Sediment-trap particle flux and composition measurements before, during, and after the passage of Hurricane Fabian (2003) and Hurricane Igor (2010) that resuspended large amounts of sediment from the Bermuda Platform

Website: https://www.bco-dmo.org/dataset/998301
Data Type: Cruise Results, Other Field Results
Version: 1
Version Date: 2026-05-22

Project
» Time Series Particle Flux Measurements in the Sargasso Sea (OFP Sargasso Sea)

Program
» Oceanic Flux Program (OFP)

Contributors	Affiliation	Role
Pedrosa Pàmies, Rut	Marine Biological Laboratory (MBL)	Principal Investigator
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset includes sediment-trap particle flux and composition measurements from the study described below: Tropical cyclones erode and remobilize coastal sediments but their impact on the deep ocean remains unclear. Hurricane-driven transport of carbonates and associated materials from reef carbonate platforms to the deep ocean has important implications for carbon storage, deep ecosystems, and ocean chemistry as carbonate platform reef-sourced aragonite and high-Mg calcite (HMC) may dissolve and contribute to deep water total alkalinity. These data were used to describe two hurricane-driven resuspension events where deep sediment plumes from the Bermuda Pedestal (NW Atlantic) were advected to deep waters surrounding the Oceanic Flux Program (OFP) mooring site, ~75 kilometers (km) southeast of Bermuda. Hurricanes Fabian (Cat. 3, 2003) and Igor (Cat. 1, 2010) generated large near-inertial waves propagating to greater than 750-meter (m) depths, leading to widespread sediment resuspension from the Pedestal. Following Fabian, carbonate fluxes at the OFP site increased 15-fold, 32-fold, and 6-fold at 500, 1,500 and 3,200 m, respectively, with the 1,500 m flux equivalent to the total annual carbonate flux. OFP traps similarly captured a large detrital carbonate plume following Igor; here, the plume was shallower and persisted longer. Microscopy, geochemistry, and mineralogy confirmed that both plumes consisted of fine-grained shallow-water detrital carbonates alongside other materials accumulated on the Pedestal including phosphorus, lithogenic, authigenic, and pollutant elements. Clay-sized particles (less than 4 micrometers (µm)) in both plumes exhibited high contents of lithogenic and authigenic elements, and Zn, Cd, and V, facilitating their transport over long distances. Grain-size, elemental, and lipid composition indicated that plumes intercepted at different depths originated from different source areas on the Pedestal.

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Coverage

Location: Sargasso Sea (North Atlantic)
Spatial Extent: **Lat**:31.9167 **Lon**:-64.0833
Temporal Extent: 2003-07-13 - 2010-11-23

Methods & Sampling

Particle Fluxes

The OFP mooring and sample collection methods are provided in Conte et al. (2001). The OFP mooring uses conical Parflux sediment traps (McLane Research Laboratories, Falmouth MA, USA) having a 0.5 square meters (m2) sampling area. Traps are deployed at 500, 1,500 and 3,200 m depths and continuously collect the sinking particle flux at an approximate biweekly resolution. Trap cups are filled with deep seawater brine (41 parts per thousand (ppt)) poisoned with ultra-trace metal purity HgCl2 (200 milligrams per liter (mg L-1)) to prevent organic matter degradation. Before deployment, trap cups are filled in a laminar flow hood with a trace metal clean brine (41 ppt), prepared from seawater collected at 3,000 m depth using trace-metal clean Go-Flo bottles, poisoned with ultra-purity mercuric chloride (200 mg L-1) to arrest bacterial activity. Process and deployment blanks are collected during each deployment to assess potential contamination.

