Announcement M13AS00014: Hurricane Sandy Coastal Recovery and Resiliency – Resource Identification, Delineation and Management Practices

Agreement M14AC00008: Maine Geological Survey's "Aggregate Exploration and Habitat Classification: Tools for Building Resiliency in Maine"

Summary of Reports August 2014 – May 2019

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SUMMARY REPORT

Cooperative Agreement Outputs including Project Deliverables:

1. Armstrong, D., 2014. Descriptive report for seafloor mapping of areas off southern Maine. Maine Coastal Program, Augusta, ME. 11 p.

The Maine Coastal Mapping Initiative conducted a multibeam survey using a Kongsberg EM 2040C multibeam in the waters off the coast of southern Maine. Data was acquired from June to October 2014. The survey was conducted as part of a grant from Bureau of Ocean and Energy Management (BOEM), for beach restoration and reconciliation. The bathymetry and backscatter will primarily be used to determine the potential for sandy deposits. The project also coincides with state efforts to update coastal data sets, and bring high resolution bathymetric maps into Maine waters. This grant allowed for the purchase of new multibeam sonar, positioning equipment, and other equipment needed for bathymetric mapping and bottom sampling. In addition to multibeam work the survey also conducted drop camera and bottom sampling to ground truth the data. The project provides new data in the areas covered by NOAA nautical charts 13286 in southern Maine, and 13296 and, 13288 in the Boothbay Harbor/ Linekin Bay region of Maine. These data were not collected or processed for navigational purposes, but are freely provided to NOAA for any use as the agency deems appropriate.

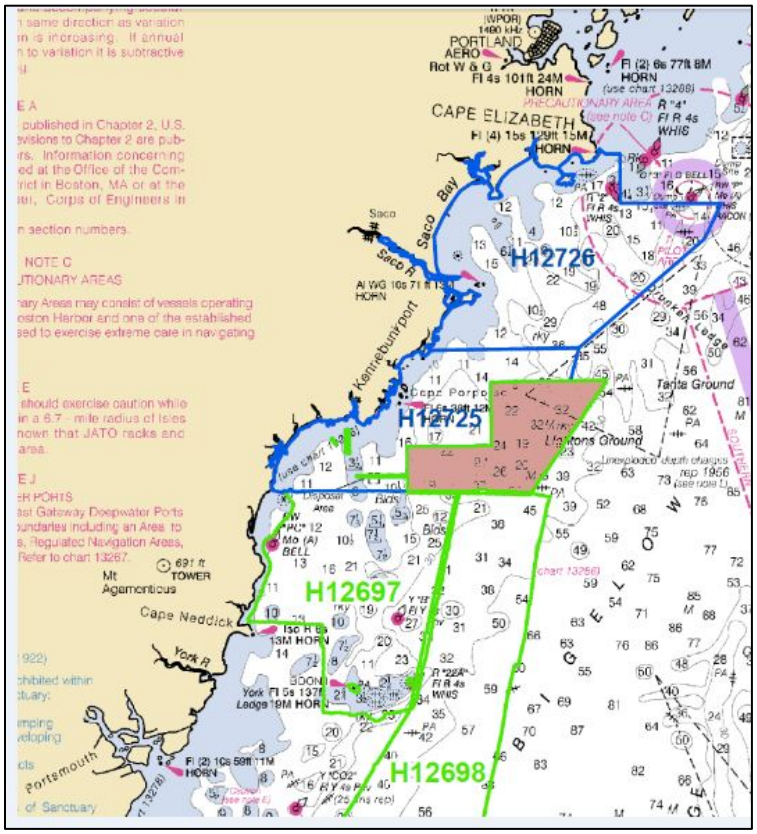


Figure 1. NOAA junction surveys, with overlay of 2014 MCMI surveyed area.

2. Dobbs, K.D., 2016. 2014 Seafloor sediment analysis and mapping - Southern Maine: Maine Coastal Program, Augusta, ME. 15 p.

One goal of the Maine Coastal Program's cooperative agreement with the Bureau of Ocean Energy was to characterize offshore sediment deposits in order to identify potential sand resources that may be used for beach nourishment in the event of an erosional storm. In 2014, the Maine Coastal Mapping Initiative collected 28 sediment samples in the federal portion of the focus area located offshore of Kennebunkport in Southern Maine, though 49 additional samples were collected nearer to shore. Samples were processed to determine the relative concentrations of gravel, sand, and mud (Folk 1954), and the sand fraction was further analyzed to determine the degree of sorting and the distribution of grain sizes within the fraction (Wentworth 1922). Additionally, sediment color (Munsell, 1923) was also determined to further explore the potential compatibility of nourishing existing beaches with sediment dredged from offshore deposits. Although sand was more abundant closer to shore, 16 out of the 28 samples collected in federal waters contained >50% sand (mean sand composition of all samples = 46.3% ± 22. 4%). Prior to sediment dredging for beach nourishment purposes, more extensive coring and/or sub-bottom profiling would need to be conducted to estimate the volumes of these sediment deposits. In addition, these data are a critical component of benthic habitat classification and modeling performed by MCMI (see Ozmon, 2016). Overall, these data have a variety of applications and are an invaluable resource to public and private agencies who wish to more effectively manage and understand coastal and marine resources.

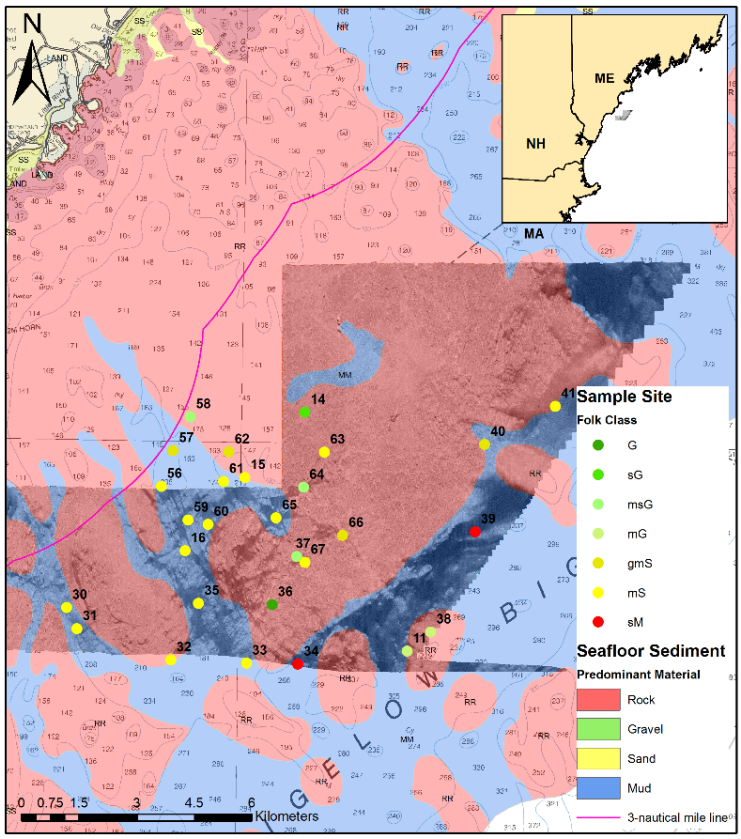


Figure 2. Generalized seafloor sediment map of the 2014 Kennebunk MCMI area showing interpreted extent of seafloor substrates (Barnhardt et al., 1998) and MCMI grab samples' Folk (1954) classification.

3. Dobbs, K.D., 2016. 2015 Descriptive report for seafloor mapping – Midcoast Maine. Maine Coastal Program, Augusta, ME. 45 p.

During the survey season (May-November) of 2015 the Maine Coastal Mapping Initiative (MCMI) conducted hydrographic surveying using a multibeam echosounder (MBES) in the waters off of mid-coast Maine. The survey was conducted in part to support the federal Bureau of Ocean and Energy Management's (BOEM) efforts to enhance coastal resiliency through identification and characterization of potential sand and gravel resources on the outer continental shelf that may be used for beach renourishment and for state efforts to update coastal data sets and increase high resolution bathymetric coverage for Maine waters. A total of approximately 82.5 mi^2 (213.5 km^2), 80 mi^2 (207 km^2) mainscheme and 2.5 mi^2 (6.5 km^2) inshore, of high-resolution multibeam data were collected by MCMI between May and November 2015. During the 2015 survey season the MCMI also collected sediment samples in 61 locations, 43 in state water and 18 in federal waters, in the approximately 80mi^2 (207 km^2) mainscheme survey area. In the coming months, MCMI plans to utilize final data products for high-resolution backscatter and bathymetry to refine existing seafloor sediment maps and determine the spatial extent of sand deposits within federal water. When combined with existing geophysical (e.g. seismic reflection profiles and side-scan sonar) data, these data may also be used to refine interpretations of coastal/nearshore geomorphology and three-dimensional assessments of potential sediment resources/valley fill in the region.

