Erodibility of sediments collected from the Northern Gulf of Mexico following laboratory resuspension at the Dauphin Island Sea Lab

Website: https://www.bco-dmo.org/dataset/875391
Data Type: experimental
Version: 1
Version Date: 2022-06-24

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
Clemo, William Cyrus	Dauphin Island Sea Lab (DISL)	Contact
Heyl, Taylor	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset represents the erodibility of sediments collected from the Northern Gulf of Mexico following laboratory resuspension at the Dauphin Island Sea Lab.

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Coverage

Spatial Extent: **Lat**:30.2222 **Lon**:-88.1391
Temporal Extent: 2020-01-29 - 2020-02-27

Methods & Sampling

We resuspended the surface 5 cm of natural muddy sediment cores in the lab and 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 erosion measurements from this experiment. A 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 is given in dataset 1. Repeated non-destructive measurements of sediment-water interface height and sound speed on cores processed on day 30 are provided in separate datasets.

To examine changes in sediment surface cohesion, we measured total eroded mass and turbidity using a custom-built Gust erosion chamber (Fig. 2 B, Gust & Muller 1997, Thomsen & Gust 2000, U-GEMS Manual, Green Eyes, LLC, 2015). Cores were capped with the erosion chamber cap in which a rotating disc generated increasing levels of shear stress (0.1, 0.2, 0.3, 0.45, 0.6 Pa). Each stress level was maintained for 20 min before increasing to the next level. At each stress level, water and eroded material were removed by a pump at the center of the disc 10 cm above the sediment surface. This effluent passed through a C-Star transmissometer (Sea-Bird Scientific, Bellevue, WA, USA) recording light attenuation coefficient (m-1) at 650 nm to determine turbidity over time and was then captured for later filtration. An initial 0.01 Pa interval was used as a flushing step and not filtered, but seawater used to replace the effluent was filtered to determine background suspended sediment concentration.

Total eroded mass at each stress level was obtained by filtering the effluent through 47mm Whatman GF/F filters (1.5 µm pore size). Filters were dried at 65° C for 24 h, then weighed. We calculated suspended sediment concentration, Cs (kg m-3), for each core at each stress level from the dry mass (kg) of filtered sediment divided by the volume (m-3) of water filtered. Cs was converted to eroded mass per area (E; kg m-2):

(3) $E=(C_s V_c)/A_c$

where Vc is chamber volume (7.24 x10-4 m3), and Ac is sediment surface area within the core (7.24 x 10-3 m2). To generate specific shear stresses, we set cap rotation and pumping rate using calibration equations from the University of Maryland Center of Environmental Science Gust Erosion Microcosm System (U-GEMS) Manual (Green Eyes, LLC, 2015):

(4) $u_{15}^*=0.0318n^{0.763}$

(5) $Q=-28.31u_{15}^{*2}+170.2u_{15}^*-23.85$

where u*15 is shear velocity at 15 °C (cm s-1), n is rotations per minute, and Q is pumping rate (mL min-1). Shear velocity at 15 °C was converted to shear velocity at the average water temperature measured during the erosion tests (20 °C) as:

(6) $u_{15}^*=u_{20}^* [1+0.006(20-15)]$

where u*20 is shear velocity at 20 °C (cm s-1) (U-GEMS Manual, Green Eyes, LLC, 2015). Shear stress (τb; Pa) was calculated from shear velocity (u*20; m s-1) and seawater density (ρw; kg m-3) as:

(7) $\tau_b=\rho_w {u_{20}^*}^2$

(U-GEMS Manual, Green Eyes, LLC, 2015).

We determined turbidity, as suspended sediment concentration (kg m-3), from light attenuation coefficient, measured continuously throughout each stress level. We calibrated the transmissometer with muddy seawater of 4 suspended sediment concentrations (0.0038, 0.018, 0.030, and 0.050 kg m-3) made from sediment from the coring site. We then filtered each muddy water sample following the steps above to determine suspended sediment concentration and determined the relationship of light attenuation and suspended sediment concentration:

(8) $C_s=0.17c+0.0015$

where Cs is suspended sediment concentration (kg m-3) and c is light attenuation coefficient (m-1).

These data were collected using a custom-built Gust chamber. For more detail, see Clemo et al., submitted, Limnology and Oceanography.

Data Processing Description

BCO-DMO Processing:
- Converted dates to format (YYYY-MM-DD)

- Adjusted field/parameter names to comply with BCO-DMO naming conventions
- Added a conventional header with dataset name, PI names, version date

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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

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Related Datasets

IsRelatedTo

Dorgan, K., Clemo, W. Cyrus (2022) **Acoustic properties of sediments collected from the Northern Gulf of Mexico following laboratory resuspension at the Dauphin Island Sea Lab.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-06-15 http://lod.bco-dmo.org/id/dataset/875501 [view at BCO-DMO]

Dorgan, K., Clemo, W. Cyrus (2022) **Elevation of sediments collected from the Northern Gulf of Mexico following laboratory resuspension at the Dauphin Island Sea Lab.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-06-15 http://lod.bco-dmo.org/id/dataset/875514 [view at BCO-DMO]

Dorgan, K., Clemo, W. Cyrus (2022) **Elevation, erodibility, and acoustic properties of sediments collected from the Northern Gulf of Mexico following resuspension at the Dauphin Island Sea Lab in 2020.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-06-28 http://lod.bco-dmo.org/id/dataset/875373 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
core	named as "D_samplingday(max30)_replicate(A-E)"	unitless
latitude	latitude of sample site	decimal degrees
longitude	longitude of sample site (West is negative)	decimal degrees
waterdepth	water depth	meters
date	date in format YYYY-MM-DD	unitless
time_day	time of day	days
timepoint	time treatment (max 30)	unitless
replicate	1-4 corresponds with A-D in coreID	unitless
shearstress_Pa	bottom shear stress in Gust chamber	Pa
erodedmass	eroded mass for shear level	kilograms per meter squared (kg m-2)
cumerodedmass	cumulative eroded mass for core	kilograms per meter squared (kg m-2)
timeturbiditymaxedout	amount of time the reading from the turbidity sensor was maxed out	minutes
timeturbiditymaxedout_fraction	fraction of time the turbidity sensor was maxed out	fraction
MaxSuspSedConc	maximum suspended sediment concentration (turbidity sensor reading if not maxed out)	kilograms per meter cubed (kg m-3)

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Instruments

Dataset-specific Instrument Name	1000 W Ninja Professional
Generic Instrument Name	Blender
Generic Instrument Description	A laboratory appliance used to mix, crush, puree or emulsify substances. A stationary blender consists of a blender container with a rotating metal blade at the bottom, powered by an electric motor that is in the base. An immersion blender configuration has a motor on top connected by a shaft to a rotating blade at the bottom, which can be used with any container.

Dataset-specific Instrument Name	
Generic Instrument Name	Vacuum chamber
Generic Instrument Description	Vacuum chambers are used in the biopharmaceutical industry for drying, degassing, sterilizing, cooling, distilling, and crystallizing medications.

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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 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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