MAPPING THE UNDERSEA LANDSCAPE

Using seafloor maps to improve management of the Gulf of Maine

Summary

Human uses of the seafloor are growing rapidly in variety and intensity, as population expands, technologies develop, and new economic activities emerge. In the Gulf of Maine, trawling, dredging, aquaculture, mining, fiber-optic and electric power cables, oil and gas pipelines, wind farms, and other activities can affect seabed habitats, which support a diversity of animals and plants.

Successful management of these activities, to balance ecological impacts and conflicting uses, requires comprehensive maps of seafloor characteristics. Ocean zoning, for example, relies on information about seafloor habitats, bathymetry, and geology. Fishermen, oil and gas companies, and other businesses also find such maps valuable. As of 2002, however, only 15 percent of the Gulf of Maine had been mapped in sufficient detail.

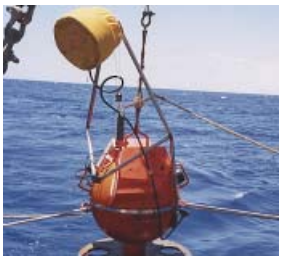
Recent technological advances allow seafloor mapping on an unprecedented scale. New technologies enable researchers to survey large underwater areas to produce high-resolution bathymetric, geological, and ecological maps. Multibeam sonar is especially noteworthy. It generates detailed images of bathymetry and geology of the seabed. To ground-truth the multibeam data and produce interpretive habitat maps, researchers conduct video and photographic surveys, and collect sediment and biota. Other mapping technologies include satellite remote sensing, CASI, LIDAR, sidescan sonar, single-beam sonar, and laser line scan.

In the Gulf of Maine, managers, scientists, and businesses are using new seafloor maps to improve decision-making (see case studies, pages 2 and 3). To broaden this capability, an international partnership of government and non-government organizations called the Gulf of Maine Mapping Initiative (GOMMI) is working to map the remaining 85 percent of the Gulf and provide the maps on the Internet.

