Sulfur, carbon, and iron biogeochemistry of biomass, below ground material, and dissolved organic matter from three mangrove ecosystems in the Caribbean and Florida collected over two field seasons in 2022 and 2024

Website: https://www.bco-dmo.org/dataset/983803
Data Type: Other Field Results
Version: 1
Version Date: 2025-09-17

Project
» Carbon Storage in Mangrove Ecosystems via Abiotic Sulfurization (Mangroves OS)

Contributors	Affiliation	Role
Capece, Lena R.	University of California-Santa Barbara (UCSB)	Student
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Abstract
Here we provide data on the sulfur, carbon, and iron biogeochemistry of biomass, below ground material, and dissolved organic matter from three mangrove ecosystems in the Caribbean and Florida collected over two field seasons in 2022 and 2024. We provide elemental concentrations (organic C/N/S, Fe, pyrite) and isotopic compositions (δ13C, δ34S) of biomass, below ground material, and dissolved organic matter. Data will be useful for those interested in assessing organic matter sulfurization and pyrite formation in blue carbon ecosystems such as mangroves. Data will also be informative for researchers investigating organic and inorganic sulfur cycling. Samples were collected by Lena Capece and Morgan Raven, data were interpreted by Lena Capece and Morgan Raven.

Table of Contents

Coverage

Location: Naples, FL and Turks and Caicos, Caribbean
Spatial Extent: **N**:26.02848 **E**:-71.69677 **S**:21.29705 **W**:-81.75085
Temporal Extent: 2022-06 - 2024-02

Methods & Sampling

We collected sediment cores, biomass, and dissolved organic matter from two mangrove locations in Rookery Bay National Estuarine Research Reserve and Little Ambergris Caye during the time period of June 2022 through February 2024. Sediment cores were extruded in the field and kept at -20 degrees Celsius (°C) until analysis could be carried out back in the lab at UC Santa Barbara. We provide elemental concentrations (organic C/N/S, Fe, pyrite) and isotopic compositions (δ13C, δ34S) of important carbon, iron, and sulfur pools. Additionally, surface material (litter or microbial mat) samples were collected between 2020 and 2023 and were also analyzed for elemental (C/N/S) and isotopic compositions (δ13C, δ34S).

Data Processing Description

After measurement of samples of data on instruments, all data were wrangled and analyzed in R version 4.4.3.

XAS spectra were obtained at the Stanford Synchrotron Radiation Lightsource (SSRL) on beam line 14–3 using a spot size of 0.5 square millimeters (mm2) and a Si(111) (Φ = 90) double crystal monochromator calibrated to the thiol pre-edge peak of thiosulfate at 2472.02 eV. Spectra were averaged and normalized in the SIXPACK (Webb 2005) software package using a K-edge E0 of 2473 and pre-edge and post-edge linear normalization ranges of -20 to -7 and 35 to 70 eV, respectively. The relative abundance (%) of individual sulfur species were determined in sediments and biomass samples using least squares fitting and a set of OS standards (Capece et al. 2025).

BCO-DMO Processing Description

- Imported original file "man_geochem.csv" into the BCO-DMO system.
- Marked "NA" as a missing data value (missing data are empty/blank in the final CSV file).
- Split the original "date" column into separate "year" and "month" columns.
- Corrected the spelling of "latitude".
- Changed longitude "81.7319" to "-81.7319" for the "station" site.
- Re-ordered columns so that pyrite_gc is next to pyrite_e.
- Saved the final file as "983803_v1_mangrove_geochem.csv".

Problem Description

There is missing data for some measurements due to detection limits or sample mishandling.

[table of contents | back to top]

Data Files

File
983803_v1_mangrove_geochem.csv(Comma Separated Values (.csv), 26.47 KB) MD5:8898be41f5a50d9eca91f40785ed57af Primary data file for dataset ID 983803, version 1

[table of contents | back to top]

Related Publications

Capece, L. R., Bailey, M., Morrison, M., Phillips, A. A., Sharpnack, L., Webb, S. M., Brenner, D. C., Gomes, M., & Raven, M. R. (2025). Evaluating sulfurization as a blue carbon sink in a southern California salt marsh. Limnology and Oceanography, 70(7), 1981–1991. Portico. https://doi.org/10.1002/lno.70089
Methods

Webb, S. M. (2005). SIXPack a Graphical User Interface for XAS Analysis Using IFEFFIT. Physica Scripta, 1011. doi:10.1238/physica.topical.115a01011
Methods

[table of contents | back to top]