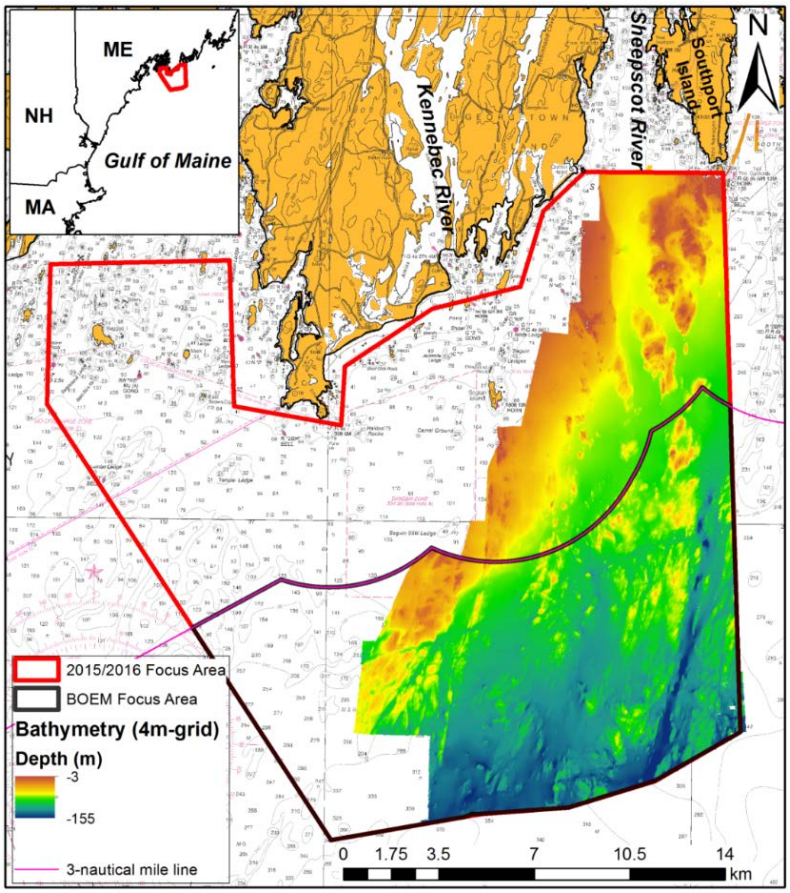


Figure 3. MCMI collected ~80 mi^2 of high resolution bathymetric off of Midcoast Maine in the 2015 mainscheme focus area, which includes portions of NOAA nautical charts 13288, 13293, and 13295.

4. Dobbs, K., 2017. 2016 Descriptive report for seafloor mapping – Midcoast Maine. Maine Coastal Program, Augusta, ME. 87 p.

During the survey season (April-October) of 2016 the Maine Coastal Program's Mapping Initiative (MCMI) conducted hydrographic surveying using a multibeam echosounder (MBES) in the waters off of mid-coast Maine. The surveying was conducted in part to support the Federal Bureau of Ocean and Energy Management's (BOEM) efforts to enhance coastal resiliency through identification and characterization of potential sand and gravel resources on the outer continental shelf that may be used for beach nourishment. The surveys also coincide with state efforts to update coastal data sets and increase high resolution bathymetric coverage for Maine's coastal waters. A total of approximately 62 mi^2 (161 km^2) of high-resolution multibeam data were collected, 57 mi^2 (148 km^2) in the "mainscheme" area of federal (19 mi^2) and state (38 mi^2) coastal marine waters, and 5 mi^2 (13 km^2) in nearshore embayments and estuaries. The project provides new data in the areas covered by National Oceanic and Atmospheric Administration (NOAA) nautical charts (e.g. coastal and harbor) 13286, 13288, 13290, 13293, 13295, and 13296 in mid-coast Maine. These data were not collected or processed for navigational purposes, but are freely provided to NOAA for any use the agency deems appropriate. During the 2016 survey season the MCMI also collected sediment samples, water column data, and video in 54 locations, 43 in state water and 11 in federal waters, all within the mainscheme survey area. MCMI has utilized final data products for high-resolution backscatter and bathymetry to refine existing seafloor sediment maps and determine the spatial extent of sand deposits within federal water. When combined with existing geophysical (e.g. seismic reflection profiles and side-scan sonar) data, these data may also be used to refine interpretations of coastal/nearshore geomorphology and three-dimensional assessments of potential sediment resources/valley fill in the region. Overall, these data have a variety of applications and are an invaluable resource to public and private agencies who wish to more effectively manage and understand coastal and marine resources.

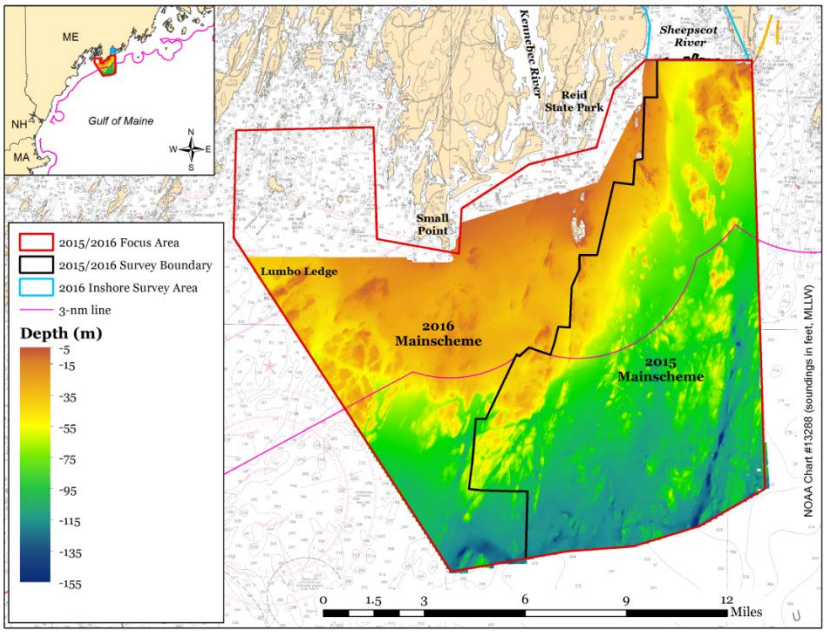


Figure 4. Mainscheme survey coverage within the 2015/2016 focus area (red outline) off of mid-coast Maine. 2016 survey area (57 mi2 (148 km2)) is west of black line. 2015 survey area (80 mi2 (207 km2)) is east of black line.

5. Dobbs, K.D., 2016. 2015 Seafloor sediment analysis and mapping – Midcoast Maine. Maine Coastal Program, Augusta, ME. 22 p.

The collection and analysis of geophysical and seafloor sediment data allow state and federal agencies to proactively identify the resources available to enhance resiliency, improve management of resources within their jurisdiction, and develop a more comprehensive understanding of potential resources. The purpose of this investigation was to describe and characterize marine sediment samples in the focus area to enable benthic habitat classification via the federally-approved Coastal and Marine Ecological Classification Standard (CMECS; FGDC, 2012), help characterize potential sediment resources for beach nourishment as outlined by BOEM, and investigate the relationship between sediment grain size and multibeam backscatter intensity to refine interpretations of seafloor sediment distribution across mapped areas. During the 2015 survey season the Maine Coastal Mapping Initiative mapped approximately 80 mi^2 (207 km^2) of seafloor and collected bottom samples in 61 locations, 43 in state water and 18 in federal waters, in the vicinity of the Kennebec River paleodelta. Grain-size analyses of sediment samples combined with interpretations of backscatter intensity and bathymetric data are consistent with general interpretations of seafloor sediment distribution and morphology in the region (e.g. Barnhardt et al., 1998 and Kelley, et al., 1997). Within the survey area, laterally extensive surficial deposits of predominantly sandy and/or gravelly material were restricted to depths less than 70 m and were most commonly associated with the Kennebec river paleodelta/nearshore ramp. Similarly, backscatter and grab sample data suggest these deposits were even more scarce within federal waters of the survey area.