Data Sources

Bedford Institute of Oceanography

Multibeam sonar & other remote methods



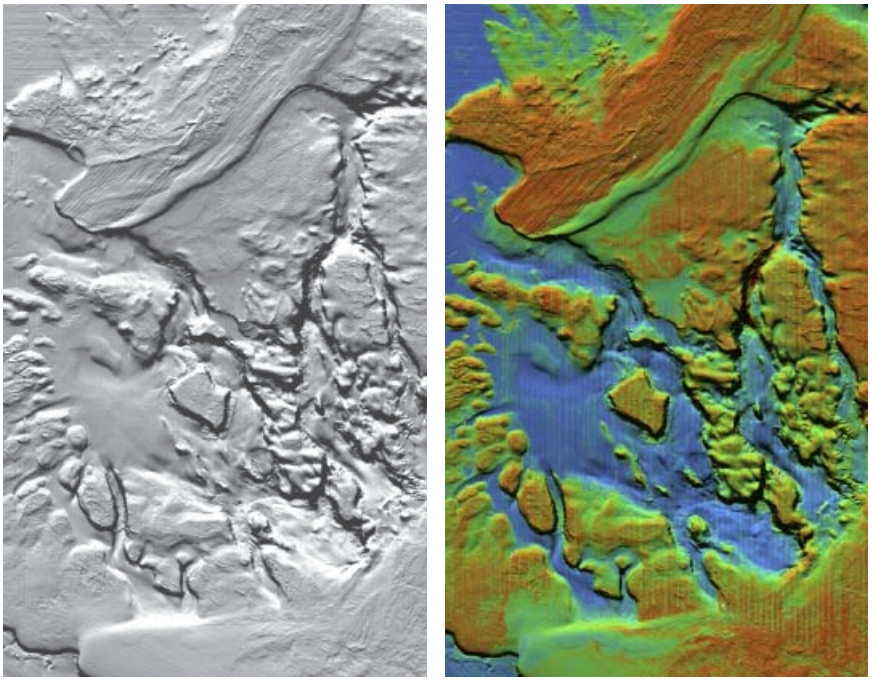
United States Geological Survey

Geophysical surveys & geological sampling

James G. Reid

Biological sampling & fisheries

Products



United States Geological Survey

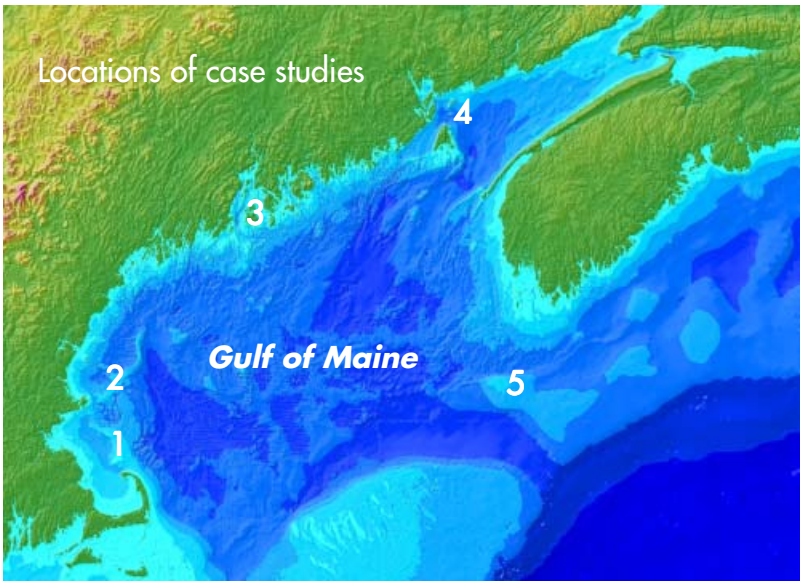
Left: Multibeam sonar image of bathymetry. Right: Multibeam backscatter data overlaid on bathymetry. Backscatter measures hardness and roughness of the substrate: coarse sand or rock (red and orange), sand or muddy sand (green), mud or sandy mud (blue). This information can be combined with biological data to produce habitat maps.

Applications

- Engineering: wind farms, pipelines, power & communications cables
- Dredging & dredge spoils disposal
- Offshore mining
- Fisheries management
- Commercial fishing
- Aquaculture
- Ocean zoning
- Marine protected areas
- Marine archaeology
- Petroleum extraction
- Navigation safety
- National defense & sovereignty
- Education on marine habitat

Applications of Seafloor Mapping

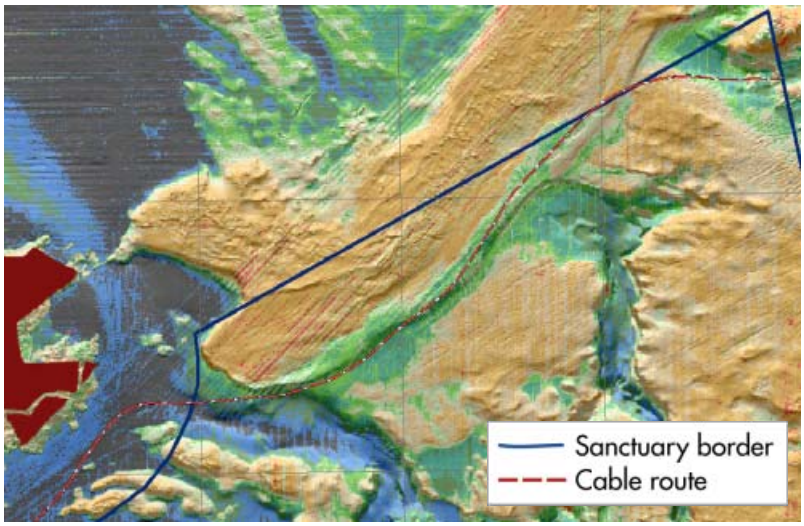
Seafloor maps are used for resource management and commercial operations in the Gulf of Maine, as illustrated in the following case studies.



