

**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 1:25,000, with topographic contours overlaid in blue. The image shown here uses a sun elevation angle of 45 degrees above the horizon from an azimuth of 150 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 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 all 18 quadrangles in the map series are available on a CD-ROM in PDF, PLT, 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 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 resting ice, and when at the same time small valley glaciers and ice falls were active in and near areas of high topographic relief. The ice invaded 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 basins. 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 7 features**  
This quadrangle covers the northeastern end of Stellwagen Bank and the central part of Stellwagen Basin. The bank crest, in the northeastern part of the quadrangle,

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 evenly through water depths of 40 to 90 m to form the head of a northwest-trending glacial valley that extends into Quadrangle 10 to the north Valentine and others, 2008b). 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 northern bank of 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 related to 20 m along the terrace edge. A band of irregular ridges at the base of the escarpment is characterized by low mounds and ridges and by shallow depressions. It 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. 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 it displays irregularly shaped depressions that possibly outline the former locations of large masses of melting glacial ice.

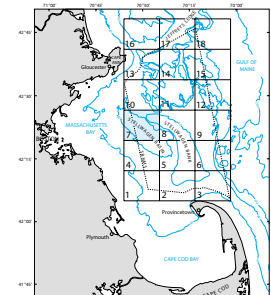
Stellwagen Basin occupies the central, western, and southern parts of the quadrangle. The basin floor ranges in depth from 70 to 95 m, is covered by mud, and is relatively smooth except where interrupted by several kinds of topographic highs and some small shallow depressions. The most prominent basin features are three large elongate banks that lie in the southern part of the quadrangle. They are part of a group of four banks that extends southwestward from this quadrangle into Quadrangles 4 and 5 Valentine and others, 2000a, 2000b). These banks are aligned with the large spur on the western margin of Stellwagen Bank in Quadrangle 5. The three banks in Quadrangle 7 are 2.7 to 6.3 km in length, their tops lie in water depths of 45 to 65 m, and they have a relief of 25 m. The bank surfaces consist of 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 elongate shape and the deep grooves and pits on two of the banks suggest formation by glacial processes that eroded surrounding low-resistant sediment and rock during ice movement toward the southeast and that further modified the banks during later melting of the ice. The surfaces and perimeters of the two westernmost banks are more irregular (boulder than the surface of the other bank in this quadrangle and in Quadrangle 4) and of the similarly aligned spur in Quadrangle 5. This suggests that other the banks differ in composition in the southeastward direction as 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 (42° 21.5' N, 70° 28' W). Its surface is covered with sand and gravel, including boulder

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 late stage of erosion than the grouping of banks that lie to the south.

In addition to containing large banks that apparently are erosional in origin, the Stellwagen 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 bedrock outcrops or dunettes composed of glacial sediment that were formed during movement of the ice (42° 21.5' N, 70° 30.0' W, 42° 22.7' N, 70° 30.0' W, 42° 22.6' N, 70° 34.1' W, and 42° 26.3' N, 70° 34.9' W). Most of 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). A rough surfaced mound of disposed dredged material 6 to 7 m in height is present at the active disposal point (42° 25.1' N, 70° 34.5' W). Hummocky deposits of disposed rock debris also are present on the edge of the terrace along the northern margin of the quadrangle (70° 24' W). In several areas of Stellwagen Basin, the smooth, almost flat mud floor is interrupted by shallow depressions that range up to several hundred meters in length. The larger depressions are irregular in outline and surrounded small mounds, and the smaller depressions are elliptical mounds that surround a central mound. 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 bottom of pits in the mud in which fish are present. The depressions are interpreted to have been formed by the scouring actions of groundfish that have exposed the gravel habitat and prevented its burial by basin mud. Representative scour depressions are present in areas centered on 42° 21.5' N, 70° 36.0' W, and 42° 21.1' N, 70° 32.2' W.

**REFERENCES CITED**  
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Location map outlining the 18 quadrangles in this series. Quadrangle 7 shown in blue. Stellwagen Bank National Marine Sanctuary (58040) boundary indicated by dashed line. Bathymetric contours in meters.

## SUN-ILLUMINATED SEA FLOOR TOPOGRAPHY OF QUADRANGLE 7 IN THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY OFF BOSTON, MASSACHUSETTS

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1999