Seafloor Classification of Area Adjacent to Maryland Wind Energy Area

Robert D. Conkwright, Stephen Van Ryswick, and Elizabeth R. Sylvia

Maryland Geological Survey
Department of Natural Resources
2300m St. Paul St.
Baltimore, MD 21218
http://www.mgs.md.gov

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A DVD data disc containing GIS data sets and media files accompanies or is available for this report.

Executive Summary

Maryland Geological Survey performed seabed analysis of acoustic seafloor survey data as part of a continuing effort to characterize bottom habitats for the potential transmission lines associated with the offshore Maryland Wind Energy Area. The study area in combination with two survey blocks surveyed and classified by MGS in 2011 and 2012 as well as an area surveyed by USGS in 2014 will provide a comprehensive seabed classification between the Maryland Wind Energy Area and the Maryland coastline. The 2011 MGS survey extended from Ocean City Inlet north approximately 3.8 nautical miles (7 km) to 68th Street. The 2012 MGS survey covered the ocean floor from 66th Street to 131st Street, about 3 nautical miles (5.6 km). Both of these surveys extended out to the 3-mile state limit. The total area analyzed for this project was approximately 98 square miles (253 square kilometers). Survey data analyzed include side scan sonar imagery, acoustic seabed classification, and multi-beam bathymetric data sets. The survey goal was to identify the surface substrate classes, i.e. surface sedimentary characteristics, which form the environment in which benthic communities develop.

The surveys revealed a dynamic seafloor composed of primarily sand deposits, highly variable in grain size and aerial distribution, and outcrops of subsurface mud deposits. Coarse sand and gravel deposits were also mapped. The surface substrate classes were classified using the CMECS substrate classification for unconsolidated mineral substrate. Sediment grain size is in part determined by wave and current activity, source sediment availability, antecedent topography, slope and depth. Ultimately it is the interaction of available water column energy with seafloor sediments that dictate the physical substrate available for benthic organism support.

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Introduction

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In 2011, a series of roughly 3-mile by 3-mile square survey blocks was laid out along the Maryland coastline, extending from the shoreline out to the 3-mile state limit, from Ocean City inlet to the Maryland / Delaware border. Block 1, covering the seafloor from Ocean City Inlet north to 68th Street, was surveyed in May, 201l. Block 2 was surveyed in May, 2012, and covered the ocean floor from 66th Street to 131st Street. These survey blocks in combination with a study area to the East surveyed and analyzed by USGS in 2014 left a significant area unclassified between the USGS study area and the Maryland Wind Energy Area (MWEA) to the East. Figure 1 shows the study area marked as CCS Target with the USGS 2014 survey area to the West and the MWEA to the East. The total CCS target area analyzed for this project was approximately 98 square miles (253 square kilometers). Survey data analyzed include side scan sonar imagery, acoustic seabed classification, and multi-beam bathymetric data sets.

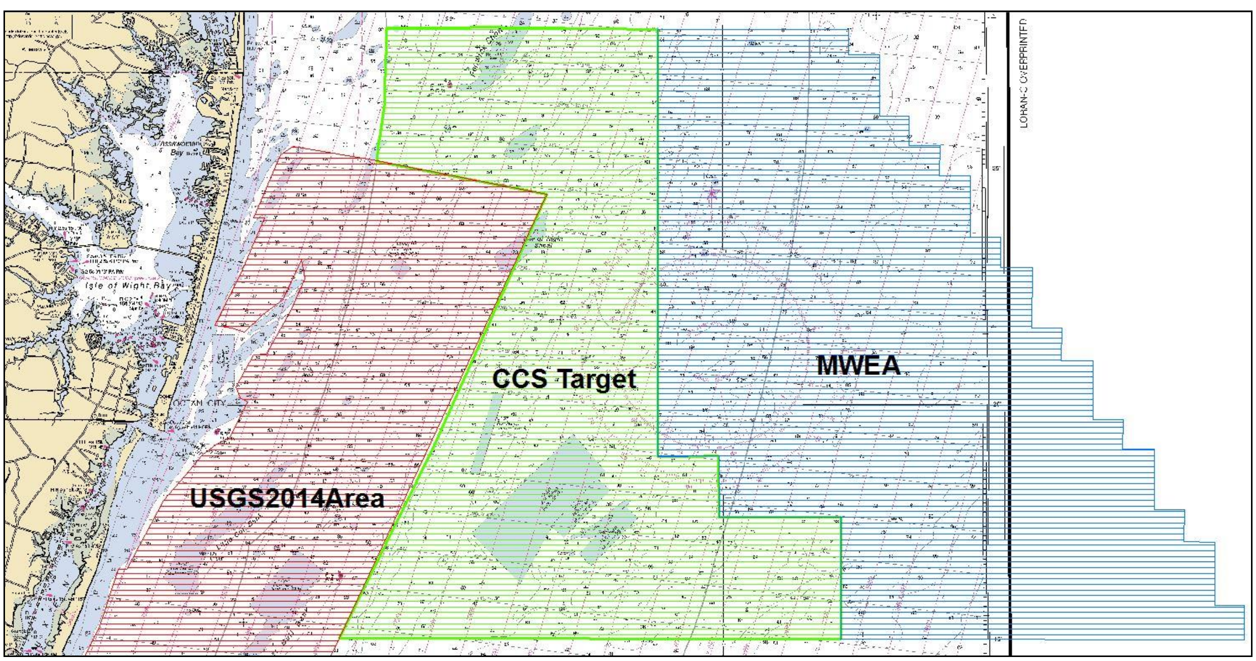

Figure 1: Study area marked as CCS Target with USGS 2014 survey area to the West and the Maryland Wind Energy Area to the East

Field Methodology

Survey Parameters

The field surveys were conducted for NOAA by SAIC on board M/V Atlantic Surveyor. Full reports and associated files are available for download at https://data.noaa.gov/dataset. Sheet H11649 was surveyed from August 17, 2007 to November 18, 2007. Sheet H11650 was surveyed from September 29, 2007 to November 18, 2007. Sheet H11872 was surveyed from July 16, 2008 to December 19, 2008. Sheet H11873 was surveyed from October 13, 2008 to December 18, 2008.

Positional data was supplied using the M/V Atlantic Surveyor's onboard GPS and depth sounding system. Horizontal coordinates were collected using a Trimble 4000 survey-grade GPS receiver with Trimble Probeacon Differential Global Positioning System (DGPS). The vessel altitude was acquired using TSS POS/MV Inertial Navigation System using TSS POS/MV 320.

Bathymetric Echosounder

Raw bathymetric data were collected using a RESON SeaBat 8101 ER multibeam sonar system. DGPS differential corrections broadcast by the United States Coast Guard (USCG) in combination with GPS satellite data provide a horizontal accuracy of 1 meter. The data was processed using an 81P sonar processor. Speed of sound corrections were provided using Brooke Ocean Technology, Ltd, Moving Vessel Profiler-30 in conjunction with a Sea-Bird Electronics, Inc. SBE 19 CTD Profiler

Side Scan Sonar

A Klein 3000 side scan sonar system was used to image the seafloor. The underwater sensor (fish) was adjusted to depth throughout the survey. Side scan data was logged in eXtended Triton Format (XTF) and maintained at full resolution.

Analytical Methods

Bathymetry

All depth data presented in this study were referenced to MLLW at the Ocean City Fishing Pier. All processing and corrections were completed prior to MGS acquisition of the dataset from NOAA. No post corrections were required.

Side scan sonar mosaic

Side scan sonar data were processed using Chesapeake Technology's SonarWiz 5 software. This software generates georeferenced side scan sonar mosaics and track line geometry. The mosaics

(.tif format) represent an image of the seafloor, based on surface sediment acoustic reflectivity. The side scan data sets for all sheets were combined into a single SonarWiz project to produce a compiled mosaic image. The .tif mosaic raster image was classified using ESRI ArcGIS using the maximum likelihood classification processor. Images (.bmp format) of the seafloor along each individual trackline are also produced, but are not georeferenced. These “waterfall” images are free of the typical distortions introduced by georeferencing, and are the highest resolution seafloor imagery available from this software.

GIS Products

GIS data were compiled with ESRI ArcGIS Desktop 10.2.2. All GIS coordinate data were projected to UTM 18N (WGS 1984). Final map products and data layers are available in various ArcGIS and graphic formats.

