# Application of high-resolution multibeam sonar backscatter to guide oceanographic investigations in the Mississippi Bight

**Lauren Quas[1], Ian Church[2], Stephan J. O'Brien[1], Jerry D. Wiggert[1], Maxwell Williamson[1]**

[1]Division of Marine Science
School of Ocean Science and Technology
University of Southern Mississippi, 1020 Balch Blvd
Stennis Space Center, MS 39529-9904
1-228-688-2951
Lauren.Quas@usm.edu

[2]Ocean Mapping Group
Department of Geodesy and Geomatics Engineering
University of New Brunswick, 15 Dineen Drive
P.O. Box. 4400, Fredericton, N.B., E3B 5A3, CANADA
1-506-447-8116
Ian.Church@unb.ca

---

## Abstract

*Hydrographic survey data, while incredibly valuable on its own, can also be used to guide oceanographic and scientific investigations. The theory of "map once, use the data many times" is the driving force behind the multibeam surveys conducted during the Gulf of Mexico Research Initiative's (GoMRI) CONsortium for oil spill exposure pathways in COastal River-Dominated Ecosystems (CONCORDE) project. Reson SeaBat 7125 SV2 acoustic backscatter data was collected along three observational corridors in the Mississippi Bight. The acoustic response of the seabed across a variety of grazing angles provides an indication of seabed scattering and, therefore, an estimate of sediment grain-size distributions. These characteristics, along with multibeam bathymetry, can be used to inform numerical model development, like the high resolution biogeochemical/lower trophic level model being developed as part of CONCORDE. Sediment grab sampling and grain-size analysis were performed to constrain the backscatter data, produce acoustically-derived sediment distribution maps, and provide sediment type input parameters for the biogeochemical model. The model simulations are used to assess sediment transport in the study region on hourly to daily timescales. Future work on the backscatter dataset will involve multi-spectral acoustic analysis and development of additional inputs for the biogeochemical model, such as spatially varying drag coefficients.*

---

# Background

The Deepwater Horizon oil spill was an unprecedented disaster in the Gulf of Mexico (GOM), causing the death of 11 offshore workers. For 87 days after the Macondo wellhead blowout on April 20, 2010, approximately 4.9 million barrels of oil were spilled approximately 70 kilometers off the Louisiana coast (Michel et al., 2013). Unfortunately, predictions of oil transport and impacts were often incorrect due to the lack of knowledge on the complex processes that occur in this region, which hindered remediation efforts. In May 2010, BP allocated $500 million to the Gulf of Mexico Research Initiative (GoMRI) for the funding of studies on the impact of oil and dispersants on the ecosystem and on human health. These funds were to be used over a 10-year period by researchers primarily located along the Gulf Coast, both for individual investigators as well as large consortiums. CONCORDE (**CON**sortium for oil spill exposure pathways in **CO**astal **R**iver-**D**ominated **E**cosystems) was one of twelve consortia funded under GoMRI's fourth Request for Proposals (RFP-IV). CONCORDE is led by the University of Southern Mississippi (USM), both at the Division of Marine Science and the Gulf Coast Research Laboratory. It also includes researchers from Mississippi State University, Rutgers University, Oregon State University, Dauphin Island Sea Lab (University of South Alabama), Old Dominion University, and the U.S. Naval Research Laboratory, with expertise ranging from chemical oceanography and plankton biology/ecology to marine acoustics, ecosystem modeling, and remote sensing. This large and diverse research team was awarded $11 million to conduct investigations within the northern Gulf of Mexico, specifically the river-dominated, coastal environment of the Mississippi Bight. CONCORDE objectives include 1) characterizing the complex 3D spatial and temporal physical, geochemical, and bio-optical fields to understand potential pathways of oil, 2) describing spatiotemporal distributions and biophysical interactions of planktonic organisms at relevant spatial scales, establishing a biological setting for sub-surface oil exposure, and 3) generating a synthesis model for pulsed, river-dominated coastal ecosystems that incorporates new information on biophysical and biogeochemical processes to predict the dispersal and potential biological impacts on continental shelves during future spill events. As part of the acoustic data collection, objective 2 called for the use of a multibeam sonar for comparison of water column acoustic backscatter data to plankton data measured by a towed-imaging system. Since objective 3 focused on making the synthesis model more robust by providing as many additional model inputs as possible, multibeam acoustic backscatter data was also considered a valuable dataset for CONCORDE.

Seafloor sediment properties are a crucial input to the CONCORDE high-resolution biogeochemical/lower trophic level model to understand how deeply oil can penetrate the seafloor and how currents can resuspend and move these contaminated sediments onto the shelf or coastline. Frequently in oceanic studies, an inadequate number of ground truth samples are collected to provide a comprehensive understanding of seafloor sediment composition and distribution; this is where acoustic backscatter can be used to fill in the gaps (Dartnell & Gardner, 2004). Multibeam acoustic backscatter intensity data can provide a proxy for the composition and distribution of surficial seabed sediments and an estimate of general grain-size distributions (Jackson, Winebrenner, & Ishimaru, 1986; Lurton & Lamarche, 2015). These characteristics, along with multibeam bathymetry, can be used to derive a spatial overview of benthic habitats and aid in informing numerical models. This makes seafloor backscatter intensity data valuable not only hydrographers, but to a wide variety of oceanographers (Lucieer, Roche, Degrendeke, Malik, & Dolan, 2015). To verify that the backscatter intensities are relatively accurate, sediment grab samples are often collected in conjunction with the multibeam data. This form of ground truthing is necessary for backscatter, especially for the classification of sediment type and the input of this data into ocean models (Weber & Lurton, 2015). To characterize grain size distributions, a Reson SeaBat 7125 (200/400 kHz) multibeam sonar was used to collect high resolution seabed backscatter along three sampling corridors during two field campaigns. Surface seabed sediment samples were also collected along the corridors to overlap with and correlate to the seabed backscatter measurements. The sediment distribution corridor maps developed as part of this project will further our understanding of the benthic and demersal ecosystems within the Mississippi Bight and guide the CONCORDE model group with proper sediment inputs. This project has been a great example of the blending of different technologies and integrating acoustics with other ocean sciences.

## Methods

### *Study Area*

The CONCORDE sampling domain encompassed the area known as the Mississippi Bight. This area is relatively shallow, with depths ranging from 10 to 50 meters. It is highly influenced by freshwater discharge from the Mississippi River and numerous barrier islands and bays. Three, North-South oriented corridors were surveyed, as shown in Figure 1, each roughly 60 kilometers in length. They are nicknamed Whiskey (Western), Mike (Middle), and Echo (Eastern). Whiskey runs south of Pascagoula, Mississippi and east of the Chandeleur Islands. Mike runs south of Mobile Bay and Dauphin Island, Alabama; and Echo runs south of Perdido Bay, on the Alabama-Florida state line. These corridors were surveyed multiple times during two CONCORDE field campaigns: one cruise during the Fall "well-mixed, low flow" period (October 27 – November 5, 2015) and one during the Spring "stratified, high flow" period (March 29 – April 12, 2016).

