

**Sea Floor Image Maps Showing Topography, Sun-Illuminated Topography, Backscatter Intensity, Ruggedness, Slope, and the Distribution of Boulder Ridges and Bedrock Outcrops in the Stellwagen Bank National Marine Sanctuary Region off Boston, Massachusetts**

**Page C. Valentine, editor**

**MAP A.—SEA FLOOR TOPOGRAPHY IN THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY REGION**

**By**

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

**2005**

## **DISCUSSION**

### **Introduction**

Sea floor mapping in the Stellwagen Bank National Marine Sanctuary (NMS) is a cooperative effort of the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration, with technical support from the University of New Brunswick and the Canadian Hydrographic Service. The maps generated from this undertaking are based on a 1994–96 survey that used a multibeam echo sounder to map 1,100 square nautical miles of the sea floor (fig. 1). The technology and methods of image acquisition and topographic contouring that were used are described in publication 4 in the References section. USGS Scientific Investigations Maps (SIM) 2840–A to –F constitute a six-map (twelve-sheet) series in digital (DVD-ROM) format. The first three maps, SIM 2840–A, –B, and –C, were previously published on paper as USGS Geologic Investigations Series Maps I–2676–A, –B, and –C (publications 43–45 in the References). Preliminary versions of those three maps also had been released earlier on a CD-ROM as USGS Open-File Report 00–410 (publication 42).

The map area shown here is a composite of 18 individual quadrangle maps (fig. 1). Two map series of the 18 quadrangles have been published at a scale of 1:25,000 and show sea floor topography (publications 4–22) and sun-illuminated sea floor topography (fig. 2; see publications 23–41). Selected sea floor maps, photographs, CD-ROMs, fact sheets, posters, and geographic names related to research conducted in the Stellwagen Bank NMS region are available online at USGS Web site <http://woodshole.er.usgs.gov/project-pages/stellwagen/index.html>. See the References section for a complete numbered list of publications.

On the maps presented in this series, the locations of the corners of the 18 quadrangles are shown for reference as ticks labeled outside the map edges, and (on maps C and E) as large crossticks within the map area. Maps A, B, D, and F show the boundaries of the individual quadrangles. On the maps that show sun-illuminated sea floor topography, blank spaces represent areas of no data.

## Sea floor topography

This map shows contoured sea floor topography at an interval of 5 meters and the boundaries of the 18 individual quadrangles that constitute the map region. Contours are shown in blue except for topographic lows, which are shown in brown. In depressions outlined by several concentric contours, only the deepest contour is colored brown. The great topographic detail of the seabed revealed by this survey warranted the naming here of many geographic features; some features were named in consultation with local fishermen. The U.S. Board on Geographic Names has approved the names shown on the maps. Background information supporting the feature names is available online at the USGS Web site given in the Introduction.

## REFERENCES

USGS publications can also be purchased from USGS Information Services, Box 25286, Denver Federal Center, Denver, CO 80225-0046; telephone (303) 202-4200 or 1-888-ASK-USGS

### Massachusetts Bay Disposal Site—Maps and Features

1. Valentine, P.C., Baker, J.L., Unger, T.S., Evans, John, and Polloni, C.F., 1999, 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. (Also available online at <http://pubs.usgs.gov/of/of98-344/>)
2. Valentine, P.C., Danforth, W.W., Roworth, E.T., and Stillman, S.T., 1996, Maps showing topography, backscatter, and interpretation of sea floor features in the Massachusetts Bay Disposal Site region off Boston, Massachusetts: U.S. Geological Survey Open-File Report 96–273, 2 sheets, scale 1:10,000 and 1:12,500.

### Massachusetts and Cape Cod Bays and Stellwagen Bank National Marine Sanctuary—Sea Floor Topography

3. Valentine, P.C., Schmuck, E.A., Signell, R.P., and Ryland, C.A., 1995, Sea floor topography of Massachusetts and Cape Cod Bays and Stellwagen Bank National Marine Sanctuary: U.S. Geological Survey Open-File Report 95–073, scale 1:100,000.

### Stellwagen Bank National Marine Sanctuary—Sea Floor Topography

4. Valentine, P.C., Baker, J.L., Unger, T.S., and Polloni, C.F., 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. (Also available online at <http://pubs.usgs.gov/of/of98-138/>)
5. Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 1 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–502, scale 1:25,000.

6. Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 2 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–503, scale 1:25,000.
7. Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 3 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–504, scale 1:25,000.
8. Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 4 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–505, scale 1:25,000.
9. Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 5 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–506, scale 1:25,000.
10. Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 6 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–507, scale 1:25,000.
11. 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.
12. Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 8 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–509, scale 1:25,000.
13. Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 9 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–682, scale 1:25,000.
14. Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, 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.
15. 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 97–684, scale 1:25,000.
16. Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 12 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–685, scale 1:25,000.
17. Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 13 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts:

U.S. Geological Survey Open-File Report 97–726, scale 1:25,000.

18. Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 14 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–727, scale 1:25,000.

19. Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 15 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–728, scale 1:25,000.

20. Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 16 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–729, scale 1:25,000.

21. Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 17 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97–730, scale 1:25,000.

22. Valentine, P.C., Unger, T.S., Baker, J.L., and Roworth, 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.

### **Stellwagen Bank National Marine Sanctuary—Sun-Illuminated Sea Floor Topographic Imagery**

23. Valentine, P.C., Unger, T.S., Baker, J.L., and Polloni, C.F., 2000, Sun-illuminated sea floor topographic maps and perspective-view imagery of Quadrangles 1–18, Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 99–363, 1 CD-ROM. (Also available online at <http://pubs.usgs.gov/of/of99-363/>)

24. Valentine, P.C., Baker, J.L., and Unger, T.S., 2000, Sun-illuminated sea floor topography of Quadrangle 1 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2701, scale 1:25,000.

25. Valentine, P.C., Unger, T.S., and Baker, J.L., 1999, Sun-illuminated sea floor topography of Quadrangle 2 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2702, scale 1:25,000.

26. Valentine, P.C., Baker, J.L., and Unger, T.S., 1999, Sun-illuminated sea floor topography of Quadrangle 3 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2703, scale 1:25,000.

27. Valentine, P.C., Unger, T.S., and Baker, J.L., 2000, 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.

28. Valentine, P.C., Baker, J.L., and Unger, T.S., 1999, 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.
29. Valentine, P.C., Unger, T.S., and Baker, J.L., 1999, Sun-illuminated sea floor topography of Quadrangle 6 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2706, scale 1:25,000.
30. Valentine, P.C., Baker, J.L., and Unger, T.S., 1999, 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.
31. Valentine, P.C., Unger, T.S., and Baker, J.L., 1999, 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.
32. Valentine, P.C., Baker, J.L., and Unger, T.S., 2000, Sun-illuminated sea floor topography of Quadrangle 9 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2709, scale 1:25,000.
33. Valentine, P.C., Unger, T.S., and Baker, J.L., 2000, 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.
34. Valentine, P.C., Baker, J.L., and Unger, T.S., 2000, 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.
35. Valentine, P.C., Unger, T.S., and Baker, J.L., 2000, Sun-illuminated sea floor topography of Quadrangle 12 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2712, scale 1:25,000.
36. Valentine, P.C., Baker, J.L., and Unger, T.S., 2001, 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.
37. Valentine, P.C., Unger, T.S., and Baker, J.L., 2001, Sun-illuminated sea floor topography of Quadrangle 14 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2714, scale 1:25,000.
38. Valentine, P.C., Baker, J.L., and Unger, T.S., 2001, 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.
39. Valentine, P.C., Unger, T.S., and Baker, J.L., 2001, Sun-illuminated sea floor topography of Quadrangle 16 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2716, scale 1:25,000.

40. Valentine, P.C., Baker, J.L., and Unger, T.S., 2001, 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.

41. Valentine, P.C., Unger, T.S., and Baker, J.L., 2001, Sun-illuminated sea floor topography of Quadrangle 18 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2718, scale 1:25,000.

### **Stellwagen Bank National Marine Sanctuary—Sun-Illuminated Sea Floor Topographic Imagery and Backscatter Intensity**

42. Valentine, P.C., Middleton, T.J., and Fuller, S.J., 2001, Sea floor maps showing topography, sun-illuminated topography, and backscatter intensity of the Stellwagen Bank National Marine Sanctuary region off Boston, Massachusetts: U.S. Geological Survey Open-File Report 00–410, 1 CD-ROM. (Also available online at <http://pubs.usgs.gov/of/of00-410/>) (Superseded by maps I-2676–A, –B, and –C; see publications 43-45 in this list.)

