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# *Didemnum lahillei* - Preparation of Ascidians for Taxonomy and Molecular Analysis

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## Preparation of Ascidians for Taxonomy and Molecular Analysis

**Gretchen Lambert, January 2004**

glambert@fullerton.edu

### Relaxing and fixing ascidians for taxonomy

The ascidians should first be relaxed, then fixed in 10% seawater formalin buffered with sodium borate to help preserve spicules and color.

The formula for 1 liter of fixative:

- 100 ml of full strength formaldehyde (37%), 850 ml of seawater, and 50 ml of distilled water (or reverse osmosis water, or tap water if it does not have a lot of minerals in it; sometimes I get a precipitate with tap water). It is necessary to use the 50 ml of distilled water instead of all sea water so that the solution will not be hypertonic. [Ethanol is definitely NOT a good preservative for taxonomy, and ascidians should never be placed directly into ethanol, except a subsample for molecular analysis. Ethanol makes the tissues opaque and brittle, and it removes all color.]
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dissolve the menthol, which is much more soluble in ethanol than in water. Place the ascidian in a dish of seawater (or the menthol/seawater from your ziploc bag). Then add about 5 drops of the menthol/ethanol and QUICKLY cover the dish tightly (I use a small sheet of glass or plastic with a weight on top) to prevent evaporation of the menthol. Every 10 minutes or so add another few drops of the menthol/ethanol until when you insert a sharp probe into an open siphon there is absolutely no response. Use a hand lens or microscope to be sure about this! Relaxation may be achieved in as little as 10-15 minutes or so for some species, but may take several hours for others.

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USGS National Geologic Studies of Benthic Habitats, Northeastern United States

# Marine Invasive Species

*Didemnum lahillei*, a colonial tunicate; ascidian; sea squirt

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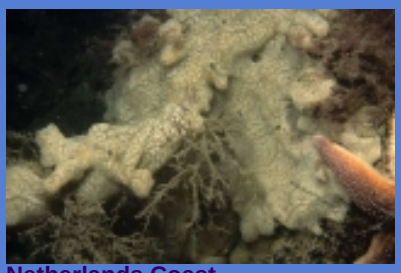

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## Taxonomic Classification

Phylum *Chordata*, Subphylum *Tunicata*, Class *Ascidiacea*, Order *Aplousobranchia*, Family *Didemnidae*, Genus *Didemnum*, Species *lahillei.* Hartmeyer, 1909.

## Summary of Occurrence

*Didemnum lahillei* is a marine colonial tunicate (ascidian; sea squirt) that has been observed at several locations in the northeast Pacific and North Atlantic Ocean basins. It exhibits the characteristics of an invasive species: 1) sudden occurrence where not before known; 2) rapid reproduction and excessive biomass; 3) no known predators. It is native to Europe.

The rapid spread of *Didemnum lahillei* alters marine habitats and threatens to interfere with fishing, aquaculture, and other coastal and offshore activities.

It is found on hard substrates that include dock structures and floats, wood and metal pilings, moorings and ropes, steel chain, automobile tires, polythene plastic, rock outcrops, gravel seabed (pebbles, cobbles, boulders), and ship hulls. It overgrows organisms such as tunicates, sponges, macroalgae, hydroids, anemones, bryozoans, scallops, mussels, and oysters. Where *D. lahillei* occurs on the seabed, it likely covers the siphons of infaunal bivalves. *D. lahillei* has been reported from coastal areas in California, New England, northwest France, and the Netherlands. It also has been observed on the continental shelf off New England in the Gulf of Maine region. It has been found at water depths ranging from intertidal to continental shelf depths of 48m (157 ft).

## Gross Morphology and Growth Habits

*Didemnum lahillei* colonies exhibit a wide variety of morphological variants that range from: 1) long, ropey or beard-like colonies that commonly hang from hard substrates such as docks, lines, and ship hulls; to 2) low, undulating mats with short surficial appendages that encrust and drape rocky seabeds (pebbles, cobbles, boulders, and rock outcrops).

