Sediment surface elevation, erodibility, and acoustic properties of sediments collected from the Northern Gulf of Mexico following laboratory resuspension at the Dauphin Island Sea Lab in 2020

Website: https://www.bco-dmo.org/dataset/875373
Data Type: experimental, Other Field Results
Version: 1
Version Date: 2025-08-25

Project
» CAREER: Mechanisms of bioturbation and ecosystem engineering by benthic infauna (Bioturbation and Ecosystem Engineering)

Contributors	Affiliation	Role
Dorgan, Kelly	Dauphin Island Sea Lab (DISL)	Principal Investigator
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Abstract
This dataset includes sediment surface elevation, erodibility, and acoustic properties of sediments collected from the Northern Gulf of Mexico, off the Alabama coast at 10 meters depth following laboratory resuspension at the Dauphin Island Sea Lab.

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Coverage

Spatial Extent: **Lat**:30.22222 **Lon**:-88.13913
Temporal Extent: 2020-01-27 - 2020-02-27

Methods & Sampling

Sediment cores were collected from 10 meters (m) depth in the northern Gulf of Mexico offshore of Dauphin Island, Alabama, in cohesive muddy sediment on January 26, 2020 (30° 13.333' N, 88° 8.348' W). Cores were collected from a Dauphin Island Sea Lab vessel, the R/V Alabama Discovery. Polycarbonate sediment cores (9.6 centimeter (cm) inner diameter x 60 cm height) were collected using an MC-400 multicorer (Ocean Instruments, Fall City, WA). We resuspended the surface 5 cm of the cores in the lab using a modified baster with holes that directed water jets laterally below the sediment surface. We compared temporal changes in sediment compaction to changes in surface and subsurface cohesion over 30 days post-resuspension.

Sediment-water interface (SWI) height and acoustic sound speed through sediment, which depends on bulk density, provided continuous and nondestructive metrics of compaction, and sediment porosity and grain size were measured destructively to characterize sediment physical structure. We determined surface cohesion by measuring both eroded mass and turbidity resulting from increasing shear stress. Subsurface cohesion was determined from the force required for sediments to fail in tension. We compared surface and subsurface exopolymeric substance (EPS) concentrations to surface and subsurface cohesion measurements. We differentiated between water-soluble (colloidal) and sediment-bound EPS as we expected bound EPS to contribute more to sediment-organic matrix development and thus cohesion because they are directly bound to sediment grains rather than dissolved in porewater.

These data include the summary of data collected on cores processed over time points 0 days (no resuspension), then 1, 2, 3, 7, 14, and 30 days post resuspension. There were 5 replicate cores per time point, but not all data were collected on each replicate core. Detailed data on erosion measurements, as well as repeated non-destructive measurements of sediment-water interface height and sound speed on cores processed on day 30 are provided in separate datasets.

Cores were extruded and sliced at 1 cm depth intervals. We calculated water content from sediment mass differences before and after drying at 65 degrees Celsius (°C) for 24 hours as mass of water divided by mass of dry sediment (Eq. 4.7 from Jackson and Richardson 2007). We measured grain size every cm in the top 5 cm and at 8 and 10 cm for undisturbed cores and cores 3 and 30 days after resuspension. We determined grain size distribution with a Malvern Mastersizer 3000 particle analyzer (Malvern Panalytical, Malvern, UK) and data were analyzed with Gradistat (Kenneth Pye Associates, Ltd., Berkshire, UK) and classified according to Folk and Ward (1957).

We performed acoustic measurements following methods from Dorgan et al. (2020). Within a seawater tank, a 400 kHz three-cycle sinusoidal tone burst was transmitted horizontally through sediment cores to a receiver at 3 depths below the sediment surface (2.5, 5, 10 cm) (see Fig. 1 in Dorgan et al., 2020). To account for sound speed differences due to temporal variability in temperature and salinity, sound speed through sediment was normalized by the sound speed in seawater to obtain sound speed ratio (SSR). Each day, we also performed acoustic measurements on cores filled with seawater and with no core present. Sound speed in seawater and the lag time between the transmitted and received signals (time of flight) through sediment and seawater cores were used to calculate sound speed in sediment (νp):

ν_p=c_w/(1-(c_w * Δt/d_s)

where cw is sound speed in water, Δt is the difference in time of flight between seawater core (tw) and sediment core (ts), and ds is the inner diameter of the core (Jackson and Richardson, 2007; Dorgan et al., 2020). SSR was then calculated by dividing νp by cw, where a higher SSR indicates more compact sediment.

