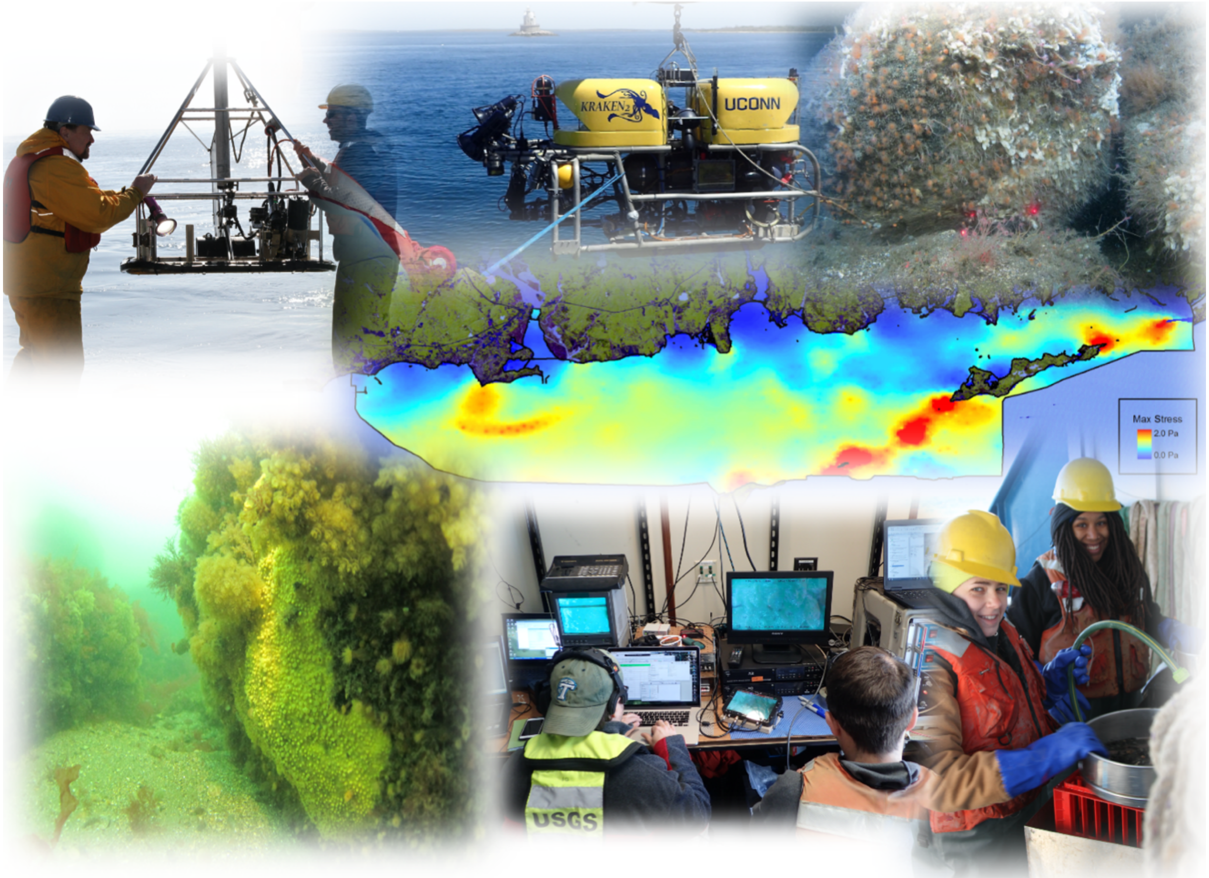
`The Long Island Sound Habitat Mapping Initiative Phase II – Eastern Long Island Sound



Final Report

Submitted by:
The Long Island Sound Mapping and Research Collaborative
(LISMaRC)

August 23, 2021

Long Island Sound Study
A Partnership to Restore and Protect the Sound

Connecticut Department of
ENERGY & ENVIRONMENTAL PROTECTION

3.0 SEDIMENT TEXTURE AND GRAIN SIZE DISTRIBUTION

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3.1 Objective

Sediment texture, which includes shape, size and three-dimensional arrangement of sediment particles, is an essential element of any habitat classification. Gravel, sand, mud and various mixtures of these major grain size classes provide very different habitats (Galparsoro et al., 2013). Besides its importance for habitats, the surface sediment classification is a key element for managing different resources in LIS. In fact, different bottom types can themselves be considered a valuable resource (e.g. sand). Further, sediment grain size is one of the main factors influencing the distribution of heavy metal contaminant levels (Bastami et al., 2015; McHugh and Kenna, 2015).

Acoustic data, especially backscatter or reflectance can provide broad-scale information on the range of grain size composition of the seafloor (coarse sediments such as gravel usually correspond to high backscatter and finer sediments are less reflective (i.e. absorb more sound) and thus correspond to lower backscatter). This acoustic information on its own, however, is insufficient to discriminate all differences in grain size that might be relevant for benthic habitats. In some cases, (e.g. in mud-dominated areas) differences in the backscatter can be caused by fine-scale morphology rather than by differences in grain size content (Ferrini and Flood, 2006; Nitsche et al., 2004). Therefore, sediment grain size distribution requires analysis of actual samples.

3.2 Historical Context

Sediment texture has been studied in LIS for many decades because it provides the basis for other studies and management applications. In 2000 USGS compiled existing grain size data and produced a sediment texture map for the entire LIS (Figure. 3.2-1).