## Purpose and attribution

The goal of this website is to assemble and communicate information on the distribution, biology, and marine habitat impacts of the highly invasive colonial tunicate *Didemnum lahillei*. Researchers and others are encouraged to share published and preliminary research results and anecdotal observations on these topics. All contributions are acknowledged. The information displayed on this website is in the public domain. Users are expected to give proper credit for images, data, and ideas they incorporate into their work.

**Contributions** to the website can be sent to Page Valentine, USGS, pvalentine@usgs.gov

Images of *Didemnum lahillei* posted on this website represent occurrences that have been verified through visual inspection or dissection by persons

familiar with the species. Images that have not been verified as *D. lahillei* are noted as a "provisional identification" in the image caption and in the occurrence tables.

**Website design:** Donna Newman, USGS

**Image processing and archival:** Dann Blackwood, USGS

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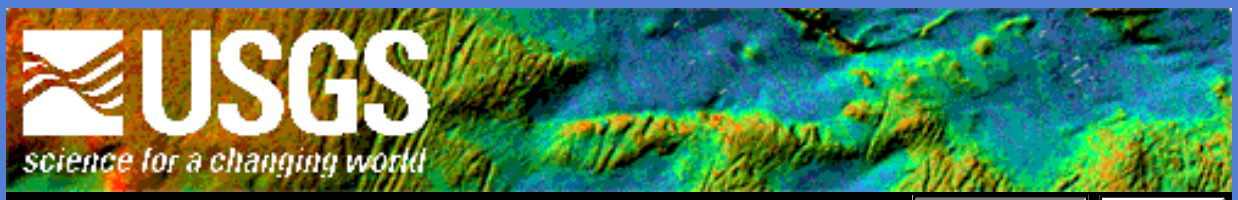


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# USGS National Geologic Studies of Benthic Habitats, Northeastern United States

- Stellwagen Bank National Marine Sanctuary Region off Boston, Massachusetts
- Marine Invasive Species
- Seabed Analyses of the Stellwagen Bank NMS Region



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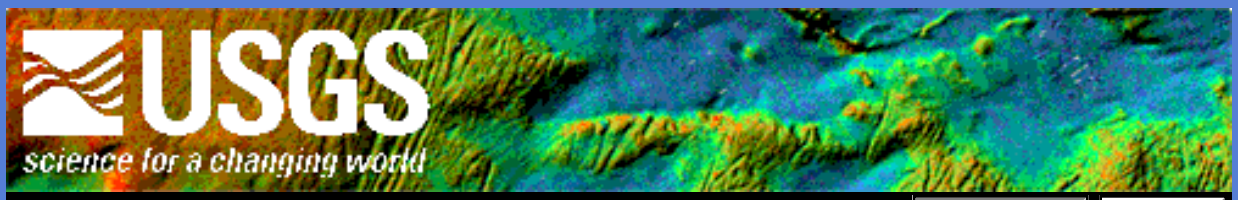


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# Stellwagen Bank National Marine Sanctuary Region off Boston, Massachusetts

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## INTRODUCTION

The Stellwagen Bank National Marine Sanctuary region is heavily utilized by humans and by marine species. It is a rich commercial and recreational fishing ground. It provides essential habitat for many species of marine mammals, including the endangered North Atlantic Right Whale; and it is the focus of a large tourism industry centered on whale watching. The sanctuary abuts the Massachusetts Bay Disposal Site, which serves as a repository for material dredged from the harbors of Boston and nearby cities; and it lies seaward of Boston's new ocean outfall that discharges treated sewage effluent into Massachusetts Bay. The sanctuary lies in the major shipping lane to and from Boston Harbor; and recently its seabed has been traversed by a fiber optics communications cable that connects New England with Nova Scotia and Europe.

