Maps Showing the Change in Modern Sediment Thickness on the Inner Continental Shelf Offshore of Fire Island, New York, Between 1996–97 and 2011

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U.S. Department of the Interior
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Conversion Factors

International System of Units to Inch/Pound

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)
	Area	
square kilometer (km^2)	247.1	acre
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic meter (m^3)	35.31	cubic foot (ft^3)
	Velocity	
meter per second (m/s)	3.281	foot per second (ft/s)

Datum

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the World Geodetic System 1984 (WGS 84).

Depth, as used in this report, refers to distance below the vertical datum.

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Abstract

The U.S. Geological Survey mapped approximately 336 square kilometers of the lower shoreface and inner continental shelf offshore of Fire Island, New York, in 1996 and 1997, using high-resolution sidescan-sonar and seismic-reflection systems, and again in 2011, using interferometric sonar and high-resolution chirp seismic-reflection systems. This report presents a comparison of sediment thickness and distribution as mapped during these two investigations. These spatial data support research on the Quaternary evolution of the Fire Island coastal system and provide baseline information for research on coastal processes along southern Long Island.

Introduction

In 1996 and 1997, the U.S. Geological Survey, in cooperation with the U.S. Army Corps of Engineers, conducted a program to produce geologic framework maps of the nearshore areas south of Long Island, New York (Schwab and others, 1997; Foster and others, 1999; Schwab, Thieler, Allen, and others, 2000). Mapping methods included high-resolution sidescan-sonar and seismic-reflection techniques. The goal of this investigation was to determine regional-scale availability of sand as a resource for future beach nourishment programs and to investigate the role that inner continental shelf morphology and geologic framework have in the evolution of the coastal region of southern Long Island.

In 2011, a high-resolution marine geophysical survey of the lower shoreface and inner continental shelf was conducted offshore of Fire Island, New York (Schwab, Denny, and Baldwin, 2014). This report presents maps of the change in modern sediment thickness and distribution detected between the 1996–97 and 2011 mapping investigations. The results suggest that the nearshore/shoreface sedimentary deposit has gained sediment at the expense of continued erosion of the marine transgressive surface. This report adds to a scientific foundation used to manage coastal systems and assess environmental changes caused by natural processes and human activities.

Regional Geologic Setting

Long Island marks the southern terminus of the Wisconsinan Laurentide glacial advance in the eastern part of North America (Stone and Borns, 1986). The coast from Southampton to Montauk Point is a headland region where the Ronkonkoma moraine (fig. 1) and associated glacial outwash sediment are eroded directly by wave action (Williams, 1976). The south shore of Long Island west of Southampton consists of reworked outwash and includes shallow back-barrier bays, marshes, and low-relief, sandy barrier islands (Leatherman and Allen, 1985). Located within this barrier-island system is Fire Island, a 0.5- to 1.0-kilometer (km)-wide, 50-km-long barrier island that is bound by two tidal inlets, Moriches Inlet to the east and Fire Island Inlet to the west (fig. 1).

Pleistocene glaciofluvial outwash deposits are exposed over much of the inner continental shelf south of Fire Island. The upper surface of the Pleistocene deposits was incised by a series of paleochannels that were subsequently filled with a transgressive sequence of glaciofluvial sediment, in places capped by lower Holocene muddy estuarine sediment (fig. 2). The modern sand deposit is derived from erosion of these Pleistocene glaciofluvial and lower Holocene fluvial channel-fill deposits exposed on the inner continental shelf by oceanographic processes during the Holocene marine transgression. The distribution of the modern sand deposit is discontinuous and variably thick, and it lies unconformably atop the Pleistocene and lower Holocene deposits (figs. 2 and 3). This unconformity is interpreted to be the Holocene transgressive surface. For a full review of the major inner continental shelf sedimentary sequences offshore of New York, see Schwab, Baldwin, Denny and others (2014) and Schwab, Denny, and Baldwin (2014) and references therein.

