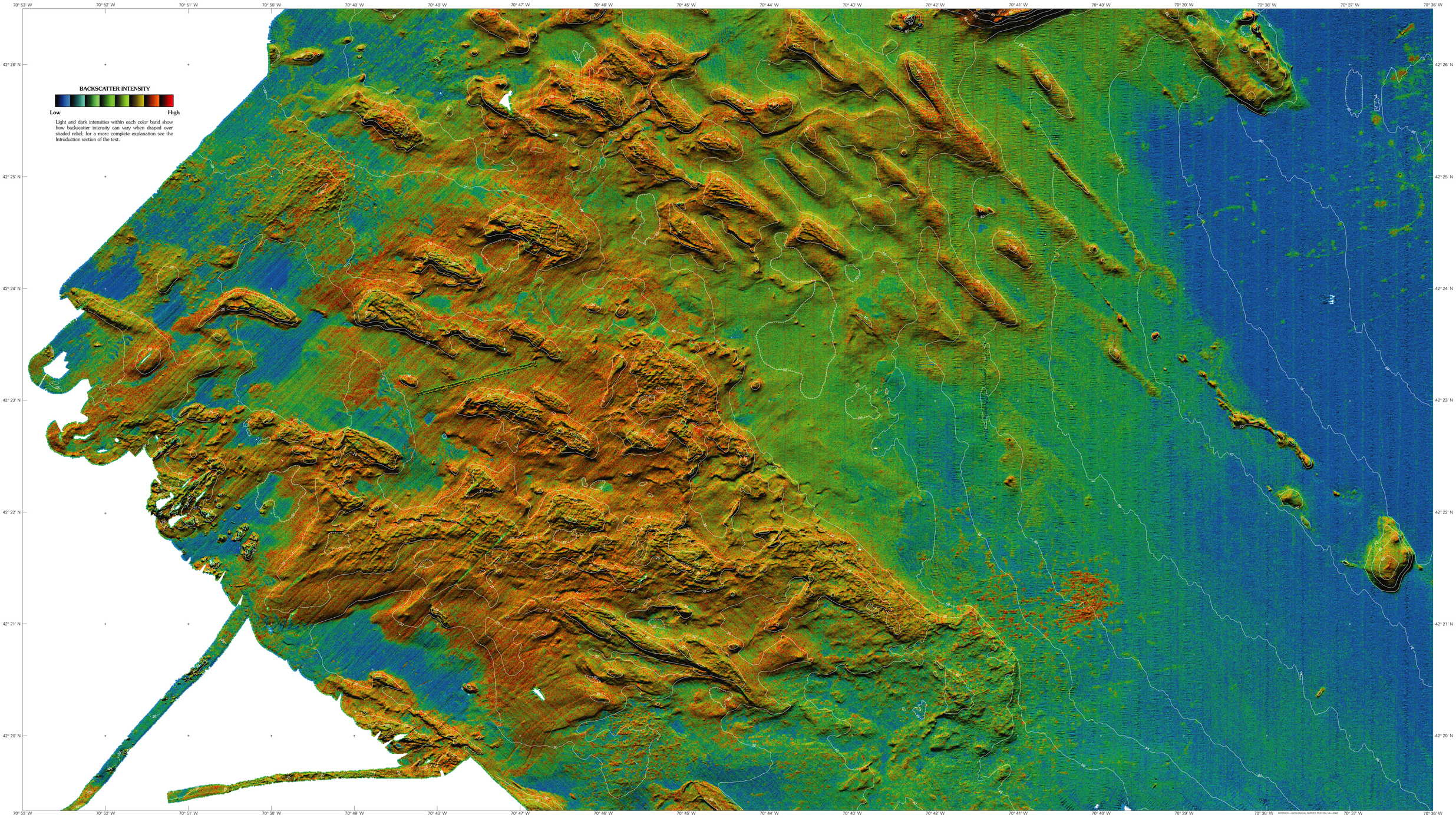
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOLOGIC INVESTIGATIONS SERIES
MAP I–2732–C



Mercator projection

Geodetic Reference System 1980; North American Datum 1983
Longitude of central meridian 70°19' W.; latitude of true scale 41°39' N.
False easting 0 m; false northing 0 m

This map is not intended for navigational purposes.

