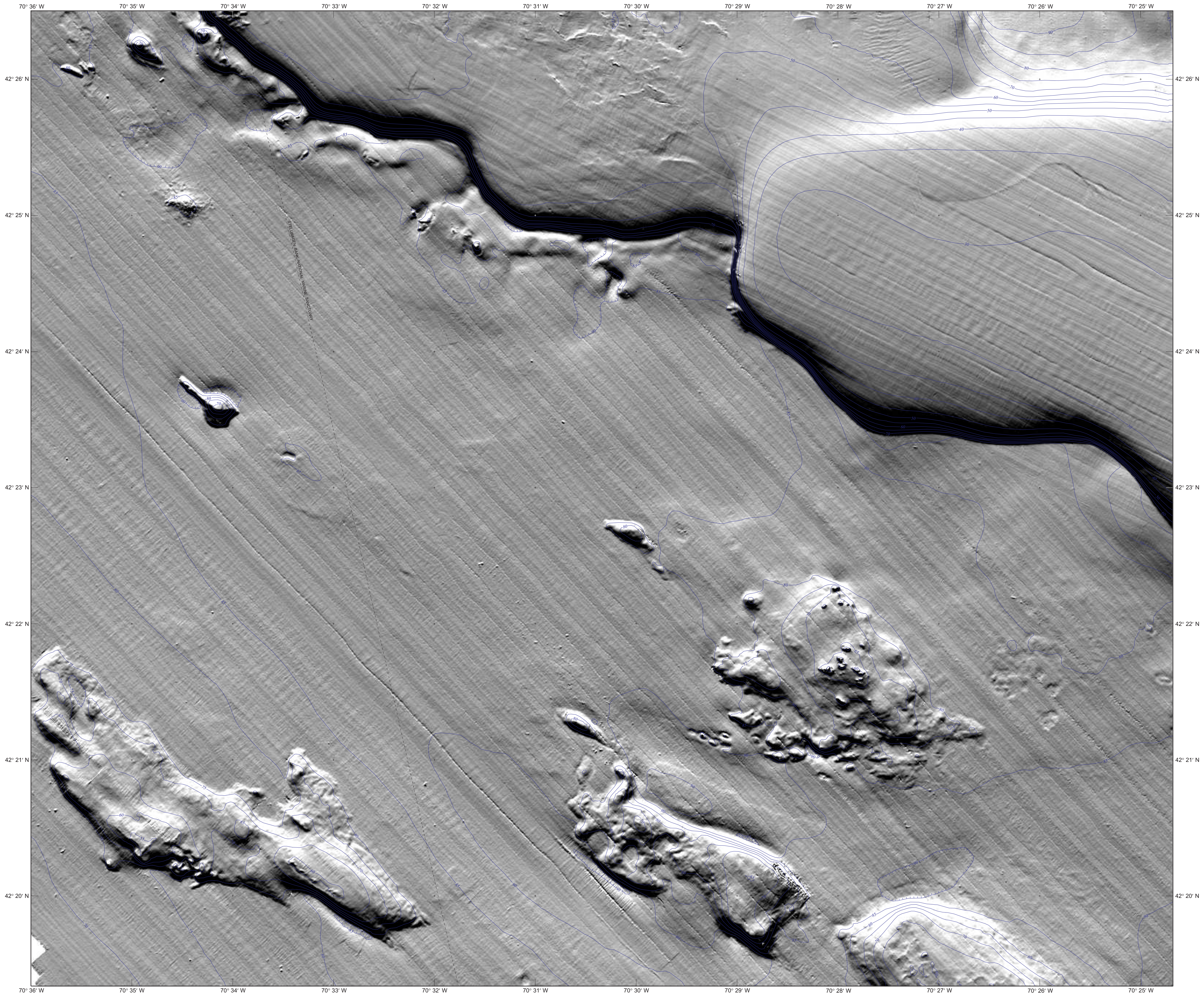
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

