

#### DISCUSSION

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 1:25,000, 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 250 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 irregular-looking features and patterns that are oriented parallel or perpendicular to survey tracklines. For a depiction 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 18 quadrangles in the map series are available on a CD-ROM in EPS, PDF, AutoCAD, and PDF file formats (Valentine and others, 1998). Black 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 sediment to form the large basins, banks, ridges, and valleys. Many other features observed here represent the latter stages of deglaciation. They are the result of processes at work when much of the area was covered by stationary retreating ice, and when at the same time small valley glaciers and ice falls were active in and near areas of high topographic relief. The sea transited the region formerly occupied by ice, and seabed features were partly eroded and some new sedimentary deposits were formed. Today, the sea floor is modified mainly by

strong southwesterly-flowing bottom currents caused by storm winds from the northeast. These currents erode sediments from the shallow banks and transport them into the basins. With time, the banks affected by these currents become scarier, 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 18 features

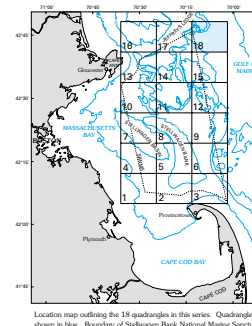
The sea floor in Quadrangle 18 slopes regionally from approximately 85 m water depth in the southwest to 155 m in the northeast. Within this regional setting, the seabed is topographically variable and includes valleys, basins, and hills. One prominent hill reaches a water depth of less than 35 m. The seabed in the southern and northeastern parts of the quadrangle exhibits a southeast-trending grain of small hills and basins that probably reflect the movement of a regional ice sheet. This is similar to the bottom type observed in the adjacent Quadrangle 15 to the south (Valentine and others, 2001a). These hills are low and rounded and typically have 5 to 10 m of relief. They are covered with gravel including patches of boulders and cobbles that is partly covered with a fine veneer of sand. Between the hills, the seabed is chiefly sand with patches of gravel and scattered cobbles and boulders. A series of elongate, shallow, east- and southeast-trending basins is present in the central and eastern parts of the quadrangle, east of 70°09' W. These basins deepen from west to east. They reach water depths of 110 to 180 m and their floors are 10 to 35 m below the surrounding seabed. The basin floors are relatively smooth and are covered with fine-grained sand and mud; the percentage of mud increases from west to east with increasing water depth.

The most striking topographic features in Quadrangle 18 are the many long, narrow, grooves that dominate all but the northeastern part of the map area. They typically are 50 to 100 m wide, up to 5 to 10 m deep, and up to 5 km long. These grooves are interpreted to be marks made by the jagged bottoms of icebergs that gouged the seabed by grounding here during the late stages of the last glaciation. The iceberg grooves are first observed at 145 m water depth in the northeast corner of the quadrangle, and they disappear at 70 to 75 m water depth in the relatively shallow northeastern part of the quadrangle. The floors of numerous basins, where deeper than 120 to 125 m, are too deep to have been reached by the grounded icebergs. The iceberg grooves have a dominant northeast-southwest orientation. They become

less distinct toward the northeast and southeast corners of the quadrangle. A large, conical hill is located along the western margin of the quadrangle (42°45.5' N) and has a relief of 90 m (35 m to 125 m) on its southwestern flank. This feature is an outcrop of resistant bedrock whose shape has been modified by the scouring of glacial ice. The ice apparently moved from west to east, removing material from the eastern or lee side of the hill and forming eastward-trending grooves and ridges (1 to 2.5 km long) in the adjacent basin. The flanks and base of the hill are covered with coarse sandy and gravelly sediments. A similar, but smaller, bedrock hill is located approximately 3.25 km to the east-northeast of the large hill (42°45.9' N, 70°10.85' W). It reaches a water depth of 50 m and has a maximum relief of 75 m (50 m to 125 m) on its southern flank. Both features are similar in character to two small hills on Jeffreys Ledge in the adjacent Quadrangle 17 to the west (Valentine and others, 2001b). North and northeast of the large hill, a sinuous basin floored with sand is bounded on the east and west by broadly washed patches of cobbles and boulders (see contour) that is partly covered with a fine veneer of sand.

#### REFERENCES CITED

- Valentine, P.C., Unger, T.S., Baker, J.L., and Rosenth, E.T., 1997, Sea floor topography of Quadrangle 18 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97-731, scale 1:25,000.
- Valentine, P.C., Baker, J.L., Unger, T.S., and Polkovi, 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 98-128, 1 CD-ROM.
- Valentine, P.C., Baker, J.L., and Unger, T.S., 2001a, Sun-illuminated sea floor topography of Quadrangle 15 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2715, scale 1:25,000.
- , 2001b, Sun-illuminated sea floor topography of Quadrangle 17 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2717, scale 1:25,000.



## SUN-ILLUMINATED SEA FLOOR TOPOGRAPHY OF QUADRANGLE 18 IN THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY OFF BOSTON, MASSACHUSETTS

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