of the sanctuary.

In addition to the benthic habitats of Cordell Bank sanctuary, the open ocean water column is another major habitat. The water column is subject 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 dynamic habitat.

Living Resources

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, scattered crabs, holothurians, and gastropods.

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 (Figure 14). The sea whip (*Halipteris spp.*) is one common soft bottom resident that extends into the water column providing structure and relief for fishes and other invertebrates on the flat, mostly featureless bottom of the continental shelf.

Zooplankton

A myriad of gelatinous zooplankters are a little known component of the open ocean ecosystem at Cordell Bank. In addition to the common jellyfish, moon jellies (*Aurelia aurita*) and sea nettles (*Chrysaora fuscescens*), as well as 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 (*Sebastes flavidus*) are opportunistic feeders, gorging themselves when gelatinous zooplankton are abundant. Fish and invertebrate larvae also comprise a large component of the plankton community in late winter and spring.

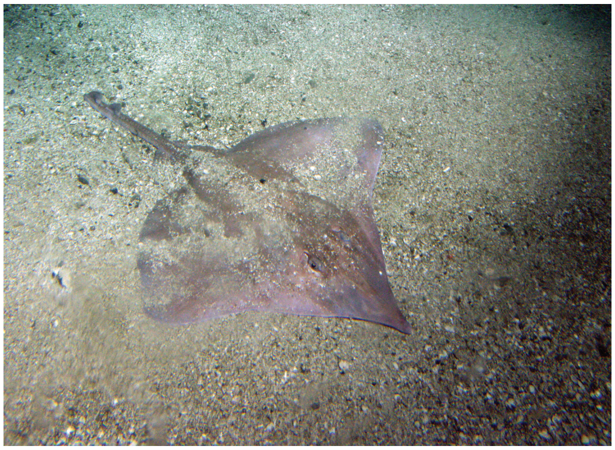


Photo: Linda Snook, CBNMS

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

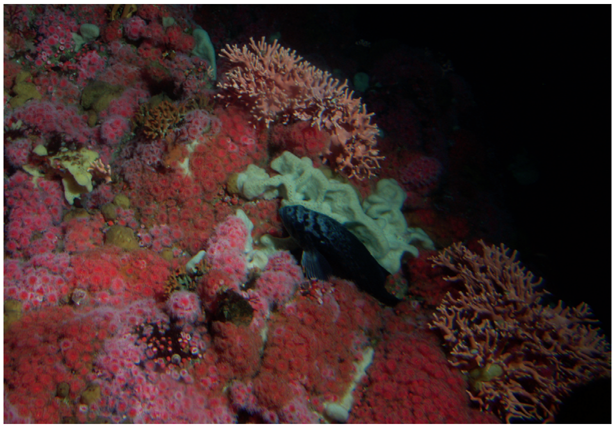


Photo: Rick Starr, CBNMS

Figure 13. Dense invertebrate cover of hydrocorals, sponges, and anemones, carpet the shallow areas on Cordell Bank.

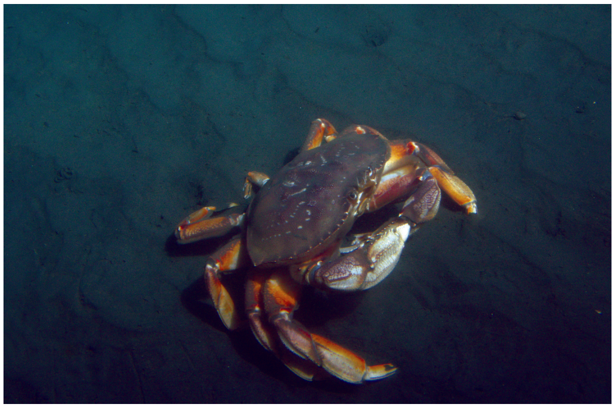


Photo: Rick Starr, CBNMS

Figure 14. Dungeness crabs occupy the soft sediment habitats on the continental shelf habitats and are an important commercial species in the region.

Figure 15. Krill are often found in large, concentrated groups, including dense swarms with as many as 100,000 krill per cubic meter of water.

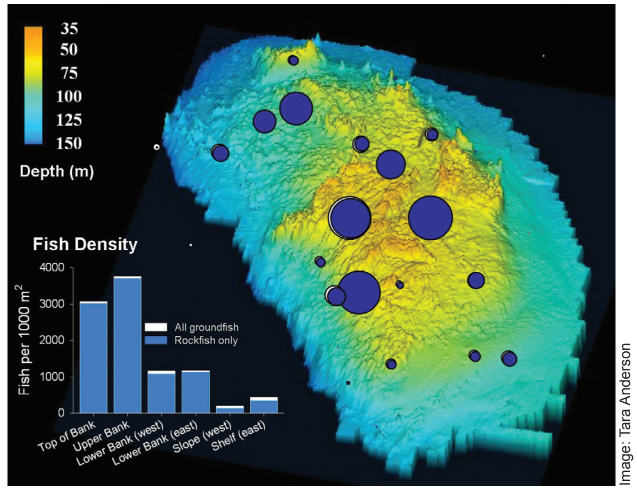


Figure 16. Groundfish density in the region of Cordell Bank as measured by Delta submersible transects to assess the benthic community and habitat affinities. Rockfish account for 95% of fishes observed, with their abundance decreasing markedly as you move off the bank. Size of circles indicates comparative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

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, the presence of krill is the primary reason why the area is a destination feeding ground for many migratory animals such as Chinook salmon, humpback whales and blue whales. In addition, krill are prey for resident species like yellowtail rockfish (*Sebastes flavidus*) and Cassin's Auklets (*Ptychoramphus aleuticus*), which nest on the nearby Farallon Islands.

Each spring and summer, massive swarms of krill provide food for dominant species 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. Many species of fish migrate with the krill in order to feed on them. These vertical migrations from seafloor to surface layers can cover almost 600 feet (over 180 m) in the span of an hour. In addition, *T. spinifera* will periodically form dense swarms at the ocean surface during daylight hours. Fishes, seabirds and whales all feed actively on *T. spinifera* when this happens. Fishermen key in on flocks of feeding seabirds, knowing that salmon are often feeding on the underside of the same patch of krill.

Squid

The nominal range of the jumbo squid is from Southern California to Peru, 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 *D. gigas* in the 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*), rockfishes, 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 as their range expands and contracts with changing ocean temperature regimes.

Fishes

More than 180 species of fish have been documented in the Cordell Bank National Marine Sanctuary (Eldridge 1994, NOAA Fisheries, unpubl. data, Cordell Bank sanctuary, unpubl. data), with rockfish dominating the fish community in both numbers and biomass (Figure 16). Between 2002 and 2005, sanctuary staff and partners conducted quantitative visual surveys from the '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 rockfishes were the most numerous, accounting for 64 percent of all rockfishes. Cordell Bank is a suitable and important site for the recruitment of juvenile rockfishes transitioning from a pelagic to benthic stage in their early life history. These young-of-year rockfish species are important prey for salmon, seabirds

Figure 17. Lingcod can be found in many different habitats on and around Cordell Bank.

and adult rockfishes as they provide an important energetic link in the trophic ecology of this system. The distribution and abundance of fishes were related to habitat type, depth, and location. 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 the canary rockfish (*S. pinniger*). Lingcod are conspicuous in the wintertime, when they move up onto the bank to lay their eggs.

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 (Allen 2006). While soft-bottom areas are predominantly the domain of flatfishes, skates, rays and 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 include the stripetail rockfish (*Sebastes saxicola*), greenstriped rockfish (*Sebastes elongatus*) and slender sole (*Lyopsetta exilis*). Beyond the shelf break in the upper 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*).

Most of the water column habitat within Cordell Bank sanctuary overlies the continental shelf and comprises the coastal pelagic realm. Fishes which occupy the epipelagic zone (depth to 200m) are a mixed group of larger, slow growing, longer-lived species and active, fast growing shorter-lived fishes (Allen and Cross 2006). Fishes commonly placed in the former group include sharks (blue shark *Prionace glauca*, white shark *Carcharodon carcharias*, thresher shark *Alopias vulpinus*) jack mackerel (*Trachurus symmetuicus*), pacific mackerel (*Scomber japonicus*) and pacific hake (*Merluccius productus*). The latter group occupying the epipelagic zone is composed of early life history stages of many fishes (including lingcod, rockfishes and many flatfish species) as well as the commercially important northern anchovy (*Engraulis mordax*) and pacific sardine (*Sardinops sagax*). Anchovies and sardines, which are an important prey for many coastal predators and a critical link in the coastal food web, have alternated as the most abundant fishes of the coastal pelagic realm off California throughout recent history. Abundance of these short lived fishes is related to oceanographic cycles within the region. For example, the alternating 20 to 30 year periods of cool and then warm phases in the Pacific Ocean track fluctuations in the alternating abundances of anchovies (cool periods) and sardines (warm periods) (Chavez et al. 2003). Other fishes that inhabit the epipelagic zone include species that frequent the sanctuary on a seasonal basis, such as albacore tuna (*Thunnus alalunga*) and salmon (*Oncorhynchus tshawytscha, O. kisutch*). Mesopelagic fishes (those found below the epipelagic zone to depths of 1000 meters) are relatively small, slow-growing and long-lived. Representatives of this group include the lanternfishes, hatchetfishes and deep-sea smelts. Many mesopleagic fishes make nocturnal vertical migrations to feed.

Sea turtles

The waters off central and northern California, including the Cordell Bank sanctuary, are critical foraging areas for one of the largest remaining Pacific nesting populations of endangered leatherback sea turtles (Benson et al. 2007a). Recent results from tagging studies revealed that these animals migrate from nesting beaches in Papua, Indonesia to feeding grounds off the west coast of North America (Benson et al. 2007b). The leatherback turtle is a regular visitor to the central and northern California coasts in late summer and fall (August through November) (Benson et al. 2007a) and is the only species of sea turtle that journeys to cold waters to feed. Leatherback turtles feed on seasonally abundant jellyfishes (e.g., *Chrysaora fuscescens*, *C. colorata*, and *Aurelia spp*.) in the Cordell Bank area. Therefore, it is thought that spatial and temporal abundance patterns of turtles in this region are driven by upwelling and relaxation events that favor phytoplankton growth and in turn an increased production of gelatinous zooplankton (Benson et al. 2007a).

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 the central portion of the California

Figure 18. Black-footed albatrosses travel thousands of miles from the northwestern Hawaiian Islands to feed in the waters of Cordell Bank sanctuary.

Figure 19. Pacific white-sided dolphins are one of the most abundant marine mammals in the Cordell Bank sanctuary.

Current are found at Cordell Bank, Monterey Bay and the Farallon Ridge (Ford et al. 2004). Over fifty 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 a large percentage of the world's population of Ashy Storm-Petrels (*Oceanodroma homochroa*), which nest on the Farallon Islands, on the waters around Cordell Bank simultaneously (Stallcup 2004). 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 "commute" to Cordell Bank waters to gather food for their chicks before returning to their nests (Hyrenbach et al. 2006) (Figure 18). 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.

Marine Mammals

Over twenty species resident and migratory marine mammal species have been observed within the sanctuary (NCCOS 2007). 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 19). Other common cetaceans include Dall's porpoise (*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 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 northern fur seals (*Callorhinus ursinus*), northern elephant seals (*Mirounga angustirostris*) and Steller sea lions.

Maritime Archaeological Resources

It is unknown if any shipwrecks rest on the seafloor in the Cordell Bank National Marine Sanctuary. Prehistoric use of the island, when the bank was exposed during the last ice age, may also have occurred but remains undocumented. Until recently, Cordell Bank and the surrounding seabed have been inaccessible due to location, depth, and currents. Advances in modern 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.

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, and steelhead (*O. mykiss*) in central California have been federally listed as 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 (Ralston 2003), and several species are currently considered overfished, including cowcod, canary, yelloweye and darkblotched rockfish.

Commercial and recreational fisheries in Cordell Bank sanctuary have generally targeted rockfish, lingcod, flatfish, salmon, Dungeness crab and albacore tuna (Figures 21 and 22). 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 sanctuary. Gear types used in the sanctuary have included bottom trawl, midwater trawl, hook and line, gill nets, crab pots and long lines (including troll long line, vertical long line, and fixed gear long line), although not all of these gear types are currently used.

Analysis of temporal patterns of landings indicate that overall landings for Bodega Bay (the closest port for fish caught within Cordell Bank sanctuary) have declined dramatically from 1981 to 2003 (Figure 21). Fisheries that made up the majority of landings in the 1980s (e.g., bottom trawl rockfish and sole, midwater trawl rockfish) have been virtually absent in the Bodega Bay landings data since 2000. Hook and line rockfish, halibut, sablefish, and lingcod made up a small proportion of landings in the late 1980s and 1990s; however, due to a stringent groundfish regulatory environment, landings from these fisheries from Bodega Bay were minimal or non-existent between 2000 and 2003. Landings from trap crab and hook and line salmon appear to be more stable through the years of 1981-2003; however, landings of these species has been low in the last several years due to population declines and restrictions on salmon fishing as well as low catch levels of Dungeness crab.