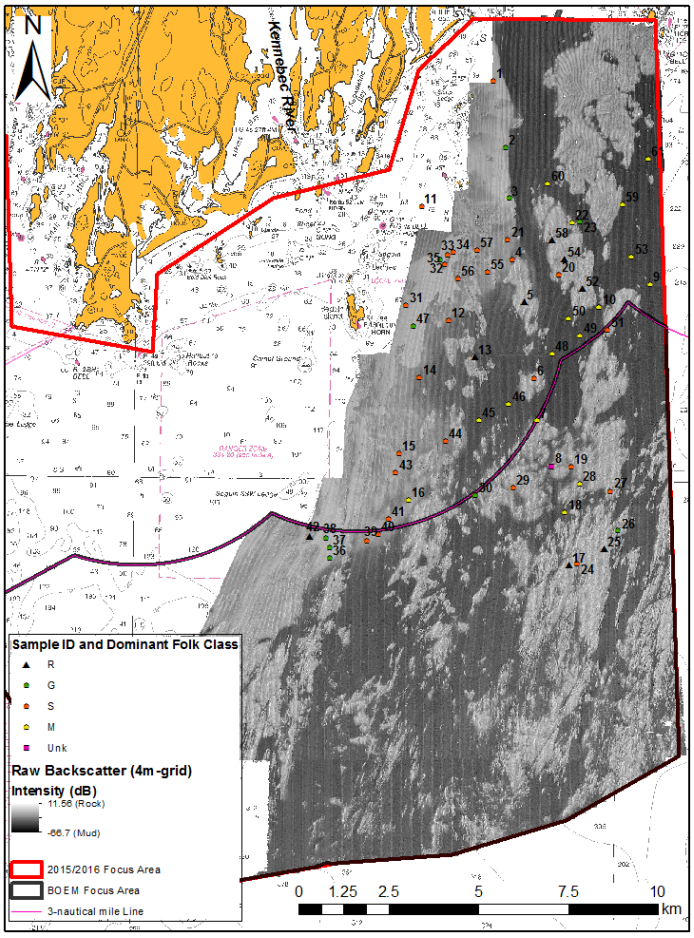


Figure 5. Sediment sample locations (ID#), dominant Folk (1954) classification, and survey area backscatter intensity (unfiltered 4 m grid with transparent bathymetry hillshade) relative to overall focus areas.

6. Dobbs, K., 2017. 2016 Seafloor Sediment Analysis and Mapping: Mid-coast Maine. Maine Coastal Program, Augusta, ME. 127 p.

As part of a multi-year, multi-agency cooperative, the Maine Coastal Mapping Initiative (MCMI) has been addressing the need for comprehensive resource assessment through high-resolution seafloor mapping using a MBES and by collecting additional seafloor substrate data. Data presented in this report represent the seafloor sampling efforts and sediment analyses conducted by the MCMI during the 2016 field season (April to October), which included bathymetric mapping for approximately 57 mi^2 (148 km^2) of seafloor and the collection of bottom samples in 54 locations, 43 in state water and 11 in federal waters, in the vicinity of the Kennebec River paleodelta. The 2016 focus area is located in Maine's mid-coast region in waters just offshore of the Kennebec River mouth, and was selected due to the high probability of being able to identify sand resources at this location. Field methods used during this investigation consisted of collecting high-resolution bathymetry and backscatter data using a MBES and bottom sampling. Sediment samples were analyzed using standard laboratory techniques for the textural analyses of marine sediments. The proportion of gravel-, sand-, silt-, and clay-sized particles were used to classify the overall sample categorize each sample by geologic substrate group and subgroup, as defined by the Coastal and Marine Ecological Classification Standard. Sand was the most common sediment type found in samples collected during 2016 within the 2015/2016 coverage areas, with 83 percent of samples containing more than 20 percent sand and 51 percent of samples in a predominantly sand classification (e.g. gS, gmS, (g)S, (g)mS, cS, mS,, zS, or S). The highest sand content was generally found in samples collected from nearshore areas at depths less than 50 meters. Within the survey area, laterally extensive surficial deposits of predominantly sandy and/or gravelly material were mostly restricted to depths less than 55 m and were most commonly associated with the Kennebec river paleodelta/nearshore ramp. Similarly, backscatter and grab sample data suggest these deposits were even more scarce within federal waters of the survey area (Figure 4). Muddy sediment and rocky outcrops were the most common at depths greater than 55 m.

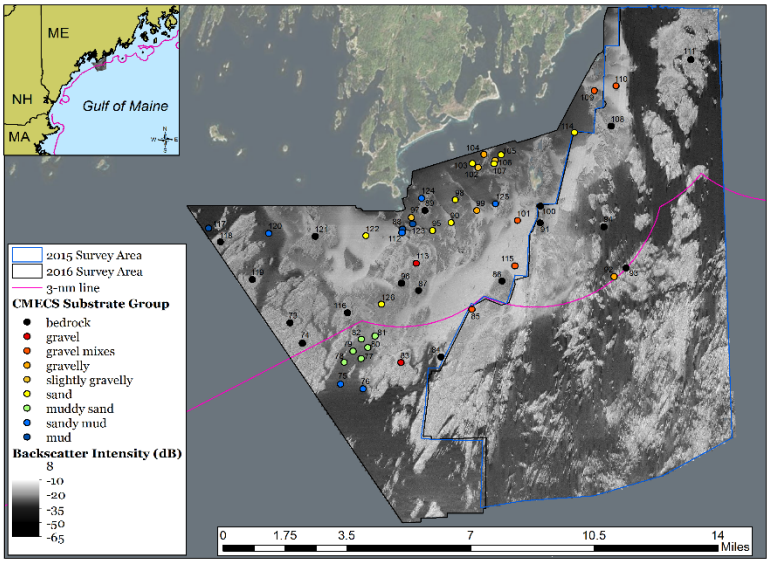


Figure 6. *2015/2016 Sample sites and sediment classification shown with backscatter intensity mosaic (4-meter pixels).*

7. Dobbs, K., 2017. 2016 Textural Mapping Report, Augusta, ME. 55 p.

As part of a multi-year cooperative program of the Maine Coastal Mapping Initiative (MCMI), the National Oceanic and Atmospheric Administration (NOAA), and the Bureau of Ocean Energy Management (BOEM), this report presents a compilation of high-resolution maps and spatial data for the seafloor offshore of mid-coast Maine, between Cape Small and Cape Newagen, where approximately 137 mi^2 (355 km^2) of inner (e.g. landward of three nautical mile line)/outer (e.g. seaward of three nautical mile line) continental shelf was mapped with multibeam echosounder (MBES) data. The Cape Small-Cape Newagen focus area lies in the northwestern Gulf of Maine just offshore of the Kennebec River mouth in mid-coast Maine. Late Quaternary deglaciation and relative sea-level changes caused by widespread isostatic adjustments have resulted in extensive reworking of sediments deposited seaward of the Kennebec River mouth. Previous work in the focus area describes the overall morphology as the submerged Kennebec River paleodelta. The lobate submarine expression of this feature consists of a sandy, gently-sloping nearshore ramp that is abruptly terminated to the east and south around the 55-meter isobaths, which has been interpreted as the early Holocene lowstand sea-level. Seafloor textural maps were generated using a supervised classification technique that required MBES (bathymetry and backscatter) data, 1st-order bathymetric derivatives, and grab sample data as inputs. The accuracy of textural output maps was evaluated using 201 sediment samples and/or bottom videos collected by the MCMI and other agencies. The accuracy of model output and its ability to produce areal distribution of sediment types and corresponding depths consistent with general interpretations of seafloor sediment distribution and morphology in the coverage area suggest this is an efficient and effective method for mapping seafloor substrate. Overall, the products of this investigation are most useful for visualizing spatial trends in sediment and benthic habitat distribution and identifying and/or refining knowledge of resource (abiotic and biotic) potential.