Data Collection and Processing

The area offshore of Fire Island was surveyed by using high-resolution sidescan-sonar, seismic-reflection, bathymetric, and sediment-sampling techniques in May 1996 aboard the research vessel *Seaward Explorer*, and in May 1997 and September to October 1997 aboard the research vessel *Diane G*. Details of the sidescan-sonar and fathometer acquisition and processing are described by Schwab, Thieler, Denny, and others (2000), and details of the seismic-reflection data acquisition and processing are described by Foster and others (1999).

The area offshore of Fire Island was resurveyed in May 2011 aboard the motor vessel *Scarlett Isabella* by using an interferometric sonar to acquire bathymetric and backscatter data and a chirp seismic-reflection profiler to define the subsurface stratigraphy and structure. The survey area extends about 50 km alongshore and about 8 km offshore in water depths ranging from approximately 8 to 32 meters (m) (fig. 1) and covers approximately 336 square kilometers (km^2). Details of the acquisition and processing of these data are described in Schwab, Denny, and Baldwin (2014).

Modern sediment thickness mapped in 2011 covered an area of about 274 km^2 (Schwab, Denny, and Baldwin, 2014) and was used for comparison to the modern sediment thickness mapped in 1996–97 (Foster and others, 1999). Ship position for both surveys was determined by using a Differential Global Positioning System (DGPS). The layback position of the seismic-reflection system towfish relative to the ship was accounted for in both surveys. We estimate that the positions of the seismic-reflection data are accurate to within 5 m.

The sediment thickness mapped in 1996–97 by Foster and others (1999) was calculated from two-way travel time on seismic-reflection profiles by using an assumed internal velocity of 1,630 meters per second (m/s). However, the sediment thickness mapped in 2011 by Schwab, Denny, and Baldwin (2014) was calculated from two-way travel time by using an assumed internal velocity of 1,500 m/s. In order to compare the 1996–97 and 2011 datasets, the 1996–97 sediment thickness was converted to the common internal velocity of 1,500 m/s used by Schwab, Denny, and Baldwin (2014) by multiplying by a factor of 0.92. The two datasets were then compared, yielding a difference grid (fig. 3) with a resolution of 100-m grid cell size to match the coarser input of the 1996–97 data.

A vertical resolution of 50 centimeters (cm) is assumed for sediment volume calculations because of a conservative estimate of the vertical resolution limits of the subbottom profiling systems used during the 1996–97 and 2011 surveys.

Mapping Results

Previous interpretations of marine geologic mapping data support the hypothesis that the Holocene evolution of Fire Island, including its modern decadal to centennial behavior, is linked directly to the geologic framework of the inner continental shelf. Schwab, Thieler, Denny, and others (2000) and Schwab and others (2013) identified the modern sediment deposit on the inner continental shelf offshore of Fire Island as a likely source of sediment required to balance the coastal sediment budget, suggesting that an onshore-directed component of the dominant westerly sediment flux (from the inner continental shelf to the shoreface), in combination with periodic contribution from beach nourishment activities, provides sufficient sediment to maintain island stability west of Watch Hill.

A comparison of modern sediment thickness mapped from seismic-reflection data in 1996–97 (Foster and others, 1999; Schwab, Thieler, Allen, and others, 2000) and 2011 (Schwab, Denny, and Baldwin, 2014) provides evidence to support the hypothesis of shoreward-directed sediment flux. The comparison (figs. 3 and 4), which shows changes in sediment thickness greater than 50 cm (the vertical resolution limit of the subbottom systems used in the two surveys), illustrates net westerly migration of the sand ridges, with erosion on their eastern flanks and crests and deposition on their western flanks, as well as significant accretion along the lower shoreface of western Fire Island.

Schwab, Baldwin, Denny, and others (2014) calculated that the modern sediment volume on the lower shoreface has accreted 7.8×10^6 cubic meters (m^3) and the modern sand deposit on the inner continental shelf was reduced by 3.1×10^6 m^3 over the 15-year period. This led them to speculate that the lower shoreface modern sediment deposit has gained volume at the expense of deflation of the large shoreface-attached sand ridges and inner continental shelf in general. This raises a question: if the shoreface-attached sand ridges are eroding, how are these prominent features maintained in the long term?