GEOLOGIC INVESTIGATIONS SERIES
MAP I-2707



INTERIOR - U.S. GEOLOGICAL SURVEY, RESTON, VIRGINIA - 1999

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 and 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 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 include 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. These currents erode sediments from the shallow banks and transport them 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 7 features - This quadrangle covers the northwestern end of Stellwagen Bank and the central part of Stellwagen Basin. The bank crest is relatively flat in water depths of 30 to 35 m where it is covered with sand and gravelly sand. A sheet of fine-grained sand caps the northern edge of the bank. The eastern part of the bank's northern flank slopes steeply through water depths of 40 to 90 m to form the head of a north-trending glacial valley that extends into Quadrangle 10 (Valentine and others, 1999a). The valley head is covered with sand, becoming finer-grained with depth. The western part of the bank's northern flank slopes less steeply to a depth of 50 m to meet the nearly flat surface of a broad terrace that extends the bank northwestward. Sand transported from the bank covers the southeastern part of the terrace, where the surface is smooth except for shallow gullies on the eastern slope. Both Stellwagen Bank and the terrace are separated from Stellwagen Basin to the southwest by a continuous northwest-trending escarpment that is 40 m high along the bank edge and is reduced to 25 m along the terrace edge. The terrace surface is smooth along its southwestern edge, where it is covered with gravelly sand and gravel; to the north, it is covered with gravel, including boulder piles and ridges, and displays irregularly-shaped depressions that possibly outline the former locations of large masses of melting glacial ice. A band of irregular seabed at the base of the escarpment that is characterized by low mounds and ridges and by shallow depressions is interpreted to be glacial debris deposited by ice that flowed off the terrace. Some of the roughness of these features has been smoothed by a veneer of mud. Stellwagen Basin occupies the central and southern part of the quadrangle. The basin floor ranges in depth from 70 to 95 meters, is covered by mud, and is relatively smooth except where it is interrupted by several kinds of topographic highs and some small shallow depressions. The most prominent basin features are three large elongated banks that lie in the southern part of the quadrangle. They are part of a group of four banks that extends southeastward into Quadrangle 4 and are alined with the large spur on the western margin of Stellwagen Bank in Quadrangle 5 (Valentine and others, 1999 b, c). The three banks in this quadrangle are 3.7 to 6.3 km in length, their tops lie in water depths of 55 to 65 m, and they have a relief of 25 m. The bank surfaces are sand and gravel, including boulder piles and ridges, and a thin veneer of mud. The internal composition of the banks is unknown. Their northwest-southeast elongated shape (and the deep grooves and pits on two of the banks) suggests formation by glacial processes that eroded surrounding less-resistant sediment and rock during ice movement to the southeast and further modified the banks during later melting of the ice. The surfaces and perimeters of the two westernmost banks are more irregular (eroded) than the surfaces of the other bank in this quadrangle (and in Quadrangle 4) and of the similarly-alined spur in Quadrangle 5. This suggests that either the banks differ in composition or the southeasternmost banks are younger. The shapes of the banks might represent an evolutionary progression (as a result of ice movement toward the southeast) of bank formation followed by destructive erosion. A large, broad, hummocky mound is located north of the banks. Its surface is sand and gravel, including boulder piles, and a veneer of mud. The tops of the boulder piles are at 60 m water depth, and the relief of the mound is 25 to 30 m. This feature is interpreted to be a former bank in a later stage of erosion than the grouping of banks that lie to the south of it. In addition to large banks that apparently are erosional in origin, the basin floor displays features that might be depositional in origin. Among these are small pear-shaped mounds that have a length of 375 to 900 m and a relief of 10 to 20 m. They are rounded and streamlined in a northwest-southeast direction and are interpreted to be drumlins composed of glacial sediment that were formed during ice movement (42° 21.3'N, 70° 30.6'W; 42° 22.7'N, 70° 30.0'W; 42° 23.6'N, 70° 34.1'W; and at 42° 26.3'N, 70° 34.9'W). The Massachusetts Bay Disposal Site lies in the northwest corner of the quadrangle, west of the sanctuary boundary (see detailed maps of the disposal site by Valentine and others, 1996, 1999d). A rough-surfaced mound of disposed dredged material 6 to 7m in height is present at the active disposal point (42° 25.1'N, 70° 34.5'W). Hummocky deposits of disposed rock debris are present on the edge of the terrace along the northern edge of the quadrangle (70° 34'W). In several areas of the basin, the smooth, almost flat mud floor is interrupted by shallow depressions. The larger depressions are irregular in outline and surround small mounds, and smaller depressions are elliptical moats that surround a central mound. The depressions range up to several hundreds of meters in length, and observations 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. Representative scour depressions are present in areas centered on 42° 21.5'N, 70° 26.0'W, and on 42° 21.1'N, 70° 29.2'W.