Photo: Michael Carver, CBNMS

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

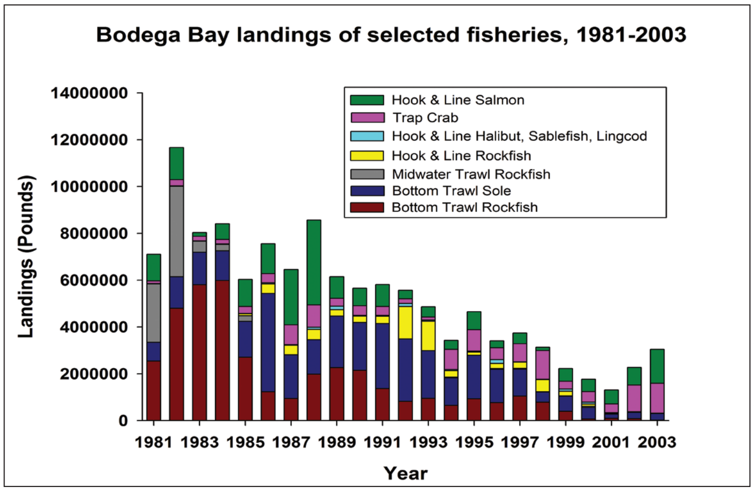
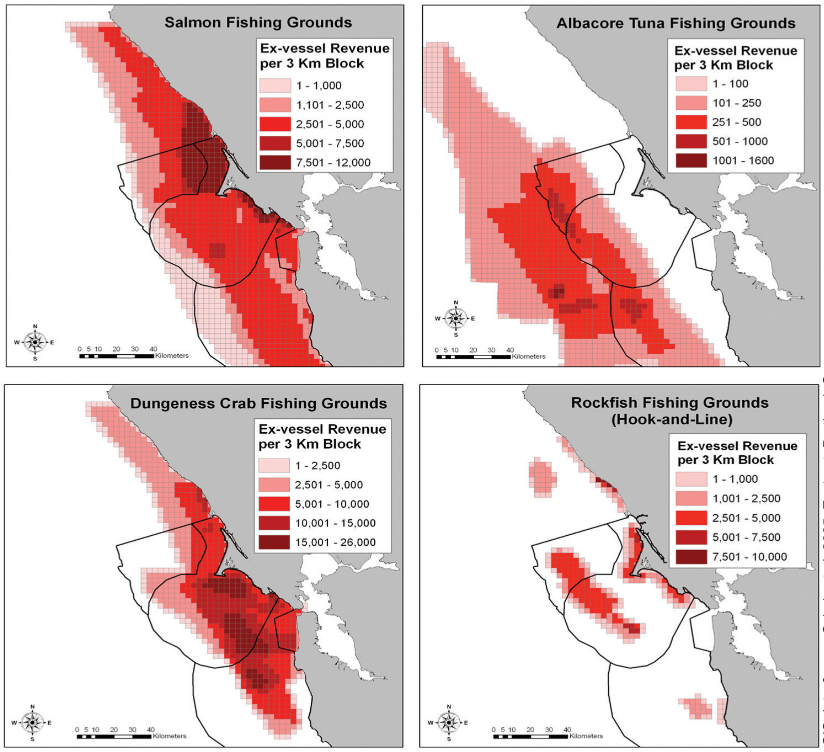


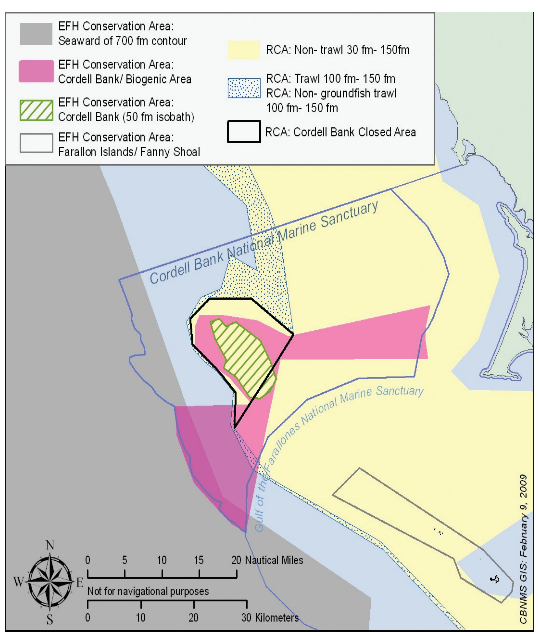
Figure modified from Scholz et al. 2005

Figure 21. Landings of selected fisheries, 1981-2003, from Bodega Bay, the closest port to Cordell Bank sanctuary.



GIS data & map: Scholz et al. 2005, Ecotrust, Portland, Oregon

Figure 22. Spatial fishing effort of various fisheries within the region of Cordell Bank and Gulf of the Farallones Sanctuaries based on fishermen's local knowledge of average ex-vessel revenues derived from California landing receipts, 1997-2003.



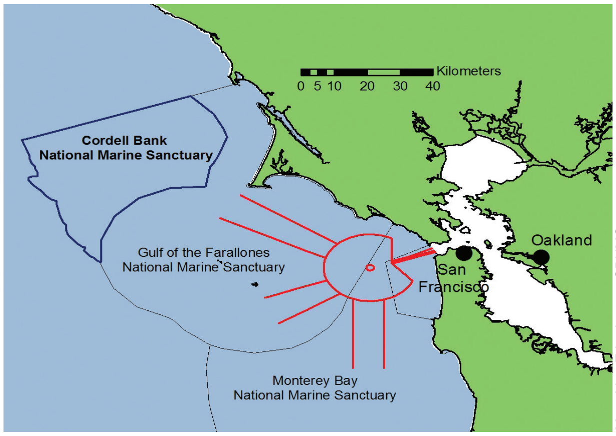
Map: Pam van der Leeden, CBNMS

Figure 23. Commercial fishing closures in the vicinity of Cordell Bank sanctuary, including Rockfish Conservation Areas (RCA) and Essential Fish Habitat (EFH) conservation areas. Note: recreational RCA not shown on map. EFH and RCA closure boundaries shown here are managed by the Pacific Fishery Management Council; specific regulations and updates can be referenced at: http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/Groundfish-Closed-Areas/Index.cfm and in the Code of Federal Regulations (CFR).

Analysis of spatial patterns of fishing effort from 1997-2003 (Figure 22) indicates that different regions of the Cordell Bank sanctuary have been targeted for different fisheries utilizing various gear types. For example, salmon and Dungeness crab fishing have generally concentrated in the more nearshore and shallower regions of the sanctuary, albacore fishing has occurred predominantly west of Cordell Bank in the deeper portions of the sanctuary, while hook and line rockfish fishing within the sanctuary has been centered on Cordell Bank (Figure 22).

Fishing activities not only impact target fish populations through direct extraction, but can also influence the sanctuary ecosystem through habitat degradation and bycatch of non-target species. Observations from submersibles have documented the presence of lost fishing gear entangled in rocky areas of the bank (Cordell Bank sanctuary unpubl. data). These bottom-tending gear types can damage sensitive habitats that provide food and shelter for invertebrates and fishes (Barnes and Thomas 2005). In addition, selected open ocean fisheries have significantly reduced some populations of seabirds that are taken as bycatch in these fisheries (Forney et al. 2001). Pinnipeds, cetaceans (Read et al. 2006) and sea turtles (Spotila et al. 2000) are also taken as bycatch and die from entanglement in active and derelict fishing gear.

West Coast groundfish fisheries, and fisheries that may take groundfish incidentally are managed with a variety of closed areas intended to either protect specific overfished groundfish stocks and aid in their recovery (Rockfish Conservation Areas (RCA)) or to protect groundfish habitat (Essential Fish Habitat (EFH) conservation areas). Fishing closures in the vicinity of the Cordell Bank sanctuary include both RCA and EFH conservation areas (Figure 23). Rockfish Conservation Areas are areas where fishing for groundfish is prohibited for 3 different modes of fishing - trawl, non-trawl and recreational. Within the RCAs, certain fishing gears and take of certain species is al-



Map: Lisa Etherington, CBNMS

Figure 24. Location of Cordell Bank National Marine Sanctuary relative to the shipping lanes (in red) that funnel vessel traffic into and out of the large ports of San Francisco and Oakland within San Francisco Bay.

Photo: Dan Howard, CBNMS

Figure 25. 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.

lowed. Additionally, the RCA boundaries change both within and among seasons. EFH conservation areas are closed to specific types of fishing gear. All EFH conservation area closures were put in place in 2006, while the date in which RCA closures were implemented varied (start date ranged between 2002 to 2005). Specific regulations associated with different gear and seasons as well as updates and archives of past closures can be found at: http://www.nwr.noaa.gov/Groundfish-Halibut/Groundfish-Fishery-Management/Groundfish-Closed-Areas/Index.cfm

Currently, there is limited commercial and recreational fishing for groundfish permitted on Cordell Bank (fishing only allowed for some flatfish, including several species of sole and Pacific sanddab (*Citharichthys sordidus*) because the bank falls within the Cordell Bank Rockfish Conservation Area established in 2005 by the Pacific Fishery Management Council to protect several species of overfished rockfish (Figure 23). The establishment of Rockfish Conservation Areas has improved the status and recovery of depleted fish stocks, including several rockfish populations. It is unclear when or if these closures 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. In 2006, Cordell Bank was identified as a Habitat Area of Particular Concern under NOAA Fisheries Essential Fish Habitat designation and the Cordell Bank (50 fathom isobath) EFH Conservation Area was implemented. Under this designation, the use of bottom contact gear was prohibited in waters shallower than 50 fathoms (90 m) on Cordell Bank. Additionally, the establishment of the Cordell Bank/Biogenic Area EFH Conservation Area and the Seaward of 700 fathom EFH Conservation Area in 2006 prohibited the use of bottom trawls on some of the soft bottom habitat in the sanctuary.

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 (Figure 24). This traffic corridor 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 potential impacts could be enormous given the number and volume of vessels and the sensitivity of resources in the area. In addition to oil tankers, large cargo vessels are a 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 (13 km) seaward of the Golden Gate Bridge disabled the tanker Puerto Rican. The vessel 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 coastal waters (Figure 25). Oil from the spill traveled over 25 miles (40 km) and reached beaches adjacent to Monterey Bay and Gulf of the Farallones sanctuary waters.

Wildlife impacted from the spill included thousands of seabirds that were oiled and killed (Oiled Wildlife Care Network, unpublished data). There is no evidence to suggest that oil from the Cosco Busan spill reached Cordell Bank sanctuary; therefore, it is not thought that habitats were directly impacted by this spill. NOAA is currently undergoing damage assessment from the spill and it is undetermined if wildlife resources of the sanctuary were impacted. Nevertheless, the impacts of these incidents demonstrate the seriousness of the potential hazards to Cordell Bank sanctuary from vessel spills, including spills from accidents that occur outside the sanctuary boundary.

Photo: Bob Wilson

Figure 26. Large vessels such as cruise ships and cargo vessels have the potential to directly impact marine mammals.

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 Bays. Many of these ships have over 3,000 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 with respect 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.

Sunken vessels residing on the seafloor have the potential to leak oil or other contaminants into the sanctuary. To date, there are no documented findings of any shipwrecks on the seafloor of the Cordell Bank sanctuary. However, the Farallon Islands and the mainland coast north of San Francisco have historically provided hazardous navigational obstacles to shipping. Many known shipwrecks litter the seafloor of the nearby Gulf of the Farallones National Marine Sanctuary; therefore it is possible that shipwrecks exist within the boundaries of the Cordell Bank sanctuary and will eventually be identified. It is uncertain if sunken vessels are currently decreasing the water quality within Cordell Bank sanctuary.

In addition to the threat of materials being deposited from vessels into the sanctuary, 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. Vessels can also injure or kill marine mammals through collisions; although no marine mammal injuries or mortalities due to vessel strikes have been directly observed within Cordell Bank sanctuary (Figure 26). 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). In the fall of 2007, there were at least three blue whales deaths off the coast of southern California that were attributed to ship strikes. This number of deaths so close together is considered a highly unusual event, and scientists are investigating potential contributing factors to these deaths.

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). As ships get bigger and noisier, this could become a larger issue within sanctuaries. 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 the Cordell Bank sanctuary, activity adjacent to the sanctuary would have the potential to affect the integrity of its 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 some mass strandings of cetaceans have been spatially and temporally coincident with the deployment of military sonar (Rommel et al. 2006). 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 (NRC 2005). 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 (Lagardere 1982). These surveys may also disrupt prey location and communication among marine mammals and in severe cases cause internal injuries.

Climate

The calendar year at the Cordell Bank sanctuary is comprised of three distinct oceanographic periods. These periods, described as upwelling, wind relaxation (oceanic), and winter storm (Davidson Current) seasons are associated with distinct 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 the El Niño-Southern Oscillation, the Pacific Decadal Oscillation, global climate change, and other processes that operate on varying 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 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 organisms 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 adapt, live under suboptimal conditions, or vanish locally. Regardless, the composition of local species assemblages is expected to change.

An 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 (Feely et al. 2004). 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, corals, and certain shell-producing plankton which rely on carbonate from seawater to build their shells and other hard parts. Recent work demonstrates that large sections of the continental shelf of western North America are affected by ocean acidification, as seasonal upwelling brings corrosive deep water (enriched in CO_2 and undersaturated with respect to aragonite) closer to the surface and near the coast (Feely et al. 2008).

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 found in the Cordell Bank sanctuary. Marine debris originates from both land 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. The potential impact of floating 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).

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. 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 loggerhead sea turtles (*Caretta caretta*) had plastic debris in their digestive tracks (Tomas et al. 2002). 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). 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 (Figure 27). 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. Tagging studies have documented Black-footed Albatross crossing the eastern Pacific to feed in and around Cordell Bank sanctuary (Hyrenbach et al. 2006); it is unknown what proportion of plastic these birds ingest comes from within sanctuary waters.


Photo: Rich Stallcup

Figure 27. Black-footed albatross picking at marine debris at Cordell Bank sanctuary.