To determine if differences in erodibility and tensile strength were driven by variability in surface and subsurface EPS, we analyzed the subcore used for water content and grain size measurements for EPS carbohydrate concentrations. Following methods of de Brouwer and Stal (2001), we lyophilized frozen sediment and extracted colloidal carbohydrates with purified water (E-Pure) for 1 hour at 30 °C. We then extracted bound carbohydrates with 0.1 M Na2EDTA for 16 hours at room temperature. We measured both carbohydrate fractions with the sulfuric acid-UV assay (Albalasmeh et al., 2013), which is based on the phenol-sulfuric acid assay (DuBois et al., 1956). 900 µL 96 % sulfuric acid was added to 300 microliters (µL) carbohydrate solution to dehydrate dissolved carbohydrates into furfural derivatives, which absorb UV light. This solution was vortexed for 30 seconds, allowed to return to room temperature for approximately 5 minutes, then UV absorbance at 315 nanometers (nm) was measured using a SpectraMax M5 microplate reader (Molecular Devices). We determined carbohydrate concentration from UV absorbance of a glucose reference.

To determine subsurface cohesion changes over time, we measured tensile force (N) using a custom probe modified from a fracture toughness probe developed by Johnson et al. (2012). A helical probe is rotated and translated into the sediment like a corkscrew, then pulled upward, breaking off a plug of sediment. Force, measured with an in-line force sensor (Futek LS-200 2-lb), increases to a peak force, then drops when the plug breaks free of the sediment below. Forces from friction with the surrounding sediment and the weight of the sediment plug are removed by repeating the corkscrew motion and subtracting the force profile from the second upward pull. The peak force in the plot of net force as a function of upward distance corresponds to the tensile strength of the sediment, a metric of cohesion. Fracture toughness can be calculated from this peak force (Johnson et al. 2012), but due to some concerns about the effect of sediment depth on these calculations (Dorgan, unpublished data), only force is presented here. These force measurements are comparable across the same depth in different cores, with higher force indicating greater cohesion.

Instruments:

Grain size analysis was done on a Malvern Mastersizer 3000 particle analyzer. Most instruments are custom built. Acoustics measurements were done following Dorgan et al. 2020, JASA. Other measurements are described in Clemo et al., 2022.

Data Processing Description

Data Processing:
Sound speed was calculated from the lag between sent and received 3-pulse sine waves at 400 kHz using a custom Matlab script (see Dorgan et al. 2020 for details). Grain size analysis was done with Gradistat.

BCO-DMO Processing Description

- Imported original file "ClemoResuspensionExperiment2020.csv" into the BCO-DMO system.
- Renamed fields to comply with BCO-DMO naming conventions.
- Converted date column to YYYY-MM-DD format.
- Rounded numeric columns to 4 decimal places.
- Saved the final file as "875373_v1_sediment_resuspension.csv".

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Data Files

File
875373_v1_sediment_resuspension.csv (Comma Separated Values (.csv), 57.63 KB) MD5:f2d47304d786a7df35a58b712c003f87 Primary data file for dataset ID 875373, version 1

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Related Publications

Clemo, W. C., Giles, K. D., & Dorgan, K. M. (2022). Biological influences on coastal muddy sediment structure following resuspension. Limnology and Oceanography. Portico. https://doi.org/10.1002/lno.12213
Results

Dorgan, K. M., Ballentine, W., Lockridge, G., Kiskaddon, E., Ballard, M. S., Lee, K. M., & Wilson, P. S. (2020). Impacts of simulated infaunal activities on acoustic wave propagation in marine sediments. The Journal of the Acoustical Society of America, 147(2), 812–823. https://doi.org/10.1121/10.0000558
Results

DuBois, Michel., Gilles, K. A., Hamilton, J. K., Rebers, P. A., & Smith, Fred. (1956). Colorimetric Method for Determination of Sugars and Related Substances. Analytical Chemistry, 28(3), 350–356. https://doi.org/10.1021/ac60111a017
Methods

Folk, R. L., and W. C. Ward. 1957. Brazos River Bar: A study in the significance of grain size parameters. J. Sediment. Res. 27: 3-26.
Methods

Green Eyes, LLC. 2015. U-GEMS Manual Version 3.0. 0-44.
Methods

Jackson, D. R., & Richardson, M. D. (2007). High-Frequency Seafloor Acoustics. Springer New York. https://doi.org/10.1007/978-0-387-36945-7
Methods

Johnson, B. D., Barry, M. A., Boudreau, B. P., Jumars, P. A., & Dorgan, K. M. (2011). In situ tensile fracture toughness of surficial cohesive marine sediments. Geo-Marine Letters, 32(1), 39–48.