Analytical Methods

OFP sample processing: Sample processing protocols are described in Conte et al. (2001, 2003, 2019). Prior to quantitative sample splitting, >1,000 micrometer (µm) -sized material is transferred to a pre-weighed Petri dish for photog- raphy, removal of swimmers, and dried at 55 degrees Celsius (°C) for mass determination. The remaining, <1000 µm material is split using a McLane rotary splitter (McLane Research Laboratories, Falmouth, MA, USA). Three subsamples are designated for organic analysis and one for trace elemental analysis. The remaining subsamples (60%) are recombined and fractionated into 500–1,000 µm, 125–500 µm, and <125 µm size fractions. For Hurricanes Fabian (25 Aug-8Sep 2003) and Igor (13-28 Sep, 28 Sep - 12 Oct 2010) samples, the <125 µm fraction was divided into additional size fractions to better characterize the hurricane sediment plumes. The 63-125 µm ("fine sand") and 37-63 µm ("coarse silt") fractions were separated using stainless-steel sieves. The 4-37 µm ("medium-fine silt") fraction was concentrated by centrifuging 7 minutes at 1,000 rpm, and the supernatant containing the <4 µm ("clay") fraction was concentrated by centrifuging 10 minutes at 3,000 rpm (modified from Pedrosa-Pàmies et al., 2013). We note that for these detrital carbonate sediments the standard nomenclature commonly used for these fractions is an operational definition only. The larger size fractions (>125 µm) were quantitatively photographed (described below), dried at 55°C and weighed to the nearest 0.01 mg. <125 µm size fraction was freeze-dried and weighed. Mass flux was calculated from combined weights of all size fractions.

Carbonate analyses: Carbonate analyses were performed using a Coulometrics model 5011 coulometer (UIC Inc.) equipped with a System 140 module for inorganic carbon determination. Analytical uncertainty is <1.8% based on repeated measurements of flux material working standards. Carbonate δ13C and δ18O were analyzed using a Finnigan MAT252 mass spectrometer following the procedure of Ostermann and Curry (2000). Analytical precision was ±0.04 for δ18O and ±0.05 for δ13C based on the reproducibility of the internal WHOI Atlantis II coral standard. Bulk and isotopic analyses are made on the <125 µm size fraction and converted to total flux by assuming that the total mass composition approximates that of the <125 µm fraction which comprises most of the mass. Analytical precision was ±0.04 for δ18O and ±0.05 for δ13C based on the reproducibility of the internal WHOI Atlantis II coral standard. Bulk and isotopic analyses are made on the <125 µm size fraction and converted to total flux by assuming that the total mass composition approximates that of the <125 µm fraction which comprises most of the mass.

Organic carbon analyses: Particulate organic carbon (POC) and nitrogen (N) concentrations and stable isotopic composition were analyzed using a Europa 20-20 CF-IRMS interfaced with the Europa ANCA-SL elemental analyzer. Before analysis, carbonates were removed by pre-treatment with 4% sulfurous acid using a modified Verardo et al. (1990) method. Analytical uncertainty is <0.18% based on repeated measurements of flux material working standards.

Elemental analysis: Elemental analyses were made on the total <1,000 µm material using a fusion-Inductively Coupled Plasma Mass Spectrometry (ICPMS) method developed for multi-elemental analysis of flux material (Huang et al., 2007). Briefly, the dried sample (4-6 mg) is fused with high purity lithium metaborate (LiBO2) flux at 1,000°C in a dedicated combustion furnace, using a sample to LiBO2 flux ratio of 1:2.5. The fused sample bead was dissolved in 1M HNO3 for ICPMS analysis. Samples were analyzed on a Finnigan Element 2 ICPMS at the Woods Hole Oceanographic ICPMS Facility. Lithogenic concentration was estimated from Si and Al concentrations, assuming that the Al flux was carried mainly by lithogenic particles whose composition approximates that of pelagic clay sediments (25% Si and 8.4% Al, Li and Schoonmaker, 2003): [Lithogenic] = [Al] /0.084. Biogenic Si was estimated by subtracting the lithogenic Si from the total Si and converted to opal

assuming an opal opal water content of SiO2·0.4H2O (Mortlock & Froelich, 1989). To assess analytical reproducibility and uncertainty over the analysis period and to allow for data intercalibration, we ran the certified standard PACS-2 (National Research Council of Canada) with each fusion group, and also periodically ran well-characterized working standards of OFP sediment trap material.