Results

The study area covered portions of four NOAA survey sheets. The area covered was 98 square miles (253 km^2). The study area in relation to the NOAA survey sheets is shown in Figure 2.

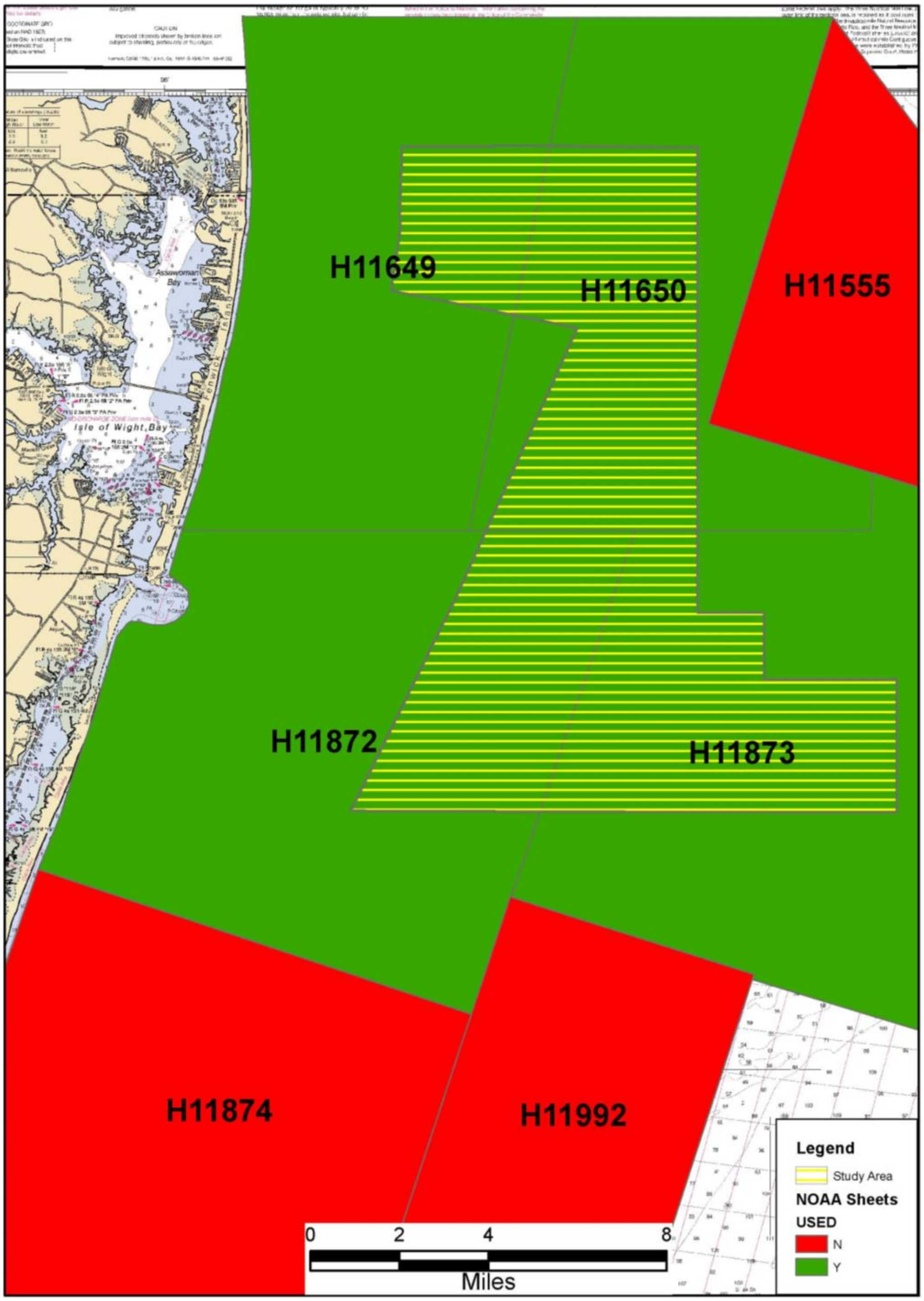

Figure 2: Study area in relation to NOAA Sheet survey blocks

Bathymetry

Figure 3 shows a bathymetric map of the survey area. Data were derived from published NOAA datasets available from the NOAA Geophysical Data Center. Bathymetry was collected between 2007 and 2008 using a Reson SeaBat 8101 multibeam echosounder. Data were corrected to mean lower low water and projected in UTM 18N (meters) NAD83. This data set was used to create a hillshade bathymetric map as well as 1 meter contours (Figures 3 and 4).

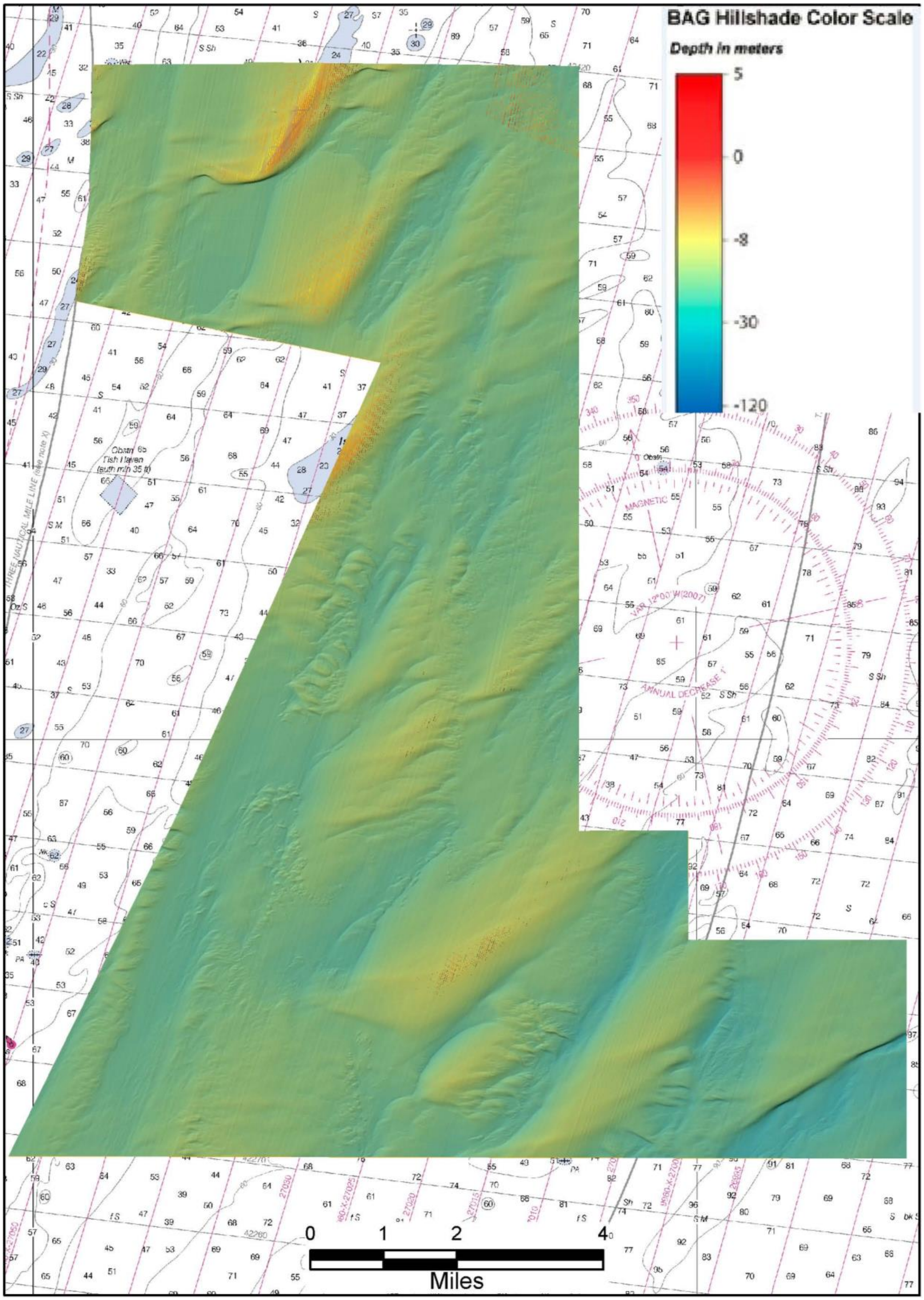

Figure 3: BAG hillshade bathymetry from NOAA BAG data sets (MLLW)