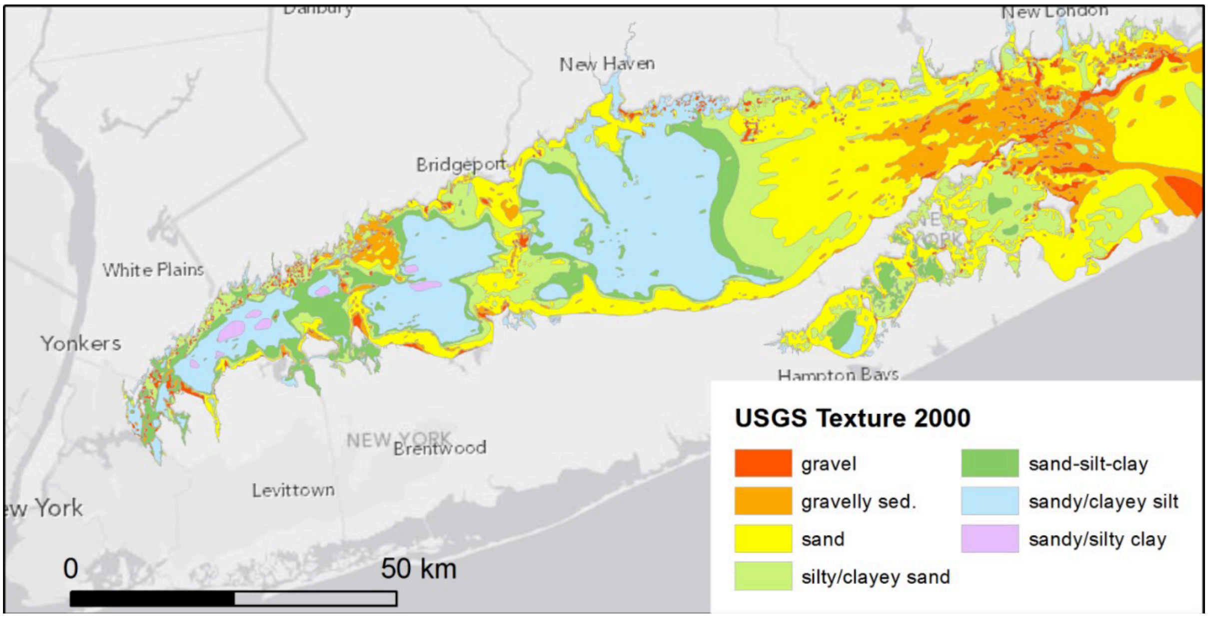

Figure 3.2-1 USGS grain size map of LIS from 2000 (Poppe et al., 2000).

This compilation is based on a large number of grain size data in combination with a limited amount sidescan data where those were available (Poppe et al., 2000). The grain size sample information is compiled in two USGS databases. The LIS Surficial Sediment Sample Database (LISSEDDATA, Poppe et al. 2004) counts >14,000 entries between 1930 and 1998 with a majority ~10,000 from the 1930s (Figure 3.2-2). The second database is the East Coast Sediment Texture Database which contains ~2420 entries for LIS between 1980 and 2010 (McMullen et al 2014). The large majority of these data are from sediment grabs and few are from sediment cores and images sources.

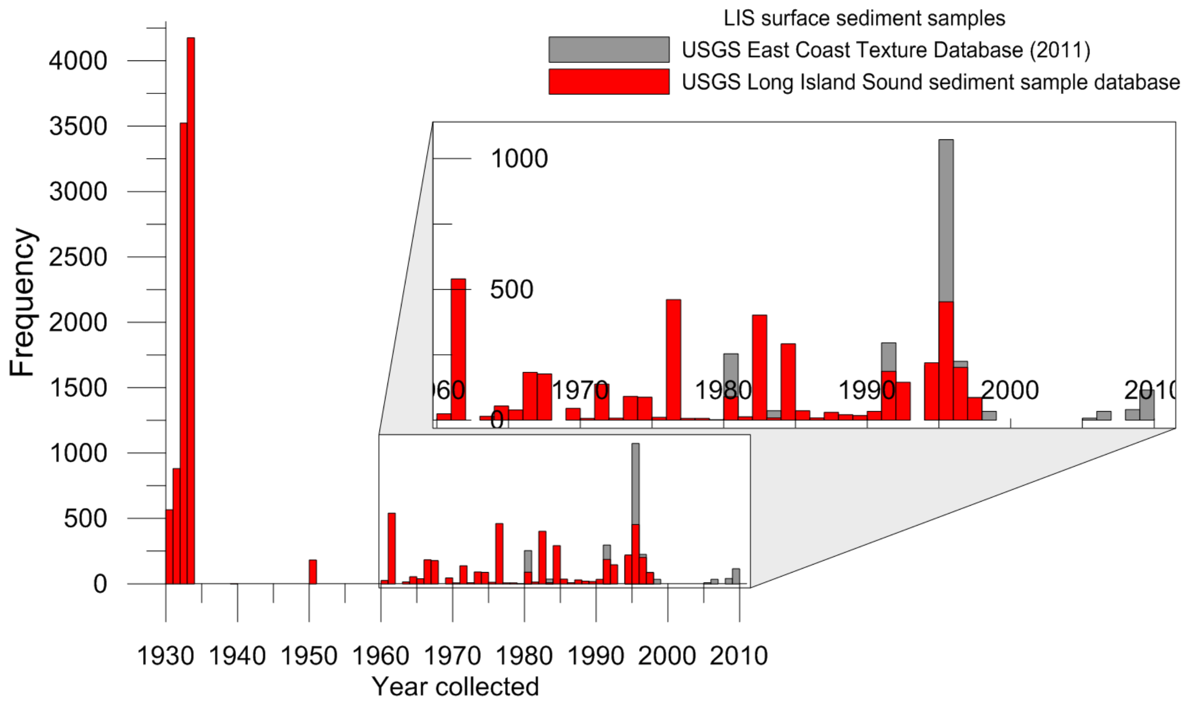

Figure 3.2-2 Number of existing sediment texture data from the USGS LIS Surficial Sediment Sample Database and the East Coast Sediment Texture Database.

While the density of older grain size data is high, the majority of these samples are older than 20 years. It is unclear to what extent older sediment samples from the 1930s reflect the present condition and if their grain size classification follows the present standards for sediment analyses. Samples from the 1930s to 1990s might not represent any changes of the LIS bottom environments during and after this period. On the other hand, grain size data from the 1990s and 2000s might still represent current conditions in some areas that have not changed much. However, the description of biological habitats requires an accurate description of the substrate texture and we cannot be sure beforehand, if the older data still reflect the present state. The distribution of these sediment samples from both databases within the Phase II area can be seen in Figure 3.2-3.

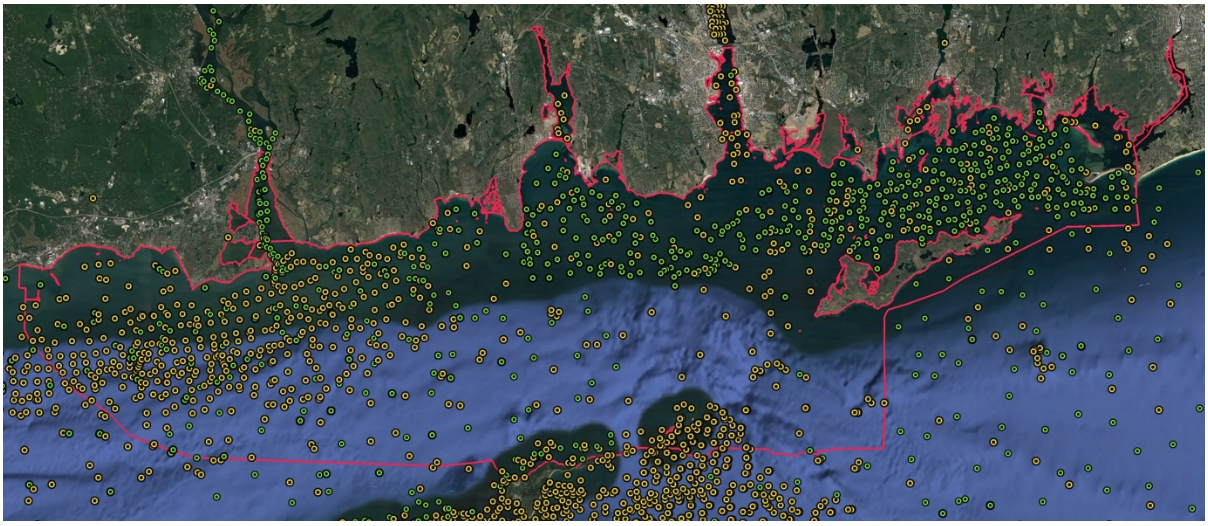

Figure 3.2-3 Map of the Phase II area with locations of the sediment grain size data from the LISSEDDATA database (yellow circles) and the east-coast sediment database (green circles).