https://doi.org/10.1007/s00367-011-0243-1
Methods

de Brouwer, J., & Stal, L. (2001). Short-term dynamics in microphytobenthos distribution and associated extracellular carbohydrates in surface sediments of an intertidal mudflat. Marine Ecology Progress Series, 218, 33–44. https://doi.org/10.3354/meps218033
Results

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Related Datasets

IsRelatedTo

Dorgan, K., Clemo, W. C. (2025) **Acoustic properties of sediments collected from the Northern Gulf of Mexico following laboratory resuspension at the Dauphin Island Sea Lab in 2020.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-08-25 doi:10.26008/1912/bco-dmo.875501.1 [view at BCO-DMO]

Dorgan, K., Clemo, W. C. (2025) **Erodibility of sediments collected from the Northern Gulf of Mexico following laboratory resuspension at the Dauphin Island Sea Lab in 2020.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-08-25 doi:10.26008/1912/bco-dmo.875391.1 [view at BCO-DMO]

Dorgan, K., Clemo, W. C. (2025) **Sediment surface elevation change of sediments collected from the Northern Gulf of Mexico following laboratory resuspension at the Dauphin Island Sea Lab in 2020.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2025-08-25 doi:10.26008/1912/bco-dmo.875514.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
coreID	core ID named as "D_samplingday(max30)_replicate(A-E)"	unitless
latitude	Latitude of sample collection	decimal degrees
longitude	Longitude of sample collection	decimal degrees
water_depth_m	Water depth in meters	meters (m)
date	Date of sample collection	unitless
time_hour	time in hours since sediment disturbance was performed	hours
time_day	time in days since sediment disturbance was performed	days

timepoint	time point of experiment (max 30)	unitless
replicate	replicate identifier	unitless
depth_cm	depth within core	centimeters (cm)
water_content_fraction	(wet mass - dry mass)/dry mass of sediment	unitless
density_seawater	density of seawater	kilograms per cubic meter (kg m-3)
density_sediment	density of sediment	kilograms per cubic meter (kg m-3)
soundspeed_ratio_mean	ratio of sound speed in mud to sound speed in water	unitless
CumErodedMass	mass of eroded material from gust chamber	kilograms per square meter (kg m-2)
time_turbiditysensor_maxedout	amount of time the reading from the turbidity sensor was maxed out	minutes
timefraction_turbiditysensor_maxedout	fraction of time the turbidity sensor was maxed out	unitless
EPScolloidal	amount of colloidal exopolymeric substances in sediment	micrograms per gram (ug g-1)
EPSsedimentbound	amount of sediment bound exopolymeric substances in sediment	micrograms per gram (ug g-1)
MaxTensileF_N	max tensile force measured with custom probe (2 lb force sensor)	newtons (N)
GrainSizeAvgd10	10th percentile of grain size	micrometers (um)
GrainSizeAvgd50	50th percentile of grain size	micrometers (um)
GrainSizeAvgd90	90th percentile of grain size	micrometers (um)
GrainSizeMEAN	mean grain size	micrometers (um)

GrainSizeSORTING	grain size sorting, which is the standard deviation of the grain size distribution	unitless
GrainSizeSKEWNESS	grain size skewness	unitless
GrainSizeKURTOSIS	grain size kurtosis	unitless
percent_GRAVEL	Percent gravel	percent (%)
percent_SAND	Percent sand	percent (%)
percent_MUD	Percent mud	percent (%)
percent_V_COARSE_GRAVEL	Percent very coarse gravel	percent (%)
percent_COARSE_GRAVEL	Percent coarse gravel	percent (%)
percent_MEDIUM_GRAVEL	Percent medium gravel	percent (%)
percent_FINE_GRAVEL	Percent fine gravel	percent (%)
percent_V_FINE_GRAVEL	Percent very fine gravel	percent (%)
percent_V_COARSE_SAND	Percent very coarse sand	percent (%)
percent_COARSE_SAND	Percent coarse sand	percent (%)
percent_MEDIUM_SAND	Percent medium sand	percent (%)
percent_FINE_SAND	Percent fine sand	percent (%)
percent_V_FINE_SAND	Percent very fine sand	percent (%)
percent_V_COARSE_SILT	Percent very coarse silt	percent (%)
percent_COARSE_SILT	Percent coarse silt	percent (%)
percent_MEDIUM_SILT	Percent medium silt	percent (%)

percent_FINE_SILT	Percent fine silt	percent (%)
percent_V_FINE_SILT	Percent very fine silt	percent (%)
percent_CLAY	Percent clay	percent (%)
SAMPLE_TYPE	grain size sorting	unitless
TEXTURAL_GROUP	sediment texture	unitless
SEDIMENT_NAME	type of sediment	unitless