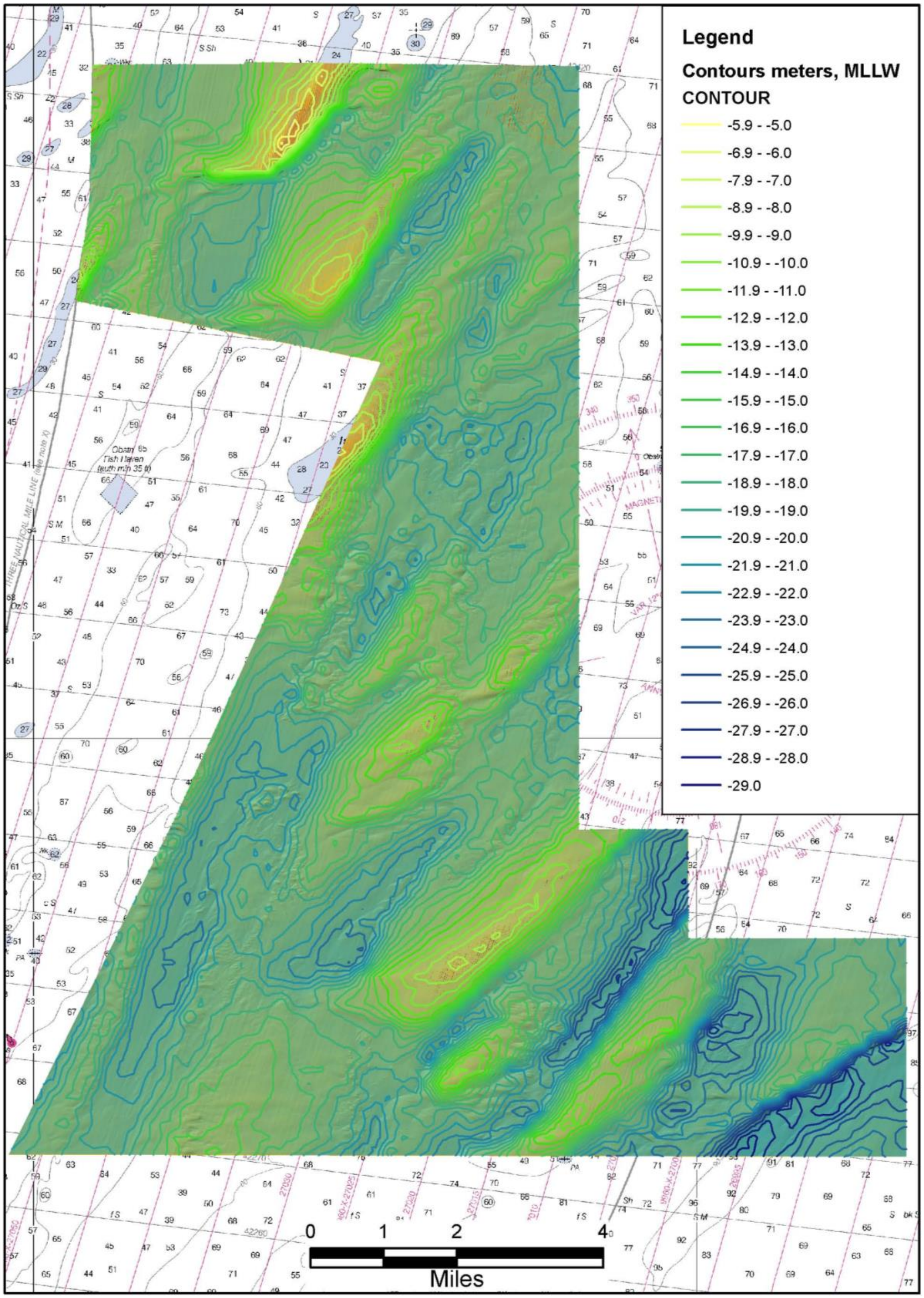

Figure 4: -1 meter bathymetric contours from NOAA BAG data sets (MLLW) overlying the hillshade

Side Scan Sonar

The side scan sonar mosaic is presented in Figure 5. In this rendering darker areas are low-backscatter/fine sediments and lighter areas are higher-backscatter/coarser sediments. Figure 6 shows this mosaic with -1 meter contours to demonstrate the relationship between depth and bottom features.

