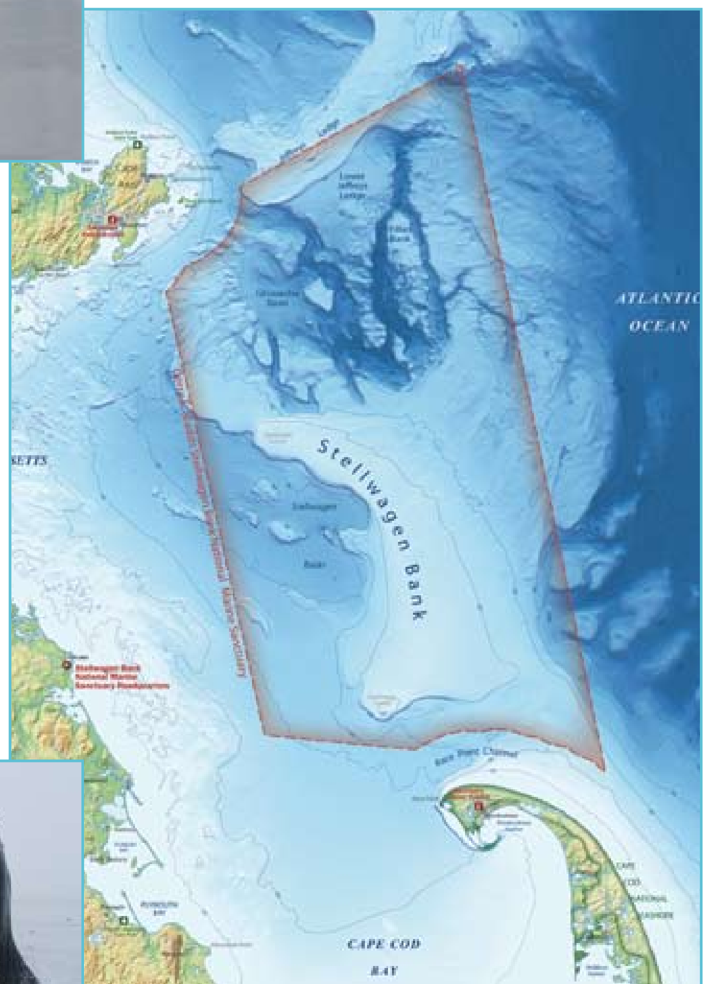
Gerry E. Studds
Stellwagen Bank
National Marine Sanctuary

CONDITION REPORT 2007





NATIONAL MARINE SANCTUARIES

April 2007

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Henry S. Stellwagen: *Courtesy of Stellwagen family (Stellwagen Bank sanctuary file photo)*

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Map: *Bathymetric data used to create the Stellwagen Bank National Marine Sanctuary map is a combined data set that includes hydrographic survey data and derived products collected and created by the U.S. Geological Survey (USGS) and National Oceanic & Atmospheric Administration (NOAA) offices listed here:*

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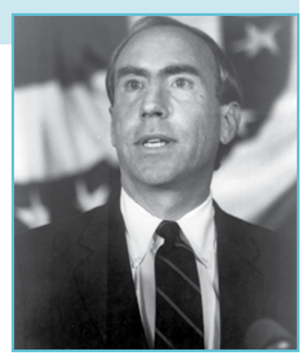
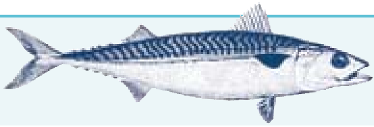
In Memoriam



The Honorable Gerry E. Studds (1937-2006) served the citizens of the Commonwealth of Massachusetts and the nation as a congressman for 12 terms, writing or co-sponsoring many major pieces of marine and environmental legislation. After he announced his retirement in 1996 his peers in Congress recognized his dedicated service by renaming Stellwagen Bank National Marine Sanctuary in his honor.



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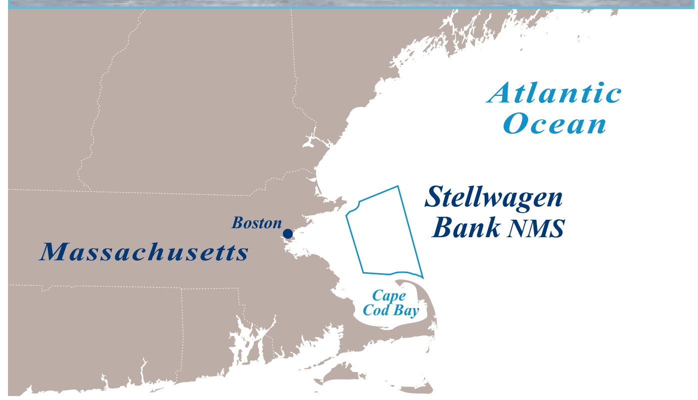
Stellwagen Bank National Marine Sanctuary serves as a critical feeding ground for endangered whales such as humpbacks shown here lunge feeding. *Photo: NOAA/Stellwagen Bank*



Abstract

Stellwagen Bank National Marine Sanctuary contains one of the richest and most productive marine habitats in the U.S. It is home to a diverse fish community and serves as one of the most important feeding grounds in the North Atlantic for a number of migratory endangered whale species as well as some apex fish predators such as bluefin tuna and sharks. Located just offshore of the Boston metropolis of 4.8 million people, the sanctuary is subject to intense human use that includes whale watching, commercial and recreational fishing, vessel traffic, and nearby sewage and other material disposal. It may also soon be adjacent to a deepwater port for the transfer of liquefied natural gas, an activity that could pose additional hazards.

Despite these activities, most water quality parameters at Stellwagen Bank sanctuary appear to suggest relatively good conditions. For example, though numerous contaminants have been identified, they appear at levels that are not likely to affect sanctuary resources. Habitat quality, on the other hand, has deteriorated over many years, primarily as a result of long-term use of bottom dragging gear to catch fish. Fishing restrictions in some areas have led to improvements in habitat quality, and it is hoped that this will continue. Living resource conditions have followed trends similar to those of habitats, and are generally considered to be in fair or fair-to-poor condition. And while the abundance and diversity of bottom dwelling communities may improve with fishing restrictions, surface dwelling marine mammals are at considerable risk from strikes by increasing vessel traffic in New England, from entanglement from lines attached to fishing gear, and noise disturbance from increasing vessel traffic. The principal threat to maritime archaeological resources in the sanctuary comes from contact by bottom fishing gear. An additional concern regarding these historical sites is the fact that once damaged, there is no potential for recovery, as there is for water, habitat, and living resources.

The new management plan for Stellwagen Bank sanctuary is scheduled for release in the summer of 2007. It recommends a number of management actions that will address these concerns. The plan stresses an ecosystem-based approach to management that requires consideration of ecological interrelationships not only within the sanctuary, but within the larger context of the Gulf of Maine ecosystem. It also points to the need for an increased level of cooperation with other management agencies in the region. Specific management recommendations include an improved water quality monitoring program, actions to reduce vessel discharges, actions to reduce the number of vessel strikes on whales and the number of entangled whales, investigations of noise sources and impacts; and management of maritime archaeological resources.

Stellwagen Bank National Marine Sanctuary

- *2180 square kilometers (638 square nautical miles)*
- *Stellwagen Bank was first mapped in its entirety in 1854 and originally noted for its importance in navigation*
- *Congressionally designated in 1992 as a national marine sanctuary*
- *Complex system of midwater and benthic habitats that support a wealth of marine wildlife*
- *Seventeen species of cetaceans are known to frequent the sanctuary, including humpback whales (Megaptera novaeangliae)*
- *Numerous shipwrecks*
- *Continued use for commerce and recreation, such as shipping, fishing and whale watching.*

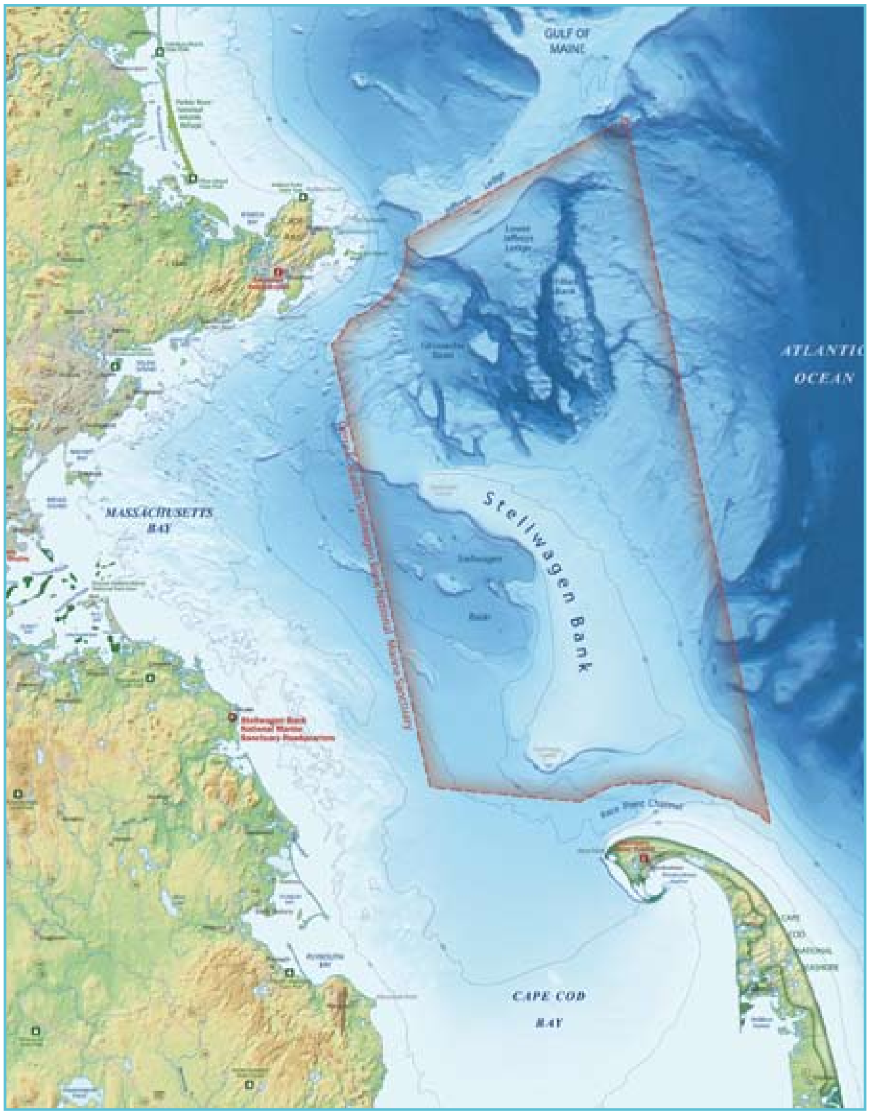
Stellwagen Bank National Marine Sanctuary Condition Summary Table

Condition Summary: The results in the following table are a compilation of findings from the "State of Sanctuary Resources" section of this report. (For further clarification of the questions posed in the table, see Appendix A.)

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

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

#	Questions/Resources	Rating	Basis for Judgement	Description of Findings	Sanctuary Response
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?	Good/Fair —	Numerous contaminants at low levels	Selected conditions may preclude full development of living resource assemblages and habitats, but are not likely to cause substantial or persistent declines.	Regulations specify allowable discharges and prohibit lightering; draft management plan increases focus on water quality monitoring, ballast water management, and contingency planning (pages 19-20).
2	What is the eutrophic condition of sanctuary waters and how is it changing?	Good —	Specific aspects of ongoing monitoring	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?	Good —	Specific aspects of ongoing monitoring	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 —	Vessel discharges and outfall discharge	Some potentially harmful activities exist, but they do not appear to have had a negative effect on water quality.	
HABITAT					
5	What are the abundance and distribution of major habitat types and how are they changing?	Fair —	Alteration of microhabitat due to bottom dragging and dredging	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.	Regulations address habitat disturbance from ocean dumping, dredge spoil, construction, and mineral removal; plans are needed to address impacts of cable and pipeline laying, ocean dumping, and mariculture, and to reduce impacts of mobile fishing gear, shipping and biomass removal (pages 20-21).
6	What is the condition of biologically structured habitats and how is it changing?	Fair/Poor —	Fishing gear impacts	Selected habitat loss or alteration has caused or is likely to cause severe declines in some but not all living resources or water quality.	
7	What are the contaminant concentrations in sanctuary habitats and how are they changing?	Good/Fair —	Limited monitoring results	Selected contaminants may preclude full development of living resource assemblages, but are not likely to cause substantial or persistent degradation.	
8	What are the levels of human activities that may influence habitat quality and how are they changing?	Fair/Poor ▼	Fishing gear impacts, shipping	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.	
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	Fair/Poor ▲	Long-term changes in fish diversity	Selected biodiversity loss has caused or is likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity.	Working to reduce vessel strikes to marine mammals by moving current shipping lane slightly north and promoting voluntary speed limits and compliance with whale watching guidelines; studying the impacts of noise on marine mammals; working to reduce marine mammal entanglement through reporting and response, and fishing gear restrictions (pages 21-24).
10	What is the status of environmentally sustainable fishing and how is it changing?	Fair/Poor —	Published and unpublished literature on regional and local groundfish populations	Extraction has caused or is likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity.	
11	What is the status of non-indigenous species and how is it changing?	Good/Fair ▼	Recent invasives discovered	Non-indigenous species exist, precluding full community development and function, but are unlikely to cause substantial or persistent degradation of ecosystem integrity.	
12	What is the status of key species and how is it changing?	Fair/Poor —	Cod (keystone species) Sand lance (key species)	The reduced abundance of selected keystone species has caused or is likely to cause severe declines in some but not all ecosystem components and reduce ecosystem integrity; or selected key species are at substantially reduced levels, and prospects for recovery are uncertain.	
13	What is the condition or health of key species and how is it changing?	Fair —	Whale strikes and entanglements	The diminished condition of selected key resources may cause a measurable but not severe reduction in ecological function, but recovery is possible.	
14	What are the levels of human activities that may influence living resource quality and how are they changing?	Fair/Poor —	Stable levels of activity	Selected activities have caused or are likely to cause severe impacts, and cases to date suggest a pervasive problem.	
MARITIME ARCHAEOLOGICAL RESOURCES					
15	What is the integrity of known maritime archaeological resources and how is it changing?	Fair ▼	Fishing gear impacts	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.	Regulations restrict seabed alteration, construction, disposal, and historical resource movement or removal; enhanced protection will require additional staff, resource inventory and assessment, and outreach (page 24).
16	Do known maritime archaeological resources pose an environmental hazard and is this threat changing?	Good —	Lack of hazardous cargo	Known maritime archaeological resources pose few or no environmental threats.	
17	What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?	Poor ▼	Fishing gear impacts	Selected activities warrant widespread concern and action, as large-scale, persistent, and/or repeated severe impacts have occurred or are likely to occur.	



NATIONAL MARINE SANCTUARIES

GERRY E. STUDDS
STELLWAGEN BANK

Stellwagen Bank National Marine Sanctuary is located off the coast of the Commonwealth of Massachusetts. Depths in the sanctuary range from 65 feet to more than 600 feet. *Map: National Marine Sanctuary Program*

About This Report

This report provides a summary of resources in the National Oceanic and Atmospheric Administration's Gerry E. Studds Stellwagen Bank National Marine Sanctuary, pressures on those resources, the current condition and trends, and management responses to the pressures that threaten the integrity of the marine environment. Specifically, this document includes information on the status and trends of water quality, habitat, living resources and maritime archaeological resources and the human activities that affect them. It presents responses to a set of questions posed to all sanctuaries (Appendix A). Resource status is rated on a scale from good to poor, and the timelines used for comparison vary from topic to topic. Trends in the status of resources are also reported, and are generally based on observed changes in status over the past five years, unless otherwise specified. Evaluations of status and trends were made by sanctuary staff, based on interpretation of quantitative and, when necessary, non-quantitative assessments and observations of scientists, managers and users.