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 thousands of 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 in the eastern north Pacific stocks of humpback whales (data from 1999-2003: Carretta et al. 2007).

Significant amounts of derelict fishing gear have been documented in Cordell Bank National Marine Sanctuary (Cordell Bank sanctuary, unpubl. data) (Figure 28). This includes long lines, gill nets, and crab gear

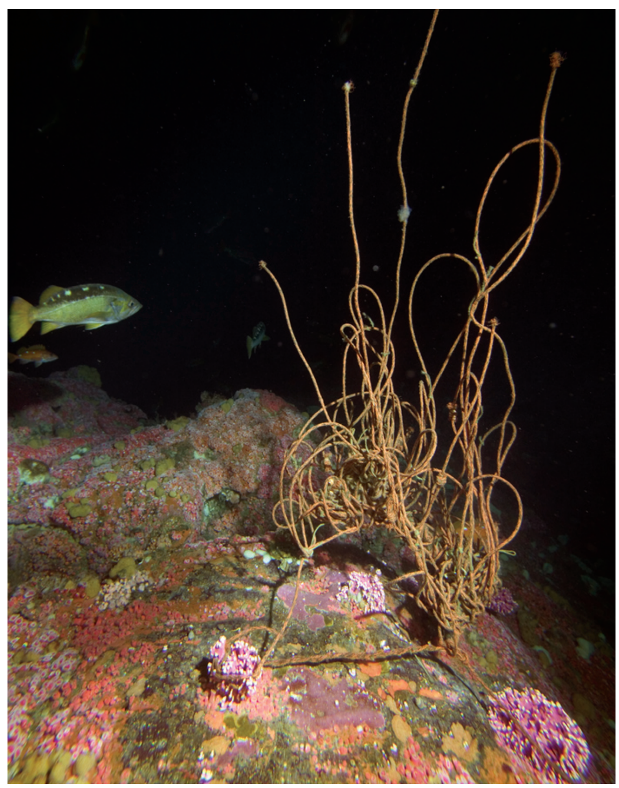


Photo: Kip Evans.

Figure 28. Derelict gear entangled on rocky substrate of Cordell Bank. The benthic community in the vicinity of the gear includes hydrocorals, anemones, sponges, and rockfish.

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. Derelict gear also poses a danger to personnel and equipment involved in sanctuary research and monitoring activities.

Non-indigenous Species

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 the Cordell Bank sanctuary, but none are known to currently exist in the sanctuary. Non-native species are still considered to be a potentially major threat to living resources and habitats in the sanctuary. Numerous non-indigenous species have been found in the adjacent Gulf of the Farallones National Marine 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 Cordell Bank 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 29).

Photo: Michael Carver, CBNNMS

Figure 29. Anemones are prominent organisms on Cordell Bank and could be sensitive to non-native species invasions.

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 (NMSP 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone and to those that use, depend on, and study the ecosystems encompassed by National Marine Sanctuaries. Appendix A (Rating Scheme for System-Wide Monitoring Questions) clarifies the set of questions and presents statements that were used to judge the status and assign a corresponding color code on a scale from "good" to "poor." These statements are customized for each question. In addition, the following options are available for all questions: "N/A" – the question does not apply; and "undetermined" – resource status is undetermined. In addition, symbols are used to indicate trends: "▲ " – conditions appear to be improving; "▬" – conditions do not appear to be changing; "▼ " – conditions appear to be declining; and "?" – 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.

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

Water

Cordell Bank is far enough offshore to be expected 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 30). A report investigating the current state of knowledge of water quality in West Coast sanctuaries concluded that the Cordell Bank sanctuary is the least likely of the five sanctuaries to be impacted by sources of water pollution due to its offshore location and open ocean conditions (Meyers 2005).

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:

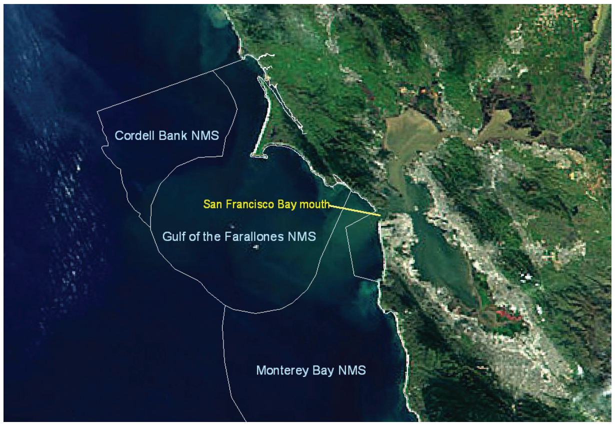


Image: Pam van der Leeden, CBNMS

Figure 30. 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.

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 location of Cordell Bank sanctuary, 40 miles (64 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 water 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 the winter, when storm conditions are characterized by heavy rainfall, strong southerly winds, and a coastal current that flows northward. As an example, in January 2006 impacts from severe flooding of coastal counties in northern California, caused by heavy rainfall, were observed at Cordell Bank during a 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. An analysis of temperature, chlorophyll concentrations, and turbidity within the sanctuary between 1997 and 2004 indicated a strong influence on these parameters from El Niño events, seasonal changes in upwelling, and seasonal changes in the strength of the California Current. However, there were no indications of reduced productivity or decreased water quality trends over time (Stumpf et al. 2005). This could change, however, if weather patterns shift.

   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. In addition, negative ecosystem impacts could result if oceanographic conditions such as temperature and pH continue to be altered by climate change. Stressors on water quality from changing oceanographic and atmospheric conditions are currently not producing long-term negative effects. For this reason, the rating for this question is "good." A trend is "undetermined" due to a paucity of data.

2. ***What is the eutrophic condition of sanctuary waters and how is it changing?*** There is no evidence of eutrophication within the Cordell Bank sanctuary or the surrounding waters. For this reason, this question is rated "good" and "not changing." 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, as measured from samples taken within the sanctuary (California Department of Health Services, monthly reports), lead sanctuary scientists 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 the Cordell Bank sanctuary during monthly monitoring cruises for the California Department of Health Services. The purpose of the sampling is to identify early warning signs of harmful algal blooms, focusing on the dinoflagellate *Alexandrium catenella* (which causes paralytic shellfish poisoning) and the diatom *Pseudonitzschia spp.* (domoic acid carriers) (Figure 31). 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 and

Photo: Michael Carver, CBNNMS

Figure 31. Monthly water sampling is conducted to identify early warning signs of harmful algal blooms.

could pose a risk to human health. For this reason, this question is rated “good” with a “stable” trend.

4. ***What are the levels of human activities that may influence water quality and how are they changing?*** The level of human activities that influence water quality in the sanctuary is considered to be minimal, so this question is rated “good/fair” and the trend is “undetermined” although threats to water quality including large vessel spills and discharges from large commercial ships exist. 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, should they occur. 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

#	Status	Rating	Basis for Judgment	Description of Findings
1	Stressors	?	Offshore location may limit impacts, but data are sparse	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.
2	Eutrophic Condition	–	Absence of harmful algal blooms and low chlorophyll levels do not indicate eutrophication	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.
3	Human Health	–	Offshore location and oceanic conditions may limit impacts; no known risks identified during monthly monitoring	Conditions do not appear to have the potential to negatively affect human health.
4	Human Activities	?	Minimal human activities, but uncertainty of the levels of vessel discharges	Some potentially harmful activities exist, but they do not appear to have had a negative effect on water quality.

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

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

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.

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?*** The Cordell Bank sanctuary’s 529 square miles (1370 km^2) of benthic habitat can be partitioned into three types: 1) the continental shelf covers 313 square miles (810 km^2) and is primarily mud bottom ranging from 230-656 feet (70-200 m) 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 Cordell Bank sanctuary has a diversity of habitats that include high relief rock pinnacles, flat rock, boulders (Figure 32),

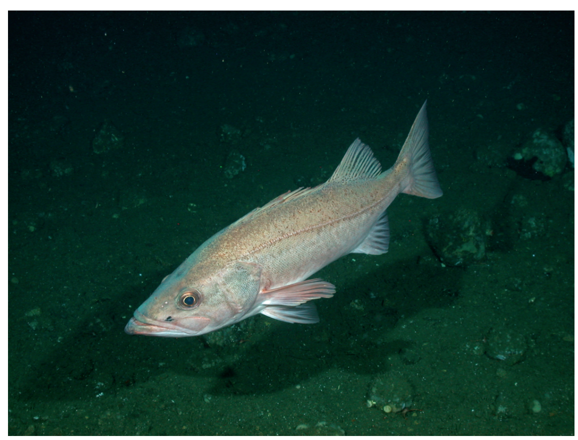


Photo: Southwest Fisheries Science Center, NOAA Fisheries

Figure 32. Cordell Bank provides deep water refugia of boulder habitats for overfished species such as Boccacio.

cobble, sand, and mud. High resolution backscatter and bathymetry data were recently collected on Cordell Bank and the surrounding soft bottom areas by California State University of Monterey Bay 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 California State University, Monterey Bay Web site: http://seafloor.csumb.edu/index.html).

The abundance and distribution of major habitat types is rated "fair," reflecting impacts from past long line and bottom trawling activities. Historically, trawl intensity was concentrated in several locations of the sanctuary, specifically in the region of the shelf break as well as within deeper regions of the sanctuary on the continental slope (Final Environmental Impact Statement 2008; Fig. 3-4). Recently, a variety of fishery management measures, including Rockfish Conservation Areas and Essential Fish Habitat Conservation Areas (see Figure 23, page 18 in pressures section), have been implemented that limit the extent of trawling activity and use of bottom contact fishing gear in the sanctuary. Currently, 86% of the Cordell Bank sanctuary is closed to some type of bottom tending fishing gear (see Figure 23, page 18 in pressures section). The net effect of these measures may be an improvement in the condition of habitats due to some recovery of seafloor habitats in the areas that were previously trawled or fished with other bottom contact gear. Nevertheless, a directed study to determine habitat differences in open and closed areas and recovery rates of benthic habitats relieved of fishing pressure has yet to be conducted. For this reason, the trend is "undetermined."

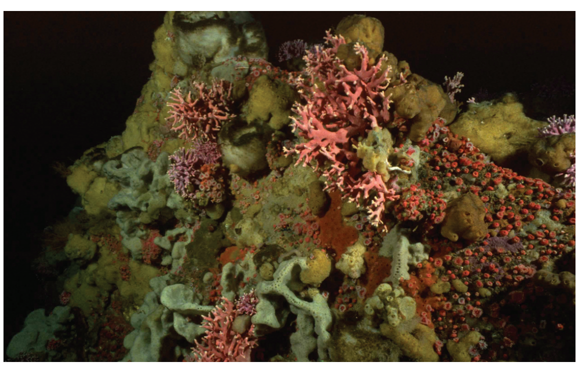


Photo: Cordell Expeditions

Figure 33. Biologically structured habitats on Cordell Bank include hydrocorals, sponges, and anemones.

6. ***What is the condition of biologically-structured habitats and how is it changing?*** Biologically-structured habitats, identified as habitat created by invertebrate communities on the upper bank (including hydrocorals and sponges) (Figure 33) and sea whip (*Halipteris sp.*) fields on the soft mud of the continental shelf appear, for the most part, to be healthy (Cordell Bank sanctuary, unpubl. data). These biologically structured habitats have, however, been impacted in the past by long lines, gill nets and bottom trawls (Cordell Bank sanctuary, unpubl. data). For this reason, this question is rated "fair." 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, the introduction of non-native species, and the construction and placement of cables and pipelines.

From 2001-2005, Cordell Bank sanctuary conducted demersal submersible surveys on and around the bank. During these surveys, fishing gear was consistently observed on the bottom (Figure 34). In 2002, derelict gear was observed entangled on the

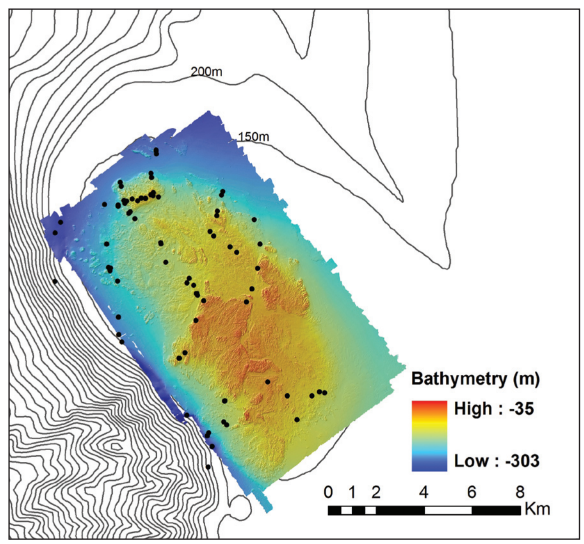


Image: Lisa Etherington, CBNMS

Figure 34. Location of derelict fishing gear (black dots) in the Cordell Bank area as 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.

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 gear is entangled among boulders or on high relief rock. Many of the high relief areas are covered with hydrocorals and other encrusting invertebrates and derelict gear has been documented entangled on these sensitive species.

As some areas in the sanctuary are now off limits to the use of bottom contact gear and bottom trawling (see Figure 23, page 18 in pressures section), condition of biologically structured habitats should improve; however, there is insufficient data to determine a trend. Further, due to the slow growth of some habitat-forming organisms, such as cold water corals, recovery from past damage could be slow. 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 and changes in pH would affect the condition of the lush invertebrate community carpeting the upper reaches of the bank.

