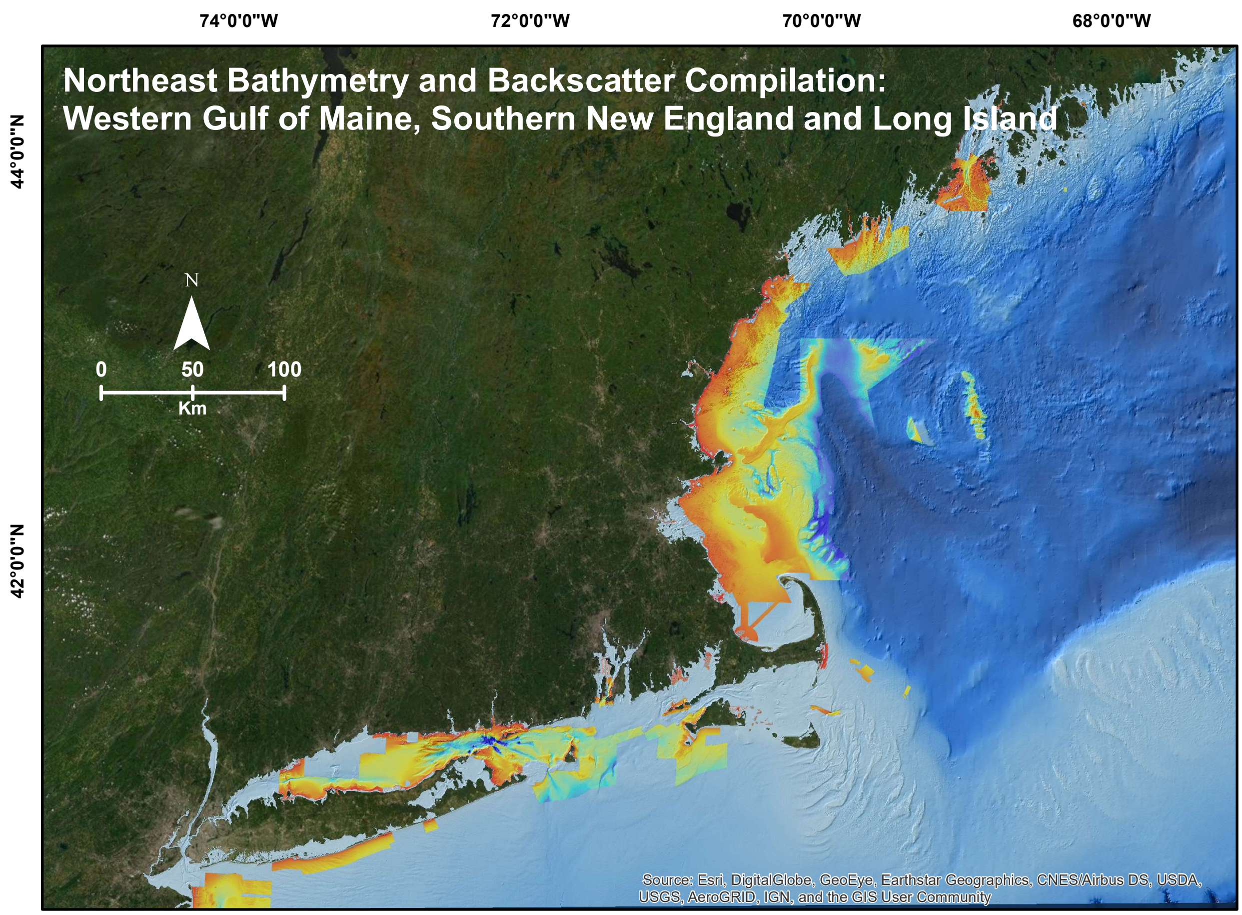
BOEM/New Hampshire Cooperative Agreement (Contract M14ACOOO10) Technical Report

Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island

By Ward, L.G., Johnson, P., Bogonko, M., McAvoy, Z.S., and Morrison, R.C.
University of New Hampshire Center for Coastal and Ocean Mapping/Joint Hydrographic Center
24 Colovos Road, Durham, NH 03824



Acknowledgements

The development of the Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island Sound was supported by the Bureau of Ocean Energy Management Award Number M14AC00010 and University of New Hampshire/National Oceanic and Atmospheric Administration Joint Hydrographic Center Award Number NA10NOS4000073.

We gratefully acknowledge NOAA National Ocean Service (NOS) for providing hydrographic and backscatter survey data. Will Fessenden (IT) and Colleen Mitchell (Graphic Design and Editing) provided valuable technical advice and support. A number of colleagues at the University of New Hampshire Center for Coastal and Ocean Mapping (CCOM) and Joint Hydrographic Center (JHC) provided scientific advice and insight including Semme Dijkstra, Larry Mayer, and Giuseppe Masetti. We would also like to acknowledge the input and advice of colleagues from NOS Office of Coast Survey (OCS) and JHC including Andrew Armstrong, Juliet Kinney, Erin Nagel, Glen Rice, and Katrina Wyllie.

Map Coordinate System, Projection and Datum

Coordinate System: WGS 1984 UTM Zone 19N

Projection: Transverse Mercator

Horizontal Datum: WGS 1984

Vertical Datum: MLLW

Website: Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island

(https://maps.ccom.unh.edu/portal/apps/webappviewer/index.html?id=5d314116ad094afebbd02ffc185164f6); accessed June 1, 2021

Recommended Citation

Ward, L.G., Johnson, P., Bogonko, M., McAvoy, Z.S., and Morrison, R.C., 2021, Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island Sound: BOEM/New Hampshire Cooperative Agreement (Contract M14ACOOO10) Technical Report, Department of Interior, Bureau of Ocean Energy Management, Marine Minerals Division, 45600 Woodland Road, Sterling, VA, 20166., 23 pp. https://dx.doi.org/10.34051/p/2021.28

Table of Contents

List of Figures

Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island Sound

By Ward, L.G., Johnson, P., Bogonko, M., McAvoy, Z.S., and Morrison, R.C.
University of New Hampshire Center for Coastal and Ocean Mapping/Joint Hydrographic Center

Abstract

High-resolution bathymetry is critical for mapping the surficial geology of the seafloor, identifying critical habitats, and assessing marine mineral resources such as sand and gravel. In 2016, a high-resolution bathymetry map was developed for the western Gulf of Maine (WGOM) utilizing all available multibeam echosounder (MBES) surveys, as well as several older extant surveys (Western Gulf of Maine Bathymetry and Backscatter Synthesis, Ward et al., 2016). As part of that effort, a backscatter mosaic also was developed for a subset of the MBES surveys. The backscatter synthesis did not include all of the MBES surveys due to low quality of some of the mosaics and limitations of combining MBES backscatter surveys (e.g., different frequencies).

In order to extend the high-resolution bathymetry coverage of the U.S. Northeast (NE), the WGOM Bathymetry and Backscatter Synthesis was substantially expanded. A careful review of the available bathymetry and backscatter from Maine to New York was conducted and the needed databases obtained. In addition, bathymetric lidar surveys were gathered, primarily in the WGOM. Unfortunately, the MBES coverage was relatively sparse over large areas of the NE region with few surveys available for mid and northern Maine, south of Cape Cod, and along the Atlantic coast of Long Island to New York Harbor. However, relatively good coverage exists for Long Island Sound. Similarly, high quality backscatter mosaics co-registered with the bathymetry was sparse. Nevertheless, the available bathymetry and backscatter does allow a significant expansion of the overall coverage and exposes areas where more information would be beneficial. Some low-resolution bathymetry data (e.g., single beam surveys that leave gaps between survey lines) were also obtained but were only used in a Regional Bathymetry Map.

The "Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island Sound" expands the coverage of high-resolution MBES to include southern New England and Long Island Sound. The main bathymetry synthesis is gridded at 4m, 8m, and 16m. Also included are MBES bathymetry surveys that provide more detail of regions where research projects have been conducted by the University of New Hampshire (UNH) Center for Coastal and Ocean Mapping/Joint Hydrographic Center (CCOM/JHC). The overall backscatter coverage for the WGOM inner continental shelf is presented as compilations and individual survey mosaics (UNH CCOM/JHC surveys). South of Cape Cod to New York Harbor the backscatter is limited and presented as individual surveys where available.

The "Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island Sound" can be viewed on the CCOM/JHC website at:
(https://maps.ccom.unh.edu/portal/apps/webappviewer/index.html?id=5d314116ad094afebbd02ffc185164f6); accessed June 1, 2021

Introduction

The continental shelf off the northeastern United States from Maine to Long Island was shaped by interactions of riverine sediment inputs, glaciations, and sea-level fluctuations. To the north, the western Gulf of Maine (WGOM) is characterized by extensive bedrock outcrops, marine-modified glacial deposits, numerous bathymetric highs (e.g., Jeffreys Ledge, Cashes Ledge, Fippennies Ledge, Stellwagen Bank), and deep ocean basins (e.g., Jeffreys Basin, Wilkinson Basin). Further south from Cape Cod to Long Island, the shelf is composed of wide sandy plains and marine-modified glacial deposits. Here, the bottom can change rapidly due to storms and other high-energy events. As a result, the seafloor in the U.S. Northeast (NE) is extremely complex and can vary significantly over short distances or have extensive homogeneous regions. Fortunately, there have been a number of high-resolution multibeam echosounder (MBES) surveys in the WGOM off southern Maine, New Hampshire, and Massachusetts that provide excellent bathymetric coverage of the seafloor. The same is true for much of Long Island Sound. Unfortunately, MBES bathymetry coverage is much less dense in mid and northern Maine and south of Cape Cod to New York Harbor along the Atlantic Coast.

The "Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island" (hereafter referred to as the "Compilation") brings together the MBES surveys for the NE with the primary goal of presenting a synthesis of all high-resolution bathymetry in a single gridded surface accompanied by backscatter where available and of good quality (Figure 1). Also, a lower resolution regional synthesis is presented. The high-resolution bathymetry synthesis primarily consists of MBES surveys gridded at 4m, 8m, and 16m. The regional bathymetry surface consists of single beam echosounder (SBES) and MBES surveys gridded at 16m. The backscatter mosaics include compilations for the inner shelf off New Hampshire (NH) by the University of New Hampshire (UNH) Center for Coastal and Ocean Mapping and Joint Hydrographic Center (CCOM/JHC), and for the Massachusetts coast north of Cape Cod by the United States Geological Survey (USGS). In addition, there are a number of individual MBES surveys presented.