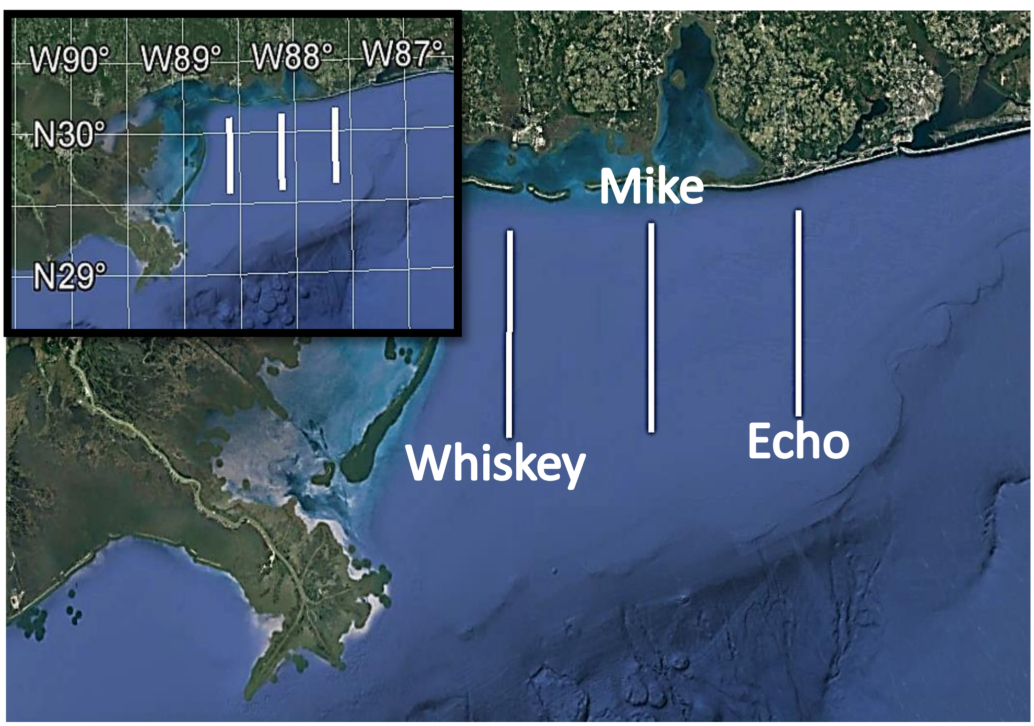



**Figure 1. CONCORDE Study Area within the Mississippi Bight. Corridors Whiskey, Mike, and Echo (west to east) are shown, each about 60 kilometers in length.**

## *Equipment*

**Figure 2. The R/V Point Sur was the survey platform for CONCORDE field operations. It is 135 feet in length with a beam of 32 feet and a draft of 9 feet.**

The survey platform for this research was the 135 foot *R/V Point Sur*, as seen in Figure 2. This research vessel is owned by USM and managed by the Louisiana Universities Marine Consortium (LUMCON) out of the Port of Gulfport in Gulfport, Mississippi. Primary hardware equipment used for field campaigns included a Reson SeaBat 7125 SV2 multibeam sonar with 200 and 400 kHz capabilities. This system was pole mounted off the port side of the main deck and integrated with an Applanix POSMv Wavemaster IMU augmented by a CNav 3050 GNSS receiver. Data collection was done using Seabat 7K software and QPS's QINSy. Processing during and after the cruises required access to the following software packages: QPS's Qimera, QPS's Fledermaus GeoCoder Toolbox (FMGT), and ESRI's ArcMap. For sediment collection, a four-core multicorer was deployed on the R/V Point Sur, and processing was performed using a Malvern Mastersizer 3000 particle-analyzer.

## *Acoustic Backscatter Data*

Backscatter data were collected during the day operations, while other towed equipment was in the water. The Reson had operation capabilities at 200 and 400 kHz. In waters deeper than 50 m, 200 kHz provided more reliable and higher quality data based on local oceanographic conditions. For this reason, frequency and range were adjusted as needed due to depth and sea state changes. During the fall cruise, only 400 kHz was used along the corridors. During the spring, the corridors were surveyed multiple times, once at 200 kHz and several times at 400 kHz. For model input, only the 400 kHz backscatter data were used to mitigate backscatter intensity effects from different frequencies.

Backscatter data were processed in FMGT. At the end of each day of data collection, a new project was generated for the corridor or area being surveyed. FMGT required paired .db and .qpd backscatter files; these are QPS proprietary formats logged in QINSy. Multibeam depths are stored in the .qpd files, and sonar beam time series data are stored in the .db files. FMGT created a new GSF file from these pairs containing both depth and time series data to use in the standard processing flow. The FMGT automated processing procedure was implemented for CONCORDE acoustic backscatter mosaicking. Navigation information and swath extent at each ping from each line was extracted during the Coverage Processing stage to create nadir, starboard, and port track lines used in the Map View of FMGT (QPS, 2016). The raw backscatter time series for each beam was then imported from the source files and corrections were performed such as Lambertian scattering adjustments, signal level adjustments from range and transmission loss, adjustments of beam footprint area and beam incidence angle, etc. (QPS, 2016). Next, the backscatter intensity data was filtered based on beam angle (angle varying gain), and then an antialiasing pass was run on the resulting backscatter swath data (QPS, 2016). Angle Range Analysis (ARA) can attempt to classify the backscatter surface based on the variation of intensity with grazing angle (QPS, 2016). This step was omitted as sediment samples were used to assist in the classification of the backscatter mosaics. Statistics on the backscatter surface were then calculated with the beam data for each cell. These included mean or median values for each cell. Lastly, the mosaic was processed using the set resolution, either by a pre-computed optimal value from the sonar beam configuration and along-track backscatter coverage or a user-set pixel size (QPS, 2016). The resulting mosaics were then exported to ESRI grids and input to ArcMap for segmentation and comparison with sediment sample grain size analysis statistics.

### *Seafloor Sediment Samples*

Sediment coring was performed during night operations since towed equipment restricted daytime vessel stops. Sediment samples were collocated with water chemistry samples, as this saved cruise time and guaranteed sediment samples spaced along the entire corridor. Sediment collection required the use of a deployable multi-corer (Figure 3A). At each sample location, the top 2-3 centimeters of one core was placed in a storage bag labeled with sample time and coordinate and stored in a dry plastic container. These samples were taken back to the USM Sediment Lab for analysis. A small subsample was saturated for twelve hours in a 500 mL beaker filled with approximately 250 mL of tap water. This was done to ensure that individual grains were fully disassociated from one another. Then, laser diffraction was performed on these subsamples using a Malvern Mastersizer 3000 particle analyzer (Figure 3B).