3.3 New Data Acquisition:

The following sections are excerpted from Ackerman et al. 2020:

(Ackerman, S.D., Huntley, E.C., Blackwood, D.S., Babb, I.G., Zajac, R.N., Conroy, C.W., Auster, P.J., Schneeberger, C.L., and Walton, O.L., 2020, Sea-floor sediment and imagery data collected in Long Island Sound, Connecticut and New York, 2017 and 2018: U.S. Geological Survey data release, https://doi.org/10.5066/P9GK29NM)

Two marine geological surveys were conducted in Long Island Sound, Connecticut and New York, in fall 2017 and spring 2018 by the U.S. Geological Survey, University of Connecticut, and University of New Haven through the Long Island Sound Mapping and Research Collaborative (LISMaRC) (Figure 3.3-1). The SEABed Observation and Sampling System (SEABOSS) (Figure 3.3-2) was deployed from the Research Vessel (R/V) Connecticut. Sea-floor images and videos were collected at 210 sampling sites within the survey area, and surficial sediment samples were collected at 179 of the sites. The sediment data and the observations from the images and videos were used to identify sediment texture and sea-floor habitats.

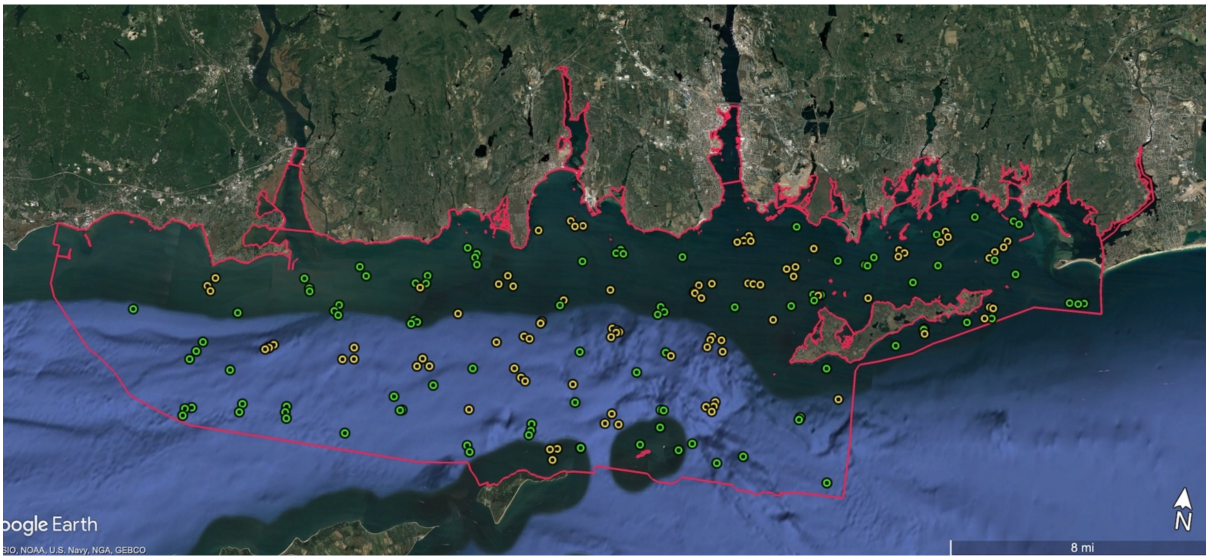

Figure 3.3-1 Map of the Phase II area showing the SEABOSS deployment sites for Fall 2017 (yellow circles) and Spring 2018 (green circles).

<u>3.3.1 Sampling</u>

The R/V Connecticut occupied one of the target sites identified by the LISMaRC Ecological Characterization team and the SEABOSS was deployed off the vessel's A-frame on the stern of the ship. The SEABOSS was equipped with a modified Van Veen grab sampler, a Nikon D300 digital still camera with a Photosea strobe, two video cameras (one forward-looking so that a shipboard operator could monitor for proper tow depth and obstacles, and one downward-looking, a Kongsberg Simrad OE1365 in this setup, that overlapped with the field of view of the still camera) with a topside feed, a GoPro HERO4 Black camera recording backup video, and lights to illuminate the sea floor for video and photograph collection. The elements of this particular SEABOSS were held within a stainless-steel frame that measured 1.15 x 1.15 meters. The frame had a stabilizer fin that oriented the system as it drifted over the seabed. The winch operator lowered the SEABOSS until the sea floor was observed in the topside live video feed. For those sites that were primarily targeted for a sediment grab, the vessel and SEABOSS then drifted with wind and current for up to a few minutes to ensure a decent image with a clear view of the sea floor was acquired; for those sites that were targeted for both a video transect of the sea floor and a sediment grab, the vessel was navigated along a planned transect for up to an hour. A scientist monitored the real-time bottom video and acquired bottom photographs at points of interest by remotely triggering the Nikon camera shutter. Bottom video was also recorded during the drift from the downward-looking video camera. Then, at most sites the winch operator lowered the Van Veen grab sampler until it rested on the sea floor. When the system was raised, the Van Veen grab sampler closed and collected a sample as it was lifted off the sea floor. Times for the sampler retrieval, which would later be used to derive the sample locations, were manually recorded in the survey log when the sampler was lifted off the seabed. The sampler was recovered to the deck of the survey vessel where a subsample was taken for grain-size analysis at the sediment laboratory at the USGS Woods Hole Coastal and Marine Science Center. Sediment samples were only attempted in areas where collecting a sample would not damage the SEABOSS; therefore, no samples were collected in areas with a cobble, boulder, or rocky seabed, as identified in real time using the topside live video feed. Samples were also not attempted if the current was too strong, if the deployment was aborted due to the strobe malfunctioning, or if the grab sampler accidentally tripped earlier in the deployment. A total of 210 sites were occupied aboard the R/V Connecticut with the SEABOSS: 93 sites were occupied in fall 2017 during field activity 2017-056-FA, and 117 sites were occupied in spring 2018 during field activity 2018-018-FA. Sediment samples were collected at 179 of the 210 sites. Duplicate sediment samples were collected for collaborators (ie Tim Kenna, LDEO) as requested.