The Compilation is a major expansion of the "Western Gulf of Maine Bathymetry and Backscatter Synthesis" published by CCOM/JHC in 2016 (Ward et al., 2016). The WGOM synthesis has been widely used by a number of federal and state agencies, as well as private individuals (e.g., the local fishing community). The purpose of expanding the bathymetry and backscatter synthesis and compilation is to provide a basis for future mapping of surficial geology and habitats in the NE, to support studies to identify marine minerals on the NE continental shelf, and to aid in conducting environmental studies if sand and gravel extraction is proposed.

Additional Bathymetry Resources

Other bathymetry compilations exist for the U.S. Northeast. Notable is a comprehensive compilation created by the National Ocean Survey (NOS) that compiles all bathymetry resources as they become available into the "National Bathymetry Source" (NBS). The NBS is frequently updated and merged into the bathymetry grid. The "Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island" presented here primarily focuses on high-resolution bathymetry and includes backscatter surveys.

For more information about the NBS go to https://nauticalcharts.noaa.gov/updates/building-the-national-bathymetry/. For questions contact ocs.nbs@noaa.gov.

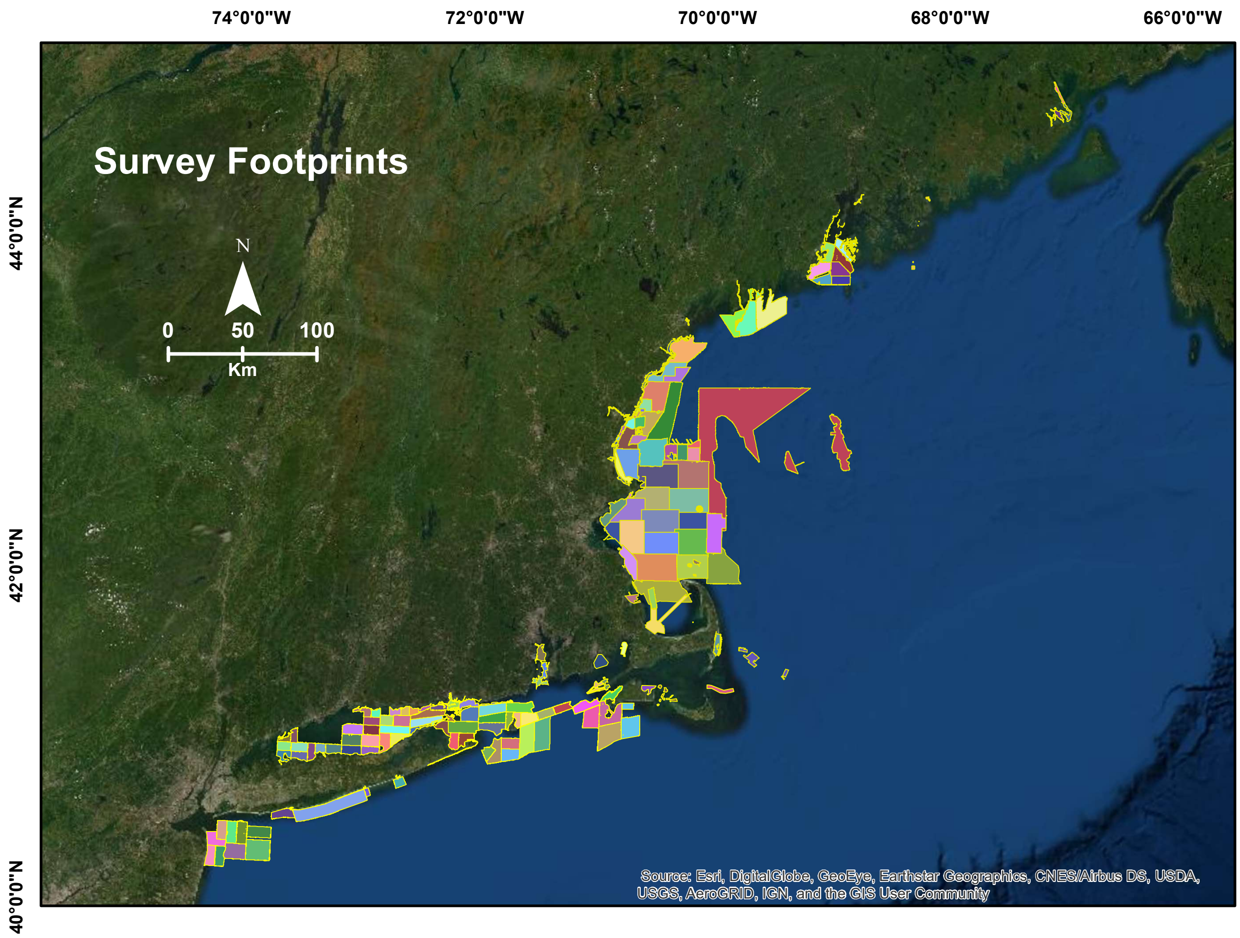


Figure 1. Multibeam echosounder surveys included in the "Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island".

Bathymetry

One hundred ninety-six surveys conducted by multiple agencies were used to construct the bathymetry compilations. The major agencies and groups include: National Oceanic and Atmospheric Administration (NOAA) National Ocean Survey (NOS); United States Geological Survey (USGS); University of New Hampshire (UNH) Center for Coastal and Ocean Mapping and Joint Hydrographic Center (CCOM/JHC); Gulf of Maine Marine Institute (GOMMI); United States Army Corps of Engineers (USACE); Maine Coastal Mapping Initiative (MCMI); and private organizations (e.g., Science Applications International Corporation, Inc., SAIC). The surveys are listed in Appendices A and B.

High-Resolution Bathymetry Synthesis

The high-resolution bathymetry synthesis covers two regions: the Western Gulf of Maine (Figure 2) and Southern New England and Long Island (Figure 3). The Western Gulf of Maine (WGOM) map extends from southern Maine to Massachusetts Bay. The high-resolution bathymetry synthesis was not extended further north into Maine due to the lack of accessible MBES surveys. However, relatively good coverage was obtained from southern Maine to Cape Cod and seaward to Jeffreys Ledge. The Southern New

England and Long Island bathymetry synthesis extends from Cape Cod south to New York Harbor and includes the inner shelf off Long Island and Long Island Sound. The MBES coverage in Long Island Sound is relatively complete. However, the high-resolution MBES bathymetry coverage along the Atlantic Coast from south of Cape Cod to New York is sparse, leaving wide gaps in coverage. All MBES surveys that were available and known to the authors are included in the Compilation.

The high-resolution bathymetry syntheses are primarily composed of MBES surveys enhanced by lidar in very shallow water. The original surveys used in the Compilation were collected over a long time period and gridded over a large range. The survey dates range from 1988 to 2019, but the majority (~82%) have been carried out since 2005. Although the cell size for the surveys ranges from 0.5m to 16m, the highest resolution gridding was used for the Compilation. In almost all cases, the larger grid sizes were only used for very small areas.

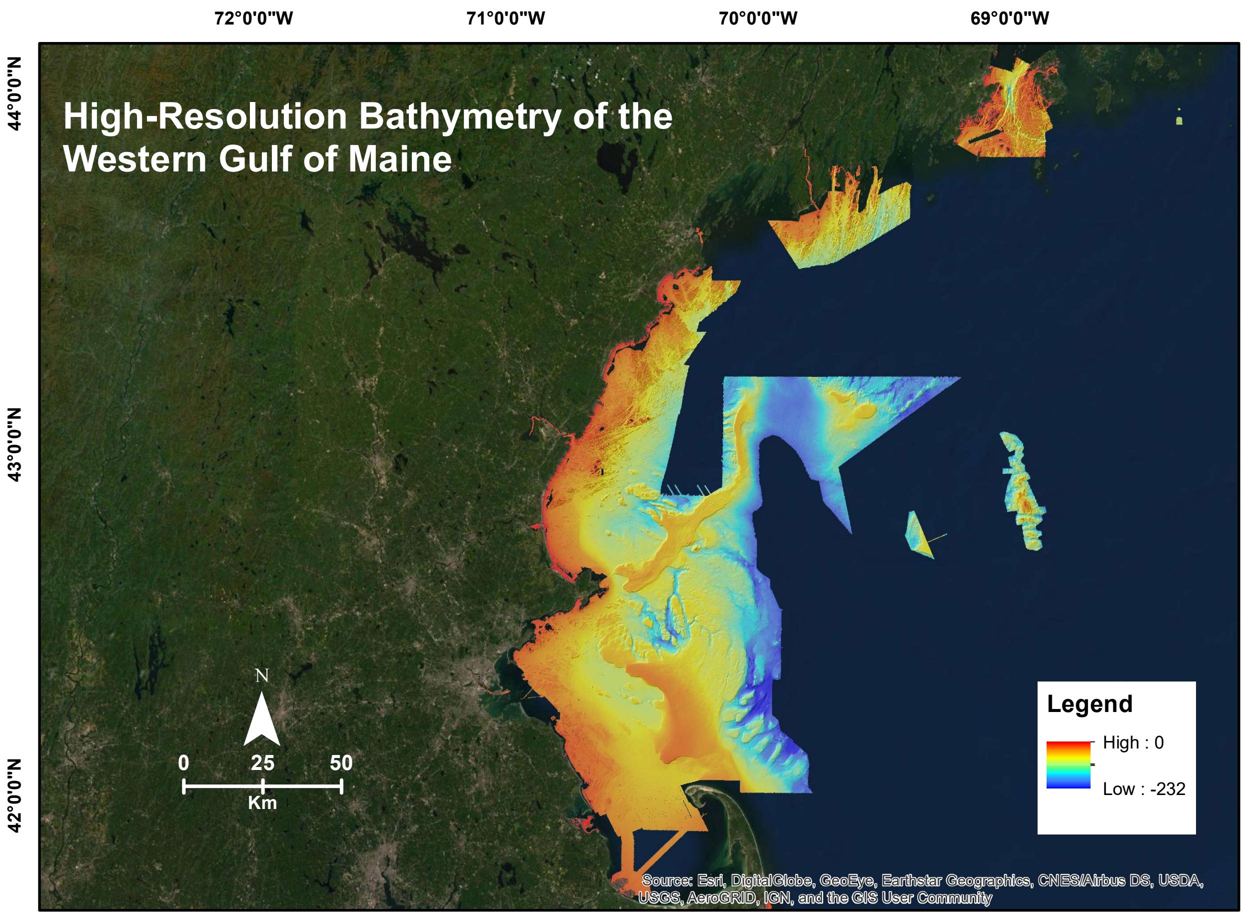


Figure 2. High-resolution bathymetry of the Western Gulf of Maine gridded at 4m. The vertical exaggeration is five.