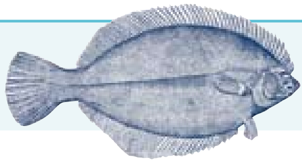
In many cases, sanctuary staff consulted outside experts familiar with the resources and with knowledge of previous and current scientific investigations. The ratings reflect the collective interpretation of the status of local issues of concern among sanctuary program staff and outside experts based on their knowledge and perceptions of local problems, but the final ratings were determined by sanctuary staff. Similar reports summarizing resource status and trends will be prepared for each marine sanctuary approximately every five years and updated as new information allows. This information is intended to help set the stage for management plan reviews at each site and to help sanctuary staff identify monitoring, characterization and research priorities to address gaps, day-to-day information needs and new threats. This report has been peer-reviewed and complies with the White House Office of Management and Budget's peer review standards as outlined in the Final Information Quality Bulletin for Peer Review.

Introduction

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

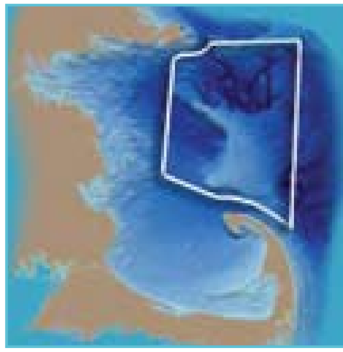
Assuming that a common marine ecosystem framework can be applied to all places, it follows that there may be a number of questions that can be posed at all sites and used as evaluation criteria to assess resource condition and trends. The questions, which are shown on page iii and explained in Appendix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

A northern right whale, one of approximately 300 in the North Atlantic population, dives to feed on subsurface zooplankton patches.



Site History and Resources

Stellwagen Bank National Marine Sanctuary is one of 14 sites in a national system of ocean and Great Lakes areas selected for their ecological, recreational, historical and aesthetic values. Congressionally designated in 1992, the sanctuary's mission is to conserve, protect, and enhance biodiversity, ecological integrity, and cultural legacy while facilitating compatible uses. The sanctuary is administered by the National Oceanic and Atmospheric Administration (NOAA), within the Department of Commerce. A key component of the sanctuary's long-term vision is that the ecological integrity of the site will be fully restored.



Stellwagen Bank sanctuary is located off the coast of Massachusetts. It was congressionally designated in 1992 as a national marine sanctuary. *Image: USGS*

A northern red anemone. *Photo: Dan Blackwood and Page Valentine, USGS*

Location

The Stellwagen Bank sanctuary is located in the southwestern Gulf of Maine and stretches between Cape Ann and Cape Cod at the mouth of Massachusetts Bay. The sanctuary is about the size of the state of Rhode Island. The sanctuary encompasses 842 square miles in a topographically diverse area that geologists estimate was created some 14,000 years ago during the retreat of the Ice Age glaciers, a time when Stellwagen Bank was emergent land and mastodons and wooly mammoth roamed about. Today, the dominant feature of the sanctuary is a shallow, glacially deposited, primarily sandy underwater bank, curving in a southeast to northwest direction for 19 miles. It is roughly six miles across at its widest point at the southern end. Water depths over and around the bank range from 65 feet to more than 600 feet.

Discovery of the Bank

In 1854 and 1855, the bank was first mapped by Henry Stellwagen, a lieutenant of the U.S. Navy on loan to the U.S. Coast Survey. Accompanying Henry Stellwagen on his surveying vessel were two other individuals of note—an amateur surveyor by the name of Alexander Wadsworth Longfellow, brother of the famous poet, and a fellow hydrographer, Edward Cordell. In 1869, Cordell, by then in charge of his own survey ship, discovered a similar-sized bank on the west coast, which would eventually be named after him. Today, both Cordell and Stellwagen banks are among the significant marine areas designated as national marine sanctuaries.

Setting

Stellwagen Bank and surrounding waters provide one of the richest, most productive marine environments in the U.S. The area sustains marine mammals and fishery resources that constitute important regional ecological and economic resources. Due to its accessibility, the region is used extensively for whale watching and commercial and recreational fishing.

Beginning in the Colonial Period, groundfish, invertebrate, and pelagic fisheries became vital commercial resources for the New England region. Though overfishing and stock collapses have caused a decline in commercial fishing, a reduced but still active domestic commercial fishery continues throughout the Gulf of Maine. The productivity of Stellwagen Bank and the surrounding coastline gave rise to 400 years of vessel traffic across what is now the sanctuary. As a result, several hundred historic vessel losses are recorded in the sanctuary's vicinity, 18 of which have been located with five identified by name.

Today, New England has a diverse economy, including manufacturing and exporting of specialized industrial and commercial machinery, electronic and electrical equipment, weaponry, and food products. With an adjacent population of

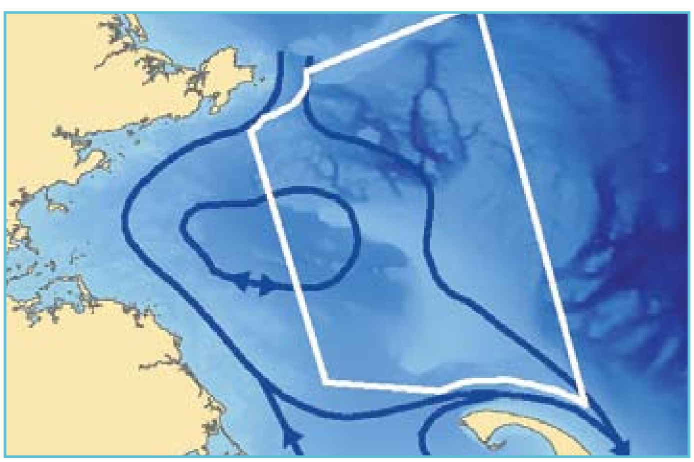
Vessels cross Stellwagen Bank sanctuary, arriving at and departing from Boston Harbor. Approximately 2,000 large commercial vessels traverse the sanctuary every year. *Photo: NOAA, National Marine Fisheries Service permit #981-1707-00*

nearly 4.8 million people, the unique features and location of Stellwagen Bank bring a wealth of resources to more and more business interests and recreational users, but with concomitant pressures on their integrity.

Water

Because of its relative inshore location, water flow over Stellwagen Bank tends to be associated primarily with a coastal current, driven by freshwater input from rivers and prevailing winds. However, water properties are also influenced by the larger counterclockwise circulation pattern within the Gulf of Maine. The physical oceanography of Massachusetts Bay is well characterized by Geyer et al. (1992).

Stellwagen's nutrient-rich waters are the result of its geology and water dynamics. The twice-daily tidal fluctuations moving east and west buffet the bank's edges with currents, which drive the nutrient-rich bottom water to the surface in a process called upwelling. The upwelling process and other water movements around the bank bring nutrients up into the sunlit waters to support a rich mix of plankton, which in turn attracts and supports a diversity of marine life. The nutrient-rich waters make Stellwagen Bank sanctuary one of the most important seasonal feeding areas for whales and bluefin tuna in the western North Atlantic.



This image depicts the general oceanographic current regime (in blue) around Stellwagen Bank (boundary in white). *Source: adapted from P. Lermusiaux, Harvard University*

Habitat

The underwater landscape of the sanctuary, which includes Stellwagen Bank and surrounding environs, is a patchwork of habitat features that is composed of both geologic and biologic components. These features can provide shelter from predators and the flow of tidal and storm generated currents, serve as sites that enhance capture of prey such as drifting zooplankton or species associated with particular features, and serve as foci for spawning activities including egg laying and brooding young. All organisms have particular habitat requirements and the important attributes of habitat vary between species and between the various life history stages within species.

Cerianthid anemones burrow their stalks into the mud. These vertical structures are often used for shelter by other animals, including redfish. *Photo: National Undersea Research Center, University of Connecticut*

Stellwagen Bank sanctuary contains each of the following five major seafloor habitat types found in the Gulf of Maine: rocky outcrop, piled boulder, gravel, sand and mud. The percent cover of the three of these sediment types are: sand - 34.2, mud - 28.2, and gravel - 37.6 (boulder reefs fall in the gravel category) (Valentine et al. 2001). Rocky outcrop comprises less than 1 percent of the sanctuary. These habitats are spread across the series of banks and deep basins that make the sanctuary a diverse topographic area. Within each habitat type there are many microhabitats formed by the combination of habitats and inhabiting organisms. For example, northern cerianthids, a type of anemone that burrows in mud, serve as important habitat for redfish and hake.

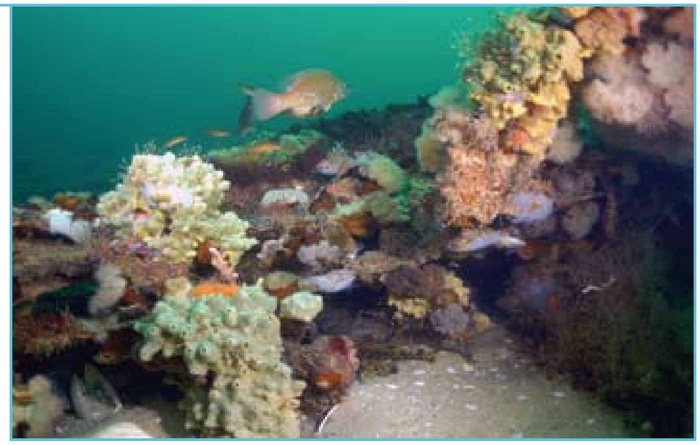
One of the major concerns of the sanctuary directly associated with habitat is called simplification, which involves the reduction of three-dimensional structure caused by human activities, principally bottom-contact fishing gear. Simplification of seafloor habitat complexity has been shown to increase the mortality of early demersal phase juvenile fish, such as Atlantic cod *(Gadus morhua)* and winter flounder *(Pseudopleuronectes americanus)* that utilize the structure provided by emergent fauna and physical substrata for protection from predation (Tupper and Boutilier 1995, Lindholm et al. 1999, Scharf et al. 2006). Modeling studies have demonstrated that such habitat-mediated mortality of juvenile fish can have significant population-level effects (Lindholm et al. 1998, 2001).

Living Resources

Stellwagen Bank sanctuary's extraordinary productivity and diverse bottom terrain provide suitable habitat for many invertebrate, fish and seabird species. The abundance of preferred prey species attracts marine mammals, such as the critically endangered North Atlantic right whale, and the sanctuary is recognized as one of the primary feeding grounds of the endangered humpback whale in the North Atlantic.

Every major taxonomic group of invertebrates that occurs in the global marine environment is present in the sanctuary. This includes large cerianthid anemones, which are visible in deep mud basins, and sand dollars and sea stars, which dominate in the shallower sand areas. Structure-forming epifauna, such as sponges and anemones, provide refuge and critical nursery habitat for juvenile fish of many species, including Atlantic cod and Acadian redfish *(Sebastes fasciatus).*

The sea scallop has over 100 blue eyes along the edge of its mantle, with which it senses light intensity. *Photo: Dann Blackwood, USGS*



Marine life inhabiting one of the many shipwrecks in the sanctuary. *Photo: Tane Casserley, NOAA Maritime Heritage Program*

The diverse seafloor topography and benthic communities in the sanctuary support 72 species of fish. The benthic fish community includes cod, haddock *(Melanogrammus aeglefinus)*, silver hake *(Merluccius bilinearis)*, and various flatfish. The sand lance (a small eel-like fish, *Ammodytes dubius*), mackerel, and herring, whose populations are seasonally prolific in the Stellwagen Bank environment, serve as the primary prey of humpback, fin *(Balaenoptera physalus)*, and minke whales *(Balaenoptera acutorostrata)* feeding within the sanctuary, as well as many finfish and seabirds.

The sanctuary is the seasonal home to two species of endangered sea turtles, the Atlantic or Kemp's ridley *(Lepiochelys kempi)* and the leatherback *(Dermochelys coriacea)*. The leatherback is an occasional summer visitor and is the only species of sea turtle that journeys to cold waters for feeding activities. Likely prey include jellyfish that are abundant in these waters during the summer. Atlantic ridleys are observed in waters off Massachusetts as juveniles, having either swum or drifted north in the Gulf Stream from hatching areas off the southern coast of Mexico. Approximately 43 species of seabirds inhabit the sanctuary intermittently throughout the year.

Whales are the most visible occupants of sanctuary waters. Seventeen species of cetaceans are known to frequent the sanctuary, humpback whales being perhaps the most conspicuous because of their large size, flamboyant behavior, and distinctive markings. North Atlantic right whales (*Eubalaena glacialis*) are some of the world's most endangered whales. Every year, approximately one-third of the North Atlantic right whale population

A humpback whale feeds within the sanctuary using a net made of bubbles to entrap fish. *Photo: William Lange, Woods Hole Oceanographic Institution*

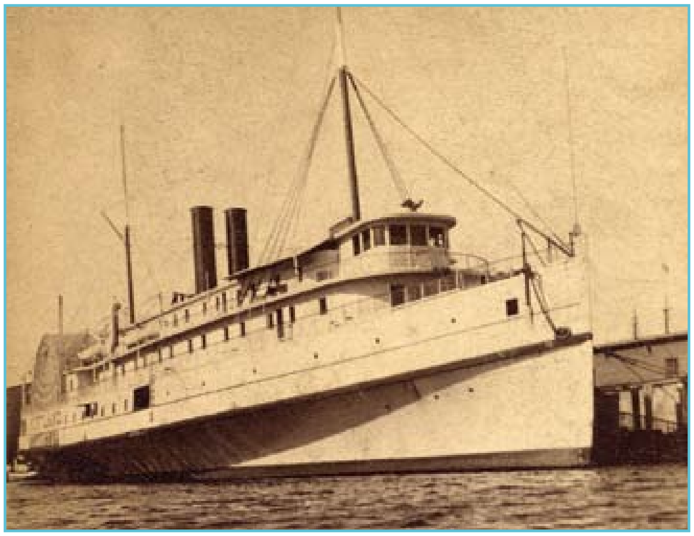
utilizes the sanctuary and nearby waters for feeding and nursing. Fin (or finback) whales, the second largest of the world's whales, are the most common species of large baleen whale in the Gulf of Maine and are regularly seen in the sanctuary, along with the smaller minke whales. Harbor (*Phoca vitulina*) and gray seals (*Halichoerus grypus*) are also commonly observed in the sanctuary.

Maritime Archaeological Resources

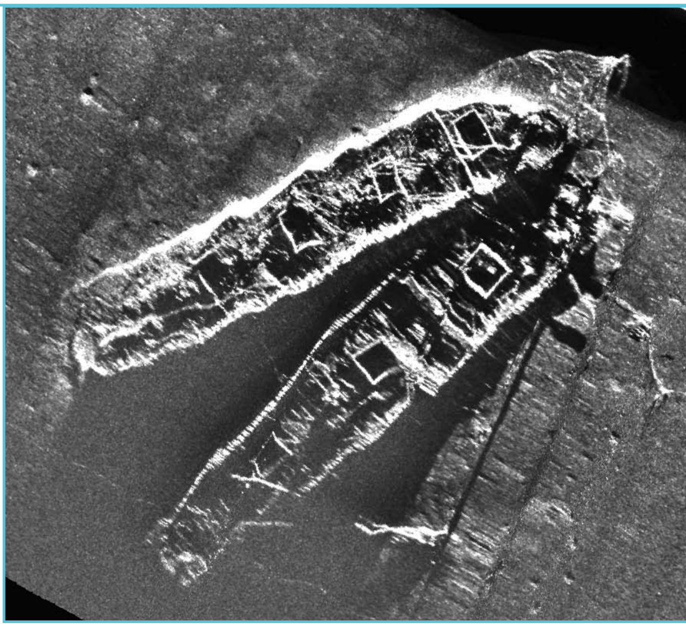
The Maritime Archaeological Resources sections of this report address the condition and threats to archaeological resources contained within the sanctuary. These include shipwrecks and other submerged archaeological sites, which are a subset of a larger category of maritime heritage resources that may include other cultural themes, such as traditions, histories, and values. The latter are not the subject of this report.