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 contaminant samples collected on the shelf and slope within Cordell Bank sanctuary. As a result, the assessment of contaminant concentrations is "undetermined" with an "undetermined" trend. Preliminary analysis of several samples indicates low levels of Dichloro-Diphenyl-Trichloroethane (DDT), polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) (I. Hartwell, NOAA' s National Status and Trends Program, unpubl. data) (Figure 35). These data indicate that accumulation of DDT, PAHs, and PCBs may be occurring in the depths of Bodega Canyon (a feature 10 km north of Cordell Bank sanctuary), a pattern that holds true for other canyons as well, as evidenced by elevated concentrations in fine grained sediments in deeper areas in Pioneer and Lucia Canyons to the south of CBNMS (Hartwell 2007, 2008). Persistent contaminants also collect in fine grained sediments at the head and down the length of Monterey, Soquel, Ascension, and Año Nuevo canyons (Figure 35). The nature of the compounds will cause them to accumulate in the food chain at some level. 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?*** In the past, bottom contact fishing gear within the Cordell Bank sanctuary affected habitat quality. However, 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 (see Figure 23, page 18 in pressures section). For this reason, this question is rated "fair" and "improving." 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.

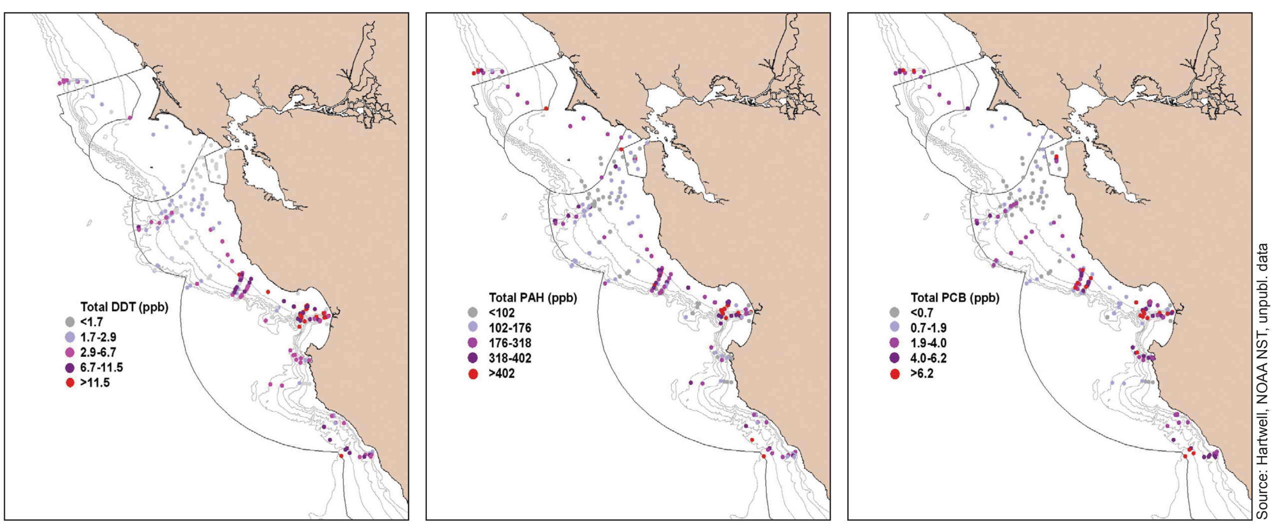


Figure 35. DDT, PAH, and PCB concentrations off the coast of California. Bodega Canyon to the north of Cordell Bank sanctuary shows higher concentrations of these contaminants compared with many of the sampling locations in the region.

Habitat Status & Trends

#	Status	Rating	Basis for Judgment	Description of Findings
5	Abundance/ Distribution	?	Prior fishing gear impacts, some activities now prohibited; sparse data	Selected habitat loss or alteration may inhibit the development of assemblages, and may cause measurable but not severe declines in living resources or water quality.
6	Structure	?	Prior fishing gear impacts, some activities now prohibited; sparse data	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.
7	Contaminants	?	Sparse data available	N/A
8	Human Activities	▲	Prior fishing impacts, some activities now prohibited	Selected activities have resulted in measurable habitat impacts, but evidence suggests effects are localized, not widespread.

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

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

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 declines caused by pollution, over-harvesting, destruction of habitat, and recruitment failure. Several species, like gray whales, brown pelicans and elephant seals, have experienced considerable population increases after exploitation or other human activities reduced their numbers dramatically. Other populations, like leatherback sea turtles, Chinook and coho salmon, and some species of rockfish, are at all time lows. In 2008, the commercial and recreational salmon season was closed for the first time ever due to reduced population levels off the coast of California and Oregon. And in recent years, jumbo squid populations have expanded to Cordell Bank from the south and have persisted in the area; this top-level predator has the potential to have significant impacts on the biodiversity and community composition within the sanctuary.

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

Species have probably not been lost from the marine ecosystem within the 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 community composition has been altered. Changes in oceanic conditions in recent years (Peterson et al. 2006, Goericke et al. 2007) have 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 affected both species composition and reduced rockfish biomass on Cordell Bank; however, recent stock assessments suggest that many populations of overfished species are increasing (Pacific Fishery Management Council 2006). 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. For these reasons, the status of biodiversity in the sanctuary is rated as "fair" and "improving."

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

- **Benthic invertebrates:** Overall biodiversity of benthic invertebrates on soft and hard substrates on the continental shelf appears healthy, based on limited observations (Cordell Bank sanctuary, unpubl. data). Photographs of the invertebrates of the reef top of Cordell Bank taken by Cordell Expeditions in the late 1970s (Schmieder 1991) reveal an assemblage very similar to that observed by sanctuary staff in 2005 (Cordell Bank sanctuary, unpubl. data), suggesting that current biodiversity of this group is 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 (Zeidberg and Robison 2007) suggests the possibility that the marine ecosystem has been or will be altered by the addition of a top level predator, resulting in shifts in community composition.

- **Fishes:** Overharvest of some rockfish populations (i.e. yelloweye, canary, and cowcod), combined with poor recruitment, has severely

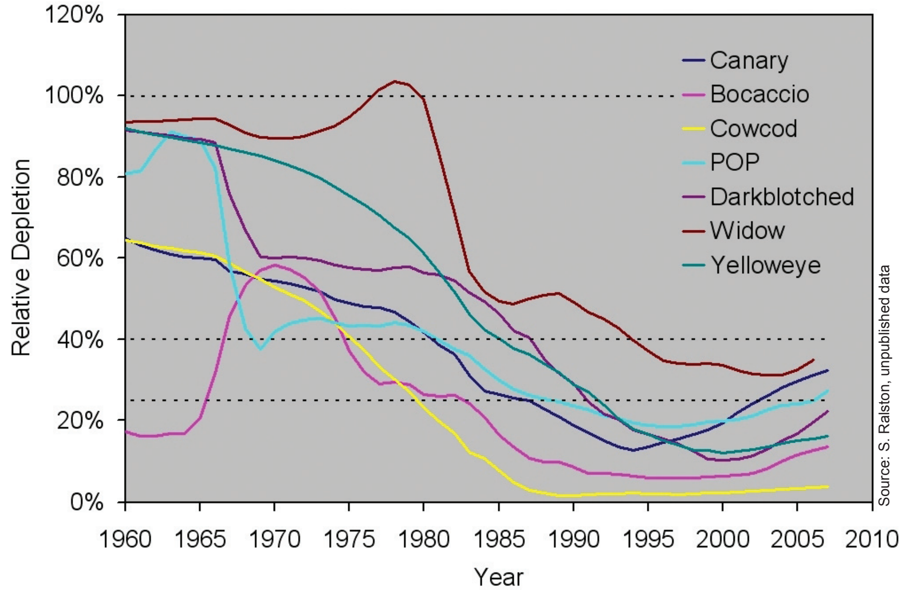


Figure 36. Relative depletion of overfished rockfish species that are managed by the PFMC. Data is based on the most recent set of stock assessments.

impacted their populations along the west coast (Ralston 2002) and has resulted in the closure of some groundfish fisheries in an attempt to rebuild depleted populations (Figure 36). There is also some indication that the general removal of large predators (e.g., yelloweye rockfish) can alter 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 review.). Closures associated with Rockfish Conservation Areas and Essential Fish Habitat Conservation Areas have been established; these protected areas will locally reduce fishing pressure and help rebuild depleted rockfish populations (see Figure 23, page 18 in pressures section). 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 considered overfished appear to be stable (Pacific Fishery Management Council 2006). Lingcod are a top predator and their population has been declared rebuilt after consecutive years of good recruitment (Pacific Fishery Management Council 2006). Nevertheless, pelagic juvenile rockfish surveys in 2005 within the northern California region indicated an all time low in catch (for a 23 year data set) (Figure 37) and an apparent shift in distribution of fish to the north and the south of the central California region (Peterson et al. 2006; S. Ralston, NOAA's Southwest Fisheries Science Center, unpubl. data). A combination of instream pressures such as water diversion and degraded spawning habitat and poor ocean conditions have taken a toll on populations of Chinook and coho salmon. Poor spawning escapement and record low numbers in the ocean elicited an unprecedented closure of the commercial and recreational fall run Chinook salmon fishery in 2008.

- **Seabirds:** Locally breeding seabird populations within central and northern California have generally suffered long term declines (Ain-

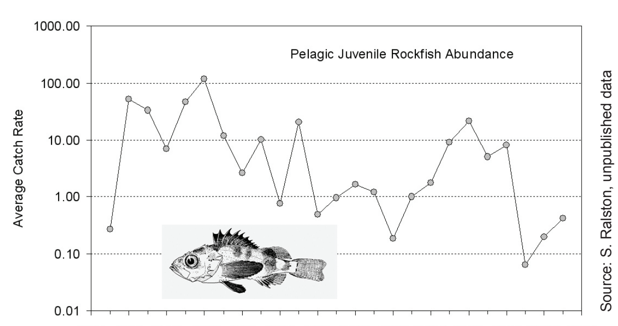


Figure 37. Pelagic juvenile rockfish abundance from midwater trawl surveys conducted from Bodega Bay to Carmel, CA. Note that the y-axis is a logarithmic scale.

ley and Hyrenbach 2007). For example, the mean density of Ashy Storm-Petrels, Rhinoceros Auklets (*Cerorhinca monocerata*) and Western Gulls (*Larus occidentalis*) from at-sea surveys in northern California have declined significantly over the time period of 1985-1994 compared to 1997-2006 (Ainley and Hyrenbach 2007). Some locally breeding species (e.g., Cassin's Auklets) have experienced reduced reproductive success in recent years due to poor feeding conditions in the coastal ocean (Sydeman et al. 2006). Abundance of non-resident species, such as Sooty Shearwaters (*Puffinus griseus*) and Black-footed Albatrosses (*Phoebastria nigripes*), have also declined within the waters of northern California (Ainley and Hyrenbach 2007), potentially due to population declines resulting from human impacts in remote locations.

- **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 (Peterson et al. 2006) due to a decrease in the overall abundance of krill in the area (Peterson et al. 2006, Sydeman et al. 2006, Jahncke et al. 2008).

10. What is the status of environmentally sustainable fishing and how is it changing? The status and trend ratings for this question are based on the available scientific knowledge (e.g., published studies, unpublished data, and expert opinion) of targeted and non-targeted living resources that are directly and indirectly affected by fishing. The rating reflects a more historical view of the potential effects of fishing activity on biological community development, function, and ecosystem integrity, over the last two to three decades. The rating does not serve as an assessment of the status of current fisheries management practices in the region. However, the determination of an increasing trend for this question does reflect recent changes in fisheries management practices and their positive effects on living resources in the sanctuary.

In the early 2000's, seven species of rockfish - widow (*Sebastes entomelas*), yelloweye (*S. ruberrimus*), canary (*S. pinniger*), darkblotched (*S. crameri*), bocaccio (*S. paucispinis*), cowcod (*S. levis*), and Pacific ocean perch (*S. alutus*) - were formally declared overfished throughout their range by the NOAA Fisheries (Figure 36); all but cowcod, Pacific ocean perch, and darkblotched rockfish are relatively common within the sanctuary (Anderson et al. in review). In addition, long lines, gillnets, and bottom trawls have negatively impacted seafloor habitats and benthic organisms in the sanctuary. For these reasons, this question is rated "fair." However, the trend is considered to be "improving" because the management strategies used by NOAA Fisheries and the Pacific Fisheries Management Council (PFMC) have become much more restrictive since the Sustainable Fisheries Act was passed in 1998. Prohibitions associated with the Rockfish Conservation Area closures and regulations implemented in 2006 by Essential Fish Habitat (EFH) Conservation Areas are encouraging sustainable fishing practices by prohibiting the use of destructive gear types on selected benthic habitats (see Figure 23, page 18 in pressures section).

NOAA Fisheries conducts an annual survey to estimate the distribution and abundance of pelagic juvenile rockfish in the immediate region of the sanctuary (Figure 37). Results show that during the late 1980s, catches averaged 10-100 fish/trawl, but during the 1990s, there was a general decline in abundance, falling to 0.2 fish/trawl in 1998. Catches later increased to ~10 fish/trawl from 2001-04, but dropped abruptly to their lowest value in the time series in 2005 (0.1 fish/trawl). Since then catches have increased slightly, but still remain low (0.4 fish/trawl in 2007). Trends in abundance of exploited and unexploited species are very similar, implying that variation in the environment is largely responsible for these trends (S. Ralston, NOAA's Southwest Fisheries Science Center, unpubl. data).

