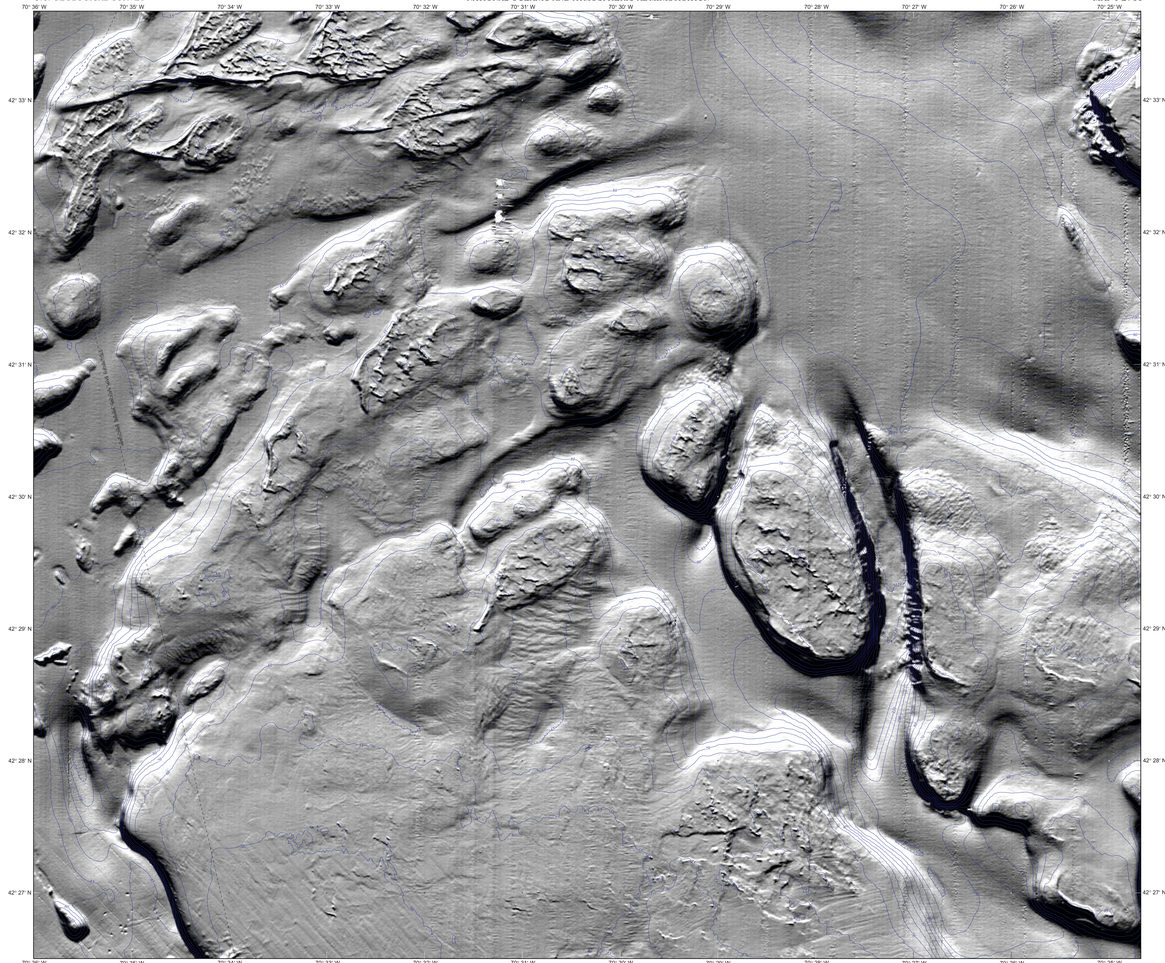
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

GEOLOGIC INVESTIGATIONS SERIES
MAP I-2710



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 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 5 METERS
DATUM MEAN LOWER LOW WATER

DISCUSSION

Introduction - The Stellwagen Bank National Marine Sanctuary Mapping Project is a cooperative effort of the U.S. Geological Survey, the National Oceanic and Atmospheric Administration, with support from the University of New Brunswick and the Canadian Hydrographic Survey. The multibeam echosounder 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 overprinted in blue. The image shows 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 the mapping process. These artifacts appear as parallel, regularly spaced, linear small highs and lows and unnatural-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 for all 18 quadrangles of the map series are available on a CD-ROM in EPS, PS, Arc export, and PDF file formats (Valentine and others, 1998). Blank areas represent places where no data exists.

