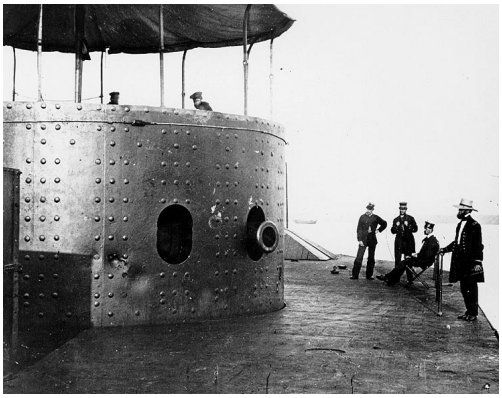
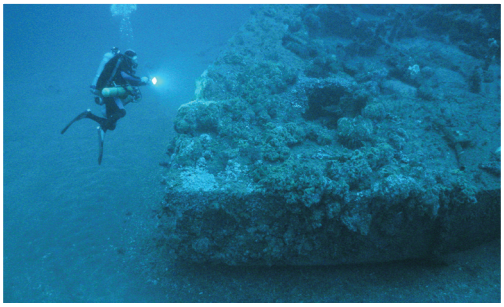
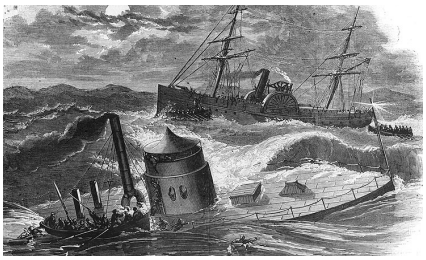
Monitor National Marine Sanctuary

CONDITION REPORT 2008







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NATIONAL MARINE SANCTUARIES

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

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

National Ocean Service
John H. Dunnigan, Assistant Administrator

Office of National Marine Sanctuaries
Daniel J. Basta, Director

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

Monitor National Marine Sanctuary
100 Museum Drive
Newport News, VA 23606
757-599-3122
http://monitor.noaa.gov/

Report Preparation:

Monitor National Marine Sanctuary:
David Alberg, Jeff Johnston, Ewa Silver, Krista Trono

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

Copy Editor: Matt Dozier

Graphic Designer: Matt McIntosh

Cover credits (Clockwise):

Map:
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About this Report

This "condition report" provides a summary of resources in the National Oceanic and Atmospheric Administration's *Monitor* National Marine Sanctuary, pressures on those resources, current condition and trends, and management responses to the pressures that threaten the integrity of the marine environment. Specifically, the document includes information on the status and trends of water quality, habitat, living resources and maritime archaeological resources and the human activities that affect them. It presents responses to a set of questions posed to all sanctuaries (Appendix). Resource status of the sanctuary is rated on a scale from good to poor, and the timelines used for comparison vary from topic to topic. Trends in the status of resources are also reported, and are generally based on observed changes in status over the past five years, unless otherwise specified. Sanctuary staff consulted with a working group of outside experts familiar with the resources and with knowledge of previous and current scientific investigations. Evaluations of status and trends are based on interpretation of quantitative and, when necessary, non-quantitative assessments, and the observations of scientists, managers and users. The ratings reflect the collective interpretation of the status of local issues of concern among sanctuary program staff and outside experts based on their knowledge and perceptions of local problems. The final ratings were determined by sanctuary staff. This report has been peer-reviewed and complies with the White House Office of Management and Budget's peer review standards as outlined in the Final Information Quality Bulletin for Peer Review.

This is the first attempt to describe, in a comprehensive way, the status, trends and pressures on resources at *Monitor* National Marine Sanctuary. Additionally, the report helps identify gaps in current monitoring efforts, as well as causal factors may require monitoring and potential remediation in the years to come. The data discussed will enable us to not only acknowledge prior changes in resource status, but will provide guidance for future management as we face challenges imposed by such potential threats as increasing coastal populations, wind farming, artificial reefs, and climate change.

Monitor National Marine Sanctuary

- *Monitor National Marine Sanctuary was designated on Jan. 30, 1975, as the nation's first national marine sanctuary.*
- *The sanctuary is located 16.1 miles SSE of Cape Hatteras, N.C.*
- *The USS Monitor was the first warship to use a rotating gun turret successfully.*
- *Management of the sanctuary is focused on preventing further deterioration of the wreck, recovery of important ship components and artifacts, and protecting the wreck from damage by human activities such as vessel anchoring and fishing.*

Summary and Findings

In an effort to preserve one of the most famous shipwrecks in U.S. history, the wreck of the USS *Monitor* was designated our first national marine sanctuary on Jan. 30, 1975. The sanctuary comprises a column of water one nautical mile in diameter extending from the ocean's surface to the seabed around the wreck of the Civil War ironclad, which lies 16 miles south-southeast of Cape Hatteras, N.C. Average water depth in the sanctuary is 230 feet, depending on the tidal cycles and the Gulf Stream. Since its sinking in 1862, the *Monitor* has become a productive artificial reef. Numerous fish species, including black seabass, oyster toadfish and great barracuda, call the *Monitor* home.

Today, scientists from the National Oceanic and Atmospheric Administration (NOAA) are studying the wreck site of the *Monitor*, revealing more details every year about the ship's construction, design and performance, and the circumstances surrounding her loss on a stormy evening in December 1862 in an area of the Atlantic Ocean known as the Graveyard of the Atlantic. While most of the research conducted in the *Monitor* sanctuary to date has focused on the archaeological documentation of the shipwreck, NOAA scientists are devoting increased attention to the water quality and marine environment of the wreck site. A NOAA data buoy installed in the sanctuary in 2006 provides scientists and the public the opportunity to monitor weather and sea conditions 24 hours a day.

The sanctuary's remote distance from shore poses special challenges for enforcement, but it is also an important factor in the *Monitor's* continued preservation. The site depends heavily on education, word-of-mouth within the dive community, and voluntary compliance with regulations. When those measures are ineffective, partnerships with other government agencies such as the U.S. Coast Guard are vital to enforcing sanctuary regulations. *Monitor* sanctuary regulations prohibit anchoring, stopping and drifting within the sanctuary; conducting salvage or recovery operations; using diving, dredging or wrecking devices; conducting underwater detonation; drilling in the seabed; laying cable; and trawling. Access is generally limited to scientific research conducted under a permit issued by NOAA; however, special-use permits may be issued for non-research visits to this historic site.

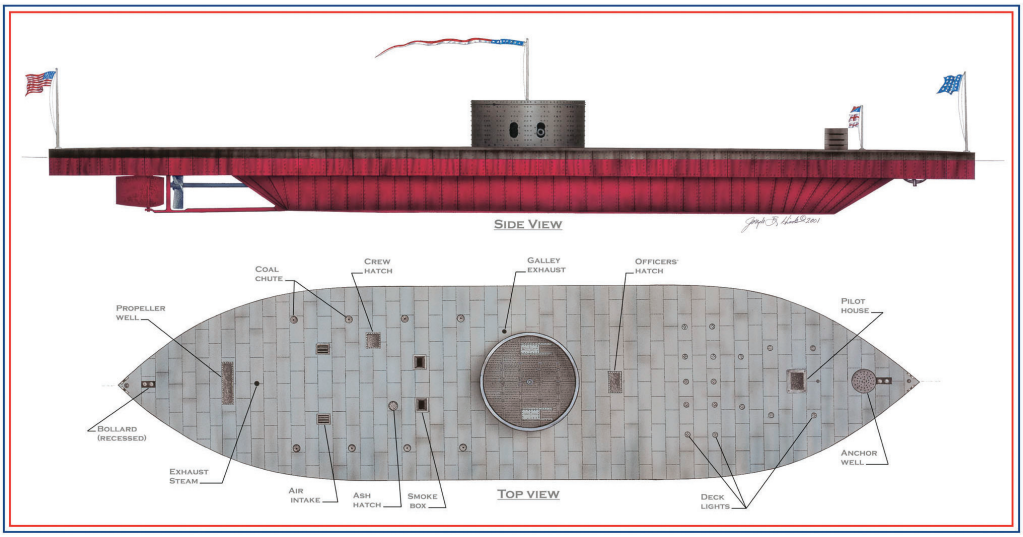


Illustration: Joe Hines

The USS *Monitor* was the prototype turreted, armored warship that changed the course of naval history forever. Made famous by its duel with the CSS *Virginia* on March 9, 1862, the *Monitor* met disaster in a gale off Cape Hatteras and sank with loss of life.

Initial dives in the 1970s and later research expeditions in the early 1990s have indicated that the *Monitor's* iron hull, having been inundated with saltwater for over 100 years, is deteriorating at an accelerated rate. In 1998 NOAA developed a plan to recover significant "iconic" sections of the wreck for conservation and public display. Additionally, NOAA developed a plan to help stabilize the wreck from further deterioration as much as possible. Numerous recovery expeditions to the *Monitor* have returned a variety of artifacts, including huge iron components such as the propeller, engine and rotating gun turret, delicate glass bottles, lumps of coal, wood paneling, a leather book cover and even walnut halves. Through a detailed, ongoing conservation process and a variety of educational programs, the history and importance of the *Monitor* lives on.

National Marine Sanctuary System and System-Wide Monitoring

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

By assuming that a common marine ecosystem framework can be applied to all places, the National Marine Sanctuary System developed a series of questions that are posed to every sanctuary and used as evaluation criteria to assess resource condition and trends. The questions, which are shown on pages 4-5 and explained in the Appendix, are derived from both a generalized ecosystem framework and from the National Marine Sanctuary System's mission. They are widely applicable across the system of areas managed by the sanctuary program and provide a tool with which the program can measure its progress toward maintaining and improving natural and archaeological resource quality throughout the system.

Similar reports summarizing resource status and trends will be prepared for each marine sanctuary approximately every five years and updated as new information allows. The information in this report is intended to help set the stage for the management plan review process. The report also helps sanctuary staff identify monitoring, characterization and research priorities to address gaps, day-to-day information needs and new threats.

Monitor National Marine Sanctuary Condition Summary Table

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

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

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 the Appendix.)