## LIST OF PUBLICATIONS

**Sea Floor Map and Imagery Publications**

## GEOLOGIC FEATURES

Thumbnail Images *of representative geologic features in the Stellwagen Bank NMS region*

## SEA FLOOR MAPS ON CD-ROM

*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

*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

*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

*Sea Floor Maps Showing Topography, Sun-Illuminated Topographic Imagery, and Backscatter Intensity of the Stellwagen Bank National Marine Sanctuary Region off Boston, Massachusetts*
U.S. Geological Survey Open-File Report 00-410

## POSTERS

Acoustic Backscatter Mapping in Stellwagen Bank National Marine Sanctuary
*By: Tanya S. Unger, Jessica L. Baker, Page C. Valentine, William W. Danforth, and John E. Hughes Clarke*

Mapping the Sea Floor of the Stellwagen Bank National Marine Sanctuary, Massachusetts Bay using GIS
*By: Jessica L. Baker, Tanya S. Unger, and Page C. Valentine*

Glacial and Post-Glacial Processes and Topography in the Stellwagen Bank National Marine Sanctuary Region off Boston, Massachusetts
*By: Page C. Valentine, Tanya S. Unger, and Jessica L. Baker*

Habitat Mapping of the Gulf of Maine
*By: B.J. Todd, P.C. Valentine, V.E. Kostylev, and R.A. Pickrill*

## FACT SHEETS

*Mapping the Sea Floor and Biological Habitats of the Stellwagen Bank National Marine Sanctuary*
U.S. Geological Survey Fact Sheet 078-98

*Seabed Observation and Sampling System*
U.S. Geological Survey Fact Sheet 142-00

## SEABED PHOTOGRAPHS

Photographs of Seabed Habitat and Fauna

## RELATED WEBSITES

Stellwagen Bank National Marine Sanctuary

NOAA National Marine Sanctuaries

NMFS Northeast Fisheries Science Center

New England Fishery Management Council

Marine Protected Areas of the United States

Boston Harbor/Massachusetts Bay On-Line Publications

The Center for Coastal Studies

National Undersea Research Center

Northeast U.S. Marine Observations

Gulf of Maine Moored Buoy Program (GoMoos)

Whale Center of New England, Gloucester, MA

New England Aquarium

Northeast Consortium

Center for Coastal and Ocean Mapping Joint Hydrographic Center

Gulf of Maine Council on the Marine Environment

Commercial Fisheries News

## FLY OVER THE SEABED

Massachusetts Bay Disposal Site

Stellwagen Bank National Marine Sanctuary

Indigenous Organisms of Stellwagen Bank

## GEOGRAPHIC NAMES

Stellwagen Bank-Jeffreys Ledge Region

## INTRODUCTION (continued)

The sea floor mapping survey of the Stellwagen Bank National Marine Sanctuary region covers approximately 1100 square nautical miles of seabed located off Boston, Massachusetts and extending from Race Point Channel (just north of Cape Cod) to the southern part of Jeffreys Ledge (north of Cape Ann). It was conducted on four cruises over a two-year period from the fall of 1994 to the fall of 1996 using a multibeam echo sounder installed aboard the Canadian Hydrographic Service vessel *Frederick G. Creed*.

The sedimentary environments and biological habitats found on the sea floor are being identified and interpreted by using video and photographic imagery and sediment samples that have been collected on many cruises to the region since the mapping was initiated. Research results and products are presented here in the form of maps, posters, fact sheets, sonar images, and bottom photographs.

The great topographic detail of the seabed revealed by the sonar images warrants the naming here of many geographic features. Some features were named in consultation with local fishermen. The names are documented in the "GEOGRAPHIC NAMES" section.

The project has published two map series of 18 quadrangles each (see location map) in which new sea floor topography and sun-illuminated topographic imagery are presented at a scale of 1:25,000 (1 cm on the map represents 250 m on the sea floor). In addition, a map series showing the entire region on a single sheet at a scale of 1:60,000 is presented as a set of 3 maps; one shows contoured seabed topography only, a second adds seabed topographic imagery, and the third adds the backscatter intensity (or reflectivity) of the seabed. See the "LIST OF PUBLICATIONS" for a complete list of maps and CD-ROMs.