Uncounted prehistoric and historic archaeological sites lie within Stellwagen Bank sanctuary. Hundreds of years of fishing, whaling, and maritime transportation have made the sanctuary a repository for valuable maritime archaeological resources. Since researchers began investigating the sanctuary's maritime archaeological resources in 2000, archaeologists have located 18 historic shipwreck sites and identified five of these shipwrecks by name, with more undoubtedly yet to be discovered.

The steamer *Portland* is considered to be the sanctuary's most historically significant wreck as it represents the most intact 19th-century New England steamship located to date. Listed on the National Register of Historic Places in 2005, it is highly significant to the history of New England, specifically Boston, Massachusetts and Portland, Maine. Constructed in 1889 by the New England Shipbuilding Co. of Bath, Maine, the 291-foot ship was lost in a 1898 gale that now bears her name. Her wreckage was finally located in 1989 by the Historical Maritime Group of New England. In July 2002, the exact location of the *Portland* shipwreck was confirmed by NOAA researchers.



The steamer *Portland* at dock. *Photo: LARC*



Sonar image of the *Frank A. Palmer* and *Louise B. Crary* shipwrecks. *Image: National Undersea Research Center, University of Connecticut and NOAA/ Stellwagen Bank*

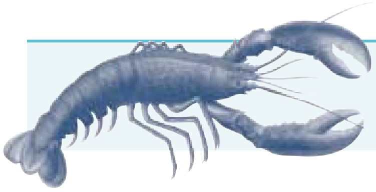
Also listed on the National Register in 2006 are the shipwrecks of two coal-carrying schooners (colliers) that collided in December 1902. The *Frank A. Palmer* and the *Louise B. Crary* were bringing coal to Boston when they collided and sank. The *Frank A. Palmer* was the longest four-masted schooner ever built at 274.5 feet, while the *Louise B. Crary* was a slightly smaller, five-masted vessel. Sidescan sonar images collected in 2002 and 2003 clearly show the hulls of the two large sailing vessels, their bows locked together for all time.

Archaeologists have located and investigated several other collier sites with varying degrees of preservation. The five-masted schooner *Paul Palmer* caught fire and sank off Highland Light in 1913. The site has been heavily degraded by storm disturbance and trawling activity.

Other collier sites include a 32-meter (100-foot) vessel that is nearly intact up to its deck level. Features of the site include copper alloy-sheathed hull planking, wooden hanging knees (braces) and a variety of ship fittings and artifacts. In contrast, the hull remains of another collier are only represented by eroded frames protruding centimeters from a pile of coal 35 meters (114.8 feet) long. Very few ship fittings and no smaller artifacts were found on this site. Both vessels were likely two-masted schooners that carried a variety of cargo, but happened to be loaded with coal when they sank. While both vessels lie in water of similar depth, the more intact vessel lies in an area that is less frequently trawled.

After colliers, the second most common category of shipwreck located thus far is the 20th-century commercial fishing vessel. Of these, wooden-hulled eastern-rig draggers represent the majority. Constructed from the 1920s through the 1970s, these side trawlers exemplify the transition from hook and line fishing to engine-powered trawling. Several of the eastern-rig dragger shipwrecks in the sanctuary are remarkably intact, with extant pilot houses and masts. Others are much more fragmentary as a result of damage from the nets and trawl doors of more recent trawlers.

Dishware in the steamship *Portland's* galley. *Photo: NOAA/Stellwagen Bank, NURC-UConn, and the Science Channel*



Pressures on the Sanctuary

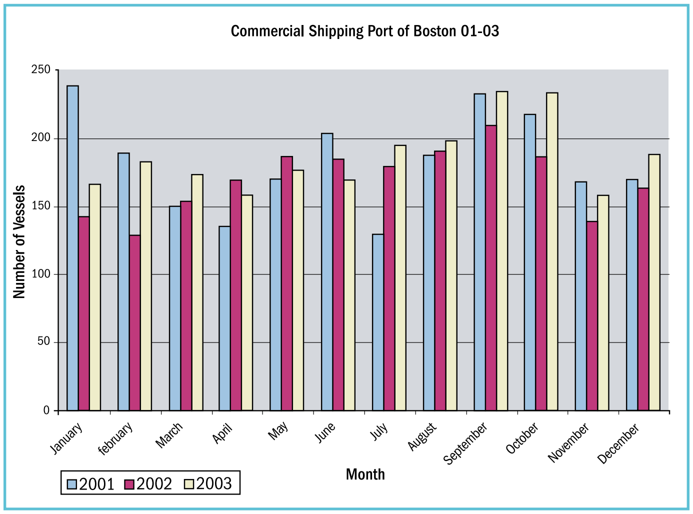
Numerous human activities and natural events and processes affect the condition of natural and archaeological resources in marine sanctuaries. This section describes the nature and extent of the most prominent pressures on the Stellwagen Bank sanctuary.

For bird watchers, the sanctuary is a popular destination.
Photo: Dann Blackwood, USGS

Large numbers of boats travel into the sanctuary to watch whales.
Photo: Brad Barr

Shipping

Stellwagen Bank sits at the mouth of Massachusetts Bay and is open to vessel traffic traveling to and from the Port of Boston, which is one of the most modern and efficient container ports in the U.S. The port handles more than 1.3 million tons of general cargo, 1.5 million tons of non-fuel bulk cargo and 12.8 million tons of bulk fuel cargos yearly. The designated traffic separation scheme for Boston passes in a roughly east-west direction through the sanctuary. These lanes are used for numerous types of domestic and foreign-flagged vessels, including container ships (some with hazardous materials), liquefied natural gas and oil tankers and barges, and an increasing number of cruise liners. While many vessels remain in the designated travel lanes, use of these lanes is not mandatory and vessel traffic occurs throughout the sanctuary. Stressors from these vessels include noise disturbance of animals, strikes to whales, pollutant discharges, and introduction of invasive species.



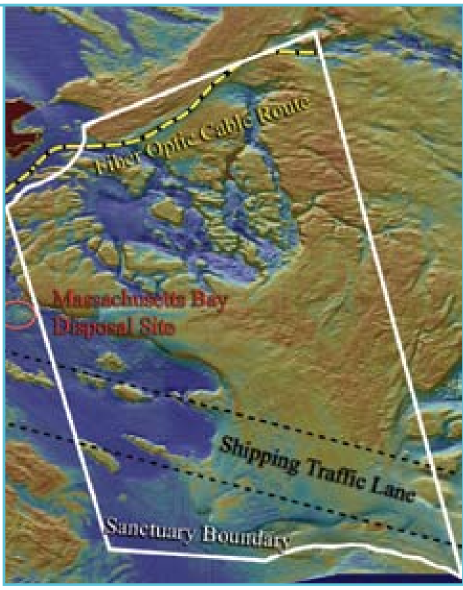
The number of commercial ships using the port of Boston by month, 2001-03.
Source: Boston Pilots Association

Outfall Discharges & Dumping Sites

The Massachusetts Water Resources Authority (MWRA) outfall discharges on the order of 350 million gallons per day of treated secondary effluent 12 miles west of the sanctuary. Potential stressors from the outfall and other point and non-point sources of pollution include eutrophication, discharge of toxic chemicals, and discharge of agents that alter biological processes (e.g., endocrine disrupters). The Massachusetts Bay Disposal Site for clean dredge material is located in Stellwagen Basin adjacent to the sanctuary's western boundary. Materials deemed free of hazardous materials by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency may be dumped at this site. Known hazardous and radioactive materials were dumped in and around this site in the 1940s and 1950s (Wiley et al. 1992). Given the proximity of the dumpsite to the sanctuary there is concern that these dumped materials have impacted sanctuary habitats and that barrels with toxic materials are leaking.

Fiber-Optic Cable

A fiber-optic cable was laid across the northern part of the sanctuary under federal permit in 2000. This cable provides a direct link between North America and the Republic of Ireland. The cable is designed for a life expectancy of 25 years and is buried at an average depth of approximately 1.5 meters into the seafloor. The major impact is habitat disturbance from the cable laying and burial process, and from potential repair or removal operations.



A fiber-optic cable runs along the northern edge of the sanctuary boundary. A shipping traffic lane bisects the sanctuary and an active dredge material disposal site sits on the western boundary. *Source: NOAA/Stellwagen Bank*

Liquefied Natural Gas Deepwater Port

It is likely that a deepwater port for the off-loading of liquid natural gas will be installed in the near future, approximately two miles west of the western boundary of Stellwagen Bank. The potential for this port, together with the existing MWRA deepwater sewage outfall and the Massachusetts Bay Disposal Site, is creating the possibility of a de facto industrial zone adjacent to the sanctuary. Concerns in this area include contamination from discharges, and in the case of proposed liquid natural gas ports, increased vessel traffic and noise, displaced commercial fishing and whale watching activities, and impacts to the sanctuary's scenic views.

Noise

The level of noise pollution in the oceans and in the Stellwagen Bank sanctuary has increased dramatically during the last 50 years. The primary source of low-frequency ocean noise is commercial shipping (NRC 2003). Many marine mammals respond to noise by altering their breathing rates, spending more time underwater before coming up for air, changing the depths or speeds of their dives, shielding their young, changing their song note durations, and swimming away from the affected area (Richardson et al. 1995). Noise pollution may cause marine mammals and other organisms to acquire temporary or permanent hearing loss. The disorientation and hearing loss may account for cases in which ships collide with marine mammals that are apparently unaware of the approaching vessel. Most strikes occur in coastal waters on the continental shelf where large marine mammals concentrate to feed.

Commercial Fishing

Fishing with mobile gear such as trawls and scallop and clam dredges, together with fixed gear such as bottom-tending gill nets and lobster pots, occurs extensively throughout the sanctuary. Commercial fishermen take species from four principal categories: groundfish, pelagics, other finfish and invertebrates. Approximately 440 commercial fishing vessels fish in the sanctuary every year (vessel trip report analyses, SBNMS unpublished). Stressors resulting from commercial fishing include alteration of habitat, removal of biomass, discharge of pollutants, entanglement of marine mammals, and destruction of historic resources.

Trawlers tow nets that sweep across the ocean floor. *Photo: Center for Coastal Studies*

Commercial Whale Watching

Currently, there are 15 commercial whale watch companies visiting the Stellwagen Bank sanctuary operating a total of 24 boats that make single and sometimes multiple trips daily from April through October. More than one million people visit the sanctuary yearly aboard these vessels. There is increasing concern regarding the short- and long-term impacts of whale watching on the targeted large whale populations. Impact studies worldwide have shown changes in ventilation rate (Baker 1988), avoidance behavior (Donovan 1986), and changes in habitat use (Corkeron 1995). The concerns may be further compounded by the increase in popularity of whale watching, not just by commercial vessels, but by privately owned recreational vessels.

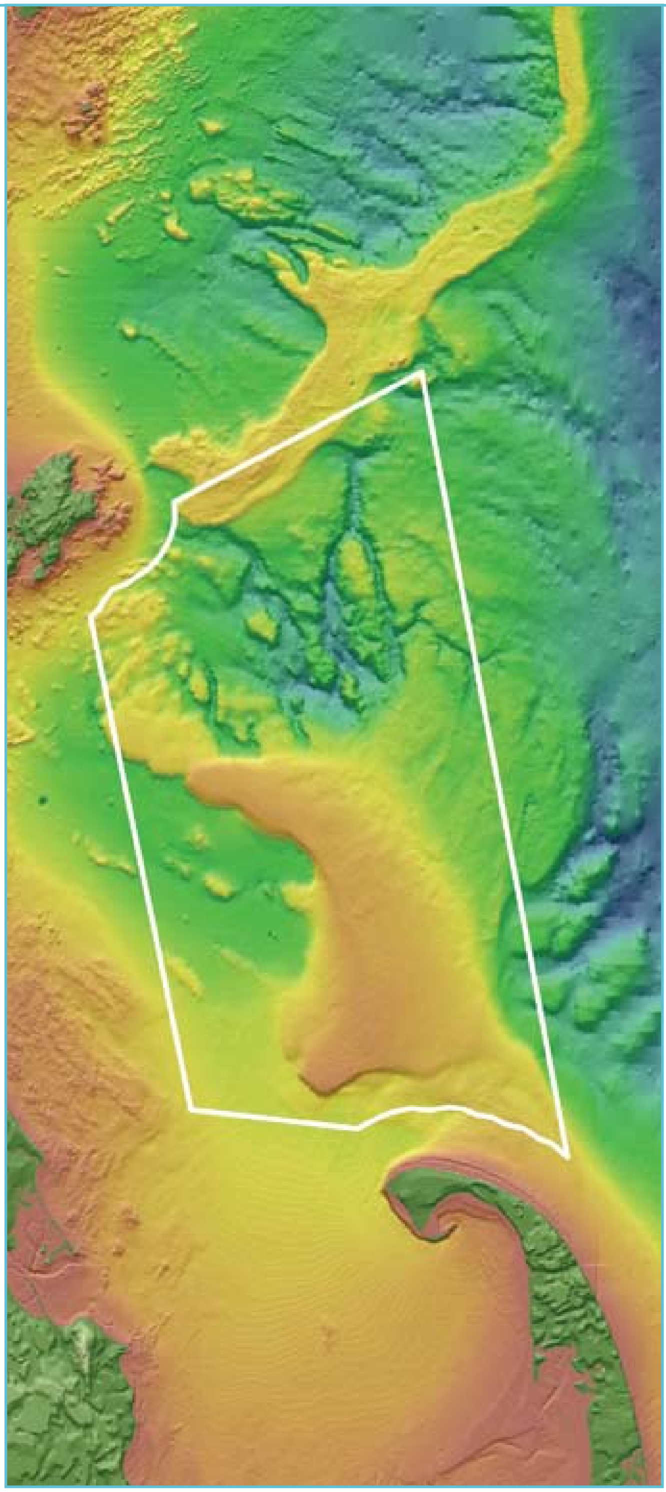
A humpback whale breaches next to a whale watching vessel. Voluntary guidelines for whale watching, issued by NOAA, have been in effect since 1985. *Photo: Anne Smrcina, Stellwagen Bank sanctuary*

Recreational Fishing & Boating

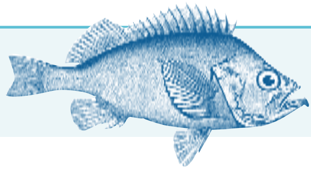
The sanctuary is a popular destination for recreational fishing boats, sailboats and powerboats. Recreational fishing by party boats, charters and private boats in the sanctuary targets groundfish and pelagic species such as tuna, shark, and bluefish *(Pomatomus saltatrix)*. It is estimated that the recreational fishing fleet takes 25 percent of the cod in the Gulf of Maine (NEFMC 2003). There are 65 small boat harbors and over 80 boating and yacht clubs sited along the Massachusetts coast with easy access to the sanctuary. Recreational boaters typically transit the sanctuary going to and from Boston, coming from the Cape Cod Canal or Cape Cod Bay, and from Provincetown or Cape Ann. Recreational boaters are most numerous and often aggregate within the sanctuary during the whale watching season from April to October. On a calm summer day, recreational boats can number in the hundreds within the Stellwagen Bank sanctuary. Potential stressors from recreational boating and fishing activities include targeted removal of large spawning and breeding fish, disturbance of whale feeding, strikes to whales, and discharge of pollutants.