Management regimes for commercial fishing are currently more risk adverse than in prior decades, and some measures are proving successful in allowing over-fished stocks to recover. Many of the species are responding positively to management changes and are showing clear evidence of recovery based on stock assessments. For depleted rockfish species with stock assessment data, all are showing increasing trends in spawning biomass over the past 10 years. Contributing to these recoveries are gear changes to reduce by-catch, limits on the number of permitted vessels in the fishery, and several closures and restricted areas (e.g., Essential Fish Habitat bottom trawl closures and the Rockfish Conservation Area). Fishing for rockfish is prohibited within the Rockfish Conservation Areas but recovery of over fished species is expected to take some time due to slow maturity rates for these species. Lingcod was previously declared overfished but is now recovered; harvest restrictions proved successful, as the rapid growth and maturity of this species resulted in more rapid population increases than the over-fished rockfish species. The prohibition of both bottom trawling and use of bottom contact gear in Essential Fish Habitat (EFH) Conservation Areas, which were designated in 2006 in some offshore areas, is expected to increase habitat protection (Figure 23). In response to dwindling groundfish populations and in an effort to protect groundfish habitat, a series of prohibitions, quotas, and gear restrictions have made it less profitable to trawl and the number of active trawlers has declined.

11. ***What is the status of non-indigenous species and how is it changing?*** A number of non-native species are present in the marine environment near Cordell Bank sanctuary, but none are known to currently exist in the sanctuary; however, there has not been a comprehensive inventory of species within the sanctuary. For this reason, this question is rated "undetermined" for both its status and trend. 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* species 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?*** Changes in oceanic conditions in recent years have altered productivity within the sanctuary, with changes in abundance and distribution of many taxa, including indicator species such as krill, blue whales and Cassin's Auklet. 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 most of these species and several of the indicator species that feed within the sanctuary exhibit healthy populations that are increasing. For these reasons, the status of key species is rated "fair" and "improving."

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:

- **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 (Schmieder 1991) reveal a biological assemblage very similar to that observed by sanctuary staff in 2005 (Cordell Bank sanctuary, unpubl. data).

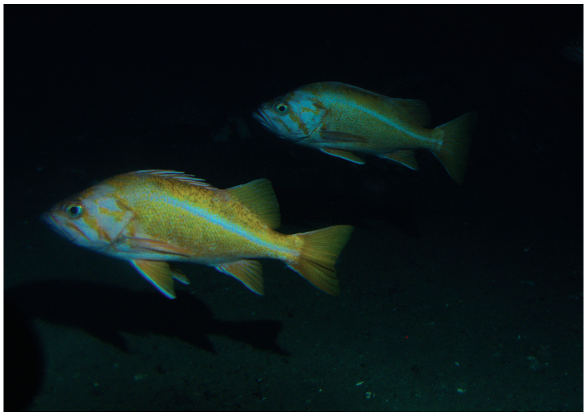


Figure 38. Canary rockfish are seen in deeper reef areas of the sanctuary.

- **Krill**: Krill are keystone species and large changes in population size are related to changing oceanic conditions. Reduced primary productivity in 2005 (Jahncke et al. 2008), 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 (Sydeman et al. 2006, Jahncke et al. 2008).

- **Rockfish**: Rockfish are the dominant group of fishes on Cordell Bank, and status varies by species. In the early 2000's, seven species of rockfish – widow (*Sebastes entomelas*), yelloweye (*S. ruberrimus*), canary (*S. pinniger*), darkblotched (*S. crameri*), bocaccio (*S. paucispinis*), cowcod (*S. levis*), and Pacific ocean perch (*S. alutus*) – were formally declared overfished throughout their range by the NOAA Fisheries; all but cowcod, Pacific ocean perch, and darkblotched rockfish are relatively common within the sanctuary (Anderson et al. in review) (Figure 38). 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 (Pacific Fishery Management Council 2006; Figure 36). Nevertheless, pelagic juvenile rockfish surveys in 2005 within the central and northern California region (Carmel to Bodega Bay) indicated an all time low in catch (for a 23 year data set) (Figure 37) and an apparent shift in distribution of fish both to the north and the south of the central California region (Peterson et al. 2006). There is also some indication that the general 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 of demersal fishes, pygmy rockfish were the most abundant rockfish observed (Anderson et al. 2007, in review).

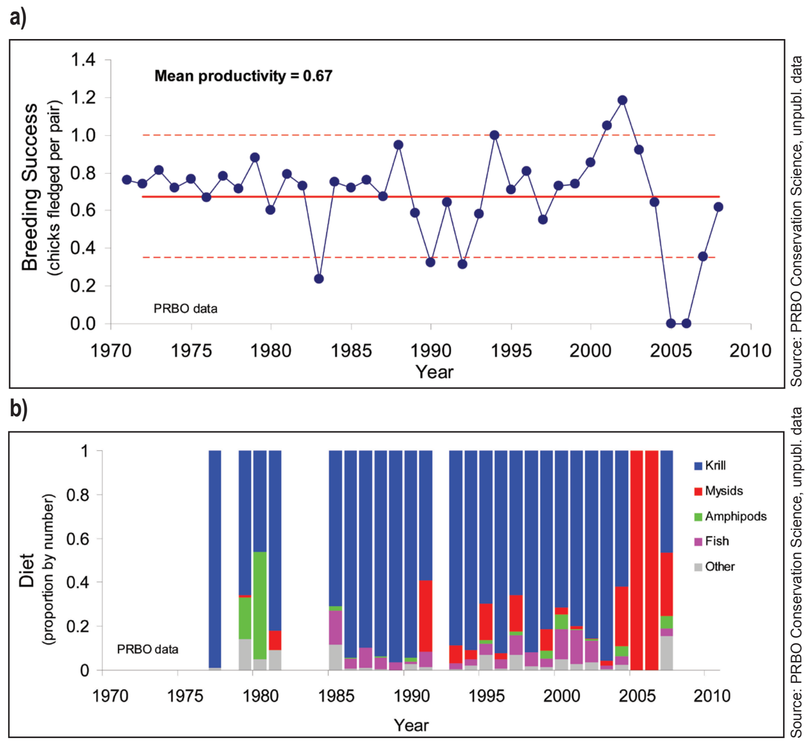


Figure 39. Breeding success (a) and diet (b) of Cassin's Auklets on Southeast Farallon Island, CA from 1970s-2007. Cassin's Auklets breeding on the Farallon Islands feed in the surrounding waters including Cordell Bank sanctuary, where they are one of the most abundant seabirds. Note the dramatic change in breeding success and diet in 2005 and 2006, a time period when upwelling was delayed and weak, causing changes in the abundance of krill, the auklets' primary prey.

- **Sea Turtles**: Between 1982 and 1996, the world population of leatherback sea turtles declined drastically, from 115,000 to 34,500 adult females (Spotila et al. 2000) and the population status is currently endangered. Much of the mortality occurs when eggs are harvested from beaches and adults are taken as bycatch in high seas fisheries. The northern California region, including the Cordell Bank sanctuary, is an important foraging area for adult leatherbacks in late summer and fall (Benson et al. 2007a). The occurrence of leatherbacks within the sanctuary is likely tied to changes in oceanic conditions and the availability of jellyfish (Benson et al. 2007a).

- **Cassin's Auklet**: Cassin's Auklets (*Ptychoramphus aleuticus*) nest on the Farallon Islands and use local sanctuary waters to feed (Jahncke et al. 2008, PRBO Conservation Science, unpubl. data, Cordell Bank sanctuary, unpubl. data), foraging primarily on krill. Abundance patterns of Cassin's Auklets from at-sea surveys in the central and northern California region (Monterey to Bodega Bay) indicate decreasing trends in abundance between the time periods of 1985-1994 and 1997-2006 (Ainley and Hyrenbach 2007). Further, complete reproductive failure of Cassin's Auklets on the Farallon Islands in 2005 and 2006 related to anomalous oceanic conditions and poor early season productivity (Figure 39, Sydeman et al. 2006, Peterson et al. 2006, Goericke et al. 2007, PRBO Conservation Science, unpubl. data) may have long term impacts; however, recent data suggest the population is rebounding (Figure 39; PRBO unpubl. data).

- **Black-footed Albatross**: Black-footed Albatrosses (*Diomedea nigripes*) nest on the northwestern Hawaiian Islands and are seasonally common and can be locally abundant within the sanctuary in the summer (NCCOS 2007, Cordell Bank sanctuary, unpubl. data, PRBO Conservation Science, unpubl. data). Analysis of nest count data of Black-footed Albatrosses from Midway, Laysan, and the French Frigate shoals indicated an increasing trend in breeding birds over the long time period (1922–2005), but a declining trend in the breeding population over the past 15 years (Naughton et al. 2007). Similarly, local patterns of Black-footed Albatross abundance in the central and northern California region (Monterey to Bodega Bay) from at-sea surveys indicate an average decrease in density of 18% between the time periods of 1985-1994 and 1997-2006, and overall cyclical trends in abundance (Ainley and Hyrenbach 2007). Populations are impacted by long-line mortality in areas outside of the sanctuary (Lewison and Crowder 2003), these impacts could eventually be observed at the Cordell Bank sanctuary. These albatrosses are also known to ingest and feed plastic to chicks, which can as a result die of starvation (Sievert and Sileo 1993, Gould et al. 1997). 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 (*Puffinus griseus*) are one of the most abundant seabirds in the sanctuary (Cordell Bank sanctuary, unpubl. data) as well as in the California Current Sys-

Figure 40. Sooty Shearwaters are one of the most abundant seabirds in the sanctuary.

tem during summer (Figure 40). Flocks with thousands of individuals pass through the sanctuary in summer and fall (NCCOS 2007, PRBO Conservation Science, unpubl. data, Cordell Bank sanctuary unpubl. data), 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). Local patterns of Sooty Shearwaters from at-surveys in the central and northern California region (Monterey to Bodega Bay) also indicate decreasing trends in abundance between the time periods of 1985-1994 and 1997-2006 (Ainley and Hyrenbach 2007).

- **California sea lion**: California sea lions (*Zalophus californianus*) are one of the most abundant pinnipeds found in the sanctuary, with highest abundance from summer through early spring (Cordell Bank sanctuary, unpubl. data) 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) decrease 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).

- **Humpback whale**: Cordell Bank and the other West Coast sanctuaries provide important foraging grounds for humpback whales (*Megaptera novaeangliae*), which are seasonally abundant, migrating into the sanctuary during late spring, summer and fall to feed in its productive waters (NCCOS 2007, PRBO Conservation Science, unpubl. data, Cordell Bank sanctuary, unpubl. data). 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).

- **Blue whale**: Cordell Bank and the other west coast sanctuaries provide important foraging grounds for migrating blue whales (Balaenoptera musculus) in summer and fall (NCCOS 2007). 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 (PRBO Conservation Science, unpubl. data, Cordell Bank sanctuary, unpubl. data) is probably a response to changing oceanic conditions and reduced krill abundance in the region during these years (Peterson et al. 2006). The population of the eastern north Pacific stock of blue whales appears to be growing (Carretta et al. 2007).

13. What is the condition or health of key species and how is it changing? The condition or health of key species in the sanctuary is rated as "good" and "not changing." Research conducted 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 (Scholin et al. 2000, Work et al. 1993). These events are often discovered when organisms wash up on beaches and have not been linked to the Cordell Bank sanctuary. The occurrence of domoic acid poisoning appears to be more prevalent in southern California, but events have occurred as close as Monterey Bay (Work et al. 1993).

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 (Sydeman et al. 2006), marine mammals and fishes. While these biological conditions are thought to be primarily a result of natural variations, the sanctuary is concerned that continued ocean warming, changes in upwelling timing and intensity, 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? The levels of human activities that may influence living resource quality in the offshore environment are rated "fair" and "improving." Specific activities that have the potential to influence living resource quality include fishing and associated habitat disturbance, vessel traffic (discharge, oil spills, noise, collision), and marine debris (derelict gear and plastics), all of which may influence living resource quality in the sanctuary. Fishing activity has been severely restricted to protect habitat and overfished rockfish populations (see Figure 23, page 18 in pressures section) and overall landings of various fisheries have declined in recent decades (Figure 21). Shipping activity remains constant, averaging about 2000 commercial vessels a year passing through the sanctuary (U.S. Coast Guard, unpubl. data). The amount of derelict fishing gear should not be increasing within the sanctuary, due to the current restrictions on bottom tending fishing activities. It is unknown how growth in the human population, especially in coastal areas, is impacting the levels of other marine debris types.

Living Resources Status & Trends

#	Status	Rating	Basis for Judgment	Description of Findings
9	Biodiversity	▲	Overharvest of some rockfish populations, but recent stock assessments suggest some overfished populations are increasing. Changes in abundance and distribution of many taxa linked to changing ocean conditions	Selected biodiversity loss has caused or is likely to cause severe declines in some, but not all ecosystem components, and reduce ecosystem integrity.
10	Sustainable Fishing	▲	Overfishing of some rockfish and prior fishing impacts; closures and gear restrictions appear to be effective	Extraction may inhibit full community development and function and may cause measurable but not severe degradation of ecosystem integrity.
11	Non-Indigenous Species	?	No known non-indigenous species; but data are sparse	N/A
12	Key Species	▲	Overharvest of some rockfish populations, but recent stock assessments suggest some overfished populations are increasing. Changes in abundance and distribution of many taxa linked to changing ocean conditions	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	Health of Key Species	–	Changes in condition appear to be caused by natural events	The condition of key resources appears to reflect pristine or near-pristine conditions.
14	Human Activities	▲	Influences on living resources include fishing and associated habitat disturbance, vessel traffic (discharge, noise, collision), and marine debris (derelict gear and plastics)	Selected activities have resulted in measurable living resource impacts, but evidence suggests effects are localized, not widespread.