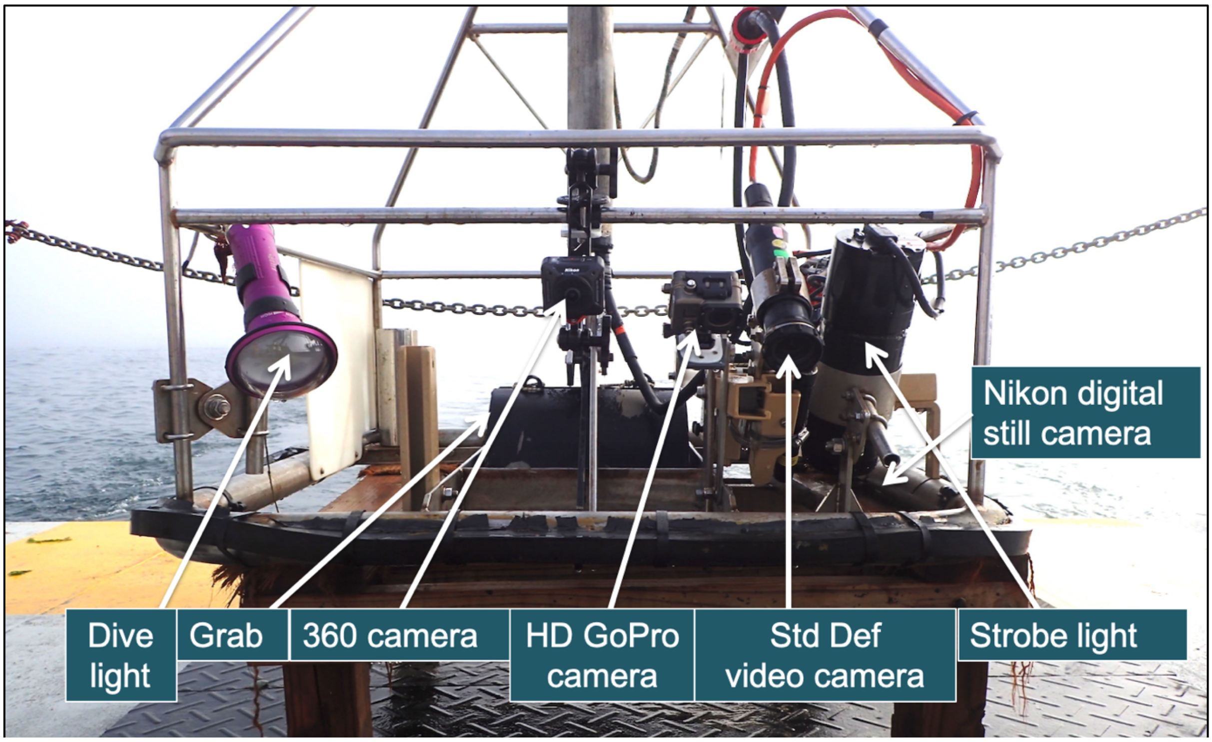

Figure 3.3-2 The USGS' SEABed Observation and Sampling System (SEABOSS) illustrating the imaging and sampling systems.

3.3.2 Acquired and processed navigation

During the surveys, WAAS-enabled GPS navigation from a Garmin GPSMAP 76C receiver was logged through a DataBridge data logger and ArcMap GPS. The GPS was set to receive fixes at a 2-second interval in geographic coordinates (WGS 84). Dates and times were recorded in Coordinated Universal Time (UTC). Log files were saved for each Julian day in text format. An AWK script (parsegprmc17056.awk for the fall 2017 log files and parsegprmc18018.awk for the spring 2018 log files) was used to parse the GPRMC navigation string from the log files for each survey and create ASCII Comma Separated Values (CSV) text files. The output files were merged for each survey and then reformatted using an AWK script (navtimereformat.awk), creating a processed navigation CSV text file for each sampling survey.

3.3.3 Assembled sample information for sediment laboratory

The sediment sample times (as recorded in the survey logs) were used to parse GPS positions for each sediment sample from the logged GPS data. Approximate depths for each sample were derived from an unpublished composite bathymetry dataset used by the Long Island

Sound Mapping and Research Collaborative project. This information was then provided to the sediment laboratory at the USGS Woods Hole Coastal and Marine Science Center with the sample analysis request form for each survey.

Duplicate samples were collected for collaborators at the Lamont Doherty Earth Observatory (LDEO) team (Tim Kenna, LDEO) as requested.

3.4 Data processing

3.4.1 Sediment Analyses

The samples from each survey were analyzed in the sediment laboratory at the USGS Woods Hole Coastal and Marine Science Center using two different methods: the Beckman Coulter Multisizer 3 and sieving of the >= 4-phi fraction, and the HORIBA LA-960 laser diffraction analyzer and sieving of the >= -2-phi fraction. Separate subsamples were taken from each sample submitted to the sediment analysis laboratory for each method.

3.4.1.1 Beckman Coulter Multisizer 3 Analyses

The subsamples for grain-size analysis using the Beckman Coulter Multisizer 3 and sieving of the >= 4-phi fraction were assigned unique analysis identifiers (ANALYSISID), and a macro-enabled Microsoft Excel data entry spreadsheet (GrainSizeWorksheetxxxx.xlsm, where xxxx is the batch number assigned to the sample submission) was created for each survey to record the measurement data. About 50 grams of wet sediment were placed in a pre-weighed beaker, weighed, oven dried at 100 degrees Celsius, and reweighed to correct for salt. The dried sample was wet sieved through a 0.062 mm (No. 230) sieve. The coarse fraction remaining in the sieve was oven dried at 100 degrees Celsius (until completely dried) and weighed. The fine fraction in water was collected in a plastic Nalgene bottle and sealed with a screw lid (stored for no longer than one week). The coarse fraction was dry sieved to determine the individual weights of the 4- to -5-phi fractions, and the weights were recorded in the data entry spreadsheet. The fine fraction was run and combined using the 200-micron and 30-micron Coulter analyses using the Multisizer 3 software to get the fine fraction grain-size distribution for each survey. The fine fraction distribution data were added to the data entry spreadsheet for each survey. The spreadsheet for each survey was used to calculate a continuous phi class distribution from the original fractions.