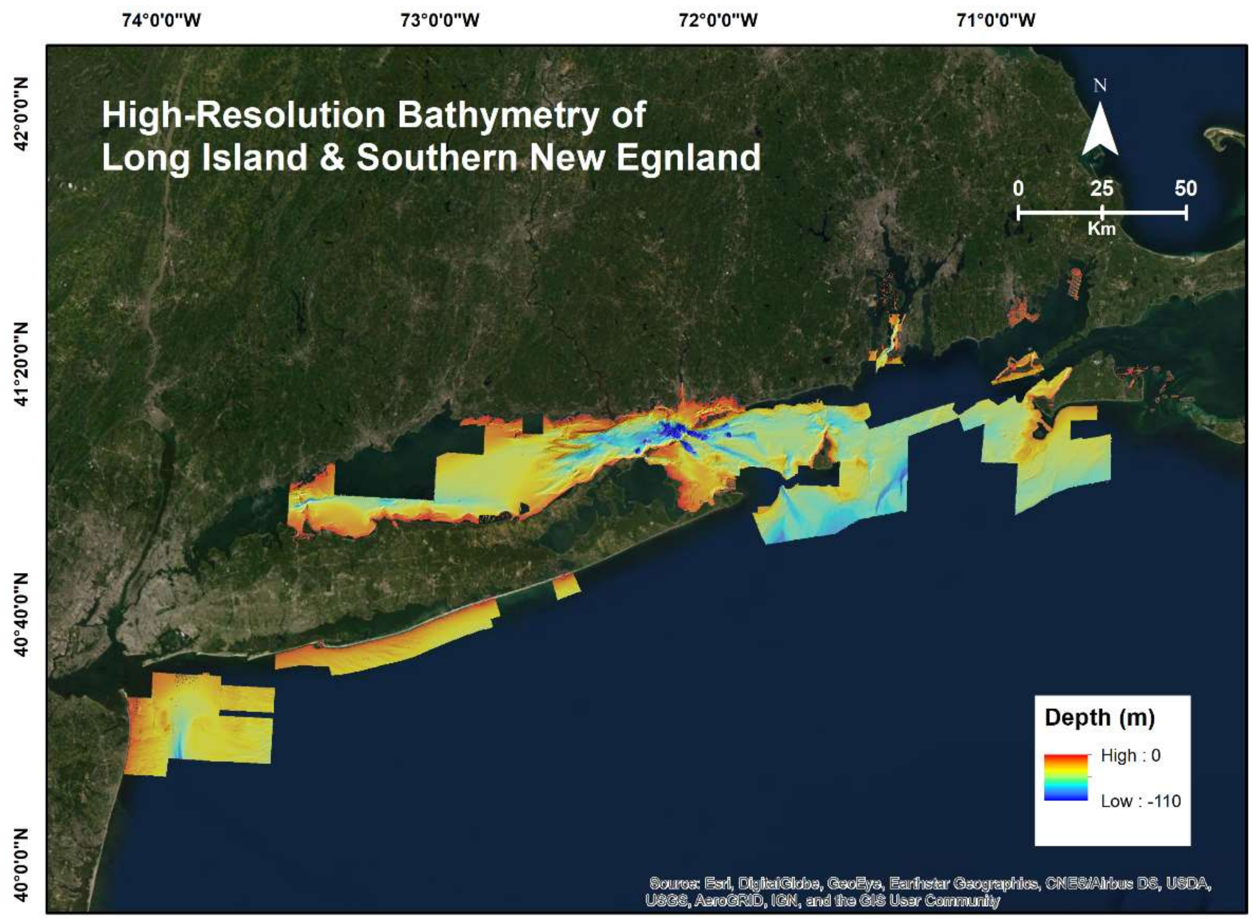


Figure 3. High-resolution bathymetry of Southern New England and Long Island Sound gridded at 4m. The vertical exaggeration is five.

Each survey was brought into Global Mapper 20, re-projected to WGS 1984 UTM Zone 19N, Transverse Mercator, and resampled at a 4m, 8m, and 16m cell sizes using bilinear interpolation. Each survey was ranked based on resolution and date and overlaid in global mapper from the highest resolution to the lowest resolution to develop the composite surface. A new shoreline for the entire area was made to ensure a clean landward boundary. To produce more uniform composites, the mosaic was resampled at 4m, 8m, and 16m and exported as 32-bit GeoTiffs. Final maps mere produced in ArcGIS. The original gridding, survey source, and other relevant information are included in the metadata for each survey presented in Appendices A and B.

Regional Bathymetry Map

The regional bathymetry compilation extends from northern Maine to New York City and over much of the Gulf of Maine, southern New England, and Long Island Sound. The regional bathymetry map was built using the same bathymetry and procedure described previously but also includes older surveys of a much lower resolution or existing regional syntheses. This included the Global Multi-Resolution Topography (GMRT) synthesis that is maintained as a multi-resolution gridded global Digital Elevation Model (DEM) and includes cleaned, processed ship-based multibeam sonar data at their full spatial resolution (~100m in the deep sea) (https://www.gmrt.org/about/). Global Multi-Resolution Topography (GMRT) grids were combined with high-resolution multibeam data available from CCOM and NOS and gridded at 16m (Figure 4).

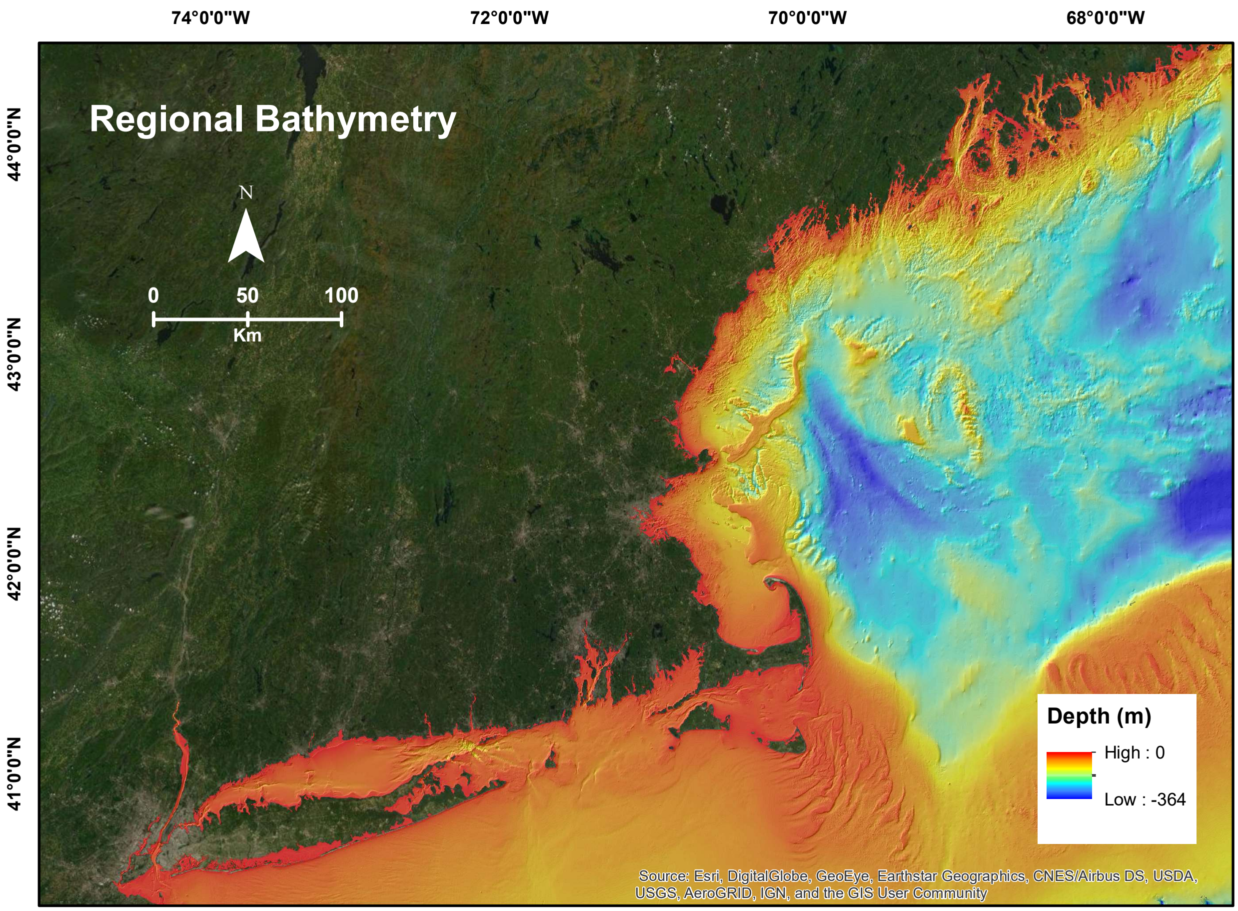


Figure 4. Regional bathymetry for the U.S. Northeast gridded at 16m. The vertical exaggeration is five.