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 rotting 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 invaded the region formerly occupied by ice, and seabed features were partly eroded and some new sedimentary deposits were formed. Today, the sea floor mainly is modified by strong southwestward-flowing bottom currents caused by storm winds from the northeast. Sediment is transported southward from the Gulf of Maine and deposited into the basins. With time, the banks affected by these currents become coarser, as sand and mud are removed but gravel remains; and the western flanks of the banks, and adjacent basins, are built up by deposits of mud and sand.

Quadrangle 10 features - The northeastern part of Quadrangle 10 is a smooth muddy sea floor that slopes northeastward through water depths of 80 to 120 m. It is part of a large basin that extends into Quadrangles 11 and 13 (Valentine and others, 1999a, b). A small part of a flat-topped bank (42° 33.0'N, 70° 24.8'W) is present along the northeastern edge of Quadrangle 10. At the base of this bank are hummocky, lobe-shaped features that extend into the basin. They are interpreted to have been formed by the deposition of sediment from sediment gravity flows that moved off the bank and down from the bank above. The smooth basin floor is interrupted by two small, elongate banks (42° 32.0'N, 70° 25.4'W; 42° 31.2'N, 70° 24.7'W). They are part of a southeastward alinement of small banks that extend into Quadrangle 11 and reflect the direction of movement of glacial ice in the basin. Most of the rest of Quadrangle 10, north of approximately 42° 29'N, is a complex of flat-topped banks and rounded hills of varying sizes that are separated by the relatively smooth seabed of small basins and valleys. The surfaces of the positive features lie at 45 to 75 m water depth and are gravel that in places is covered with a thin veneer of sand. The elongated, rounded features resemble drumlins, streamlined hills formed under the ice sheet. Their trend in the northeastern trend suggests the direction of ice movement in this area. The banks are modified by small valleys and basins, and by boulder piles and ridges that have a relief of up to 5 m and are interpreted to be lateral moraines (deposits of rock debris piled up at the edges of moving ice) and eskers (sand and gravel deposited by running water within stationary glacial ice). Lateral moraines are present along many of the upper margins of the banks (42° 30.4'N, 70° 33.6'W; 42° 30.2'N, 70° 32.0'W). Another lateral moraine on the bank top at about the same elevation is within (42° 29.5'N, 70° 28.3'W) and as networks of sinuous gravel ridges (42° 33.3'N, 70° 32.8'W). The boulder piles and ridges commonly are constructed of boulders and cobbles that are now separated by voids from which sand and small gravel presumably were eroded during advance of the sea after the glacial ice melted. The seabed in the small basins and valleys on the banks and around the margins of the banks and hills is muddy sand; the deep parts of the small basins and valleys that separate the banks are sandy mud. A deep valley floored with sandy mud is present in the southeastern corner of the quadrangle. It extends northeastward through water depths of 83 to 105 m and turns northward to form a narrow basin (42° 29.5'N, 70° 27.2'W) that is part of a valley that extends into Quadrangle 11. The valley floor in this area reaches a depth of 125 m and its hummocky surface possibly represents gravelly debris (now covered with muddy sand) that was transported by glacial ice. A low ridge across the valley floor (42° 28.7'N, 70° 27.2'W) resembles an end moraine deposited by the forward edge of glacial ice that occupied the southern part of the valley. The large bank located along the southeastern edge of the quadrangle is dissected by valleys (42° 27.8'N, 70° 25.4'W) that lie partly in the adjacent Quadrangle 11 to the east. The valley floors are muddy sand, and the bank surface is covered with gravel, including boulder piles and ridges. The gravel is covered in places by a veneer of sand. The bank surface is characterized by numerous small, flat shallow depressions on the bank surface than on the hilltops. The southern part of the quadrangle is occupied by the northern part of a large, relatively flat bank that lies at a water depth of 50 to 60 m. The bank's surface is gravel, including scattered boulder piles and ridges, that represent eskers for the most part. Shallow, irregularly-shaped depressions in the sea floor (42° 27.4'N, 70° 28.8'W), in association with gravel ridges, possibly represent the former locations of large masses of melting glacial ice. The bank margin is incised by shallow valleys whose floors are covered with muddy sand. However, a small basin in the interior of the bank is covered with sandy mud (42° 28.3'N, 70° 30.7'W). Sand with a gulfed surface covers the flanks of a valley (42° 29.0'N, 70° 30.8'W) on the northern part of the bank. The valley floor is sandy mud and is characterized by gullies (42° 28.8'N, 70° 26.8'N, 70° 27.4'W). The sand exhibits shallow downslope gullies, and it has been transported here from the northern edge of Stellwagen Bank that lies at a higher level to the south in the adjacent Quadrangle 7 (Valentine and others, 1999c). In the western part of Quadrangle 10, the surface of the gravel bank is separated from a deep muddy basin to the west by a northwestward-trending escarpment 30 m high. The basin floor slopes northward from 85 m at the foot of the bank to 105 m in a small basin (42° 28.0'N, 70° 35.6'W) at the mouth of a valley that incises the bank edge. A small drumlin that trends southeastward is present in the southwestern corner of the quadrangle. In the deep basin along the western edge of the quadrangle, the smooth, almost flat, mud seabed is interrupted by shallow depressions that are elliptical, moats that surround a central mound, and irregularly-shaped pits that are surrounded by gravel ridges. Small depressions of similar features in Quadrangles 7 and 8 (Valentine and others, 1999c, d) have shown the mounds to be patches of gravel, including boulders, that are frequented by groundfish. Some boulders and smaller gravel are exposed in the bottoms of pits in the mud in which fish are present. The depressions are interpreted to have formed by the scouring actions of groundfish that have exposed the gravel habitat and prevent its burial by basin mud.

