Carbon content and radioisotope data from sampling conducted at the Compass Station in Bedford Basin, Nova Scotia, Canada from February to August 2019

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Data Type: Cruise Results
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Project
» Ocean Frontier Institute Seed Fund Grant: Bedford Basin 2019 (Bedford Basin 2019)

Contributors	Affiliation	Role
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Abstract
These data include carbon content and radioisotope (234Th-excess) data collected at the Compass Station in Bedford Basin, Nova Scotia, Canada at four time periods from February to August 2019. A four-core multicorer was used to obtain the cores and samples were analyzed via beta counting (234Th) and CHN analysis (carbon content). These data were collected in conjunction with water column samples that were measured for total 234Th, particulate 234Th, and particulate carbon to assess carbon export and the carbon budget of Bedford Basin.

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Coverage

Spatial Extent: **Lat**:44.692 **Lon**:-63.642
Temporal Extent: 2019-02-12 - 2019-08-02

Methods & Sampling

Methods & Sampling:
Data were collected on four cruises conducted as day trips in 2019 (from February to August) aboard the SigmaT, as indicated by the sampling dates. The SigmaT is a local vessel with an appropriate winch for the deployment of coring equipment and Niskins. This vessel is privately owned and operated. All samples were taken at the Compass Station. Drs. Erin Black and Stephanie Kienast can be contacted about all cruises and equipment deployments.

Sediment cores ranging from 20 to 32 centimeters (cm) in length were taken with a KC Denmark four-core multi-corer at the Compass Station on February 18, April 11, May 9, and August 2 of 2019. Cores were capped, preserved, and transported back to Dalhousie University for sectioning, except for the February core, which was sectioned on the ship. The cores were extruded and sectioned in 1-4 cm intervals, with greater

resolution in the upper 5 cm. In February, April, and May, one core was used for carbon and Thorium-234 (234Th) measurements. In August, two sets of paired cores (four cores total) were homogenized in 1 cm increments to provide more mass for analysis in the upper 5 cm and to test for spatial heterogeneity.

Methods follow the processing and counting procedures in Black and Buessler (2014) with details and any modifications noted here. After sectioning, sediment samples were dried in plastic sample boats at low temperatures (<50 °Celsius) over a period of 2-3 days and ground using a mortar and pestle. Samples were homogenized and then tightly packed into 50-millimeter (mm) by 9-mm falcon dishes and with masses ranging from ~8-15 grams. For the February and April sampling events, separate 234Th measurements for the 0-1 cm and 1-2 cm layers were not possible because of mass requirements for gamma counting. Therefore, there are separate carbon measurements reported for each layer, but not for 234Th activities. After a carbon subsample was taken for carbon measurements, the 0-1 cm and 1-2 cm sediment was combined and homogenized for gamma counting. The results listed for the 0-1 cm and 1-2 cm layers for the February and April sampling events represent the 234Th value for the homogenized 0-2 cm layer, not two separate values for the individual depth layers. The C:234Th ratios were determined by averaging the total carbon for the individual depth layers (0-1 cm and 1-2 cm) and dividing by the 234Th activity.

All gamma counting of sediments was completed at the Radionuclide Facility at Dartmouth College using Canberra Intrinsic High Purity Germanium Detectors. 234Th was determined at 63.3 kiloelectron volts (keV). Samples from the upper 5 cm of the cores were analyzed within 32 days. All sample activities were decay-corrected to the sampling date. A visual inspection indicated the sediments were fine-grained, organic-rich, and relatively homogenous. Porosity (i.e. water content) was determined for the upper 5 cm using the mass difference between wet and dry sediment subsamples, correcting for salt content, and assuming a sediment density of 2.65 grams per cubic centimeter (g cm-3) (Burdige 2006). Sediment uncertainties for 234Th activities are the propagation of gamma counting errors and an assessment of potential variability in porosity and density estimates.

Carbon content of sediments was analyzed in the CERC.OCEAN facility at Dalhousie University using a Costech Instruments Elemental Combustion System 4010. Approximately 4-5 mg of sediment from each depth layer were analyzed. The average carbon content (± s.d.) did not differ between acid-fumigated samples (n = 29, 5.5% ± 0.5%) and non-fumigated samples (n = 39, 5.7% ± 0.8%), suggesting that most of the total carbon is organic in nature. Therefore, it is assumed the reported 'total' carbon content here can be used interchangeably with 'organic' carbon content. For acid-fumigation tests, a drop of milli-Q water was added to each sample cup with sediment. The cups were left lid-off in a desiccator with an open bottle of concentrated hydrochloric acid overnight and then dried in a standard oven at 50 °Celsius prior to carbon analysis.

Data Processing Description

Known Issues/Problems:
Small data issues are noted in the methods section because they are related to subsampling methods.

Standard data quality flags are used as follows:
2 = probably good,
3 = probably bad,
4 = bad,
6 = below detection,
9 = missing data.