While attempting to address this question, an error was discovered in the volumetric calculations presented in Schwab, Baldwin, Denny, and others (2014); they did not convert the modern sediment thickness isopach of the 1996–97 survey produced by Foster and others (1999) to the common velocity of 1,500 m/s prior to comparing to the 2011 data (Schwab, Denny, and Baldwin, 2014). Although seemingly a minor correction (see “Data Collection and Processing” section above), following conversion the modern sediment volume of the lower shoreface is shown to have increased on the lower shoreface by 10.2×10^6 m^3 and increased on the inner continental shelf by 10.0×10^6 m^3 over the 15-year timespan; total accretion of 20.2×10^6 m^3. This calculation includes the mining of 2.4×10^6 m^3 of sand for beach nourishment activities (Lentz and others, 2013). Thus, speculation by Schwab, Baldwin, Denny, and others (2014) that the lower shoreface has gained volume at the expense of deflation of the shoreface-attached sand ridges is incorrect.

Modern sediment thicknesses greater than 50 cm were mapped over 112 km^2 in the 1996–97 surveys (41 percent of the mapped area) and over 119 km^2 of the 2011 survey (43 percent of the mapped area). The mean change in modern sediment thickness for the mapped area is +0.07 m, with the mean gain in areas of accretion +0.56 m and mean loss in areas of erosion -0.14 m. This strongly implies that erosion of Pleistocene glaciofluvial and lower Holocene channel-fill deposits exposed at the seafloor continues to yield the modern sediment required to balance the coastal sediment budget (Schwab and others, 2013) and maintain the shoreface-attached sand ridges.

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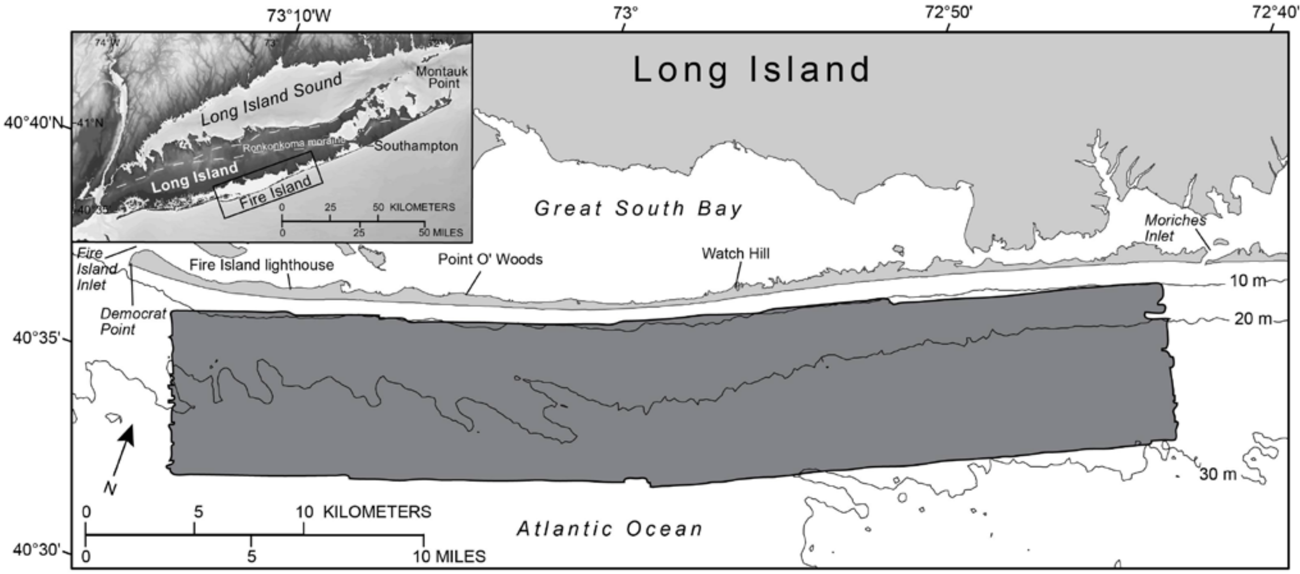

Base from U.S. Geological Survey
Universal Transverse Mercator, zone 18N, World Geodetic System 1984

Figure 1. Map showing the survey area (shaded in dark gray) offshore of Fire Island, New York, 2011. Inset map shows location of study area (outlined in black). Bathymetric contours are in meters (m) below the North American Vertical Datum of 1988 (NAVD 88). Figure modified from Schwab and others (2013).

