

**DISCUSSION**

**Introduction**

The Stellwagen Bank National Marine Sanctuary Mapping Project is a cooperative effort of the U.S. Geological Survey and the National Oceanic and Atmospheric Administration, with support from the University of New Brunswick and the Canadian Hydrographic Service. The multibeam echo sounder survey was conducted on four cruises over a two-year period from the fall of 1994 to the fall of 1996. This map shows one of a series of 18 quadrangles (see location map) in which sea floor depth information is depicted in sun-illuminated (or shaded relief) view at a scale of 1:20,000, with topographic contours superimposed in blue. The image shown here uses a sun elevation angle of 45 degrees above the horizon from an azimuth of 350 degrees and a vertical exaggeration of four times. In effect, topographic relief is enhanced by having the sun illuminate the sea floor from a position 10 degrees west of north, so that shadows are cast on the southern flanks of seabed features. Some features in the images are artifacts of data collection. They are especially noticeable where the seabed is smooth, and they include small highs and lows and unusual-looking features and patterns that are oriented parallel or perpendicular to survey tracklines. For a description of the topographic contours alone, and for an explanation of survey and topographic data processing methods, see the companion map by Valentine and others (1997). Topographic contour maps of all 18 quadrangles in the map series are available on a CD-ROM in EPS, PLT, Arc export, and PDF file formats (Valentine and others, 1998). Blank areas represent places where no data exist.

**Regional seabed features**

The major topographic features depicted in the map series were formed by glacial processes. In broad terms, these features are interpreted here to represent a geologic history that developed in several stages. Ice containing rock debris moved across the region, sculpting its surface and depositing sediments to form the large basins, banks, ridges, and valleys. Many other features observed here represent the latter stages of deposition. They are the result of processes at work much of the area was covered by stationary retreating ice, and when at the same time small valleys and ice falls were active in and near areas of high topographic relief. The sea masked the region formerly occupied by ice, and seabed features were partly eroded and some

new sedimentary deposits formed. Today, the sea floor is modified mainly by strong southwestward flowing bottom currents caused by storm winds from the northeast. These currents erode sediments from the shallow banks and transport them into the basin. With time, the banks affected by these currents become coarser as sand and mud are removed and gravel remains, and the western flanks of the banks, as well as adjacent basins, are built up by deposits of mud and sand.

**Quadrangle 11 features**

Quadrangle 11 covers the northern part of Stellwagen Bank 80 to 70 m water depth and a topographically varied region to the north of the bank that is characterized by banks and complex ridges whose summits lie at 60 to 90 m water depth, separated by deep valleys and basins whose depth ranges between 120 to 195 m. In the southern part of the quadrangle, Stellwagen Bank is relatively flat except where it is intersected by generally north-trending glacial valleys. The bank surface here is chiefly gravel and includes boulder pits and ridges. Some of these short linear ridges resemble eskers (sand and gravel deposited by running water in channels within stationary glacial ice); they are located along the southern margin (70°19'W) and in the southeast corner of the quadrangle. Other, larger ridges are located along the upper walls of both shallow and deep glacial valleys in the southwestern part of the quadrangle (42°26.9'N, 70°20.4'W; 42°27.6'N, 70°23.1'W); these ridges are interpreted to be lateral moraine deposits of rock debris piled up at the edges of moving ice. The northern flank of Stellwagen Bank, below 60–75 m water depth, and the shallow valleys in the southwestern part of the quadrangle are sandy, becoming muddy with increasing depth into the basin to the north. Sand deposits that display east-west trending bedforms are located on the northern flank between 70°17' and 70°19'W and between 70°21' and 70°22'W. Broad depressions in the seabed along the eastern margin of the quadrangle, extending from the southeast corner to 42°30'N, possibly indicate the former locations of large masses of melting ice. The sea floor here is chiefly gravel in places partly covered by a thin veneer of sand. Two deep valleys that incise the bank in the southwestern part of the quadrangle are floored with muddy sand. In the larger of these valleys, which heads at 70°20.5'W at the southern edge of the quadrangle, the floor is smooth to a depth of 115 m, from where it displays low ridges and mounds that clog the valley as it proceeds northeast into a large basin north of 42°29.3'N. The ridges and mounds possibly represent deposits of gravelly glacial debris transported by ice flows down the

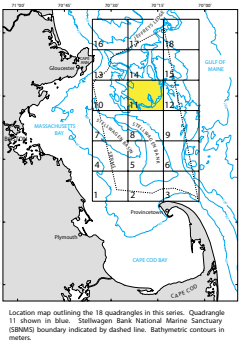
steep west wall of the valley. These deposits now are covered with muddy sand. The other valley, which heads at 70°24.5'W, is shorter and has a relatively smooth floor.

The rugged topography of the central and northern parts of the quadrangle displays a regional southeast trending grain imposed by the direction of movement of the glacial ice sheet. Deep southeast trending basins separate the banks and ridges. The relatively smooth basin floors are interrupted in some places by small elongate banks (for example, at 42°28.4'N, 70°23.9'W; and 42°32.5'N, 70°16.9'W) that are aligned with the basins. The regional grain was modified during the late stages of the last glaciation by the movement of small valley glaciers and ice falls and by the melting of masses of stationary ice. Residing topographic features include well-defined banks with steep flanks and flat tops, and complex ridges, also with relatively steep flanks, whose surfaces have been dissected by erosion into many small valleys and rounded hills. The flat topped banks (42°33'N, 70°24'W; and 42°29.7'N, 70°17.2'W) are covered with sandy gravel and gravel, including boulder pits and ridges. Many hummocky, lobe-shaped depositional features extend from the bases of banks and ridges into the adjacent valleys and basins. They are interpreted to have been formed by glacial debris flows covered by muddy sand that was deposited by ice falls that flowed from the elevated surfaces of the banks and ridges. Several good examples of ice fall deposits lie on the perimeter of the large bank in the northwest corner of the quadrangle (42°23'N, 70°24'W). Two complex ridges trend southward from the northern margin of the quadrangle (70°17' and 70°21'W) and display a wide range of topographic features: hills, valleys, and small basins and related sediment types. Generally, hills are covered with gravel, valleys are sandy, and small basins are muddy sand. The floors of the large basins in this quadrangle are covered with mud that becomes sandy near the perimeters of banks and ridges.

**REFERENCES CITED**

Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 11 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open File Report 97-484, scale 1:20,000.

Valentine, P.C., Baker, J.L., Unger, T.S., and Polloni, C., 1998, Sea floor topographic map and perspective view imagery of Quadrangles 1-18, Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open File Report 98-139, 1 CD-ROM.



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SUN-ILLUMINATED SEA FLOOR TOPOGRAPHY OF QUADRANGLE 11 IN THE STELLWAGEN BANK  
NATIONAL MARINE SANCTUARY OFF BOSTON, MASSACHUSETTS

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