Missing data is only used once where the sample was analyzed and there was a subsequent issue with the instrument. Otherwise, NaN is used for depths where no result exists for a given parameter.

BCO-DMO Processing:
- renamed fields to comply with BCO-DMO naming conventions (replaced spaces with underscores);
- converted dates to format YYYY-MM-DD.

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Data Files

File	
sediments.csv	(Octet Stream, 5.96 KB) MD5:6ef0bb5b31a600ec2f56b688d325b661
Primary data file for dataset ID 889551	

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Related Publications

Black, E. E., & Buesseler, K. O. (2014). Spatial variability and the fate of cesium in coastal sediments near Fukushima, Japan. Biogeosciences, 11(18), 5123–5137. https://doi.org/10.5194/bg-11-5123-2014
Methods

Black, E. E., Algar, C. K., Armstrong, M., & Kienast, S. S. (2023) Insights into constraining coastal carbon export from radioisotopes. Frontiers in Marine Science, volume 10. doi: 10.3389/fmars.2023.1254316
Results

Burdige, D. J. (2006). Geochemistry of marine sediments. Princeton University Press. https://isbnsearch.org/isbn/9780691095066
Methods

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Parameters

Parameter	Description	Units
Station_ID	Station number (always 1 which is the Compass Station in Bedford Basin)	unitless
Latitude	Latitude of sampling location reported to 3 decimal places. Samples were all taken at the Compass Station in Bedford Basin.	degrees [+N, -S]
Longitude	Longitude of sampling location reported to 3 decimal places. Samples were all taken at the Compass Station in Bedford Basin	degrees [+E, -W]
Sampling_Date	Date when sediment samples were collected. Sediment coring took place between 9 am and 4 pm local time.	unitless
Event_ID	There are three sampling events (1, 2, 3) corresponding to sampling date groupings for seawater and sediment sampling. Event 1 for seawater sampling will correspond to Event 1 for sediment sampling, and so on.	unitless
Core_ID	For most dates, one sediment core was used and the Core ID = 1. For the August sampling date there were multiple cores and thus Core IDs of 1 and 2.	unitless
Average_Layer_Depth	Sediment cores were sectioned into layers. The Average Layer Depth represents the midpoint of this layer below the sediment core surface (i.e. a depth of 2 cm represents 2 cm below sediment core surface). The sediment core surface is assumed to represent the in-situ sediment-water interface. Average Layer Depth is found by subtracting the Layer Start Depth value from the Layer End Depth value.	centimeters (cm)
Layer_Start	Sediment cores were sectioned into layers. The Layer Start Depth represents the top of this layer relative to the sediment core surface (i.e. a depth of 2 cm represents 2 cm below sediment core surface). The sediment core surface is assumed to represent the in-situ sediment-water interface.	centimeters (cm)

Layer_End	Sediment cores were sectioned into layers. The Layer End Depth represents the bottom of this layer relative to the sediment core surface (i.e. a depth of 2 cm represents 2 cm below sediment core surface). The sediment core surface is assumed to represent the in-situ sediment-water interface.	centimeters (cm)
C_PT_SED	Percent total carbon content of the sediments.	percent
Unc_C_PT_SED	Uncertainty for C_PT_SED. Uncertainties are set at 0.05% which is derived from replicate standard analysis.	percent
Flag_C_PT_SED	Data quality flag for C_PT_SED: (2) probably good, (3) probably bad, (4) bad, (6) below detection, (9) missing data	unitless
C_CONC_SED	Total carbon concentration of the sediments in millimoles per gram.	millimoles per gram (mmol/g)
Unc_C_CONC_SED	Uncertainty for C_CONC_SED. Uncertainties are extrapolated from the percent total carbon content uncertainty.	millimoles per gram (mmol/g)
Flag_C_CONC_SED	Data quality flag for C_CONC_SED: (2) probably good, (3) probably bad, (4) bad, (6) below detection, (9) missing data	unitless
Th_234_EX_CONC_SED	Excess 234Th activity in sediments (decays per minute per gram). BD indicates that while 234Th activities were measured, the activity of 234Th determined was within the uncertainty values of the supported 234Th determined for the sediment core. Thus, the supported and measured 234Th activities are indistinguishable.	decays per minute per gram (dpm/g)
Unc_Th_234_EX_CONC_SED	Uncertainty for Th_234_EX_CONC_SED. Sediment uncertainties for 234Th activities are the propagation of gamma counting errors and an assessment of potential variability in porosity and density estimates.	decays per minute per gram (dpm/g)
Flag_Th_234_EX_CONC_SED	Data quality flag for Th_234_EX_CONC_SED: (2) probably good, (3) probably bad, (4) bad, (6) below detection, (9) missing data	unitless
DerRatio_CTh_SED	Derived ratio of sediment carbon content to 234Th excess activity (C:234Thex in micromoles:decays per minute). Note: Values have been calculated from the raw carbon content and thorium data values, not the rounded reported values in this published dataset. Raw ratio values and uncertainties are reported here. Ratios that account for significant figures and extrapolation can be calculated directly from the carbon and thorium data published here.	micromoles to decays per minute (umol:dpm)
Unc_DerRatio_CTh_SED	Uncertainty for DerRatio_CTh_SED. Uncertainties are extrapolated from the percent total carbon content uncertainty and the thorium excess uncertainty.	micromoles to decays per minute (umol:dpm)
Flag_DerRatio_CTh_SED	Data quality flag for DerRatio_CTh_SED: (2) probably good, (3) probably bad, (4) bad, (6) below detection, (9) missing data	unitless