UNH CCOM/JHC High-Resolution Bathymetry and Backscatter Surveys

The UNH CCOM/JHC Hydrographic Field Course MBES surveys, which were primarily conducted on the continental shelf off NH, feature very high-resolution MBES bathymetry with co-registered backscatter. Backscatter, or reflectivity, is the strength of the acoustic signal that returns to the transponder and is strongly affected by complex interactions with seafloor properties such as bottom sediment texture, roughness, and biota. Although MBES backscatter can be problematic due to calibration issues and differences in instrumentation used in surveys (e.g., frequency), it often provides valuable information concerning the seafloor. The bathymetry from the Hydrographic Field Course is gridded between 0.5 and 2.0m, and the backscatter is gridded at the same or finer resolution. The reflectivity mosaics primarily use decibel units which allow quantitative analysis. The Field Course surveys are presented separately in the Compilation and include the bathymetry and the backscatter (Figure 5).

Figure 5. UNH CCOM/JHC Hydrographic Field Course MBES surveys from the NH continental shelf.

Multibeam Echosounder Backscatter Syntheses

Two grayscale backscatter mosaics incorporating multiple backscatter surveys are included in the Compilation that cover the inner shelf off New Hampshire and Massachusetts Bay and are referred to here as the USGS Backscatter Composite and the CCOM/JHC Backscatter Synthesis.

The USGS Composite includes MBES and side scan sonar surveys gridded at 10m and covers the continental shelf from the NH border to Massachusetts Bay, including parts of Jeffreys Ledge and Stellwagen Bank (Figure 6). Details and metadata for the USGS synthesis are given in Pendleton et al. (2013).

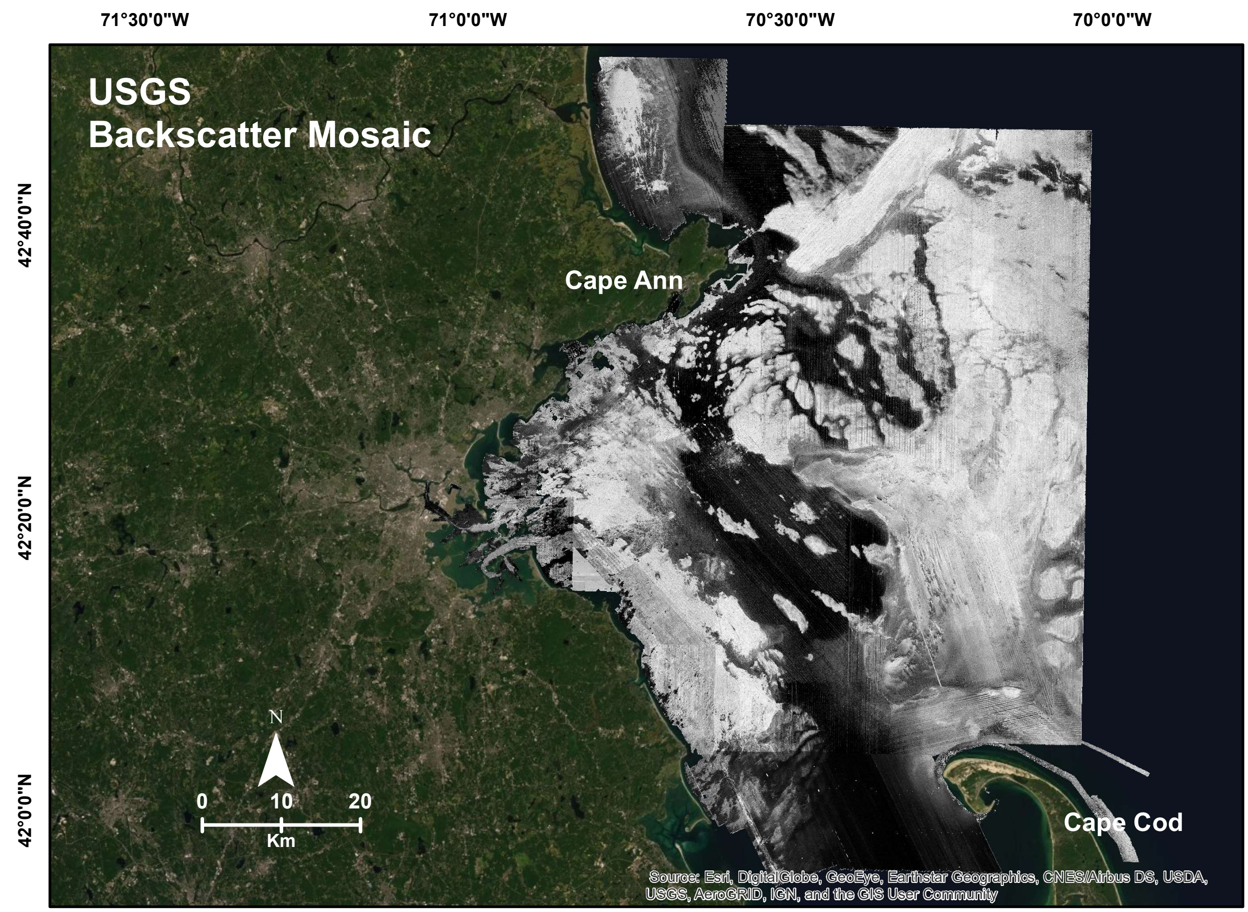


Figure 6. Backscatter mosaic developed by the USGS (see Pendleton et al., 2013).

UNH CCOM/JHC WGOM Backscatter Synthesis

In order to develop a composite of MBES backscatter for the NH shelf, a subset of available surveys was assembled that were available from NOS and CCOM/JHC. No attempt was made to include all MBES surveys in the region due to the difficulties of combining varying datasets. Instead, a subset (twelve) for a region off New Hampshire was chosen. The UNH CCOM/JHC surveys were processed by survey in QPS Fledermaus Geocoder Toolbox (FMGT). However, some of the NOS backscatter mosaics used in this compilation contained residual artifacts that required pre-processing. The NOS surveys were then processed in CARIS and FMGT. The additional processing of the NOS MBES is described in detail in Ward et al. (2016). Using ERSI ArcGIS, the backscatter surveys were then standardized and rescaled using a Z score normalization method and mosaicked. Ultimately, a mosaic gridded at 2.0m was built that minimized the artifacts and allowed visual interpretation. However, the result is a qualitative product showing high and low reflectivity that is somewhat inconsistent across surveys with different frequencies. As a result, quantitative analysis using the backscatter mosaic is not possible. However, the UNH CCOM/JHC surveys can be used for quantitative analysis (Figure 7).

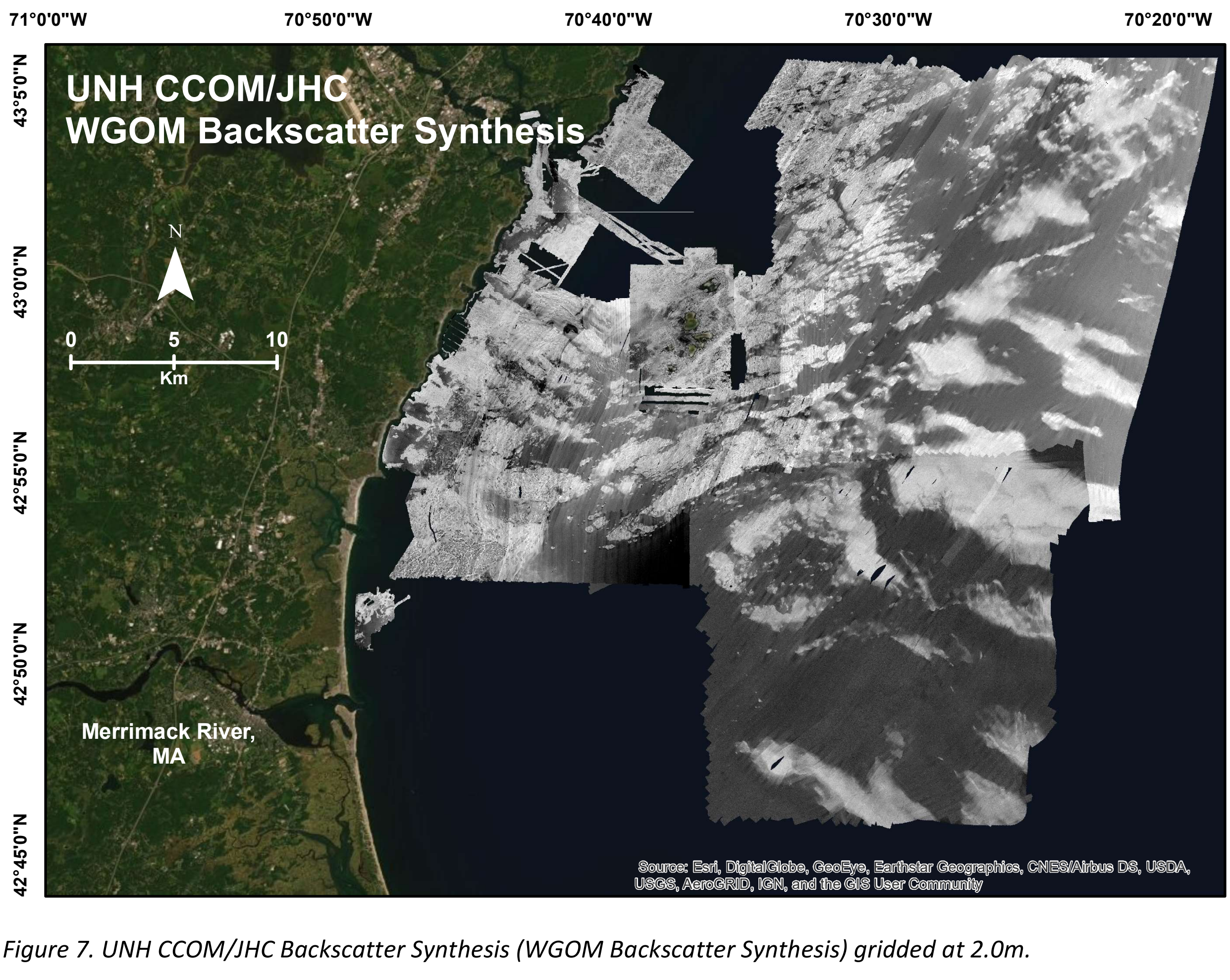


Figure 7. UNH CCOM/JHC Backscatter Synthesis (WGOM Backscatter Synthesis) gridded at 2.0m.