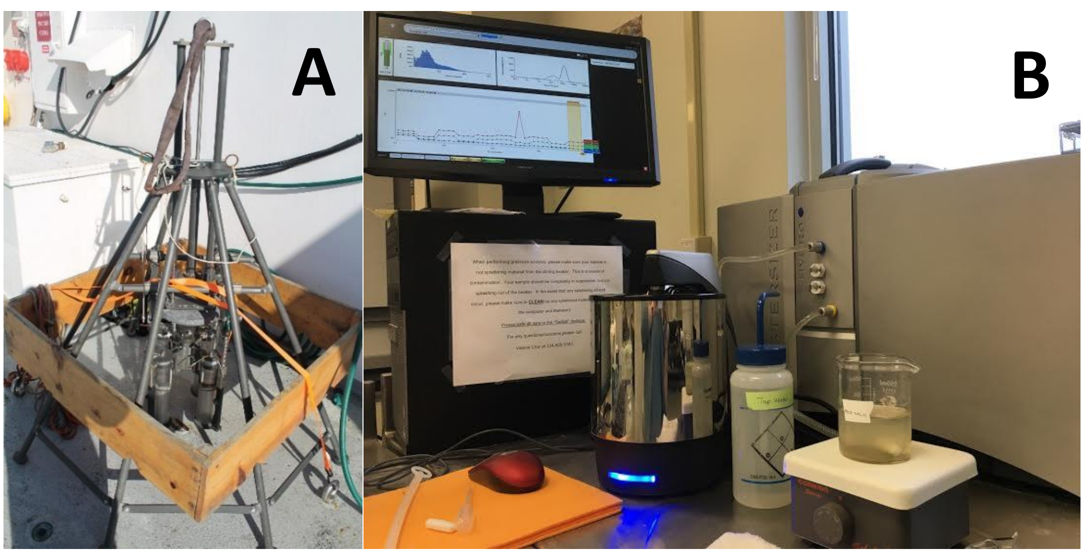



**Figure 3. (A) Multi-corer deployed from the R/V Point Sur and (B) the Malvern Mastersizer 300 Particle Analyzer used for grain size analysis.**

This device applies principles of Mie scattering to measure the angular variation in light intensity as a laser beam passes through the dispersed sample (Malvern Instruments Ltd., 2013). The pattern at which the laser is scattered is then analyzed for particle size; typically, larger grains will have a smaller scattering angle (Malvern Instruments Ltd., 2013). A magnetic stirrer was placed into the sample beakers, and then the beakers were placed on a magnetic stir plate. This was done to ensure even distribution of the sample within the beaker. While still on the stir plate, a pipet was submerged halfway into the beaker to collect the saturated sediment sample and add to the Hydro MV automated dispersion unit. The sample is circulated through the dispersion unit and into the wet cell so it can be measured by the optical unit located within the main body of the Mastersizer (Malvern Instruments Ltd., 2014). For accurate measurements, the laser must be obscured by the sample by 10-20 percent (Malvern Instruments Ltd., 2014). Once the obscuration rate on the operating software read between 10-12 percent, laser diffraction was started. The Malvern measured the sample in triplicate and statistics including average grain size were calculated. Proper rinsing of all sampling tools was conducted between runs to prevent any cross-contamination between the samples.

### *Modeling Inputs*

The research consortium has developed a four-dimensional biogeochemical/lower trophic level synthesis model encompassing Mississippi Sound and Mississippi Bight with extents 29.00 °N, -89.96 °W (southwest) and 30.82 °N, -87.23 °W (northeast). The model has 400-m horizontal resolution and includes 24 vertical layers, with denser vertical resolution near the surface and bottom to resolve light attenuation and boundary layer processes. The basis of the ecosystem model component is from a recent Chesapeake Bay application (Wiggert et. al., 2017). The synthesis model foundation is COAWST (Coupled Ocean-Atmosphere-Wave-Sediment Transport Modeling System) (Warner et al., 2010), which uses the Model Coupling Toolkit to exchange data fields between the circulation model (Regional Ocean Modeling System, ROMS) the sediment transport model (Community Sediment Transport Modeling, CSTM), and the surface wave model (Simulating Waves Nearshore, SWAN).

The synthesis model ecosystem has been expanded to include two size classes of phytoplankton and detritus, three size classes of zooplankton, larval fish, dissolved organic nitrogen, nitrate, ammonium, and dissolved oxygen. ROMS is a free surface, terrain-following numerical model that solves the three-dimensional Reynolds-averaged Navier-Stokes equations using the hydrostatic and Boussinesq approximations (Shchepetkin and McWilliams, 2005 and Shchepetkin and McWilliams, 2009). SWAN is needed in order to accurately represent resuspension processes in shallow water systems, such as Mississippi Sound. CSTM consists of an algorithm to simulate the advective-diffusive transport of an unlimited number of user defined sediment classes in the water column and on the seabed. Each sediment class is defined by the attributes of grain diameter, density, settling velocity, critical stress threshold for erosion and erosion rate (Warner et al., 2008). The sediment classes present in the model domain are identified using multibeam backscatter and sediment core grain size distribution, and implemented in CSTM to assess sediment transport and resuspension on the timescale of hours to days.

## Results

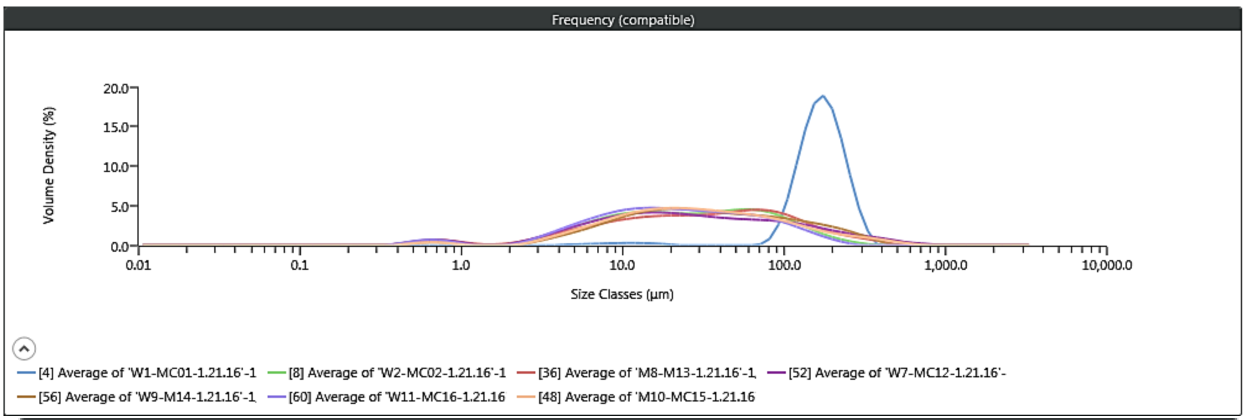
In total, twenty sediment samples were collected and analyzed: 15 during the fall campaign along corridors Whiskey and Mike and 5 during the spring campaign along corridor Echo. Table 1 shows the results for each of the twenty samples, including the sample ID's, associated corridor, coordinates (decimal degrees), and grain size analysis results (μm).