3.4.1.2 HORIBA LA-960 Analyses

For the sediments analyzed using the HORIBA LA-960 laser diffraction analyzer and sieving of the >= -2-phi fraction, the subsamples for grain-size analysis were assigned unique analysis identifiers (ANALYSISID) and divided into batches of no more than 30 samples. Each batch was entered into a Microsoft Excel data entry spreadsheet (LD Worksheet Templatexxxx.xlsx, where xxxx is the identifier assigned to the sample submission) to record the initial and dried sample weights, as well as the sieved coarse fraction weights. Each batch was also entered into macro-enabled Microsoft Excel data entry spreadsheets (GrainSizeWorksheetLD1-30xxxx(batchyy).xlsm or GrainSizeWorksheetLD31-60xxxx(batchyy).xlsm, where xxxx is the identifier assigned to the sample submission, "LD1-30" and "LD31-60" refer to the pre-labeled and weighed glass laser diffraction vials in which the samples will be run, and "batchyy" refers to the sample batch) to record the measurement data coming from the laser diffraction unit and incorporate the initial, dried, and sieved weights. About 10-15 grams of wet sediment were placed in a pre-weighed beaker and the gross weight was recorded. The sample was wet sieved through a 4 mm (No. 5) sieve. If there was any coarse fraction remaining in the sieve, the coarse material was oven dried at 100 degrees Celsius in a pre-weighed beaker, and weighed again when dry. This coarse fraction was dry sieved to determine the individual weights of the -2- to -5-phi fractions, and the weights were recorded in the data entry spreadsheet LD Worksheet Templatexxxx.xlsx. The fine fraction in water was collected in a pre-labeled and weighed glass laser diffraction vial. If there was any coarse fraction remaining in the sieve from wet sieving, this vial was also oven dried at 100 degrees Celsius and weighed when dry. If there was no coarse fraction remaining from wet sieving, the sample can proceed directly to processing for analyses by the HORIBA LA-960 laser diffraction unit. Fine fractions ready for analysis by the HORIBA laser diffraction unit were rehydrated with distilled water if they had been dry. Fifteen (15) ml of pre-mixed 40 g/l sodium hexametaphosphate [(NaPO3)6] were added to each sample. If the height of the fluid in the laser diffraction vial was less than 5 cm, more distilled water was added to raise the level to no more than 8 cm in the vial. The samples were gently stirred, covered, and allowed to soak for at least 1 hour (for samples that were not dried) or up to 24 hours (for samples that were dried). Soaked vials were placed into an ultrasonic bath and run for 10 minutes at a frequency of 37 Hz with a power level of 100. If the samples appeared to be fully disaggregated, they were placed into pre-determined autosampler locations and were run using the HORIBA LA-960 for Windows software to get the fine fraction grain-size distributions. The fine fraction distribution data were added to the appropriate data entry spreadsheets (GrainSizeWorksheetLD1-30xxxx(batchyy).xlsm or GrainSizeWorksheetLD31-60xxxx(batchyy).xlsm) for each survey. The spreadsheet for each survey was used to calculate a continuous phi class distribution from the original fractions.

3.4.2 Calculated grain-size classification and statistical analyses.

Sediment grain size classification was based on a rigorous definition (Shepard [1954] as modified by Schlee and Webster [1967], Schlee [1973], and Poppe and others [2005]). In the definitions below, gravel is defined as particles with nominal diameters greater than 2 mm; sand consists of particles with nominal diameters less than 2 mm, but greater than or equal to 0.0625 mm; silt consists of particles with nominal diameters less than 0.0625 mm, but greater than or equal to 0.004 mm; and clay consists of particles with nominal diameters less than 0.004 mm.

A continuous phi class distribution from the original fractions was transposed to the "results" tab in the macro-enabled Microsoft Excel data entry workbook (GrainSizeWorksheetLD1-30xxxx(batchyy).xlsm or GrainSizeWorksheetLD31-60xxxx(batchyy).xlsm for the laser diffraction results, where xxxx is the identifier assigned to the sample submission, "LD1-30" and "LD31-60" refer to the pre-labeled and weighed glass laser diffraction vials in which the samples were run, and "batchyy" refers to the sample batch; or GrainSizeWorksheetxxxx.xlsm for the Multisizer results, where xxxx is the identifier assigned to the sample submission) for each survey. Macros in the workbook ("GSMoMArithmatic," "GSstatistics," and "sedimentname" for the laser diffraction results, and "GSstatistics" and "sedimentname" for the Multisizer results) were run to calculate grain-size classification and statistical analyses and finish processing the data. Sample, navigation, and field identifiers along with continuous phi class distribution data, grain-size classification, and statistical analysis results were copied and pasted into a final Microsoft Excel spreadsheet (xxxxGS-LDresults.xlsx for the laser diffraction results and xxxxGS-MSresults.xlsx for the Multisizer results, where xxxx is the batch number assigned to the sample submission) for each survey. The processed data were quality control checked and assigned a quality grade based on the examination of the analytical data. Processed data were released to the submitter and incorporated into the laboratory's database. All raw analytical data generated by the samples were archived in the sediment analysis laboratory.

3.4.3 Final sediment grain-size analysis results CSV files

For the laser diffraction results, the sediment grain-size analysis results spreadsheets for each survey were merged in Microsoft Excel 2016 for Mac and then edited to remove the quality grade and metric distribution fields and to format fields. The Microsoft Excel spreadsheet was then saved as a CSV file (2017-056-FAand2018-018-FAsamplesGS-LD.csv). For the Multisizer results, the sediment grain-size analysis results spreadsheets for each survey were merged in Microsoft Excel 2016 for Mac and then edited to remove some fields, format fields, add site locations for those sites where no sample was successfully collected, and add a no data value (-9999) to empty attributes as needed. The sites with no successful grab were located using the start time of the sampler retrieval from the survey logs; the sampler retrieval position was chosen as the sample location because the video clip is considered the sample in the absence of a physical sample. Some of these site locations from the survey logs did not intersect a bottom video trackline, so they were moved to the last navigation fix along the site's bottom video trackline. Finally, the Microsoft Excel spreadsheet was saved as a CSV file (2017-056-FAand2018-018-FAsamplesGS-MS.csv).

3.4.4 Simplified sediment grain-size analysis results shapefile from the Multisizer analysis.

The CSV file of the sediment grain-size analysis results from the Multisizer analysis was copied and edited to create a simplified version of the CSV file with fewer attribute fields (specifically, STDEV, SKEWNESS, KURTOSIS, and the individual phi measurements [e.g., PHI11] were removed). A shapefile was created using the simplified version of the CSV file in Esri ArcGIS (version 10.3.1), and XTools Pro (version 12.0) for Esri ArcGIS was used to modify some field parameters in the point shapefile (Table Operations - Table Restructure).