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
WATER					
1	Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?	–	Water current modeling and its effects on dissolved oxygen. No human impacts.	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.	*Monitor* National Marine Sanctuary regulations state that discharge of waste material within sanctuary boundaries is prohibited. There is a need to develop a water quality monitoring program in order to track conditions that could affect the integrity of the site.
2	What is the eutrophic condition of sanctuary waters and how is it changing?	–	The *Monitor* is located in water that is deep and well-mixed, therefore eutrophication is not a management concern.	Conditions do not appear to have the potential to negatively affect living resources or habitat quality.	
3	Do sanctuary waters pose risks to human health and how are they changing?	–	No evidence that there is any risk posed.	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?	–	Relatively few hazardous discharges, debris or other impacts.	Few or no activities occur that are likely to negatively affect water quality.	
HABITAT					
5	What is the abundance and distribution of major habitat types and how is it changing?	▲	*Monitor* attracts biological assemblages as an artificial reef.	Habitats are in pristine or near-pristine condition and are unlikely to preclude full community development.	*Monitor* National Marine Sanctuary regulations prohibit activities that could in any way alter the sanctuary's existing habitats or disturb or damage its natural resources. Activities such as anchoring, discharging waste material into the water, seabed drilling, seabed cable-laying, detonation of explosive material, dredging and trawling are highly restricted within the sanctuary's boundaries.
6	What is the condition of biologically structured habitats and how is it changing?	?	No specific studies conducted; encrusting faunal organisms reduce the rate of corrosion.	Undetermined status and trend.	
7	What are the contaminant concentrations in sanctuary habitats and how are they changing?	–	Lack of sources and constant resuspension of sediments flushing any contaminants that may accumulate.	Contaminants do not appear to have the potential to negatively affect living resources or water quality.	
8	What are the levels of human activities that may influence habitat quality and how are they changing?	–	Limited human activity due to remote location and restrictions.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality.	
LIVING RESOURCES					
9	What is the status of biodiversity and how is it changing?	?	Lack of biological monitoring program.	Undetermined status and trend.	Prohibition of commercial fishing and trawling in the sanctuary helps to eliminate the pressure of fishing gear on the living resources. The *Monitor* sanctuary's long-term goal is to coordinate scientific research and monitoring of the ecological conditions of the sanctuary.
10	What is the status of environmentally sustainable fishing and how is it changing?	NA	NA	NA	
11	What is the status of non-indigenous species and how is it changing?	▼	One Red Lionfish identified in sanctuary in summer 2007.	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?	?	No key species have been identified; no specific studies conducted.	Undetermined status and trend.	
13	What is the condition or health of key species and how is it changing?	?	No key species have been identified; no specific studies conducted.	Undetermined status and trend.	
14	What are the levels of human activities that may influence living resource quality and how are they changing?	–	Evidence that fishing activities affect habitat quality and thus living resources.	Some potentially harmful activities exist, but they do not appear to have had a negative effect on living resource quality.	

Table is continued on the following page.

Monitor National Marine Sanctuary Condition Summary Table (Continued)

#	Questions/Resources	Rating	Basis for Judgment	Description of Findings	Sanctuary Response
MARITIME ARCHAEOLOGICAL RESOURCES					
15	What is the integrity of known maritime archaeological resources and how is it changing?	–	Combination of natural deterioration and site alteration due to archaeology activities from 1998-2002.	Selected archaeological resources exhibit indications of disturbance, but there appears to have been little or no reduction in historical, scientific or educational value.	The *Monitor* sanctuary was specifically designated to protect and preserve the remains of the *Monitor*. Therefore, regulations prohibit removal of or damage to any historical or cultural resource in the sanctuary. Activities such as subsurface salvage or recovery operation, diving, and lowering below the water any grappling, suction, conveyor, dredging or wrecking device are also prohibited. A major exhibit on the *Monitor* opened in March 2007 at The Mariners' Museum in Newport News, Va., to better inform the public about the *Monitor* and its history.
16	Do known maritime archaeological resources pose an environmental hazard and how is this threat changing?	–	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?	–	Prior evidence of marine debris and anchoring. Site is susceptible to future incidents of fishing strikes and debris accumulation.	Selected activities have resulted in measurable impacts to maritime archaeological resources, but evidence suggests effects are localized, not widespread.	

Credit: NOAA

The *Monitor* was designated the nation's first sanctuary on January 30, 1975. The sanctuary encompasses the wreck of the USS *Monitor*, a Civil War vessel that lies off the coast of North Carolina.

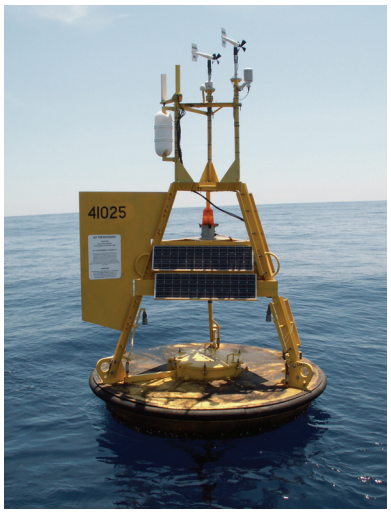


Photo: NOAA, *Monitor* Collection

A NOAA data buoy, installed in 2006, makes possible the real-time reporting of wind direction, wave height and water temperature at the site of the *Monitor* National Marine Sanctuary.

Photo: NOAA, *Monitor* Collection

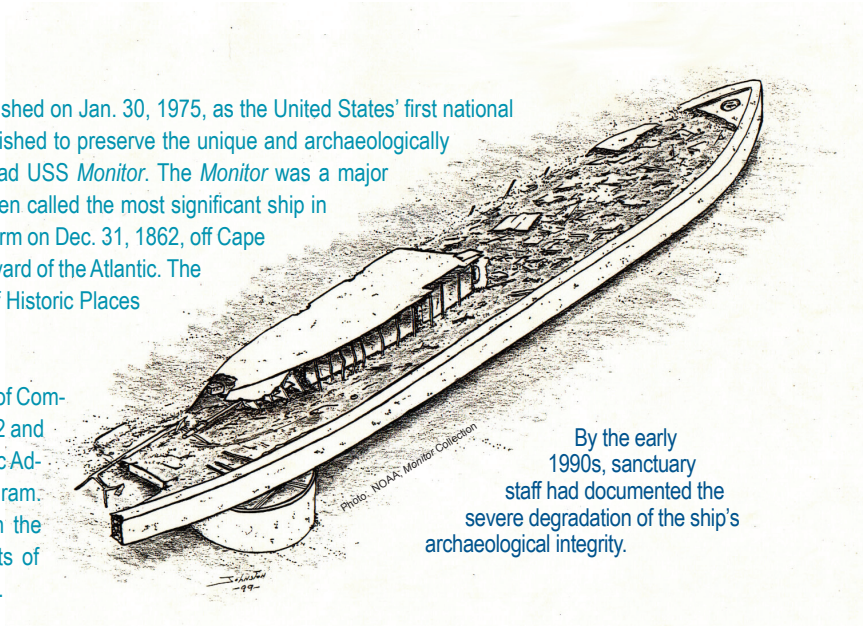
In 1996, Congress directed the sanctuary to begin recovering significant elements of the *Monitor's* structure. The nine-foot cast iron propellor was the first recovered feature in 1998.

Site History and Resources

Overview

Monitor National Marine Sanctuary was established on Jan. 30, 1975, as the United States' first national marine sanctuary. The sanctuary was established to preserve the unique and archaeologically significant wreck site of the Civil War ironclad USS *Monitor*. The *Monitor* was a major technological advancement in warship design and is often called the most significant ship in American history. It sank in 230 feet of water during a storm on Dec. 31, 1862, off Cape Hatteras, N.C., in an area popularly known as the Graveyard of the Atlantic. The wreck of the *Monitor* is listed on the National Register of Historic Places and is a national landmark.

The *Monitor* sanctuary was designated by the Secretary of Commerce under the National Marine Sanctuaries Act of 1972 and is administered by the National Oceanic and Atmospheric Administration's (NOAA) National Marine Sanctuary Program. The *Monitor* was the first national marine sanctuary in the National Marine Sanctuary System, which now consists of thirteen sanctuaries and one marine national monument.



By the early 1990s, sanctuary staff had documented the severe degradation of the ship's archaeological integrity.

The mission of the *Monitor* sanctuary is to preserve, protect and manage the remains of the USS *Monitor*. Since the establishment of the sanctuary, dozens of research and recovery expeditions have been conducted within the sanctuary. These expeditions have resulted in detailed documentation of the wreck and surrounding area and the recovery of over 1,200 artifacts from the wreck site. Many of these artifacts have already completed the conservation process and are currently on exhibit at The Mariners' Museum in Newport News, Va., and elsewhere around the country.

Location

The *Monitor* sanctuary is located on the Atlantic continental shelf approximately 16 miles south-southeast of Cape Hatteras, N.C. The sanctuary encompasses a vertical column of water around the wreck site from the surface to the seabed one nautical mile in diameter. Water depth in the sanctuary is an average of 230 feet, depending on the tidal cycles and the Gulf Stream. (*Monitor* National Marine Sanctuary 2003)

Discovery and Designation

The *Monitor* was discovered in 1973 by an interdisciplinary team of scientists from Duke University's Marine Laboratory. The discovery was preceded by extensive historical research and the selection of probable areas for the *Monitor's* sinking. The search team located what they believed to be the wreck of the *Monitor* using side-scan sonar and remotely operated cameras. In 1974, the U.S. Navy and the National Geographic Society launched a second expedition that confirmed the identity of the *Monitor* and produced detailed photographic documentation of the wreck site. One year later, on Jan. 30, 1975, the *Monitor* site was designated as the nation's first marine sanctuary. (*Monitor* National Marine Sanctuary 1994)

Recovery, Research and Conservation Efforts

Since the establishment of *Monitor* National Marine Sanctuary in 1975, numerous research and recovery expeditions have been organized by NOAA and other partners. Recovered artifacts are transported to The Mariners' Museum in Newport News, Va. for conservation. Once conservation is complete, artifacts are available for exhibition and study. While the majority of the *Monitor* artifacts remain at The Mariners' Museum, other facilities including the Richmond National Battlefield Park in Virginia, Civil War Naval Museum in Columbus, Ga., Nauticus in Norfolk, Va., and soon the Graveyard of the Atlantic Museum in Hatteras, N.C., also display artifacts from the historic ship.

Timeline

1977 – The very first artifact recovered from the *Monitor* site after sanctuary designation was a red-lens brass signal lantern. It was raised from the ocean floor during the first submersible dive in 1977.

1979-83 – Expeditions in 1979 and 1983 recovered numerous small artifacts and the *Monitor's* unique four-fluked anchor.

1980s-1990s – During the 1980s and through the late 1990s, many brief reconnaissance expeditions were carried out to recover exposed artifacts and to further document the wreck and assess the preservation of the site. During these expeditions the researchers began to notice extensive deterioration of the wreck, some caused by recovery operations. The dramatic change in the condition of the *Monitor* motivated Congress to require NOAA to prepare a preservation plan for the *Monitor*.

1987 – On March 9, 1987, The Mariners' Museum in Newport News, Va., was designated the principle repository for artifacts recovered from *Monitor* National Marine Sanctuary. The Mariners' museum serves as the principal repository for the archival and archaeological collection of the *Monitor* Sanctuary as well as being the home of the primary conservation facility.

1998 – NOAA released a six-step plan for stabilizing portions of the hull and recovering the vessel's steam machinery and rotating gun turret. With the help of the U.S. Navy, the *Monitor's* propeller and 11 feet of the propeller shaft were recovered in 1998.

1999 – Starting in 1999, NOAA and the Navy began planning large-scale recovery expeditions and implementing the stabilization plan.

2000 – Shoring was placed beneath the port armor belt to provide support for areas that hung above the seabed. The engine recovery structure was also placed over the wreck, setting the stage for engine recovery in 2001.

2001 – More than 250 artifacts, including the *Monitor's* vibrating lever steam engine were successfully recovered.