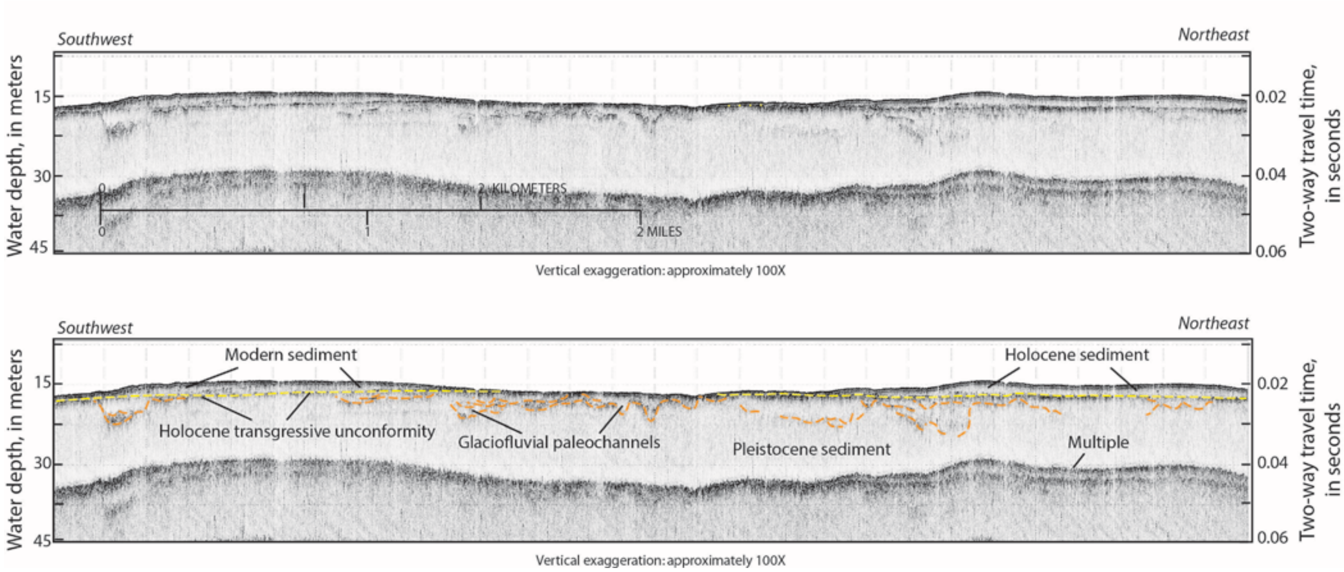

Figure 2. High-resolution chirp seismic-reflection profile and interpretation illustrating stratigraphic features and geometries discussed in the text. Location of the profile is shown in figure 3. Approximate water depth in meters is based on a two-way travel time of 1,500 meters per second. The Holocene transgressive unconformity is marked by a yellow dashed line. Glaciofluvial channels and older Pleistocene sediments are marked by orange dashed lines. Figure modified from Schwab and others (2013).