REFERENCES CITED

Valentine, P.C., Unger, T.S., Baker, J.L., and Haworth, E.T., 1997, Sea floor topography of Quadrangle 10 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97-683, scale 1:25,000.

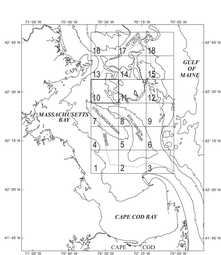
Valentine, P.C., Baker, J.L., Unger, T.S., and Polloni, C., 1998, Sea floor topographic map and perspective view imagery of Quadrangles 1-18, Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 98-138,1 CD-ROM.

Valentine, P.C., Baker, J.L., and Unger, T.S., 1999a, Sun-illuminated sea floor topography of Quadrangle 11 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2711, scale 1:25,000.

Valentine, P.C., Baker, J.L., and Unger, T.S., 1999b, Sun-illuminated sea floor topography of Quadrangle 13 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2713,scale 1:25,000.

Valentine, P.C., Baker, J.L., and Unger, T.S., 1999c, Sun-illuminated sea floor topography of Quadrangle 7 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2707,scale 1:25,000.

Valentine, P.C., Unger, T.S., and Baker, J.L., 1999d, Sun-illuminated sea floor topography of Quadrangle 8 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2708,scale 1:25,000.



Location map - Shows mapped quadrangle outlined. Stellwagen Bank National Marine Sanctuary (SBNMS) boundary shown as dashed line. Bathymetric contours in meters.

SUN-ILLUMINATED SEA FLOOR TOPOGRAPHY OF QUADRANGLE 10 IN THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY OFF BOSTON, MASSACHUSETTS

By

Page C. Valentine, Tanya S. Unger, and Jessica L. Baker

1999

AUTHOR AFFILIATIONS
U.S. Geological Survey, Woods Hole Field Center
384 Woods Hole Road, Woods Hole, MA 02543

PRE-PUBLICATION COPY