**Table 1. CONCORDE Sediment Sample Information with Coordinates in Decimal Degrees (DD.DDDD) and Grain Sizes in** μm.

| Sample Name | Corridor Name | Date Collected (UTC) | Latitude (DD) | Longitude (DD) | Dx(10) μm | Dx(50) μm | Dx(90) μm | Mode μm |
|---|---|---|---|---|---|---|---|---|
| **W1-MC01** | Whiskey | 10/29/15 | 29.6033 | -88.6079 | 111.8708 | 169.3898 | 250.7874 | 171.6472 |
| **W2-MC02** | Whiskey | 10/29/15 | 29.7247 | -88.6075 | 4.9976 | 25.2995 | 109.1110 | 58.4361 |
| **M1-MC03** | Mike | 10/30/15 | 29.7164 | -88.1257 | 8.8746 | 175.1234 | 339.3916 | 220.0900 |
| **M2-MC04** | Mike | 10/30/15 | 29.8862 | -88.1253 | 6.5889 | 37.3931 | 204.3022 | 130.9874 |
| **M3-MC05** | Mike | 10/30/15 | 29.9699 | -88.1255 | 12.2025 | 131.6560 | 259.0154 | 153.9747 |
| **M4-MC06** | Mike | 10/30/15 | 30.0529 | -88.1292 | 17.2069 | 163.5257 | 301.3918 | 186.0454 |
| **M8-MC08** | Mike | 10/31/15 | 29.5979 | -88.1257 | 6.7865 | 95.5188 | 308.1340 | 184.6894 |
| **M8-MC09** | Mike | 10/31/15 | 29.7943 | -88.1255 | 21.5214 | 169.8394 | 315.7415 | 181.2053 |
| **M9-MC09** | Mike | 10/31/15 | 29.9961 | -88.1251 | 9.5664 | 113.0729 | 242.9856 | 156.5579 |
| **M10-MC11** | Mike | 10/31/15 | 30.1004 | -88.1250 | 7.6768 | 99.3778 | 317.4178 | 183.0442 |
| **M8-M13** | Whiskey | 11/02/15 | 29.7997 | -88.6082 | 4.7107 | 30.9764 | 141.0965 | 68.4834 |
| **W7-MC12** | Whiskey | 11/02/15 | 29.6190 | -88.6078 | 4.7657 | 25.5258 | 176.4051 | 15.6106 |
| **W9-M14** | Whiskey | 11/02/15 | 29.8825 | -88.6076 | 6.8123 | 31.0284 | 165.1998 | 20.5121 |
| **M10-MC15** | Whiskey | 11/02/15 | 29.9671 | -88.6076 | 6.3109 | 28.0293 | 148.5239 | 20.8306 |
| **W11-MC16** | Whiskey | 11/02/15 | 30.0450 | -88.6076 | 4.7221 | 20.9345 | 94.9885 | 15.0307 |
| **E8S** | Echo | 04/04/16 | 29.7421 | -87.5195 | 154.2783 | 244.6214 | 379.4245 | 246.7448 |
| **E2S** | Echo | 04/04/16 | 29.8342 | -87.5317 | 128.1469 | 223.2449 | 354.6112 | 230.0540 |
| **E9S** | Echo | 04/04/16 | 29.9464 | -87.5252 | 96.1769 | 231.4425 | 479.4748 | 236.1566 |
| **E10S** | Echo | 04/04/16 | 30.0494 | -87.5128 | 311.2234 | 758.2844 | 2072.3177 | 524.9864 |
| **E11S** | Echo | 04/04/16 | 30.1687 | -87.5148 | 61.3027 | 236.1566 | 1943.8161 | 183.8103 |

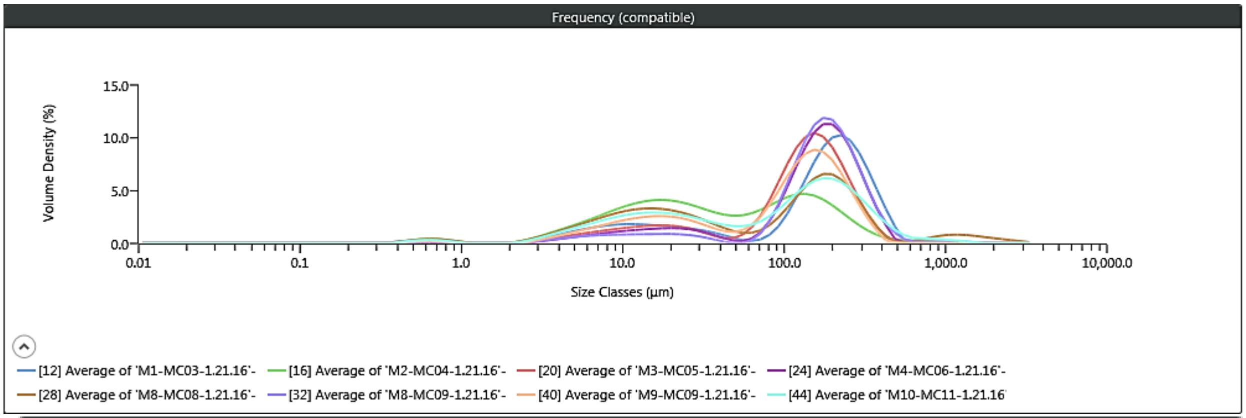
Figures 4, 5, and 6 show the results from the grain size analysis via the Mastersizer 3000 particle analyzer and software. The average from each sample is used for visualization since triplicate runs were performed by the particle analyzer. The selected sample name, record number, and laser obscuration percent are listed in the data table below each graph, as well as the computed Dx(10), Dx(50), and Dx(90) values. It also shows the mean, standard deviation, and relative standard deviation (RSD) for the selected data, along with a graph comparing grain size to percent volume density. Relative standard deviation is calculated by dividing the standard deviation by the mean and multiplying by 100. A low RSD value means the data is tightly clustered about the mean, and a high RSD values means the data is spread out about the mean. All grain sizes are listed in units of micrometers and classified using the Wentworth grain size scale, which is one of the common classification methods used in industry.

Figure 4 shows the results from corridor Whiskey's sediment samples. The Dx(50) grain size for Whiskey of 47.3 μm is in the silt-sized range. Whiskey's sediment samples have the most spread in their data, with RSD values between 30 and 200. Figure 5 is the results from the sediment samples along corridor Mike. The Dx(50) grain size of 123 μm is a fine-sand on the Wentworth scale. This data is also the most tightly clustered about the mean, with RSD values between 15 and 50. Figure 6 shows the results from corridor Echo's sediment samples. Medium to coarse-grained size classes were the average along this corridor, with a Dx(50) grain size of 339 μm. With RSD values between 60 and 85, Echo's samples are slightly more spread than Mike's samples but not as varying as Whiskey's samples.