43. Valentine, P.C., Baker, J.L., and Unger, T.S., 2003, Sea floor topography of the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2676–A, scale 1:60,000.

44. Valentine, P.C., Unger, T.S., and Baker, J.L., 2003, Sun-illuminated sea floor topography of the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2676–B, scale 1:60,000.

45. Valentine, P.C., Unger, T.S., and Baker, J.L., 2003, Backscatter intensity and sun-illuminated sea floor topography of the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I–2676–C, scale 1:60,000.

### **Stellwagen Bank National Marine Sanctuary—Seabed Ruggedness and Distribution of Boulder Ridges and Bedrock Outcrops**

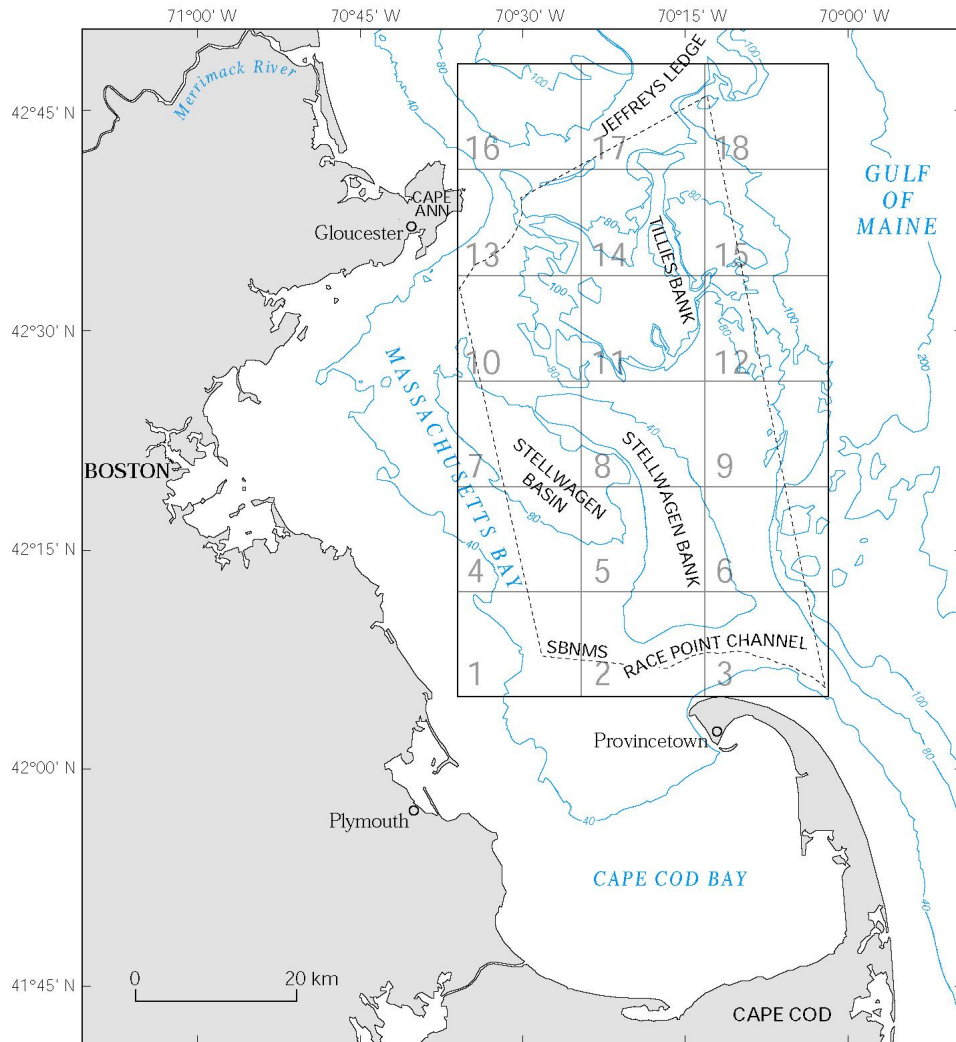
46. Valentine, P.C., Fuller, S.J., and Scully, L.A. [2004], Terrain ruggedness analysis and distribution of boulder ridges and bedrock outcrops in the Stellwagen Bank National Marine Sanctuary region—seabed ruggedness: U.S. Geological Survey poster available online at <http://woodshole.er.usgs.gov/project-pages/stellwagen/posters/rugged.html> (Downloaded July 27, 2005.)