BCO-DMO Processing Description

- Imported sheet 1 from original Excel file "Hurricanes FABIAN03 and IGOR10 SUMMARY BCODMO_18Feb2026.xlsx" into the BCO-DMO system.
- Renamed columns to comply with BCO-DMO naming conventions.
- Applied find/replace to Latitude column: corrected value "31°50'" to "31 55N".
- Applied find/replace to Longitude column: corrected value "64°10" to "64 05W".
- Converted Latitude from degrees-decimal_minutes format to decimal degrees (N direction) in-place.
- Converted Longitude from degrees-decimal_minutes format to decimal degrees (W direction, resulting in negative values) in-place.
- Converted Sampling_Start_Date from "%d %b %y" format to ISO date format "%Y-%m-%d".
- Applied find/replace to Sampling_End_Date at rows 36, 45, and 54: corrected malformed value "23Nov 10" to "23 Nov 10".
- Converted Sampling_End_Date from "%d %b %y" format to ISO date format "%Y-%m-%d".
- Rounded Latitude and Longitude to a maximum of 4 decimal places.
- Saved the final file as "998301_v1_sedtrap_flux_bermuda_carbonate_platform.csv".

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Related Publications

Conte, M. H., Carter, A. M., Koweek, D. A., Huang, S., & Weber, J. C. (2019). The elemental composition of the deep particle flux in the Sargasso Sea. Chemical Geology, 511, 279–313. doi:10.1016/j.chemgeo.2018.11.001
Methods

Conte, M. H., Dickey, T. D., Weber, J. C., Johnson, R. J., & Knap, A. H. (2003). Transient physical forcing of pulsed export of bioreactive material to the deep Sargasso Sea. Deep Sea Research Part I: Oceanographic Research Papers, 50(10-11), 1157–1187. https://doi.org/10.1016/s0967-0637(03)00141-9
Methods

Conte, M. H., Pedrosa-Pàmies, R., Weber, J. C., & Johnson, R. J. (2025). The climatology of the deep particle flux in the oligotrophic western North Atlantic gyre, 1978–2022. Progress in Oceanography, 234, 103433. https://doi.org/10.1016/j.pocean.2025.103433
General

Conte, M. H., Ralph, N., & Ross, E. H. (2001). Seasonal and interannual variability in deep ocean particle fluxes at the Oceanic Flux Program (OFP)/Bermuda Atlantic Time Series (BATS) site in the western Sargasso Sea near Bermuda. Deep Sea Research Part II: Topical Studies in Oceanography, 48(8-9), 1471–1505. doi:10.1016/s0967-0645(00)00150-8
Methods

Huang, S., Sholkovitz, E. R., & Conte, M. H. (2007). Application of high-temperature fusion for analysis of major and trace elements in marine sediment trap samples. Limnology and Oceanography: Methods, 5(1), 13–22. doi:10.4319/lom.2007.5.13
Methods

Li, Y.-H., & Schoonmaker, J. E. (2003). Chemical Composition and Mineralogy of Marine Sediments. Treatise on Geochemistry, 1–35. https://doi.org/10.1016/b0-08-043751-6/07088-2
Methods

Mortlock, R. A., & Froelich, P. N. (1989). A simple method for the rapid determination of biogenic opal in pelagic marine sediments. Deep Sea Research Part A. Oceanographic Research Papers, 36(9), 1415–1426. doi:10.1016/0198-0149(89)90092-7
Methods

Ostermann, D. R., & Curry, W. B. (2000). Calibration of stable isotopic data: An enriched $\delta^{18}O$ standard used for source gas mixing detection and correction. Paleoceanography, 15(3), 353–360. Portico.

https://doi.org/10.1029/1999pa000411
Methods

Pedrosa-Pàmies, R., Sanchez-Vidal, A., Calafat, A., Canals, M., & Durán, R. (2013). Impact of storm-induced remobilization on grain size distribution and organic carbon content in sediments from the Blanes Canyon area, NW Mediterranean Sea. Progress in Oceanography, 118, 122–136. https://doi.org/10.1016/j.pocean.2013.07.023
Methods

Pedrosa-Pamies, R., Conte, M. H., Weber, J. C., & Andersson, A. J. (2025). Hurricane-Driven Transport of Bermuda Reef Carbonate Platform Sediments to the Deep Ocean. Journal of Geophysical Research: Oceans, 130(3). Portico. https://doi.org/10.1029/2023jc020500
Results

Pedrosa-Pamies, R., Conte, M. H., Weber, J. C., & Johnson, R. (2019). Hurricanes enhance labile carbon export to the deep ocean. Geophysical Research Letters. doi:10.1029/2019gl083719
General