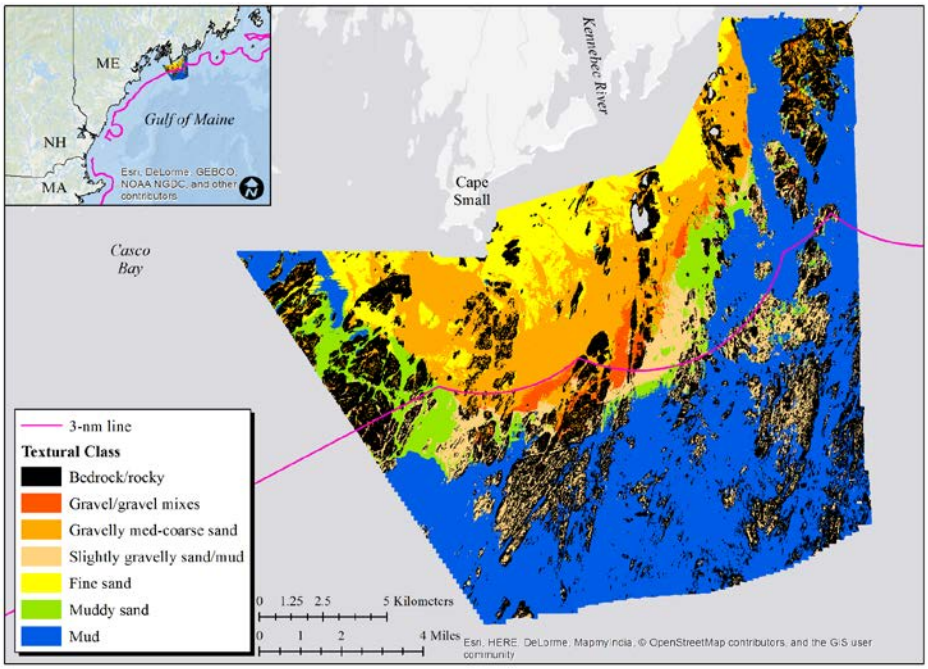
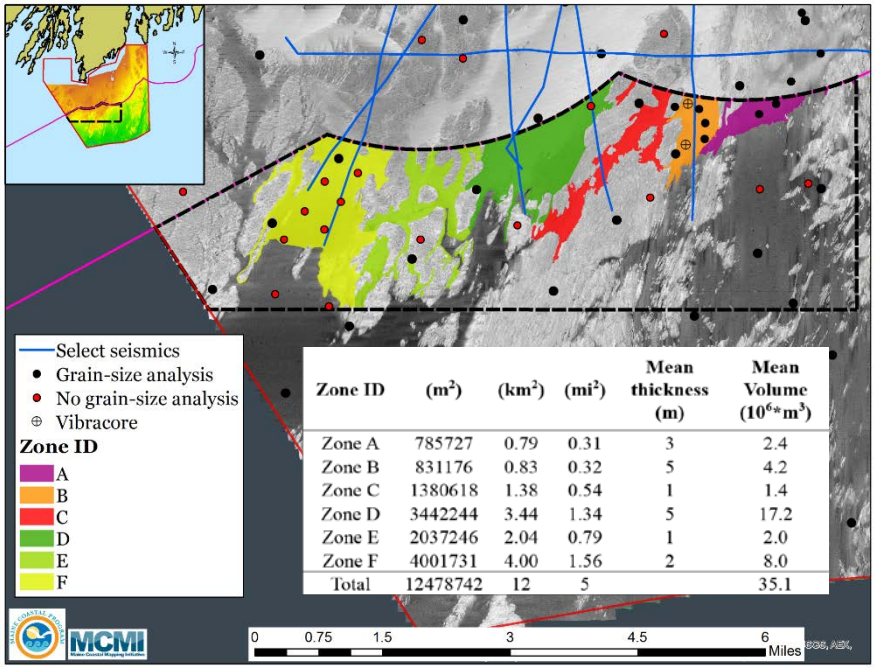


Figure 7. Generalized raster output for 7-class seafloor textural classification model. Raster showing textural classifications from initial classification scheme based on a modified version of CMECS substrate groups corresponding to seven training polygon classes.

8. Dobbs, K., 2017. Preliminary Sand and Gravel Reservoirs Assessment for Federal Waters: Mid-coast Maine, Augusta, ME. 26 p.

Recently, the Bureau of Ocean Energy Management (BOEM) has recognized the need to identify additional outer continental shelf (OCS) sand resources for beach nourishment and coastal restoration projects because sand resources in state waters are either diminishing or are of poor quality, or otherwise unavailable. Quantitative assessments for many of these resources have only been conducted in nearshore waters within Maine state jurisdiction (e.g. waters landward of 3-nautical mile line). However, much of the seafloor sediment and subsurface data (e.g. cores and seismic reflection profiles) used to perform these assessments does extend into waters of federal jurisdiction. As part of a multi-year, multi-agency cooperative, the Maine Coastal Program's Mapping Initiative (MCMI) has been addressing the need for comprehensive resource assessment through high-resolution seafloor mapping using a multibeam echosounder (MBES) and by collecting additional seafloor substrate data. In this investigation, the MCMI combined new and pre-existing geological and geophysical data to characterize and estimate volume for potential sediment resources in waters of federal jurisdiction within Maine's mid-coast region. Results identified 6 distinct zones containing potential sand and gravel resources within federal waters, with a combined total volume of approximately 32 million cubic meters (42 million cubic yards); approximately one order of magnitude smaller than estimated by Kelley et al. (1997) for the nearshore/shoreface reservoirs in the vicinity. Although considerable error exists for calculated volumes due to the lack of vertical resolution in many areas, these are considered best estimates using the available data. Despite the total volume, these deposits are somewhat unattractive as potential sand and/or gravel resources due to low overall quality and depths (30 m – 70 m) prohibitive to traditional dredging operations. The overall average sand, gravel, and mud content in all zones were approximately 60%, 19%, and 36%, respectively. Overall, this investigation highlights the need for more comprehensive assessment and management of additional potential resources (e.g. shoreface/nearshore deposits) for beach nourishment and coastal restoration efforts within the region.



Zone ID	(m^2)	(km^2)	(mi^2)	Mean thickness (m)	Mean Volume (10^6*m^3)
Zone A	785727	0.79	0.31	3	2.4
Zone B	831176	0.83	0.32	5	4.2
Zone C	1380618	1.38	0.54	1	1.4
Zone D	3442244	3.44	1.34	5	17.2
Zone E	2037246	2.04	0.79	1	2.0
Zone F	4001731	4.00	1.56	2	8.0
Total	12478742	12	5		35.1

Figure 8. Sand and gravel zones shown with representative seismic lines (blue lines with label) were used to estimate mean thickness for each zone and geological data (vibracores and grab samples) used to characterize them. Lighter tones in backscatter intensity represent coarser sediment and darker tones represent fine sediment. Irregular-shaped areas with intermediate to light tones represent rock.

9. Dobbs, K., 2017. 2017 Descriptive report for seafloor mapping – Midcoast Maine. Maine Coastal Program, W. Boothbay Harbor, ME. 65 p.

During the survey season (April-September) of 2017 the Maine Coastal Program's Mapping Initiative (MCMI) conducted hydrographic surveying using a multibeam echosounder (MBES) in the waters off of mid-coast Maine. The surveying was conducted in part to support the Federal Bureau of Ocean and Energy Management's (BOEM) efforts to enhance coastal resiliency through identification and characterization of potential sand and gravel resources on the outer continental shelf that may be used for beach nourishment. The surveys also coincide with state efforts to update coastal data sets and increase high resolution bathymetric and provides new data in the areas covered by National Oceanic and Atmospheric Administration (NOAA) nautical charts 13288, 13293, and 13301. A total of approximately 125 mi^2 (325 km^2) of high-resolution multibeam data were collected in the surveyed area. During the 2017 survey season the MCMI also collected sediment samples, water column data, and video in 69 locations.

