Maine Outdoor Heritage Fund
Final Report: 181-01-14

Assessing Various Methods to Map the Health and Extent of Eelgrass Beds

Project summary

During July to September 2018, the Maine Coastal Program (MCP), Maine Department of Environmental Protection (DEP), independent consultant to the DEP Seth Barker, Nearview LLC, Southern Maine Community College (SMCC), Maine Geological Survey (MGS) and the Casco Bay Estuary Partnership (CBEP) performed a method comparison for mapping and delineating eelgrass beds at representative sites in Casco Bay, Maine. This comparison and its findings have implications for available methods for eelgrass mapping statewide.

Eelgrass (*Zostera marina*) meadows, or beds, provide critical nursery habitat for larval and juvenile invertebrates and fish, and serve as feeding and nesting areas for adult fishes and migratory birds. Maine's 2015 Wildlife Action Plan cites the importance of eelgrass habitat for at least 20 of Maine's Species of Greatest Conservation Need. These include species important to the local economies of Maine's communities, like softshell clam, as well as federal Species of Concern that have experienced drastic declines in the past few decades, like rainbow smelt. Further, eelgrass meadows provide water quality benefits through nutrient uptake, sediment stabilization, and buffering of pH in the adjacent water column while storing carbon and attenuating wave and current energy.

This project enhanced the state's ability to map and assess eelgrass beds by comparing past used methods side-by-side with new technologies. Traditionally, eelgrass beds in Maine have been mapped by taking aerial images, hand digitizing eelgrass bed extent, and ground-truthing a portion of the mapped beds and percent cover using underwater video. In this project, we evaluated data collected by side-scan sonar, multibeam echosounder (MBES), Unmanned Aerial System (UAS) imaging, and single-beam echosounder (SBES) alongside the traditional aerial image based method. We compared the data products, data collection feasibility, equipment and operational costs, and time required for each method at a representative sample of eelgrass beds in Casco Bay.

Project outcomes

1. Comparison of methodologies to map the extent of eelgrass beds, percent cover, and additional site information

MCP and our project partners evaluated the feasibility, research need, and potential comparative results of various methods to map and assess eelgrass beds at a representative sample of beds in Casco Bay. These included beds off the East End of Portland, Fort Gorges, Macworth Island, Clapboard Island, and Maquoit Bay. We found that each method was able to detect and map the eelgrass beds with some considerations. While UAS image collection can be deployed rapidly and collect high-resolution images, the method is limited by the necessity to tie images together with a land-based feature or other surface feature that can be geo-referenced. This method, therefore, has limitations for mapping the deep edge of eelgrass beds or large beds that extend well beyond the shoreline. Considering other methods, MBES and side-scan sonar, both mounted on lobster boats for this project, were limited in their ability to map in shallow areas because of boat draft. Conversely, these methods were able to collect more detailed information about eelgrass location on the deep edge of the beds and provided a better picture of the extent and percent cover of eelgrass beds in turbid water. In future data collection, the side-scan sonar or an MBES system could be mounted on a smaller vessel or personal watercraft to allow shallow depth collection. In this project, the SBES was mounted on a personal watercraft and was thus able to collect information about the location and depth of eelgrass beds in both shallow and mid-depth waters, and was able to be deployed and collect relatively quickly compared to the other methods. The SBES is, however, not able to collect information for the deeper edge of eelgrass beds. The SBES was also limited in the resolution of the data collected – while the aerial images, UAS images, MBES, and side-scan sonar all give relatively high-resolution "pictures" of the eelgrass bed, the SBES collects only tracks of eelgrass directly below the vessel, and so information about the presence of eelgrass between the tracklines must be interpreted.

2. Assessment of data derivatives

Project partners analyzed and compared the data products from each method including scale, resolution, image quality, and spatial accuracy. We assessed the ability of each method to detect and map the percent cover of eelgrass, and compared the scale, resolution, and area of eelgrass beds that each method was the most successful for collecting. Examples of these comparisons are provided in the photos and figures section below.

3. Comparison and evaluation of the logistical feasibility, cost-effectiveness, and data products among the methods employed

Each partner provided information about these different factors for their data collection that MCP summarized in a technical report. A summary table from this report is provided in the figures section below.

4. Recommendation for future use of methods based on their ability to map the extent and health of eelgrass beds for different projects based on the projects' goals, budget, and mobilization ability.

While various technologies are capable of mapping eelgrass beds through either visual or bathymetric (depth sounding collection) interpretation, the traditional method of collecting low tide ortho-imagery, performing visual interpretation, and ground-truthing eelgrass bed delineation and percent cover assignments remains the most cost-effective for large-scale (regional to statewide) mapping and the most comparable method to previous mapping products.

We confirmed that side-scan sonar, SBES, and MBES data collection are beneficial technologies where field conditions limit the usefulness of aerial images, for example in deeper or turbid water. Further, side-scan sonar and MBES collect additional information including bottom hardness and water depth, and SBES and MBES were able to collect information about the height of the eelgrass. UAS technology provided opportunities for rapid deployment and collection of high-resolution images that could be used to better delineate percent cover and nearshore delineations and vegetation type (specifically separate identification of eelgrass and seaweeds such as rockweed). MCP and our project partners are currently finalizing a technical report that presents an evaluation and recommendation for the applicability and effectiveness of each approach to conduct survey on local, regional, or statewide levels. This report will inform future efforts to map and assess eelgrass beds around the state.

In addition to the mapping comparisons, this project also resulted in the discovery of two non-native species that were previously undocumented in Casco Bay. As part of the MBES ground-truthing methods, the MCP used a platform outfitted with a Ponar grab sampler and underwater video system. These samples and images documented an invasive encrusting bryozoan, *Cribrilina (Juxtacribrilina) mutabilis*, the first record of this species in the Northwest Atlantic Ocean, and an amphipod, *Grandidierella japonica*, the first record in Maine and published together with recent findings from Connecticut, the first published description of this species in the Northwest Atlantic Ocean. The abstracts for these two papers are included in the figures section below. The papers formally acknowledged MOHF in their publication.