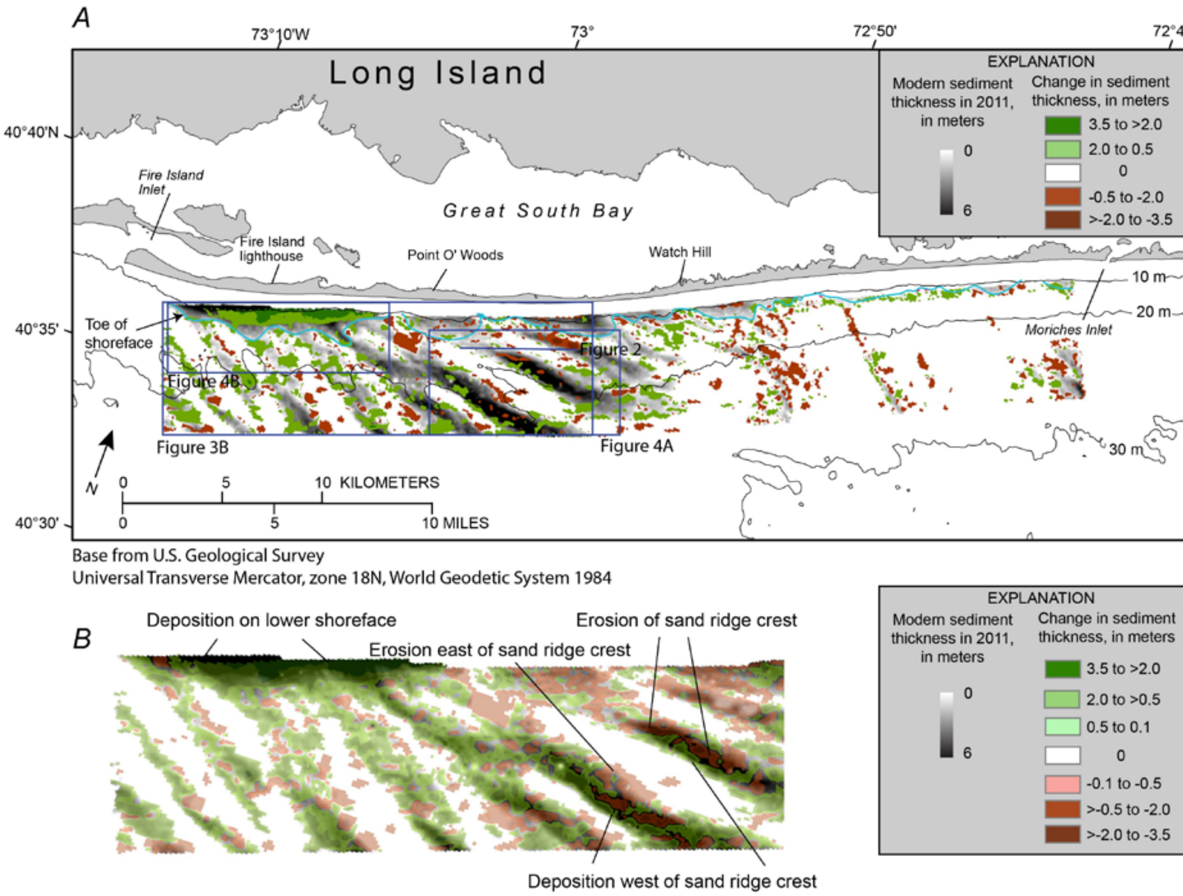

Figure 3. *A*, Map showing the change in modern sediment thickness greater than 0.5 meter (m) between isopachs interpreted from 1996–97 (Foster and others, 1999) and 2011 (Schwab, Denny, and Baldwin, 2014) seismic-reflection data, overlain on the 2011 modern sediment thickness isopach (Schwab, Denny, and Baldwin, 2014), offshore of Fire Island, New York. Blue line shows seaward extent (toe) of the shoreface (Schwab, Baldwin, Denny, and others, 2014). Regional bathymetric contours are in meters below the North American Vertical Datum of 1988 (NAVD 88). Figure modified from Schwab, Baldwin, Denny, and others (2014). *B*, Enlargement of area shown in *A*. Change in sediment thickness shown by using a less conservative vertical resolution limit of 10 centimeters to illustrate net westerly migration of the sand ridges, with erosion on the eastern flanks and crests of the ridges and deposition on the western flanks.