3.5 Results

The goal of the Sediment Characterization effort was actually three-fold: 1) provide additional data on the sediment grain size in the Phase II area, 2) provide sediment samples taken by the SEABOSS' modified Van Veen grab for subsequent analysis by the Infaunal Ecological Characterization team of the Long Island Sound Mapping and Research Collaborative (LISMaRC) and 3) provide digital still images and videos for subsequent analysis by the LISMaRC Epifaunal Ecological Characterization team.

3.5.1 Sediment Grain Size

The sediment grain size data were collected to explore the nature of the sea floor and to characterize the seabed by identifying sediment texture. The sediments were analyzed using two different methods: the Beckman Coulter Multisizer 3 and sieving of the >= 4-phi fraction as was done in the Phase I Pilot area, and the HORIBA LA-960 laser diffraction analyzer and sieving of the >= -2-phi fraction. The HORIBA LA-960 laser diffraction analyzer is a new method for analyzing grain-size distribution at the sediment laboratory at the USGS Woods Hole Coastal and Marine Science Center. This dataset was analyzed using both methods so that the results could be compared, but no comparison was presented in the data release.

The results of the sediment grain size analyses revealed the preponderance of sand as the primary seafloor constituent. Figure 3.5-1 illustrates the percent (by weight) of the major components of each of the samples taken in 2017 and 2018. Figure 3.5-2 presents the results of the sediment classification based on Shepard (1954).

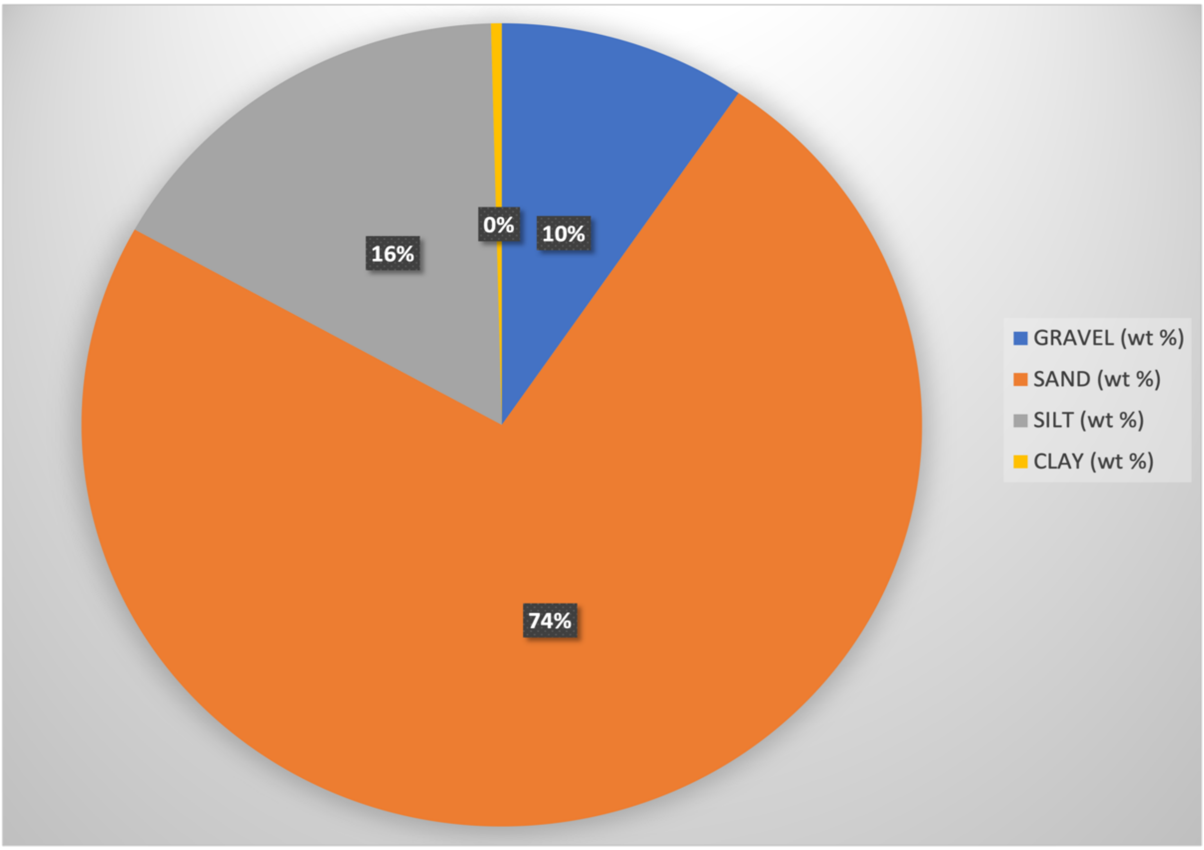

Figure 3.5-1 Percent (by weight) of the main constituents of the sediment samples collected by the USGS' SEABOSS in 2017 and 2018.