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Instruments

Dataset-specific Instrument Name	Costech Instruments Elemental Combustion System 4010
Generic Instrument Name	Costech International Elemental Combustion System (ECS) 4010
Dataset-specific Description	Carbon content of sediments was analyzed using a Costech Instruments Elemental Combustion System 4010 owned and operated by Dalhousie University.
Generic Instrument Description	The ECS 4010 Nitrogen / Protein Analyzer is an elemental combustion analyser for CHNSO elemental analysis and Nitrogen / Protein determination. The GC oven and separation column have a temperature range of 30-110 degC, with control of +/- 0.1 degC.

Dataset-specific Instrument Name	Canberra Intrinsic High Purity Germanium Well Detectors
Generic Instrument Name	Germanium detector
Dataset-specific Description	All gamma counting of sediments (for Thorium and associated radioisotopes) was completed using Canberra Intrinsic High Purity Germanium Detectors owned and operated by Dartmouth College.
Generic Instrument Description	Germanium detectors are semiconductor diodes having a p-i-n structure in which the intrinsic (i) region is sensitive to ionizing radiation, particularly x rays and gamma rays. Under reverse bias, an electric field extends across the intrinsic or depleted region. When photons interact with the material within the depleted volume of a detector, charge carriers (holes and electrons) are produced and are swept by the electric field to the p and n electrodes. This charge, which is in proportion to the energy deposited in the detector by the incoming photon, is converted into a voltage pulse by an integral charge sensitive preamplifier. Germanium detectors are mostly used for gamma spectroscopy in nuclear physics, as well as x-ray spectroscopy.

Dataset-specific Instrument Name	mortar and pestle
Generic Instrument Name	Homogenizer
Dataset-specific Description	After sectioning, sediment samples were dried in plastic sample boats at low temperatures and ground using a mortar and pestle.
Generic Instrument Description	A homogenizer is a piece of laboratory equipment used for the homogenization of various types of material, such as tissue, plant, food, soil, and many others.

Dataset-specific Instrument Name	KC Denmark four-core multi-corer
Generic Instrument Name	Multi Corer
Dataset-specific Description	All sediment cores were collected using a KC Denmark four-core multi-corer owned and operated by Dalhousie University.
Generic Instrument Description	The Multi Corer is a benthic coring device used to collect multiple, simultaneous, undisturbed sediment/water samples from the seafloor. Multiple coring tubes with varying sampling capacity depending on tube dimensions are mounted in a frame designed to sample the deep ocean seafloor. For more information, see Barnett et al. (1984) in Oceanologica Acta, 7, pp. 399-408.

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Project Information

Ocean Frontier Institute Seed Fund Grant: Bedford Basin 2019 (Bedford Basin 2019)

Coverage: Compass Station in Bedford Basin, Nova Scotia, Canada

In coastal regions, the transport of carbon from surface waters to the seafloor is a key mechanism of carbon burial and it has been suggested that one-fifth of the carbon entering coastal areas off of eastern North America (from the atmosphere and through rivers) is subsequently buried in these coastal areas (Najjar et al., 2018). However, direct measurements coupling carbon fluxes in coastal waters to accumulation in sediment remains a challenge.

Bedford Basin is a well-studied coastal system in Nova Scotia, Canada (Bedford Basin Monitoring Program) that can provide unique insight into carbon cycling in these shallow marine regions. To quantify sinking particulate carbon and benthic-pelagic carbon cycling, and to examine the potential factors influencing coastal carbon budgets, carbon content and radioisotope (i.e., Thorium-234) measurements were collected at the Compass Station in Bedford Basin at four time periods (February to August 2019). Sediment cores and seawater samples were analyzed. Size fractionated filtration was performed to examine differences in 'sinking' (>51 micrometers) and 'suspended' (1-51 micrometers) particulate organic carbon and Thorium-234.

References Cited:
Najjar, R. G., et al. (2018). Carbon Budget of Tidal Wetlands, Estuaries, and Shelf Waters of Eastern North America. In Global Biogeochemical Cycles (Vol. 32, Issue 3, pp. 389–416). American Geophysical Union (AGU). https://doi.org/10.1002/2017gb005790

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Funding

Funding Source	Award
Ocean Frontier Institute (OFI)	OFI Seed Fund Phase II

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