47. Valentine, P.C., Scully, L.A., and Fuller, S.J. [2004], Terrain ruggedness analysis and distribution of boulder ridges and bedrock outcrops in the Stellwagen Bank National Marine Sanctuary region—boulder ridges and bedrock outcrops: U.S. Geological Survey poster available online at <http://woodshole.er.usgs.gov/project-pages/stellwagen/posters/ridges.html> (Downloaded July 27, 2005.)

### **Terrain Ruggedness Index (TRI)**

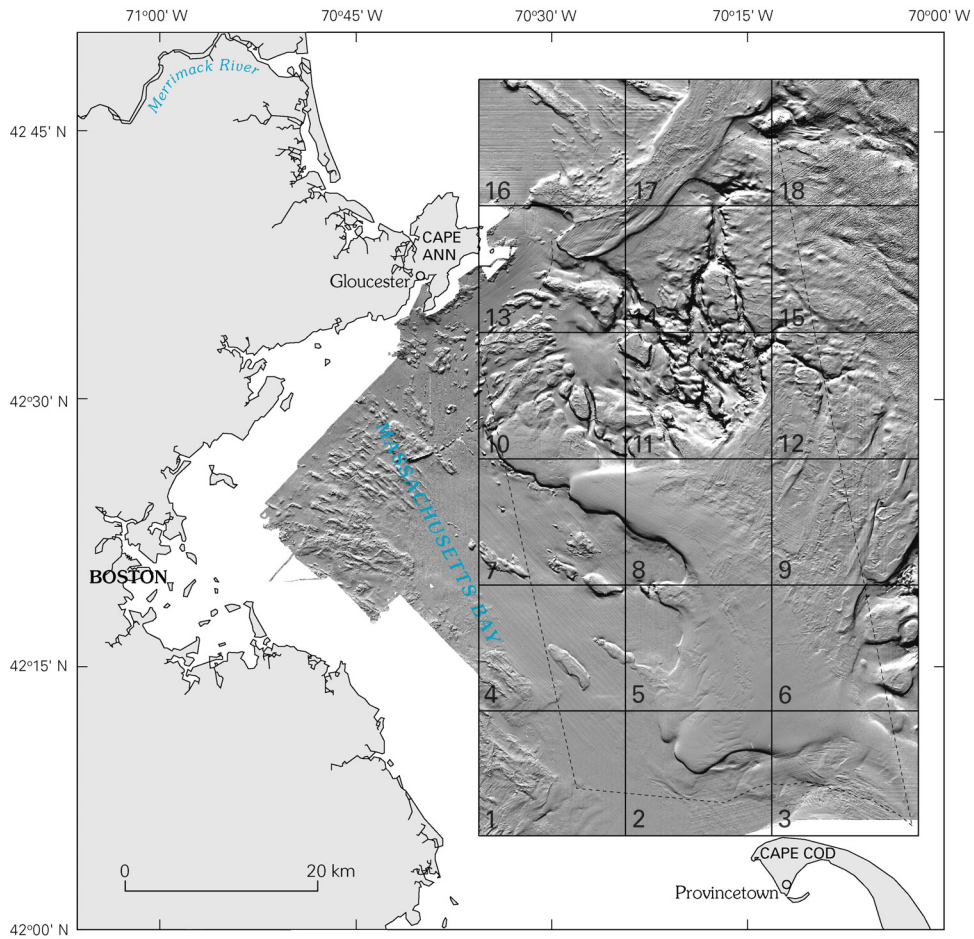
48. Riley, S.J., DeGloria, S.D, and Elliott, R., 1999, A terrain ruggedness index that quantifies topographic heterogeneity: Intermountain Journal of Sciences, v. 5, no. 1-4, p. 23–27.

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.



**Figure 1.** Regional setting of the map area (outlined in black). Publications specific to the entire map area or to individual quadrangles 1–18 (outlined in gray) are listed in the References section. Stellwagen Bank National Marine Sanctuary (SBNMS) boundary is shown as a dashed line. Bathymetric contours are labeled in meters.





**Figure 2.** Sun-illuminated sea floor topographic imagery of the Stellwagen Bank National Marine Sanctuary and Massachusetts Bay region, and the 18 quadrangles of the map area. Dashed line is the sanctuary boundary.