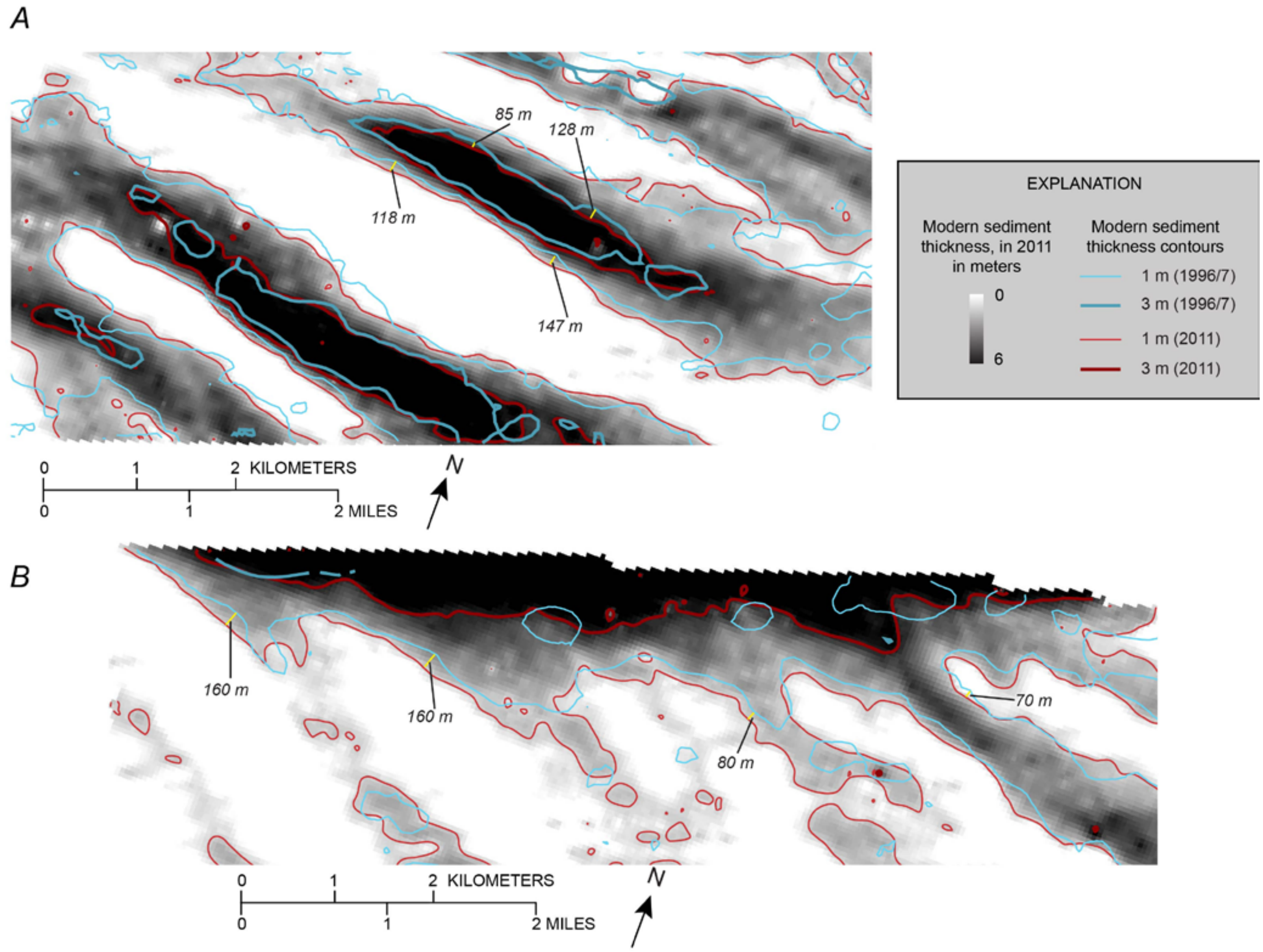

Figure 4. Maps showing the 1- and 3-meter (m) contours of sediment thickness from the 1996–97 and 2011 surveys offshore of Fire Island, New York, of the *A*, shoreface-attached sand ridges and *B*, area of accretion on the lower shoreface overlain on the 2011 modern sand thickness (Schwab, Denny, and Baldwin, 2014). Yellow lines illustrate the southwest migration of contours. See figure 3*A* for locations.

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For more information concerning this report, contact:

Director
Woods Hole Coastal and Marine Science Center
U.S. Geological Survey
384 Woods Hole Road
Quissett Campus
Woods Hole, MA 02543-1598
WHSC_science_director@usgs.gov
508-548-8700 or 508-457-2200

or visit our Web site at:
http://woodshole.er.usgs.gov/

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