2002 – The last of the major recovery expeditions to the *Monitor* took place in 2002, culminating in the raising of the gun turret and two XI-inch Dahlgren smoothbore guns. The engine, guns and gun turret are currently undergoing conservation at The Mariners' Museum.

2006 – A team of researchers conducted a major mapping expedition to the *Monitor* site to collect high-resolution digital still and video imagery that will be used to generate a high-definition photographic mosaic of the site. The data collected on this expedition will help scientists and historians to monitor the condition of the wreck for years to come. During the same year, the Batten Conservation Laboratory Complex at The Mariners' Museum opened. This state-of-the-art facility, where scientists study the corrosion process and preserve components of the shipwreck, houses thousands of small and large *Monitor* artifacts. The conservation facility is open to the public during regular museum hours.

2007 – The new USS *Monitor* Center opened at The Mariners' Museum. The sanctuary continues to plan for future archaeological, surveying and mapping expeditions to the site.

Water

The *Monitor* sanctuary's waters are dominated by the Gulf Stream current that interacts dynamically with the southerly-flowing Labrador Current. Cold, fresh Labrador waters influence the path of the Gulf Stream, pushing it south in the spring. The Gulf Stream is the primary determinant of the chlorophyll concentration and the level of biological productivity in the region. Its velocity is high enough to transport fine to medium sand. Interaction of the Gulf Stream and the Labrador Currents create unpredictable eddies and rapidly changing weather conditions. The northeast currents are faster (more then 0.2 knots) than the currents flowing to the west and southwest (less then 0.2 knots). (University of Rhode Island 2004, Schollaert et al. 2004, Sheridan 1979)

Habitat

Monitor National Marine Sanctuary, located on the slope of the continental shelf in the warm Gulf Stream waters, is a suitable place for a variety of marine life. The types of habitats observed within the sanctuary's boundaries include scattered natural rocky outcrops, sand flats, muddy patches, and artificial hard surfaces created by the *Monitor* itself and a few scattered artifacts. The sanctuary has high densities of benthic infauna, organic carbon, and a significant concentration of benthic fish and megafaunal invertebrates. An exact census of the *Monitor's* bio-diversity has not been conducted to date. The sanctuary was established primarily because of its cultural resources, and for over 30 years the vast majority of research at the site has focused on the shipwreck and her history. As the sanctuary moves further into the 21st century, detailed studies are planned to conduct an accurate census of the diverse marine life, which is known to include varieties of tree coral (Oculina arbuscula); whip corals (Leptogorgia sp. and Lothogorgia sp.); vase, barrel, finger and garlic sponges (Xestospongia sp.); sea squirts; sea anemones; barnacles; a variety of hydroids; date mussels (Lithophaga sp.); oysters (Ostera sp.); a variety of shrimp, crabs, and urchins; and over 25 species of fishes.

Geology

In 1979, the University of Delaware's Department of Marine Geology and Geophysics performed a geological survey in *Monitor* National Marine Sanctuary, focusing primarily on the area near and under the wreck. Geophysical profiling and stratigraphic sampling of the sea floor was required in order to estimate the hazards of the future recovery operations at the *Monitor* site. The survey's results were as follows:

- A detailed magnetic map of the *Monitor* site was prepared. The total magnetic field of the site varies from 53,850 gammas on the north and west to 53,870 gammas on the south and east, with a regional gradient at the wreck site of 1.2 gammas per 100 meters.
- The acoustic system penetrated sediments up to 50 feet deep and revealed four subbottom reflectors that were named for convenience A, B, C and D (from shallowest to deepest). All four reflectors were inclined to the southeast and truncated at the sea floor. The acoustic profiles exposed a 10-meter relief, low-level ridge and swale features in reflectors A and B around the wreck site. The relief was caused by erosion and deposition in a coastal environment during periods of low sea level. The ridge and the swale are evidence of ancient galleys and stream valleys. Also, accumulation of peat observed in the area indicates ancient estuary environments.
- Piston core had seven important sections: three below the hiatus (2.9 – 5.5 meters) and three above it (2.7 – 0 meters). Starting from the bottom, the three units below the hiatus included: coarse shell hash mixed with sand; medium to coarse sand with worm burrows, echinoid and pelecypod shells; and gravelly mud. The units above the hiatus included: coarse sand with many shell fragments; muddy sand and plastic clay; and fine sand. The piston core proved that the *Monitor* terrace is an erosional environment where a thin layer of transitory sand is underlain by older Pleistocene sediments. The silty clay units were deposited during glacial events that caused regression of the sea. Water content of the sediments indicates a density of 2.0 grams per cubic centimeter. (Newton 1974, Sheridan 1979, Sheridan 2004)

Living Resources

The presence of the Gulf Stream and the wreck's location near the northern boundary of tropical reef fish habitat makes the *Monitor* National Marine Sanctuary very attractive for a variety of marine life. From the surface to the bottom, the sanctuary experiences seasonal migrations of cetaceans, sea turtles and fishes, including sharks and manta rays. Temperate and sub-tropical fish species, such as the greater amberjack, black seabass, bank seabass, scup and grouper, represent the most abundant species that seasonally visit the sanctuary's waters. Additionally, the sanctuary acts as an artificial reef and provides winter habitat for loggerhead sea turtles.

Encrusting organisms and motile invertebrates are also present in the *Monitor* sanctuary. Invertebrates include crabs, brittle stars, sea urchins, snapping shrimp and spiny lobsters. Tree coral, whip coral, sea anemones, hydroids, barnacles, tube worms, mussels, oysters and at least 40 species of sponges have been identified in the sanctuary. (Dixon 1990)

Maritime Archaeological Resources

There is only one identified archeological site within *Monitor* National Marine Sanctuary waters — the wreck of the USS *Monitor*. The

Courtesy: Naval Historic Center

The *Monitor* sank in a storm on the night of Dec. 31, 1862, while under tow by the USS *Rhode Island*.

Monitor represents one of the most important naval vessels in the American history. Designed by Swedish-American engineer John Ericsson and constructed in 1862, the *Monitor* was a significant technological advancement in warship design. The most innovative feature of the *Monitor* and the one that became her distinguishing characteristic was her rotating turret. Though other designers had toyed with the idea of developing turrets for warships, the *Monitor* was the first warship to use the invention successfully. It measured 21 feet in diameter and nine feet in height, and its armored walls were made of eight layers of one-inch armor plate. It could rotate two XI-inch Dahlgren smoothbore guns in any direction. The *Monitor* was built almost entirely from iron and was fully steam-powered. Its engineering spaces, galley, crew and officer quarters were all located below the waterline.

The *Monitor* was launched at Greenpoint, N.Y., where it was constructed, on Jan. 30, 1862. Following final construction and sea trials, the *Monitor* was ordered to steam to Hampton Roads, Va. On March 9, 1862, the ironclad engaged in battle with the CSS *Virginia*, a confederate ironclad launched on Feb. 17, 1862. The *Virginia* was constructed over the burned hull of the USS *Merrimack*.

In the early morning hours on March 9, 1862, the *Monitor* and the *Virginia* began bombarding each other at point-blank range. After four hours, the battle ended in a draw and neither vessel suffered considerable damage. Following the fall of Norfolk and the destruction of the *Virginia* (at the hands of her own crew) in May 1862, the *Monitor* steamed up the James River in support of McClellan's Peninsular Campaign. The *Monitor* unsuccessfully engaged in an attack on Drewry's Bluff on May 15 and withdrew with the rest of Union forces to Hampton Roads in July following the Seven Days Battle. Ordered to Washington, D.C. for repairs, she spent much of October undergoing a refit and returned to Hampton Roads in November. She was ordered to Beaufort, N.C., in late December 1862.

The *Monitor's* short history came to an end on Dec. 31, 1862 as the ship was rounding Cape Hatteras, N.C., under tow by the USS *Rhode Island*. The ships encountered severe weather as they neared the cape. The *Monitor* began taking on water, and while the steam pumps were initially able to handle the water leaking in from around the turret, a leak was soon reported at the bow. As the storm increased in intensity, it became obvious to her commander that the *Monitor* was in grave danger.

Around 10:30 p.m. Commander John Bankhead ordered a red signal lantern hoisted signaling to the *Rhode Island* that the *Monitor* was in danger of going down. Three boats were launched from the Rhode Island in an attempt to rescue the ironclad's crew. Through their heroic efforts, all but 16 were rescued before the ship finally succumbed to the turbulent seas just after 1:00 a.m. on New Year's Eve. In recognition of their heroic deeds, five Congressional Medals of Honor were awarded to the crew of the *Rhode Island*. Three of these were posthumous.

The ship came to rest upside down on the seabed in 230 feet of water, where it remained undiscovered until 1973. Less than two years after its discovery, the wreck site was designated as NOAA's first national marine sanctuary. Through the site's remote location and its protection under the National Marine Sanctuaries Act, the archaeological integrity of the *Monitor* wreck has been preserved throughout its entire history. (*Monitor* National Marine Sanctuary 1994)

Pressure on Sanctuary Resources

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 *Monitor* sanctuary.

Recreational Fishing and Marine Debris

Recreational fishing may be a potential stressor to marine species and artifacts at the site of the *Monitor*. The structure of the wreck is very fragile and any assault, including anchoring and use of bottom fishing gear, could cause considerable damage.

Due to its location in the Gulf Stream, the *Monitor* sanctuary is a popular destination for recreational fishing. Many charter boat captains take their clients to fish within sanctuary borders. Live boat fishing is allowed within the sanctuary, however, regulations restrict drifting without the boat motor running or anchoring. Recreational fishing is targeted at species such as black seabass (*Centropristis striata*), bank seabass (*Centropristis ocyurus*), groupers (*Epinephelus* and *Mycteroperca*), snappers (*Lutjanus* and *Rhomboplites*), grunts (*Haemulon*) and many others.

Between 1987 and 1990, patterns of accelerated deterioration were noted along the remaining segments of the lower hull, and sections of the midship's bulkhead collapsed. This damage has been attributed to natural deterioration as well as human activities.

In 1991, a private fishing vessel was cited by the U.S. Coast Guard for illegally anchoring in the sanctuary. Evidence documented by NOAA strongly suggested that this anchoring incident resulted in the skeg and propeller shaft dislocation, pulling it to starboard and down, ripping it loose from the lower hull and exposing the aft end of the engine room. In an effort to relieve stresses on the stern, the propeller and 11 feet of shaft were recovered in 1998.

Within the past few years, the biggest concern among the sanctuary's staff has been marine debris, particularly the possibility of commercial fishing gear striking the wreck. Other concerns include the dumping of soda cans, beer cans and leftover food in the sanctuary. Leftover food, such as chicken bones, presents a particular threat to archaeological research because it could be recovered and mistakenly treated as a part of the *Monitor's* pantry supplies. (Dixon 1990, Cuffey 1982)

Commercial Fishing

There have been incidents involving commercial fishing activity within the sanctuary that have caused serious damage to the sanctuary's living and archaeological resources. In addition to the 1991 anchoring incident mentioned above, increasing quantities of commercial and sport fishing gear are being found in the sanctuary. In 1997, commercial fishing gear was found tangled on the *Monitor*. Also, during a 2004 NOAA and U.S. Navy expedition to the site, divers identified damage to the hull of the wreck and observed remains of a trawling net and long lines. However, because damage may have occurred due to the recent passing of a hurricane, no criminal charges were pursued.