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

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

Maritime Archaeological Resources

To date, there are no documented shipwrecks in the 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	Rating	Basis for Judgment	Description of Findings
15	Integrity	?	No documented underwater archaeological sites	N/A
16	Threat to Environment	?	No documented underwater archaeological sites	N/A
17	Human Activities	?	No documented underwater archaeological sites	N/A

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

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

Response to Pressures

This section describes current or proposed responses to pressures 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. The Pacific Fishery Management Council (PFMC) and NOAA Fisheries manage fisheries in federal waters (3 to 200 nautical miles from shore). Although the Cordell Bank National Marine 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 Office of National Marine Sanctuaries 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 sanctuary works closely with the Pacific Fisheries Management Council and NOAA Fisheries to address issues related to fishing impacts.

Fishing closures in the vicinity of the Cordell Bank sanctuary include both Rockfish Conservation Areas (RCA) and Essential Fish Habitat (EFH) conservation areas (see Figure 23, page 18 in pressures section). All EFH conservation area closures were put in place in 2006, while RCA closures varied in their initial implementation date, ranging between 2002 and 2005. These closures were implemented under the authority of the Magnuson-Stevens Fishery Conservation and Management Act. They are subject to periodic review and it is possible that these protections could be removed at some point in the future by a PFMC action. Representatives from the Office of National Marine Sanctuaries are members of the EFH Review Committee that evaluates proposals to modify EFH designations, areas, or gear types.

The Cordell Bank Final Management Plan includes five action plans that 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.

Pacific Fishery Management Council

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

Cordell Bank Final Management Plan

The Cordell Bank Final 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 plans describe regulations, boundaries, resource protection, research, and education programs to guide future management activities. They specify how sanctuaries can continue to conserve, protect, and enhance their nationally significant living and cultural resources.

- 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.

Cordell Bank sanctuary is working cooperatively with NOAA Fisheries law enforcement to increase enforcement of regulations that prohibit fishing activity in certain zones within the sanctuary. Methods of enforcement include a vessel monitoring system (More information can be found at: http://www.nmfs.noaa.gov/ole/vms.html) and aerial over flights in conjunction with United States Coast Guard.

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 management plan review process (Figure 41). Their 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/) (Scholz et al. 2005).

Cordell Bank sanctuary staff will continue monitoring fish and invertebrate assemblages in relation to the fine-scale habitat on and adjacent to Cordell Bank to assess changes in distribution and abundance of prominent taxa (Figures 42, 43). Monitoring work will also identify locations and severity of anthropogenic impacts, including derelict gear and other marine debris. In addition, the sanctuary management plan has made it a priority to assess the role of Cordell Bank in the supply and receipt of fish larvae within the regional marine ecosystem. Research activities linking population genetics and oceanography would broaden our understanding of the Cordell Bank fish community and the connections with regional populations.

Vessel Traffic

The Office of National Marine Sanctuaries 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,


Photo: Steve Howell, CBNMS

Figure 41. Bodega Harbor is the closest port to Cordell Bank sanctuary, and is used by both commercial and recreational fishermen.

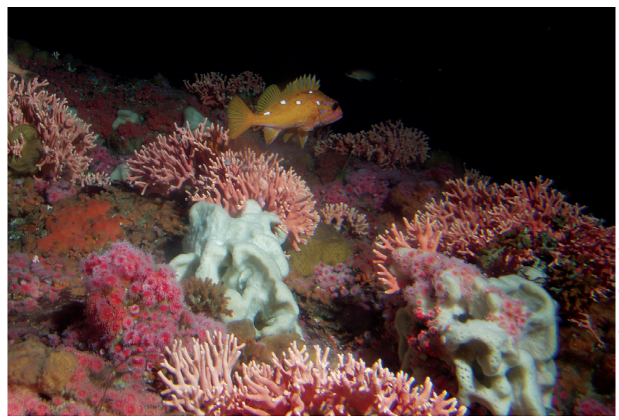


Photo: Rick Starr, CBNMS

Figure 42. Sensitive habitats on the reef crest of Cordell Bank. Prominent invertebrates found in these habitats include California hydrocoral (*Stylaster californicus*), strawberry anemone (*Corynactis californica*), and various sponges. Several rockfish species, such as this rosy rockfish (*Sebastes rosaceus*), are associated with these upper pinnacles of Cordell Bank.

Photo: Kip Evans

Figure 43. 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.

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 Office of National Marine Sanctuaries 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). 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 the spring of 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.

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.

Climate

Cordell Bank sanctuary is working jointly with Gulf of the Farallones sanctuary to develop a long-term climate change site scenario for the sanctuary. The primary purpose of this document is to gather and synthesize existing information on the main climate change impact drivers and the potential impacts to ecosystems, heritage/cultural resources, and communities relevant to the sanctuary. This document is the precursor and companion to a Climate Change Action Plan that will identify priority actions for the sanctuary to take to help address the impacts of climate change specific to the site, its communities, and the region. The site-specific climate change summary document and Climate Change Action Plan will be developed for all sites in the National Marine Sanctuary System.

The Office of National Marine Sanctuaries recognizes that our knowledge of the drivers and impacts of climate change is constantly growing and that some problems will be present at too large of a scale for Office of National Marine Sanctuaries to tackle alone. Although there may never be a complete suite of information to manage a protected area for climate change impacts, the Office of National Marine Sanctuaries has mandated responsibilities for protecting sanctuary resources. Ameliorating existing local and regional stressors and increasing the resilience of local and regional resources will be a most effective management response to climate change. We must therefore be proactive; the price—monetary and otherwise—of being reactive is too high. It is therefore the intent of the Office of National Marine Sanctuaries, using the best available science, expertise, tools, and authorities, to manage our sites to minimize, alleviate, and otherwise adapt to the impacts of climate change on sanctuary resources.

Photo: Peter Pyle, CBNMS

Figure 44. Floating marine debris is surveyed monthly to determine patterns of type, abundance, and seasonality.

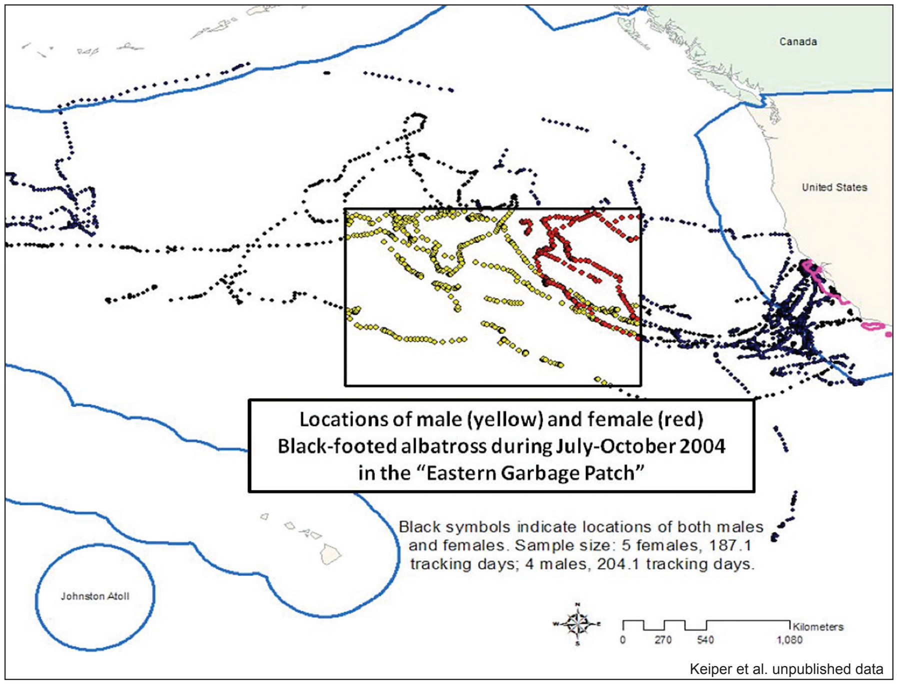
Marine Debris

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 44). 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.

Another activity outlined as a priority in the management plan is to expand Geographic Information System (GIS) databases to characterize benthic marine debris in the sanctuary. The 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.

In 2006, researchers completed high-resolution, bathymetric mapping of Cordell Bank that will enhance future research, monitoring and restoration efforts. 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 2008, sanctuary staff tested methods to remove entangled fishing gear from these deep water habitats using a remotely operated vehicle (ROV) (http://www.sanctuaries.noaa.gov/missions/2008cordellbank/) and have written up recommendations for procedures for deep water gear removal.



Source: Keiper et al. 2006

Figure 45. Hourly locations of 18 albatross that were tagged in Cordell Bank sanctuary and then tracked in 2004 and 2005. Black rectangles represent the approximate extent of the Eastern Garbage Patch. Blue lines represent the Exclusive Economic Zone (EEZ) boundaries; pink lines represent the boundaries of the three northern California National Marine Sanctuaries.

Cordell Bank National Marine 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 educate students about the diets of seabirds and the global problem of marine debris in the ocean. One educational tool used by sanctuary staff is the tracking data from Black-footed albatrosses tagged within Cordell Bank sanctuary, which can be examined to determine the potential consequences of albatrosses spending time in the 'Eastern Garbage Patch' (Figure 45). 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 46). In 2008, the sanctuary embarked on a new collaborative exhibit at the Oakland Museum of California, where environmental issues such as marine debris will be highlighted.

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 Cordell Bank may be incorporated into current benthic community transect surveys. Scientists at University of California-Davis Bodega Marine Laboratory have compiled a list of potential non-native species for the sanctuary

Photo: Jennifer Stock, CBNMS

Figure 46. Students learning about marine debris through dissection of albatross boluses.

based on data from nearshore areas north and south of Cordell Bank.

Researchers need to establish baseline information and monitor for new invasions to rapidly evaluate the most feasible and efficient methods of eradication, containment, or management of existing and future introduced species. It is necessary to identify the pathways by which new species are introduced into the sanctuary, and prioritize which pathways pose the greatest threat to sanctuary resources. This type of information is critical to minimizing the impact of introduced species and to implementing the protection of species and habitats threatened by introductions.

In the revised Cordell Bank National Marine Sanctuary management plan, a new regulation was established that prohibits 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 reflected in fairly good water and habitat quality ratings. However, the sanctuary is still susceptible to a number of human impacts including pollutants from land and ocean sources, overfishing, and habitat disturbance. All of these impacts have reduced, to some extent, the quality of some living resources within the sanctuary. 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. Much remains to be understood about the ecosystem of Cordell Bank sanctuary, and an increase in monitoring programs is needed in certain areas, particularly contaminants and non-native species. 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.

Acknowledgements

Cordell Bank National Marine Sanctuary would like to acknowledge the assistance of Clancy Environmental Consultants, Inc. who was instrumental in developing the template and initial content for this document and for providing edits and reviews under contract to NOAA. We appreciate the efforts of subject area experts who provided responses to questions that guided drafting of the "State of Sanctuary Resources" section of the report: Dr. John Largier (University of California-Davis, Bodega Marine Laboratory), Peter Pyle (Institute for Bird Populations), Dr. Steve Ralston (NOAA Fisheries, Southwest Fisheries Science Center) and Dale Roberts (Cordell Bank National Marine Sanctuary and Point Reyes National Seashore). We would also like to thank Megan Forbes (NOAA Marine Debris Program), Dr. Ian Hartwell (NOAA's National Status and Trends Program), and Dr. Karin Forney and Dr. Steve Ralston (NOAA Fisheries, Southwest Fisheries Science Center) for providing resources, comments and edits on sections of a preliminary draft of this report. We also thank Lorraine Anglin (Office of National Marine Sanctuaries West Coast Region) and Dr. Jennifer Brown (Monterey Bay National Marine Sanctuary) for reviewing a preliminary draft of this report. Our grateful thanks are also extended to the Influential Scientific Information reviewers of this document: Chris Caldow (NOAA's Center for Coastal Monitoring and Assessment), Dr. Lance Morgan (Marine Conservation Biology Institute), and Dr. William J. Sydeman (Farallon Institute for Advanced Ecosystem Research).

Cited Resources

Ainley, D.G. and K.D. Hyrenbach. 2007. Long- and short-term factors affecting seabird population trends in the California Current system 1985-2006. Report to Office of Spill Prevention and Response. Scientific Study and Evaluation Program. SSEP 2007-03. 36pp.

Allen,M.J. 2006. Continental shelf and upper slope. In: The Ecology of Marine Fishes: California and adjacent waters. L.G. Allen, D.J. Pondella II and M.H. Horn (Eds.). University of California Press.

Allen, L.G. and J.N. Cross. 2006. Surface Waters. In: The Ecology of Marine Fishes: California and adjacent waters. L.G. Allen, D.J. Pondella II and M.H. Horn (Eds.). University of California Press.

Anderson, T.J., D.A. Roberts and D. Howard. 2007. The distribution, abundance, and habitat relationships of deep-water demersal fishes in the Cordell Bank National Marine Sanctuary (CBNMS), USA: Abstract #019. pp. 222-223. In: First International Marine Protected Areas Congress, 23-27 October 2005, Conference Proceedings: IMPAC1 2005, Geelong, Victoria, Australia. 665 pp.

Anderson, T.J., D.A. Roberts, C. Syms, and D.F. Howard. In Review. Multi-scale fish-habitat associations and the use of habitat surrogates to predict the organization and abundance of deep-water fish assemblages. Submitted to Journal of Experimental Marine Biology and Ecology.

Angermeier, P.L. and J.R. Karr, 1994. Biological integrity versus biological diversity as policy directives: Protecting biotic resources. BioScience 44:690-697.

Barnes, P.W. and J.P. Thomas, editors. 2005. Benthic habitats and the effects of fishing. American Fisheries Society, Symposium 41, Bethesda, Maryland.