Web Serving

The "Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island Sound" is available via the UNH CCOM/JHC web site at: (https://maps.ccom.unh.edu/portal/apps/webappviewer/index.html?id=5d314116ad094afebbd02ffc185164f6); accessed May 2021. The Compilation is web-served using ArcGIS Server/ArcGIS Portal and rendered with web-served dynamic interactive maps written in JavaScript. The interactive maps can display the multibeam synthesis, the backscatter synthesis, and the individual surveys for the UNH CCOM/JHC Hydrographic Field Course, and also query information on each of the surveys or grids (e.g., original gridding, survey source, and other relevant information).

Summary

A very large and diverse set of high-resolution MBES surveys were successfully brought together and combined into maps that display the bathymetry gridded at 4m, 8m, and 16m in the "Northeast Bathymetry and Backscatter Compilation: Western Gulf of Maine, Southern New England, and Long Island Sound" (Figures 1, 2 and 3). In addition, a regional bathymetry surface gridded at 16m is included which utilizes lower resolution bathymetry and existing regional syntheses (Figure 4). Available backscatter from selected MBES surveys and existing syntheses are also presented which cover the inner shelf from southern Maine to Cape Cod (Figures 5, 6 and 7). Collectively, these products summarize the high-resolution bathymetric coverage of the U.S. Northeast inner continental shelf. The Compilation will aid visualization and analyses of seafloor surficial geology, habitats, and marine minerals. Examples of the quality and resolution of the bathymetry and backscatter are shown by the enlargements of the bathymetry survey re-gridded at 4m (Figures 8, 9, 10, and 11).

References

Pendleton, E.A., Baldwin, W.E., Barnhardt, W.A., Ackerman, S.D., Foster, D.S., Andrews, B.D., and Schwab, W.C., 2013, Shallow geology, seafloor texture, and physiographic zones of the Inner Continental Shelf from Nahant to northern Cape Cod Bay, Massachusetts: U.S. Geological Survey Open-File Report 2012-1157. http://pubs.usgs.gov/of/2012/1157/.

Ward, L.G., Johnson, P., Nagel, E., McAvoy, Z.S., and Vallee-Anziani, M., 2016, Western Gulf of Maine bathymetry and backscatter synthesis: BOEM/New Hampshire Cooperative Agreement (Contract M14ACOOO10) Technical Report, BOEM Marine Minerals Branch, 381 Elden Street, Herndon, VA, 20170. 18 pp, https://dx.doi.org/10.34051/p/2021.27

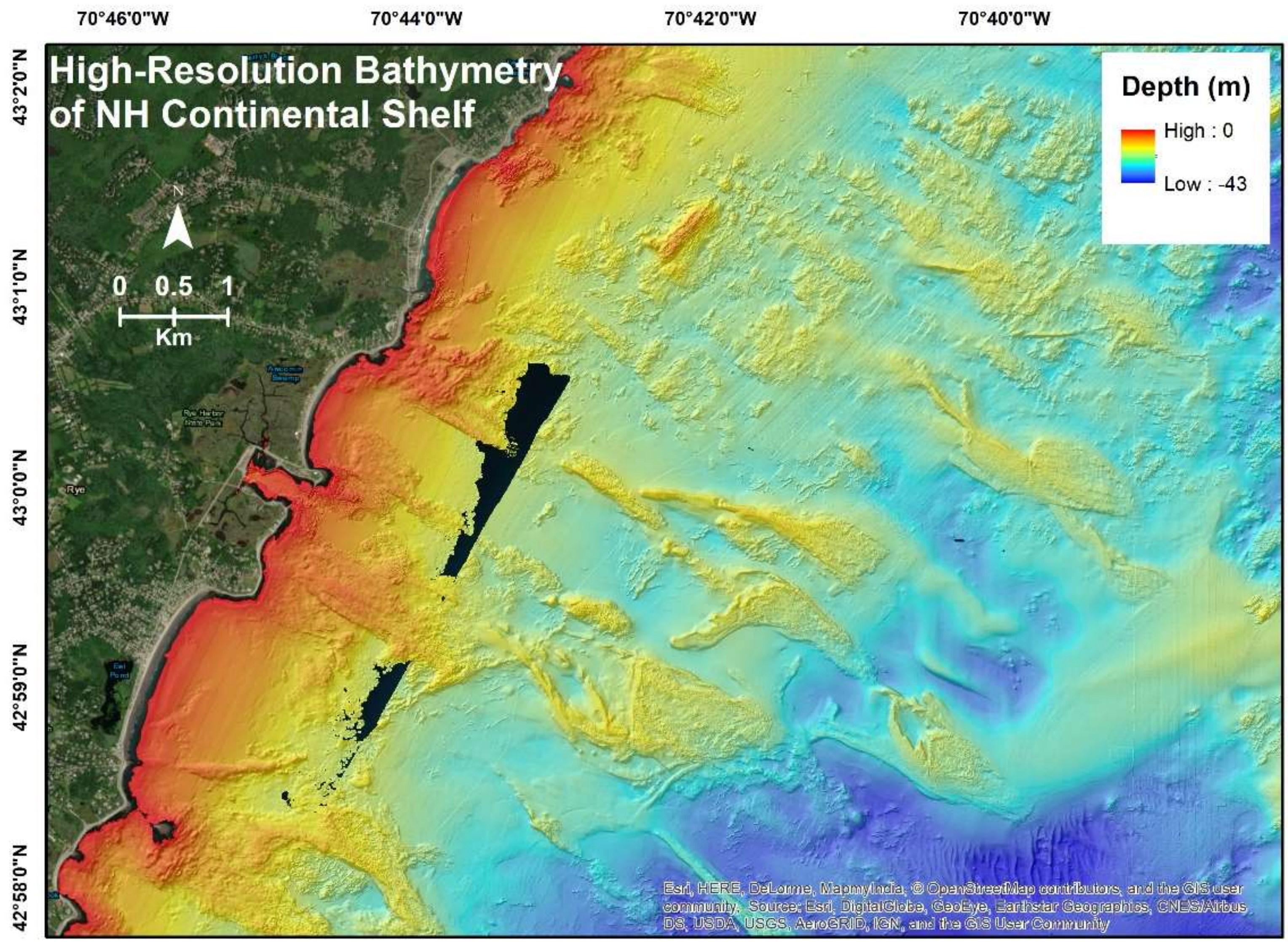


Figure 8. High-resolution bathymetry off the NH inner shelf. Many of the northwest-southeast trending features are marine-modified glacial features that extend onto shore. The vertical exaggeration is five.

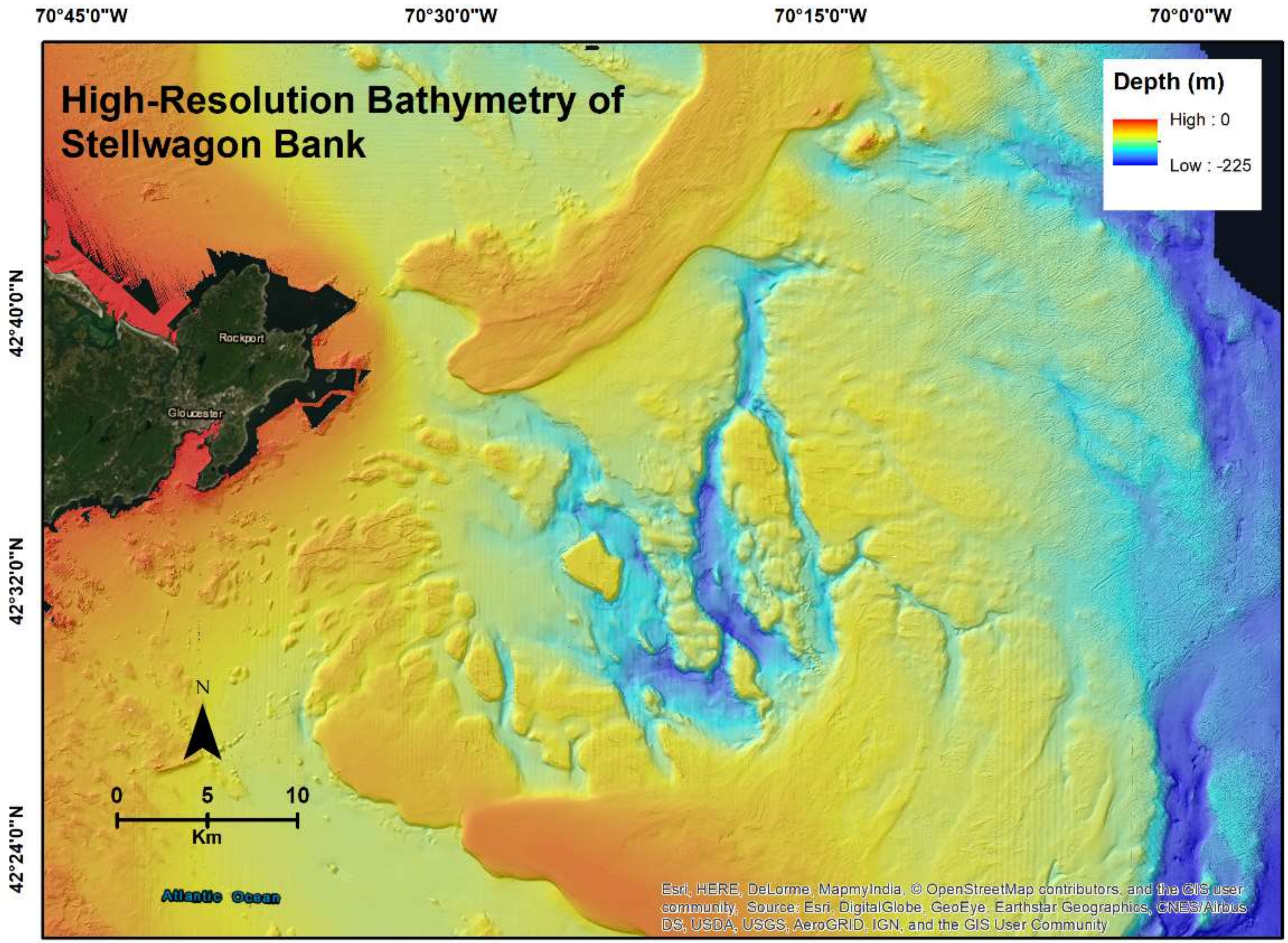


Figure 9. High-resolution bathymetry off Cape Ann, MA showing the complexity of the seafloor at the southern end of Jeffreys Ledge (top) and Stellwagen Bank (lower middle). The vertical exaggeration is ten.