The sea floor observed in the Stellwagen Bank NMS region has been shaped for the most part by glacial processes, and the resulting topographic features have been modified since the melting of the ice and the return of the sea. Seabed shapes 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 major basins, banks, ridges, and valleys. Minor features 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. Subsequently, the sea invaded the region formerly occupied by ice, and glacial features were partly eroded and some new 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 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.

The Stellwagen Bank National Marine Sanctuary Mapping Project is a cooperative effort supported by the Coastal and Marine Geology Program of the U.S. Geological Survey and agencies of the National Oceanic and Atmospheric Administration (including the National Marine Sanctuary System, the National Marine Fisheries Service, the National Undersea Research Program, and the Office of Coast Survey). The acquisition and processing of the multibeam sonar data that form the basis of the maps was conducted with technical support from the University of New Brunswick and the Canadian Hydrographic Service.

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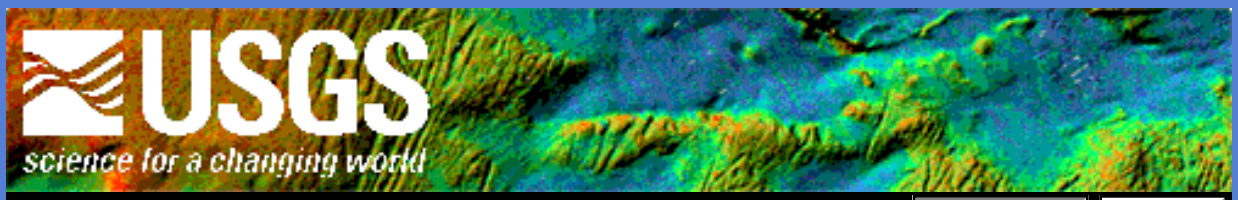


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## Geologic Studies of Benthic Habitats



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# List of Sea Floor Map and Imagery Publications

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Notes:

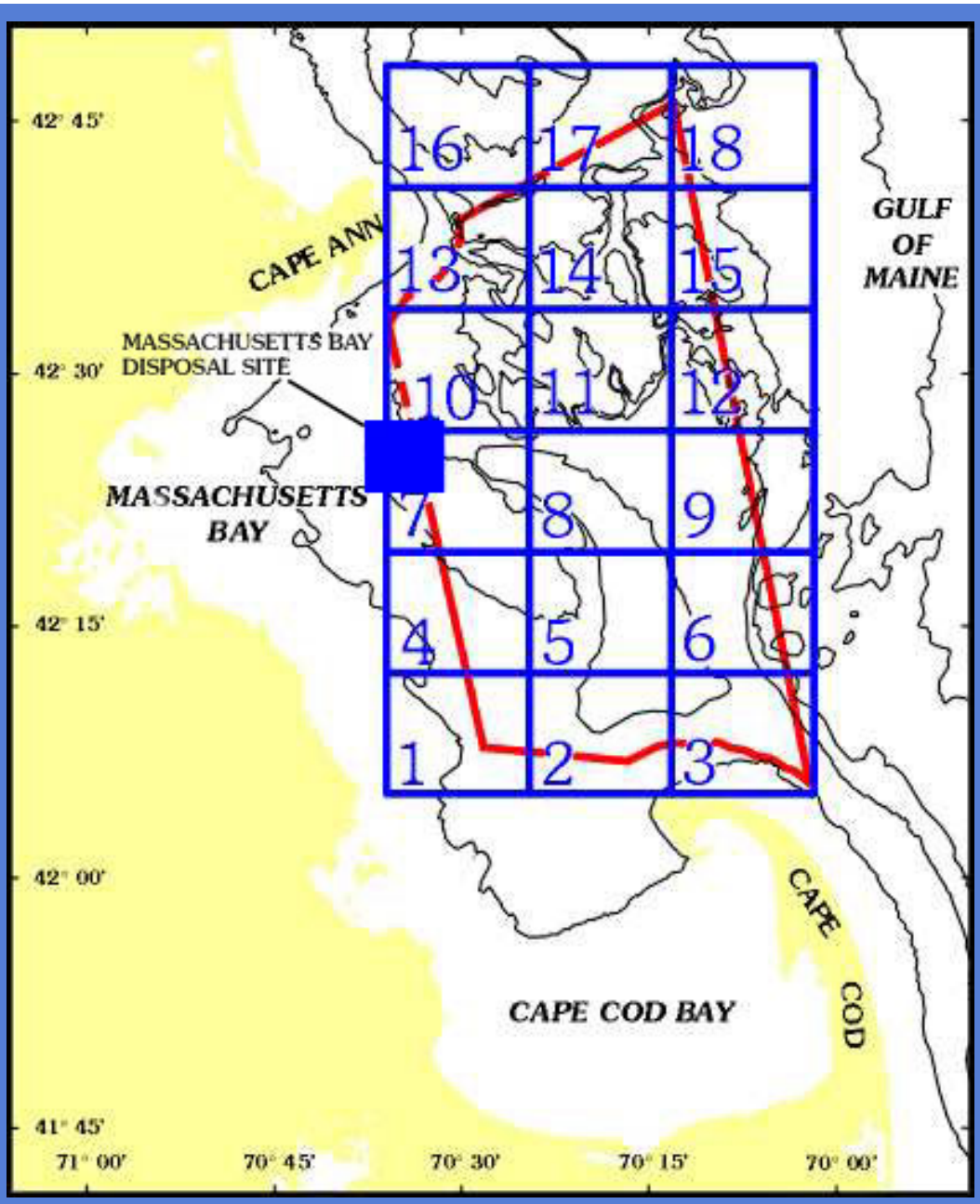
A. CD-ROMs contain PDF, EPS, and PS files for printing individual map sheets on large format printers. CD-ROMs are accessible on this Web site.