Climate Change

Over the next century, climate change is projected to profoundly impact coastal and marine ecosystems. Climate change can have significant effects on sea level, temperature, and currents. These changes could result in more intense storms and more extreme floods and droughts. Rising seawater temperatures may give rise to increased algal blooms, major shifts in species distributions, local species extirpations, and increases in pathogens (Epstein et al. 1993, Harvell et al. 1999).

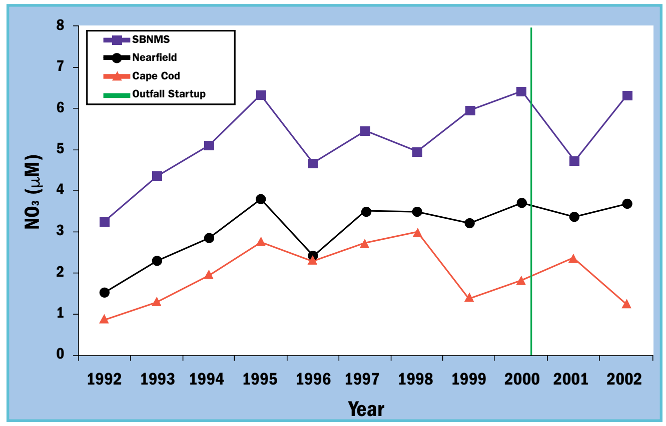


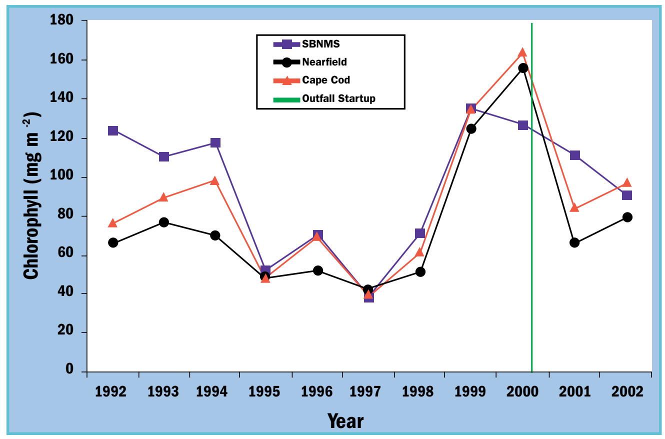
Bathymetric relief map of Stellwagen Bank National Marine Sanctuary. *Image: U.S. Geological Survey and NOAA/Stellwagen Bank*



State of Sanctuary Resources

This section provides summaries of the condition and trends within four resource areas: water, habitat, living resources, and archaeological resources. For each, sanctuary staff and selected outside experts considered a series of questions about each resource area. 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.





Nutrient and chlorophyll levels appear to decline or remain stable in the first two years after the MWRA Boston Harbor outfall was activated in September 2000.
Source: Carlton Hunt, Battelle Ocean Sciences

Water

Much of the pollution reaching the sanctuary comes from non-point sources or from distant-point sources. Several waste water treatment facilities discharge into Massachusetts Bay to the north and south of the sanctuary, the largest being the Massachusetts Water Resources Authority (MWRA) Boston Harbor outfall located 9.5 miles from Boston and 12 miles west of the Stellwagen Bank sanctuary border. Air pollution from power plants comes from as far away as the Midwest. A variety of chemicals move from the air to the water where they can be accumulated by organisms. In addition, the region is heavily traveled by commercial and recreational vessels and cruise ships that discharge wastes during their voyages. Other sources of contamination include clean material disposal at the Massachusetts Bay Disposal Site, and disturbances during the laying of underwater pipes and cables (only one of which crosses the sanctuary). Of concern are the cumulative impacts of multiple activities that may affect the resources of the sanctuary.

In 2001, sanctuary staff developed a monitoring plan to examine whether the MWRA outfall (which began operating in September 2000) was causing increased eutrophication and contaminant loading in the sanctuary. To maximize the use of resources and obtain compatible information with ongoing monitoring efforts, the sanctuary added four stations to the MWRA's existing five stations within the sanctuary. Since 2001, independent contractors have sampled those four additional stations in August and October (this sample collection coincides with two of the six MWRA surveys each year). Sampling includes measurements of water column physical variables (salinity, temperature, density structure), nutrients, chlorophyll and dissolved oxygen, as well as phytoplankton and zooplankton. The four sanctuary stations are strategically placed to detect nutrient inputs to the sanctuary from the Gulf of Maine to the north, and from the MWRA outfall to the west. The data allow inferences about fine-scale circulation patterns and water column productivity in the sanctuary, and are used for a three-dimensional model that has been developed to assist managers with understanding how the system might respond to increased and decreased levels of nutrients, dilution of outfall, and dispersion.

Results to date show no evidence of increased eutrophication or contaminant loading in the sanctuary (MWRA 2004).

Nutrient enrichment is one factor in the development of harmful algal blooms (HABs). HABs are high densities of toxic phytoplankton (*Alexandrium* sp.) that can kill marine life and impair human health. The most recent HAB event occurred in 2005 and covered a broad area encompassing all of Massachusetts Bay (including Stellwagen Bank) and Cape Cod Bay. The highest concentration of *Alexandrium* cysts were recorded in the sediment of the sanctuary. The presence of these cysts may cause another bloom in the future although none occurred in 2006.

Since the 1970s there have only been a few adequate water quality studies that have provided contaminant concentrations in the water column within or adjacent to Stellwagen Bank sanctuary. Results from the most recent study in 2004 are discussed below in the section on habitat status.

Although studies show that water quality in and around the sanctuary is currently at acceptable levels of most contaminants, the continuing pressures of point and non-point sources of pollution are cause for concern. Therefore, it will be critical to continue water quality monitoring and improve methods of conducting these activities.

The following information provides an assessment by sanctuary staff of the status and trends pertaining to water quality and its effects on the environment:

- Numerous contaminants have been identified, but they are at low levels, suggesting fair to good conditions; at present, conditions appear to be stable.
- Eutrophication does not appear to be a problem, and conditions appear favorable for both habitat and living resource quality.
- Water quality does not pose a risk to human health at this time, and conditions appear to be relatively stable.
- The high levels of human activities that may influence water quality (particularly discharges from vessel traffic) are not currently having an adverse effect on water quality conditions, and appear to be stable.

Water Quality Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

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

Issue	Rating	Basis for Judgment
Stressors	— (Good/Fair)	Numerous contaminants at low levels
Eutrophic Condition	— (Good)	Specific aspects of ongoing monitoring
Human Health	— (Good)	Specific aspects of ongoing monitoring
Human Activities	— (Good/Fair)	Vessel discharges and outfall discharge

Habitat

Activities that currently have the greatest potential impact on the habitats of Stellwagen Bank are the laying of cables and pipelines, the use of mobile fishing gear, removal of key forage species and bycatch due to fishing activities, ocean dumping, and the disposal of dredged materials. Currently, regulations are in place that protect the sanctuary, to some extent, from the effects of fishing, laying cables and pipelines, ocean dumping, and disposal of dredged material. However, fishing activity continues to threaten the integrity of sanctuary habitats and trophic relationships.

Studies conducted to date indicate significant impacts of bottom fishing gear on benthic habitats in New England, particularly habitats with vertical relief and complex structure (Auster and Langton 1999, Dorsey and Pederson 1998). Hard-bottom habitats support complex epifaunal communities that are removed, damaged, or destroyed by bottom trawling and dredging (Watling and Norse 1998). In contrast, mobile sand habitats that cover parts of Stellwagen Bank are less vulnerable to gear impacts because the sediment is routinely perturbed by storm events.

Fishing activities alter the structure of marine habitats and influence the diversity, composition, biomass, and productivity of the associated biota (Auster et al. 1996). These effects vary according to gear used, habitats fished, and the magnitude of natural disturbance, but tend to increase with depth and the stability of the substrate.

A long-term study (Seafloor Habitat Recovery and Monitoring Project) was initiated in 1998, when the Western Gulf of Maine habitat closed area, overlapping 22 percent of the sanctuary, went into effect. The study took advantage of the opportunistic closure to quantify the recovery of communities and habitats previously subject to fishing activities and to understand the dynamics of communities and habitats over time. The study design initially included sites inside and outside the closure in mud, sand, gravel, and boulder habitat types. The study was designed to compare and contrast the effects on community structure from natural disturbance versus anthropogenic disturbance (e.g. a single acute impact, such as a cable installation, and chronic impacts from a range of fishing activities).

In 2001, the seafloor monitoring study was expanded when a telecommunications company installed a fiber-optic cable across the sanctuary after receiving a NOAA permit. Monitoring is now conducted at sampling sites to distinguish differences between recovery rates from fishing and cable impacts. Separate projects are focusing on dynamics and effects on infaunal communities, epifaunal communities, fish microhabitat structure, and landscape dynamics.

To date, samples have been collected from 1998-2006. Analysis and preliminary results of the various approaches are at different stages. However, preliminary analyses demonstrate some interesting patterns and trends:

1) There are significant differences in epifaunal community structure between boulder and gravel habitats despite the fact that both are composed of hard substrate (Tamsett in prep).

2) Within boulder and gravel habitat types there are differences in community structure between sites inside and outside the habitat closed area indicative of impacts from fishing activities (Tamsett in prep).

3) Within mud habitat types there are differences in community structure between sites inside and outside the habitat closed area indicative of impacts from fishing activities (Grannis 2001).

4) Contrasts in the composition of sand habitat communities inside and outside of the habitat closed area are not clearly different, suggesting that fishing effects superimposed on background patterns of natural disturbance have similar effects on sand communities (Grannis 2001).

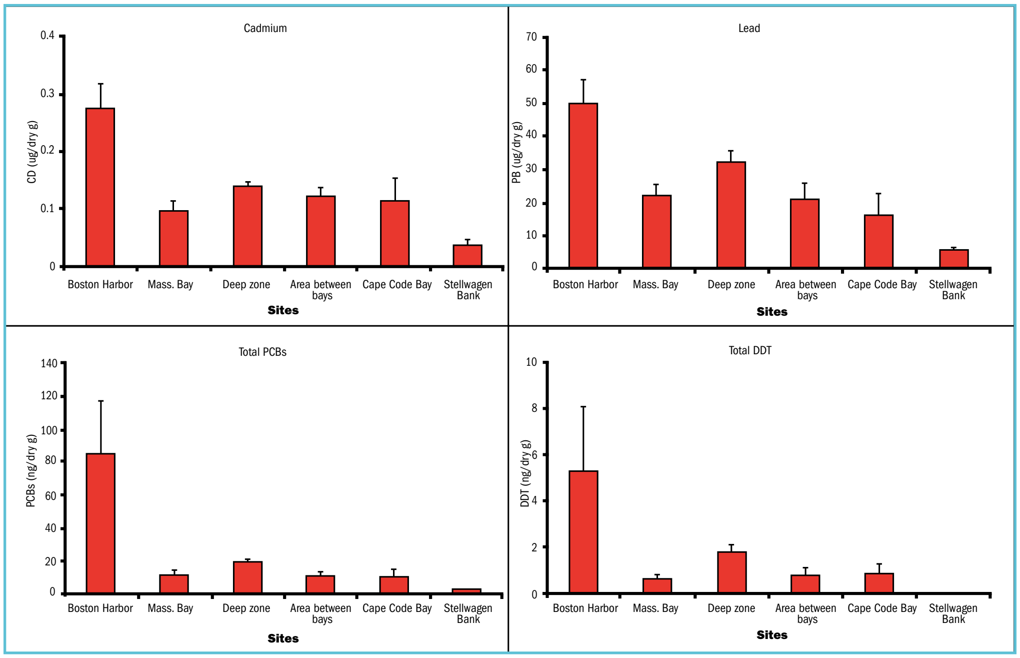
5) Community structure is changing across time both inside and outside the habitat closed area in all habitats, suggesting a dynamic environment where both natural and human caused disturbances (from fishing) mediate the composition and trajectory of seafloor communities (Grannis 2001, Tamsett in prep).

6) Samples from inside and outside the habitat closed area along the route of the fiber-optic cable do not demonstrate an effect of the acute impact of the cable but do suggest an effect from fishing (Grannis 2001).

7) The trench that was produced during the cable burial operation in 2001 was still visible along significant parts of the path through the sanctuary in 2006. The side scan sonar records demonstrate that five years of time have been insufficient for sediment transport processes to fill in the feature (Auster and Lindholm, unpublished).

There are also some trends in the composition of particular species and groups (Tamsett in prep). The abundance of ascidians (primarily *Mogula* sp.) has increased significantly inside the closed area over time, while the brachiopod *Terebratulina septentrionalis* has increased outside. The exact mechanism is not clear from these observations, but we can hypothesize various types of direct and indirect interactions where either differential rates of survivorship or competitive interactions mediated by fishing disturbance result in such patterns. Across the entire area there has been a decline in brittle stars, obviously resulting from some type of area-wide effect, such as increased predation by increasing demersal fish populations. Finally, there is a general pattern in species groups that provide shelter resources for fishes, such as sponges and erect bryozoans, to be more abundant inside the closed area than outside (McNaught, unpublished ms). This pattern is supported by multiple reviews of fishing effects studies.

Contaminant levels are a concern due to the opening of the Boston Harbor outfall pipe in 2000, the historic and current discharge of municipal sewage from the Boston metropolitan area and other cities and towns along Massachusetts Bay, and the historic dumping of toxic material at the Massachusetts Bay Disposal Site. In 2004, field samples were taken to assess the status and trends of chemical contamination in sediments and resident biota, and to assess the biological condition of the various habitat types found in the region. Sampling efforts



Concentrations of selected metals, cadmium (Cd) and lead (Pb), and organics (total PCBs and DDT) in sediments within Massachusetts Bay. Note that the lowest concentration for each contaminant is at Stellwagen Bank. *Source: National Status and Trends Bioeffects, 2004*

employed a combination of protocols from the NOAA National Status and Trends Bioeffects Program and the National Benthic Surveillance Program. The Bioeffects Program assesses sediment contamination, toxicity, and benthic community condition. The Benthic Surveillance Program also addresses sediment contamination, in addition to contaminant body burdens and histological indicators in resident fish. Sampling was coordinated between National Status and Trends in collaboration with the NOAA Northwest Fisheries Science Center. Data from 2004 were contrasted with historical data and data from the Massachusetts Water Resources Authority (MWRA) to assess the spatial and temporal trends in chemical contamination in the region as a whole. Both the NOAA and MWRA sampling regimes included sampling sites within the following four zones: Boston Harbor, Massachusetts Bay, Area Between Bays, and Stellwagen Bank. The lowest contaminant concentrations were consistently found in the Stellwagen Bank sites (NOAA in prep, also see Bothner et al. 1993, Bothner et al. 1994, Bothner and Butman 2005).

The following information provides an assessment by sanctuary staff of the status and trends pertaining to the current state of the marine habitat:

- Currently, the abundance and distribution of major habitat types within sanctuary boundaries are being affected by human activities, and are improving only in the habitat closed area overlapping the sanctuary.
- The condition of biologically structured habitats (i.e., those formed primarily by the presence of large benthic macrofauna or flora) is currently fair to poor, owing to ongoing disturbance, and is improving only in the habitat closed area overlapping the sanctuary.
- Contaminant concentrations in sanctuary habitats are low and currently stable.
- The levels of human activities that may influence benthic and water column habitats are considerable, primarily bottom dragging, dredging, shipping, and trap fishing.