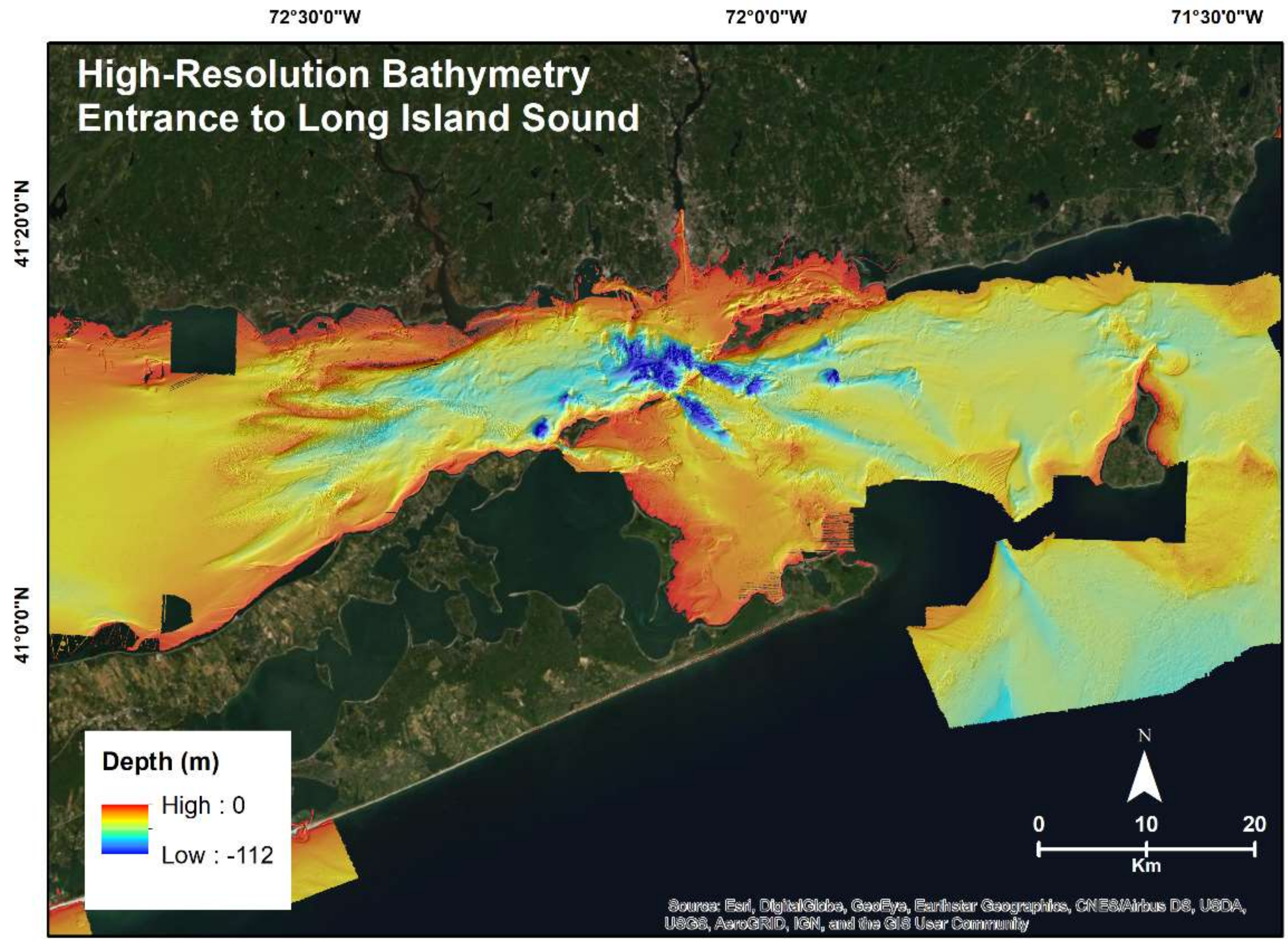


Figure 10. High-resolution bathymetry of the entrance to Long Island Sound. Figure 11 is an enlargement of the narrows at the entrance. The vertical exaggeration is five.

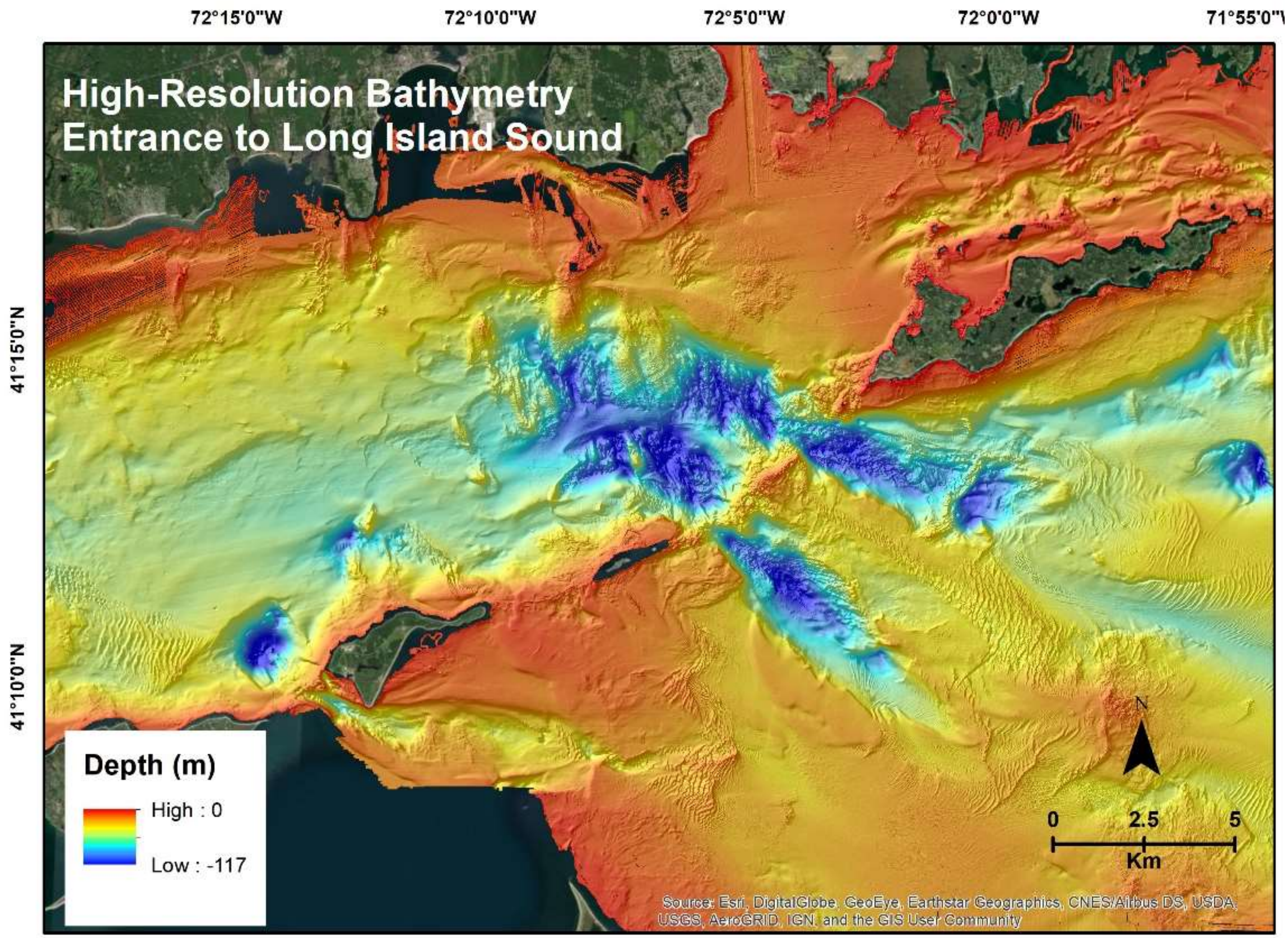


Figure 11. High-resolution bathymetry of the entrance to Long Island Sound showing an enlargement of the narrows. The vertical exaggeration is ten.

Appendix A: Metadata for bathymetry and backscatter surveys used for the Western Gulf of Maine

Agency	Survey	Year	Data Type	Cell Size (m)	System	Frequency	Data Location
NOAA	D00149	2009	MB	1	Reson Seabat 7125	400 kHz	NCEI
NOAA	D00185	2013	MB	4, 8, 16	Reson 7111 and 7125	75 kHz	NCEI
NOAA	F00524	2005	MB	0.75	Simrad EM3002	445 kHz	NCEI
NOAA	F00545	2007	MB	0.75	Simrad EM3000	445 kHz	NCEI
NOAA	F00553	2008	MB	0.50, 2	Simrad EM3002	445 kHz	NCEI
NOAA	F00574	2009	MB	1, 2	Reson Seabat 7125 and 8125		NCEI
NOAA	F00603	2011	MB	0.5, 2	Reson Seabat 7125	401 kHz	NCEI
NOAA	F00619	2012	MB	0.5	Kongsberg EM3002	300 kHz	NCEI
NOAA	H10763	1997	MB	2	Reson 9003	445 kHz	NCEI
NOAA	H10771	1997	MB	2	Reson 9003	455 kHz	NCEI
NOAA	H11014	2000	MB	1	Reson 8101	240 kHz	NCEI
NOAA	H11277	2003	MB	0.5, 1	Reson 8101 & 8125	239 kHz and 455 kHz	NCEI
NOAA (Fugro Pelagos)	H11296	2005	MB	5	SHOALS 1000T		NCEI
NOAA	H11421	2005	MB	4, 6, 8	Kongsberg EM1002	95 kHz	NCEI
NOAA	H11467	2005	MB	1	Kongsberg EM3000	300 kHz	NCEI
NOAA	H11636	2007	MB	2	Kongsberg EM3002	300 kHz	NCEI
NOAA	H11695	2007	MB	1, 2	Reson 7125,8101 & 8125	200/400 kHz, 240/455 kHz	NCEI
NOAA	H12256	2005	MB	0.5, 1, 2, 4, 8	Kongsberg EM3002	300 kHz	NCEI
NOAA	H12477	2012	MB	1, 2, 4, 8	Teledyne RESON SeaBat 7125 SV2		NCEI
NOAA	H12478	2012	MB	1, 2, 4	Reson 7125 SV2		NCEI
NOAA	H12613	2013	MB	2, 4	Reson 7125	400 kHz	NCEI
NOAA	H12614	2013	MB	0.5, 2, 4	Reson 7125	400 kHz	NCEI
NOAA	H12615	2013	MB	0.5, 2, 4	Reson 7125	400 kHz	NCEI
NOAA	H12696	2014	MB	0.5, 2, 4	Reson 7125	400 kHz	NCEI
NOAA	H12697	2014	MB	0.5, 2, 4, 8	Reson 7125	400 kHz	NCEI
NOAA	H12698	2014	MB	2, 4, 8	Reson 7125	400 kHz	NCEI
NOAA	H12725	2015	MB	Variable Resolution	Reson 7125	400 kHz	NCEI
NOAA	H12726	2015	MB	1, 2, 4	Reson 7125	400 kHz	NCEI
NOAA	W00037	2003	MB	5, 10	Simrad EM1002	95 kHz	NCEI
NOAA	W00038	2003	MB	5	Simrad EM1002	95 kHz	NCEI
NOAA	W00039	2003	MB	5, 10	Simrad EM1002	95 kHz	NCEI
NOAA	W00040	2003	MB	5, 10	Simrad EM1002	95 kHz	NCEI