Baskett, M, M. Yoklavich and M. Love. 2006. Predation, competition, and the recovery of overexploited fish stocks in marine reserves. Canadian Journal of Fisheries and Aquatic Science 63:1214-1229.

Benson, S.R., K.A. Forney, J.T. Harvey, J.V. Carretta, P.H. Dutton. 2007a. Abundance, distribution, and habitat of leatherback turtles (*Dermochelys coriacea*) off California, 1990-2003. Fishery Bulletin 105:337-347.

Benson, S.R., P.H. Dutton, C. Hitipeuw, B. Samber, J. Bakarbessy, and D. Parker. 2007b. Post-nesting migrations of leatherback turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's head Peninsula, Indonesia. Chelonian Conservation Biology 6(1):150-154.

Bullard, S.G., G. Lambert, M.R. Carman, J. Byrnes, R.B. Whitlatch, G. Ruiz, R.J. Miller, L. Harris, P.C. Valentine, J.S. Collie, J. Pederson, D.C. McNaught, A.N. Cohen, R.G. Asch, J. Dijkstra and K. Heinonen. 2007. The colonial ascidian *Didemnum sp*. A: current distribution, basic biology and potential threat to marine communities of the Northeast and West coasts of North America. Journal of Experimental Biology and Ecology 342:99-108.

Byrnes, J. E., P.L. Reynolds and J.L. Stachowicz. 2007. Invasions and extinctions reshape coastal marine food webs. PLoS ONE 2(3): e295. doi:10.1371/journal.pone.0000295.

Byrnes, J.E. Unpublished data. List of nonindigenous species of Gulf of the Farallones and Cordell Bank national marine sanctuaries. University of California, Davis, CA.

California Department of Health Services. Monthly Marine Biotoxin Technical Reports. Electronic document available from: http://www.cdph.ca.gov/healthinfo/environhealth/water/Pages/Shellfish.aspx

California Environmental Protection Agency. 2003. Regulation of Large Passenger Vessels in California - Report to the Legislature. Prepared by Cruise Ship Environmental Task Force of State Water Resources Control Board. 99pp. Electronic document available from: http://www.waterboards.ca.gov/publications_forms/publications/legislative/2003.shtml

Carretta, J.V., K.A. Forney, M.M. Muto, J. Barlow, J. Baker, B. Hanson and M.S. Lowry. 2007. U.S. Pacific marine mammal stock assessments: 2006. NOAA Technical Memorandum NMFS. NOAA-TM-NMFS-SWFSC-398 32 pp.

Chavez, F.P., J. Ryan, S.E. Lluch-Cota and M. Niquen. 2003. From anchovies to sardines and back: multidecadal change in the Pacific Ocean. Science 299: 217-221.

Cordell Bank sanctuary. Unpublished data. Cordell Bank Ocean Monitoring Program, 2004-present. Cordell Bank National Marine Sanctuary, Olema, CA. Electronic document available from: http://sanctuarysimon.org/cordell/sections/oceanography/project_info.php?projectID=84&sec=o

Cordell Bank sanctuary. Unpublished data. Benthic biological characterization and monitoring on Cordell Bank using Delta submersible, 2001-2005. Cordell Bank National Marine Sanctuary, Olema, CA. Electronic document available from: http://sanctuarysimon.org/cordell/sections/fisheries/project_info.php?projectID=88&sec=f

Cordell Bank sanctuary. Unpublished data. Derelict fishing gear on Cordell Bank. Cordell Bank National Marine Sanctuary, Olema, CA. Electronic document available from: http://sanctuaries.noaa.gov/missions/2008cordellbank/

deRivera C.E., G.M. Ruiz, J.A. Crooks, K. Wasson, S.I. Longhart, P. Fofonoff, B.P. Steves, S.S. Rumrill, M.S. Brancato, W.S. Pegau, D.A. Bulthuis, R.K. Preisler, G.C. Schoch, E. Bowlby, A. Devogelaere, M.K. Crawford, S.R. Gittings, A.H. Hines, L. Takata, K. Larson, T. Huber, A.M. Leyman and E. Collinetti, T. Pasco, S. Shull, M. Anderson, S. Powell. 2005. Broad-scale nonindigenous species monitoring along the West Coast in national marine sanctuaries and national estuarine research reserves. Report to the National Fish & Wildlife Foundation. 125 pp.

Eldridge, M.B. 1994. Hook-and-line fishing study at Cordell Bank, California, 1986-1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-197 24 pp.

Feely, R.A., C.L. Sabine, K. Lee, W. Berelson, J. Kleypas, V.J. Fabry, F.J. Millero. 2004. Impact of anthropogenic CO_2 on the CaCO3 system in the oceans. Science 305:362-366.

Feely, R.A., C.L. Sabine, J.M. Hernandez-Ayon, D. Lanson, B. Hales. 2008. Evidence for upwelling of corrosive "acidified" water onto the continental shelf. Science 320:1490-1492.

Field, J.C., K. Baltz, A.J. Phillips and W.A. Walker. 2007. Range expansion and trophic interactions of the jumbo squid, *Dosidicus gigas*, in the California Current. CalCOFI Reports.

Final Environmental Impact Statement. 2008. Cordell Bank, Gulf of the Farallones, and Monterey Bay National Marine Sanctuaries. Prepared as part of the joint management plan review (JMPR). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, National Marine Sanctuary Program.

Ford, R.G., D.G. Ainley, J.L. Casey, C.A. Keiper, L.B. Spear and L.T. Balance. 2004. The biogeographic patterns of seabirds in the central portion of the California current. Marine Ornithology 32: 77-96.

Forney, K.A., S.R. Benson, G.A. Cameron. 2001. Central California gillnet effort and bycatch of sensitive species, 1990-1998. In: E.F. Melvin and J.K. Parrish (eds.) Seabird bycatch: trends, roadblocks, and solutions. University of Alaska Sea Grant, Fairbanks, Alaska. pp 141-160.

Goericke, R., E. Venrick, T. Koslow, W.J. Sydeman, F.B. Schwing, S.J. Bograd, W.T. Peterson, R. Emmett, J. Ruben Lara Lara, G. Gaxiola Castro, J. Gomez Valdex, K. David Hyrenbach, R.W. Bradley, M.J. Weise, J.T. Harvey, C. Collins, N.C.H. Lo. 2007. The State of the California Current, 2006-2007: Regional and local processes dominate. California Cooperative Oceanic Fisheries Investigations. Vo. 48. pp. 33-66.

Gould, P. J., P. Ostrom, W. Walker, and K. Pilichowski. 1997. Laysan and black-footed albatrosses: Trophic relationships and driftnet fisheries associations of non-breeding birds. Pp 199–207. In R. Robertson and R. Gales (eds.), Albatross Biology and Conservation. Surrey Beatty & Sons, Chipping Norton, Australia.

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.

Hartwell, S.I. 2008. Distribution of DDT and other persistent organic contaminants in Canyons and on the continental shelf off the central California coast. Marine Environmental Research 65:199-217.

Hartwell, I. Unpublished data. Contaminants in sediments of the central California continental shelf and slope. NOAA, NCCOS, Center for Coastal Monitoring and Assessment, Silver Spring, MD.

Hyrenbach K.D., C. Keiper, S.G. Allen, D.G. Ainley, and D.J. Anderson. 2006. Use of marine sanctuaries by far-ranging predators: commuting flights to the California Current System by breeding Hawaiian albatrosses. Fisheries Oceanography 15 (2): 95-103.

Hyrenbach, D. Unpublished data. Hawaii Pacific University, Kaneohe, HI.

Jahncke, J., B.L. Saenz, C.L. Abraham, C. Rintoul, R.W. Bradley, W.J. Sydeman. 2008. Ecosystem responses to short-term climate variability in the Gulf of the Farallones, California. Progress in Oceanography 77:182-193.

Keiper, C.A., Nevins,H., Hyrenbach, K.D., Hester M.M., Baudini, C.L., Adams, J., Moore, C., Stock, J., and Webb, S. 2006. Tracking albatross and trash across borders: A tool for integrated ocean, coastal, and watershed conservation. Poster presentation. Society for Conservation Biology Meeting, San Jose, CA.

Lagardere, J.P. 1982. Effects of noise on growth and reproduction of Crangon crangon in rearing tanks. Marine Biology 71(2):177-185.

Largier, J.L., C.A. Lawrence, M. Roughan, D.M. Kaplan, E.P. Dever, C.E. Dorman, R.M. Kudela, S.M. Bollens, F.P. Wilkerson, R.C. Dugdale, L.W. Botsford, N. Garfield, B. Kuebel Cervantes and D. Koracin. 2006. WEST: A northern California study of the role of wind-driven transport in the productivity of coastal plankton communities. Deep-Sea Research II 53:2833-2849.

Levitus S., Antonov J.I., Boyer T.P. and Stephens C. 2000. Warming of the world ocean. Science 287: 2225-2229.

Lewison, R.L. and L.B. Crowder. 2003. Estimating fishery bycatch and effects on a vulnerable seabird population. Ecological Applications 13: 743-753.

Lowry, M.S. and K.A. Forney. 2005. Abundance and distribution of California sea lions (*Zaolphus californianus*) in central and northern California during 1998 and summer 1999. Fishery Bulletin 103:331-343.

Meyers, D. 2005. National marine sanctuary program regional water quality program – West coast sanctuary sites: framework for water quality program development at west coast sanctuary sites. 18 pp.

National Research Council. 2003. Ocean noise and marine mammals. National Academy Press: Washington, D.C. 204pp.

Naughton, M. B, M. D. Romano, T. S. Zimmerman. 2007. A Conservation Action Plan for Black-footed Albatross (*Phoebastria nigripes*) and Laysan Albatross (*P. immutabilis*), Ver. 1.0.

NCCOS (NOAA National Centers for Coastal Ocean Science). 2007. A Biogeographic Assessment off North/Central California: In support of the National Marine Sanctuaries of Cordell Bank, Gulf of the Farallones and Monterey Bay. Phase II – Environmental Setting and Update to Marine Birds and Mammals. Prepared by NCCOS's Biogeography Branch, R.G. Ford Consulting Co. and Oikonos Ecosystem Knowledge, in cooperation with the National Marine Sanctuary Program. Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 40, 302 pp.

Nevins, H., D. Hyrenbach, C. Keiper, J. Stock, M. Hester and J. Harvey. 2005. Seabirds as indicators of plastic pollution in the North Pacific. Plastic Debris Rivers to the Sea Conference 2005, Redondo Beach, CA, September 7-9, 2005.

NMSP (National Marine Sanctuary Program). 2004. A monitoring framework for the National Marine Sanctuary System. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. Silver Spring, MD. 22 pp. Electronic document available from: http://sanctuaries.noaa.gov/library/alldocs.html

NOAA Fisheries. Unpublished data. NOAA Fisheries triennial bottom trawl survey, 1974-2000. Seattle, WA.

NRC (National Research Council). 2005. Marine mammal populations and ocean noise: determining when noise causes biologically significant effects. Committee on characterizing biologically significant marine mammal behavior. National Academies Press, Washington, DC. 142 pp.

Oiled Wildlife Care Network. Unpublished data. Live and dead birds collected Cosco Busan Spill, San Francisco Bay, November 2007. Davis, CA. Electronic document available from: http://www.vetmed.ucdavis.edu/owcn/cosco-busan.html

Okihiro, M.S., J.A. Whipple, J.M. Groff and D.E. Hinton. 1992. Chromatophoromas and related hyperplastic lesions in Pacific rockfish (*Sebastes spp*). Marine Environmental Research 34 (1-4):53-57.

Pacific Fishery Management Council. 2006. Proposed Acceptable Biological Catch and Optimum Yield Specifications and Management Measures for the 2007-2008 Pacific Coast Groundfish Fishery and Amendment 16-4: Rebuilding Plans for Seven Depleted Groundfish Species. Final Environmental Impact Statement, Pacific Fishery Management Council, 7700 NE Ambassador Pl., Suite 200, Portland, OR 97220, 695 p.

Peterson, W.T., R. Emmett, R. Goericke, E. Venrick, A. Mantyla, S.J. Bograd, F. Schwing, R. Hewitt, N. Lo, W. Watson, J. Barlow, M. Lowry, S. Ralston, K.A. Forney, B.E. Lavaniegos, W.J. Sydeman, K.D. Hyrenbach, R.W. Bradley, P. Warzybok, F. Chavez, K. Hunter, S. Benson, M. Weise, J. Harvey, G. Gaxiola-Castro and R. Durazo. 2006. The state of the California Current, 2005-2006: Warm in the North, cool in the South. California Cooperative Oceanic Fisheries Investigations. Vo. 47. pp. 30-74.

PRBO Conservation Science. Unpublished data. Breeding seabird data from Southeast Farallon Island. Petaluma, CA. Electronic document available from: http://www.prbo.org/cms/index.php

PRBO Conservation Science. Unpublished data. Seabird, marine mammal, zooplankton, and oceanographic data from at-sea surveys in Gulf of the Farallones and Cordell Bank. Petaluma, CA. Electronic document available from: http://sanctuarysimon.org/cordell/sections/birds/project_info.php?projectID=90&sec=ss

Ralston, S. 2002. West coast groundfish harvest policy. North American Journal of Fisheries Management 22:249-250.

Ralston, S. 2003. West coast groundfish: the rockfish problem. In: G. M. Watters (ed.), Proceedings of the NMFS Workshop on Building Environmentally Explicit Stock Assessments, Pacific Fisheries Environmental Laboratory, SWFSC, Pacific Grove, CA.