Verardo, D. J., Froelich, P. N., & McIntyre, A. (1990). Determination of organic carbon and nitrogen in marine sediments using the Carlo Erba NA-1500 analyzer. Deep Sea Research Part A. Oceanographic Research Papers, 37(1), 157–165. https://doi.org/10.1016/0198-0149(90)90034-s
Methods

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Parameters

Parameter	Description	Units
Depth	OFP sediment trap depth	meters (m)
Hurricane	Name of the Hurricane (Fabian or Igor)	unitless
pre_passage_post_hurricane	descriptor of hurricane passage (pre-hurricane, hurricane, or post-hurricane)	units
Latitude	Latitude of sampling location	decimal degrees
Longitude	Longitude of sampling location	decimal degrees
CUP	OFP trap cup ID	unitless
Sampling_Start_Date	Trap cup sampling start date	unitless
Sampling_End_Date	Trap cup sampling end date	unitless
Duration	Duration of trap cup sampling	days
Total_mass_Flux	Total mass Flux	milligrams per square meter per day (mg/m2/d)

Mass_gt_1000_um	percentage of >1000 µm Mass	% of Total Mass Flux
Mass_500_to_1000_um	percentage of 500-1000µm Mass	% of Total Mass Flux
Mass_125_to_500_um	percentage of 125-500µm Mass	% of Total Mass Flux
Mass_lt_125_um	percentage of less than 125µm Mass	% of Total Mass Flux
Corg	percentage of Organic Carbon from less than 125µm particles	percent (%)
Corg_std	Stdv from percentage of Organic Carbon from less than 125µm particles (3 replicates)	percent (%)
Corg_Flux_lt_125_um	Organic Carbon Flux from less than 125µm particles	milligrams per square meter per day (mg/m2/d)
Total_lipids	Total lipid flux from <1000 um particles	micrograms per square meter per day (ug/m2/d)
pcnt_lipids_of_total_POC	Percentage of lipids of the total particulate organic carbon	percent (%)
d13C	stable isotope 13C of particulate organic carbon. Analytical precision ±0.05, internal WHOI Atlantis II coral standard.	per mil (‰)
d13C_std	stdv of stable isotope 13C of particulate organic carbon	per mil (‰)
N	percentage of Nitrogen from less than 125µm particles	percent (%)
N_std	Stdv percentage of Nitrogen from less than 125µm particles (3 replicates)	percent (%)
N_Flux	N Flux from less than 125µm particles	milligrams per square meter per day (mg/m2/d)
C_N_molar_ratio	C/N molar ratio from less than 125µm particles	unitless
d15N	stable isotope 15N of particulate organic matterfrom less than 125µm particles	per mil (‰)
d15N_std	stdv stable isotope15N of particulate organic matter from less than 125µm particles	per mil (‰)

PIC_POC	Particulate Inorganic Carbon/Particulate Organic Carbon ratio	unitless
CaCO3	Percentage of Carbonates from less than 125µm particles	percent (%)
CaCO3_std	Stdv Percentage of Carbonates from less than 125µm particles (3 replicates)	percent (%)
CaCO3_Flux	Carbonate flux from less than 125µm particles	milligrams per square meter per day (mg/m2/d)
d13C_CaCO3	delta 13C stable isotope of carbonates from less than 125µm particles . Analytical precision ±0.05, internal WHOI Atlantis II coral standard.	per mil (‰)
d13C_CaCO3_std	stdv of delta 13C stable isotope of carbonates from less than 125µm particles (3 replicates)	per mil (‰)
d18O	delta 18O stable isotope of carbonates from less than 125µm particles. Analytical precision ±0.04, internal WHOI Atlantis II coral standard.	per mil (‰)
d18O_std	stdv of delta 18O stable isotope of carbonates from less than 125µm particles (3 replicates)	per mil (‰)
pcnt_Opal	Percentage of Opal of particles less than 1000 um	percent (%)
pcnt_lithogenic	Percentage of lithogenic of particles less than 1000 um	percent (%)

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Instruments

Dataset-specific Instrument Name	Coulometrics model 5011 coulometer (UIC Inc.)
Generic Instrument Name	CO2 Coulometer
Dataset-specific Description	Carbonate analyses: Coulometrics model 5011 coulometer (UIC Inc.) equipped with a System 140 module for inorganic carbon determination.
Generic Instrument Description	A CO2 coulometer semi-automatically controls the sample handling and extraction of CO2 from seawater samples. Samples are acidified and the CO2 gas is bubbled into a titration cell where CO2 is converted to hydroxyethylcarbonic acid which is then automatically titrated with a coulometrically-generated base to a colorimetric endpoint.