SCALE 1:25 000
ONE CENTIMETER ON THE MAP REPRESENTS 250 METERS ON THE SEA FLOOR

1 .5 0 1 2 3 4 5 KILOMETERS

1 .5 0 1 2 NAUTICAL MILES

CONTOUR INTERVAL 5 METERS
DATUM MEAN LOWER LOW WATER

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—2003

DISCUSSION

Introduction

This map shows backscatter intensity of the sea floor draped over shaded relief, with sea floor depth as topographic contours overprinted in white, at a scale of 1:25,000. It is based on multibeam echo-sounder data collected using a Simrad Subsea EM 1000 Multibeam Echo Sounder (95 kHz) during four cruises conducted between the fall of 1994 and the fall of 1998 aboard the vessel *Frederick G. Creed*. The map is part of a 3-quadrangle map series showing the area offshore of Boston, Mass., that is companion to the Stellwagen Bank National Marine Sanctuary map series (Valentine and others, 2001, 2003a–c; also see location map). Other maps of Quadrangle 2 depict topographic contours (Butman and others, 2003a), and shaded relief and topographic contours (Butman and others, 2003b).

Backscatter intensity is a measure of surficial sediment texture and bottom roughness. Generally, high backscatter intensity is associated with rock or coarse-grained sediment, and low backscatter intensity characterizes finer grained sediments. Direct observations, using bottom photography or video and sampling techniques such as grab sampling or coring, are needed to verify interpretations of the backscatter intensity. In the image shown here, the backscatter intensity is represented by a suite of eight colors ranging from blue, which represents low intensity (fine-grained sediments), to red, which represents high intensity (rock outcrops and coarse-grained sediments). These data are draped over a shaded relief image created by vertically exaggerating the topography four times and then artificially illuminating the relief by a light source positioned 45 degrees above the horizon from an azimuth of 350 degrees. The resulting image displays light and dark intensities within each color band that result from a feature's position with respect to the light source. For example, north-facing slopes, receiving strong illumination, show as light intensity within a color band, whereas south-facing slopes, being in shadow, show as dark intensity within a color band. The shaded relief image accentuates small features that could not be effectively shown by contours alone at this scale. The bathymetric soundings were gridded at 6 m/pixel resolution and smoothed using a 9-cell by 9-cell median filter; contours having a 5-meter interval were generated from the resulting grid. Blank areas in the image represent places where no data exists. Most areas of no data in this backscatter intensity image are smaller than in the shaded relief image (Butman and others, 2003b) because depth measurements at the outer edge of the swath were sometimes removed as bad data; in many of these cases, the backscatter intensity data were still useable, resulting in greater spatial coverage for backscatter intensity. The two narrow strips of data in the southwest corner of the quadrangle were collected along single ship transits to Boston Harbor. Topographic lows are identified by hachured contours (hachures face deeper water).

Some features in the image are artifacts of data collection and environmental conditions. They include small highs and lows and unnatural-looking features, and patterns oriented parallel or perpendicular to survey tracklines (tracklines were run north-south in the eastern and north-central part of the map area, northwest-southeast in the south-central part, and northeast-southwest in the western part). For example, the wrinkle-like features about 100 m long, oriented east-west and perpendicular to the ship's track between 70°39' W. and 70°42' W., are a result of heave of the vessel during data collection caused by large surface waves; the northeast-southwest-trending lines in the vicinity of 42°21.5' N., 70°47.5' W. are a result of data loss in the far range of individual swaths; and small offsets in features in the southwestern part of the study area, most notable along features that have sharp transitions, are a result of errors in synchronization of the navigation and multibeam clocks during the 1994 survey (a diamond-shaped area with corners at 42°19.5' N., 70°48' W.; 42°23' N., 70°43.5' W.; 42°26' N., 70°48' W.; and 42°23' N., 70°52.5' W.). For example, see the northeast-southwest offsets of the northwest-southeast-trending features near 42°-21.94' N., 70°47.88' W., and near 42°23.74' N., 70°48.59' W.