Parameters

Parameter	Description	Units
site	sampling location with study designated with "rb" for Rookery Bay pristine (b1=basin1, b2 = basin2, f1= fringe1, f2=fringe2, o=overwash), ffc for Rookery Bay restored (t=transitional, d=deteriorated) , or basin (1-3) and fringe (1-3) for Little Ambegris Caye	unitless
latitude	site latitude	decimal degrees
longitude	site longitude	decimal degrees
year	year of collection	unitless
month	month of collection	unitless
habitat	type of mangrove environment (deteriorated, transitional, basin, fringe, overwash)	unitless
type	study location either at Rookery Bay (pristine or restored) or Little Ambergris Caye (ambergris)	unitless
depth	sampling interval in centimeters	centimeters (cm)
OC	organic carbon content as a weight percent carbon	percent
OC_e	standard error associated with OC	percent
SC	molar total sulfur to carbon ratio as a percent	percent
SC_e	standard error associated with SC	percent
CN	molar carbon to nitrogen ratio	unitless
CN_e	standard error associated with CN	unitless
d13C	total organic carbon isotope composition expressed in per mille	per mille
d13C_e	standard error associated with d13C	per mille
d34S	total sulfur isotope composition expressed in per mille	per mille

d34S_e	standard error associated with d34S	per mille
pyrite_gc	pyrite content as a weight percent sulfur	percent
pyrite_e	standard error associated with pyrite_gc	percent
CPK	protokerogen organic carbon content as a weight percent carbon	percent
CPK_e	standard error associated with CPK	percent
SPK	protokerogen organic sulfur content as a weight percent sulfur	percent
SPK_e	standard error associated with SPK	percent
SCPK	molar protokerogen organic sulfur to carbon ratio as a percent	percent
SCPK_e	standard error associated with SCPK	percent
CNPK	molar protokerogen organic carbon to nitrogen ratio as a percent	percent
CNPK_e	standard error associated with CNPK	percent
d13CPK	protokerogen organic carbon isotope composition expressed in per mille	per mille
d13CPK_e	standard error associated with d13CPK	per mille
d34SPK	protokerogen organic sulfur isotope composition expressed in per mille	per mille
d34SPK_e	standard error associated with d34SPK	per mille
d34Spy	pyrite sulfur isotope composition expressed in per mille	per mille
d34Spy_e	standard error associated with d34Spy	per mille
CSPK	inverse of SCPK, molar protokerogen organic carbon to sulfur ratio	unitless
depth_bin	bins below ground samples by depth in cm (0-2, 2-10, 15-25), mangrove biomass into "surface" and fine root="roots" material, and dissolved organic matter as dom	unitless

surfmat	dominant above ground surface material (either mat, litter, or mat/litter = mlit)	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Conflo IV
Generic Instrument Name	Continuous Flow Interface for Mass Spectrometers
Dataset-specific Description	Thermo Scientific Delta V Plus Isotope Ratio Mass Spectrometer (IRMS) via Conflo IV to measure relative abundance of isotopes, in this case δ34S.
Generic Instrument Description	A Continuous Flow Interface connects solid and liquid sample preparation devices to instruments that measure isotopic composition. It allows the introduction of the sample and also reference and carrier gases. Examples: Finnigan MATConFlo II, ThermoScientific ConFlo IV, and Picarro Caddy. Note: This is NOT an analyzer

Dataset-specific Instrument Name	Elementar vario ISOTOPE select elemental analyzer
Generic Instrument Name	Elemental Analyzer
Dataset-specific Description	Elementar vario ISOTOPE select elemental analyzer interfaced to a Nu Horizon isotope ratio mass spectrometer to measure CNS and δ13C
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

Dataset-specific Instrument Name	Metrosep A Supp 5-100/4.0 column and Metrohm 930 Compact IC Flex
Generic Instrument Name	Ion Chromatograph
Dataset-specific Description	Metrosep A Supp 5-100/4.0 column and Metrohm 930 Compact IC Flex to measure CRS
Generic Instrument Description	Ion chromatography is a form of liquid chromatography that measures concentrations of ionic species by separating them based on their interaction with a resin. Ionic species separate differently depending on species type and size. Ion chromatographs are able to measure concentrations of major anions, such as fluoride, chloride, nitrate, nitrite, and sulfate, as well as major cations such as lithium, sodium, ammonium, potassium, calcium, and magnesium in the parts-per-billion (ppb) range. (from http://serc.carleton.edu/microbelife/research_methods/biogeochemical/ic....)