United States Geological Survey - Woods Hole Field Center

1. Stellwagen Bank *Minimizing ecological and financial costs of routing a fiber-optic cable*

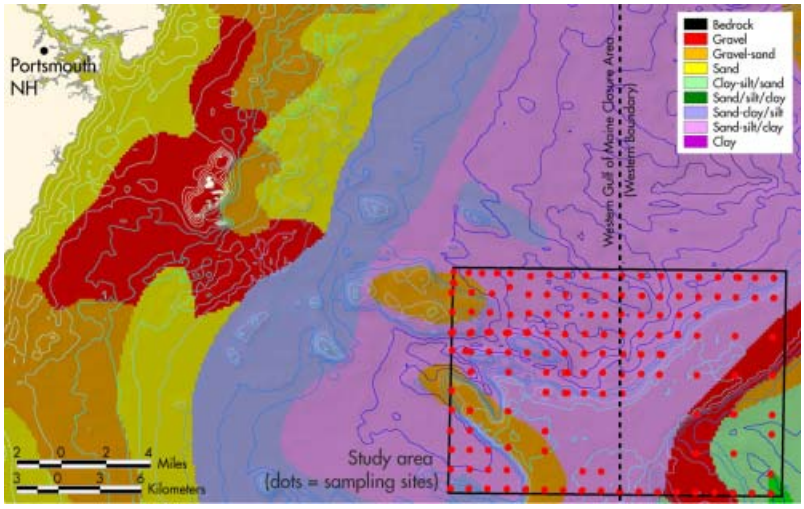
Between 1994 and 1996, the National Marine Sanctuary Program worked with the U.S. Geological Survey to map Stellwagen Bank National Marine Sanctuary and portions of western Massachusetts Bay. Scientists collected multibeam sonar data on bathymetry and substrate, which they ground-truthed with video, photography, and sediment samples. The maps cover 3,900 square kilometers and provide important information for management and research activities. When a private company needed to place a fiber-optic cable through the Sanctuary in 2000, they used the maps to route it across areas of soft sediment, avoiding hard gravel bottom where the cable could not be buried for its protection. Normally, extensive bottom sampling would have been required, increasing both project costs and ecological impacts on seafloor habitats.



Stellwagen Bank National Marine Sanctuary

2. Jeffreys Ledge *Assessing ecosystem effects of an area closed to fishing*

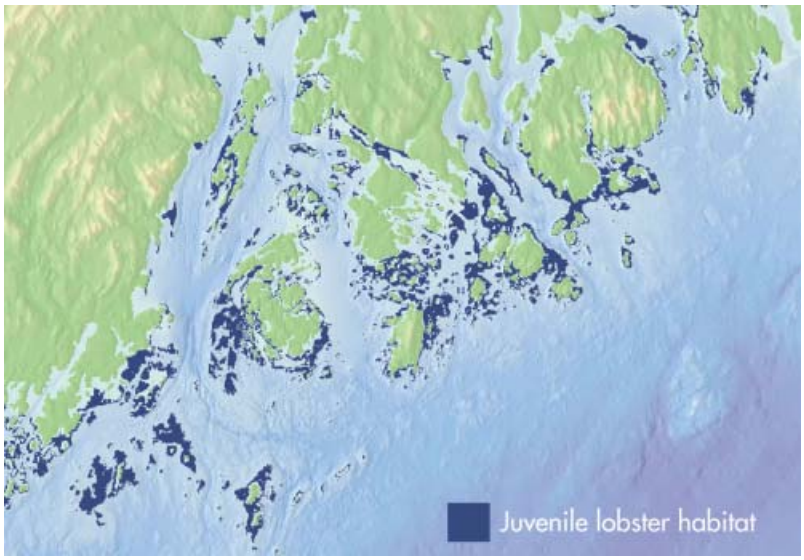
In September 2002, scientists from the University of New Hampshire began an ecosystem-level assessment of biological, ecological, and social effects of the Western Gulf of Maine Closure Area, where fishing has been excluded since 1997. The 150-square-mile study encompasses portions of Jeffreys Ledge, a rich fishing ground off New Hampshire and Massachusetts. The scientists will produce GIS-based maps of geological and biological characteristics using satellite remote sensing, multibeam sonar, video, core sampling, fish tagging, studies of trophic interactions, and genetic analysis of fish tissues. They will also incorporate information from fishermen and other sources. Far more detailed than existing seafloor maps, such as this example (right), the forthcoming maps will improve understanding of the ecosystem and help guide resource management.