Geologic history

The major topographic features shown in this map series were formed by glacial processes that occurred in several stages. Ice containing rock debris moved across the region, sculpting its surface and depositing sediment, forming the ridges and valleys that characterize the region. Other features are the result of processes at work when much of the area was covered with rotting ice, and when at the same time small valley glaciers and ice falls were active. Ice retreat and marine submergence occurred between 18 and 14 ka, resulting in a highstand of sea level approximately 33 m above modern sea level about 14 ka (Oldale and others, 1993). A lowstand of sea level approximately 45 m below modern sea level occurred about 12 ka as the earth's crust rebounded from ice loading. Thus, the sea floor of Massachusetts Bay in water depths shallower than about 45 m was reworked during the marine transgression between 18 and 14 ka, again during a relatively rapid sea-level regression between 14 and 12 ka, and finally during the transgression between 12 ka and the present. Today, the surficial sediments and features are reworked and shaped by tidal and storm-generated currents that erode and transport sediments from the shallow areas into the deeper basins. Over time, the shallow areas affected by these processes have become coarser as sand and mud are removed and gravel remains, and the deeper basins have been built up as they receive the sand and mud. Knebel and Circé (1995) have identified areas of erosion, sediment reworking, and deposition in this region.

Quadrangle 2 features

One of the most striking aspects of the sea floor shown by this survey is the variability in bottom morphology and texture over scales of a few kilometers or less, caused by both natural and anthropogenic processes. The topography, surface features, and surficial sediment texture are the result of glacial processes, reworking during the last rise in sea level, reworking by modern processes, and the disposal of dredged and other material in this region over the last century.

West of about 70°40' W., the sea floor is characterized by a varying topography having relief of 10 to 15 m. The crests of the submerged features are typically covered with high-backscatter-intensity material. Between 70°40' W. and about 70°48' W., backscatter intensity is moderate in the topographic lows between the ridges; these lows contain some isolated small patches of medium- to low-backscatter-intensity material (for example, see features near 42°22.25' N., 70°46' W. and 42°22.85' N., 70°48.09' W.). West of about 70°48' W., the backscatter intensity is low except on the crests and flanks of ridges. North of approximately 42°23' N., the sea floor is shaped into a series of northwest-southeast-trending features that are about 2 km long and 0.5 km wide and that typically rise 5 to 10 m above the surrounding sea floor. Oldale and others (1994) examined 11 of these features in the region centered at 42°25' N., 70°48' W. (originally mapped by Bothner and others, 1992), and hypothesized that they are submerged drumlins. In general, their tops are smooth (that is, little texture is evident in the shaded relief image) in water deeper than 45 m, and rough in water shallower than 45 m. It is hypothesized that the rougher surface is the result of reworking and removal of fine material as sea level transgressed the region from its -45 m lowstand.

South of 42°22' N. and west of 70°41' W., the sea floor is dominated by a discontinuous and in places poorly defined ridge that extends roughly east-west. Its depth ranges from 40 to 45 m in the east to about 25 m in the west. Eastward of 70°41' W., backscatter intensity decreases as the sea floor gradually deepens toward Stellwagen Basin. The sea floor is relatively flat and featureless with the exception of a thin, northwest-southeast-trending feature centered near 42°22.8' N., 70°38.15' W. This ridge, having relief of about 5 m, is steeper and narrower than the ridges to the west. In addition, a knob approximately 1 km in diameter and centered near 42°-21.5' N., 70°36.5' W., rises about 10 m above the surrounding sea floor. Both features are characterized by high backscatter intensity.

Several features are hypothesized to be remnants of meandering channels, which possibly are drainage routes formed during a lower stand of sea level. One channel starts at about 40 m water depth near 42°25.4' N., 70°45.8' W. and ends at about 50 m water depth in a lobe-like feature centered at about 42°25.4' N., 70°42.6' W. The channel is 100 to 200 m wide. The material flooring this channel generally has higher backscatter intensity than the surrounding sea floor. A second, narrower channel starts near 42°22.2' N., 70°45.0' W. at about 35 m water depth, and ends near 42°22.15' N., 70°43.1' W. in water depth between 45 and 50 m. In this channel, the backscatter intensity is typically lower than that of the surrounding sea floor.

Several areas suggest active sediment movement. Ribbon-like features, typically 0.5 to 2 km long and less than 40 m wide, are observed near 42°19.8' N., 70°46.9' W., and are suggestive of downslope sediment transport. The relief across these features is about 30 cm or less. Fans of higher-backscatter-intensity material are evident at their southern (downslope) end. Similar features are observed in the vicinity of 42°25.0' N., 70°46.5' W. (data artifacts in this area that also appear as ribbon-like features are more easily identified in the shaded relief image; see Butman and others, 2003b). Sand waves, having wavelengths of about 50 m, are apparent in the area between 42°21' N., 70°42' W. and 42°23' N., 70°43' W., and in low areas between 70°44' W. and 70°47' W. at about 42°26' N.