Brief Summary of Project for use in MOHF newsletter and/or Facebook posts

Eelgrass (*Zostera marina*) meadows, or beds, provide critical nursery habitat for larval and juvenile invertebrates and fish, and serve as feeding and nesting areas for adult fishes and migratory birds. During July to September 2018, the Maine Coastal Program, Maine Department of Environmental Protection, Nearview LLC, Southern Maine Community College, and Maine Geological Survey performed a method comparison for mapping and delineating eelgrass beds at representative sites in Casco Bay, Maine. Traditionally, eelgrass beds in Maine have been mapped by taking aerial images, hand digitizing eelgrass bed extent, and ground-truthing a portion of the mapped beds and percent cover using underwater video. In this project, we evaluated data collected by side-scan sonar, multibeam echosounder, Unmanned Aerial System imaging, and single-beam echosounder alongside the traditional aerial image based method. We compared the data products, data collection feasibility, equipment and operational costs, and time required for each method at a representative sample of eelgrass beds in Casco Bay. This comparison increases our understanding of capabilities of different mapping platforms available in the state, and enables resource managers understand the trade-offs in different mapping technologies that can rapidly deployed to map and assess eelgrass beds.

Detailed Accounting

The MOHF grant provided the funding for the following:

1) Acquisition and interpretation of side scan sonar images by the Southern Maine Community College.
2) Acquisition and interpretation of high-resolution UAS collected images by Nearview LLC, including image post-processing and image stitching, photo interpretation, method reporting, and finally comparison of all data collection platforms in seamless maps.
3) Method analysis, comparison and interpretation of various methods' feasibility by Seth Barker, the contractor responsible for mapping and ground-truthing eelgrass beds for previous and current mapping efforts in Maine.

Match funding supported the following:

1) A benthic fauna expert, who led the Maine Coastal Program's ground truthing and eelgrass characterization component by planning and performing benthic sampling operations, infauna sample preservation and analysis, and video interpretation of eelgrass beds, density, and health.
2) Collection, post-processing, and interpretation of multi-beam echosounder bathymetry and backscatter, identification of eelgrass signals, and height and volume calculations.
3) Aerial surveys of Casco Bay collecting of low tide ortho-imagery, interpretation of aerial images to denote eelgrass beds in GIS, and ground truthing of bed extent and percent cover, performed by the Maine DEP and their contractors.

4) Collection, post-processing, and interpretation of single-beam echosounder bathymetry to identify the location and extent of eelgrass beds, performed by the Maine Geological Survey.

Maine Outdoor Heritage Fund Project Application Budget

Project Title: Assessing various methods to map the health and extent of eelgrass beds

Date: 12/20/2019	**(F)**	**(H)**	**(J)**	**(L)**	**(N)**	**(O)**	**(P)**	**(R)**
1. Funding Description:	**MOHF Request**	**Cash Secured Source #1:**	**Cash Secured Source #2:**	**Cash Secured Source #3:**	**Cash Secured Source #3:**	**Cash Pending All Sources**	**In-Kind Services**	**Total Budget**
(List Cash Secured, Pending & Inkind Sources, if more space needed list in sections 8, 9 & 10 below)		CBEP EPA Grant	DEP EPA Grant	DACF Submerged Lands Program	TNC Maine	IFW State Wildlife Grant	MCP NOAA CZM Grant	
2. Personnel Expenses								
Salary & Benefits	$0	$0	$0	$0	$0	$0	$4,649	**$4,649**
3. Other Expenses								
Contractual Services	$14,490	$15,000	$15,000	$10,000	$7,500	$5,000	$12,270	**$79,260**
Supplies	$0	$0	$0	$0	$0	$0	$0	**$0**
Travel	$0	$0	$0	$0	$0	$0	$0	**$0**
Other: (List)	$0	$0	$0	$0	$0	$0	$0	**$0**
	$0	$0	$0	$0	$0	$0	$0	**$0**
	$0	$0	$0	$0	$0	$0	$0	**$0**
	$0	$0	$0	$0	$0	$0	$0	**$0**
Total Other Expenses	**$14,490**	**$15,000**	**$15,000**	**$10,000**	**$7,500**	**$5,000**	**$12,270**	**$79,260**
4. Capital/Land Acquisition *(Equipment GT $5,000 or Land)*								
Describe:	$0	$0	$0	$0	$0	$0	$0	**$0**
5. Subtotal	**$14,490**	**$15,000**	**$15,000**	**$10,000**	**$7,500**	**$5,000**	**$16,919**	**$83,909**
6. Indirect Costs ***(30%)***								
StaCap/DiCap or Other	**$4,347**	**$0**	**$0**	**$0**	**$0**			**$4,347**
7. Total Budget	**$18,837**	**$15,000**	**$15,000**	**$10,000**	**$7,500**	**$5,000**	**$16,919**	**$88,256**

Communications

Several presentations were made for the program - presentation and report outputs are listed below. MCP is currently finalizing a technical report detailing the project, methods used, and findings that will be publicly available on the MCP's Maine Coastal Mapping Initiative website in late winter of 2020.

Presentations:

- Brewer, Angie, and Seth Barker. Maine Department of Environmental Protection. *Comparison of aerial mapping results and dive transects*. March 2019 Partner Presentation Comparison Meeting.
- Slovinsky, Peter. Maine Geological Survey. *Testing the MGS Nearshore Survey System ("NSS") for mapping Eelgrass Habitat*. March 2019 Partner Presentation Comparison Meeting.
- Claesson, Stefan. Nearview LLC. *UAS Casco Bay Eelgrass Study*. March 2019 Partner Presentation Comparison Meeting.
- Trott, Thomas J. Maine Coastal Program. *Benthic Survey of Eelgrass (Zostera marina) beds in Casco Bay, Maine*. March 2019 Partner Presentation Comparison Meeting.
- Kraun, Benjamin. Maine Coastal Program. *Using Multibeam Echosounder Methods for Mapping Coastal Eelgrass (Zostera marina).* March 2019 Partner Presentation Comparison Meeting.
- Hayden, Lauren, Brian Tarbox, and Carol White. Southern Maine Community College. *Mapping eelgrass beds with side-scan sonar.* March 2019 Partner Presentation Comparison Meeting.
- Enterline, Claire. Maine Coastal Program. *Maine Coastal Program's Mapping Initiative*. Casco Bay Monitoring Network Biannual Meeting. April 2019.

Reports and Publications:

- Trott TJ, Enterline C (2019) First record of the encrusting bryozoan *Cribrilina (Juxtacribrilina) mutabilis* (Ito, Onishi and Dick, 2015) in the Northwest Atlantic Ocean. BioInvasions Records 8(3): 598–607, https://doi.org/10.3391/bir.2019.8.3.16
- Trott TJ, Lazo-Wasem EA, Enterline C (Accepted for publication December 2019) *Grandidierella japonica* Stephenson 1938 (Amphipoda: Aoridae) in the Northwest Atlantic Ocean. Aquatic Invasions AI19-047
- Enterline C, Brewer A, Claesson S, Tarbox B, Slovinsky P, Kraun B, Barker S, Hayden L, White C, Trott TJ, and Craig M. In preparation. Comparing methods for mapping eelgrass beds using available technologies in Maine. Maine Coastal Program Technical Report.