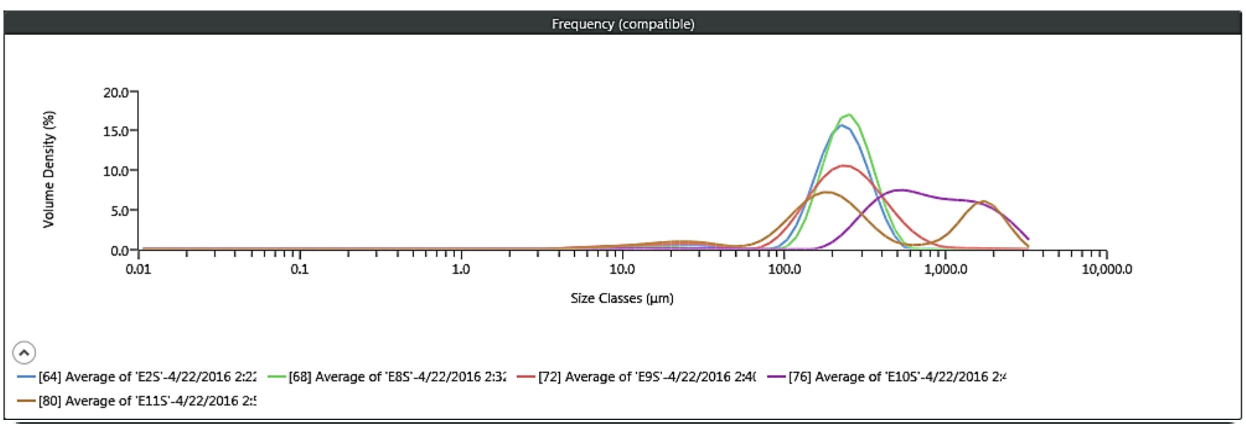

| | Record Number | Sample Name | Dx (10) (μm) | Dx (50) (μm) | Dx (90) (μm) | Laser Obscuration (%) |
|---|---|---|---|---|---|---|
| | 4 | Average of 'W1-MC01-1.21.16' | 112 | 169 | 251 | 10.42 |
| | 8 | Average of 'W2-MC02-1.21.16' | 5.00 | 25.3 | 109 | 11.83 |
| | 36 | Average of 'M8-M13-1.21.16' | 4.71 | 31.0 | 141 | 15.86 |
| | 52 | Average of 'W7-MC12-1.21.16' | 4.77 | 25.5 | 176 | 11.38 |
| | 56 | Average of 'W9-M14-1.21.16' | 6.81 | 31.0 | 165 | 11.30 |
| | 60 | Average of 'W11-MC16-1.21.16' | 4.72 | 20.9 | 95.0 | 12.47 |
| | 48 | Average of 'M10-MC15-1.21.16' | 6.31 | 28.0 | 149 | 16.25 |
| **Mean** | | | **20.6** | **47.3** | **155** | **12.79** |
| **1xStd Dev** | | | **40.3** | **53.9** | **51.1** | **2.32** |
| **1xRSD (%)** | | | **195** | **114** | **32.9** | **18.14** |

**Figure 4. Grain size distribution for corridor Whiskey. This corridor has a Dx(50) grain size of about 47 μm, which is classified as a coarse silt on the Wentworth Grain Size Scale.**




| | Record Number | Sample Name | Dx (10) (μm) | Dx (50) (μm) | Dx (90) (μm) | Laser Obscuration (%) |
|---|---|---|---|---|---|---|
| | 12 | Average of 'M1-MC03-1.21.16' | 8.87 | 175 | 339 | 10.80 |
| | 16 | Average of 'M2-MC04-1.21.16' | 6.59 | 37.4 | 204 | 12.70 |
| | 20 | Average of 'M3-MC05-1.21.16' | 12.2 | 132 | 259 | 11.05 |
| | 24 | Average of 'M4-MC06-1.21.16' | 17.2 | 164 | 301 | 11.53 |
| | 28 | Average of 'M8-MC08-1.21.16' | 6.79 | 95.5 | 308 | 12.05 |
| | 32 | Average of 'M8-MC09-1.21.16' | 21.5 | 170 | 316 | 11.25 |
| | 40 | Average of 'M9-MC09-1.21.16' | 9.57 | 113 | 243 | 11.94 |
| | 44 | Average of 'M10-MC11-1.21.16' | 7.68 | 99.4 | 317 | 10.84 |
| **Mean** | | | **11.3** | **123** | **286** | **11.52** |
| **1xStd Dev** | | | **5.41** | **46.9** | **45.8** | **0.67** |
| **1xRSD (%)** | | | **47.9** | **38.0** | **16.0** | **5.80** |

**Figure 5. Grain size distribution for corridor Mike. This corridor has a Dx(50) grain size of about 123 μm, which is classified as a very fine to fine sand on the Wentworth Grain Size Scale.**




| | Record Number | Sample Name | Dx (10) (μm) | Dx (50) (μm) | Dx (90) (μm) | Laser Obscuration (%) |
|---|---|---|---|---|---|---|
| | 64 | Average of 'E2S' | 128 | 223 | 355 | 10.16 |
| | 68 | Average of 'E8S' | 154 | 245 | 379 | 9.79 |
| | 72 | Average of 'E9S' | 96.2 | 231 | 479 | 10.43 |
| | 76 | Average of 'E10S' | 311 | 758 | 2070 | 9.78 |
| | 80 | Average of 'E11S' | 61.3 | 236 | 1940 | 11.05 |
| **Mean** | | | **150** | **339** | **1050** | **10.24** |
| **1xStd Dev** | | | **96.5** | **235** | **881** | **0.53** |
| **1xRSD (%)** | | | **64.2** | **69.3** | **84.2** | **5.15** |

**Figure 6. Grain size distribution for corridor Echo. This corridor has a Dx(50) grain size of about 339 μm, which is classified as a medium to coarse sand on the Wentworth Grain Size Scale.**

Acoustic backscatter data were collected over each of the three CONCORDE corridors with multiple passes between the fall and spring field campaigns. Examples of the processed backscatter data overlaid with the locations of sediment samples can be seen below in Figure 7. This data was collected during the spring 2016 field campaign at 400 kHz. All backscatter data were processed onboard the R/V Point Sur using the FMGT software, as described above.