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Instruments

Dataset-specific Instrument Name	MC-400 multicorer
Generic Instrument Name	Ocean Instruments MC-400 Multi corer
Dataset-specific Description	Polycarbonate sediment cores (9.6 centimeter (cm) inner diameter x 60 cm height) were collected using an MC-400 multicorer (Ocean Instruments, Fall City, WA).
Generic Instrument Description	The Ocean Instruments MC-400 {Hedrick/Marrs} multi-corer is a sediment multi-corer with a series of cores attached to one deployment frame. This model carries four sample tubes. It is designed to retrieve sediment and water samples in lakes and shelf waters. The sample tubes are sealed with a silicone rubber upper door gasket and a neoprene or carpet lower door seal. Each of the four sample tubes can be removed from the coring unit for immediate processing in the laboratory without exposing their contents to the surface environment. It is designed to recover undisturbed surface sediments and is therefore well-suited to study benthic processes. The multi-corer is disposed on a research vessel and is lowered into the water body by a cable. When the multi-corer touches the sediment the units ballast weight pushes the assembled cores into the substrate. Each of the tubes contains a unique sediment core. The multi-corer uses a unique hydrostatic damping system that slows the penetration rate down to approximately 1 cm/s. Provisions have been made to carry up to two 4-liter water bottles that actuate as the frame legs touch bottom. The overall sample tube length is 58 cm, with a maximum penetration of 34.5 cm. The tube diameter is 10 cm.

Dataset-specific Instrument Name	Malvern Mastersizer 3000
Generic Instrument Name	Particle Size Analyzer
Dataset-specific Description	Grain size analysis was done on a Malvern Mastersizer 3000 particle analyzer.
Generic Instrument Description	Particle size analysis, particle size measurement, or simply particle sizing is the collective name of the technical procedures, or laboratory techniques which determines the size range, and/or the average, or mean size of the particles in a powder or liquid sample.

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Project Information

CAREER: Mechanisms of bioturbation and ecosystem engineering by benthic infauna (Bioturbation and Ecosystem Engineering)

Coverage: Dauphin Island Sea Lab, Dauphin Island, AL

NSF Award Abstract:
Marine sediments are important habitats for abundant and diverse communities of organisms that are important as food sources for higher trophic levels, including commercially important species. Through burrowing, constructing tubes, and feeding on sediments, these animals modify their physical and chemical environments to such an extent that they are considered ecosystem engineers. Bioturbation, the mixing of sediments by animals, is important in regenerating nutrients and transporting pollutants and carbon bound to mineral grains. Despite its importance, our ability to predict bioturbation rates and patterns from the community structure is poor, largely due to a lack of understanding of the mechanisms by which animals mix sediments. This project builds on earlier work showing that animals extend burrows through muddy sediments by fracture to test the hypothesis that the mechanical properties of sediments that affect burrowing mechanics also affect sediment mixing. More broadly, this project examines the relative contributions of (i) the functional roles of the organisms in the community, (ii) the mechanical properties of sediments, and (iii) factors that might increase or decrease animal activity such as temperature and food availability to bioturbation rates. Burrowing animals modify the physical properties of sediments, and this project quantifies these changes and tests the hypothesis that these changes are ecologically important and affect community succession following a disturbance. In addition to this scientific broader impact, this project involves development of instrumentation to measure sediment properties and includes a substantial education plan to introduce graduate, undergraduate, and middle school students to the important role that technology plays in marine science.

Through burrowing and feeding activities, benthic infauna mix sediments and modify their physical environments. Bioturbation gates the burial of organic matter, enhances nutrient regeneration, and smears the paleontological and stratigraphic record. However, current understanding of the mechanisms by which infaunal activities mix sediments is insufficient to predict the impacts of changes in infaunal community structure on important sediment ecosystem functions driven by bioturbation. This project tests specific hypotheses relating infaunal communities, bioturbation, and geotechnical properties with the ultimate goal of understanding the dynamic changes and potential feedbacks between infauna and their physical environments. This project integrates field and lab experiments to assess the relative importance of infaunal community structure and activities to bioturbation rates. Additionally, this project builds on recent work showing that muddy sediments are elastic gels through which worms extend burrows by fracture to propose that geotechnical properties of sediments mediate bioturbation by governing the release of particles from the sediment matrix during burrow extension. Finite element modeling determines how the release of particles by fracture during burrowing depends on the fracture toughness (cohesion) and stiffness (compaction) of sediments and complements laboratory experiments characterizing the impact of geotechnical properties on burrowing behaviors. The proposed research also aims to determine whether impacts of infauna on geotechnical properties are ecologically important. Changes in infaunal communities and geotechnical properties following an experimental physical disturbance address the hypothesis that ecosystem engineering of bulk sediment properties facilitates succession.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1844910

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