Project Maps, Figures,
& Method Comparisons

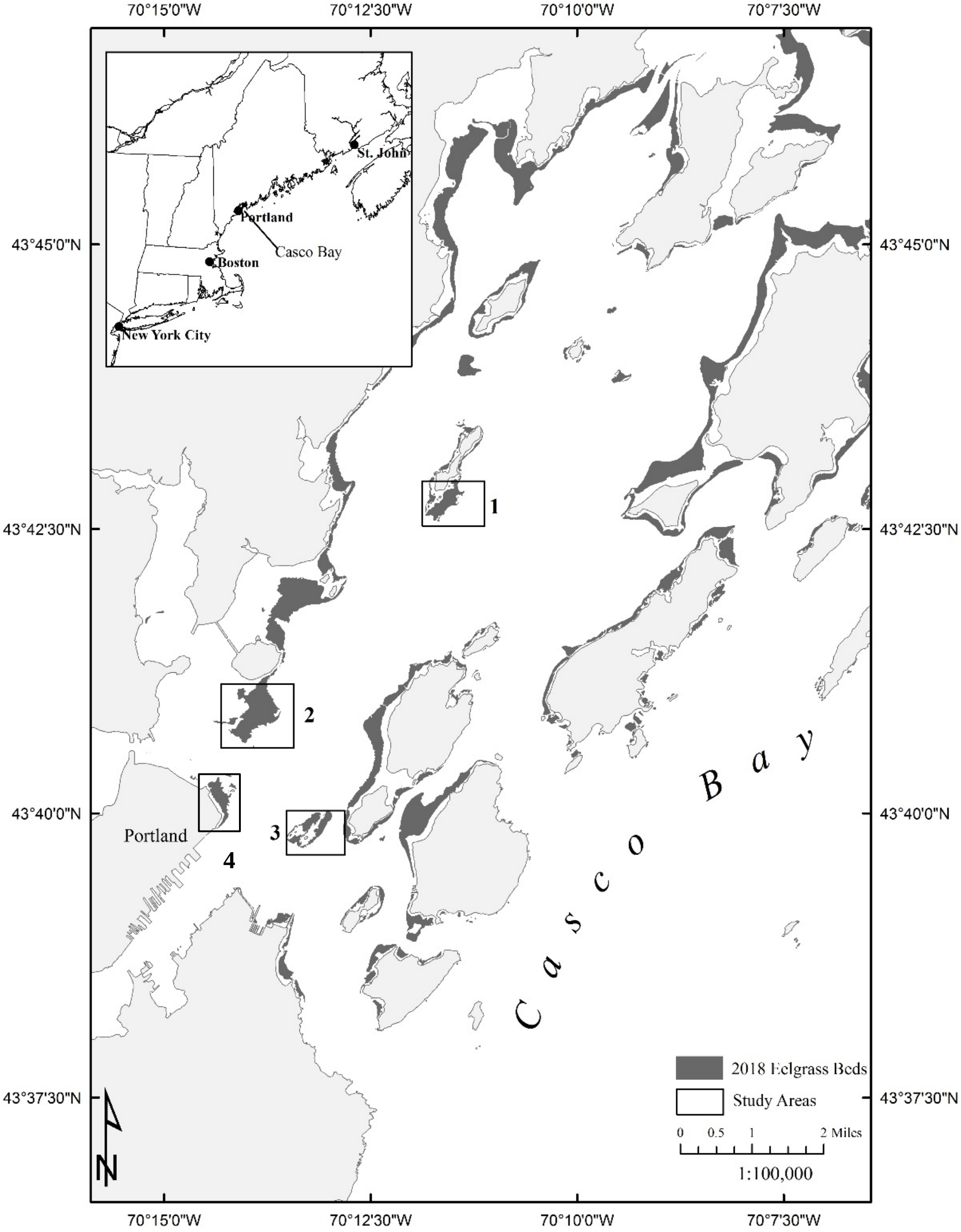
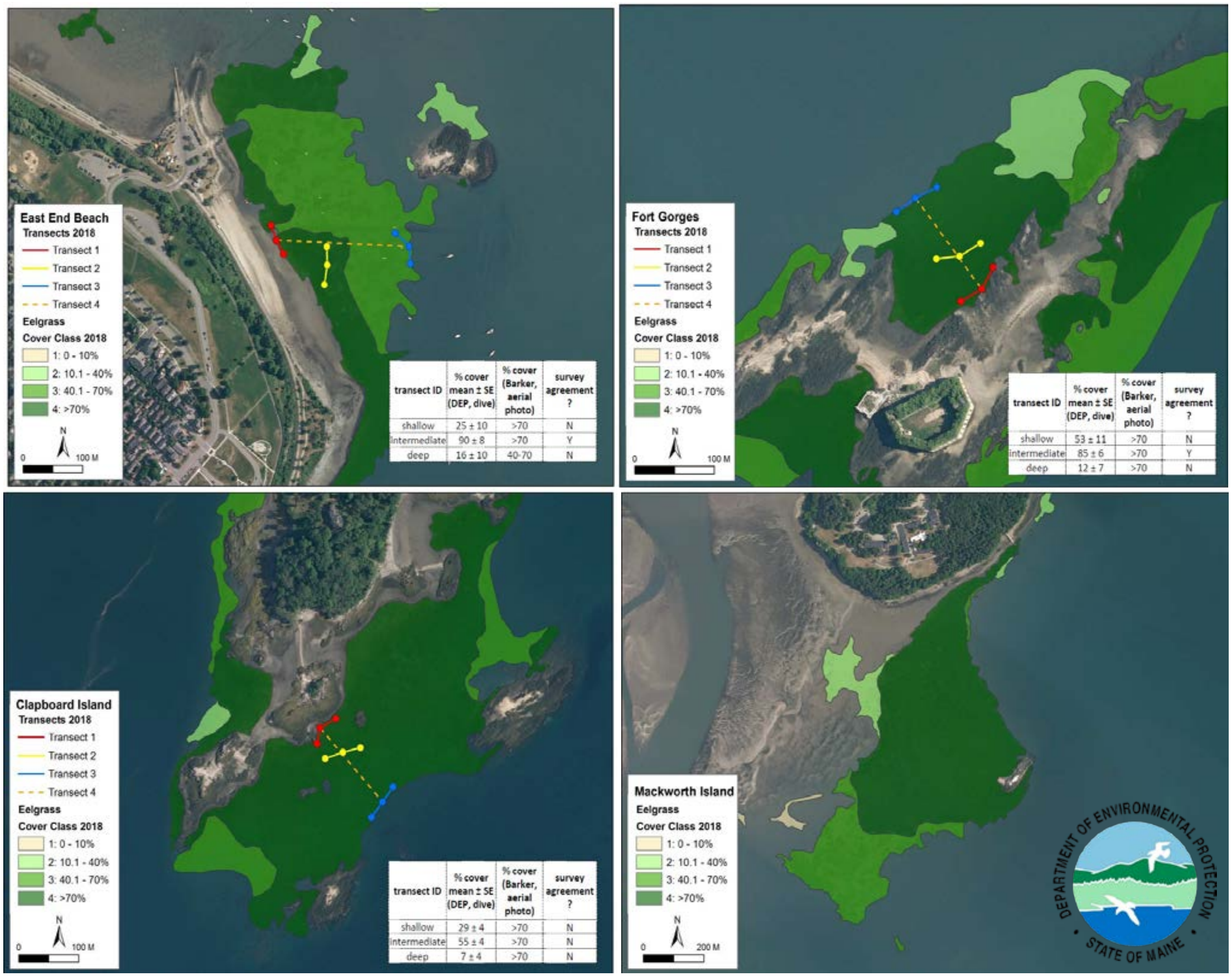