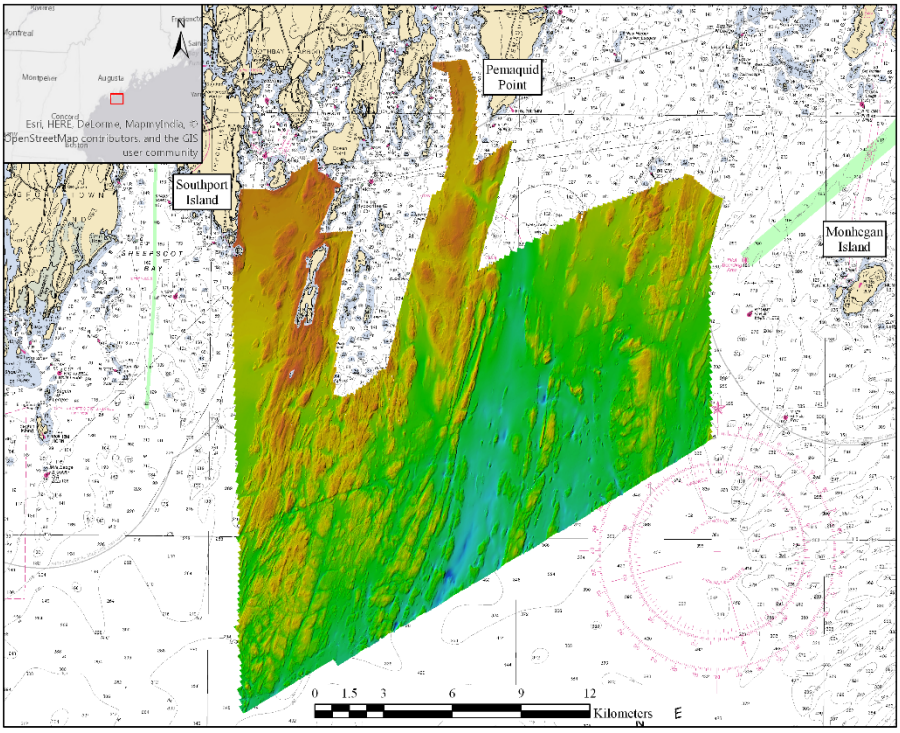


Figure 9. Bathymetry data collected by MBES in the 2017 mainscheme survey coverage off mid-coast Maine.

10. Dobbs, K., 2017. 2017 Seafloor Sediment Sampling: Southport Island to Monhegan Island, Gulf of Maine, W. Boothbay Harbor, ME. 96 p.

As part of a multi-year, multi-agency cooperative, the Maine Coastal Mapping Initiative (MCMI) has been addressing the need for comprehensive resource assessment through high-resolution seafloor mapping using a multibeam echosounder (MBES) and by collecting seafloor substrate data. The purpose of this investigation was to collect seafloor substrate data within the 2017 focus area and combined with existing data will help accomplish the following objectives: benthic habitat classification, modeling and mapping via the federally-approved Coastal and Marine Ecological Classification Standard (CMECS) generation of generalized seafloor sediment maps, build upon existing knowledge of local and regional geologic framework, and assess potential sand and gravel reservoirs. This report presents summarized bottom sample (69 sites) data collected by the MCMI during the 2017 field season (April to September), generalized descriptions of sand and gravel deposits, and preliminary sediment mapping of the approximately 125 mi^2 (325 km^2) survey area offshore of midcoast Maine between Southport Island and Monhegan Island. Preliminary analyses indicated that laterally extensive sand and gravel deposits were scarce, of poor quality, and limited to four isolated areas near lowstand shoreline positions, suspected glacial moraine segments and/or presumably reworked glacial outwash. Analysis and interpretation of these and pre-existing geological and geophysical data collected in the vicinity allowed the MCMI examine the relationship between seabed morphology and generate preliminary seafloor sediment maps, adding insight to the extensively studied seafloor sediment in the region.

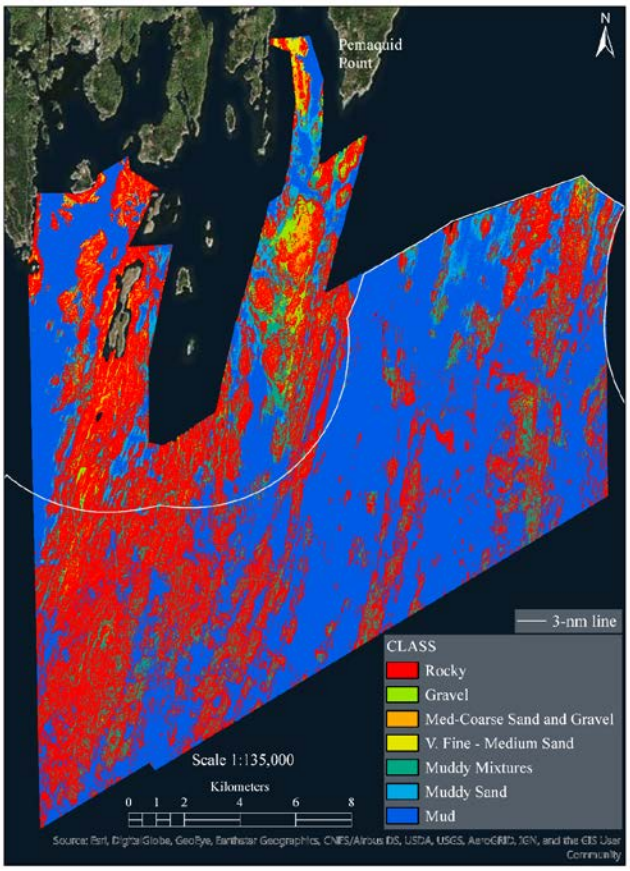


Figure 10. Generalized seafloor substrate map of survey area; this map is considered preliminary and for conceptual purposes only; scale of mapped sediment types is unspecified; sediment classes were based on predominant grain-size components described in the field and do not strictly adhere to a specific classification system (e.g. Folk, 1974); areas classified as rocky include cobble-boulder areas.

11. Kraun, B., 2019. 2018 Descriptive report for seafloor mapping –Southern and Midcoast Maine. Maine Coastal Program, W. Boothbay Harbor, ME. 62 p.

During the survey season (July-November) of 2018 the Maine Coastal Mapping Initiative (MCMI) conducted hydrographic surveying using a multibeam echosounder (MBES) in the waters off southern and mid-coast Maine. The surveying was conducted in part to support the Federal Bureau of Ocean and Energy Management's (BOEM) efforts to enhance coastal resiliency through identification and characterization of potential sand and gravel resources on the outer continental shelf that may be used for beach nourishment. The surveys also coincide with state efforts to update coastal data sets and increase high resolution bathymetric coverage for Maine's coastal waters. A total of approximately 18 mi2 (47 km2) of high-resolution multibeam data were collected in the surveyed area. An additional 3.6 mi2 were collected in nearshore waters for the purposes of assessing nearshore sand movement and mapping eelgrass beds. This work is summarized in separate reports.

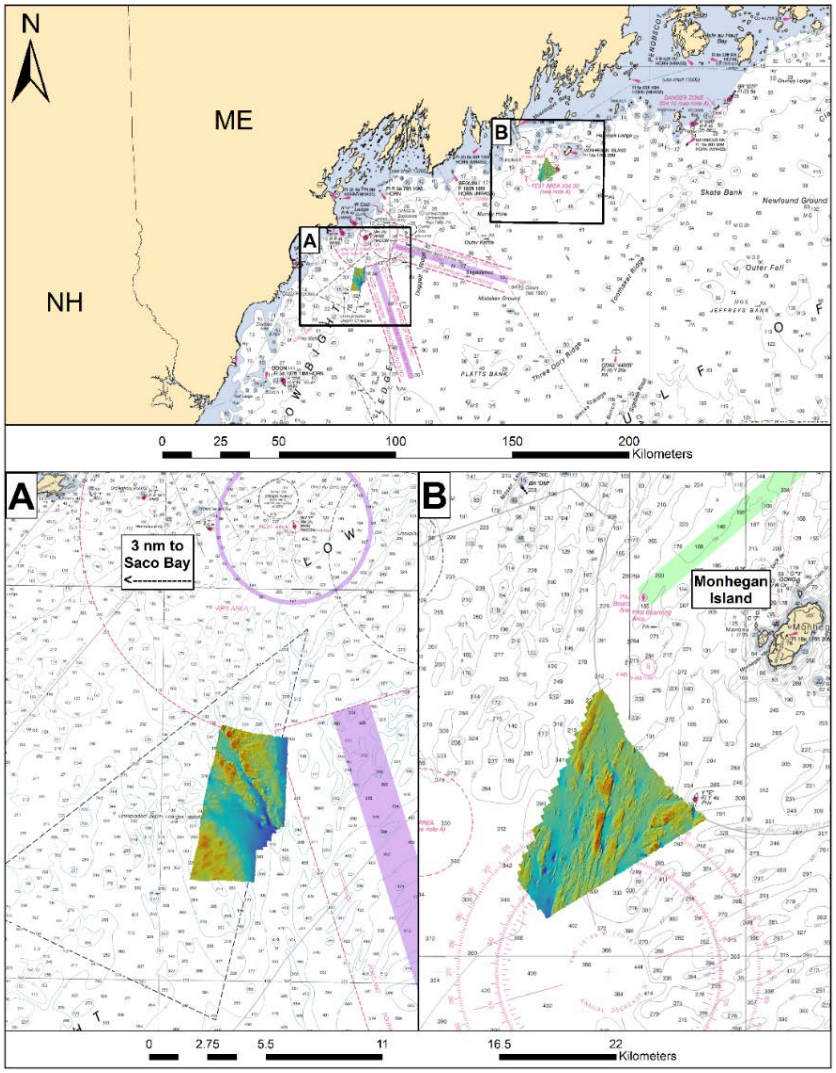


Figure 1 – General localities of 2018 mainscheme survey coverage off southern and mid-coast Maine