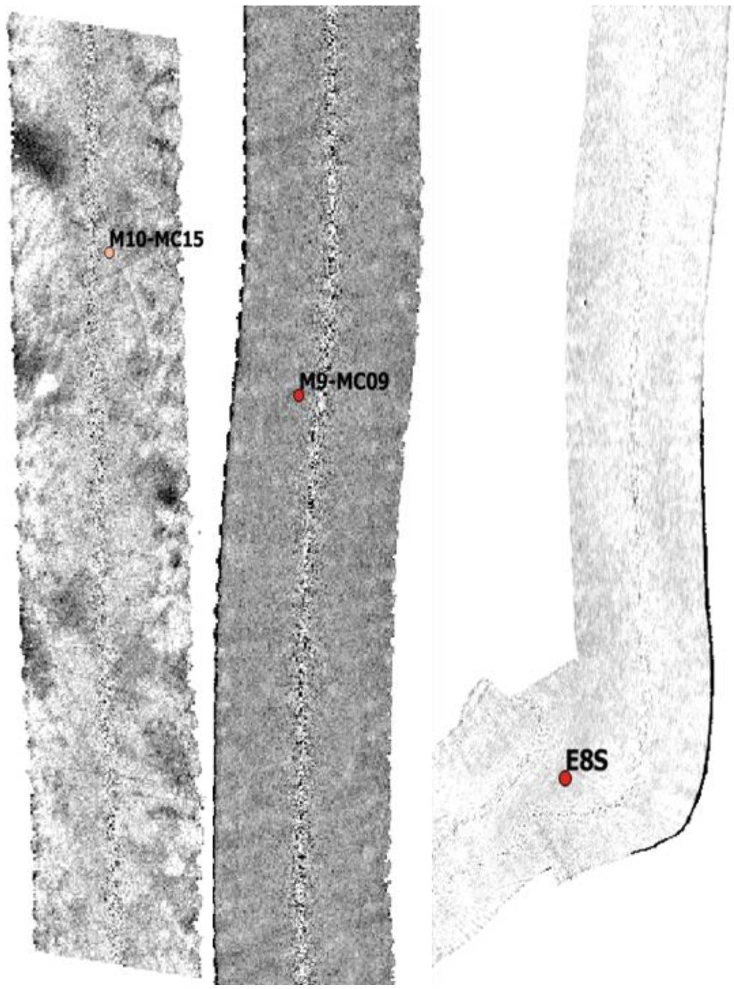



**Figure 7. Processed backscatter data from CONCORDE Spring 2016. Left to right, the images are from corridors Whiskey, Mike, and Echo.**

Figure 8 shows the location of the sediment samples collected and classified by grain size. Grain size results showed a decrease in size towards the northern end of each corridor and increased moving from west to east across the Bight. Data displayed in the sediment distribution map (Figure 8) and the areas between grab samples, interpolated from backscatter mosaic analysis, will be input to sediment transport models to aid in sediment suspension estimates. These data can be augmented with existing sporadic sediment samples from the area and used to provide a more complete picture of surficial grain size distribution.

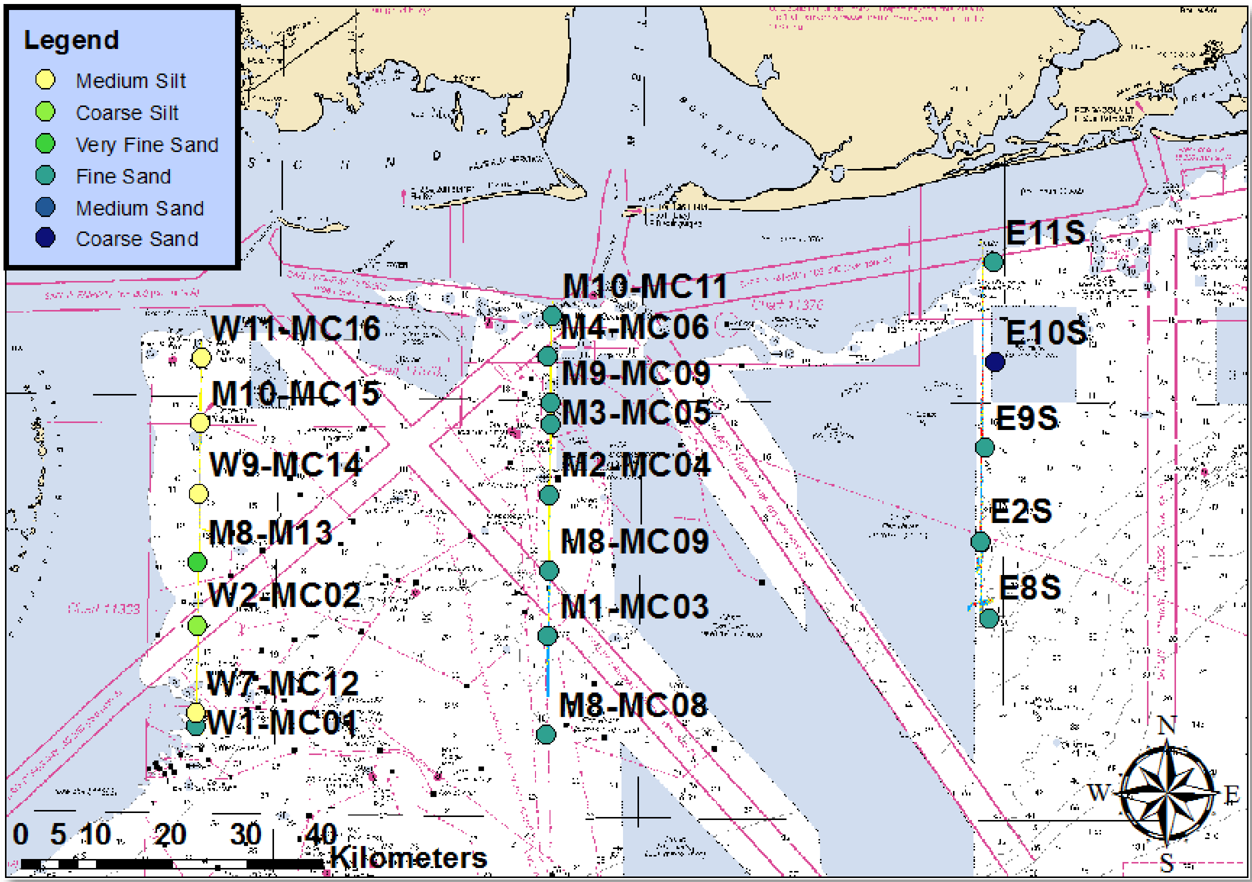



**Figure 8. Sediment Distribution Map showing location and size classification of seafloor sediment samples.**

## Discussion and Conclusions

From the acoustic backscatter data and sediment samples, there are clear differences in sediment grain size distributions throughout the Mississippi Bight sampled during the CONCORDE cruises. Grain sizes along each corridor were smallest towards the northern end, reflecting the influence of Mississippi Sound waters. The finer grain sizes along the western corridor are most likely Mississippi River sediment discharge, as medium silt was common along corridor Whiskey, but larger grain sizes were seen along Mike and Echo. Using the backscatter intensity measurements, the mosaics were brought into ArcGIS software, segmented and assigned color patterns to group areas of similar backscatter intensity. Examples of this are shown in Figures 9 – 11. These figures provide examples of select areas along corridors Whiskey and Mike where varying backscatter intensities were observed on or near sediment sample sites. Once suitable comparisons with the segmented backscatter and sediment grainsize statistics are developed, the intensity ranges are assigned a grain size to show an estimate of the overall distribution of sediments in the Mississippi Bight.