Jamie Adams

3. Penobscot Bay *Improving management of a lobster fishery*

From 1996 to 2001, scientists from government agencies, non-profit organizations, and research institutions collaborated with fishermen to investigate the status and ecology of the lobster population in Penobscot Bay. The goal was to improve management of the resource. One question was whether the amount of shallow, cobble-and-boulder habitat, which young lobsters favor, limited their numbers. Using sidescan sonar, video surveys, and sediment samples, researchers mapped sediments and rock types in a geographic information system (GIS). By adding data on water depth, researchers found that favored habitat of juvenile lobsters (indicated in dark blue on the map) is widespread enough in Penobscot Bay to not limit the population. Therefore, management activities can target other factors.



Chris Brehme, Island Institute

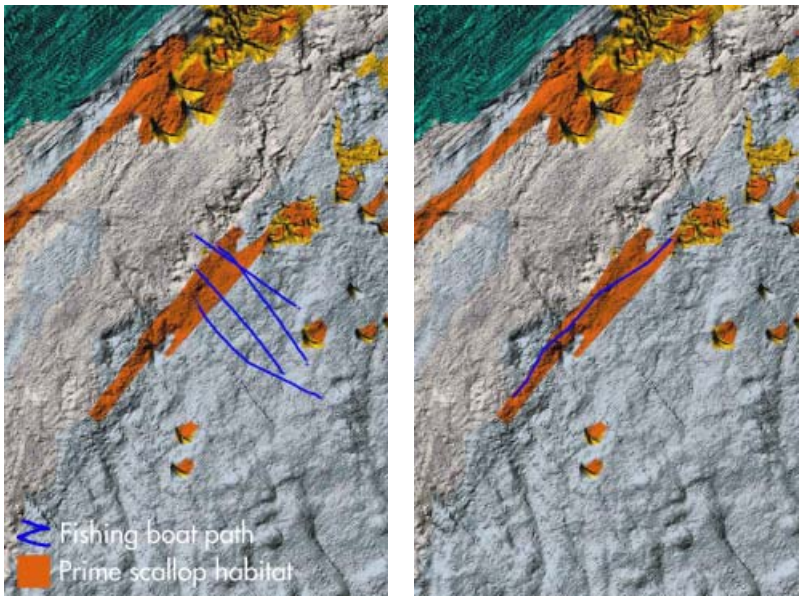
4. New Brunswick *Identifying low-impact sites for salmon aquaculture*

Aquaculture is an important commercial activity in the coastal waters of New Brunswick. Typically, salmon pens are sited in calm bays. However, feces and uneaten food can build up in substantial quantities on the seabed below, causing eutrophication. To avoid this problem, managers now prefer to site salmon pens in erosional areas, where currents carry away the pollutants. They use maps of seafloor geology, produced with multibeam sonar, to identify suitable erosional sites.

Canada Department of Fisheries and Oceans, St. Andrews

5. Browns Bank *Reducing seabed damage and improving efficiency of scallop fishing*

Off Nova Scotia, the scallop beds of Browns Bank support a valuable fishery. Beginning in the 1990s, several scallop companies worked with the Canadian Hydrographic Service and the Geological Survey of Canada to map the area with multibeam sonar. They produced three-dimensional maps of bathymetry, sediments, and benthic habitat, which helped fishermen improve their efficiency and reduce ecological impacts. These two images show the paths of fishing boats before (left) and after (right) obtaining habitat maps, when they could target scallop habitat precisely. Total catch remained restricted by quotas, but fishing time per metric ton of scallop meat plunged from 6.37 hours to 2.41 hours. The total area dragged declined 74 percent and by-catch decreased. The fishermen could better avoid hazards, and fuel usage dropped 36 percent. Fisheries managers use the maps to monitor individual scallop beds and improve stock assessments.