Dataset-specific Instrument Name	Agilent 7890A GC coupled to a 5975C MS
Generic Instrument Name	Gas Chromatograph Mass Spectrometer
Dataset-specific Description	Lipid analyses: Gas chromatograph-mass spectrometer (GC-MS): Agilent 7890A GC coupled to a 5975C MS equipped with triple-axis MS and FID detectors
Generic Instrument Description	Instruments separating gases, volatile substances or substances dissolved in a volatile solvent by transporting an inert gas through a column packed with a sorbent to a detector for assay by a mass spectrometer.

Dataset-specific Instrument Name	Go-Flo bottles
Generic Instrument Name	GO-FLO Bottle
Dataset-specific Description	Before deployment, trap cups are filled in a laminar flow hood with a trace metal clean brine, prepared from seawater collected at 3,000 m depth using trace-metal clean Go-Flo bottles, poisoned with ultra-purity mercuric chloride to arrest bacterial activity.
Generic Instrument Description	GO-FLO bottle cast used to collect water samples for pigment, nutrient, plankton, etc. The GO-FLO sampling bottle is specially designed to avoid sample contamination at the surface, internal spring contamination, loss of sample on deck (internal seals), and exchange of water from different depths.

Dataset-specific Instrument Name	Finnigan MAT252 mass spectrometer
Generic Instrument Name	Mass Spectrometer
Dataset-specific Description	Carbonate δ13C and δ18O were analyzed using a Finnigan MAT252 mass spectrometer.
Generic Instrument Description	General term for instruments used to measure the mass-to-charge ratio of ions; generally used to find the composition of a sample by generating a mass spectrum representing the masses of sample components.

Dataset-specific Instrument Name	Europa 20-20 CF-IRMS
Generic Instrument Name	PDZ Europa 20-20 isotope ratio mass spectrometer
Dataset-specific Description	Organic carbon analyses: Europa 20-20 CF-IRMS interfaced with the Europa ANCA-SL elemental analyzer.
Generic Instrument Description	The PDZ Europa 20-20 is a dedicated continuous flow isotope ratio mass spectrometer for hyphenated stable isotope analyses able to measure 15N, 13C, 18O, and 34S in a host of applications. The analyzer has been purposely designed to measure 2H by continuous flow methodology and is also suitable to analyze the light stable isotopes in all the commonly measured gases: H2, N2, NO, N2O, O2, CO, CO2, SO, and SO2.

Dataset-specific Instrument Name	Europa ANCA-SL elemental analyzer
Generic Instrument Name	PDZ Europa ANCA-GSL elemental analyzer
Dataset-specific Description	Organic carbon analyses: Europa 20-20 CF-IRMS interfaced with the Europa ANCA-SL elemental analyzer.
Generic Instrument Description	The ANCA-GSL module allows samples such as soil, viscous liquids, plant material, and organic compounds, to be analyzed directly by using Dumas combustion for 15N, 13C, and 34S or pyrolysis for 18O and D. It also allows isotope analysis of abundant gases from septum sealed containers. During combustion mode, a capsule containing the sample falls into the combustion tube and is converted in the presence of oxygen to CO2, N2, NOx, and H2O. An elemental copper stage reduces NOx, a MgClO4 trap removes water vapor, a switchable Carbosorb trap can be used to remove CO2 (for 15N only analyses) and a GC column separates CO2 from N2 (allowing dual isotope analysis). Modified packings, a Nafion dryer and different GC column allow 34S analysis. The sample preparation unit consists of a 66-place autosampler for unattended operation (larger options are available), 2 furnaces able to operate to 1100 deg C, and an on-board microprocessor. The analyzer is capable of dual isotope analysis of 15N and 13C. For CO (18O), H2 (2H), N2 (15N), CO2 (13C), CO2 (18O), and SO2 (34S) with precisions between 0.1 and 3 dependent on the element.