Diving and Artifact Recovery

The development of underwater technologies now affords the public the opportunity to locate and visit deep-water archaeological resources in the offshore environment. As diving technology advances the threat of site looting has become an increasing concern. Site looting (where objects are intentionally pilfered from submerged sites) poses a major threat to submerged archaeological resources. Divers visiting sites may cause injury through poor diving techniques, inadvertently holding onto fragile artifacts or striking them with dive gear. To address this concern, the National Marine Sanctuary Program has developed a permitting system to allow divers access to the site while ensuring continued protection of the resource by placing a sanctuary observer aboard. Permits can be obtained by applying through the *Monitor* sanctuary offices.

Research

General research goals for the sanctuary include archaeological artifact recovery, dissemination of historical and cultural information preserved at the site, and the continued scientific study of the *Monitor* as an artificial reef. Research activities themselves can cause damage and potentially accelerate deterioration of the site, so there is careful review and monitoring of both public- and private-sponsored research activities in order to ensure that the site is protected and preserved. Archaeological investigation, recovery efforts and excavation conducted on the *Monitor* between 1998-2002 have exposed wood and metals to the environment, which has lead to increased deterioration. The impacts of the recovery efforts to the integrity of the wreck are described later in this report.

Natural Deterioration

Strong currents, high water temperatures and high-salinity water in *Monitor* National Marine Sanctuary have a major effect on the sanctuary's living and non-living resources. Since its discovery, the wreck has suffered significant, ongoing deterioration in almost every portion of its hull, with the most extensive damage occurring in the stern.

Additionally, hurricanes present a significant threat to the sanctuary resources. In 2003, Hurricane Isabel passed through the *Monitor* sanctuary, with its eye located only three-quarters of a mile from the actual *Monitor* site, dislodging bottom plating and disrupting the galley area. These environmental stressors accelerate deterioration of the wreck of the *Monitor*.

State of Sanctuary Resources

This section provides summaries of the condition and trends within four resource areas: water, habitat, living resources, and maritime archaeological resources. For each, sanctuary staff and selected outside experts considered a series of questions about each resource area. The set of questions derive from the National Marine Sanctuary System's mission, and a system-wide monitoring framework (National Marine Sanctuary Program 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on, and study the ecosystems encompassed by the sanctuaries. The questions are meant to set the limits of judgments so that responses can be confined to certain reporting categories that will later be compared among all sanctuary sites and combined. The Appendix (Rating Scheme for System-Wide Monitoring Questions) clarifies the set of questions and presents statements that were used to judge the status and assign a corresponding color code on a scale from "good" to "poor." These statements are customized for each question. In addition, the following options are available for all questions: "N/A" – the question does not apply; and "undetermined" – resource status is undetermined. In addition, symbols are used to indicate trends: "▲" – conditions appear to be improving; "**–**" – conditions do not appear to be changing; "▼" – conditions appear to be declining; and "**?**" – the trend is undetermined.

Photo: NOAA, *Monitor* Collection

The *Monitor's* steam-powered turret is a national icon that was the model for all turreted warships through modern times. The partnership that included NOAA and the U.S. Navy resulted in the recovery of the turret in 2002.

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

Water

Water quality in *Monitor* National Marine Sanctuary varies with turbidity, water temperature, the presence of organic matter in the water column and the intensity of sunlight. Visibility in the sanctuary ranges from zero to 200 feet.

Although there is not a water quality monitoring program at the *Monitor* sanctuary, an abundance of apparently healthy marine life in the sanctuary may indicate that the water quality is good and that there are few, if any, risks to human health. Nutrient levels fluctuate with oceanographic conditions but are generally low, and there are no apparent coastal anthropogenic influences.

In spring 2004, NOAA's National Centers for Coastal Ocean Science conducted a survey of ecological conditions in the U.S. South Atlantic Bight. The survey covered the near-coastal shelf waters (one nautical mile from shore, or ~10 meters in depth, seaward to the 100-meter shelf break) from Nags Head, N.C., to West Palm Beach, Fla. The primary focus of the survey was to collect bottom sediment samples for the analysis of benthic macroinfaunal community structure and measurement of concentrations of chemical contaminants in sediments. Some of the samples were collected in the vicinity of the *Monitor* sanctuary. General results of the survey have shown that bottom water physical characteristics were highly variable across the region. Temperature ranged from 6.8° to 24.2° Celsius. Salinity ranged from 21.2 psu to 37.2 psu, and dissolved oxygen ranged from 6.8 mg/L to 9.8 mg/L (Cooksey 2004).

While the above ranges may characterize the *Monitor* sanctuary's waters, there has been no additional scientific study conducted to date to support it. Research addressing water quality and eutrophic condition in the *Monitor* sanctuary is needed.

In 2006, the NOAA Diamond Shoals Data Buoy was moved into the boundaries of *Monitor* National Marine Sanctuary. This buoy collects real-time data on water temperature, surface and subsurface currents, and wind speed at the site. The buoy will allow for future tracking of these conditions within the sanctuary.

1. ***Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality and how are they changing?*** The water quality in the *Monitor* sanctuary is considered to be good; conditions do not appear to have the potential to negatively affect living resources or habitat quality. The trend is not changing. However, it is important to note the distinction that although water quality can be considered good in relation to living marine resources, such conditions can be considered poor with regard to the preservation of wreck sites.

   The strong currents, high water temperatures and high-salinity water that are found off the coast of Cape Hatteras, N.C., has the potential to accelerate the deterioration rate of the USS *Monitor*. The strong currents bring dissolved oxygen that corrodes the metal on the wreck. The data buoy therefore provides critical information on the changes in these parameters over time. Trends seem to indicate a relationship between corrosion and salinity measurements; however, the sanctuary does not currently have long-term data comparing these parameters. Water current modeling will be an area of heavy focus in research in coming years (NURC pers. comm.).

   In 2007, the *Monitor* sanctuary, working with the National Data Buoy Center, added an acoustic doppler current profiler to the Diamond Shoals data buoy. This instrument will allow the public and scientists to better understand the subsurface environment over the wreck. Additionally, staff at the *Monitor* sanctuary is looking to collect water quality data by installing pH and water chemistry instruments to the buoy at the site. Such meters would allow for a better understanding of the pH levels at the site and the effects that acidification may be having on the wreck and the ecosystem.

2. ***What is the eutrophic condition of sanctuary waters and how is it changing?*** The *Monitor* is located in an open ocean environment that is well mixed and too deep for eutrophication to be a management concern. Therefore the situation is considered to be good and not changing; conditions do not appear to have the potential to negatively affect living resources or habitat quality at the site.

3. ***Do sanctuary waters pose risks to human health and how are they changing?*** There is no evidence suggesting that sanctuary waters pose any risks to human health; in this respect, water quality is considered to be good, and conditions do not appear to have the potential to negatively affect human health. The condition appears to be stable.

4. ***What are the levels of human activities that may influence water quality and how are they changing?*** Although there is visitation to the site, typically by charter fishing boats, there are relatively few hazardous discharges, minimal debris at present, or other known impacts on the water quality at the sanctuary. Thus, few human activities occur that are likely to negatively affect water quality. The trend is not changing.

Water Quality Status & Trends

#	Issue	Rating	Basis for Judgment
1	Stressors	–	Water current modeling and its effects on dissolved oxygen. No human impacts.
2	Eutrophic Condition	–	The *Monitor* is located in water that is deep and well-mixed, therefore eutrophication is not a management concern.
3	Human Health	–	No evidence that there is any risk posed.
4	Human Activities	–	Relatively few hazardous discharges, debris or other impacts.

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

Trends: Improving (▲), Not Changing (**–**), Getting Worse (▼), Undetermined Trend (**?**), Question not applicable (**NA**)

Habitat and Living Resources

Since designation in 1975, *Monitor* National Marine Sanctuary has focused primarily on documenting, preserving and managing the remains of the *Monitor*. Because of this focus, studies have been conducted regarding the habitats and living resources of the sanctuary. In 1982, scientists from Pennsylvania State University conducted a study of organisms encrusting the hull of the *Monitor* shipwreck. They examined the wreck's concretionary crust for growth and diversity of bryozoans — tiny polyps that live in colonies attached to hard objects on the seafloor. The study identified 11 species of encrusting cheilostome bryozoans, serpulid worms, corals and pelecypods. The species found are typical of hard bottoms at mid-depths on the Atlantic shelf. (Cuffey 1982)

In 1990, the NOAA Fisheries Lab in Beaufort, North Carolina conducted a study of the living resources in the *Monitor* sanctuary. Utilizing visual observations on two dives and video tape from four dives the NOAA researchers were able to assess species diversity in the sanctuary. Twenty-five species of fish were observed. The most abundant species appeared to be red barbier (*Hemanthias vivanus*), while the predominant predator was greater amberjack (*Seriola dumerili*). Other common species included scad, black seabass, bank seabass, slippery dick and vermilion snapper. The study also identified encrusting organisms and motile invertebrates from one grab sample and recorded video footage. The most abundant coral growing on the wreck of the *Monitor* was the ivory bush coral (*Oculina arbuscula*). Approximately 40 species of sponges were identified. (Dixon 1990)

A study being conducted in the vicinity of the *Monitor* sanctuary is examining zooplankton and ichthyoplankton dynamics, as well as other aspects of the ecosystem. The National Marine Fisheries Service Northeast Fisheries Science Center (NEFSC) initiative started in the1960s and led to the Marine Resources Monitoring Assessment and Prediction Program in 1987, and later to the Ecosystem Monitoring Program, which started in the mid-1990s. Most of the NEFSC plankton sampling has occurred north of Cape Hatteras, thus, samples are sparse in the vicinity of the *Monitor* sanctuary. The top 25 taxa accounted for 78 percent of the total zooplankton collected. The most abundant was the copepod *Centropages typicus*, followed by the cladoceran Penilia avirostris and unclassified ostracods. Other abundant taxa included appendicularia, chaetognaths and several other copepods.

Other studies underway near the *Monitor* sanctuary include benthic surveys organized by researchers from NOAA and the University of North Carolina at Wilmington and University of North Carolina Chapel Hill.

5. ***What is the abundance and distribution of major habitat types and how is it changing?*** Habitats in the *Monitor* sanctuary are in near-pristine condition and are unlikely to preclude full community development at the site. Further, conditions appear at present to be improving, following recent changes in habitat availability at the site. The USS *Monitor*, like many other shipwrecks in the Graveyard of the Atlantic area, provides a habitat structure to the otherwise sandy bottom that is found off the coast of Cape Hatteras. The *Monitor* and other wrecks create new habitat by acting as an artificial reef that supports both transitory organisms, such as sea turtles and fishes, and local communities such as encrusting organisms and motile invertebrates.

   It has been observed that when a piece of the *Monitor* is removed or disturbed there is succession of life that returns to the site over time. So while the *Monitor* diversifies the area's habitat types, ecological succession results in a diversification of biological assemblages.