Figure 1. Casco Bay eelgrass beds as mapped in 2018 by aerial surveys and ground truthing, with locations of method comparison sites identified: (1) Clapboard Island, (2), Macworth Island, (3) Fort Gorges, (4) East End Beach



transect ID	% cover mean ± SE (DEP, dive)	% cover (Barker, aerial photo)	survey agreement ?
shallow	25 ± 10	>70	N
intermediate	90 ± 8	>70	Y
deep	16 ± 10	40-70	N

transect ID	% cover mean ± SE (DEP, dive)	% cover (Barker, aerial photo)	survey agreement ?
shallow	53 ± 11	>70	N
intermediate	85 ± 6	>70	Y
deep	12 ± 7	>70	N

transect ID	% cover mean ± SE (DEP, dive)	% cover (Barker, aerial photo)	survey agreement ?
shallow	29 ± 4	>70	N
intermediate	55 ± 4	>70	N
deep	7 ± 4	>70	N

Figure 2. Maps of eelgrass bed delineations derived by aerial imaging and ground truthing at the project comparison sites are shown together with the locations of DEP dive surveys. The maps show the percent cover of eelgrass as mapped a wide-scale using the aerial images compared to dive survey percent cover transects. The differences encountered in comparing percent cover for these two methods was expected because of the difference in sampling scale – while the maps derived from aerial images are meant to show large scale patterns, dive transects count each "strand" of eelgrass by hand and are meant to provide fine scale information.

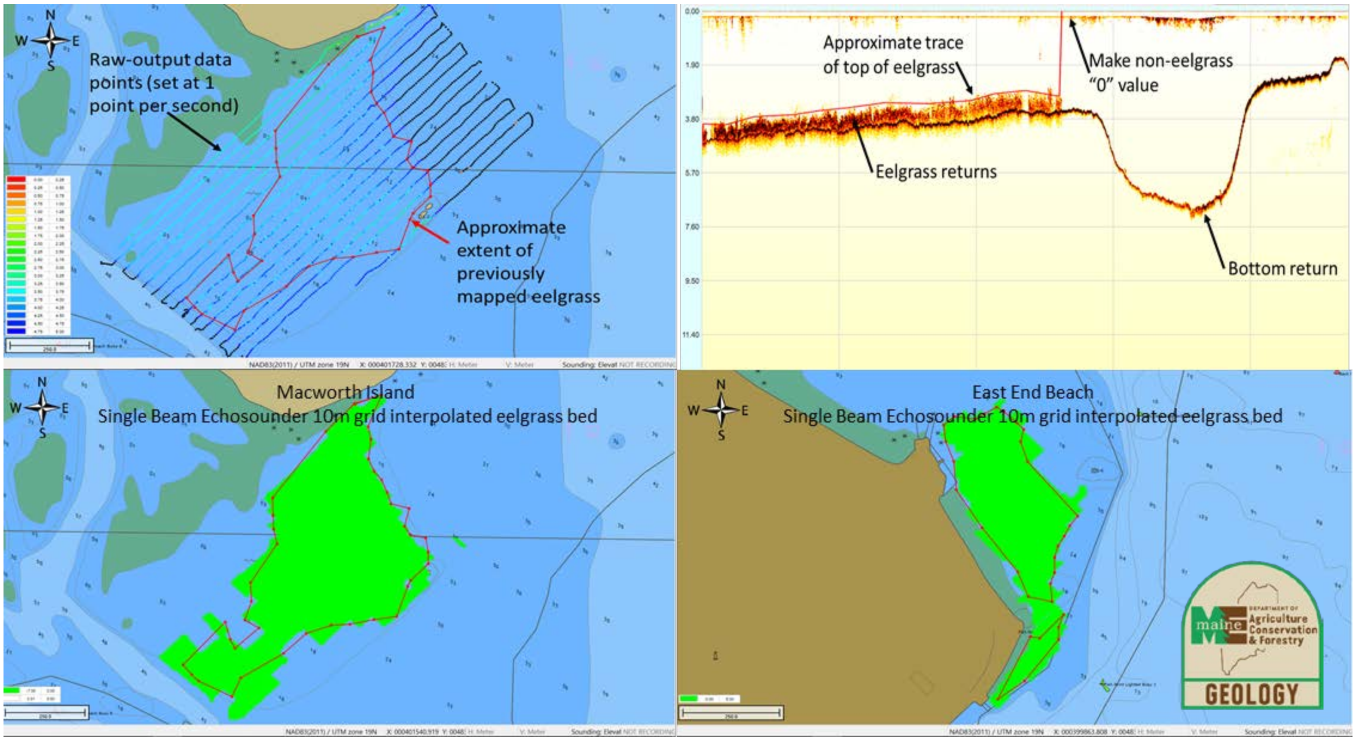


Figure 3. The Maine Geological Survey used their "Near Shore Survey System" (NSS) outfitted with a single-beam echosounder to map eelgrass beds off of East End Beach and Macworth Island. The figures show how the NSS surveyed the eelgrass beds by running lines at 10 meter spacing and used the images of the depths collected on each line to delineate the extent of the beds. The presence of eelgrass in between the lines was interpolated. An image of the depth information for one line shows how eelgrass height can be interpreted.