REFERENCES CITED

Valentine, P.C., Danforth, W.W., Roworth, E.T., and Stillman, S.T., 1996, Maps showing topography, backscatter, and interpretation of seafloor features in the Massachusetts Bay Disposal Site region off Boston, Massachusetts: U.S. Geological Survey Open-File Report 96-273, scale 1:10,000 and 1:12,500.

Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 7 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97-508, scale 1:25,000.

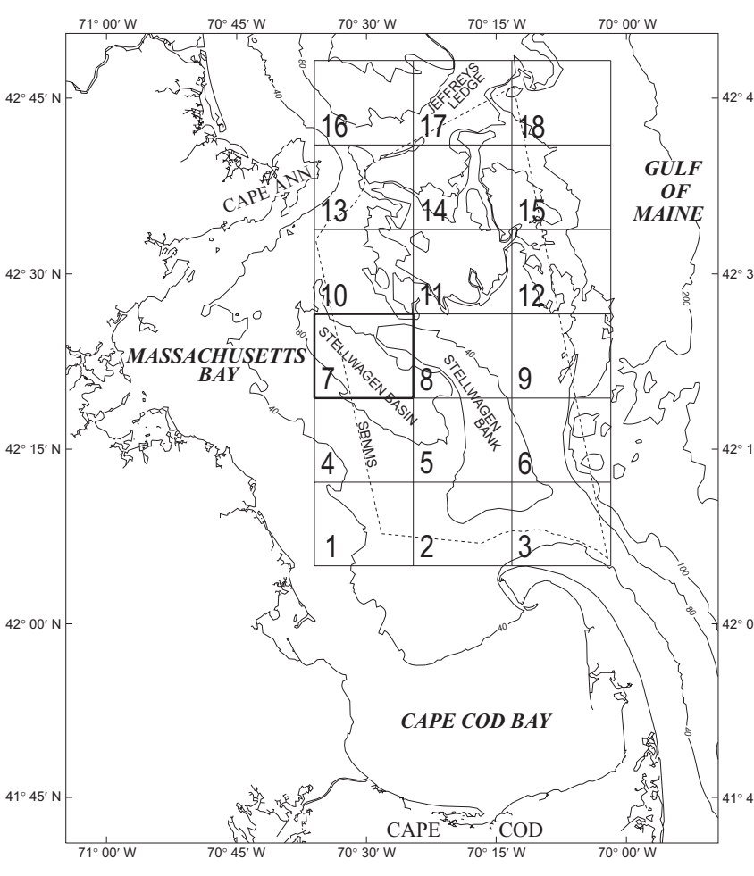
Valentine, P.C., Baker, J.L., Unger, T.S., and Polloni, C., 1998, Sea floor topographic map and perspective view imagery of Quadrangles 1-18, Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 98-138, 1 CD-ROM.

Valentine, P.C., Unger, T.S., and Baker, J.L., 1999a, Sun-illuminated sea floor topography of Quadrangle 10 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2710, scale 1:25,000.

Valentine, P.C., Unger, T.S., and Baker, J.L., 1999b, Sun-illuminated sea floor topography of Quadrangle 4 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2704, scale 1:25,000.

Valentine, P.C., Baker, J.L., and Unger, T.S., 1999c, Sun-illuminated sea floor topography of Quadrangle 5 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2705, scale 1:25,000.

Valentine, P.C., Baker, J.L., Unger, T.S., Evans, J., and Polloni, C., 1999d, Sea floor topographic, backscatter, and interpretive maps and bottom photos of the Massachusetts Bay Disposal Site region off Boston, Massachusetts: U.S. Geological Survey Open-File Report 98-344, 1 CD-ROM.



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 7 IN THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY OFF BOSTON, MASSACHUSETTS

By

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

1999

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