6. ***What is the condition of biologically structured habitats and how is it changing?*** Although there are no biologically structured habitats at the *Monitor* sanctuary, there is a thriving assemblage of encrusting faunal organisms on the wreck. Such organisms can reduce the corrosion rates of the site. However, data has not been collected to determine the condition of such communities and how they are changing. Therefore, the status and trends of biologically structured habitats are currently undetermined. To date, the *Monitor* sanctuary staff has not conducted research on natural resources within its boundaries. The need for additional studies will likely be identified through the sanctuary's management plan review process, and a long-term monitoring and data collection program will be established.

   An exact census of the biodiversity within *Monitor* National Marine Sanctuary has not been conducted. The sanctuary was originally established based on cultural resources and not on the natural resources found within its boundaries. To date, no rare or endangered species have been reported living on the wreck or within the sanctuary's borders. Loggerhead sea turtles (*Caretta caretta*) are often sighted within sanctuary borders swimming or drifting along in the Gulf Stream. As an artificial habitat, the wreck saw significant changes during the recovery operations from 1998-2002. Areas at the stern of the wreck were altered or removed to gain access to components of the *Monitor* that were targeted for recovery. The forward areas of the wreck have remained mostly untouched since the *Monitor* originally sank in December 1862 and a variety of sponges and soft corals thrive on this part of the wreck. The hard structure provided by the *Monitor's* hulk is completely covered with a thick marine calcareous growth that provides an excellent surface for sponge and coral growth. Fishes and invertebrates also abound in this area, using shipwreck structure for feeding grounds or shelter.

7. ***What are the contaminant concentrations in sanctuary habitats and how are they changing?*** Contaminants in sediments at the *Monitor* sanctuary do not appear to be at levels that have the potential to negatively affect living resources or water quality. The trend is not changing. The low levels of contaminant concentrations are most likely attributable to the remote location of the wreck and the strong currents of the Gulf Stream. The strong currents cause a constant resuspension of sediments, thus flushing any contaminants that might otherwise accumulate.

8. ***What are the levels of human activities that may influence habitat quality and how are they changing?*** There is relatively little human activity that influences the habitat quality at the *Monitor* sanctuary. There is limited visitation to the site, and those that do visit are typically on chartered fishing boats, but there are relatively few hazardous discharges, little debris or other impacts on the habitat quality. Thus, while some potentially harmful activities exist, but they do not appear to have had a negative effect on habitat quality, and the status does not appear to be changing.

Habitat Status & Trends

#	Issue	Rating	Basis for Judgment
5	Abundance/ Distribution	▲	*Monitor* attracts biological assemblages as an artificial reef.
6	Structure	?	No specific studies conducted; encrusting faunal organisms reduce the rate of corrosion.
7	Contaminants	–	Lack of sources and constant resuspension of sediments flushing any contaminants that may accumulate.
8	Human Impacts	–	Limited human activity due to remote location and restrictions.

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

Trends: Improving (▲), Not Changing (**–**), Getting Worse (▼), Undetermined Trend (**?**), Question not applicable (**NA**)

9. ***What is the status of biodiversity and how is it changing?*** The living resource assemblage at the *Monitor* sanctuary is currently poorly known due to the lack of a biological monitoring program; therefore, the status and trend of biodiversity are undetermined. Anecdotal evidence shows that the sanctuary experiences seasonal migrations of cetaceans, sea turtles, and fishes, including sharks and manta rays. Tropical and temperate fish, such as black sea bass, snapper and grouper, represent the most abundant species that seasonally visit the sanctuary's waters. Encrusting organisms and motile invertebrates are also present in the sanctuary. Invertebrates include crabs, brittle stars, sea urchins, snapping shrimp and spiny lobsters. Sea anemones, hydroids, barnacles, tube worms, mussels, oysters and at least 40 species of sponges have been identified in the sanctuary.

10. ***What is the status of environmentally sustainable fishing and how is it changing?*** Currently, the removal of fish is not an issue that affects the *Monitor* sanctuary. The *Monitor* sanctuary lies within the jurisdiction of the South Atlantic Fishery Management Council, which manages fishery species of interest at the *Monitor* site. The Council is responsible for the conservation and management of fish stocks within the federal 200-mile limit off the coasts of North Carolina, South Carolina, Georgia and east Florida to Key West. Commercial fishing, including live boating by charter boats, is allowed within the sanctuary; however, other commercial fishing activities including anchoring, bottom trawling, dredging, stopping or drifting without power at any time is prohibited due to the potential threat to the fragile *Monitor* shipwreck.

11. ***What is the status of non-indigenous species and how is it changing?*** At least one non-indigenous species (red lionfish, *Pterois volitans*) exists in the *Monitor* sanctuary, likely affecting to some extent the development and function of the associated biotic assemblage at the site. But given current abundance, they are unlikely to cause substantial or persistent degradation of ecosystem integrity. The condition, however, appears to be getting worse.

    Marine biologists at NOAA's Center for Coastal Fisheries and Habitat Research in Beaufort, N.C., are currently conducting research on the red lionfish. It is the first marine invasive fish suspected to have established itself in the sanctuary (Private Research Permit MNMS-01-2007).

    During a private research dive to the site in 2007, a large adult red lionfish was observed on the wreck. Adult red lionfish are about 17 inches long and have been observed and caught from Florida to Cape Hatteras, usually on wrecks and natural hardbottom at depths of 85 to 300 feet. The red lionfish is a voracious predator and could threaten local ecosystems. Species such as snapper and grouper may be at risk as red lionfish feed on the same food sources and compete for the same habitat. Also, red lionfish pose a danger to divers and fisherman — spines of the fish may cause an extremely painful sting, resulting in swelling and sometimes paralysis. In the future, the sanctuary plans to expand its biological monitoring program to track red lionfish status and trends, as well as monitor other potential non-indigenous species.

12. ***What is the status of key species and how is it changing?*** A comprehensive biological inventory and assessment of the *Monitor* would need to be conducted to identify key species at the site. No species that inhabit the *Monitor* are currently identified as key species. Nearly all monitoring and research is devoted to archaeological resources. Nevertheless, it might be useful to identify and track the status of particular fouling and reef associated species in order to track the progress of artificial reef development. This is partly because the level of development of the fouling com-

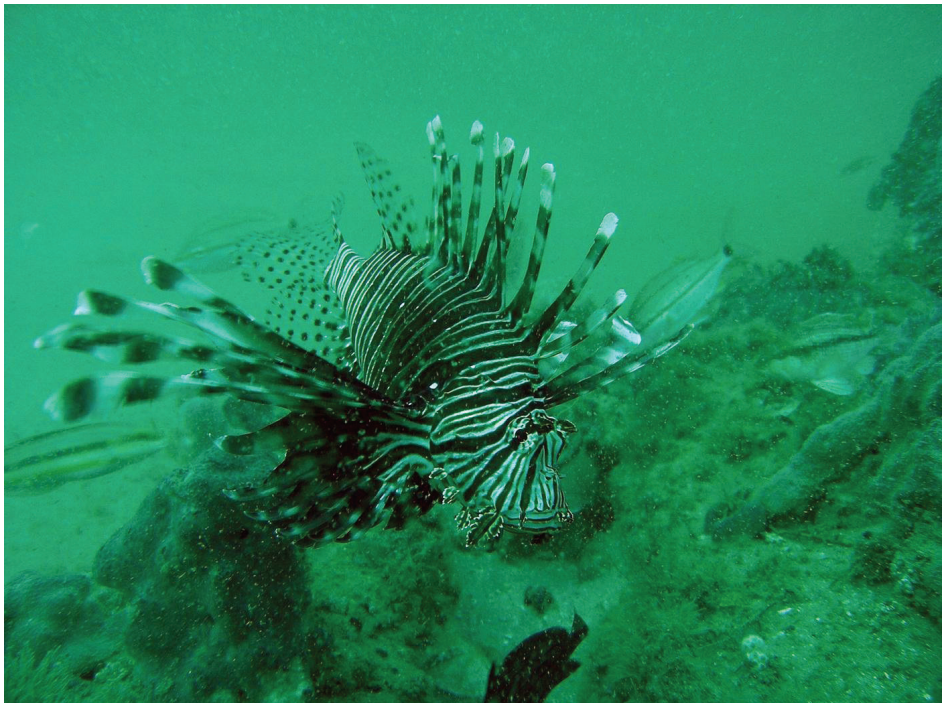


Photo: Matt Kendall, NOAA

Monitor's location at the edge of the Gulf Stream provides an opportunity to study indigenous and invasive species such as this red lionfish, *Pterois volitans*.

munity can affect the rate of deterioration of the structure of the *Monitor*, and because the nature of the fouling assemblage and associated fish communities, affects the level of visitation by fishers and others that could affect the quality of the *Monitor*.

13. What is the condition or health of key species and how is it changing? No species that inhabit the *Monitor* are currently identified as key species, but for reasons stated above, it would be helpful to do so.

14. What are the levels of human activities that may influence living resource quality and how are they changing? Fishing activities can affect artificial reef habitat quality but it does not appear that they have had a negative effect on living resource quality at the *Monitor*. The condition is currently stable. Nevertheless, trawling and anchoring can affect the biological community at the sanctuary by removing or damaging portions of the wreck, resulting in the removal of hiding locations for fish and invertebrates. These activities are prohibited by sanctuary regulations.

Living Resources Status & Trends

#	Issue	Rating	Basis for Judgment
9	Biodiversity	?	Lack of biological monitoring program.
10	Extracted Species	NA	NA
11	Non-Indigenous Species	▼	One Red Lionfish identified in sanctuary in summer 2007
12	Key Species	?	No key species have been identified; no specific studies conducted.
13	Health of Key Species	?	No key species have been identified; no specific studies conducted.
14	Human Activities	–	Evidence that fishing activities affect habitat quality and thus living resources.

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

Trends: Improving (▲), Not Changing (–), Getting Worse (▼), Undetermined Trend (?), Question not applicable (**NA**)

Maritime Archaeological Resources

Since the establishment of *Monitor* National Marine Sanctuary in 1975, dozens of research and recovery expeditions have been conducted within the sanctuary. These expeditions have resulted in detailed documentation of the wreck and surrounding area and the recovery of the anchor, steam engine, propeller and propeller shaft, rotating gun turret, two XI-inch guns and carriages, and over 1,000 smaller artifacts from the wreck site.

To date, research expeditions have recovered over 1,200 artifacts from the wreck. Many of these artifacts have already undergone conservation and are currently on exhibit at The Mariners' Museum in Newport News, Virginia. Many other artifacts, including the gun turret, guns and engine are still undergoing conservation.

The wreck of the *Monitor* lies upside down on a relatively flat, sandy bottom in 230 feet of water. The hull lies in an east-west orientation with the bow pointing at approximately 273 degrees. The port side of the inverted hull is raised above the seabed, as it was originally supported by the turret following sinking. Prior to turret recovery in 2002, a series of grout bags were installed underneath the armor belt to provide structural support. The port side's maximum relief is 9.5 feet at the stern, angling down towards the seabed at the bow. Height above the seabed at the bow is 6.5 feet. Maximum elevation in the wreck is 12.5 feet at the port boiler.