The correlation of the sediment samples with the backscatter mosaic data, as shown in Figures 9, 10 and 11, demonstrates the potential for using backscatter as a guide for sediment distribution estimates. While the backscattered acoustic energy of the sediments from a multibeam sonar depends on many factors, when it is linked with near-simultaneous surficial sediment sampling and quantitative grainsize analysis it can provide useful environmental information. The backscatter data qualitatively provides an estimate of the distribution of sediments with a similar grainsize distribution, homogeneity of the sediments, and sediment type boundaries, all of which are useful inputs to sediment transport modeling.

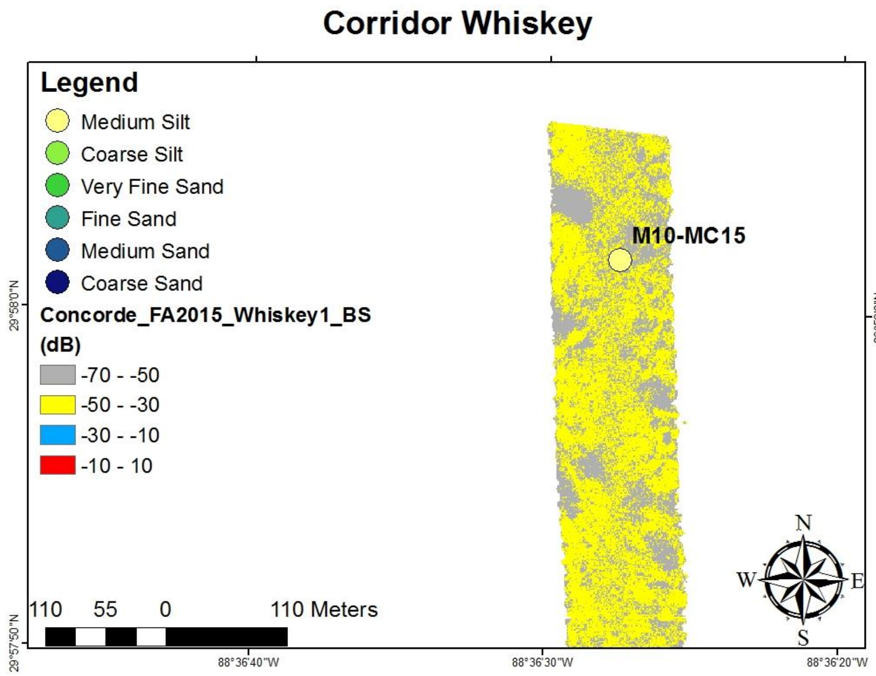



**Figure 9. Correlation of Backscatter Mosaic along Whiskey with sediment sample M10-MC15 (medium silt).**

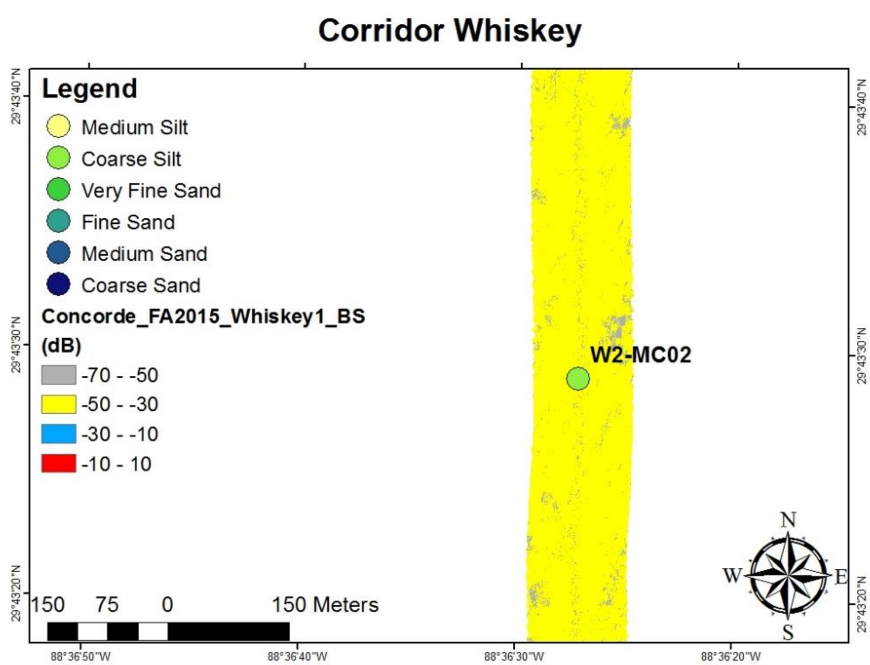



**Figure 10. Correlation of Backscatter Mosaic along Whiskey with sediment sample W2-MC02 (coarse silt).**

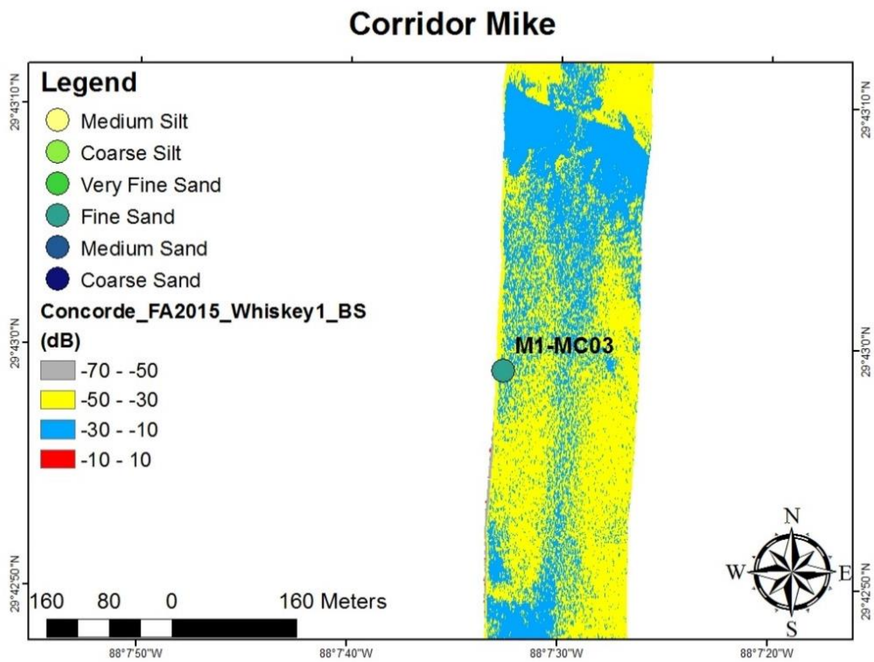



**Figure 11. Correlation of Backscatter Mosaic along Mike with sediment sample M1-MC03 (fine sand).**

Individual sediment sample statistical distributions (Figures 4, 5 and 6) might be more important for comparison to backscatter results than average grain sizes. The swath footprint of the backscatter data incorporates all grain sizes in the area, not just one "average" grain size or patch of identically-sized sediments. Since the distribution of grain sizes that is ensonified varies between sample locations, it could be assumed that variations in backscatter intensity are driven by these variations as much as the change in average grain size. A number of areas of future research have been identified from this investigation. These include: 1) further inter-calibration and processing of the acoustic backscatter and sediment data from the CONCORDE cruise; 2) continued analysis of the sediment distribution curves, including standard deviation, skewness and kurtosis, as well as their relationship to the backscatter angular response curves; and 3) comparison and correlation of backscatter intensity from the 200 and 400 kHz datasets.