Habitat Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

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

Issue	Rating	Basis for Judgment
Abundance/Distribution	—	Alteration of microhabitat due to bottom dragging and dredging
Structure	—	Fishing gear impacts
Contaminants	—	Limited monitoring results
Human Impacts	▼	Fishing gear impacts, shipping

Living Resources

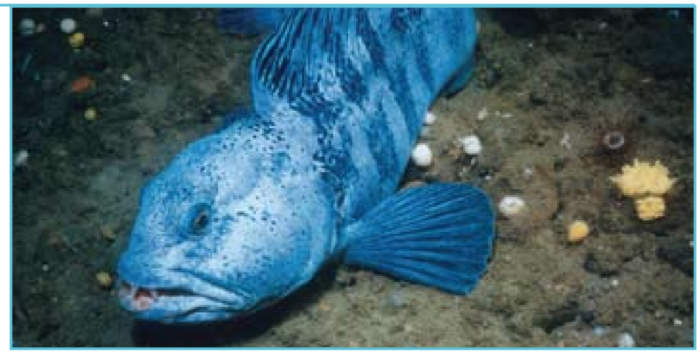
A primary objective of sanctuary management is resource protection, including the restoration and maintenance of natural biological communities and ecological processes. Specific concerns related to this objective are the diversity, abundance, and size range of fishes (including sand lance and herring, which serve as the primary prey of many fish, marine mammals, and seabirds), the health and integrity of marine mammals, the contaminant levels in marine organisms, and colonization by invasive species.

The Stellwagen Bank area has had a long history as a productive fishing ground, popular for finfish and crustaceans (including cod, haddock, yellowtail flounder *(Limanda ferruginea)*, groundfish, crabs, lobsters, shrimp, scallops and bluefin tuna *(Thunnus thynnus)*. This area has been fished for nearly 400 years since European colonization, and for the past half century with trawl and dredge gear. Fishing pressures have depleted populations of important local stocks, reducing the size and age structure of the populations, causing restructuring of food webs and resulting in changes to the composition of biological communities. Sanctuary-supported research is focused on determining patterns of diversity, status of communities, and effects of human-caused disturbance, as well as developing monitoring strategies for key species and habitats.

Fish

In a study using a 25-year trawl time series (1970-1994), Auster (2002) found that while the effects of exploitation of fish populations did not result in local extinctions, there were significant declines in a range of diversity metrics that take both species richness and abundance into account and that can be attributed to extensive exploitation of dominant species and bycatch mortality of species of lower abundance and of little economic value.

A more recent analysis of spatial patterns in the diversity of fishes shows trends in recovery of diversity to levels comparable to the 1970s. However, as years were teased apart (in five-year blocks of time), trends in diversity indices over the 30-year time series showed that diversity of fishes at Stellwagen Bank, measured using six different indices, varied over the time series. The fish community in fall was generally more diverse than in spring. This can be attributed to warmer surface waters in the fall, which allow warm water and cold water species to co-occur across the diversity of shallow and deep habitats that occur along a wide depth gradient within the sanctuary.



The wolf fish pictured here is currently not a managed species but is on NOAA's species of concern list (NOAA 2006). *Photo: Peter Auster and Paul Donaldson, National Undersea Research Center, UConn.*

NOAA National Marine Fisheries Service research trawl data (1963-2000) from within sanctuary boundaries have been analyzed to determine the effects of fishing on fish size and structure. Data on the change in length of the largest individuals for 15 species, and the change in length of those individuals that fell within the top 10 percent for length were examined. The 15 species were: white hake *(Urophycis tenuis)*, goosefish *(Lophius americanus)*, pollock *(Pollachius virens)*, winter flounder *(Pseudopleuronectes americanus)*, silver hake, cod, windowpane flounder *(Scophthalmus aquosus)*, yellowtail flounder, haddock, American plaice *(Hippoglossoides platessoides)*, redfish, ocean pout *(Macrozoarces americanus)*, witch flounder *(Glyptocephalus cynoglossus)*, red hake *(Urophycis chuss)*, and dogfish *(Squalus acanthias).*

All of the species examined showed decreasing trends in maximum length over the 37-year period. For seven of these (white hake, goosefish, winter flounder, silver hake, cod, yellowtail flounder, haddock), regressions were highly significant, and 37-year length decreases ranged from 15 to 49 percent. The average 37-year decrease was 20 percent + 14 standard deviations and the distribution of decreases was highly significant (Crawford in prep).

The selective removal of top predators in large numbers by commercial and recreational fishing has been shown to have cascading effects on trophic dynamics that reduces ecological integrity (Jackson et al. 2001, Steneck et al. 2004, Frank et al. 2005).

The sand lance is a key species within the sanctuary and serves as the primary prey of humpback whales. Sand lance availability is largely dependent on environmental conditions and predator-prey interactions, which can be highly variable and difficult to predict. According to researchers at the University of New Hampshire, the southern range of the copepod *Calanus finmarchicus* is receding northward from Cape Cod as part of a warming trend. This copepod is considered to be an important prey species for sand lance. Additionally, the availability of sand lance is associated with the species mix and abundance of its principal larval predators, herring and mackerel. A dramatic population increase in herring is being observed, and it is uncertain how the ecosystem shift favoring small pelagic species factors into the rate of predation on sand lance. Also, there are two species of sand lance in Massachusetts waters, and it is uncertain which predominates within sanctuary waters, complicating the understanding of their respective population dynamics. Finally, there is the possibility that sand lance spawn in the sanctuary, where they deposit their eggs in sand habitats. The cyclic availability of sand lance may partly or entirely be due to variations in year class strength associated with local inter-annual spawning success.

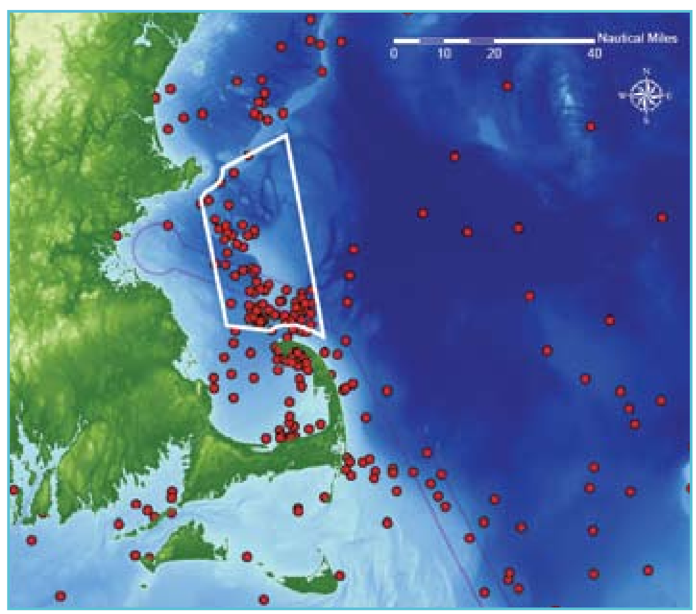
Contaminants

There are few studies that have measured contaminant concentrations in Stellwagen Bank organisms. In cases where analyses have been conducted on species from the bank or adjacent areas, concentrations of contaminants appear to be the same or only slightly elevated compared to clean control sites. At present, it is not possible to determine whether these slightly elevated contaminant concentrations are adversely affecting the health of sanctuary organisms. A number of studies on species closer to shore have shown much higher levels of contaminant body burdens, such as metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides, than the species sampled from Stellwagen Bank. However, a measurable adverse impact on organism health has only been demonstrated for the most contaminated sites (e.g. Boston Harbor, Salem Harbor, New Bedford Harbor). Therefore, it is unlikely that the low levels of contaminants measured in Stellwagen Bank species are having adverse effects on organisms' health.

Marine Mammals

Vessel collisions with whales along the east coast of the United States have received a great deal of attention in recent years because of their role in inhibiting the recovery of North Atlantic right whales. Vessel strikes are the leading cause of human-induced mortality in this species, followed by entanglement in fixed fishing gear (NOAA 2001). Given the precarious position and current decline of the right whale population, and the probability that saving only two additional right whale females per year would halt the decline, the issue is serious and demands immediate attention.

Research indicates that approximately 10 percent of the worldwide data regarding collisions were reported from the Stellwagen Bank area (including Cape Cod Bay and Boston Harbor) and that the sanctuary area is a "hot spot" for vessel strikes along the eastern U.S. seaboard (Anon 2004). Data indicate that about 39 percent of reported strikes result in mortality or serious injury (Anon 2004). Species involved included four endangered species: humpback, finback, sei *(Balaenoptera borealis),* and right and one protected species (minke), with most strikes involving humpback whales. Vessels involved in the strikes include commercial whale watch vessels, private recreational-type boats and large commercial ships.



This map shows the location of entangled whales between 1985 and 2003, many of which were sighted within the sanctuary. *Source: Provincetown Center for Coastal Studies, 2003*

Also of concern is the disturbance, or potential for disturbance, of marine mammals by human activities occurring within and around the sanctuary. Causes for behavioral disturbances include a large number of whale watching boats in the area (Stellwagen is one of the top 10 whale watching locations in the world), a high frequency of aircraft overflights in the vicinity, and noise from the high number of vessels passing through and near the bank.

Marine mammal entanglement in fishing gear is also a priority concern. Stellwagen Bank is heavily populated by marine mammals and fishing gear capable of entangling them (Wiley et al. 2003). The immediate effects of entanglement range from minor injuries to mortality. Long-term effects can include deteriorating health and decreased reproductive ability. Marine mammal species reported to be most susceptible to entanglement include baleen whales, harbor porpoises *(Phocoena phocoena)*, white-sided dolphins *(Lagenorhynchus acutus)*, and harbor seals.

Invasive Species

Invasive species exist in the sanctuary and have for many decades. However, their abundance and distribution have not been documented. Most recently, the invasive tunicate *Didemnum* sp. was observed in the sanctuary (Auster personal comm.). Monitoring the trends in invasive species is an important consideration as they can alter ecosystem structure and function.

The following information provides an assessment by sanctuary staff of the status and trends pertaining to the current state of the sanctuary's living resources:

- Sanctuary biodiversity is currently in fair to poor condition, having sustained considerable impacts from high levels of prior and current human activity, but is improving.
- The condition of extracted species from the sanctuary is currently fair to poor, with considerable fishing pressure on resources throughout the sanctuary.
- The level of non-indigenous (invasive) species is not high, but new species are being identified, which could threaten other sanctuary resources.
- The populations of key species, such as sand lance, are unstable, and fluctuate widely from year to year, with concomitant effects on consumers, such as whales. Cod, a keystone species, is significantly depleted, affecting populations of numerous other species.
- Key resources, especially marine mammals, are vulnerable to vessel strikes, entanglement, and to an unknown extent, noise. All are currently under active investigation, and proposed management actions are expected to reduce impacts.
- Numerous types of human activities occur that may influence living resource quality; levels do not appear to be changing.

Living Resources Status & Trends

Good | Good/Fair | Fair | Fair/Poor | Poor | Undet.

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

Status	Trend	Basis for Judgment
Biodiversity	▲ (Fair/Poor)	Long-term changes in fish diversity
Extracted Species	— (Fair/Poor)	Published and unpublished literature on regional and local groundfish populations
Invasive Species	▼ (Good/Fair)	Recent invasives discovered
Key Species	— (Fair/Poor)	Cod (keystone species) Sand lance (key species)
Health of Key Species	— (Fair)	Whale strikes & entanglements
Human Activities	— (Fair/Poor)	Stable levels of activity

Maritime Archaeological Resources

In the past, fishermen in the sanctuary have recovered paleontological remains representing a period when portions of Stellwagen Bank were dry land. However, most of the known archaeological resources are in the form of shipwrecks. Spanning the mouth of Massachusetts Bay, the sanctuary represents the current and historic gateway to several of America's oldest ports. Vessels entering and leaving Gloucester, Salem, Boston, Plymouth and Provincetown traversed the sanctuary's waters. Historical records indicate that several hundred vessels sank in the vicinity of the sanctuary.

Shipwrecks resting within the sanctuary's boundaries have a level of protection unavailable in other federal and international waters off Massachusetts. Sanctuary regulations prohibit moving, removing or injuring, or attempting to move, remove or injure, any submerged cultural or historical resources, including artifacts and pieces of shipwrecks (unless under permit or while conducting traditional fishing activities). Anyone violating these regulations is subject to civil penalties.

The extent of the sanctuary's archaeological inventory is just beginning to be known. Historical research indicates there could be more than 100 shipwrecks in the sanctuary. Sanctuary researchers are systematically exploring the seafloor to locate archaeological sites. They have confirmed the locations of three historic shipwrecks, the steamship *Portland* and the schooners *Frank A. Palmer* and *Louise B. Crary*. After several seasons of archaeological documentation and historical research, the three shipwrecks have been listed on the National Register of Historic Places. In addition to these shipwrecks, sanctuary researchers have located another eight shipwrecks that are now being documented.

Public meetings initiated in 2002 revealed several concerns regarding maritime archaeological resources in the Stellwagen Bank sanctuary. The three primary issues of concern are:

- The need for inventory and assessment.
- The lack of a plan for management and protection.
- The lack of interpretation.

The following information provides a summary by sanctuary staff of the status and trends pertaining to the current state of the sanctuary's maritime archaeological resources:

- The integrity of the sanctuary's maritime archaeological resources is fair, though there is evidence of prior and continuing damage caused primarily by commercial fishing gear on shallow and deep wrecks.
- Few shipwrecks have the potential to leak substantial amounts of toxic materials and no evidence of new risks (e.g. hull deterioration) is apparent.
- Both commercial and recreational fishing activities are degrading maritime archaeological resources. The most destructive are trawling and dredging, which permanently impact the integrity and archaeological value of the resource.

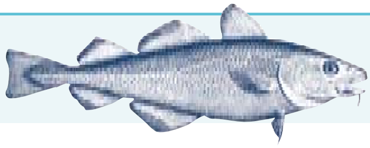
Maritime Archaeological Resources Status & Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

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

Issue	Rating	Basis for Judgment
Integrity	▼ (Fair)	Fishing gear impacts
Threat to Environment	— (Good)	Lack of hazardous cargo
Human Activities	▼ (Poor)	Fishing gear impacts

The sanctuary's state-of-the-art exhibit for the Gloucester Maritime Heritage Center opened in May 2006. *Photo: Anne Smrcina, NOAA/Stellwagen Bank*



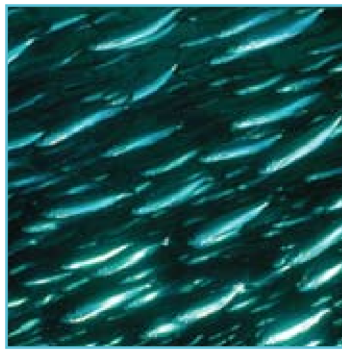
Response to Pressures

This section describes current or proposed responses to pressures. Current responses are based on implementation of the sanctuary's 1993 management plan. Proposed responses are those strategies outlined in the draft management plan developed in conjunction with the sanctuary's advisory council, a 15-member citizen advisory body. The draft plan is scheduled for release in the summer of 2007. Some recommendations are already being acted on by the sanctuary, such as moving the Boston shipping lanes to better protect endangered whales.