Appendix A: *continued*

Agency	Survey	Year	Data Type	Cell Size (m)	System	Frequency	Data Location
NOAA	W00041	2003	MB	5, 10	Simrad EM1002	95 kHz	NCEI
NOAA	W00044	2003	MB	5	Simrad EM1002	95 kHz	NCEI
NOAA	W00045	2003	MB	5	Simrad EM1002	95 kHz	NCEI
NOAA	W00046	2003	MB	10	Simrad EM1002	95 kHz	NCEI
NOAA	W00047	2003	MB	10	Simrad EM1002	95 kHz	NCEI
NOAA	W00048	2003	MB	8, 10	Simrad EM1002	95 kHz	NCEI
NOAA	W00050	2003	MB	2, 4	Simrad EM1002	95 kHz	NCEI
NOAA	W00051	2003	MB	2, 4	Simrad EM1002	95 kHz	NCEI
NOAA	W00052	2003	MB	2, 4	Simrad EM1002	95 kHz	NCEI
NOAA	W00053	2003	MB	2, 4	Simrad EM1002	95 kHz	NCEI
USGS (UNH and SAIC)	W00181	2007	MB	2, 4	Reson 8101	240 kHz	NCEI
GOMMI (UNH and SAIC)	W00194	2005	MB	8	RESON 8101	240 kHz	NCEI
GOMMI(UNH and SAIC)	W00195	2005	MB	Variable Resolution	Reson SeaBat 8101	240 kHz	NCEI
Maine Coastal Mapping Initiative	W00288	2014	MB	2, 4, 8	Kongsberg Maritime EM 2040C	300 kHz	NCEI
NOAA (USACE JALBTCX)	W00313	2015	Lidar	5	CZMIL system		NCEI
UNH (JHC/CCOM)		2002	MB	1			UNH
UNH (JHC/CCOM)		2003	MB	1	Reson 8101 & 8125	240 kHz & 455 kHz	UNH
UNH (JHC/CCOM)		2004	MB	1			UNH
UNH (JHC/CCOM)	W00178	2006	MB	0.5, 1	Kongsberg EM3002 Dual Head	293/307 kHz	NCEI
UNH (JHC/CCOM)	W00276	2007	MB	1	Kongsberg EM3002 Dual Head	293/307 kHz	NCEI
UNH (JHC/CCOM)	W00277	2007	MB	1	Kongsberg EM3002 Dual Head	293/307 kHz	NCEI
UNH (JHC/CCOM)	W00273	2008	MB	0.5, 1	Kongsberg EM3002 Dual Head	293/307 kHz	NCEI
UNH (JHC/CCOM)	W00274	2010	MB	1, 2	Kongsberg EM3002 Dual Head	293/307 kHz	NCEI
UNH (JHC/CCOM)		2011	MB	2	Reson 7125	200/400 kHz	UNH
UNH (JHC/CCOM)		2008	MB	1			UNH
NOAA	F00508	2005	MB	2, 2.5	Simrad EM1002	95 kHz	NCEI
NOAA	F00620	2012	MB	0.5	Kongsberg EM3002	300 kHz	NCEI
NOAA	F00725	2018	MB	Variable Resolution	Kongsberg Maritime EM 2040C	300 kHz	NCEI
UNH (JHC/CCOM)	W00505	2017	MB	0.5	KongsbergMaritime EM 2040	300 kHz	NCEI
NOAA	H12257	2010	MB	1, 2	Simrad EM3002	445 kHz	NCEI
NOAA	H12258	2010	MB	1, 2	Kongsberg EM3002	301 kHz	NCEI
NOAA	H12259	2010	MB	2, 4, 8	Kongsberg EM3002	302 kHz	NCEI
NOAA	H12270	2010	MB	1, 2, 4	Kongsberg EM3002	303 kHz	NCEI
NOAA (Fugro Pelagos)	H12884	2016	MB and Lidar	1, 2, 4, 5, 8, 16	Reson 7125 and SHOALS-1000T		NCEI
NOAA	H12885	2016	MB	1, 2, 4, 5, 8	Reson 7125	400 kHz	NCEI
NOAA	H12886	2016	MB	1, 2, 4, 5, 8	Reson 7125	400 kHz	NCEI
NOAA	H12887	2016	MB	1, 2, 4, 5, 8	Reson 7125	400 kHz	NCEI

***Appendix A:** continued*

Agency	Survey	Year	Data Type	Cell Size (m)	System	Frequency	Data Location
UNH (SAIC)		2003	MB	5	Reson 8101	240 kHz	UNH
UNH (JHC/CCOM)	W00501	2013	MB	0.5	Kongsberg Maritime EM 2040	300 kHz	NCEI
UNH (JHC/CCOM)	W00503	2015	MB	1	Kongsberg Maritime EM 2040	300 kHz	NCEI
UNH (JHC/CCOM)	W00504	2016	MB	0.5			NCEI
UNH (JHC/CCOM)	W00506	2018	MB	1	R2Sonic 2024	300 kHz	NCEI
UNH (JHC/CCOM)	W00492	2019	MB	Variable Resolution	R2Sonic 2026	450 kHz	NCEI
UNH (JHC/CCOM)	W00500	2001	MB	1	SeaBat 8101	240 kHz	NCEI
USACE		2010	Lidar	2			USACE
USACE		2010	Lidar	4			USACE
USACE		2014	Lidar	2			USACE
USACE		2014	Lidar	2			USACE
USACE		2014	Lidar	2			USACE
USACE		2014	Lidar	2			USACE
USACE		2014	Lidar	2			USACE
USACE		2014	Lidar	2			USACE
USACE		2014	Lidar	2			USACE
USACE		2015	Lidar	1			USACE
USGS		1988	MB	10	Simrad EM1000	95 kHz	USGS
NOAA	W00042	1995	MB	10	Simrad EM1002	95 kHz	NCEI
NOAA (USACE JALBTCX)	W00203	2007	Lidar	5	SHOALS 1000T		NCEI
UNH (JHC/CCOM)	W00206	2009	MB	1	Kongsberg EM3002 Dual Head	293/307 kHz	NCEI
UNH (JHC/CCOM)	W00244	2012	MB	0.5, 1	Simrad EM2040	300 kHz	NCEI
UNH (JHC/CCOM)	W00272	2005	MB	1, 2	Kongsberg Maritime EM 3002	300 kHz	NCEI
UNH (JHC/CCOM)	W00275	2007	MB	0.5	Kongsberg Maritime EM 3002	300 kHz	NCEI
NOAA	W00289	2015	MB	1, 2, 4	Kongsberg Maritime EM 2040C	300 kHz	NCEI
NOAA	W00384	2012	MB	2, 4	SeaBat 7125 SV		NCEI
NOAA	W00395	2008	MB	2, 4, 8	Kongsberg Maritime EM 1002	95 kHz	NCEI
NOAA	W00448	2016	MB	1, 2, 4, 8	Kongsberg Maritime EM 2040C	300 kHz	NCEI
NOAA	W00449	2016	MB	1	Kongsberg Maritime EM 2040C	300 kHz	NCEI
NOAA	W00450	2017	MB	1, 2, 4, 8, 16	Kongsberg Maritime EM 2040C	300 kHz	NCEI
NOAA	W00451	2017	MB	1	Kongsberg Maritime EM 2040C	300 kHz	NCEI
USGS	W00483	2004	MB	5	SEA Submatrix 2000		NCEI
USGS	W00484	2005	Bathymetric SSS	5	Sea SwathPlus-M Interferometric	445 kHz	NCEI
USGS	W00486	2007	Bathymetric SSS	5	Sea SwathPlus-M Interferometric	445 kHz	NCEI
USGS	W00487	2007	Bathymetric SSS	5	Sea SwathPlus-M Interferometric	445 kHz	NCEI
UNH (JHC/CCOM)		2011	MB	2	Reson 7125	200/400 kHz	UNH
UNH (JHC/CCOM)	W00504	2016	MB	0.5			NCEI
UNH (JHC/CCOM)	W00502	2014	MB	0.5	Kongsberg Maritime EM 2040	400 kHz	NCEI

Appendix B: Metadata for bathymetry and backscatter surveys used for Southern New England and Long Island