Five areas of the sea floor in Quadrangle 2 show the effects of ocean disposal of anthropogenic material. The areas are characterized by numerous small features, each having high backscatter intensity. These features are most apparent where the surrounding sediment has low backscatter intensity. In the shaded relief image (Butman and others, 2003b), these areas are typically identified by a low mound having an unnatural-appearing roughness resulting from numerous individual dumps of material. The areas that are impacted by disposal are (1) centered near 42°26.0' N., 70°48.0' W.; (2) located between 42°24.5' N., 70°49.0' W. and 42°25.5' N., 70°50.0' W.; (3) located between 42°21.0' N., 70°39.75' W. and 42°21.5' N., 70°40.5' W.; (4) located between 42°19.5' N., 70°45.0' W. and 42°20.25' N., 70°46.0' W.; and (5) located between 42°24' N., 70°36' W. and 42°26' N., 70°39' W. At sites 1, 2, and 4, the accumulation of material is a few meters higher than the surrounding sea floor. Areas 1 and 3 are within discontinued dumping grounds, as shown on National Ocean Service (1997) Chart 13267, and area 2 is near the location of a former dumping ground buoy (Butman and Lindsay, 1999). Area 4 is located to the south of the previous location of the Boston Lightship. Numerous additional isolated dumps, identified as small features with high backscatter intensity, are observed in a corridor between areas 3 and 4. The dumps in area 5 are near the Massachusetts Bay Disposal Site (42°25.1' N., 70°34.5' W.) but are outside the designated disposal area. See Valentine and others (1996) for a detailed description of the features of the Massachusetts Bay Disposal Site.

The 50 individual diffuser heads for the new ocean outfall that discharges treated sewage effluent from the Boston metropolitan region into Massachusetts Bay extend between 42°23.06' N., 70°48.23' W. and 42°23.33' N., 70°46.81' W. The heads are located in 30 to 35 m water depth in a topographic low; west-northwest-trending ridges rise to about 25 m below the sea surface to the north and south. The most notable features are two parallel rows, about 2 km long, of individual mounds, which consist of material discarded on the sea floor from the holes drilled for the risers that extend to the outfall tunnel below. The diffuser heads, which are about 3 m high and 4 m in diameter, are located between the rows and are not well resolved in the 6-meter-gridded data. Note that a single survey trackline was run over the diffuser heads' location in 1997. This data replaced the original survey in this area, eliminating the offsets caused by errors in the synchronization of the navigation and multibeam clocks during the 1994 survey.

ACKNOWLEDGMENTS

The multibeam echo-sounder surveys were conducted with support from the Canadian Hydrographic Service and the University of New Brunswick. For their skillful work at sea, we thank G. Costello, N. Doucet, J. Gagne, R. Samfacon, and B. Tessier of the Canadian Hydrographic Service, E. Radford of the National Oceanic and Atmospheric Administration, and the officers and crew of the Canadian Hydrographic Service survey vessel *Frederick G. Creed*. We also thank J.H. Clark of the University of New Brunswick for his assistance in data acquisition, processing, and interpretation.

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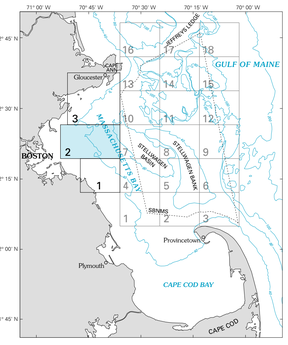

Location map showing mapped Quadrangle 2 shaded in blue. The western Massachusetts Bay map series comprises quadrangles 1–3 (outlined in black); the maps for Quadrangle 2 include this map and Butman and others (2003a,b). Backscatter intensity, shaded relief, and sea floor topography of Quadrangle 1 are shown at scale 1:25,000 in Butman and others (2003c). Quadrangles 1–18 (outlined in gray) compose the companion Stellwagen Bank National Marine Sanctuary (SBNMS) map series. The backscatter intensity, shaded relief, and sea floor topography of the entire area of quadrangles 1–18 are shown at scale 1:60,000 in Valentine and others (2001, 2003c). The SBNMS boundary is shown as a dashed line. Selected bathymetric contours are labeled in meters.

BACKSCATTER INTENSITY, SHADED RELIEF, AND SEA FLOOR TOPOGRAPHY OF QUADRANGLE 2 IN WESTERN MASSACHUSETTS BAY OFFSHORE OF BOSTON, MASSACHUSETTS

By

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2003

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