The starboard side of the wreck is completely buried in the sand, except for short segments of the armor belt at the bow and stern. Hull frames also protrude from the sand on the starboard side.

All of the lower hull plating forward of the midships bulkhead degraded and collapsed before the *Monitor* was discovered in 1973. The last three sections of intact hull plating and a section of bottom plating over the engine and fire room were removed by NOAA and the U.S. Navy in 2001 to gain access to the *Monitor's* steam engine. Bottom plating covering the boilers and galley area was dislodged from the wreck in 2003. This damage is attributed to the eye of Hurricane Isabel passing within three-quarters of a mile of the wreck in September 2003. The damage caused by Isabel also destroyed the remaining side framing along the port and starboard sides of the boilers and completely collapsed the remaining portions of the midships bulkhead.

Accelerated deterioration of the stern was first documented in 1990. By 1995, approximately six feet of the port armor belt had deteriorated in this area. Approximately 24 feet of the stern has disintegrated since the vessel sank in 1862.

This accelerated deterioration of the armor belt was combined with deterioration of the ship's armored decking. Several deck plates were observed hanging down from the wood planking to which they were originally spiked. Others had completely dropped off and were buried in the sand.

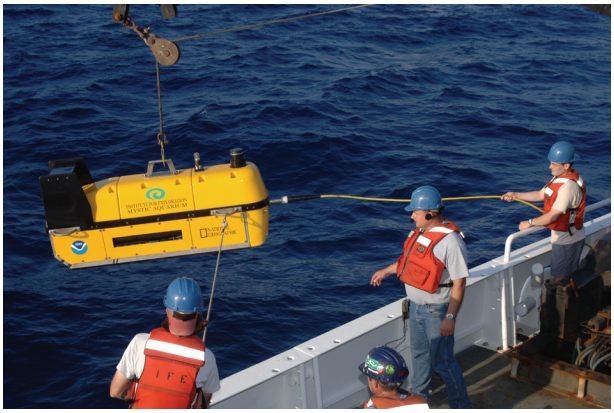


Photo: NOAA, *Monitor* Collection

The site of the remains of the USS *Monitor* provides NOAA the opportunity to test applications of new remote technology.

All of these observations prompted NOAA to release a revised management plan in 1998 that led to the shoring-up of the hull in 2000 and the recovery of the *Monitor's* steam engine in 2001 and rotating gun turret in 2002. A 45-foot section of the port armor belt was removed by NOAA and the Navy in 2002 to gain access to the rotating gun turret. This segment was cut free and lifted off the wreck and placed 50 feet to the north of its original location.

During the summer of 2006, NOAA worked with a private research organization to continue documenting the damage from the 2003 hurricane. Deterioration at the stern is continuing. (*Monitor* National Marine Sanctuary 2003)

15. What is the integrity of known maritime archaeological resources and how is it changing? Strong currents, high-temperature, and high-salinity water in *Monitor* National Marine Sanctuary have a significant effect on the sanctuary's living and non-living resources. Since its discovery, the wreck has suffered significant natural deterioration in almost every portion of its hull, with the most extensive damage occurring in the stern. Unauthorized human activities (including an illegal anchoring incident in 1991) also affected the deterioration rate. In response to accelerated deterioration documented in the early 1990s, NOAA issued a new management plan in 1998 for the *Monitor* sanctuary that outlined goals for stabilizing raised portions of the ship's hull and recovering some of the ships iconic components.

In 1998, NOAA partnered with the U.S. Navy and recovered the *Monitor's* cast iron propeller and an 11-foot section of the propeller shaft. The *Monitor's* unique steam engine was recovered in 2001, and the rotating gun turret and cannons were recovered in 2002. All of these sanctioned activities had

a significant impact on the wreck. Areas of concretion covering portions of the hull and hull plating had to be cleared away. Removal of this material reintroduces fresh oxygen to areas of the hulk where corrosion had been slowed by the marine calcareous growth. Recovery operations also exposed areas of wood components of the ships structure that were previously buried. Exposed areas of wood now show signs of being attacked by shipworms (Teredo navalis) which are accelerating the deterioration rate. This form of collateral damage was anticipated and expected by NOAA owing to the scope of work being conducted on the wreck. Thus, the *Monitor* does exhibit indications of disturbance, but there appears to have been little or no reduction in historical, scientific, or educational value. There are currently negligible unexpected changes occurring, and the condition is therefore considered stable.

16. Do known maritime archaeological resources pose an environmental hazard and how is this threat changing? The *Monitor* does not pose an environmental threat to its environment because it does not contain potential contaminants or hazardous cargo. The threat is not changing.

17. What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing? Selected activities have resulted in measurable impacts to the archaeological resources of the *Monitor* sanctuary, but evidence suggests effects are localized, not widespread. Furthermore, perhaps because there is currently limited visitation to the site, typically by charter fishing boats, there are relatively few hazardous discharges, debris or other impacts to the *Monitor*. The level of these threats does not appear to be changing.

However, some evidence of marine debris and anchoring impacts has been observed at the site. The first evidence of anchoring was documented in the 1990s and incidents have continued. However, the frequency of anchoring does not seem to be changing. In 1991, a private fishing vessel illegally anchored in the sanctuary and likely resulted in the skeg and propeller shaft dislocation and removal from the lower hull, exposing the aft end of the engine room.

Within the past few years, debris has been observed on the wreck. Most debris, like cans and food, is the result of charter fishing vessels visiting the site. One threat that marine debris poses to the site is that it could be recovered and mistakenly treated as part of the *Monitor's* artifacts. There have also been observations of commercial fishing gear, monofilament, trawling nets and long lines tangled on the site. Looting is a potential pressure that exists; however, because of the depth and remote location of the site, it is unlikely to occur. Likewise, it is believed that human impacts at the site are likely not to change within the next five years. Therefore, the level of human activities that may influence maritime archaeological resource quality is considered to be "fair" and not changing.

Non-divers interested in learning about the *Monitor* can visit one of the many partner museums and aquariums with exhibits that tell the story of the historic vessel and NOAA's efforts to preserve it. The USS *Monitor* Center at The Mariners' Museum in Newport News, Va., opened in March 2007 and is the primary visitor center for the sanctuary. Over 125,000 people visit this museum each year. With visitation of approximately 250,000 per year, Nauticus in Norfolk, Va. is home to an interactive exhibit on the Clelia, a submersible that visited the *Monitor* wreck site on several occasions. The North Carolina Aquarium on Roanoke Island (400,000 visitors/year) and the Graveyard of the Atlantic Museum (60,000 visitors/year) in Hatteras, N.C., are great places to see the marine life that call the *Monitor* home and learn more about the important history of the vessel. Increased visibility for the sanctuary via these and other exhibits provide public outreach and educational value that help promote preservation of the shipwreck.

Maritime Archaeological Resources Status & Trends

#	Issue	Rating	Basis for Judgment
15	Integrity	–	Combination of natural deterioration and site alteration due to archaeology activities from 1998-2002.
16	Threat to Environment	–	Lack of hazardous cargo
17	Human Activities	–	Prior evidence of marine debris and anchoring. Site is susceptible to future incidents of fishing strikes and debris accumulation

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

Trends: Improving (▲), Not Changing (**–**), Getting Worse (▼), Undetermined Trend (**?**), Question not applicable (**NA**)

Response to Pressures

Monitor National Marine Sanctuary was specifically designated to protect and preserve the remains of the *Monitor*. Therefore, the *Monitor* sanctuary regulations prohibit the removal and damage to any historical or cultural resource in the sanctuary. Sanctuary regulations also prohibit anchoring, stopping and drifting within the sanctuary; conducting salvage or recovery operations; using diving, dredging or wrecking devices; conducting underwater detonation; drilling in the seabed; laying cable; and trawling. Access is generally limited to scientific research conducted under a permit issued by NOAA; however, special-use permits are issued for non-research visits to this historic vessel.

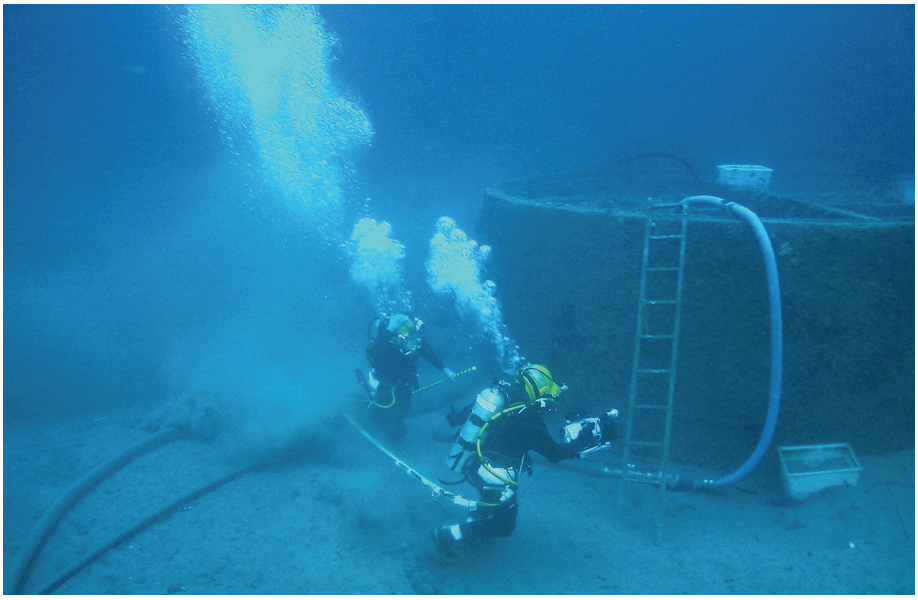


Photo: NOAA, *Monitor* Collection

U.S. Navy salvage divers were instrumental in the recovery of the *Monitor's* turret.

Access to the wreck site is restricted to those with research and non-research permits. NOAA has issued a number of research permits since 1976 to private and public groups interested in conducting research on the *Monitor* in direct support of NOAA goals. Non-research permits have been issued since 1994 in response to requests by the technical diving community. Each private vessel that enters the sanctuary to conduct diving operations, whether for research or non-research purposes, is required to have a NOAA observer aboard. Enforcement of sanctuary regulations is led by the U.S. Coast Guard, with support from NOAA and guidance by the National Marine Fisheries Service (NMFS). NMFS and the Coast Guard hold annual briefings to assess enforcement efforts.

Enforcing sanctuary regulations is difficult given the *Monitor's* remote location. The sanctuary does not have the resources to maintain a physical presence on-site. Therefore, sanctuary staff depends heavily on the watchful eyes of fishermen and dive operators, as well as patrolling efforts by the Coast Guard. Officers from NOAA Fisheries Office for Law Enforcement also help collect evidence and prosecute offenders, when necessary.