Dataset-specific Instrument Name	Nu Horizon isotope ratio mass spectrometer
Generic Instrument Name	Isotope-ratio Mass Spectrometer
Dataset-specific Description	Elementar vario ISOTOPE select elemental analyzer interfaced to a Nu Horizon isotope ratio mass spectrometer to measure CNS and δ13C
Generic Instrument Description	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

Dataset-specific Instrument Name	MARS-6 microwave CEM
Generic Instrument Name	Microwave Digestion Platform
Dataset-specific Description	MARS-6 microwave CEM to extract lipids from sediments
Generic Instrument Description	Microwave digestion is a chemical technique used to decompose sample material into a solution suitable for quantitative elemental analysis

Dataset-specific Instrument Name	Genesys 150 UV-Vis Spectrophotometer
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	Genesys 150 UV-Vis Spectrophotometer to measure iron extracts
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

Dataset-specific Instrument Name	Thermo Scientific Delta V Plus Isotope Ratio Mass Spectrometer (IRMS) via Conflo IV
Generic Instrument Name	Thermo Fisher Scientific DELTA V Plus isotope ratio mass spectrometer
Dataset-specific Description	Thermo Scientific Delta V Plus Isotope Ratio Mass Spectrometer (IRMS) via Conflo IV to measure relative abundance of isotopes, in this case δ34S.
Generic Instrument Description	The Thermo Scientific DELTA V Plus is an isotope ratio mass spectrometer designed to measure isotopic, elemental and molecular ratios of organic and inorganic compounds. The DELTA V Plus is an enhanced model of the DELTA V series of isotope ratio mass spectrometers, which can be upgraded from the DELTA V Advantage. The DELTA V Plus can be operated in Continuous Flow or Dual Inlet mode and can accommodate up to 10 collectors, ensuring flexibility to cover many applications. The DELTA V Plus is controlled by an automated, integrated Isodat software suite. A magnet, whose pole faces determine the free flight space for the ions, eliminates the traditional flight tube. The magnet is designed for fast mass switching which is further supported by a fast jump control between consecutive measurements of multiple gases within one run. The sample gas is introduced at ground potential, eliminating the need for insulation of the flow path, ensuring 100 percent transfer into the ion source. The amplifiers register ion beams up to 50 V. The DELTA V Plus has refined optics, enabling greater ion transmission than the DELTA V Advantage. It has a sensitivity of 800 molecules per ion (M/I) in Dual Inlet mode and 1100 M/I in Continuous Flow mode. It has a system stability of < 10 ppm and an effective magnetic detection radius of 191 nm. It has a mass range of 1 - 96 Dalton at 3 kV.

[table of contents | back to top]

Project Information

Carbon Storage in Mangrove Ecosystems via Abiotic Sulfurization (Mangroves OS)

Website: http://ravennoiselab.com

Coverage: Floridian and Caribbean mangroves; Californian salt mashes

NSF Award Abstract:
Mangrove forest sediments are important hotspots of organic carbon preservation, and they have the potential to sequester substantial amounts of atmospheric CO2. Currently, however, is it not fully understood why these environments are able to bury so much organic carbon, or how they will respond to future changes in sea level, land use, and climate. This project will investigate a mechanism that may help explain this carbon burial: organic matter sulfurization, the transformation and effective ‘pickling’ of sedimentary organic matter by sulfide. Its central aim is to understand what controls the extent of sulfurization in mangrove sediments, and to estimate the contribution of organic matter sulfurization to sediment carbon storage in different parts of the environment. By providing some of the first constraints on how, when, and where organic matter sulfurization happens in mangroves, the results of this work will guide decisionmakers managing coastal watersheds and carbon stocks in the face of land use, climate and sea level change. As part of this work, four undergraduate students and one PhD student at UC Santa Barbara will gain field and research experience. And, in collaboration with local groups associated with the field site, the team will produce a season of ‘Ocean Solutions’ podcast episodes related to conservation and human impacts of Caribbean mangroves.

The overarching goal of this project is to understand how microbial sulfur cycling affects organic matter preservation in vegetated coastal sediments, which have substantial leverage to impact the global carbon cycle on decadal to millennial timescales. It specifically investigates organic matter sulfurization, which can transform fresh, easily respired organic matter into recalcitrant, polymerized carbon stocks with long-term preservation potential. Although organic matter sulfurization is known to occur in mangrove sediments, the scale of its impact is essentially unknown. A pair of field expeditions will be conducted at a mangrove forest on the southwestern coast of Florida. In the first field season, geochemical profiles will be used to quantify organic matter sulfurization in sediments and its relationships with carbon storage, iron mineralogy, and the characteristics of sedimentary organic matter inputs. In the second field season, cyclic voltammetry will be used to target redox dynamics at the millimeter scale. Laboratory experiments will be conducted to test the susceptibility of various local organic matter sources to sulfurization and characterize their sulfurized forms. Throughout, the project applies a holistic approach to sedimentary organic matter by characterizing the dissolved, lipid, protein/carbohydrate, and proto-kerogen pools with isotopic and spectroscopic techniques. This work will yield a first quantitative, mechanistic framework for predicting the extent of organic matter sulfurization in coastal vegetated habitats and its likely response to changes in ecology, land use, or sea level.

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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Earth Sciences (NSF EAR)	EAR-2053163

[table of contents | back to top]