Ralston S. Unpublished data. Juvenile rockfish (*Sebastes spp*) midwater trawl surveys, 1983 to present. NOAA Fisheries, Santa Cruz Laboratory, Santa Cruz, CA. Electronic document available from: http://sanctuarysimon.org/cordell/sections/fisheries/project_info.php?projectID=100118&sec=f

Read, A.J., P. Drinker, S. Northridge. 2006. Bycatch of marine mammals in U.S. and global fisheries. Conservation Biology 20(1):163-169.

Rommel, S.A., A.M. Costidis, A. Fernandez, P.D. Jepson, D.A. Pabst, W.A. McLellan, D.S. Houser, T.W. Cranford, A.L. van Helden, D.M. Allen, and N.B. Barros. 2006. Elements of beaked whale anatomy and diving physiology and some hypothetical causes of sonar-related stranding. Journal of Cetacean Research and Management 7(3): 189-209.

Schmieder, R.W. 1991. Ecology of an Underwater Island. Cordell Expeditions, Walnut Creek, CA. 98 pp.

Scholin, C.A., F. Gulland, G.J. Doucette, S. Benson, M. Busman, F.P. Chavez, J. Cordaro, R. DeLong, A. De Vogelaere, J. Harvey, M. Haulena, K. Lefebvre, T. Lipscomb, S. Loscutoff, L.J. Lowenstine, R. Marin III, P.E. Miller, W.A. McLellan, P.D.R. Moeller, C.L. Powell, T. Rowles, P. Silvagni, M. Silver, T. Spraker, V. Trainer, and F.M. Van Dolah. 2000. Mortality of sea lions along the central California coast linked to a toxic diatom bloom. Nature 403:80-84.

Scholz, A., C. Steinback, S. Klain, and A. Boone. 2005. Socioeconomic profile of fishing activities and communities associated with the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries. 122 pp.

Sievert, P. R., and L. Sileo. 1993. The effects of ingested plastic on growth and survival of albatross chicks, Pp. 212–217. In K. Vermeer, K. T. Briggs, K. H. Morgan, and D. Siegal-Causey (eds.). The status, ecology, and conservation of marine birds of the North Pacific. Canadian Wildlife Service Special Publication, Ottawa, Canada.

Spotila, J.R., R.D. Reina, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 2000. Pacific leatherback turtles face extinction. Nature 405:529-530.

Stallcup, R. 2004. The Amazing Seabirds of Cordell Bank National Marine Sanctuary. 28 pp.

Stumpf, R., S. Dunham, L. Ojanen, A. Richardson, T. Wynne and K. Holderied. 2005. Characterization and monitoring of temperature, chlorophyll, and light availability patterns in National Marine Sanctuary Waters: Final Report. NOAA Technical Memorandum NOS NCCOS 13. NOAA/NOA/NCCOS/CCMA, Silver Spring, MD. 48pp.

Sydeman, W.J., R.W. Bradley, P. Warzybok, C.L. Abraham, J. Jahncke, K.D. Hyrenbach, V. Kousky, J.M. Hipfner, and M.D. Ohman. 2006. Planktivorous auklet Ptychoramphus aleuticus responses to ocean climate, 2005: Unusual atmospheric blocking? Geophysical Research Letters 33:L22S09, doi:10.1029/2006GL026736, 2006.

Tomas, J., R. Guitart, R. Mateo and J.A. Raga. 2002. Marine debris ingestion by loggerhead sea turtles, Caretta caretta, from the Western Mediterranean. Marine Pollution Bulletin 44: 211-216.

U.S. Coast Guard. Unpublished data. Automatic Identification System, Vessel Tracking Service. Yerba Buena Island, California; U.S. Coast Guard Research and Development Lab, Groton, Connecticut

U.S. Dept. of Commerce and U. S. Navy. 1999. Turning to the Sea: America's Ocean Future. 56 pp.

U.S. Fish and Wildlife Service. 2006. Alaska Seabird Information Series – Sooty Shearwater. 2pp.

Wallace, N. 1985. Debris entanglement in the marine environment. A review. pp. 259-277 In: R.S. Shomura, H.O. Yoshida (eds.) Proceedings of the Workshop on the Fate and Impact of Marine Debris. NOAA Technical Memorandum. NMFS, NOAA.

Work, T. M, A.M. Beale, L. Fritz, M.A. Quilliam, M. Silver, K. Buck, J.L.C. Wright. 1993. Epidemiology of domoic acid poisoning in brown pelicans (*Pelicanus occidentalis*) and Brandt's cormorants (*Phalacrocorax penicillatus*) in California. Journal of Zoo and Wildlife Medicine 24: 5-62.

Zeidberg, L.D. and B.H. Robison. 2007. Invasive range expansion by the Humboldt squid, *Dosidicus gigas*, in the eastern North Pacific. Proceedings of the National Academy of Sciences 104:12948-12950.

Additional Resources

Bodega Marine Laboratory, University of California – Davis: http://www-bml.ucdavis.edu

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

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

Cordell Bank National Marine Sanctuary: http://cordellbank.noaa.gov

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

Ecotrust Web site, Joint management plan review: http://www.ecotrust.org/jmpr

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

Marine Protected Areas of the United States: http://www.mpa.gov

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

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

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

NOAA Fisheries: http://www.nmfs.noaa.gov

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

NOAA's NCCOS Center for Coastal Monitoring and Assessment: http://ccma.nos.noaa.gov

NOAA's NCCOS Center for Coastal Monitoring and Assessment Web site, A biogeographic assessment off North/Central California: http://ccma.nos.noaa.gov/products/biogeography/canms_cd/welcome.html

NOAA's Ocean Explorer: http://www.oceanexplorer.noaa.gov/welcome.html

Oiled Wildlife Care Network: http://www.vetmed.ucdavis.edu/owcn

PRBO Conservation Science: http://www.prbo.org/cms/index.php

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

Seafloor Mapping Laboratory at California State University Monterey Bay: http://seafloor.csumb.edu/index.html

Seafloor Mapping Laboratory at California State University Monterey Bay, data library: http://seafloor.csumb.edu/SFMLwebDATA.htm

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

Appendix A: Rating Scheme for System-Wide Monitoring Questions

The purpose of this appendix is to clarify the 17 questions and possible responses used to report the condition of sanctuary resources in "Condition Reports" for all national marine sanctuaries. Individual staff and partners utilized this guidance, as well as their own informed and detailed understanding of the site to make judgments about the status and trends of sanctuary resources. The questions derive from the National Marine Sanctuary System's mission, and a system-wide monitoring framework (National NMSP 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on and study the ecosystems encompassed by the sanctuaries. They are being used to guide staff and partners at each of the 14 sites in the sanctuary system in the development of this first periodic sanctuary condition report. Evaluations of status and trends may be based on interpretation of quantitative and, when necessary, non-quantitative assessments and observations of scientists, managers and users.

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.

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

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

Water Stressors

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

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

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

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

Water Eutrophic Condition

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

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

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

Water Human Health

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

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

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

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

Water Human Activities

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

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

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

Habitat Abundance & Distribution

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

Habitat loss is of paramount concern when it comes to protecting marine and terrestrial ecosystems. Of greatest concern to sanctuaries are changes caused, either directly or indirectly, by human activities. The loss of shoreline is recognized as a problem indirectly caused by human activities. Habitats with submerged aquatic vegetation are often altered by changes in water conditions in estuaries, bays, and nearshore waters. Intertidal zones can be affected for long periods by spills or by chronic pollutant exposure. Beaches and haul-out areas can be littered with dangerous marine debris, as can the water column or benthic habitats. Sandy subtidal areas and 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.

Habitat Structure

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

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

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

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

Habitat Contaminants

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

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

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

Habitat
Human Activities

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

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

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

Living Resources
Biodiversity

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

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

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

Living Resources
Extracted Species

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

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

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

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

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

Living Resources
Non-Indigenous Species

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

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

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

Living Resources Key Species

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

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

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

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

Living Resources Health of Key Species

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

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

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

Living Resources
Human Activities

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

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

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

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

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

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

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

Maritime Archaeological Resources Integrity

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

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

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

Maritime Archaeological Resources Threat to Environment

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

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

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

Maritime Archaeological Resources Human Activities

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

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

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

Appendix B: Consultation with Experts and Document Review

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

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

In order to address the 17 questions, sanctuary staff selected and consulted outside experts familiar with water quality, living resources, habitat, and maritime archaeological resources. Phone calls and one-on-one meetings were convened where experts participated in discussions with sanctuary staff about each of the 17 questions. Experts represented various affiliations including University of California-Davis Bodega Marine Laboratory, NOAA Fisheries Southwest Fisheries Science Center, Institute for Bird Populations, and Point Reyes National Seashore. During each consultation, experts were introduced to the questions and asked to provide recommendations and supporting arguments for their suggested rating. The ratings and text found in the report are intended to summarize the opinions and uncertainty expressed by the experts, who based their input on knowledge and perceptions of local conditions. Comments and citations received from the experts were included, as appropriate, in text supporting the ratings.

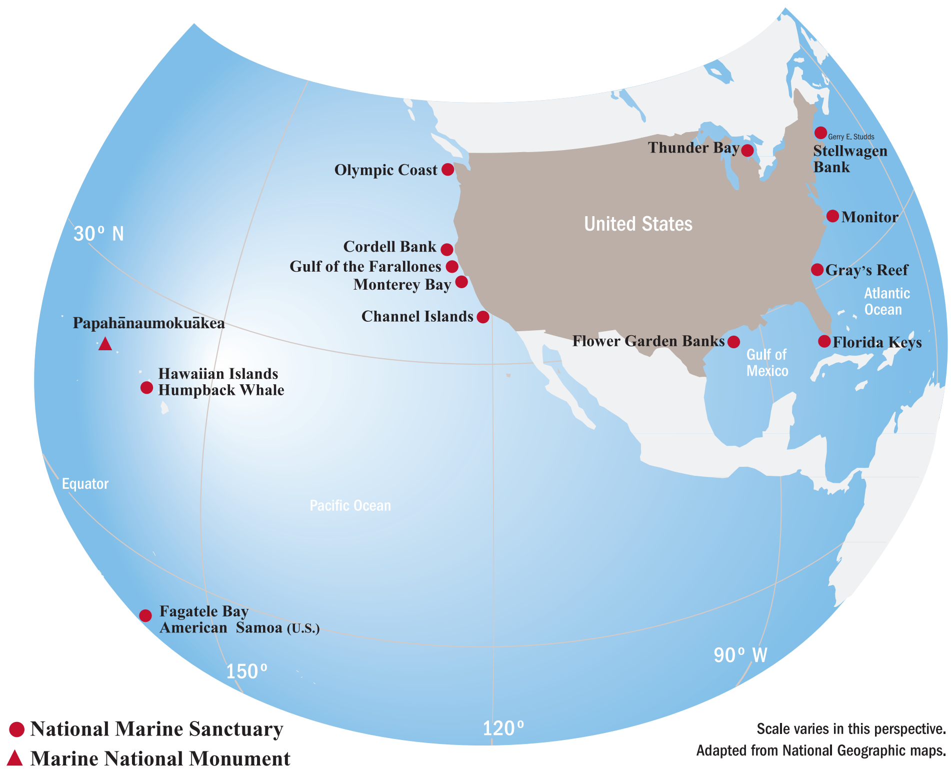
The first draft of the document was sent to various subject matter experts and important partners in research and resource management for what was called an Invited Review. Individuals included representatives from the Monterey Bay National Marine Sanctuary, NOAA's Marine Debris Program, NOAA's National Status and Trends Program, NOAA Fisheries, and the Office of National Marine Sanctuaries West Coast Region. Review was also requested from stakeholder representatives on the Cordell Bank Sanctuary Advisory Council. These bodies were asked to review the technical merits of resource ratings and accompanying text, as well as to point out any omissions or factual errors. The comments and recommendations of invited reviewers were received, considered by sanctuary staff, and incorporated, as appropriate, into a final draft document.

A draft final report was then sent to Chris Caldow (NOAA's Center for Coastal Monitoring and Assessment), Dr. Lance Morgan, (Marine Conservation Biology Institute), and Dr. William J Sydeman (Farallon Institute for Advanced Ecosystem Research) who served as external peer reviewers. This External Peer Review is a requirement that started in December 2004, when the White House Office of Management and Budget (OMB) issued a Final Information Quality Bulletin for Peer Review (OMB Bulletin) establishing peer review standards that would enhance the quality and credibility of the federal government's scientific information. Along with other information, these standards apply to Influential Scientific Information, which is information that can reasonably be determined to have a "clear and substantial impact on important public policies or private sector decisions." The Condition Reports are considered Influential Scientific Information. For this reason, these reports are subject to the review requirements of both the Information Quality Act and the OMB Bulletin guidelines. Therefore, following the completion of every condition report, they are reviewed by a minimum of three individuals who are considered to be experts in their field, were not involved in the development of the report, and are not Office of National Marine Sanctuaries employees. Comments from these peer reviews were incorporated into the final text of the report. Furthermore, OMB Bulletin guidelines require that reviewer comments, names, and affiliations be posted on the agency website: http://www.osec.doc.gov/cio/oipr/pr_plans.htm. Reviewer comments, however, are not attributed to specific individuals. Reviewer comments are posted at the same time as with the formatted final document. Following the External Peer Review the comments and recommendations of the reviewers were considered by sanctuary staff and incorporated, as appropriate, into a final draft document. In some cases sanctuary staff reevaluated the status and trend ratings and when appropriate, the accompanying text in the document was edited to reflect the new ratings.

Notes

THE NATIONAL MARINE SANCTUARY SYSTEM

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



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

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

National Marine Sanctuaries