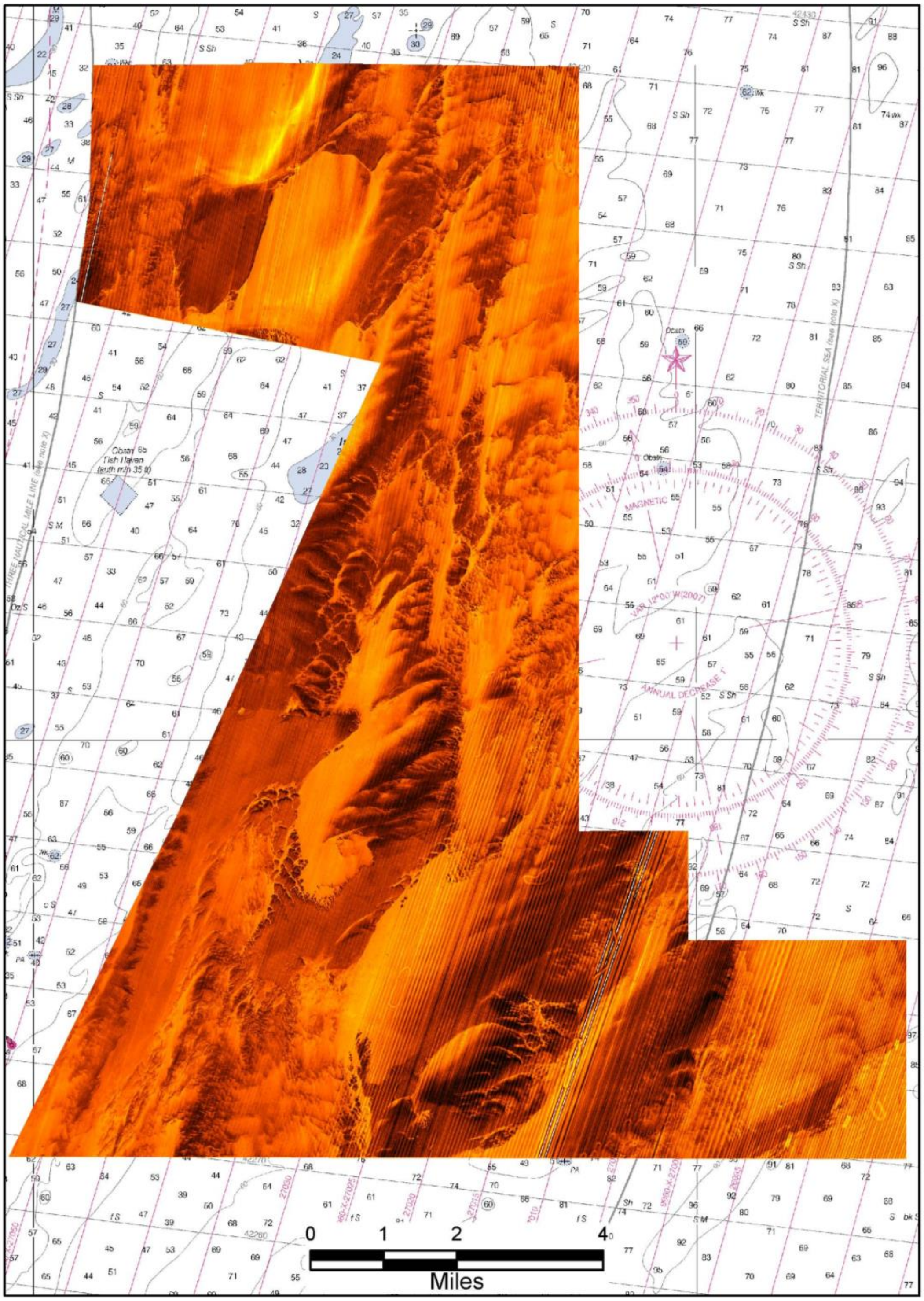

Figure 5: Study area side scan mosaic

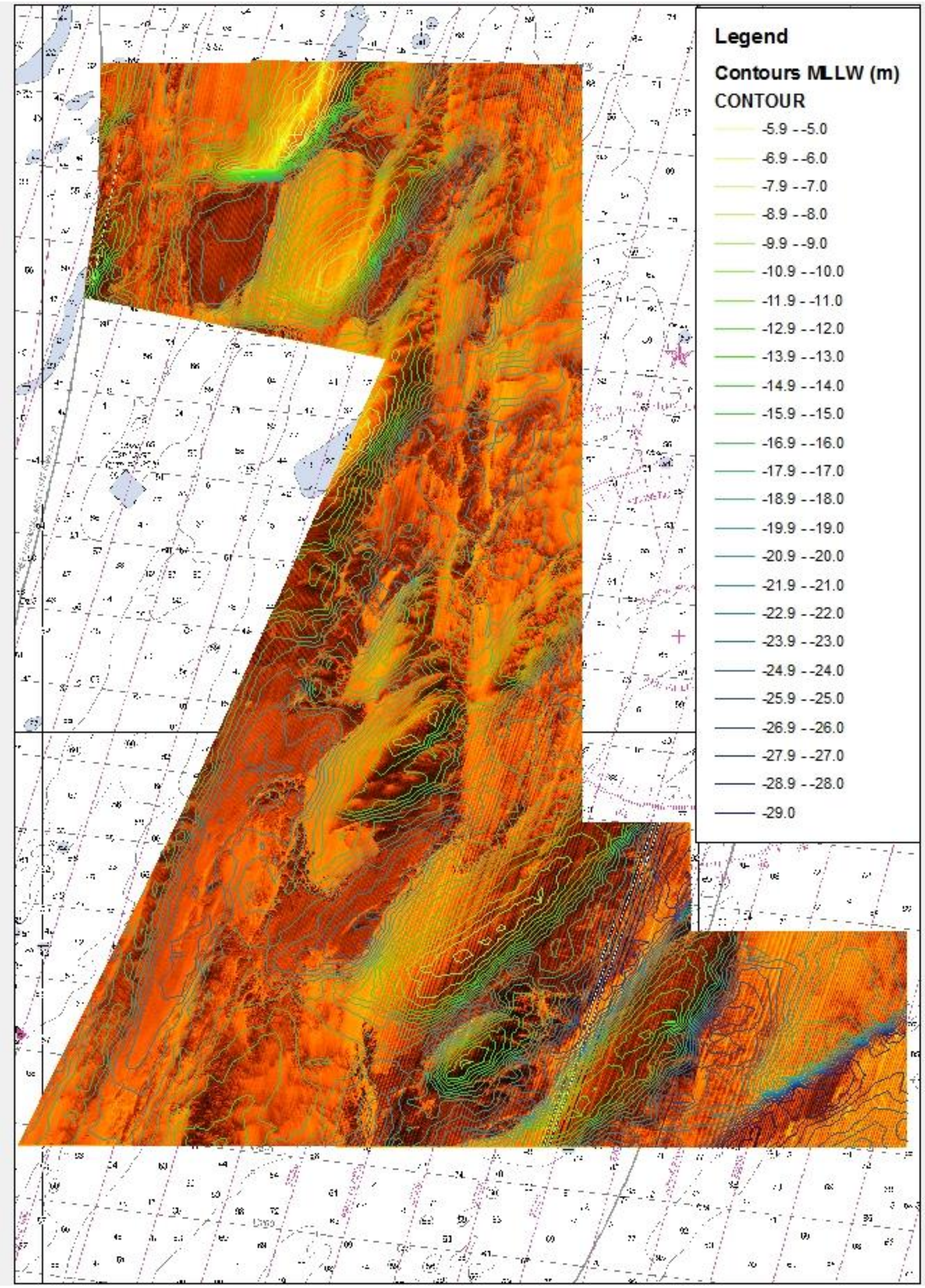

Figure 6: Side scan mosaic with -1 m bathymetric contours (MLLW)

Acoustic Seabed Classes

Bottom sediment composition is influenced by bottom geomorphology, water depth, substrate composition and biologic activity. The interaction of these factors with water column energy, such as waves and currents, determines in part the seafloor surface composition. Sediments often range from mud and muddy sand to coarse sand and gravel over an area of a few meters.

The compiled side scan sonar mosaic raster was classified using Image Classification in ArcGIS Spatial Analyst. The classification software extracts information classes from the multiband mosaic raster image to produce a raster image that represents bottom classes with graded colors. Two supervised classifications were performed to create rasters with four and six classes based on the training samples signature files and are shown in Figures 8 and 9 respectively. A similar process can also be performed using SonarWiz 5 with the exception that SonarWiz analyzes each sonar line file individually. The data set for this project was too large for SonarWiz processing. A comparison of the side scan mosaic, Sonar Wiz 5 classification, and the ArcGIS classifications are shown in Figure 7. The classification analysis of the side scan raster data indicated that a combination of the four and six class classification rasters be used. This resulted in an optimum number of acoustically distinct bottom types in this area of seven. By grouping some similar classes that were in both the four and six class rasters together, eliminating signal noise, and integrating small, distinct classes into surrounding larger classes, the seven major bottom types emerged. These types were correlated with bottom grab samples and bathymetry to produce a map of bottom classes, based on dominant sediment types. Table 1 lists grab sample characteristics and sample locations are shown in Figure 10.

By comparing the acoustic raster analysis with bottom samples, side scan imagery and bathymetry, patterns of sediment types become evident. The seafloor bottom types were digitized in ArcGIS to indicate the areas of distinct bottom classes. Each class was then classified based on the Federal Geographic Data Committee (FGDC) Coastal and Marine Ecological Classification Standard (CMECS) substrate classification for unconsolidated mineral substrate. Figure 11 shows the bottom class map for the five Substrate Group classes derived from these various data sources. The bottom class map for the Substrate Sub Group breaks the sand bottom class in the Substrate Group further into coarse, medium and fine sand classes. The resulting Substrate Sub Group bottom class map contains seven bottom classes and is shown in Figure 12.

These classes are necessarily broad due to the highly variable surface sediment composition. The classification process attempts to select the dominant acoustic class in a given area, which may contain several acoustic classes. The square kilometer area of each class as well as the percent of the survey area covered is shown in Table 2. In the surveyed region, surface sediments in the Substrate Sub Class tend to group into seven classes. The Substrate Group is listed in parenthesis.

1- Slightly gravelly sand (slightly gravelly)
2- Coarse sand (sand)
3- Medium sand (sand)
4- Fine sand (sand)
5- Silty sand (muddy sand)

6- Sandy silt (sandy mud)
7- Silty clay (mud)

The ‘slightly gravelly sand’ class describes a seafloor that is predominantly coarse to very coarse sediment, including coarse sand, gravel and pebbles. This class is interpreted to represent lag deposits left behind when water column energy moves finer sediments out of the area. Muddy sediments may be present in small amounts, usually less than 5%, particularly where the coarse sediments form a relatively thin layer over underlying mud. Bed forms in this class tend to be in the several-meter range, including megaripples and sand waves. Typically, bedforms are not well-developed; therefore this class can produce a relatively featureless side scan image. This class makes up about 15% of the study area.

The ‘sand’ Substrate Group class is a catch-all class that contains well-mixed sediments from fine to coarse sand that covers 78% of the study area. The Substrate Sub Group classification breaks the sand group into three sub groups. The ‘coarse sand’ class covers 22% of the study area and is found in similar energy and depth environments as the ‘slightly gravelly sand’ class with slightly less reflectivity and may contain small gravel near transitions to coarser sediments.

The ‘medium sand’ and ‘fine sand’ classes are dominated by medium to fine sand, with varying amounts (less than 5%) of shell hash and/or mud. The ‘medium sand’ class typically exhibit ripples with a wavelength of a meter or less and covers about 20% of the study area. The ‘fine sand’ class covers 36% of the study area with bedforms that are generally on a scale of a few meters or less, and can have more complex ripple patterns than the ‘medium sand’ class. These sediments are finer than the ‘coarse sand’ class, and are readily mobilized by water column energy. They tend to migrate in the direction of prevailing currents and wave propagation, and can overrun underlying muddy beds or coarser sediments.