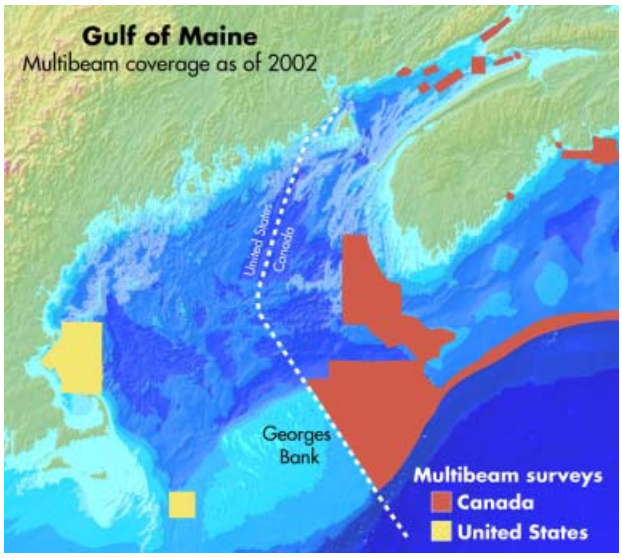


Ginette Robert, Bedford Institute of Oceanography and Canadian Offshore Scallop Industry Mapping Group

Mapping the Future

Recognizing the importance of seafloor maps for management, the Gulf of Maine Mapping Initiative (GOMMI) is working to map the entire Gulf. Endorsed by the Gulf of Maine Council on the Marine Environment, GOMMI is a partnership of government and non-government organizations in Canada and the United States. GOMMI grew out of a mapping workshop in October 2001 that was sponsored by the Gulf of Maine Council and the National Oceanic and Atmospheric Administration.

GOMMI is a multi-year project to secure funding and conduct a comprehensive mapping program of areas not already covered by multibeam surveys (right). The goal is to provide seafloor images, maps, and surveys that are fundamental for resource management, planning, and many commercial activities. For more information, visit http://sh.nefsc.noaa.gov/gommi or email Susan.Snow-Cotter@state.ma.us.



Base map: United States Geological Survey - Woods Hole Field Center

Further Reading

Web Sites

http://www.gulfofmaine.org
Includes a directory of information about seafloor mapping in the Gulf of Maine.

http://sh.nefsc.noaa.gov/gommi
The Gulf of Maine Mapping Initiative (GOMMI) is a partnership of government and non-government organizations working to map the entire Gulf.

http://woodshole.er.usgs.gov/project-pages/stellwagen/
Mapping data, images, and information from Stellwagen Bank National Marine Sanctuary.

http://dusk.geo.orst.edu/djl/links.html
Links about seafloor mapping, including overviews of the technology.

http://seamap.bio.ns.ca/
The Seabed Resource Mapping Program (SeaMap) is an initiative of the Canadian government.

http://www.omg.unb.ca/omg/
The Ocean Mapping Group at the University of New Brunswick.

http://www.ccom.unh.edu/index.htm
The Center for Coastal and Ocean Mapping (C-COM)/Joint Hydrographic Center (JHC) at the University of New Hampshire is a national center for ocean mapping and hydrographic sciences.

http://cinemar.unh.edu/2002_report/index.html
Intensive study of Jeffreys Ledge and the Western Gulf of Maine Closure Area.

http://www.ngu.no/geohab/
GeoHab is an international organization of scientists working with acoustic mapping.

Publications

Anonymous. 2002. Using multibeam sonar to map MPAs: tool of the future for planning and management? *MPA News* 4(2):1-2. [Includes case studies and cost information]

Anonymous. 2002. Using multibeam sonar to reduce the seabed impacts of fishing. *MPA News* 4(2):3-4.