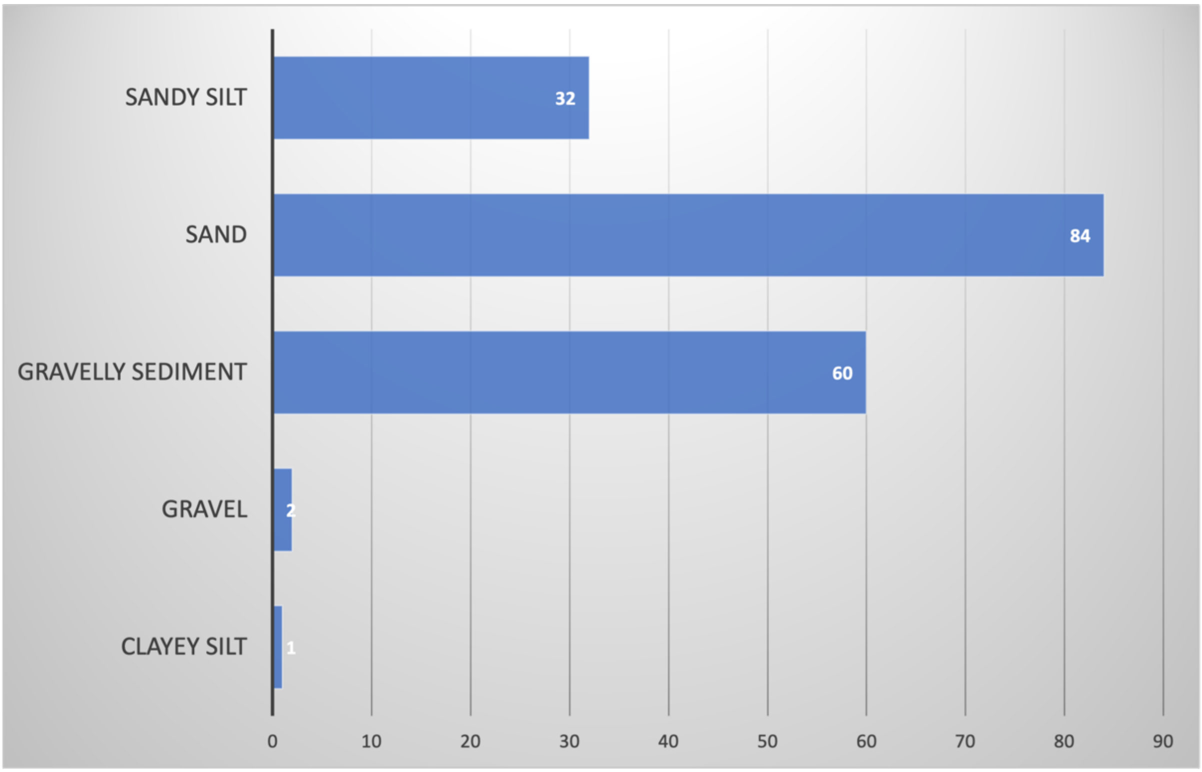

Figure 3.5-2 Sediment classification (Shepard, 1954) of 2017 and 2018 samples.

The series of maps below (Figures 3.5-3, 3.5-4 and 3.5-5) illustrate the distribution of the major sediment types in the Phase II area. As can be seen in each map there is a widespread geographic distribution of sand as the major seafloor constituent throughout the Phase II area.

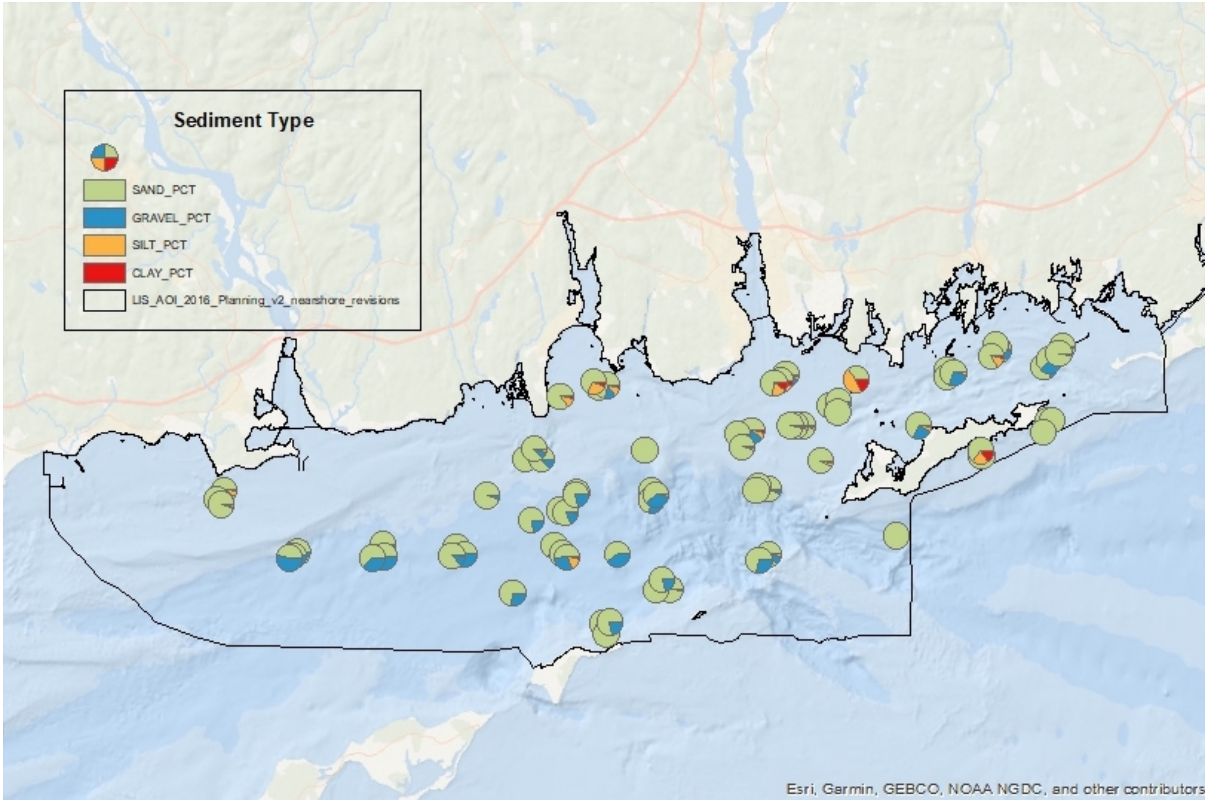

Figure 3.5-3 Map showing the percent (by weight) of the major sediment types in each of the samples collected in the Fall, 2017.