The remaining three classes, ‘silty sand’, ‘sandy silt’ and ‘silty clay’, cover less than 7% of the study area combined with increasing amounts of fines and mud respectively. The ‘silty sand’ class consists mostly of silt and fine sand in the transitional areas between ‘fine sand’ and ‘sandy silt’ bottom classes. The ‘sandy silt’ and ‘silty clay’ classes occur mostly as narrow deposits that trend in a southwest to northeast direction, and are primarily associated with the deeper swales between sand ridges covering only 0.79% and 0.13% respectively. The muddy sediments are interpreted as outcrops of ancestral coastal bay deposits. Muddy sediments tend to be cohesive below the seafloor surface and probably do not migrate much. Near-surface mud is often loosened and mobilized by infaunal and epifaunal processes, and subsequently transported by water column energy. This suspended fine sediment will eventually, if temporarily, be deposited in lower-energy habitats. Typically the ‘silty clay’ mud class does not display obvious bedforms, but most often presents a dark, mottled appearance in the side scan mosaics. Bottom features in muddy areas are often associated with benthic communities, such as tube worm, tunicate, or sponge colonies, cold-water corals, etc.

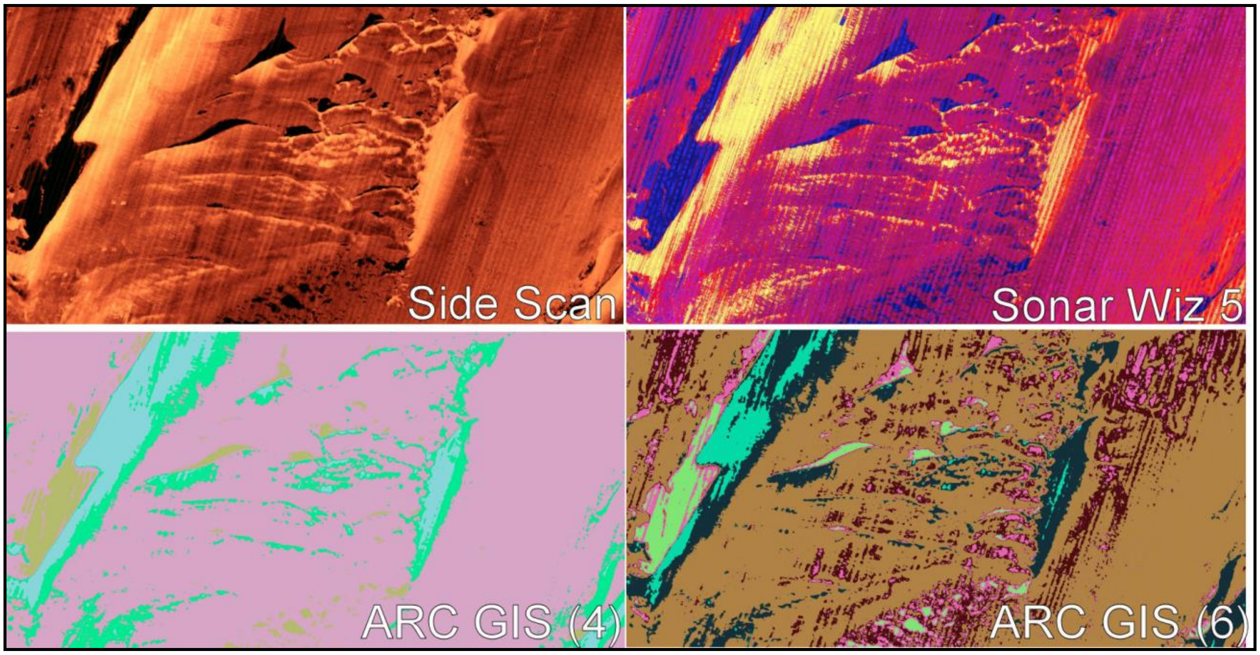

Figure 7: An example of the relationship of SonarWiz 5 seabed classification to ArcGIS raster classification with four and six classes compared to the side scan mosaic raster

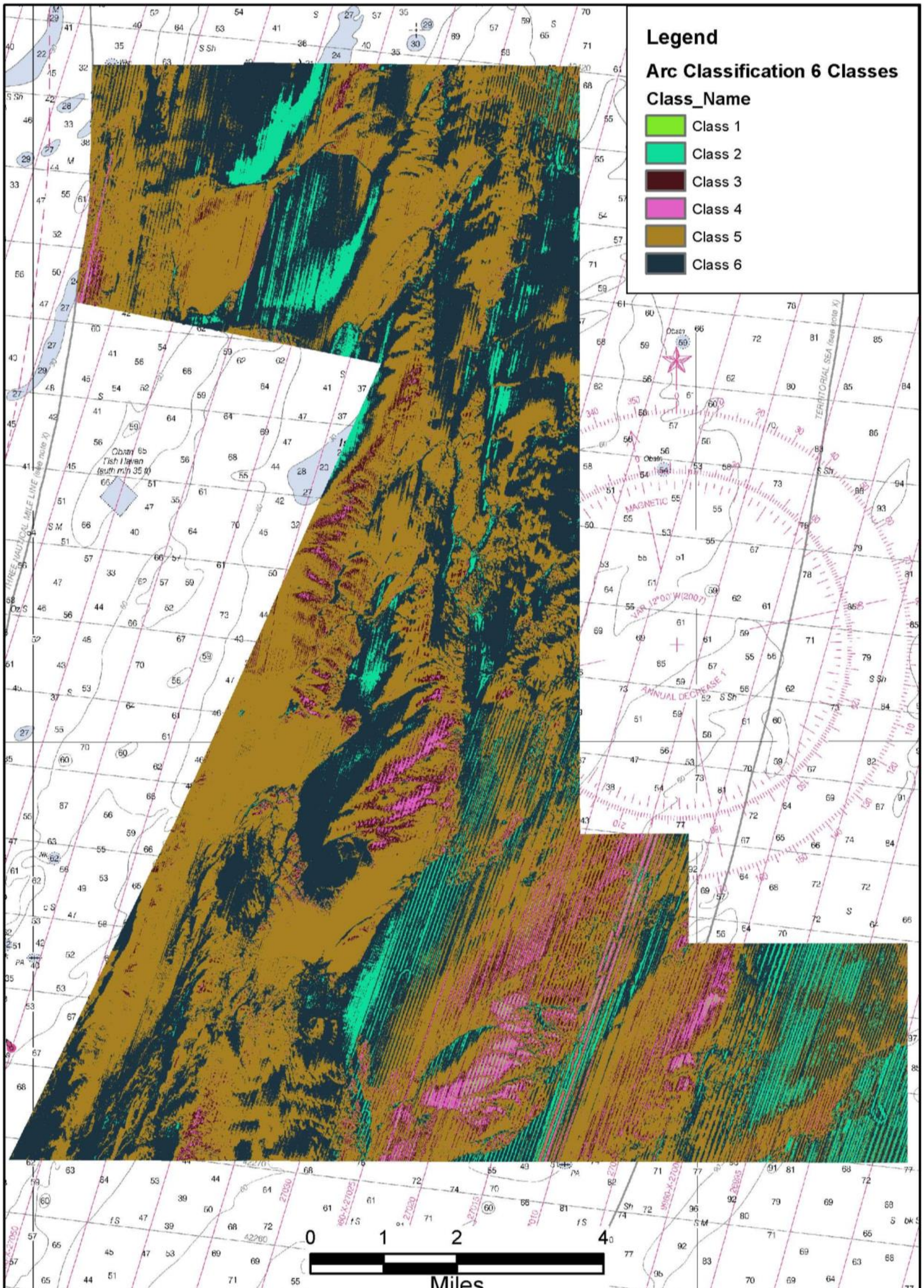

Figure 8: ArcGIS maximum likelihood classification of the side scan mosaic for six classes