12. Kraun, B., 2019. 2018 Seafloor Sediment Sampling: –Southern and Midcoast Maine. Maine Coastal Program, W. Boothbay Harbor, ME. 96 p.

The collection and processing of the 2018 sediment samples is funded by another source and therefore the timeline is not coincident with our BOEM CA timeline. The completion of the sediment analysis is due May 2019 and the Sediment Report will be completed once the data have been delivered to the Maine Coastal Program. The report will be delivered to BOEM as it is completed.

13. Dickson, S. M., Kraun, B., and Dobbs, K., 2019, Unlocking the Lowstand: Geomorphology of Maine's Inner Continental Shelf and the Holocene Transgression Revealed by Multibeam, Geological Society of America Abstracts with Programs. Vol. 51, No. 1, ISSN 0016-7592. doi: 10.1130/abs/2019NE-328394

Relative sea level in the Gulf of Maine has varied over 120 m vertically since the Laurentide Ice Sheet retreated. Marine transgression over the last 12 ka reworked glacial sedimentary deposits infilling depressions and exposing Paleozoic bedrock. Multibeam data, collected by the Maine Coastal Mapping Initiative (MCMI) since 2014 and earlier by NOAA, provides new geomorphic evidence confirming a paleo-shoreline to at least a 60-m depth. Off Kennebunkport, we discovered an esker with a N-S sinuous 48-m deep crest truncated in a 12-m bluff with a base-of-slope from -60 to -67 m along a 220-m shoreline. This feature is in an embayment facing SW into a 95-m deep basin with distinct sediment depocenters, possibly submerged deltas. A smooth sediment apron seaward of the bluff's base suggests wave reworking to an 80-m depth along a distance of at least 1.4 km. Beginning around 12 ka, rapid sea-level rise at about 7.5 m/century would have submerged the bluff's toe and crest below wave base to a 15-m depth in 500 years, contributing to its preservation.

During the lowstand, the Penobscot River discharged to the sea through one or more deep bedrock valleys between Rockland and Vinalhaven. Bedrock constrictions apparently caused sediment deposition along the west shore, seaward of present-day Rockland to Port Clyde. Located here is a large sedimentary body with a level surface at -35 m which could have formed during rapid sea level rise. A bedrock shelf valley 80 to 90 m deep exits the ancestral Penobscot Bay, curving to the southeast of Vinalhaven Island. This pronounced shelf valley is sediment-starved and draped with moraines unburied by Holocene fluvial or marine sediment. This paleo-channel through coastal highlands would have provided a narrow marine connection to a broader, possibly euryhaline, paleo-Penobscot Bay. Adjacent shoals have 20 preserved De Geer moraines across 3.2 km. If the moraines were annual, regional ice-margin retreat to the NW would have been on the order of 160 m/year.

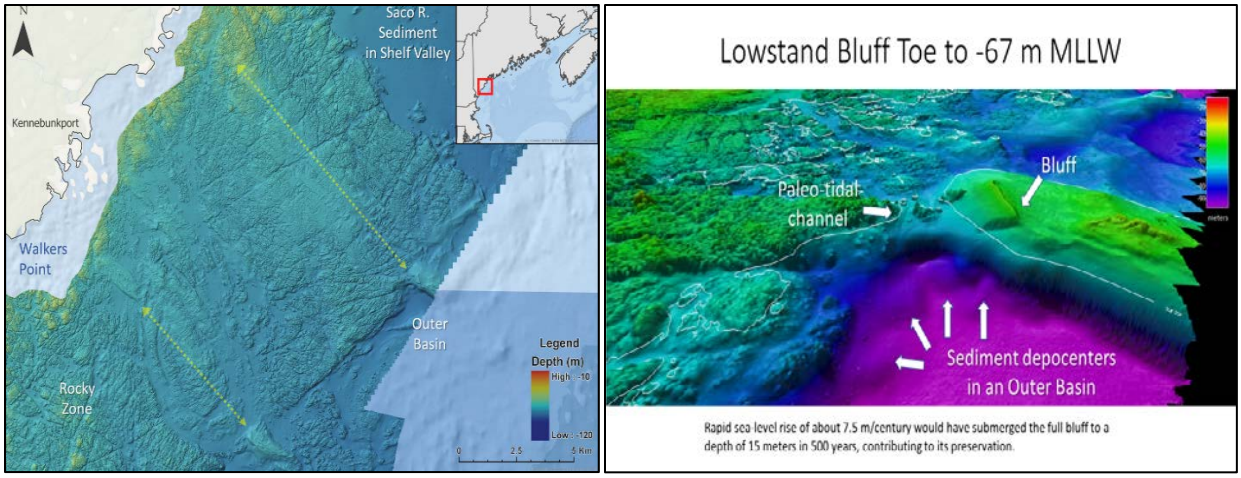


Figure 13. In the area of the MCMI's Kennebunk MBES data collection, an esker truncated in a bluff with a base of slope from -60 to -67 m along a 220-m shoreline.

Presentations/Posters:

Oral and poster presentations were conducted for diverse audiences over the course of the cooperative agreement. In all instances, the aim of the presentation was to update the audience, whether it was composed of legislators, geological professionals, or college or high school students, on the mapping progress made by the Maine Coastal Mapping Initiative as part of the cooperative agreement with BOEM. Methods of bathymetric and backscatter data collection, ground truthing, data processing and analysis were discussed, and applications for the data were highlighted, including increased coastal resiliency through identification of offshore sand deposits, improved navigation, and informed ocean planning.

Dobbs, K., Ozmon, I., Norton, E.L., and M. Nixon. Maine Coastal Mapping Initiative progress update: Applications and utilization of high resolution multibeam echosounder data. Southern Maine Community College, Marine Technology course invitational lecture. South Portland. November 6, 2015. Oral presentation.

Dobbs, K., Ozmon, I., Norton, E.L., and M. Nixon. Maine Coastal Mapping Initiative progress update: Applications and utilization of high resolution multibeam echosounder data. Maine Geological Survey Annual Meeting. Augusta, ME. November 11, 2015. Oral presentation.

Nixon, M., and E. Norton. Mapping Maine's seafloor: Maine Coastal Mapping Initiative. Port Safety Forum. Portland, ME. December 16, 2015. Oral presentation.

Norton, E.L., Dobbs, K., Ozmon, I., and M. Nixon. Under the sea: Exploring submerged geologic features using multibeam sonar. Maine Geological Society Annual Meeting. Augusta, ME. November 11, 2015. Poster presentation.

Norton, E.L., and M. Nixon. Mapping Maine's seafloor: Maine Coastal Mapping Initiative. The Nature Conservancy Brown Bag Webinar. Brunswick, ME. April 15, 2015. Oral presentation.

Norton, E.L., and I. Ozmon. Aggregate exploration and habitat classification: Tools for building resiliency in Maine. Geological Society of America Northeastern Section Meeting. Bretton Woods, NH. March 24, 2015. Oral presentation.

Norton, E., and I. Ozmon. Mapping Maine's seafloor: Maine Coastal Mapping Initiative. Bowdoin College 2015 Summer Research Symposium. Brunswick, ME. July 23, 2015. Oral presentation.