Figure 4. Side-scan sonar uses acoustic signals to create a picture of the seafloor, with the color of each cell representing differences in the hardness, depth, and shadow of the substrate below. Eelgrass beds at East End Beach and Clapboard Island can be differentiated from the seafloor bottom by visual interpretation, aided here by overlaying the Maine DEP aerial image derived eelgrass areas.

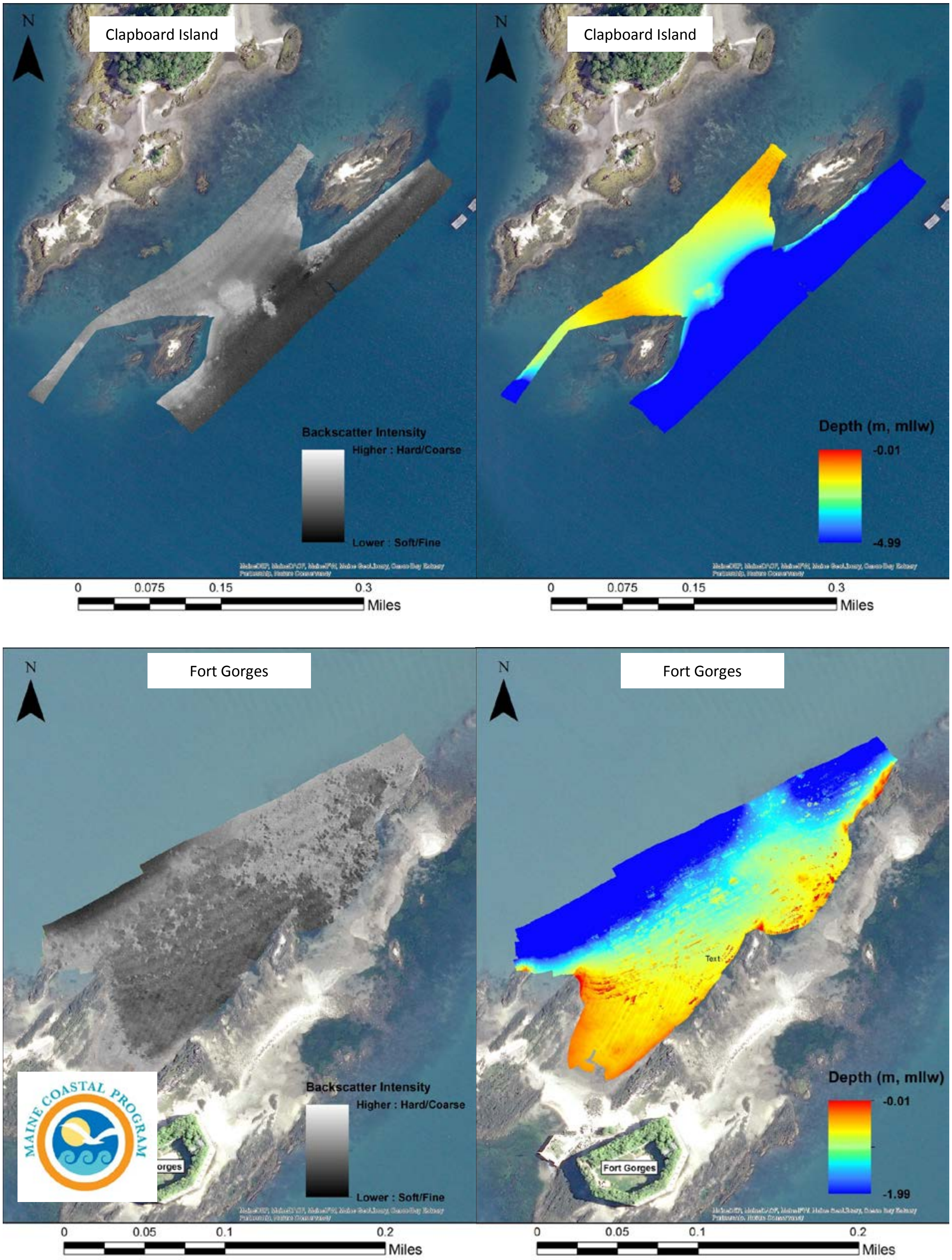


Figure 5a. Multi-beam echosounder (MBES) data show the intensity of the acoustic return (backscatter) as a measure of the substrate hardness (maps on the left), and the seafloor depth, or bathymetry (right). Abrupt changes in depth and hardness show where eelgrass is present.