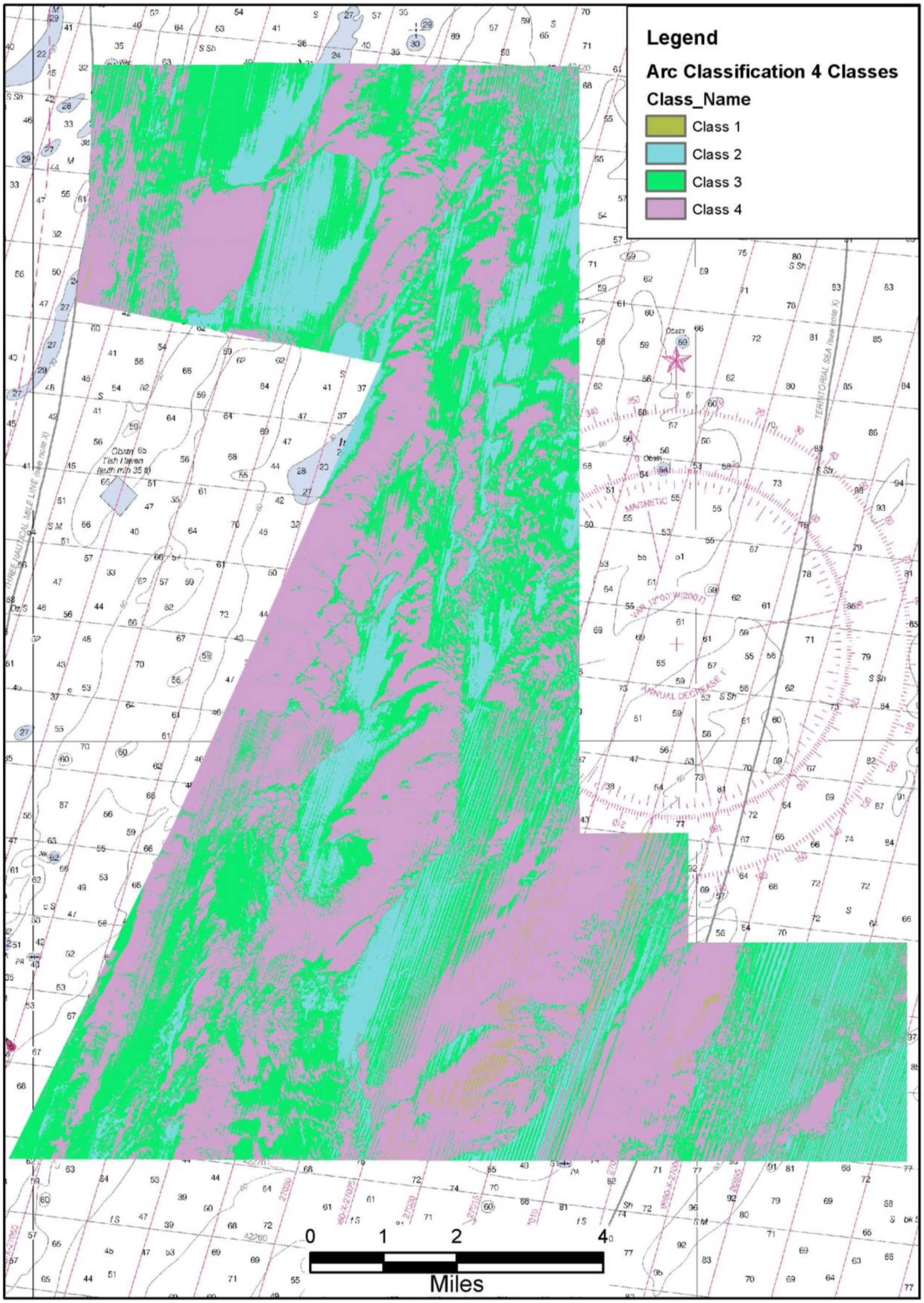

Figure 9: ArcGIS maximum likelihood classification of the side scan mosaic for four classes

Table 1: Bottom sampling locations and grab sample descriptions

Block ID	Sample	NAD83 Latitude	Longitude	UTM NAD83 (m) Northing	Easting	Bottom Type	Depth (m)	Charted Bottom
11649	BS-16	38.429361	74.98075	4253455.45	501680.20	med S Sh	14.18	S Sh
11649	BS-10	38.459556	74.975806	4256805.94	502110.88	fne S Sh	17.15	S Sh
11650	BS-4	38.460111	74.908861	4256871.24	507951.50	med S	14.07	S Sh
11650	BS-5	38.458361	74.870472	4256681.07	511301.05	med S Sh	19.33	S Sh
11650	BS-8	38.451861	74.877667	4255958.97	510674.30	med S fne G	17.67	h
11650	BS-9	38.436444	74.929972	4254243.56	506111.64	crs S med G	13.74	S Sh
11650	BS-10	38.427417	74.871944	4253247.28	511177.37	fne S	15.28	S Sh
11650	BS-12	38.374556	74.924083	4247376.79	506631.24	fne S	13.87	S
11650	BS-13	38.3435	74.920361	4243931.18	506959.34	crs S fne G	17.26	S Sh
11650	BS-14	38.344222	74.890278	4244014.01	509588.12	fne S	15.79	S Sh
11872	G_BS-7	38.342722	74.890639	4243847.53	509556.76	medS brkSh	14.67	S Sh
11872	G_BS-8	38.317833	74.925	4241082.91	506556.28	medS brkSh	16.12	c S
11872	G_BS-16	38.259778	74.962889	4234639.19	503246.73	medS brkSh	17.67	f S

Table 2: Area of seafloor bottom types and percent of study site covered for CMECS Substrate Group and Substrate SubGroup

Substrate Group	Area (sq. km)	Percent		Substrate SubGroup	Area (sq. km)	Percent
Slightly Gravelly	37.48	14.80		Slightly Gravelly Sand	37.48	14.80
Sand	198.23	78.29		Coarse Sand	55.30	21.84
Muddy Sand	15.16	5.99		Medium Sand	51.71	20.42
Sandy Mud	2.01	0.79		Fine Sand	91.22	36.03
Mud	0.32	0.13		Silty Sand	15.16	5.99
				Sandy Silt	2.01	0.79
				Silty Clay	0.32	0.13