Ecosystem-Based Management

As the sanctuary is not an ecosystem unto itself but rather part of the much larger Gulf of Maine ecosystem, the application of ecosystem-based management to Stellwagen Bank can be approached along two parallel tracks. First, the application of ecosystem-based management in the sanctuary will involve collaboration with other regional agencies charged with managing components of the ecosystem beyond the sanctuary boundaries. Second, for management within sanctuary boundaries, a subset of the larger ecosystem can be determined by defining components unique to Stellwagen Bank, and identifying characteristics of the larger ecosystem that influence the sanctuary.

Even though NOAA's National Marine Fisheries Service is in the process of implementing ecosystem-based management principles for the management of the nation's fisheries, there are no ecosystem-based management plans in the southern Gulf of Maine at this time. The sanctuary currently regulates the mining of sand and gravel, disturbance of the seafloor (with the exception of fishing activity), and dumping of waste material within its boundaries. Fisheries management in the federal waters of the region is conducted on a species-by-species basis. Similarly, even though NOAA's National Marine Fisheries Service's Atlantic Large Whale Take Reduction Team has grouped a number of large cetaceans under its auspices, the Marine Mammal Protection Act is enforced on a species-by-species basis.



Atlantic herring is one of the marine fish species in Stellwagen Bank not considered overexploited. *Photo: Jon Witman*

A smooth sun star sits on the muddy sea floor of Stellwagen Bank. *Photo: Dann Blackwood and Page Valentine, USGS*

The sanctuary advisory council has come to consensus on the following definition and goal of ecosystem-based management for Stellwagen Bank:

"Ecosystem-Based Management [in the Stellwagen Bank sanctuary] integrates knowledge of ecological interrelationships to manage impacts within sanctuary boundaries. The general goal of ecosystem-based management is to protect the ecological integrity of [Stellwagen Bank] while recognizing that the sanctuary is nested within the Gulf of Maine's large marine ecosystem. Effective implementation of ecosystem-based management should: (1) consider ecological processes that operate both inside and outside sanctuary boundaries, (2) recognize the importance of species and habitat diversity, and (3) accommodate human uses and associated benefits within the context of conservation requirements."

In an effort to begin the implementation of ecosystem-based management, the sanctuary advisory council also recommends the following research and management strategies:

- Understand ecosystem structure and function.
- Protect ecological integrity.
- Evaluate the need and feasibility for modifying the sanctuary boundary.

- Establish a research steering committee.
- Establish a collaborative research consortium.
- Establish an information management program.

Ecosystem Alteration

Humans alter ecosystems in numerous ways. A variety of activities and issues of direct relevance to the alteration of the Stellwagen Bank ecosystem have been identified and ranked by the sanctuary advisory council's ecosystem alteration working group, as follows:

- **mobile fishing gear**
- **biomass removal resulting from fishing**
- **pollution**
- **ocean dumping and marine debris**
- **disposal of dredged materials**
- **laying of pipelines and cables**
- **exotic species**
- **mariculture**
- **coastal activities**

Water Quality

National marine sanctuaries have long been places that prohibit discharges within their boundaries. Every sanctuary has been designated with the authority to develop some form of discharge regulation to protect its natural and cultural resources. For example, most national marine sanctuaries prohibit the discharge of garbage, trash, and plastics, and oily wastes from bilge pumping. However, most sanctuaries have specific exemptions to their discharge prohibition.

Scientists from the Marine Biological Laboratory in Woods Hole monitor sediment metabolism for the Massachusetts Water Resources Authority. *Photo: Carlton Hunt, Battelle Ocean Sciences*

Regulations for Stellwagen Bank sanctuary specifically prohibit:

1) Discharging or depositing, from within the boundary of the sanctuary, any material or other matter except:
   - fish, fish wastes, chumming materials or bait used in or resulting from traditional fishing operations in the sanctuary;
   - biodegradable effluent incidental to vessel use and generated by marine sanitation devices approved in accordance with the Federal Water Pollution Control Act;
   - water generated by routine vessel operations (e.g., cooling water, deck wash down and graywater as defined by the Federal Water Pollution Control Act), excluding oily wastes from bilge pumping; or
   - engine exhaust.
2) Discharging or depositing, from beyond the boundary of the sanctuary, any material or other matter except those listed above, that subsequently enters the sanctuary and injures a sanctuary resource or quality;
3) Lightering in the sanctuary (transferring cargo, usually oil, between vessels).

In many areas, more research must be undertaken before it can be determined whether certain waste streams present potential human and/or environmental threats. In other areas, it was decided that partnerships with outside monitoring, modeling and research efforts may provide the technical resources needed by the sanctuary for a better understanding of water quality at the site. Sanctuary staff have determined that at this time, the focus on water quality will be divided into two initiatives, both of which will be proposed in the Stellwagen Bank draft management plan and implemented within the next five years.

Water Quality Monitoring

The Massachusetts Water Resources Authority initiated a water quality monitoring program in 1992 with some sampling sites occurring within sanctuary boundaries. In 2001, the sanctuary augmented the two MWRA sites with four additional sites sampled twice annually. Together, these initiatives include a water quality monitoring, modeling and assessment program for Stellwagen Bank that assures the goals of protecting natural and cultural resources and human health. The draft management plan includes development of a comprehensive water quality monitoring program, implementation of an ocean observing system, and evaluation and use of water quality models for sanctuary management. The water quality monitoring plan will evaluate the inclusion of sediment monitoring, recognizing that contaminants in sediments contribute to the quality of the overlying water and the health of living resources.

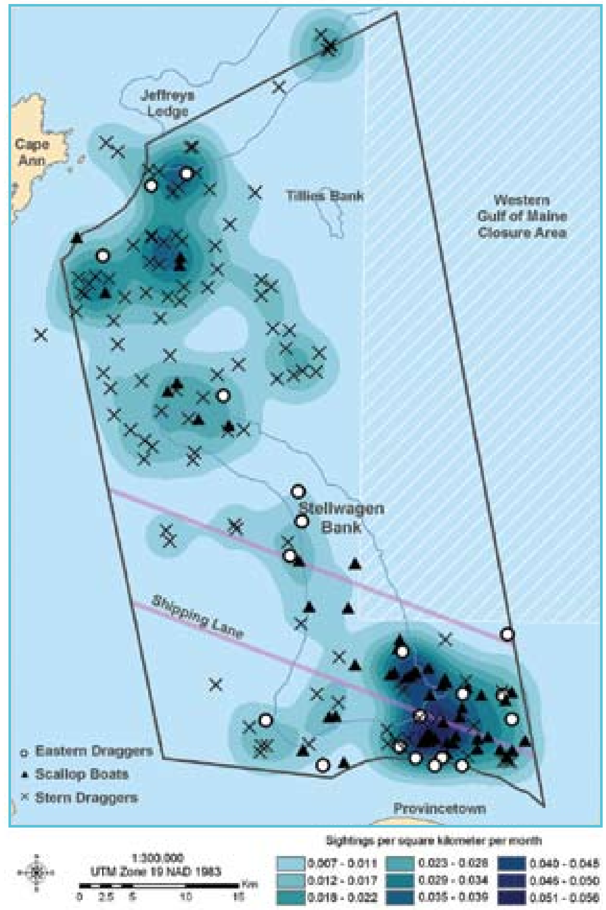
Vessel Discharges and Other Waste Streams

This initiative will implement strategies to prevent impacts to sanctuary resources from discharges from vessels, sewage outfalls, and other waste streams. The emerging plans include discussion of the designation of a no-discharge zone for the sanctuary and development of a ballast water management strategy. Furthermore, strategies for addressing contingency planning for oil or other hazardous material spills as well as responses to catastrophic failures or other pollution events from sewage effluents and disposal activities are also being developed. There is a strong emphasis on interagency cooperation and responsibility.

Habitat

To effectively address pressures on the integrity of the sanctuary habitat, it is necessary to observe the sanctuary's marine ecosystem in its entirety. Elements of the marine ecosystem are closely associated with one another, and an understanding of these relationships can assist in determining the overall health of the environment. For example, there is a high degree of correlation between habitat and biological recovery rates. That is, if habitat is severely disturbed such that it causes a noticeable reduction in a fish species, the recovery rate of the species is likely to be highly correlated with the recovery rate of the associated habitat. Correlations between these living and nonliving resources provide methods of measuring the health of the sanctuary habitat.

Currently, regulations pertaining to Stellwagen Bank sanctuary prohibit drilling into, dredging or otherwise altering the seabed of the sanctuary; or constructing, placing or abandoning any structure or material or other matter on the seabed of the sanctuary, except as an incidental result of (1) anchoring vessels; (2) traditional fishing operations; or (3) installation of navigation aids.



Distribution and relative density of bottom-tending trawler fishing effort in the sanctuary, 2001-2002. *Source: Wiley et al. 2003*

Substantial regulations promulgated by NOAA's National Marine Fisheries Service and state agencies also govern fishing effort in the Northeast, including Stellwagen Bank. Some directly or indirectly affect the impact of mobile gear on benthic habitats, particularly in areas considered to be essential fish habitat. The regulations direct the New England Fishery Management Council and NOAA's National Marine Fisheries Service to: (1) describe and identify essential fish habitat in each fishery management plan, (2) minimize to the extent practicable the adverse effects of fishing on essential fish habitat, and (3) identify other actions to encourage the conservation and enhancement of essential fish habitat. These regulations apply to Stellwagen Bank sanctuary, but the sanctuary does not have the independent ability to modify or maintain those regulations.

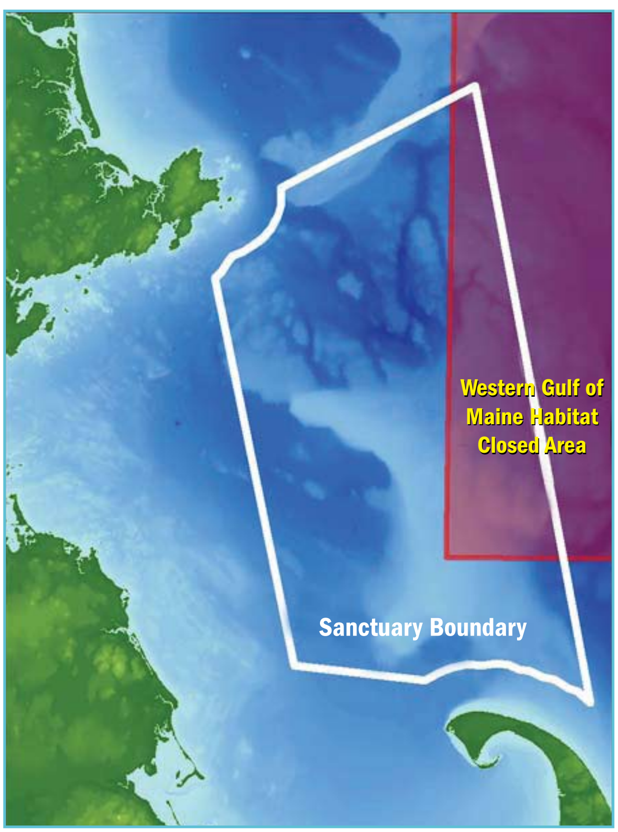
Although numerous regulations exist to protect the Stellwagen Bank habitat, several concerns remain, as indicated in the list above. Six in particular are receiving current attention:

(1) alteration of benthic habitat due to commercial fishing activities; (2) the potential issuance of permits to lay cables and pipelines within sanctuary boundaries: (3) ocean dumping; (4) discharge of dredge spoil; (5) lack of an undisturbed reference area; and (6) the potential for mariculture activities.

To address these issues, the sanctuary advisory council has recommended the development of plans to:

- Focus on the ecosystem impacts of the laying of cables and pipelines within the sanctuary.
- Reduce the alteration of benthic habitat by mobile fishing gear.
- Reduce the ecosystem impacts of biomass removal by fishing activity.
- Focus on the ecosystem impacts of ocean dumping, the disposal of dredged materials and mariculture.

The sanctuary advisory council has convened a working group to consider zoning as a means to restore and protect the ecological integrity of the sanctuary.



The Western Gulf of Maine Habitat Closed Area was created by NOAA's National Marine Fisheries Service and the New England Fishery Management Council in 1998 to aid in the recovery of groundfish. It overlaps with 22 percent of the sanctuary and serves as a de facto reference area. *Source: NOAA/Stellwagen Bank*

Living Resources

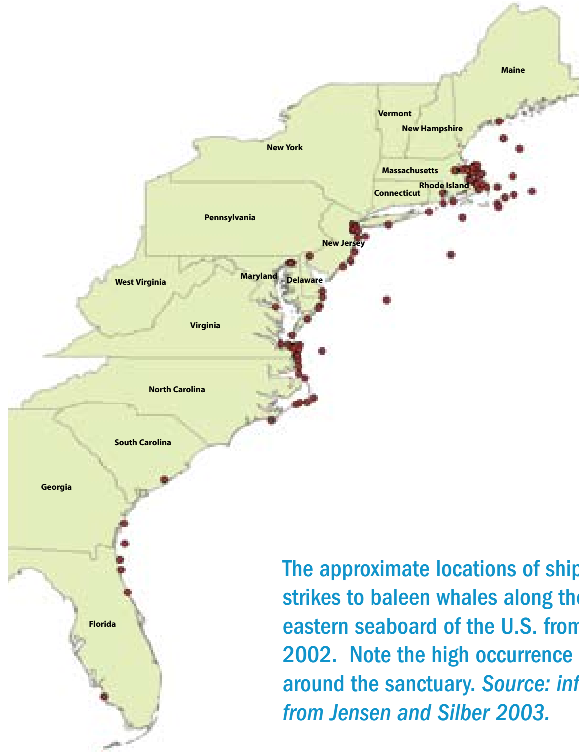
Fishing regulations in Stellwagen Bank, promulgated by various fishery management agencies, focus on managing exploitation of particular taxa and not necessarily on conservation of biological diversity overall. Besides the National Marine Sanctuaries Act, currently only the Endangered Species Act deals with the protection of taxa not linked to fishing. Of the 3,317 species in the Gulf of Maine region (COML 2006), there are only 41 species that are managed by the regional fishery management councils (as well as tunas, sharks, swordfish, and billfish groups that are managed separately as highly migratory species) and 12 species managed under the Endangered Species Act. This leaves the majority of biodiversity in the Stellwagen Bank sanctuary with little or no management or protection unless a new fishery develops or it is found that populations have declined to the extent that they are somehow endangered.

Fishery resources in the Northeast, including in the sanctuary, are regulated by NOAA's National Marine Fisheries Service with input from the New England and Mid-Atlantic fishery management councils and the Atlantic States Marine Fisheries Commission. Some restrictions on fishing that affect the sanctuary have been put in place, including rolling closures for groundfishing, catch limits for individual species, and a large, permanent year-round habitat closure in the Western Gulf of Maine. Although NOAA's National Marine Fisheries Service is the primary regulatory authority for fishing, the National Marine Sanctuaries Act provides a mechanism for interagency consultation allowing the sanctuary to have input on the fishing regulations that may affect its resources. Periodic reviews of a sanctuary management plan also allow the sanctuary to adjust or create regulations to better protect its resources.

Due to the large number of threatened and endangered species, and the increasing pressures of human activity in and around the sanctuary, marine mammals are of special interest. Three critical issues have been identified and will be addressed in the Stellwagen Bank National Marine Sanctuary Draft Management Plan: marine mammal vessel strikes, marine mammal behavioral disturbances, and marine mammal entanglements.