Overall, this data is incredibly valuable to the scientists involved with the CONCORDE project. Because geochemical mechanisms might protect nearshore waters from toxicological exposure, it is crucial to include sediment type parameters to any model that might predict these processes. Continued research efforts with CONCORDE will form the foundation of future work in this area. The saying "map once, use the data many times" should be much more than a slogan. The goal of marine acoustic datasets, such as the ones presented in this paper, should be used to not only support hydrographic science but to support the diverse realm of oceanographic science fields, like the ones represented by CONCORDE.

## Acknowledgments

This research was made possible by a grant from The Gulf of Mexico Research Initiative. Data are publicly available through the Gulf of Mexico Research Initiative Information & Data Cooperative (GRIIDC) at https://data.gulfresearchinitiative.org/.

## References

Dartnell, P., & J.V. Gardner. 2004. Predicting Seafloor Facies from Multibeam Bathymetry and Backscatter Data. *Photogrammetric Engineering & Remote Sensing*, 70(9). 1081- 1091.

Druon, J., A. Mannino, S. Signorini, C. McClain, M. Friedrichs, J. Wilkin, & K. Fennel. 2010. Modeling the dynamics and export of dissolved organic matter in the Northeastern US Continental Shelf. *Estuaries Coastal and Shelf Sci*, 88:488-507. doi:/10.1016/j.ecss.2010.05.010

Fennel, K., J. Wilkin, J. Levin, J. Moisan, J. O'Reilly, & D. Haidvogel. 2006. Nitrogen cycling in the Middle Atlantic Bight: Results from a three-dimensional model and implications for the North Atlantic nitrogen budget. *Global Biogeochemical Cycles*, 20:GB3007 (1-14) doi:/10.1029/2005GB002456

Hasan, R.C., D. Ierodiaconou, L. Laurenson, & A. Schimel. 2014. Integrating Multibeam Backscatter Angular Response, Mosaic and Bathymetry Data for Benthic Habitat Mapping. *PLOS One*, 9(5). doi: 10.1371/journal.pone.0097339

Hofmann, E., J.N. Druon, K. Fennel, M. Friedrichs, D. Haidvogel, C. Lee, A. Mannino, C. McClain, R. Najjar, J. O'Reilly, *et al.* 2008. Eastern US continental shelf carbon budget integrating models, data assimilation, and analysis. *Oceanography* 21(1):86-104.

Jackson, D.R., D.P. Winebrenner, & A. Ishimaru. 1986. Application of the composite roughness model to high-frequency bottom backscattering. *Acoustical Society of America*, 79(5).

Lucieer, V., M. Roche, K. Degrendeke, M. Malik, & M. Dolan. 2015. Seafloor Backscatter User Needs and Expectations. In X. Lurton & G. Lamarche. Backscatter Measurements by Seafloor-Mapping Sonars: Guidelines and Recommendations. http://geohab.org/wp-content/uploads/2013/02/BWSG-REPORT-MAY2015.pdf

Lurton, X., & G. Lamarche. 2015. Introduction to Backscatter Measurements by Seafloor-Mapping Sonars. In X. Lurton & G. Lamarche. Backscatter Measurements by Seafloor-Mapping Sonars: Guidelines and Recommendations. http://geohab.org/wp-content/uploads/2013/02/BWSG-REPORT-MAY2015.pdf

Malvern Instruments Ltd. 2014. Mastersizer 3000: Basic Guide. MAN0475 Version 2.1. Worchestershire, UK: Malvern Instruments Ltd.

Malvern Instruments Ltd. 2013. Mastersizer 3000: User Manual. MAN0474 Version 2.1. Worchestershire, UK: Malvern Instruments Ltd.

Michel, J., E.H. Owens, S. Zengel, A. Graham, Z. Nixon, T. Allard, W. Holton, P.D. Reimer, A. Lamarche, M. White, N. Rutherford, C. Childs, G. Mauseth, G. Challenger, & E. Taylor. 2013. Extent and Degree of Shoreline Oiling: Deepwater Horizon Oil Spill, Gulf of Mexico, USA. *PLoS ONE* 8(6): e65087, http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0065087

QPS. (2016) FMGeocoder Toolbox Online Manual. Fledermaus 7.7.x Documentation. https://confluence.qps.nl/display/FM770/FMGT

Shchepetkin, A.F. & J.C. McWilliams. 2009. Correction and commentary for "Ocean forecasting in terrain-following coordinates: Formulation and skill assessment of the regional ocean modeling system" by Haidvogel et al., J. Comp. Phys. 227, pp. 3595-3624. *Journal of Computational Physics*, 228: 8985-9000. doi: 10.1016/j.jcp.2009.09.002

Shchepetkin, A.F. & J.C. McWilliams. 2005. The regional oceanic modeling system (ROMS): a split-explicit, free-surface, topography-following-coordinate oceanic model. *Ocean Modelling*, 9: 347-404. doi: 10.1016/j.ocemod.2004.08.002

Warner, J.C., B. Armstrong, R. He, & J.B. Zambon. 2010. Development of a Coupled Ocean-Atmosphere-Wave-Sediment Transport (COAWST) Modeling System. *Ocean Modelling*, 35 (3): 230-244. doi: 10.1016/j.ocemod.2010.07.010

Warner, J.C., C.R. Sherwood, R.P. Signell, C.K. Harris, & H.G. Arango. 2008. Development of a three-dimensional, regional, coupled wave, current, and sediment-transport model. *Computers and Geosciences*, 34: 1284-1306. doi: 10.1016/j.cageo.2008.02.012

Weber, T.C., & X. Lurton. 2015. Background and Fundamentals. In X. Lurton & G. Lamarche. Backscatter Measurements by Seafloor-Mapping Sonars: Guidelines and Recommendations. http://geohab.org/wp-content/uploads/2013/02/BWSG-REPORT-MAY2015.pdf

Wiggert, J. D., R. R. Hood, & C. W. Brown. 2017. Modeling Hypoxia and its Ecological Consequences in Chesapeake Bay, in *Modeling Coastal Hypoxia: Numerical Simulations of Patterns, Controls and Effects of Dissolved Oxygen Dynamics*, edited by D. Justic, et al., p. *in press*, Springer, New York.