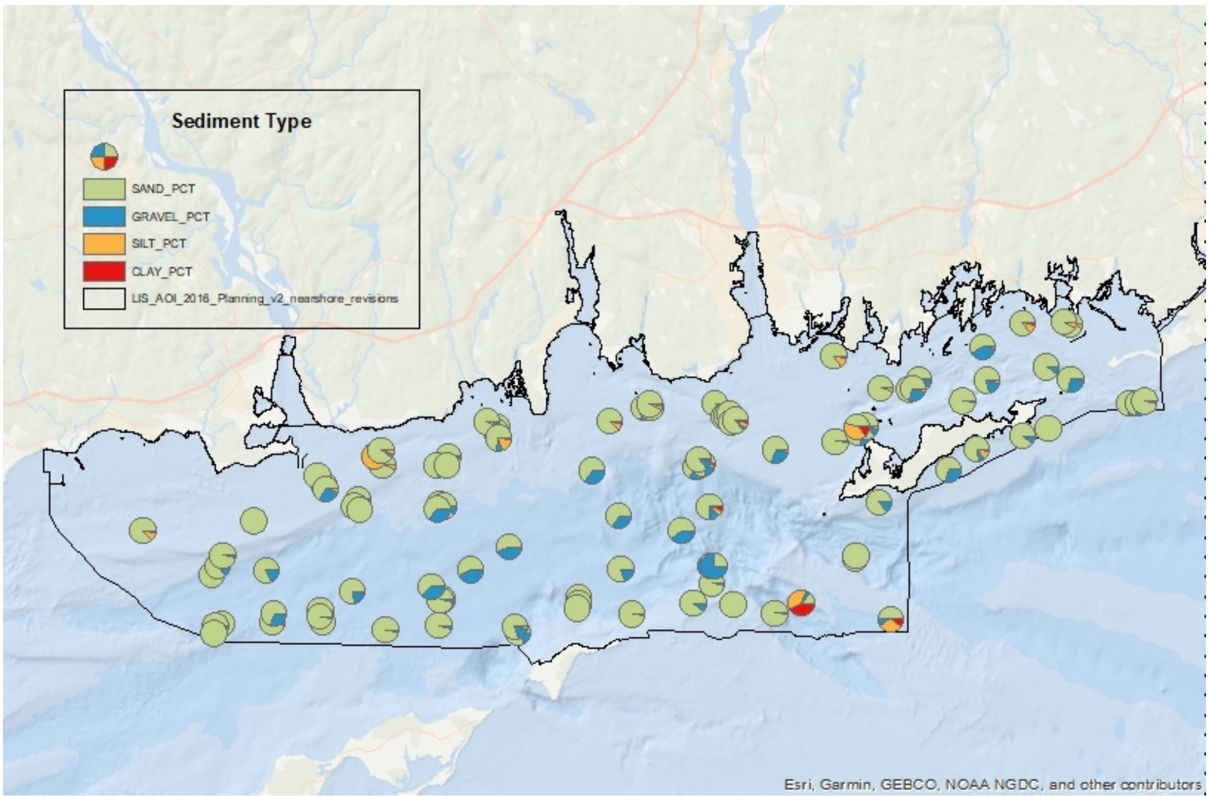

Figure 3.5-4 Map showing the percent (by weight) of the major sediment types in each of the samples collected in the Spring, 2018.

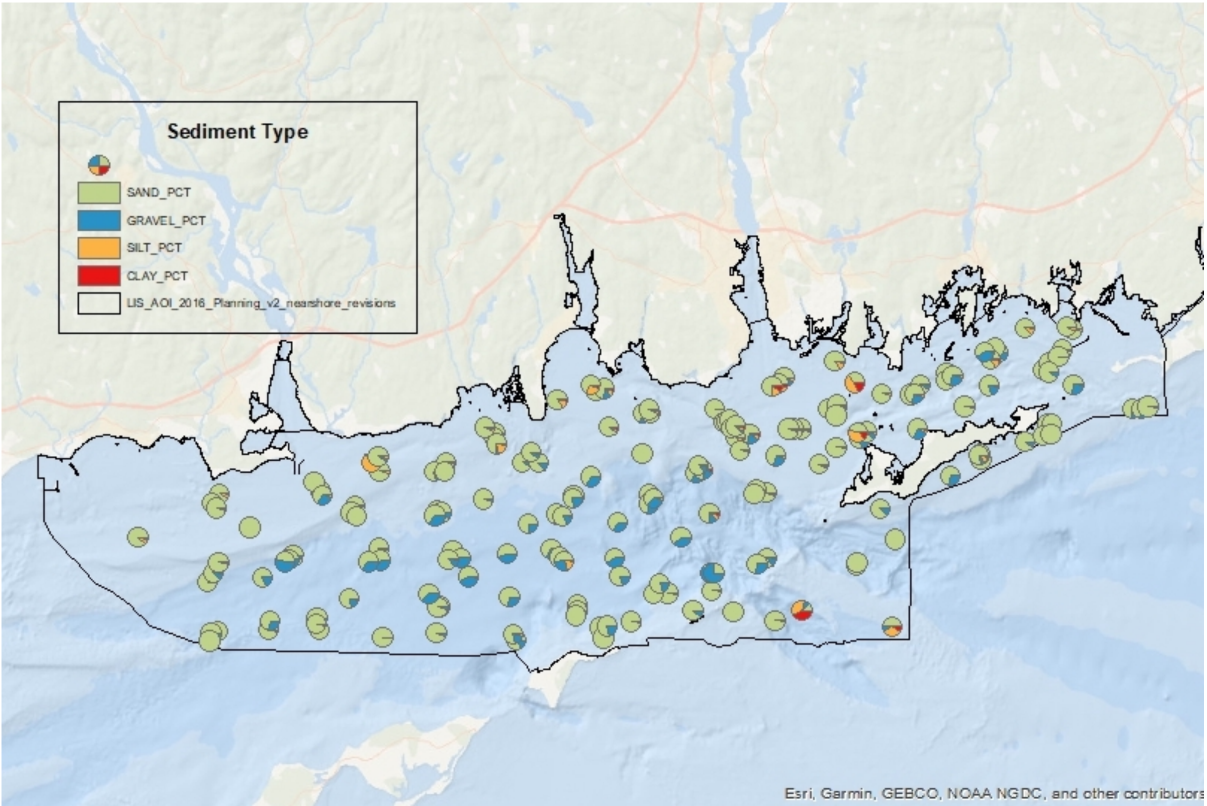

Figure 3.5-5 Map showing the percent (by weight) of the major sediment types in each of the samples collected in both Fall, 2017 and Spring, 2018.

<u>3.5.2 Ecological Characterization – Infauna</u>

Infaunal samples were collected with the 0.1 m^2 modified Van Veen grab on the SEABOSS system. The SEABOSS was lowered to just above the sea floor and then was allowed to drift for several minutes to collect video and still images, after which a grab sample was collected. Of the 179 sediment samples taken, a total of 160 were collected and processed for infauna and results are reported below.

<u>3.5.3 Ecological Characterization – Epifauna</u>

The SEABOSS also recorded digital, geotagged sea-floor images and locations of bottom images acquired with a Nikon D300 digital still camera, GoPro HERO4 Black camera, and Kongsberg Simrad OE1365 video camera. A total of 602 images were utilized for epifaunal analyses from the fall 2017 and 595 images from the spring 2018 campaign. These data were collected and analyzed using ImageJ software and the results are reported below.

3.6 Discussion

In addition to the 179 sediment samples collected by the USGS' SEABOSS during Fall, 2017 and Spring, 2018, the Lamont Doherty Earth Observatory at Columbia University Long Island Sound Mapping collaborative collected additional sediment samples in the Phase II area that were analyzed using both a Beckman Coulter Multisizer and by a Sedigraph. They received a duplicate sediment sample from each of the SEABOSS sediment grabs, however, to date these samples have not been analyzed (Frank Nitsche, personal communication). This does, however, represent a rich dataset of sediment grain size analyses from the Phase II area derived from three separate analyses methods. This data set could provide the grist for further analysis and cross-comparison of the results to guide future work in Long Island Sound or in other regions conducting similar sediment texture assessments.

3.6 Summary/Conclusions

The LISMaRC Sediment Texture and Grain Size element provided a comprehensive dataset to assist with several other elements of the overall Long Island Sound Cable Fund Habitat Mapping Initiative. These include: 1) acoustic backscatter groundtruth data, 2) sedimentary environments, 3) both infaunal and epifaunal ecological characterization, and 4) additional groundtruth data to assist with the physical oceanography component of the initiative. Furthermore, the USGS Data Release (Ackerman et al., 2020) has already been utilized as part of the data sets assisting the Equinor Corporation with its power cable routing in support of the Beacon Wind offshore windfarm they are permitted to develop.

3.7 References

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