Auster, P.J., K. Joy, and P.C. Valentine. 2001. Fish species and community distributions as proxies for seafloor habitat distributions: the Stellwagen Bank National Marine Sanctuary example (Northwest Atlantic, Gulf of Maine). *Environmental Biology of Fishes* 60:331-346.

Cochrane, G.R. and K.D. Lafferty. 2002. Use of acoustic classification of sidescan sonar data for mapping benthic habitat in the northern Channel Islands, California. *Continental Shelf Research* 22:683-690.

Gulf of Maine Council on the Marine Environment. 2002. Gulf of Maine marine habitat characterization and mapping: A workshop report and strategy for ocean mapping in the Gulf of Maine.

Hughes Clarke, J.E., L.A. Mayer, and D.E. Wells. 1996. Shallow-water imaging multibeam sonars: a new tool for investigating seafloor processes in the coastal zone and on the continental shelf. *Marine Geophysical Research* 18:607-629.

Kelley, J.T., W.A. Barnhardt, D.F. Belknap, D.F., S.M. Dickson, and A.R. Kelley. 1998. The seafloor revealed: The geology of Maine's inner continental shelf. A report to the Regional Marine Research Program, Maine Geological Survey Open-File Report 98-6. 55 pp. Available at http://www.state.me.us/doc/nrimc/pubedinf/pubs/plcoast.htm.

Kostylev, V.E., B.J. Todd, G.B.J. Fader, R.C. Courtney, G.D.M. Cameron, and R.A. Pickrill. 2001. Benthic habitat mapping on the Scotian Shelf based on multibeam bathymetry, surficial geology and sea floor photographs. *Marine Ecology Progress Series* 219:121-137.

Kostylev, V.E., R.C. Courtney, G. Robert, and B.J. Todd. 2003. Stock evaluation of giant scallop (*Placopecten magellanicus*) using high-resolution acoustics for seabed mapping. *Fisheries Research* 60:479-492.

Manson, G. and B.J. Todd. 2000. Revolution in the Nova Scotia scallop fishery: seabed maps turn hunting into harvesting. *Fishing News International* 39(2):20-22.

Smith, G.F. and K.N. Greenhawk. 1998. Shellfish benthic habitat assessment in the Chesapeake Bay: progress toward integrated technologies for mapping and analysis. *Journal of Shellfish Research* 17(5):1433-1437.

Todd, B.J., G.B.J. Fader, R.C. Courtney, and R.A. Pickrill. 1999. Quaternary geology and surficial sediment processes, Browns Bank, Scotian Shelf, based on multibeam bathymetry. *Marine Geology* 162:165-214.

Links to many of these publications, along with expanded and updated information about seafloor mapping, can be found at www.gulfofmaine.org

Editorial: Peter H. Taylor, ptgomc@suscom-maine.net
Design & Illustration: Ethan Nedeau, ejnedeau@attbi.com

Thanks to the following scientists and managers for reviewing and providing information: Paul Boudreau (Canadian Department of Fisheries and Oceans), Joseph Kelley (University of Maine), James Lindholm (Stellwagen Bank National Marine Sanctuary), Larry Mayer (University of New Hampshire), Tom Noji (U.S. National Marine Fisheries Service), Susan Snow-Cotter (Massachusetts Office of Coastal Zone Management), Brian Todd (Geological Survey of Canada), Megan Tyrrell (Massachusetts Office of Coastal Zone Management), and Page Valentine (U.S. Geological Survey).

Gulf of Maine Council on the Marine Environment

SCIENCE TRANSLATION PROJECT
Accelerating the transfer of science to management

This is a publication of the Science Translation Project of the Gulf of Maine Council on the Marine Environment. The Council's mission is to maintain and enhance environmental quality in the Gulf of Maine to allow for sustainable resource use by existing and future generations.

The Science Translation Project provides timely scientific information to state, provincial, and federal decision-makers to advance management of the Gulf of Maine and its watershed.