Additional enforcement is accomplished by educating potential user groups about sanctuary regulations and the resources they are designed to protect. By creating an understanding of the value and beauty of the sanctuary we hope to encourage voluntary compliance with sanctuary regulations. Education programs are a powerful tool, not only for enforcement of sanctuary regulations, but also for promoting an ocean conservation ethic among user groups. To date, education efforts have mainly focused on K-12 students, Civil War enthusiast groups, the general public and citizen groups via lectures, participation in community events and presentations at schools located in the sanctuary region. Expanded education efforts in North Carolina focusing on dive clubs and charter boat companies are currently underway.

The *Monitor* sanctuary is committed to providing educational programs and materials that teach about the history, discovery, recovery, conservation and wreck site of the USS *Monitor*. One of the best ways to learn about the *Monitor* is to visit The Mariners' Museum in Newport News, Va. The museum and NOAA have brought the story of this unique ironclad to the public through the dramatic USS *Monitor* Center. The center serves as the primary visitor center for the *Monitor* sanctuary, and tells the story of the *Monitor* through a rich array of original artifacts, archival materials, immersive multimedia experiences, a full-scale external replica of the vessel, and recreated ship interiors that transport visitors back in time to 1862. The opening of the USS *Monitor* Center represented a major milestone for NOAA's Maritime Heritage Program as well as education and outreach efforts for the program.

Recreational and Commercial Fishing

Monitor National Marine Sanctuary's regulations prohibit activities that could impact the wreck or alter the sanctuary's existing biological habitats or disturb and damage its natural resources. Recreational and commercial fishing are potential stressors to marine species and the site of the *Monitor*. Therefore, the sanctuary prohibits anchoring without a permit within its boundaries. Other activities such as discharging waste material into the water, detonation of explosive material, seabed drilling, seabed cable-laying, and dredging are also prohibited within the sanctuary's boundaries. Each violation can result in civil penalties of $50,000. Prohibition of commercial fishing (other than those types of commercial fishing that do not pose a threat to the site, such as live-boating sport charter fishing) and trawling in the sanctuary helps to eliminate the pressure of fishing gear on the living resources and integrity of the wreck.

Diving and Artifact Recovery

Site looting poses a major threat to submerged archaeological resources. The diving community must be educated on proper wreck diving etiquette and the regulations in place in order to protect these non-renewable resources. Diving in *Monitor* National Marine Sanctuary requires a permit and high technical skill as the site of the historic ironclad is 230 feet deep and influenced by strong currents typical of the Graveyard of the Atlantic off Hatteras, N.C. In 2007, the *Monitor* sanctuary was visited by 35 scuba divers and one private diving expedition. Special use or research permits are required for dives in the sanctuary.

The sanctuary program works hard to balance access to the site with resource protection, and will continue to work diligently to provide a system of access to the wreck for divers wherever possible as long as protection of the wreck site can be assured. In the future, *Monitor* National Marine Sanctuary staff will continue to work to find

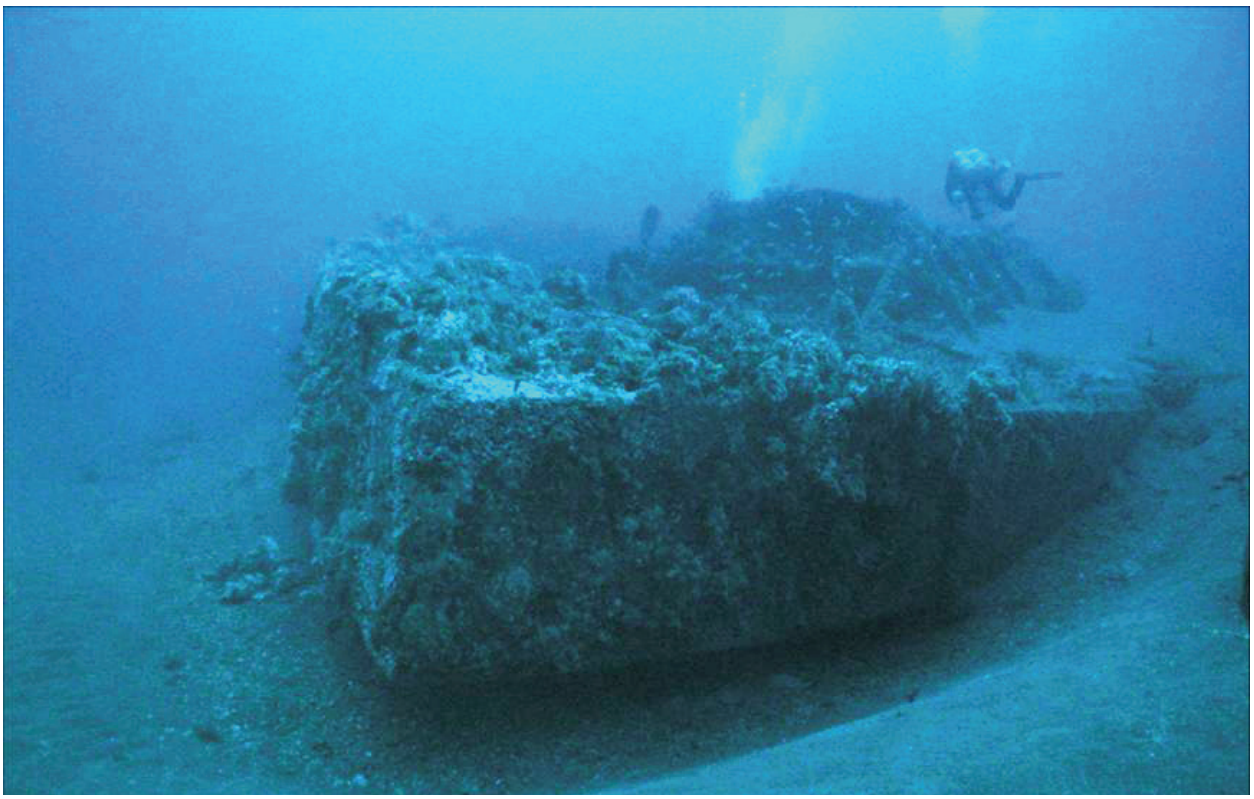


Photo: NOAA, *Monitor* Collection

Pressure from the dive community led the sanctuary staff to create a permit system allowing diving and artifact recovery in fulfillment of the sanctuary's mission to preserve the site.

additional ways to increase the number of divers who visit the site on an annual basis. Resource protection will always be a priority with regard to site access so the wreck may be preserved for future generations of historians, researchers and divers.

Research

Since 1977, research at the *Monitor* site has focused on documenting the wreck in detail and understanding how it has been affected by natural deterioration and human activities. Because research itself may result in harm to the resource, or increase the risk of harm, all research conducted at the *Monitor* site is subject to the sanctuary's permit regulations.

Research activities within the *Monitor* sanctuary have focused on documenting the wreck and surrounding site in detail to obtain a better understanding of the ship itself and to monitor deterioration of the habitat attributed to natural deterioration and human-related activities. All research and diving activities that take place within the sanctuary must be approved by the sanctuary in the form of special use or research permits. NOAA's Maritime Heritage Program, committed to preserving historical, cultural and archaeological resources within the National Marine Sanctuaries, is a leader in these research efforts.

The *Monitor* sanctuary's long-term goal is to coordinate scientific research and monitoring of the ecological conditions of the sanctuary. This will allow staff to track and compare natural and human-caused changes in habitat and living resources, including the impacts of invasive species on the condition of the sanctuary and the *Monitor*.

Archaeological research will continue to be the main focus of the *Monitor* sanctuary. The majority of the wreck site is still unexcavated. Future expeditions will continue to document the wreck site for deterioration related to natural and human activities. Additional archaeological recoveries will document gaps in the details of the *Monitor's* construction and provide a better understanding of the social environment aboard the novel 19th-century warship, giving insight into the ship's stores, tools and personal items used by the officers and crew.

The University of North Carolina at Chapel Hill (UNC) has been collecting data on water quality off Cape Hatteras for several years. Considering the proximity of the *Monitor* sanctuary to the area of UNC research, the existing data may be applicable to the sanctuary's waters. A partnership with UNC could be a starting point to establish the *Monitor* sanctuary's own water quality monitoring plan in the near future. Parameters of particular interest include currents, temperature, salinity and pH, all of which affect deterioration rates of artifacts, as well as living resource conditions.

Natural Deterioration

The *Monitor* will continue to deteriorate due to the natural process of corrosion. It is believed that with proper management the wreck will remain for centuries, as we have seen on other shipwrecks. Sanctuary staff are working to reduce disturbance of the site as much as possible and limit access to the site to individuals with a legitimate research design and those who are specifically trained to dive on wrecks without disruption. Additionally, NOAA is exploring the impact of placing cathodic protection on the wreck site to further reduce the corrosion rate.

Photo: NOAA, *Monitor* Collection

Recovery of the engine will permit researchers a unique opportunity to study builder John Ericsson's innovative vibrating side-lever engine.

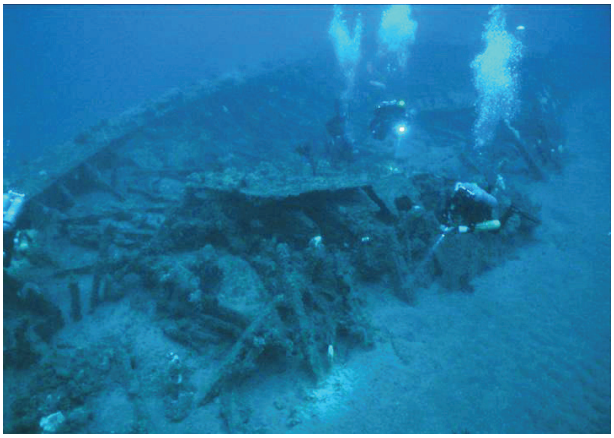


Photo: NOAA, *Monitor* Collection

The sanctuary continues to minimize the deterioration of the remaining structure through controlled visitation and other potential technological applications.

Concluding Remarks

Since its designation, the *Monitor* National Marine Sanctuary has accomplished many missions to protect and preserve the wreck of the famous Civil War ironclad. This report indicates that additional study of the sanctuary's living resources and general marine environment is warranted. Conducting biological research, ongoing archaeological investigation, developing effective monitoring programs and establishing new partnerships with scientific communities will help guide management actions and better preserve sanctuary resources. Continued efforts in public education through exhibiting and various media outlets are important approaches to ensuring long-term protection of the sanctuary and the information it has yet to reveal about the life and times of the *Monitor*.

Photo: NOAA, *Monitor* Collection

The new *Monitor* Center in Newport News, Va., permits the public to watch the careful conservation of the turret.

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Additional Resources

Encyclopedia of the Sanctuaries Web site: http://www8.nos.noaa.gov/onms/park/Parks/USS*Monitor*/

Mariners' Museum Web site: http://www.mariner.org/

Monitor National Marine Sanctuary. (2003). NOAA Year 2003 Research Expedition to the *Monitor* National Marine Sanctuary. Newport News: National Oceanic and Atmospheric Administration.