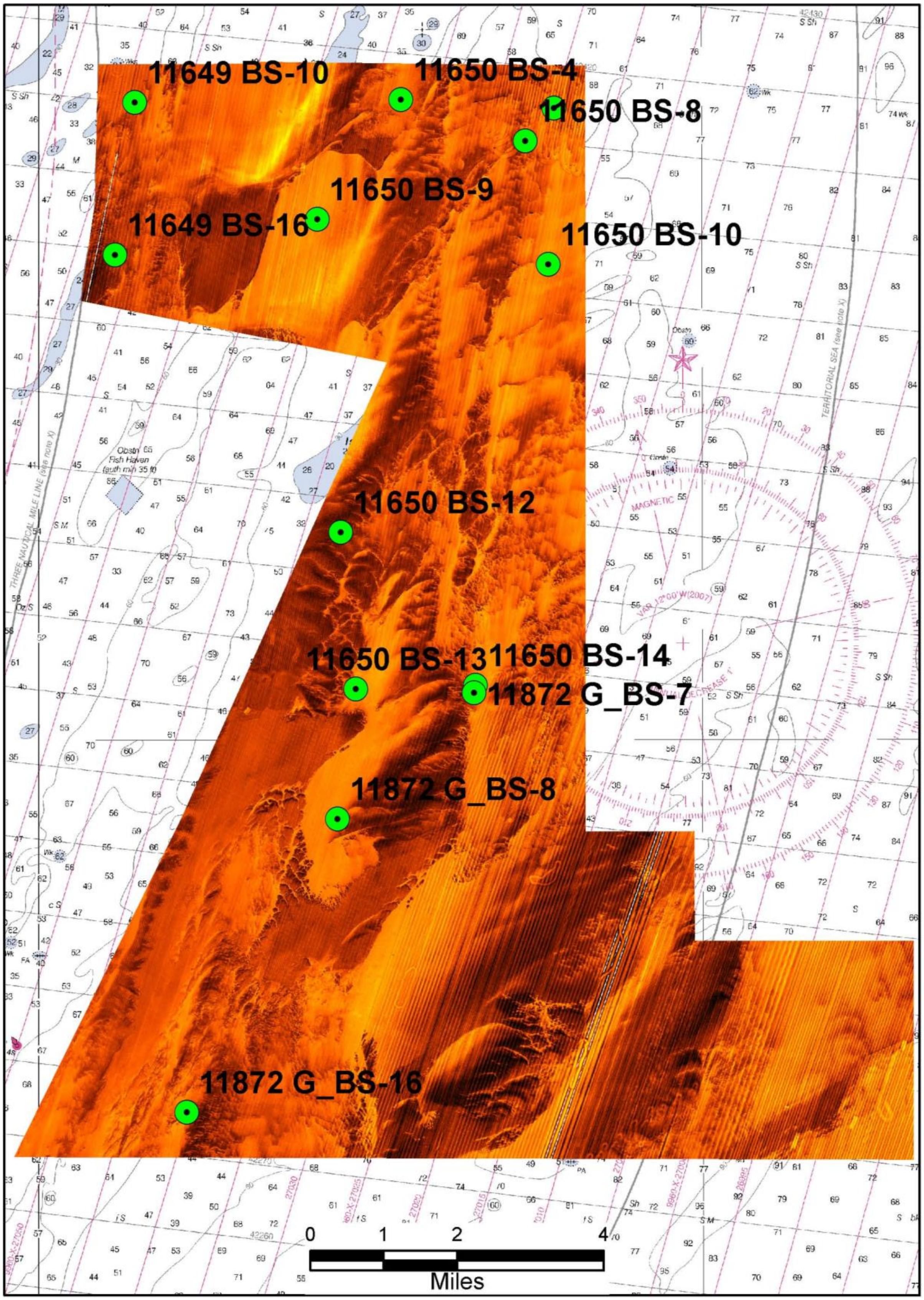

Figure 10: Grab sample locations

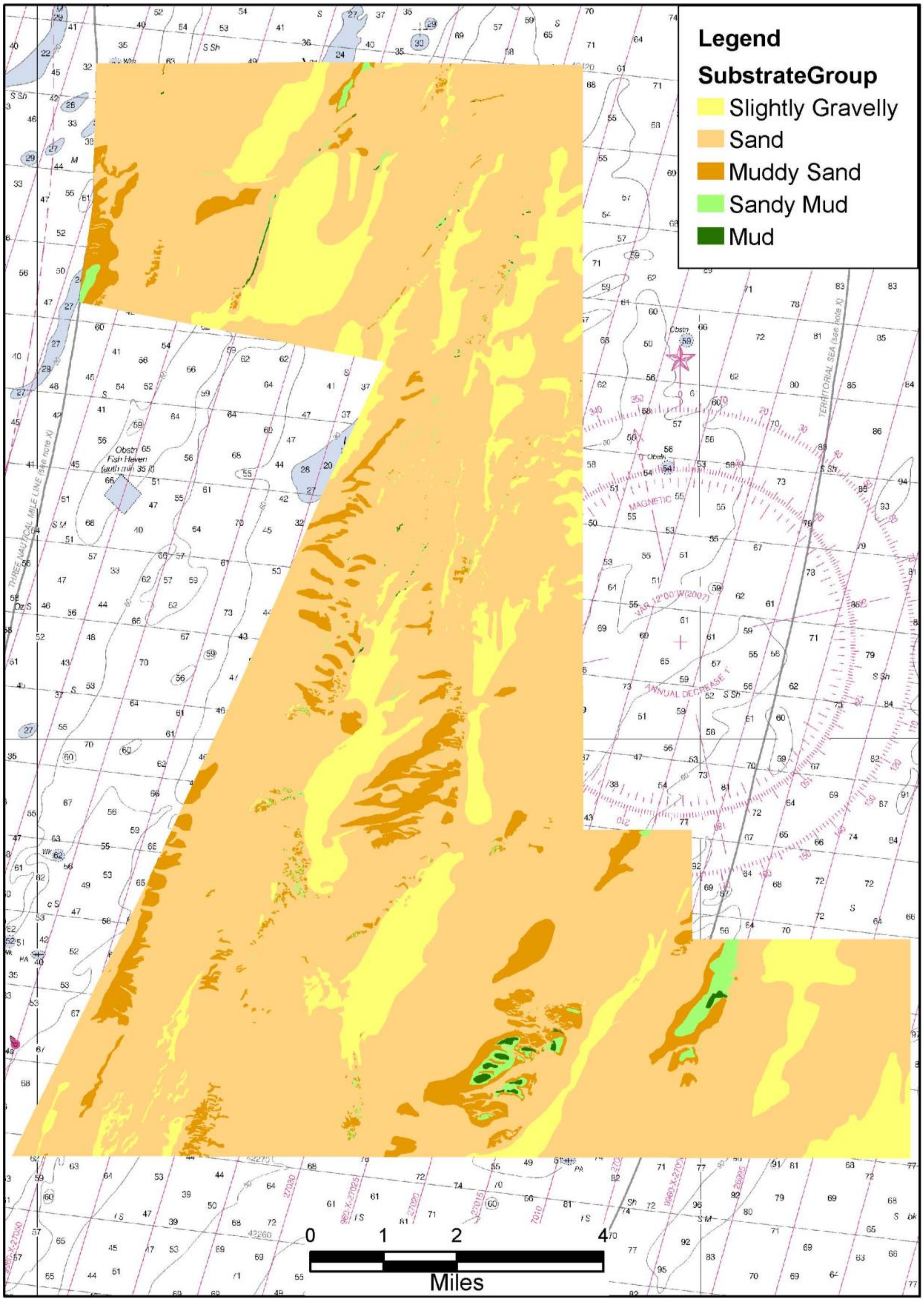

Figure 11: Seafloor bottom types in Substrate Groups classes

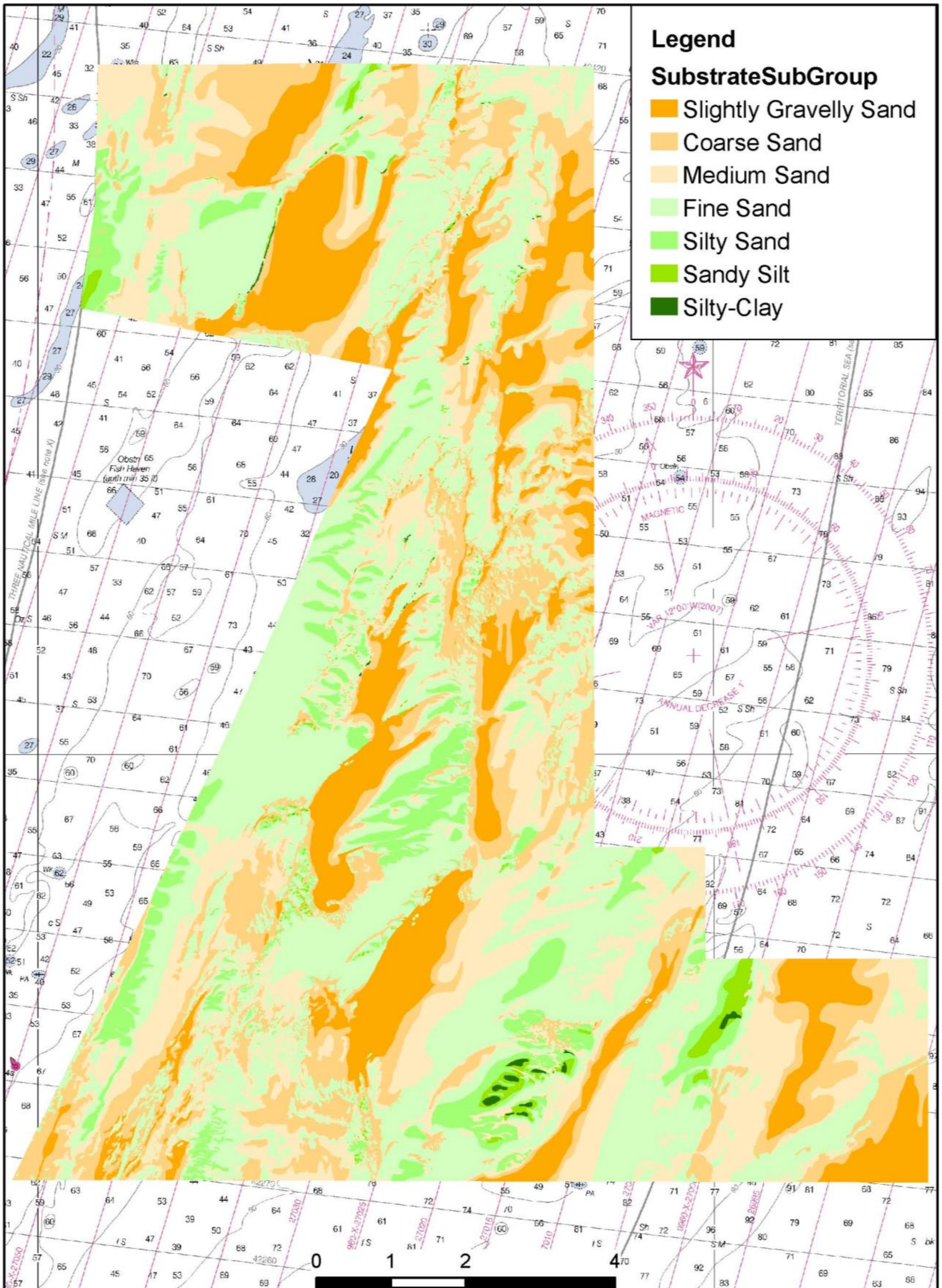

Figure 12: Seafloor bottom types in Substrate Sub Group classes

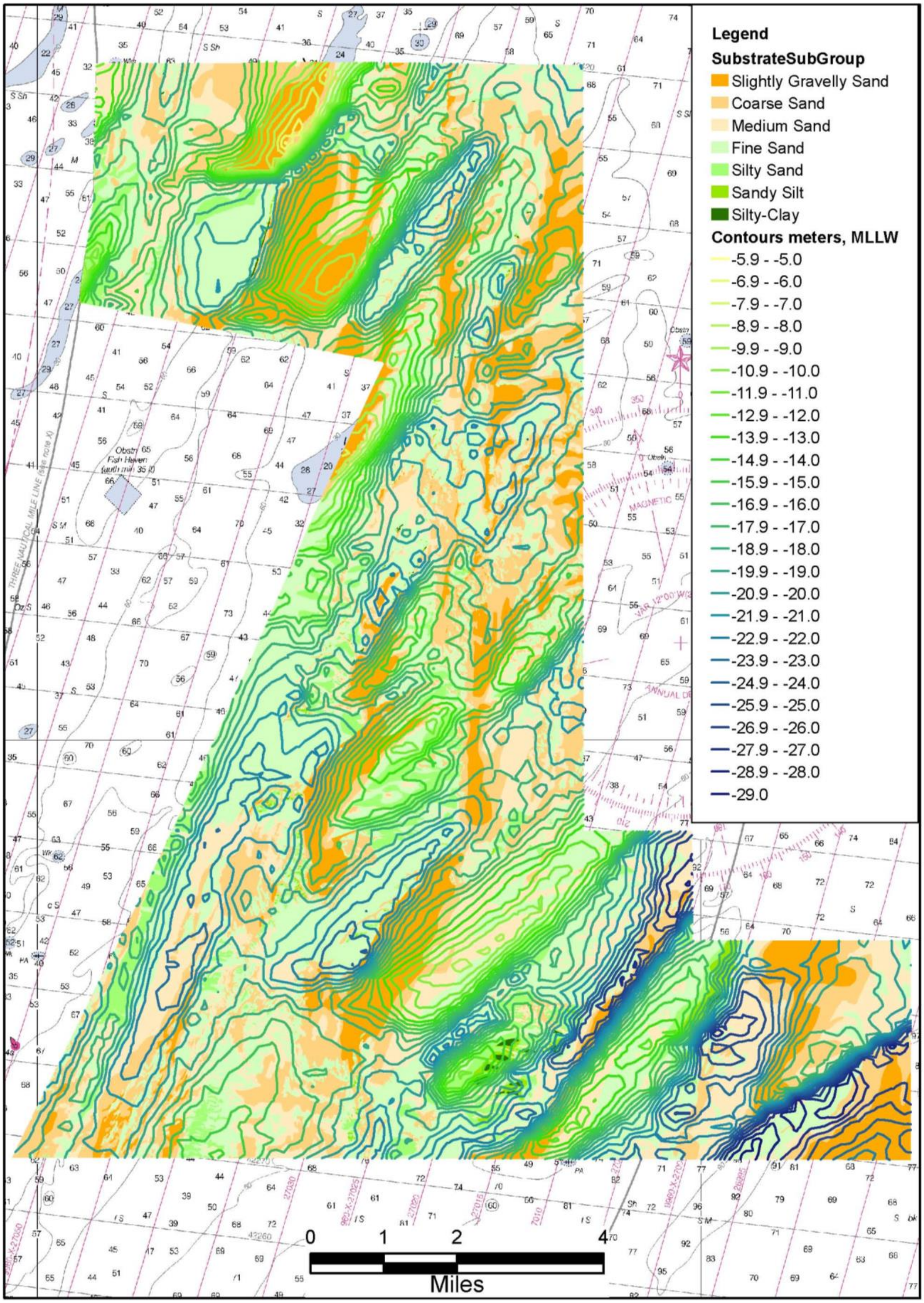

Figure 13. Seafloor Sub Group bottom types with -1m contours overlaid

Summary

The study area seafloor adjacent to the Maryland Wind Energy Area is highly dynamic, displaying a variety of surface features and sediment types. The study area is dominated by sands with 15% gravelly sand, 78% fine to coarse sand, and 7% silty sand to clayey mud. The sands fine to coarse sands were separated into fine, medium and coarse which coverage of 36%, 20% and 22% respectively. Of the 7% classified as silty sand to clayey mud, only 1% of the study area contains silty mud and clayey mud. The most mobile sediment classes appear to be the fine and medium sand and non-cohesive mud, (which is not a formal class). Fine- to medium- sand bodies exhibit several bedforms, and form sheet and ribbon deposits on the seafloor surface. These deposits can migrate over relatively short periods, from days to weeks, depending on available water column energy. Non-cohesive mud is highly mobile, suspended by relatively little water column energy and deposited in low energy environments. This mobile, very fine sediment is probably derived from cohesive mud outcrops that are reworked by infaunal and epifaunal activity, which exposes the mud to wave and current motion. It forms ephemeral surface deposits in the troughs of bedforms and other low areas, tends to be aerially limited to less than a few square meters, and is readily resuspended.