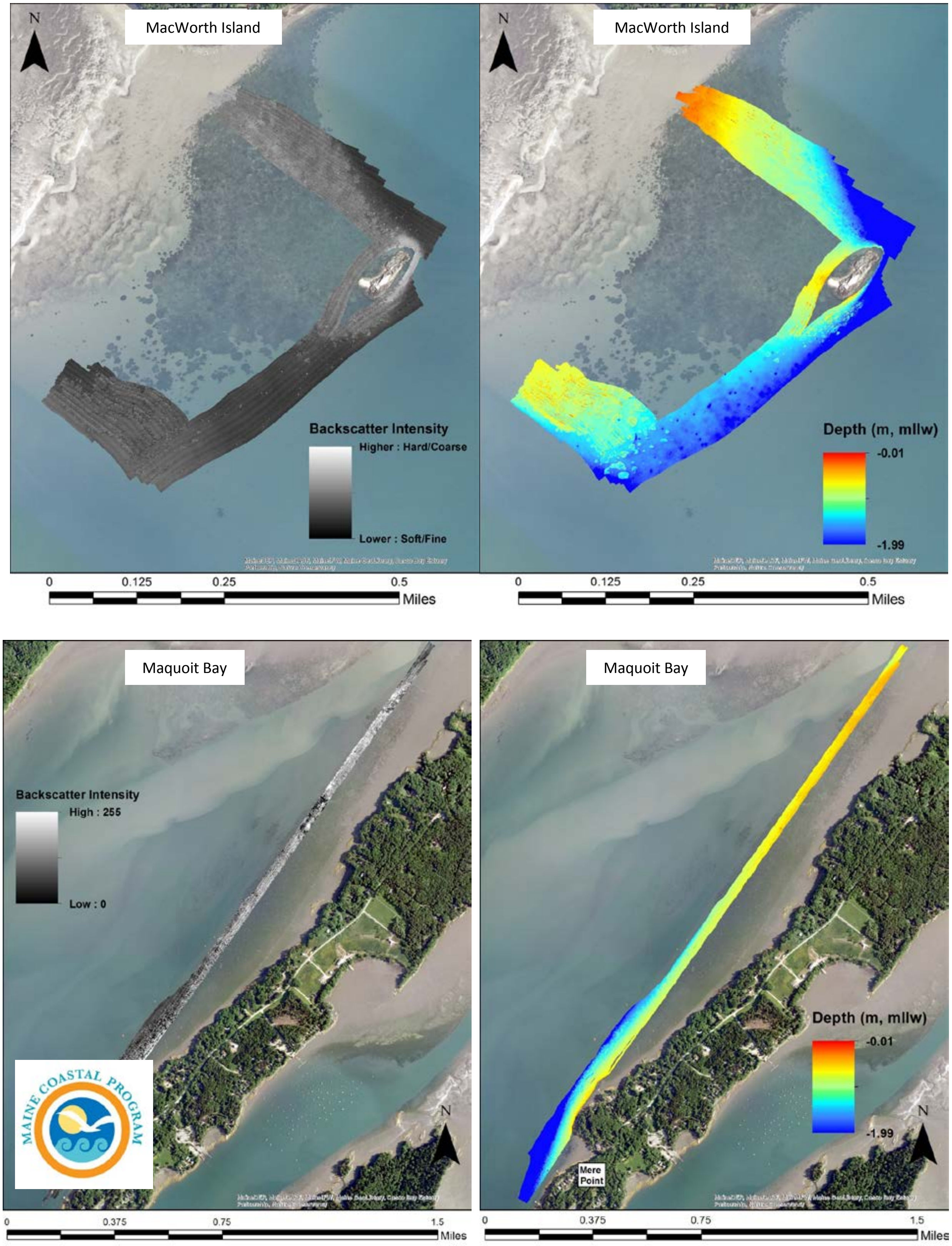
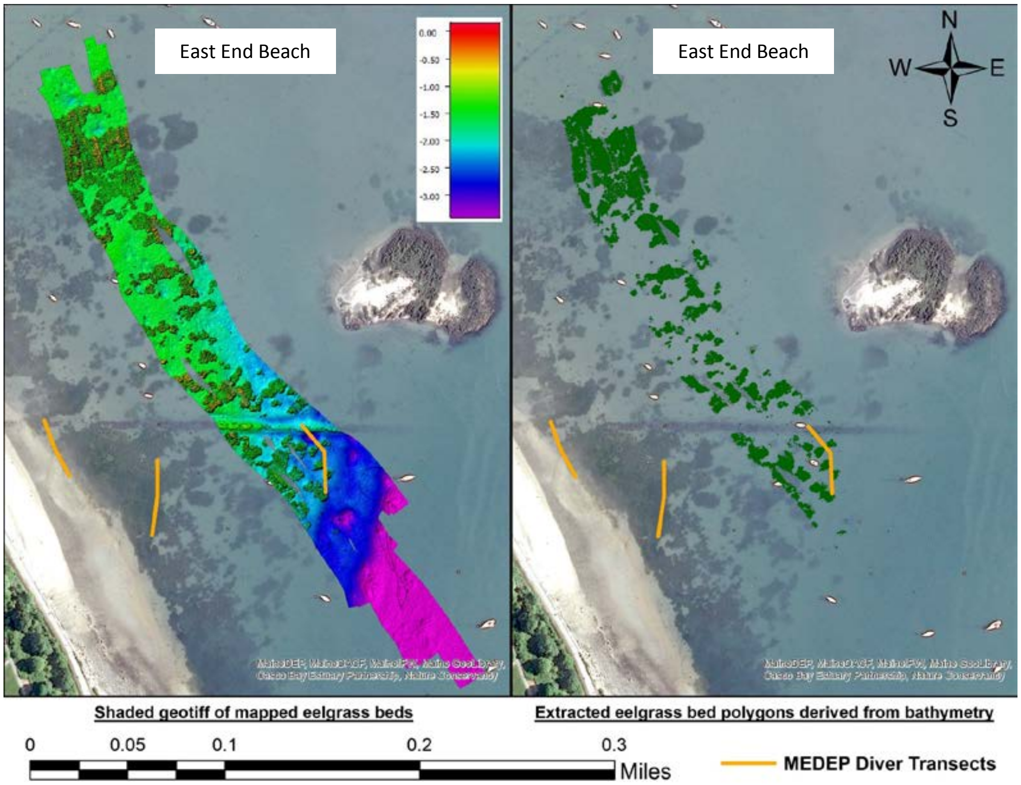
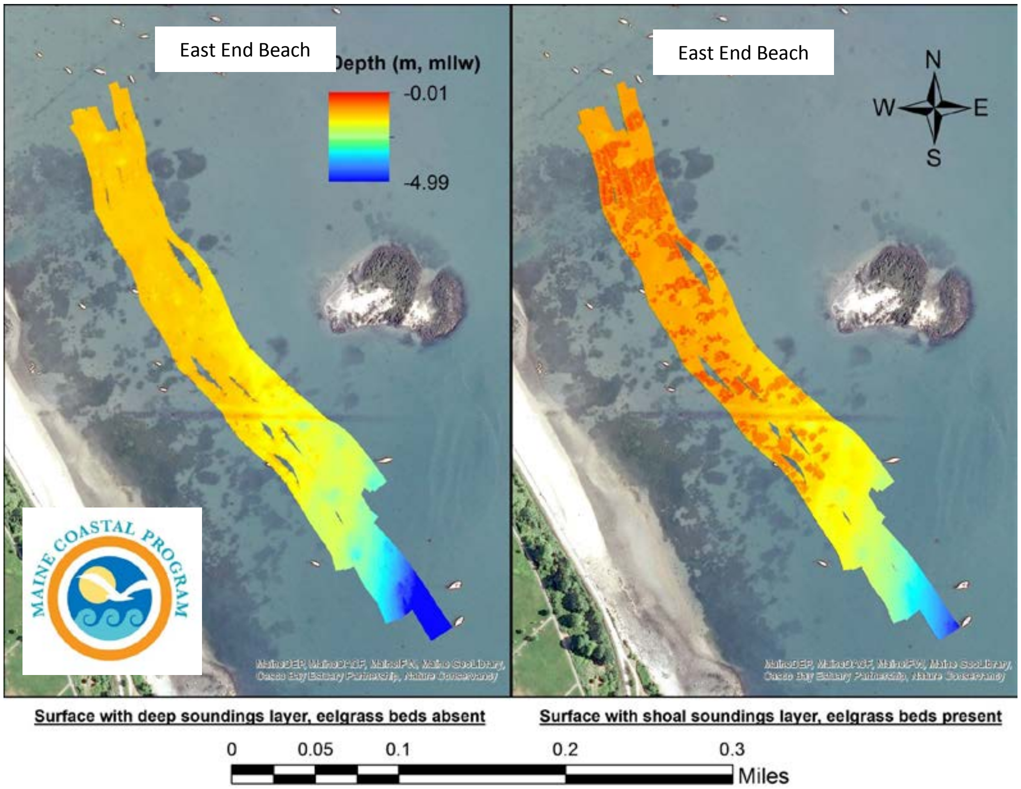


Figure 5b. Multi-beam echosounder (MBES) data show the intensity of the acoustic return (backscatter) as a measure of the substrate hardness (maps on the left), and the seafloor depth, or bathymetry (right). Abrupt changes in depth and hardness show where eelgrass is present.