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Monitor National Marine Sanctuary Web site, Charting a New Course for the *Monitor*: http://monitor.noaa.gov/plan/page03.html

Monitor National Marine Sanctuary Web site, Expeditions: http://monitor.noaa.gov/about/expeditions.html

Monitor National Marine Sanctuary Web site, Location: http://monitor.noaa.gov/visit/welcome.html

Monitor National Marine Sanctuary Web site, Publications: http://monitor.noaa.gov/publications/welcome.html

Monitor National Marine Sanctuary Web site, Regulations: http://monitor.noaa.gov/about/regs.html

Photo: NOAA, *Monitor* Collection

During the conservation process, the 11-inch rifled Dahlgren guns that fought the famous battle with the CSS *Virginia*, are removed for individual care.

Acknowledgements

We would like to thank our three reviewers for their helpful comments: John McCord, UNC Coastal Studies Institute; Susan Langley, Maryland Department of Planning; Anna Holloway, The Mariners' Museum. We would also like to thank researchers from East Carolina University and the Woods Hole Oceanographic Institute who provided background information for the natural resource sections of the report.

Monitor National Marine Sanctuary Web site: http://monitor.noaa.gov/

National Resources Defense Council Web site, Discussion of Overlapping Areas for Protection: http://www.nrdc.org/water/oceans/priority/part2.asp

NOAA Ocean Explorer Web site, Stream/South Atlantic Bight Expedition, Web site: http://oceanexplorer.noaa.gov/explorations/islands01/background/islands/sup8_thepoint.html

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The Mariners' Museum Web site: http://www.mariner.org/

The North Carolina Coastal Ocean Observing System Web site: http://nccoos.unc.edu

NOAA's Northeast Fisheries Science Center Web site: http://www.nefsc.noaa.gov/

The Reef Environmental Education Foundation Web site, Geographic Report for USS *Monitor*: http://www.reef.org/cgi-bin/georep.pl?region=TWA&geogr=93030026&min_date=00%2f00%2f&max_date=00%2f00%2f&species=&sort=&inverts=&exp

The USS *Monitor* Center Web site: http://www.monitorcenter.org/

Appendix: 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. Evaluations of status and trends may be based on interpretation of quantitative and, when necessary, non-quantitative assessments and observations of scientists, managers and users.

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

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

Water Stressors

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

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

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

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

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 causev measurable but not severe declines in living resources and habitats.
Fair/Poor	Selected conditions have caused or are likely to cause severe declines in some but not all living resources and habitats.
Poor	Selected conditions have caused or are likely to cause severe declines in most if not all living resources and habitats.

Water Human Health

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

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

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

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

Water
Human Activities

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

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

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

Habitat
Abundance & Distribution

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

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

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

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

Habitat Structure

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

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

Kelp beds may not be biogenic habitats to the extent of coral reefs, but kelp provides essential habitat for assemblages that would not reside or function together without it. There are other communities of organisms that are also similarly co-dependent, such as hard-bottom communities, which may be structured by bivalves, octocorals, coralline algae, or other groups that generate essential habitat for other species. Intertidal assemblages structured by mussels, barnacles, 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 Non-Indigenous Species

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

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

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

Living Resources
Key Species

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

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

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

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

Living Resources
Health of Key Species

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

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

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

Living Resources
Human Activities

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

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

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

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

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

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

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

Maritime Archaeological Resources **Integrity**

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

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

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

Maritime Archaeological Resources **Threat to Environment**

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

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

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

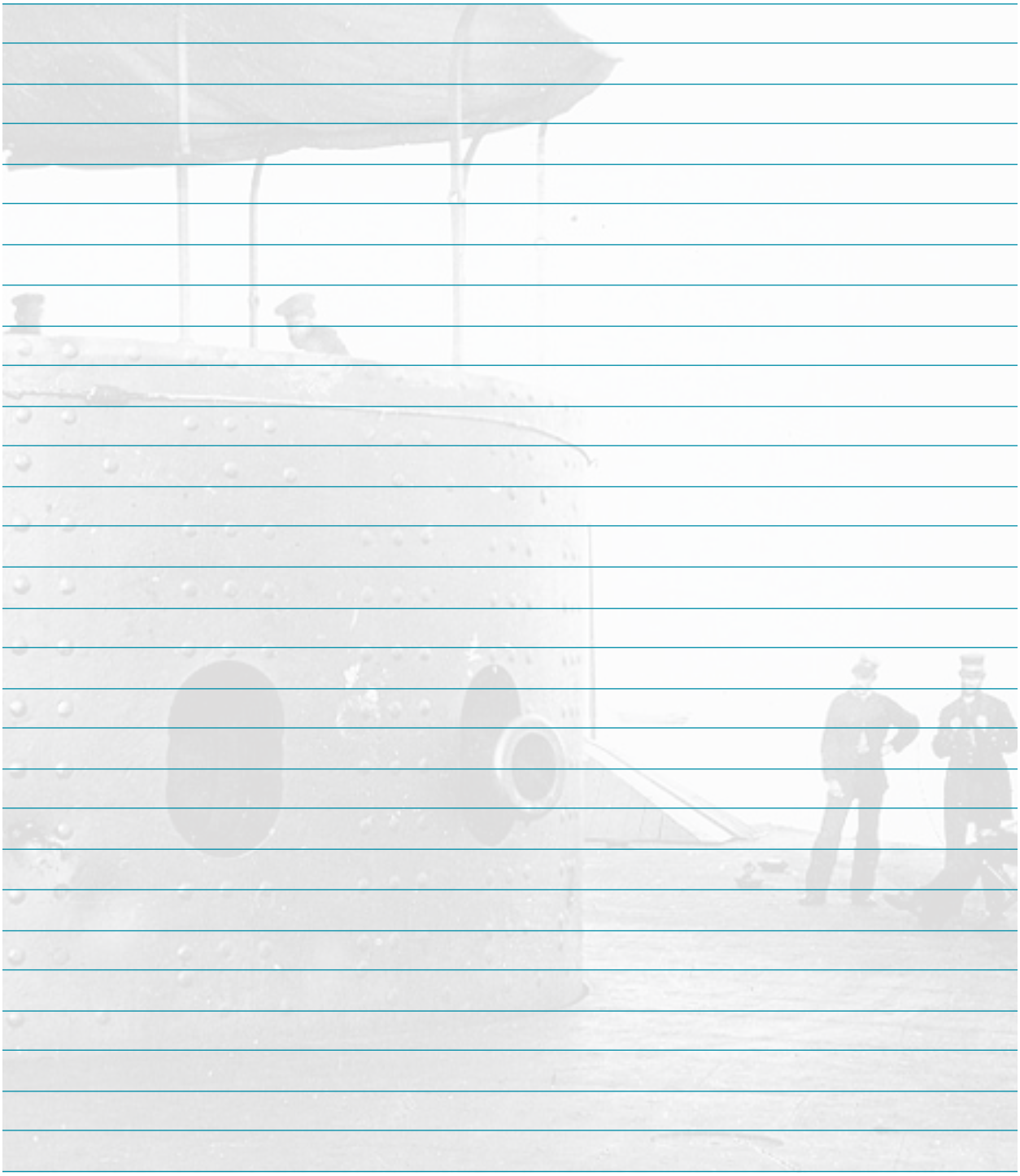
Maritime Archaeological Resources
Human Activities

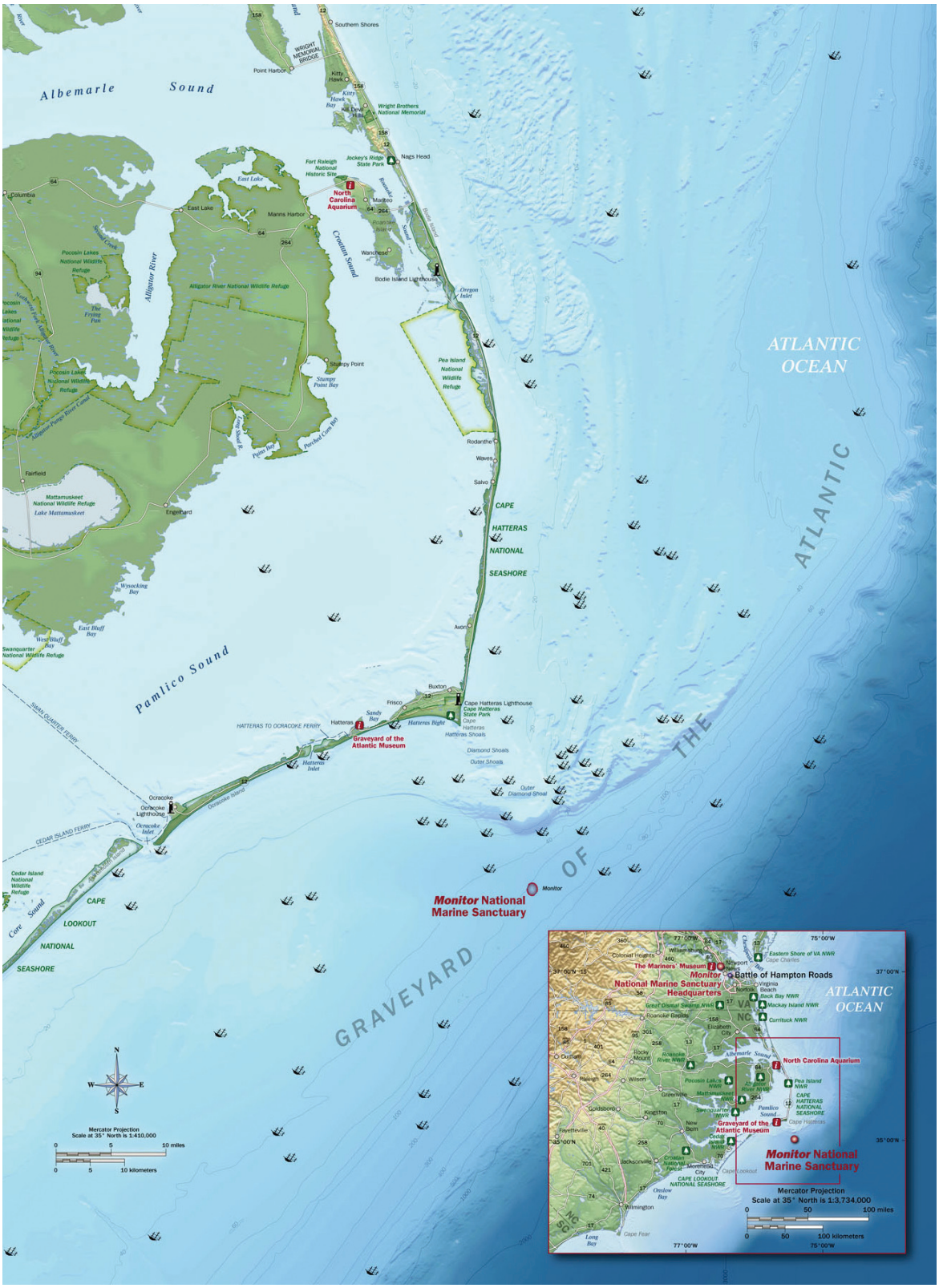
17. What are the levels of human activities that may influence maritime archaeological resource quality and how are they changing?

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

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

Notes





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