Agency	Survey	Year	Data Type	Cell Size (m)	System	Frequency	Data Location
NOAA	F00561	2008	MB	2	Simrad EM1002	445 kHz	NCEI
NOAA	F00660	2015	MBVB	2	Reson SeaBat 7125 SV,Reson 7125	400 kHz	NCEI
NOAA	H11076	2004	MB	1, 2, 4	SeaBat 8125, 8101	455 kHz	NCEI
NOAA (Tenix LADS Inc.)	H11224	2004	Lidar	4	LADS MKII		NCEI
NOAA	H11251	2008	MB	Variable Resolution	SeaBat 8125 &8101	455 kHz	NCEI
NOAA	H11252	2004	MB	1	Simrad EM1002 RESON SeaBat 8125	455 kHz	NCEI
NOAA	H11346	2004	MB	3	Simrad EM1002 RESON SeaBat 8125	455 kHz	NCEI
NOAA	H11360	2004	MBVB	0.5, 1	Simrad EM1002 RESON SeaBat 8125	455 kHz	NCEI
NOAA	H11361	2004	MB	0.5, 1, 2	Simrad EM1002 RESON SeaBat 8125	455 kHz	NCEI
NOAA	H11441	2005	MB	0.4, 0.8	SeaBat 8101, 8125	455 kHz	NCEI
NOAA	H11445	2008	MB	Variable Resolution	SeaBat 8125 & 8101	455 kHz	NCEI
NOAA	H11446	2008	MB	Variable Resolution	SeaBat 8125 & 8101	455 kHz	NCEI
NOAA	H11916	2008	MB	1, 2	SeaBat 8125 & 8101	455 kHz	NCEI
NOAA	H11920	2008	MB	Variable Resolution	SeaBat 8125 & 8101	455 kHz	NCEI
NOAA	H11921	2008	MB	1, 2	SeaBat 8125 & 8101	455 kHz	NCEI
NOAA	H11922	2008	MB	2	SeaBat 8125 & 7125	455 kHz	NCEI
NOAA	H11995	2008	MB	2	SeaBat 8125 & 7125	455 kHz	NCEI
NOAA	H11996	2008	MB	2	SeaBat 8125 & 7125	455 kHz	NCEI
NOAA	H11997	2008	MB	Variable Resolution	SeaBat 8125 & 7125	455 kHz	NCEI
NOAA	H11999	2008	MB	Variable Resolution	SeaBat 8125, 7125 & 8101	455 kHz	NCEI
NOAA	H12009	2009	MB	2	SeaBat 8125 & 7125		NCEI
NOAA	H12010	2009	MB	Variable Resolution	SeaBat 8125 & 7125	455 kHz	NCEI
NOAA	H12011	2009	MB	Variable Resolution	Seabat 7125		NCEI
NOAA	H12013	2009	MB	2	SeaBat 8125 & 7125	455 kHz	NCEI
NOAA	H12015	2009	MB	Variable Resolution	Seabat 7125		NCEI
NOAA	H12033	2009	MB	0.5, 2	SeaBat 8125 & 7125	455 kHz	NCEI
NOAA	H12036	2009	MB	0.5, 1, 2	Seabat 7125	445 kHz	NCEI
NOAA	H12137	2009	MB	Variable Resolution	Seabat 7125		NCEI
NOAA	H12139	2009	MB	Variable Resolution	Seabat 7125		NCEI
NOAA	H12158	2009	MB	0.5, 2	Seabat 7125	445 kHz	NCEI
NOAA	H12296	2011	MB	0.5, 1, 2, 4	Seabat 7125	445 kHz	NCEI
NOAA	H12298	2011	MB	0.5, 1, 2, 4, 8	Seabat 7125	445 kHz	NCEI

Appendix B: *continued*

Agency	Survey	Year	Data Type	Cell Size (m)	System	Frequency	Data Location
NOAA	H12299	2011	MB	Variable Resolution	Reson 7125 SV1 & 7125 ROV		NCEI
NOAA	H12324	2011	MB	1, 2, 4	Simrad EM3002		NCEI
NOAA	H12386	2011	MB	Variable Resolution	Reson 7125 ROV	400 kHz	NCEI
NOAA	H12411	2012	MB	0.5, 2	Reson 7125 SV1 & 7125 ROV	400 kHz	NCEI
NOAA	H12412	2012	MB	Variable Resolution	Reson 7125 SV1 & 7125 ROV	400 kHz	NCEI
NOAA	H12413	2012	MB	1, 2, 4	Reson 7125 SV1 & 7125 ROV	445 kHz	NCEI
NOAA	H12414	2012	MB	0.5	Reson 7125 SV1 & 7125 ROV	445 kHz	NCEI
NOAA	H12415	2012	MB	Variable Resolution	Reson 7125	400 kHz	NCEI
NOAA	H12416	2012	MB	0.5, 2, 4	SeaBat 7125 SV, Reson 7125 ROV	400 kHz	NCEI
NOAA	H12417	2012	MB	0.5, 2, 4	SeaBat 7125 SV, Reson 7125 ROV	400 kHz, 200 kHz	NCEI
NOAA	H12429	2012	MB	Variable Resolution	Seabat 7125-ROV	400 kHz	NCEI
NOAA	H12430	2012	MB	4	Seabat 7125	400 kHz	NCEI
NOAA	H12431	2012	MB	Variable Resolution	Reson7125 ROV	400 kHz	NCEI
NOAA	H12437	2012	MB	0.5, 2	Seabat 7125-ROV	400 kHz	NCEI
NOAA	H12438	2012	MB	2	Seabat 7125	400 kHz	NCEI
NOAA	H12479	2012	MB	Variable Resolution	Reson 7125 SV1	400 kHz	NCEI
NOAA	H12480	2012	MB	1, 2	Seabat 7125-ROV		NCEI
NOAA	H12481	2012	MB	0.5, 2	SeaBat 7125 SV, Reson 7125 ROV	400 kHz	NCEI
NOAA	H12482	2013	MB	Variable Resolution	SeaBat 7125 SV, Reson 7125 ROV	400 kHz	NCEI
NOAA	H12483	2013	MB	Variable Resolution	SeaBat 7125 SV, Reson 7125 ROV	400 kHz	NCEI
NOAA	H12484	2012	MB	0.5, 2	Reson 7125 SV1	400 kHz	NCEI
NOAA	H12485	2013	MB	Variable Resolution	SeaBat 7125 ROV, SeaBat 7125 SV, Reson 7125	400 kHz	NCEI
NOAA	H12488	2012	MB	0.5, 2	Reson 7125 SV1 & 7125 ROV	400 kHz	NCEI
NOAA	H12489	2012	MB	0.5, 2, 4	Reson 7125 SV1 & 7125 ROV	400 kHz	NCEI
NOAA	H12508	2014	MB	1, 2	Kongsberg Maritime EM 3002	300 kHz, 400 kHz	NCEI
NOAA	H12509	2014	MB	0.5, 1	Kongsberg Maritime EM 3002	400 kHz	NCEI
NOAA	H12510	2014	MB	0.5, 1	Kongsberg Maritime EM 3002	300 kHz, 400 kHz	NCEI
NOAA	H12526	2013	MB	0.5, 2	SeaBat 7125 SV, Reson 7125 ROV		NCEI
NOAA	H12601	2014	MB	Variable Resolution	R2Sonic 2024	540 kHz	NCEI
NOAA	H12602	2013	MB	Variable Resolution	R2Sonic 2024	540 kHz	NCEI
NOAA	H12603	2014	MB	0.5	R2Sonic 2024 & Reson 7125	540 kHz	NCEI
NOAA	H12608	2014	MB	0.5, 2, 4	Kongsberg Maritime EM 3002	300 kHz	NCEI
NOAA	H12609	2015	MB	0.5, 4	Kongsberg Maritime EM 3002	600 kHz	NCEI
NOAA	H12610	2015	MB	0.5, 2	Kongsberg Maritime EM 3002	300 kHz	NCEI
NOAA	H12627	2013	MB	2, 4	Reson 7125	400 kHz	NCEI
NOAA	H12629	2013	MB	1, 2	Reson 7125		NCEI

Appendix B: *continued*

Agency	Survey	Year	Data Type	Cell Size (m)	System	Frequency	Data Location
NOAA	H12676	2014	MB	Variable Resolution	SeaBat 7125 SV, Reson 7125 ROV	400 kHz	NCEI
NOAA	H12677	2014	MB	0.5, 1	Reson 7125 SV1	400 kHz	NCEI
NOAA	H12678	2014	MB	Variable Resolution	Reson 7125 SV1 & SV2	400 kHz	NCEI
NOAA	H12679	2014	MB	Variable Resolution	Reson 7125 SV1 & SV2	400 kHz	NCEI
NOAA	H12700	2014	MB	1, 2, 4	Reson 7125	400 kHz	NCEI
NOAA	H12702	2014	MB	1, 2	Reson 7125	400 kHz	NCEI
NOAA	H12707	2014	MB	0.5, 1, 2	Reson 7125	400 kHz	NCEI
NOAA	H12801	2015	MB	1, 2	Reson 7125	400 kHz	NCEI
NOAA	H12802	2015	MB	1, 2, 4	Reson 7125	400 kHz	NCEI
USGS (Alpine Ocean Seismic Survey Inc)	W00294	2014	MB	1, 2	R2Sonic 2024	300 kHz, 400 kHz	NCEI
NOAA	W00318	2010	Interferometric	4	Klein Marine Systems System 3000 ***SSS	100 kHz	NCEI
NOAA	W00352	2014	Lidar	3	RIEGL VQ-820G Lidar System		NCEI
NOAA	W00405	2015	MB	1, 2, 4, 8	Kongsberg Maritime EM 710, RESON SeaBat 7125 SV		NCEI
NOAA	H12811	2015	MB	1, 2, 4	Reson 7125	400 kHz	NCEI
NOAA	H11442	2005	MB	1,2,4	SeaBat 8101	455 kHz	NCEI
NOAA	H12643	2015	MB	0.5	Reson 7125-SV1 & 7125-SV2	400 kHz	NCEI
NOAA	H11930	2011	MB	0.5, 1, 4	Simrad EM3002		NCEI
NOAA	H11079	2004	MB	2	SeaBat 8101		NCEI
NOAA	H11255	2004	MB	2	Simrad EM1002		NCEI
NOAA	H12462	2015	MB	0.5, 4	Reson 7125-SV1 & 7125-SV2	400 kHz	NCEI
NOAA	H11998	2009	MB	05, 4	Simrad EM3000	400 kHz	NCEI