Shaded geotiff of mapped eelgrass beds

Extracted eelgrass bed polygons derived from bathymetry



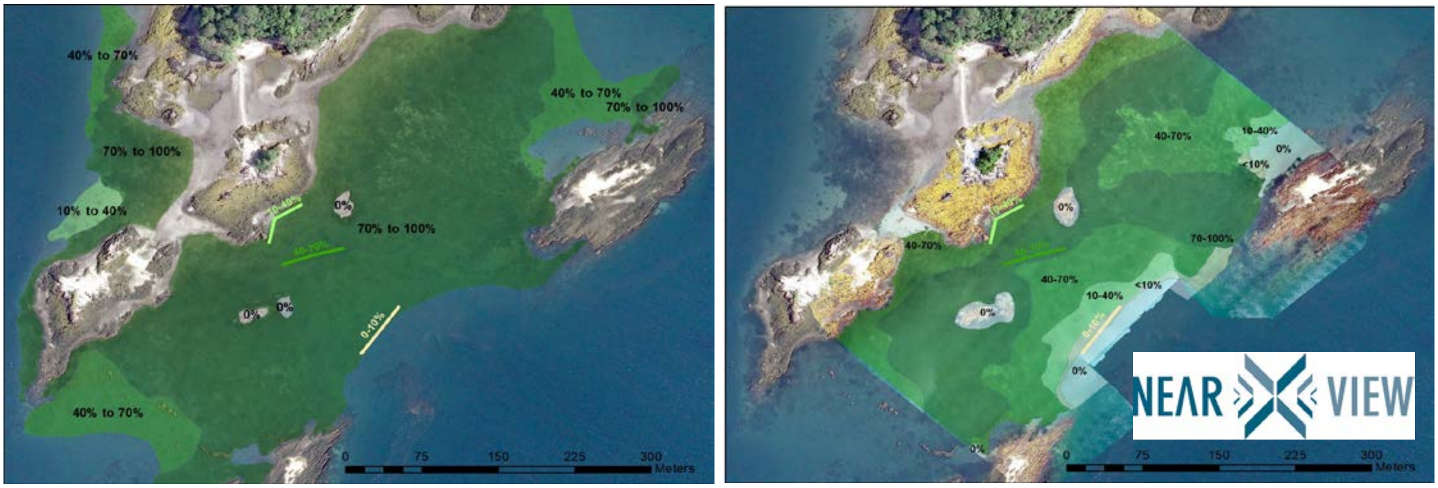
Surface with deep soundings layer, eelgrass beds absent

Surface with shoal soundings layer, eelgrass beds present

Figure 5c. Shading the MBES bathymetry layer helps visualize the differences in depth at the eelgrass beds (top left). Using differences in the maximum and minimum heights of acoustic return signals, eelgrass can be "removed" by subtracting the shoal (shallow) depth returns and retaining the deep soundings layer (bottom left). The result is a layer containing only eelgrass returns, enabling volume and height calculations (top right).

2018 DEP acquired aerial imagery

UAS acquired orthomosaic imagery



2018 DEP aerial imagery, dive survey transects, and DEP image eelgrass cover map

UAS orthomosaic, dive survey transects, and UAS image derived eelgrass cover map

Figure 6. Maps of eelgrass bed delineations derived by aerial imaging and Unmanned Aerial Survey (UAS) are shown together with the locations of DEP dive surveys. The maps show the percent cover of eelgrass as mapped a wide-scale using the aerial images, the percent covers as manually derived using the UAS high-resolution images, and dive survey percent cover transects. The differences encountered in comparing percent cover for these methods was expected because of the difference in sampling scale – while the maps derived from aerial images are meant to show large scale patterns, high-resolution UAS images were collected for only a few sample sites and thus more time and attention could be applied to fine-scale delineations.

	Aerial Images &Ground Truthing	Dive Surveys	UAS (drone) Imaging	Side-Scan Sonar	Single-Beam Sonar	MBES and grab sampling
Area Best Covered	Shallow to Mid	Entire Bed	Shallow only	Deep Edge only with current platform (Entire bed mapping possible if mounted onshallow-draft vessel)	Shallow to Mid	Deep Edge only with current platform (Entire bed mapping possible if other MBES system was mounted on shallow-draft vessel)
Logistical Feasibility	Intensive	Intensive	Intensive	Moderate	Moderate	Moderate
Logistical Considerations	Flight certifications and considerations, weather/cloud dependent, tide and turbidity dependent for both flights and ground-truthing work	Dive certification and safety, tide and turbidity dependent	UAS certification and FAA regulations, wind dependent, tide and turbidity dependent, must maintain visual contact throughout flight, requires in-depth system training and operational knowledge	Tide dependent, requires system training and operational knowledge	Tide dependent, requires system training and operational knowledge	Tide dependent, requires system training and operational knowledge
Time Needed for Data Collection	Least to Moderate (comparatively based on wider coverage area)	Intensive	Moderate	Intensive	Moderate	Intensive
Example coverage area for one day of data collection	Imaging - entire bay, plus time needed for ground-truthing	One eelgrass bed location	One eelgrass bed location	Multiple days needed to map one eelgrass bed	One eelgrass bed location	Multiple days needed to map one eelgrass bed
Post-Processing	Intensive, manual	Light to Moderate	Intensive, manual	Intensive, manual	Intensive, manual	Automated
Cost Estimate per 50 acres	$10	N/A, not a wide-scale mapping method	$1500-$3000	$1500 estimate based on student volunteer work and university costs	$1500-$3000	$1500-$4500 depending on depth (more expensive for shallower areas)
Value added information	Large scale mapping possible, percent cover	Height, percent cover, shoot density	High-res images identify SAV type, percent cover	Percent cover, relative hardness of substrate	Eelgrass height, bottom depth	Eelgrass height, percent cover, subtrate type, bottom depth, eelgrass bed volume
Other Considerations	Turbidity, Depth, and other SAV can obsure analysis	Provides data of an entirely different scale	Can only use images tied to a point on land	Learning curve for collection and processing	Best for Presence/Absence	Provides good image for deep edge and turbid waters