Norton, E.L., Ozmon, I., and M. Nixon. Developing high resolution bathymetric maps for ocean planning in Maine. Tech Night for high school students. Augusta, ME. March 19, 2015. Poster presentation.

Norton, E.L., Ozmon, I., and M. Nixon. Maine bathymetric update: Maine Coastal Mapping Initiative. Maine GIS Users Group Annual Conference. Portland, ME. February 2, 2015. Oral presentation.

Norton, E., and Ozmon, I., and M. Nixon. Mapping Maine's seafloor: Maine Coastal Mapping Initiative. Coastal Caucus of the Maine Legislature. Augusta, ME. March 12, 2015. Oral presentation.

Ozmon, I., K. Dobbs, C. Enterline, M. Nixon. Developing habitat classifications and models based on bathymetry, backscatter, and benthic sampling in Maine. Regional Association for Research on the Gulf of Maine (RARGOM) 2016 Annual Meeting. Portsmouth, NH. October 14, 2016. Poster Presentation.

Dobbs K., C. Enterline, M. Nixon, I. Ozmon. A Collaborative Approach to Characterizing Sand and Gravel Deposits in the Gulf of Maine. American Shores and Beaches Preservation Association (ASPBA) Annual Meeting. October 26-28, 2016. Oral presentation.

Enterline, C., Ozmon, I., K. Dobbs, S. Dickson, M. Nixon. Maine Coastal Mapping Initiative, Summary of Collected Data. Workshop on marine geological and geophysical data collection in Maine. Augusta, ME. November 7, 2016.

Ozmon, I., K. Dobbs, C. Enterline, M. Nixon. Developing habitat classifications and models based on bathymetry, backscatter, and benthic sampling in Maine. Coastal Summit Bi-Annual Conference. New Orleans, LA. December 12-15, 2016. Poster Presentation.

Dobbs K., C. Enterline, M. Nixon, I. Ozmon. ASPBA Talk Update: A Collaborative Approach to Characterizing Sand and Gravel Deposits in the Gulf of Maine. Webinar with BOEM, Post-Award Meeting. February 1, 2017. Oral presentation.

Ozmon, I. Benthic habitat mapping: An inventory of the what, where and who on the seafloor offshore of Maine. Webinar with BOEM, Post-Award Meeting. February 1, 2017. Oral presentation.

Dobbs, K., I. Ozmon, Enterline, C., S. Dickson, M. Nixon. Maine Coastal Mapping Initiative, Summary of Collected Data. Webinar with BOEM and all BOEM Project Partners for Data Coordination Meeting. April 5, 2017. Oral presentation.

Dobbs, K., I. Ozmon, S. Garvey, Enterline, C., S. Dickson, M. Nixon. Maine Coastal Mapping Initiative. Presentation for NOAA OCM staff. West Boothbay Harbor, ME. May 3, 2017. Oral presentation.

Enterline, C., K. Dobbs, I. Ozmon, S. Dickson, M. Nixon. Maine Coastal Mapping Initiative. Maine Harbormasters' Conference. Castine, ME. March 4, 2018. Oral presentation.

Ozmon, I. Subtidal benthic habitat mapping with CMECS in Midcoast Maine. Northeast Regional Ocean Council's Habitat Classification and Ocean Mapping Committee Workshop on the Coastal and Marine Ecological Classification Standard and its Applications in the Northeast. March 12, 2018. Oral Presentation.

Enterline, C., K. Dobbs, I. Ozmon, S. Dickson, M. Nixon. Spatial modeling of marine subtidal sediment and benthic habitat using supervised classification techniques based on backscatter and bathymetry data. University of New Hampshire and Center for Coastal and Ocean Mapping Northeast Regional Environmental Acoustics Symposium. Durham, NH. March 20, 2018. Oral presentation.

Enterline, C., S. Dickson, K. Dobbs, I. Ozmon, M. Nixon. Maine Coastal Mapping Initiative. Maine Port Authority. Belfast, ME. April 25, 2018. Oral presentation.

Dickson, S. M., Kraun, B., and Dobbs, K. Unlocking the Lowstand: Geomorphology of Maine's Inner Continental Shelf and the Holocene Transgression Revealed by Multibeam, Geological Society of America Abstracts with Programs. Vol. 51, No. 1, ISSN 0016-7592. doi: 10.1130/abs/2019NE-328394, March 18, 2019.

Available data

Processed bathymetric and other data will be available for viewing and downloading through an ArcGIS mapping portal (currently in development) through the Maine Coastal Mapping Initiative's webpage on mainecoastalprogram.org. Bathymetry, backscatter and habitat classification maps, along with all other physical, geological, and biological raw data will be available upon request to Matthew Nixon (matthew.e.nixon@maine.gov) or Claire Enterline (claire.enterline@maine.gov) at the Maine Coastal Program. All associated data have been provided to BOEM for inclusion in the Marine Minerals Information System.

Associated Cooperative Agreement Outputs:

Ozmon, I.M., 2016, Maine Coastal Mapping Initiative benthic infauna analyses and habitat classification in Southern Maine. Maine Coastal Program, Augusta, ME. 45 p.

In 2014 a multibeam sonar survey was completed for a 40 mi^2 area off of Southern Maine to create high resolution bathymetric and backscatter intensity products. Benthic sampling, conducted to ground truth surficial sediment grainsize, also was used to benthic habitat classifications. Twenty one grab samples were collected in the survey area to determine benthic substrate composition and quantify abundance and diversity of the infauna at those sites. Individuals from 66 taxa (54 species and 12 to Family level) were identified in the grab samples dominated by Phylum Mollusca and Class Polychaeta on the basis of either biomass or abundance. Average infauna abundance measured 1531 ± 864 (s.d.) individuals m^{-2} and the mean biomass was 134 ± 194 (s.d.) g wet weight m^{-2}. Diversity (Shannon-Wiener index) ranged from 0.35 to 2.69, and species richness measured 14 ± 5 (mean ± s.d.). Infauna abundance data were combined with water column data (temperature and salinity) and identifications of major geologic features to classify benthic habitat at the grab sampling sites according to the Coastal and Marine Ecological Classification System (CMECS; FGDC 2012). Results were explored using a variety of multivariate statistical methods to determine whether a relationship between environmental variables (sediment grain size distributions, bathymetry and backscatter intensity) and infauna communities existed. Five subtly distinct groups of infauna communities emerged from results of the multi-dimensional scaling ordination and hierarchical cluster analysis based on Bray-Curtis dissimilarities between communities observed at grab sampling sites. However, strong relationships between environmental and biological variables were not found, likely due to limitations of the dataset. Future efforts will be made to gather a higher diversity of grab samples in study areas to improve the capacity to develop a predictive model that could be used to generate comprehensive habitat maps based on multibeam survey data products.

Dobbs, K., 2016. Jackknife Ledge and Vicinity Sediment Disposal Site – Multibeam Bathymetry and Backscatter Interpretation Summary. Augusta, ME. 9 pp.

Preliminary interpretations of multibeam backscatter and bathymetry data and sediment samples suggest that the sediment previously disposed at the site south of Jackknife Ledge has experienced minimal landward transport and dispersal. Bathymetry data in the immediate vicinity of the former disposal site suggest landward transport and redistribution of nearshore sediments are locally inhibited by a series of low-relief (approximately 0-5 meters), NE-SW-trending submarine bedrock outcrops that extend SW from Jackknife Ledge. Based on observations of seabed morphology, sediment samples, and sediment proxy data (e.g. backscatter intensity) in the vicinity of the former disposal site it is reasonable to presume that negligible beach nourishment has occurred to date as a result of the most recent sediment disposal efforts performed by USACE (2011, approximately 15,000 – 20,000 cubic yards). The findings provided in the following text have been made based on experience and a review of data collected by the Maine Coastal Mapping Initiative in 2016 only, and have no bearing on previous assessments or interpretations of prior surveys conducted/data collected in the vicinity. However, it is likely that the incorporation/consideration of any previous data collected in the

vicinity would strengthen future assessments. In addition, estimates of disposed sediment volume and/ subsequent mobilization volume estimates were made without prior knowledge of disposed sediment volume to avoid biasing interpretations.

Dobbs, K., 2016. Preliminary Report of Saco River Submerged Debris Investigation. Augusta, ME. 36 pp.