Under NOAA's National Marine Fisheries Service, fish species taken commercially and recreationally in the Stellwagen Bank are managed through a number of fishery management plans, including:

- American Lobster Fishery
- Northeast Multispecies Fishery
- Atlantic Sea Scallops
- Herring
- Dogfish
- Monkfish
- Whiting
- Northern shrimp
- Skate
- Atlantic Salmon
- Atlantic Mackerel, Squid, and Butterfish
- Atlantic Surf Clam and Ocean Quahog
- Atlantic Bluefish
- Summer Flounder



The approximate locations of ship strikes to baleen whales along the eastern seaboard of the U.S. from 1979-2002. Note the high occurrence in and around the sanctuary. *Source: inferred from Jensen and Silber 2003.*

Marine Mammal Vessel Strikes

NOAA and the members of the commercial shipping industry currently disagree over the sanctuary's authority to regulate commercial shipping activities. NOAA asserts that the National Marine Sanctuaries Act provides broad powers to manage commercial shipping, while industry believes that their activities are outside of the sanctuary's purview.

NOAA's objective for addressing the issue of vessel strikes is to determine where and when the potential of collision with marine mammals exists within the sanctuary, to determine what mitigation measures might be necessary and appropriate to minimize that potential and, if necessary, determine what steps might be taken to assess the potential of collision where insufficient information currently exists. Additional objectives are to foster cooperation with cross-jurisdictional partners addressing the issues, and educate sanctuary users regarding the issues.

NOAA staff will work in partnership with various agencies, industries and organizations to address the issue of vessel strikes to marine mammals. NOAA and the U.S. Coast Guard recommended moving the current Boston shipping lanes to reduce the risk of ship strikes to whales. The change was approved by the International Maritime Organization in December 2006. Primary actions that have been recommended by the sanctuary advisory council are:

- Management of commercial ships to reduce the risk of vessel strikes by large commercial ships with right whales and other baleen whales. At a minimum, voluntary speed restrictions should be instituted for large commercial ships to mitigate vessel strikes to marine mammals.
- Management of other vessels not actively engaged in approaching whales for viewing. Voluntary speed restrictions should be instituted for vessels other than large commercial ships to mitigate vessel strikes to marine mammals.
- Management of vessels actively engaged in approaching whales for viewing. The sanctuary proposes to seek ways to increase compliance with the current whale watching guidelines established for the northeast region of the United States.

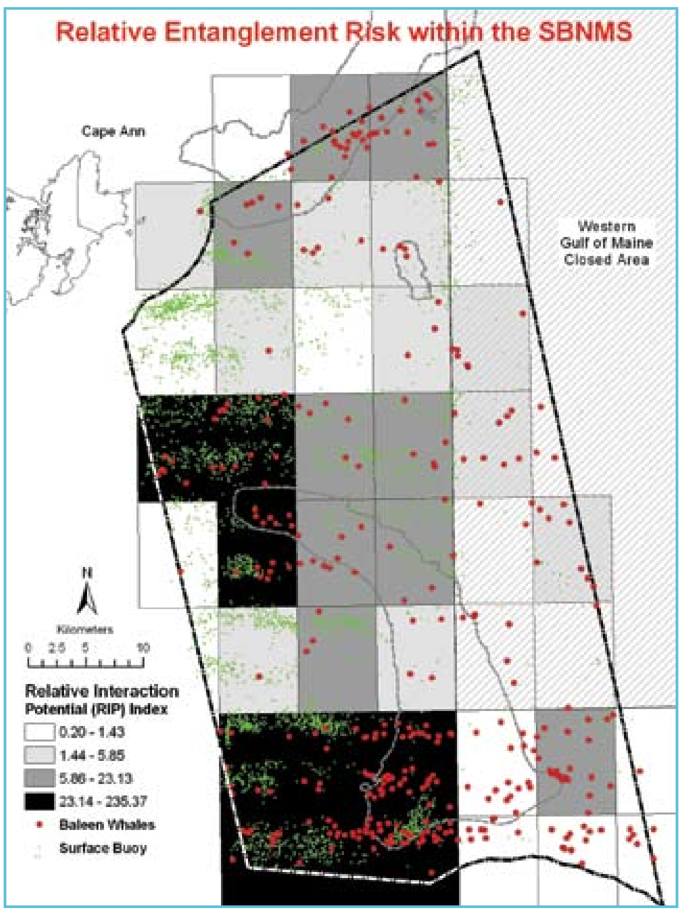
Marine Mammal Behavioral Disturbance

There are numerous ways in which marine mammals are potentially disturbed by human activities in the sanctuary. These include activities associated with vessels, aircraft flying over the sanctuary, fishing activities, and other noise disturbances in the vicinity.

Guidelines exist that are intended to reduce these disturbances (e.g., NOAA's National Marine Fisheries Service whale watch guidelines). Underlying these guidelines is the Marine Mammal Protection Act, which federally protects all whales, dolphins and porpoises in U.S. waters. Most large whales are further protected under the Endangered Species Act, including North Atlantic right, humpback, fin, sei, and blue whales.

As there is limited protection from human disturbance of marine mammals in the vicinity of Stellwagen Bank, the sanctuary advisory council has proposed several actions:

- Develop regulations governing the operation of vessels in the vicinity of whales, porpoises, and dolphins. This action includes enforcement, education, outreach, and research.
- Sponsor a consortium to examine and promulgate research on noise in and around the sanctuary and determine its effects on marine life.
- Include the recreational and commercial fishing communities in the development of education materials regarding precautionary operation of vessels around whales.



This map indicates high risk areas for whale entanglement based on co-occurrence of whales (red dots) and fixed fishing gear (green dots). *Source: NOAA/Stellwagen Bank*

Marine Mammal Entanglement

Marine mammal entanglement in fishing gear is a global problem that impacts many species. Relative to other areas, entanglement reports in Stellwagen Bank are frequent, which could reflect an increased rate of entanglement, increased observer effort, or both. There is frequent co-occurrence between various marine mammal species and types of fishing gears; however, such co-occurrence varies on a spatial and temporal basis.

A number of existing regulations and plans designed to reduce the risk of marine mammal entanglement in the Northeast apply to, but are not specific to, Stellwagen Bank sanctuary. Regulations that are most applicable to marine mammal entanglement within the sanctuary are those pertaining to trap/pot fisheries and gillnet fisheries.

Examples are:

- Federal lobster trap limits
- Lobster trap gear identification
- Lobster trap maximum size
- Trap/pot gear restrictions
- Lobster trap gear configuration
- Special restrictions on critical habitat areas
- Restrictions on anchored gillnet gear
- Multispecies sink gillnet regulations (aimed at rebuilding overfished groundfish stocks)
- Seasonal and rolling closure areas
- Gear stowage requirements

Continuing reports of entangled marine mammals, despite federal and state regulations, are of concern. The sanctuary advisory council has recommended four strategies to address the issue:

- Work in partnership with various agencies, industries, and organizations identifying, reporting, and responding to entangled whales to increase the degree to which entangled whales within the sanctuary are sighted, reported, and assisted.
- Work toward a regulation enforcing the use of sinking groundline within the sanctuary within five years, or comply with NOAA's National Marine Fisheries Service regulations (whichever is more stringent). It is also recommended that the breaking strength of buoy weak links in trap and pot gear throughout the sanctuary be lowered to 600 pounds.

- Act on an expedited basis to require gillnet fisheries to implement gillnet modifications under the Seasonal Area Management Program (the program is designed to protect seasonal, predictable aggregations of right whales).
- Secure a NOAA vessel for permanent duty at the sanctuary to provide a regular presence and team with other state and federal agencies to achieve the desired coverage. The vessel should be equipped to haul gear to check for compliance with state and federal regulations.

Maritime Archaeological Resources

The National Marine Sanctuaries Act requires each sanctuary to inventory and document its maritime archaeological resources. Given the existence of historically important shipwrecks in the Stellwagen Bank sanctuary, the likelihood of finding more, and the keen public interest in these resources, it is incumbent upon the sanctuary to continue its effort to inventory and document maritime archaeological resources. NOAA has been charged with protecting and managing maritime archaeological resources within its marine sanctuaries. The National Marine Sanctuary Program regulations mandate that NOAA abide by laws and regulations of the Federal Archaeological Program. These include developing archaeological resource inventory and management programs, overseeing federal activities that may affect historic and cultural resources, and nominating potentially eligible sites to the National Register of Historic Places.

Currently there are three sanctuary specific regulations that pertain to the protection of archaeological resources within Stellwagen Bank sanctuary. Prohibited or otherwise regulated activities are:

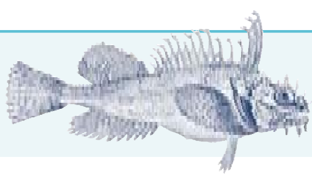
- Drilling into, dredging or otherwise altering the seabed of the sanctuary; or constructing, placing or abandoning any structure, material or other matter on the seabed of the sanctuary, except as an incidental result of: (1) anchoring of vessels; (2) traditional fishing operations; or (3) installation of navigational aids.
- Moving, removing or injuring, or attempting to move, remove or injure, a sanctuary historical resource. This prohibition does not apply to moving, removing or injury resulting incidentally from traditional fishing operations.
- Possessing within the sanctuary (regardless of where taken, moved or removed from), except as necessary for valid law enforcement purposes, any historic resource, or any marine mammal, marine reptile or seabird taken in violation of the Marine Mammal Protection Act, Endangered Species Act or Migratory Bird Treaty Act.

The sanctuary advisory council has recommended strategies to address the further protection and inventory of Stellwagen Bank sanctuary's maritime archaeological resources. The following four items highlight each of these strategies:

- Develop the foundation and infrastructure for a maritime heritage program at Stellwagen Bank sanctuary, including a full-time maritime/marine archaeologist on staff and the familiarization of all sanctuary staff with the maritime heritage program. The sanctuary will also integrate the maritime heritage program into existing natural resource protection programs.
- Develop and implement a systematic plan for the inventory and assessment of archaeological resources.
- Create and implement a maritime heritage management system to protect the archaeological resources while allowing for compatible uses.
- Assess existing sanctuary outreach programs and incorporate the maritime heritage program information into already established programs, such as: (1) the sanctuary website (with links to and from other websites); (2) trade show booths; (3) annual publications (*Banknotes, Soundings, State of the Sanctuary*); (4) workshops.

Cod congregate under a portion of the *Paul Palmer* shipwreck in the sanctuary. *Photo: Tane Casserley, NOAA Maritime Heritage Program*

The *Portland* steaming out of Boston Harbor during its first visit to the city. *Source: Maine Maritime Museum*



Concluding Remarks

This initial report on resource status and trends for Stellwagen Bank National Marine Sanctuary indicates the need for management actions that address the degraded conditions of some key habitats and living resources in the sanctuary. Over half the categories (10 of 17) had fair through poor ratings, with eight of ten relating to habitat or living marine resources. The general trend for living resources appears to be static and in need of improvements, an indication that pressures on living resources are high, requiring targeted management efforts. The status of benthic communities and habitats remains problematic, as well. The report also suggests that monitoring programs for water quality and a number of other resources (e.g., habitat contaminants and invasive species) need to be enhanced.

Stellwagen Bank sanctuary has moved proactively in recent years to address critical monitoring and research needs, such as understanding the relationship between whale distributions and ship traffic, and ascertaining the acoustic environment of the sanctuary in order to determine what threats noise may pose. The sanctuary has used this information to make relatively minor changes in vessel traffic patterns that could reduce the threat of vessel strikes of whales by over 80 percent. The site is also working with partners in academia and industry to tag whales in order to understand behaviors such as dive times and feeding strategies. These behaviors may affect their vulnerability to human activities and natural environmental changes.

Research and monitoring programs will continue to be essential precursors to management at Stellwagen Bank National Marine Sanctuary. Through its revised management plan and reports like this one, the site and its partners will set a course for actions that have as their sole target the restoration and protection of the sanctuary's rich natural resources and cultural legacy.

The moon jelly is a common jellyfish in these waters. It has four distinct horseshoe-shaped gonads and small tentacles. It is usually found close to the surface and near shore. *Photo: Jeff Hannigan*

Acknowledgements

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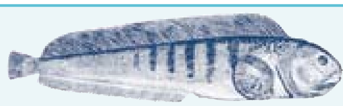


Cited Resources

Introduction

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.

Overview

Stellwagen Bank National Marine Sanctuary: Sanctuary Setting
http://stellwagen.noaa.gov/about/setting.html

Site History and Resources

Discovery of the Bank

Stellwagen Bank National Marine Sanctuary: Discovery of the Bank
http://stellwagen.noaa.gov/about/discovery.html

Commerce

U.S. Dept. of Commerce: Background on the New England Economy
http://www.buyusa.gov/newengland/background.html

Water

Stellwagen Bank National Marine Sanctuary: Physical Oceanography
http://stellwagen.noaa.gov/about/sitereport/oceanog.html

Geyer, W. R. and others 1992. Physical oceanographic investigation of Massachusetts and Cape Cod Bays. Massachusetts Bays Program Report MBP-92-03.

Habitat

Stellwagen Bank National Marine Sanctuary: Resources
http://stellwagen.noaa.gov/management/mpr/resource.html

Lindholm, J., L. Kaufman, M. Ruth and P. Auster. 1998. A modeling approach to the design of marine refugia for fishery management. Science & Management of Protected Areas:138-150.

Lindholm, J.B., P.J. Auster and L.S. Kaufman. 1999. Habitat-mediated survivorship of juvenile (0-year) Atlantic cod Gadus morhua. Marine Ecology Progress Series: 180: 247-255.

Lindholm, J.B., P.J. Auster, M. Ruth and L. Kaufman. 2001. Modeling the effects of fishing and implications for the design of marine protected areas: Juvenile fish responses to variations in seafloor habitat. Conservation Biology: 15(2): 424-437.

Scharf, F.S., J.P. Manderson and M.C. Fabrizio. 2006. The effects of seafloor habitat complexity on survival of juvenile fishes: Species-specific interactions with structural refuge. Journal of Experimental Marine Biology and Ecology: 335: 167-176.

Tupper, M. and R.G. Boutilier. 1995. Effects of habitat on settlement, growth, and post-settlement survival of Atlantic cod (*Gadus morhua*). Canadian Journal of Fisheries and Aquatic Sciences: 52: 1834-1841.

Valentine, P.C., T.S. Unger, and J.L. Baker. 2001. Sun-illuminated sea floor topography and backscatter intensity of the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts. US Geological Survey, Woods Hole, Massachusetts. 1:60,000.

Living Resources
Stellwagen Bank National Marine Sanctuary: Resources http://stellwagen.noaa.gov/management/mpr/resource.html

Maritime Archaeological Resources
Stellwagen Bank National Marine Sanctuary: Maritime Heritage Resources http://stellwagen.noaa.gov/about/cultural.html

NOAA Ocean Explorer / Explorations: The Wreck of the *Palmer* and the *Crary* http://www.oceanexplorer.noaa.gov/explorations/03portland/background/palmercrary/palmercrary.html

Pressures on the Sanctuary

Shipping
Massport, Port of Boston http://www.massport.com/ports/

Outfall Discharges & Dumping Sites
Wiley, D., V. Capone, D.A. Carey, and J.P. Fish. 1992. Location survey and condition inspection of waste containers at the Massachusetts Bay Industrial Waste Site and surrounding areas. Report submitted to EPA Region I by the International Wildlife Coalition, Falmouth, MA.

Stellwagen Bank National Marine Sanctuary Water Quality Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/wqaction.pdf

Fiber-Optic Cable
Stellwagen Bank National Marine Sanctuary: Human Uses http://stellwagen.noaa.gov/management/mpr/humanuse.html

Industry
Stellwagen Bank National Marine Sanctuary: Sediment and Water Quality http://stellwagen.noaa.gov/about/sitereport/sedwat.html

Noise
National Research Council. 2003. Ocean Noise and Marine Mammals. The National Academies Press. Washington, DC.

Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. Academic Press. New York, NY.

Commercial Fishing
Stellwagen Ban National Marine Sanctuary: Human Uses http://stellwagen.noaa.gov/management/mpr/humanuse.html

Commercial Whale Watching
Baker, S. 1988. Behavioral response of humpback whales to vessels in Glacier Bay. In *Proceedings of the Workshop to Review and Evaluate Whale Watching Programs and Management Needs,* 14-16 November 1988, Monterey, CA.

Corkeron, P.J. 1995. Humpback whales in Hervey Bay, Queensland: Behavior and responses to whale-watching vessels. *Canadian Journal of Zoology* 73(7): 1290-1299.

Donovan, G.P. 1986. Behavior of whales in relation to management. Report of the International Whaling Commission, Special Issue 8. Cambridge, UK.

Recreational Fishing and Boating
New England Fishery Management Council. 2003. Final Amendment 13 to the Northeast Multispecies Fishery Management Plan. Vol. 1. (http://www.nefmc.org/nemulti/index.html)

Stellwagen Bank National Marine Sanctuary: Human Uses http://stellwagen.noaa.gov/management/mpr/humanuse.html

Climate Change
Epstein, P. R., T. E. Ford, and R. R. Colwell. Health and climate change: Marine ecosystems. The Lancet 1993; 342:1216-1219.

Harvell CD, et al. Diseases in the ocean: emerging pathogens, climate links, and anthropogenic factors. Science 1999: 285:1505-1510.

MA Office of Coastal Zone Management http://www.mass.gov/czm/oceanmanagement/waves_of_change/pdf/troceancc.pdf

State of Sanctuary Resources

Water
Battelle Ocean Sciences. 1987. Marine ecology and water quality field program: Deer Island Secondary Treatment Plan - Water column chemistry. Report to Massachusetts Water Resources Authority.

Menzie-Cura and Associates, Inc. 1995. Organic loadings from the Merrimack River to Massachusetts Bay. Report submitted to the Massachusetts Bays Program.

MWRA. 2004. Massachusetts Water Resources Authority effluent outfall ambient monitoring plan Revision 1, March 2004. Boston: Massachusetts Water Resources Authority. Report ENQUAD ms-092. 65 p.

Stellwagen Bank National Marine Sanctuary Water Quality Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/wqaction.pdf

Stellwagen Bank National Marine Sanctuary: Contaminants in the Water http://stellwagen.noaa.gov/about/sitereport/watercont.html

Habitat
Auster, P. and R. Langton. 1999. The effects of fishing on fish habitat. Pages 150-187 in L. Benaka, editor. Fish habitat: Essential fish habitat and rehabilitation. American Fisheries Society, Symposium 22, Bethesda, Maryland.

Auster, P. J., R. J. Malatesta, R. W. Langton, L. Watling, P. C. Valentine, C. L. S. Donaldson, E. W. Langton, A.N. Shepard, and I. G. Babb. 1996. The impacts of mobile fishing gear on sea floor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Rev. Fish. Sci., 4:185-202.

Bothner, M.H., and B. Butman, eds. 2005. Processes influencing the transport and fate of contaminated sediments in the coastal ocean – Boston Harbor and Massachusetts Bay. USGS Open-File Report 2005-1250.

Bothner, M.H., M. Bucholtz ten Brink, C.M. Parmenter, W.M., d'Angelo, and M.W. Doughten. 1993. The distribution of silver and other metals in sediments from Massachusetts and Cape Cod Bays: U.S. Geological Survey Open-File Report 93-725. 31 p.

Bothner, M.H., M. Bucholtz ten Brink, Marilyn, B. Butman, J.H. Knebel, F.T., Manheim, and R.P. Signell. 1994. Circulation and contaminant transport in Massachusetts coastal waters -- A summary of achievements and future plans: U.S. Geological Survey Open-File Report 94-649, 43 p.

Dorsey, E.M. and J. Pederson. 1998. Effects of Fishing Gear on the Sea Floor of New England. Conservation Law Foundation. Boston, MA http://www.clf.org/general/index.asp?id=352

Grannis, B.M. (2001) Impacts of Mobile Fishing Gear and a Buried Fiber-optic Cable on Soft-sediment Benthic Community Structure. M.S.Thesis, University of Maine, Orono.

McNaught, D. (Unpublished MS) SHRMP Final Report.

NOAA National Centers for Coastal Ocean Science (NCCOS). In Prep. An ecological characterization of the Stellwagen Bank National Marine Sanctuary region: oceanographic, biogeographic and contaminant assessment. Silver Spring, MD. NOAA Technical Memorandum.

Stellwagen Bank NMS: Activities and Conditions which Indirectly Affect Marine Mammals http://stellwagen.noaa.gov/about/sitereport/indirect.html

Stellwagen Bank NMS Ecosystem Alteration Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/eaaction.pdf

Tamsett, A. (In Preparation) Fishing Effects on Epifaunal Communities, and the Role of Attached Epifauna as Fish Habitat. University of Connecticut.

Watling, L. and E.A. Norse. 1998. Disturbance of the seabed by mobil fishing gear: a comparison to forest clear cutting. Conservation Biology. 12: 1180-1197.

Living Resources

Anon. 2004. Marine Mammal Vessel Strike Action Plan. A Report to the Stellwagen Bank National Marine Sanctuary Advisory Council, October 2004.

Auster, P.J. 2002. Representation of biological diversity of the Gulf of Maine region at Stellwagen Bank National Marine Sanctuary (Northwest Atlantic): patterns of fish diversity and assemblage composition. p. 1096-1125. Managing Protected Areas in a Changing World. S. Bondrup-Nielson, T. Herman, N.W.P. Munro, G. Nelson and J.H.M. Willison (eds.). Science and Management of Protected Areas Association, Wolfville, Nova Scotia.

Crawford, J. In Prep. An analysis of change in maximum fish length of 17 commercially important fish species. SBNMS.

Frank et al. 2005. Trophic Cascades in a Formerly Cod-Dominated Ecosystem. Science 308: 1621–1623.

Jackson et al. 2001. Historical Overfishing and the Recent Collapse of Coastal Ecosystems. Science 293: 629-637.

Jensen, A.S., and G.K. Silber. 2003. *Large Whale Ship Strike Database.* NOAA Technical Memorandum NMFS-F/OPR-25, U.S Department of Commerce, National Oceanic and Atmospheric Administration.

Lindholm, J. 2003. The Seafloor Habitat Recovery Monitoring Program (SHRMP) at the Stellwagen Bank National Marine Sanctuary: A Review of Sampling Effort and Results to Date. Report to the Stellwagen Bank National Marine Sanctuary.

NOAA. 2001. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments- 2001. NOAA Technical Memorandum NMFS-NE-168. U.S Department of Commerce, National Oceanic and Atmospheric Administration.

NOAA. 2006. Species of concern list. (http://www.nmfs.noaa.gov/pr/species/concern/)

NOAA National Centers for Coastal Ocean Science (NCCOS). In Prep. An ecological characterization of the Stellwagen Bank National Marine Sanctuary region: oceanographic, biogeographic and contaminant assessment. Silver Spring, MD. NOAA Technical Memorandum.

Steneck et al. 2004. Accelerating Trophic-level Dysfunction in Kelp Forest Ecosystems of the Western North Atlantic. Ecosystems 7: 323–332.

Wiley, D. N., J.C. Moller, and K.A. Zilinskas. 2003. The distribution and density of commercial fisheries and baleen whales within the Stellwagen Bank National Marine Sanctuary: July 2001-June 2002. *Marine Technology Society Journal* 37:1 35-53.

Stellwagen Ban National Marine Sanctuary: Contaminants in Organisms' Tissues http://stellwagen.noaa.gov/about/sitereport/orgcont.html

Stellwagen Bank National Marine Sanctuary Ecosystem Alteration Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/eaaction.pdf

Stellwagen Bank National Marine Sanctuary Marine Mammal Behavioral Disturbance Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/mmbdaction.pdf

Stellwagen Bank National Marine Sanctuary Marine Mammal Entanglement Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/mmeaction.pdf

Maritime Archaeological Resources

NOAA Ocean Explorer / Explorations: The Wreck of the Palmer and the Crary http://www.oceanexplorer.noaa.gov/explorations/03portland/background/palmercrary/palmercrary.html

Stellwagen Bank National Marine Sanctuary Maritime Heritage Resources Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/mhraction.pdf

Response to Pressures

Stellwagen Bank National Marine Sanctuary Ecosystem-Based Management Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/ebmaction.pdf

Water

Stellwagen Bank National Marine Sanctuary Water Quality Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/wqaction.pdf

Habitat

Stellwagen Bank National Marine Sanctuary Ecosystem Alteration Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/eaaction.pdf

Living Resources

Jensen, A.S., and G.K. Silber. *Large Whale Ship Strike Database*. NOAA Technical Memorandum NMFS-F/OPR-25, U.S Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 2003, 37.

Stellwagen Bank National Marine Sanctuary: About Fishing http://stellwagen.noaa.gov/about/faq.html#fishing

Stellwagen Bank National Marine Sanctuary Marine Mammal Vessel Strike Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/mmvsaction.pdf

Stellwagen Bank National Marine Sanctuary Marine Mammal Behavioral Disturbance Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/mmbdaction.pdf

Stellwagen Bank National Marine Sanctuary Marine Mammal Entanglement Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/mmeaction.pdf

Maritime Archaeological Resources

Stellwagen Bank National Marine Sanctuary Maritime Heritage Resources Action Plan http://stellwagen.noaa.gov/management/workinggroups/wgpdf/mhraction.pdf

Additional Resources

Census of Marine Life – Gulf of Maine
http://www.usm.maine.edu/gulfofmaine-census/

Gerry E. Studds Stellwagen Bank National Marine Sanctuary
http://stellwagen.noaa.gov/

Gulf of Maine Council on the Marine Environment
http://www.gulfofmaine.org/

Gulf of Maine Ocean Observing System (GoMOOS)
http://www.gomoos.org/

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

Massachusetts Office of Coastal Zone Management
http://www.mass.gov/czm/

Massachusetts Water Resources Authority
http://www.mwra.state.ma.us/

NOAA National Marine Sanctuary Program
http://www.sanctuaries.nos.noaa.gov/welcome.html

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

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

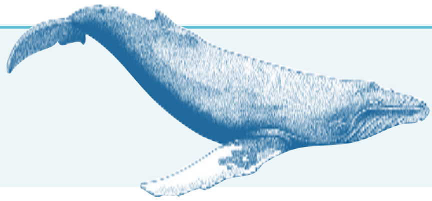
NOAA's Undersea Research Center
http://www.uncwil.edu/nurc/

New England Aquarium http://www.neaq.org/

New England Fishery Management Council
http://www.nefmc.org/

Provincetown Center for Coastal Studies
http://www.coastalstudies.org/

Woods Hole Oceanographic Institution
http://www.whoi.edu/



Appendix A: Rating Scheme for System-Wide Monitoring Questions

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

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

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

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

Water Stressors

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

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

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

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

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 resources 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, and algae are another example, seagrass beds another.

This question is intended to address these types of places, where organisms form structures (habitats) on which other organisms depend.

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

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 Invasive 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 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.

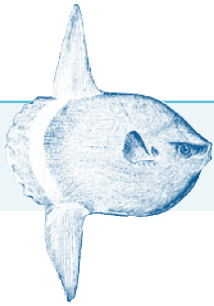
Good	Known maritime archaeological resources pose few or no environmental threats.
Good/Fair	Selected maritime archaeological resources may pose isolated or limited environmental threats, but substantial or persistent impacts are not expected.
Fair	Selected maritime archaeological resources may cause 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 mayinfluence maritime archaeological resource quality and how are they changing?

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

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



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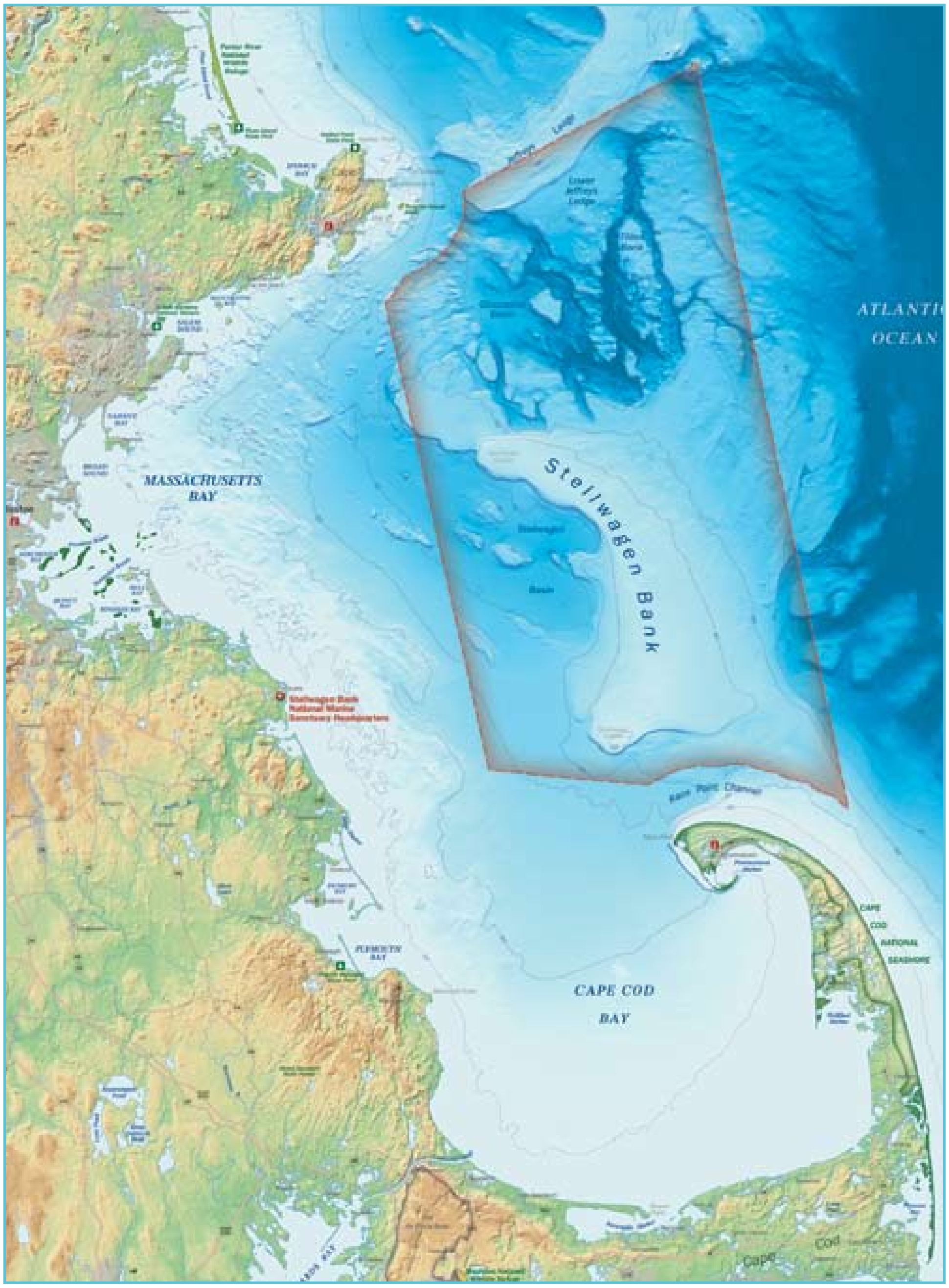

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National Marine Sanctuary

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