The least mobile classes are coarse sand, slightly gravelly sand and cohesive clayey mud. Coarse sediments tend to form lag deposits because they require more energy to mobilize than is ordinarily present in the regional water column. Only during extreme conditions is there enough current or wave energy to move coarse material. These coarser sediments were found predominantly on the crests of shoals. The cohesive clayey mud, mostly found in bottom outcrops in deeper water, resists mobilization due its cohesiveness.

Generally, the clayey silt to fine sand classes are associated with deeper water and swales between ridges. The sand Substrate Group class, which is highly mixed and heterogeneous, can occur at all depths, since it is formed in mixed-energy environments and as a transitional class between coarse and fine sediment-dominated areas. The coarse sand and slightly gravely sand classes are found in elevated areas, slopes and channels where there is sufficient energy to winnow fine and medium sand, leaving the coarser fraction in place.

References

[1] Coastal and Marine Ecological Classification Standard. *Federal Geographic Data Committee* (2012): 276. July 2012. Web

Appendices

I. GIS data supplement to this report

Appendix I: GIS data supplement to this report

A DVD containing GIS data sets and images accompanies, or is available for, this report. The following items are included.

ArcGIS 10.2.2 file geodatabase:

- OffshoreWindHabitats.gdb
    -

ArcGIS 10.2.2 map file for use with geodatabase:

- OffshoreWindHabitats.mxd

ArcGIS 10.2.2 shape files derived from geodatabase:

- Contours1mMLLW
- NOAA_Samples

Side scan sonar mosaics:

- SideScan_OffshoreWindCompiled.tif: 1-meter resolution, UTM 18N (WGS84)

Ground-truth data:

- NOAA_Samples_Target.shp: Sample locations and descriptions

Seabed classification rasters:

- Arc Classification 4 Classes.tif: ArcGIS 10.2.2 raster classification, 4 bottom classes, TIF format
- Arc Classification 6 Classes.tif: ArcGIS 10.2.2 raster classification, 6 bottom classes, TIF format

Layers:

- ArcGIS 10.2.2 layer files for geodatabase display

Navigation chart:

- NOAA Navigation chart 12211_1, Cape Henlopen to Fenwick Island