B. Paper copies can be obtained from:

Page Valentine, U.S. Geological Survey, 384 Woods Hole Rd., Woods Hole, MA 02543, (508) 457-2239, pvalentine@usgs.gov

Stellwagen Bank NMS, 175 Edward Foster Road, Scituate, MA 02066, (781) 545-8026

USGS Information Services, Box 25286 Denver Federal Center, Denver, CO 80225-0046, (303) 202-4200




Map showing Stellwagen Bank National Marine Sanctuary 18 quadrangles and Massachusetts Bay Disposal Site location.

**MASSACHUSETTS BAY DISPOSAL SITE MAPS AND FEATURES**
*[2 maps; scales 1:10,000 and 1:12,000]*

***CD-ROM:***
Valentine, P.C., Baker, J.L., Unger, T.S., Evans, J., and Polloni, C., 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.

***Paper:***
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, 2 sheets.

**MASSACHUSETTS AND CAPE COD BAYS AND STELLWAGEN BANK NATIONAL MARINE SANCTUARY SEA FLOOR TOPOGRAPHY**
*[scale 1:100,000]*

***Paper only:***
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 95073, scale 1:100,000.

**STELLWAGEN BANK NATIONAL MARINE SANCTUARY SEA FLOOR TOPOGRAPHY**
*[a series of 18 individual quadrangle maps; scale 1:25,000]*

***CD-ROM:***
Valentine, P.C., Baker, J.L., and 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.

***Paper:***
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.

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.

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.

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.

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.

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.

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., 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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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**
*[a series of 18 individual quadrangle maps; scale: 1:25,000]*

***CD-ROM:***
Valentine, P.C., Unger, T.S., Baker, J.L., and Polloni, C., 2000, Sun-illuminated 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 99-363, 1 CD-ROM.

***Paper:***
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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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**
*[a series of 18 individual quadrangle maps combined into one map; scale 1:60,000]*

***CD-ROM:***
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.

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

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

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

[3 maps of the 18-quadrangle region showing topography, sun-illuminated topographic imagery, and backscatter intensity, respectively; also new sea floor feature names]

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