Table Comparison:
Mapping technologies available in Maine capable of detecting and mapping eelgrass beds are presented with a comparison of their data collection feasibility and value of the data derivatives

BioInvasions Records (2019) Volume 8, Issue 3: 598–607

Rapid Communication

First record of the encrusting bryozoan *Cribrilina* (*Juxtacribrilina*) *mutabilis* (Ito, Onishi and Dick, 2015) in the Northwest Atlantic Ocean

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Citation: Trott TJ, Enterline C (2019) First record of the encrusting bryozoan *Cribrilina (Juxtacribrilina) mutabilis* (Ito, Onishi and Dick, 2015) in the Northwest Atlantic Ocean. *BioInvasions Records* 8(3): 598–607, https://doi.org/10.3391/bir.2019.8.3.16

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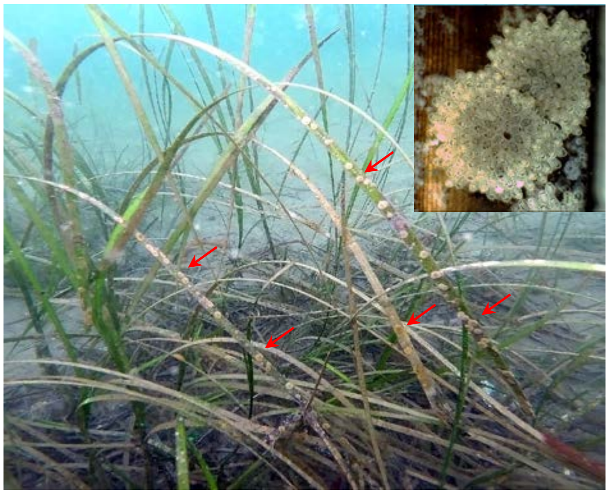
Abstract

The cribrimorph bryozoan *Cribrilina (Juxtacribrilina) mutabilis* (Ito, Onishi and Dick, 2015), originally described from Hokkaido, Japan, is reported for the first time in the Gulf of Maine and the whole of the Northwest Atlantic coast. In September 2018, numerous colonies of *C. mutabilis* were collected from eelgrass (*Zostera marina* Linnaeus, 1753) beds near Clapboard and Mackworth Islands, and Hog Island Ledge, all located within inner Casco Bay, Maine. Bryozoan colonies encrusted eelgrass, rockweed (*Ascophyllum nodosum* (Linnaeus) LeJolis, 1863), and laminarian drift algae. Situated near the discovery location, the city of Portland (Maine, USA) is an active seaport, suggesting introduction through shipping as a likely introduction mechanism. The North Sea is hypothesized to be the most probable area for the source population. Since *C. mutabilis* appears to have high potential for introduction, it likely occurs on other parts of the Northwest Atlantic coast where it has yet to be identified and recorded.

Key words: *Zostera marina,* introduced species, Cribrilinidae, zooids, Casco Bay, Gulf of Maine



Colonies of *Cribrilina (Juxtacribrilina) mutabilis* encrusting blades of eelgrass (*Zostera marina*) at Clapboard Island in Casco Bay, Maine. Red arrows point to representative colonies.

Aquatic Invasions manuscript AI19-047

Grandidierella japonica **Stephenson 1938 (Amphipoda: Aoridae) in the Northwest Atlantic Ocean**

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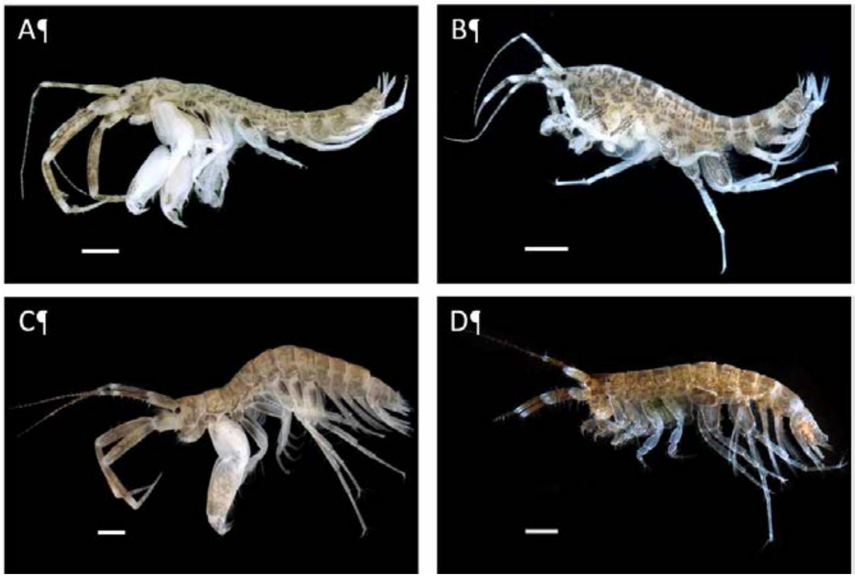
Abstract

The aorid amphipod *Grandidierella japonica* Stephenson, 1938, originally described from northern Japan, is reported for the first time from the Gulf of Maine and Long Island Sound in the Northwest Atlantic Ocean. It was discovered among grab samples of eelgrass (*Zostera marina* Linnaeus, 1753) beds taken in Casco Bay, Maine in summer 2018 and has been found intertidally in Long Island Sound since 2013 along Connecticut shores. It occurs in habitats like its native range but also in rocky areas and tidepools in bedrock. The presence of adults of both sexes, ovigerous females, and immature stages in all collections indicates the species is established. Among males, some morphological characteristics of gnathopod 1 vary with increasing total body length: the number of accessory carpal teeth increases, the carpus shape (length/width ratio) changes, and numbers of stridulating ridges increase. Maine and Connecticut specimens are distinguished from each other by the shape of male gnathopod 1 basis. Morphological variation, temporal differences in discovery, and separation by the biogeographic barrier Cape Cod suggests Maine and Connecticut populations originate from separate introductions.



Grandidierella japonica from the Northwest Atlantic, U.S.A. (A) Male, Macworth Island, Maine. (B) Female, Macworth Island, Maine. (C) Male, Savin Rock, Connecticut. (D) Female, Thimble Islands, Connecticut.