In May of 2016 the Maine Coastal Mapping Initiative (MCMI) conducted hydrographic surveying within the navigable waters of the Saco River between Camp Ellis and the Biddeford/Saco area located approximately 8 km (5 mi) upstream. Bathymetric (e.g. depth) and backscatter (e.g. seafloor substrate) data were collected using a multibeam echosounder (MBES). Preliminary analyses of these data provided the basis for a more specific investigation using underwater video recordings to help characterize the distribution and nature of submerged debris in the vicinity of a proposed dredging of the federal channel in the Biddeford/Saco portion of the Saco River. This investigation was performed at the request of the Maine Submerged Lands Program on behalf of the Cities of Saco and Biddeford, Maine. This project also coincides with state efforts to update coastal data sets and increase high resolution bathymetric coverage for Maine's navigable waters and provides new data in the areas covered by National Oceanic and Atmospheric Administration (NOAA) nautical charts (e.g. coastal and harbor) 13286 and 13287 in southern Maine. These data were not collected or processed for specifically for navigational purposes, but are freely provided to NOAA for any use the agency deems appropriate.

Dobbs, K., 2017. Memo Report: Submerged Glacial Features Offshore Kennebunkport, Southern Maine. Augusta, ME. 16 pp.

During the 2014 survey season (April – November) the Maine Coastal Mapping Initiative (MCMI) conducted hydrographic surveys using a Kongsberg EM2040C multibeam echosounder (MBES) in the waters off the coast of southern Maine. The approximately 40 mi2 (104 km2) coverage area was centered approximately 9 miles (14.5 km) east-southeast of Kennebunkport, with depths ranging from 30 to 105 meters (below mean lower low water). The main objective of these surveys was to support the Federal Bureau of Ocean and Energy Management's (BOEM) efforts to enhance coastal resiliency through identification and characterization of potential sand and gravel resources on the outer continental shelf that may be used for beach nourishment and state efforts to update coastal data sets and increase high resolution bathymetric coverage for Maine's coastal waters. Visualization and experienced interpretation and of seabed features within these high-resolution MBES data (bathymetry and backscatter intensity) and 1st-order derivatives (e.g. bathymetric hillshade) may also provide additional geomorphologic context within the region.

Dobbs, K., 2017. Summary – MCMI discovers large wreck south of Pemaquid Point. W. Boothbay Harbor, ME. 6 pp.

On July 26, 2017, the MCMI discovered a large, uncharted wreck while conducting hydrographic surveying in the waters offshore of Pemaquid Point, Maine. Interpretations of high-resolution multibeam sonar data suggest the wreck remains largely intact and rests upright (slightly listing to port) on the seabed at a depth of approximately 90 meters (295 feet). The vessel was approximately 70 meters (230 feet) in length and 10 meters (33 feet) wide, with a stern height of 5 meters (16 feet) and a 10 meter (33 feet) raised bow. On August 2, 2017, the MCMI attempted to recover bottom samples and video of the wreck by deploying their seafloor bottom sampling rig, which was outfitted with a grab sampler, video camera, dive light, and green lasers. Sediment retrieved from each sampling attempt contained an abundance of coarse (2mm – 30mm length), decomposed wood fragments and small (2mm – 10mm length), blocky coal chips. A review of underwater videos did not reveal the wreck itself due to a combination of turbid water and the difficultly of precise sampler deployment in such a dynamic environment.

Series of Eleven Reports:

1. *Dobbs, K., 2017. Kennebec River Bathymetric Map Series. Maine Coastal Program, Augusta, ME. 12 p.*
2. *Dobbs, K., 2017. Submerged Lands Investigation Summary for Submerged Cable Areas: Phippsburg – Squirrel Point (Arrowsic), Sagadahoc County, Maine. Augusta, ME. 16 pp.*
3. *Dobbs, K., 2017. Submerged Lands Investigation Summary for Submerged Cable Areas: Parker Head (Phippsburg) – West Georgetown (Georgetown), Sagadahoc County, Maine. Augusta, ME. 18 pp.*
4. *Dobbs, K., 2017. Submerged Lands Investigation Summary for Submerged Cable Areas: Perkins Island – Marrtown, Georgetown Island County, Maine. Augusta, ME. 14 pp.*
5. *Dobbs, K., 2017. Submerged Lands Investigation Summary for Submerged Cable Areas: Gilbert Head to Bay Point (Long Island Narrows), Georgetown, Sagadahoc County, Maine. Augusta, ME. 14 pp.*
6. *Dobbs, K., 2017. Submerged Lands Investigation Summary for Submerged Cable Areas: Popham Beach-Hunniwell Beach to Seguin Island, Phippsburg-Georgetown, Sagadahoc County, Maine. Augusta, ME. 19 pp.*
7. *Dobbs, K., 2017. Submerged Lands Investigation Summary for Submerged Cable Areas: Cape Newagen-The Cuckolds, Southport, Lincoln County, Maine. Augusta, ME. 19 pp.*
8. *Dobbs, K., 2017. Submerged Lands Investigation Summary for Submerged Cable Areas: Ocean Point-Ram Island-Damariscove Island, Lincoln County, Maine. Augusta, ME. 14 pp.*
9. *Dobbs, K., 2017. Submerged Lands Investigation Summary for Submerged Cable Areas: McKown Point – Boothbay Harbor, Lincoln County, Maine. Augusta, ME. 13 pp.*
10. *Dobbs, K., 2017. Submerged Lands Investigation Summary for Submerged Cable Areas: Linekin Bay, Lincoln County, Maine. Augusta, ME. 20 pp.*
11. *Dobbs, K., 2017. Submerged Lands Investigation Summary for Submerged Cable Areas: John's Bay – South Bristol, Lincoln County, Maine. Augusta, ME. 12 pp.*

The Bureau of Parks and Lands (BPL) administers the Maine Submerged Lands Program (SLP) which has management responsibilities for the Submerged Lands Fund and the Shore and Harbor Management Fund, established pursuant to 12M.R.S.A., Section 1863, to provide grants to municipalities and state agencies to support harbor management and public access improvements. The Bureau of Resource Information and Land Use Planning (BRILUP) administers the Maine Coastal Program (MCP) to provide technical assistance and responsible planning for the coastal and marine environment, and to promote healthy and vibrant coastal communities, as well as providing technical assistance grants to municipalities to promote sound planning, harbor management, and balanced development to improve marine infrastructure and assure public access to the shore. The BPL and the BRILUP recognize the benefits of combining resources within the Department of Agriculture, Conservation and Forestry (DACF) to achieve the common goals of the two programs.

As part of a new interdepartmental agreement, the Maine Coastal Mapping Initiative (MCMI; created by the MCP in 2012) is actively providing support for harbor and mooring field management, as well as investigating submarine cables areas and marine debris in the midcoast region. The products of these efforts are delivered as a series of summary reports which outline the findings of high-resolution hydrographic surveys and desktop and field reconnaissance conducted in the vicinity of 11 submerged cable areas in the midcoast region.

Ozmon, I.M., 2018. Maine Coastal Mapping Initiative 2015-2017 Benthic Infauna Analyses and Habitat Classification – Midcoast Maine. Maine Coastal Program, Augusta, ME. 449 p.

From 2015 to 2017 multibeam sonar surveys were completed for a 257 mi^2 area in Midcoast Maine to create high resolution bathymetric maps and to collect backscatter intensity data for the region. Benthic sampling was conducted to ground truth surficial sediment classifications made from interpretations of the bathymetric and backscatter maps, and these data were used in combination with the hydrographic data to inform benthic habitat classification. One hundred and ninety-four sites were sampled in the surveyed area to classify benthic habitat per the Coastal and Marine Ecological Classification Standard (CMECS). CMECS aquatic setting and geoformation designations were determined using analyses of hydrographic data, water column characterizations were made from analyses of vertical profiles of temperature and salinity, and seafloor substrate and benthic community classifications were generated from analyses of grab samples and seafloor imagery. Relationships between benthic community types and environmental variables were explored using multivariate statistical analysis methods. Predicted distributions of benthic communities were mapped for the surveyed area based on biotic-abiotic associations defined *a posteriori*, and using an abiotic surrogate, defined by a priori combined substrate-depth classification. Biotic and substrate component classification models based on analyses of data collected from 2015-2016 will be assessed using the CMECS classifications for sites sampled in 2017 once complete.