Dataset-specific Instrument Name	McLane rotary splitter (McLane Research Laboratories). The remaining,
Generic Instrument Name	sample dividers
Dataset-specific Description	Material is split using a McLane rotary splitter (McLane Research Laboratories, Falmouth, MA, USA).
Generic Instrument Description	A device used to subdivide material samples into two or more representative portions.

Dataset-specific Instrument Name	Parflux sediment traps (McLane Research Laboratories, Falmouth MA, USA)
Generic Instrument Name	Sediment Trap
Dataset-specific Description	The OFP mooring uses conical Parflux sediment traps (McLane Research Laboratories, Falmouth MA, USA) having a 0.5 m2 sampling area
Generic Instrument Description	Sediment traps are specially designed containers deployed in the water column for periods of time to collect particles from the water column falling toward the sea floor. In general a sediment trap has a jar at the bottom to collect the sample and a broad funnel-shaped opening at the top with baffles to keep out very large objects and help prevent the funnel from clogging. This designation is used when the specific type of sediment trap was not specified by the contributing investigator.

Dataset-specific Instrument Name	Finnigan Element 2 ICPMS
Generic Instrument Name	Thermo Fisher Scientific ELEMENT 2 inductively coupled plasma mass spectrometer
Dataset-specific Description	Elemental analysis: Finnigan Element 2 ICPMS.
Generic Instrument Description	The Thermo Scientific Element 2 ICP-MS is a double-focussing magnetic-sector-field Inductively Coupled Plasma Mass Spectrometer equipped with a discrete dynode detector system, linear over nine orders of magnitude - from ppq to ppm concentrations. Other features include: Sensitivity (Concentric Nebuliser) greater than 1 x 10^9 counts per second (cps)/ppm In; Dark noise less than 0.2 cps; Mass resolution 300, 4,000, 10,000 (10 percent valley, equivalent to 5 percent height), 600, 8,000, 2,000 (FWHM); Signal stability better than 1 percent RSD over 10 minutes or 2 percent RSD over 1 hour; Mass stability: 25 ppm / 8 hours; Magnetic scan speed: m/z 7 to 240 to 7 in less than 150 ms, Electronic scan speed: 1 ms/jump, independent of mass range.

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Deployments

OFP_Time-Series

Website	https://www.bco-dmo.org/deployment/704779
Platform	OFP_mooring
Start Date	1978-04-06
Description	The Oceanic Flux Program (OFP) time-series began in 1978 at the Hydrostation S hydrographic time-series site (32 05N, 64 15W), located approximately 45 km southeast of Bermuda. The time-series was originally called the SCIFF (Seasonal Changes in Isotopes and Flux of Foraminifera) program. Location: 1978-1984: 31deg 10min N, 64deg 30min W, 3300m (SCIFF site) 1984-2010: 31deg 50min N, 64deg 10min W, 4500m 2011-present: 31deg 55 N, 64deg 05 W, 4550m

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Project Information

Time Series Particle Flux Measurements in the Sargasso Sea (OFP Sargasso Sea)

Website: https://www.mbl.edu/research/research-centers/ecosystems-center/research-projects/oceanic-flux-program-ofp

Coverage: Sargasso Sea

The Oceanic Flux Program (OFP) has continuously measured particle fluxes in the deep Sargasso Sea since 1978. The OFP is the longest running continuous time-series of its kind, and has produced a unique record of temporal variability in material transfer from the surface to the deep ocean (the “biological pump") resulting from the interplay between physical, biological and chemical processes. The OFP deploys a subsurface mooring anchored in 4500m of water with three McLane Research Parflux Mark 8 sediment traps located at 500m, 1500m and 3200m depths. These traps continuously collect the sinking particle flux at an approximate 2 week sampling resolution.

The most recent project awards and abstracts are listed below. A detailed history of funding with summary of all project awards for OFP can be found below.

October 2024 through September 2027
NSF Award OCE-2421112 Abstract:

This award provides an additional three years of support for the Oceanic Flux Program (OFP). The OFP was established in 1978 to measure the export flux of particles from the surface to the deep ocean in the deep Sargasso Sea near Bermuda. The OFP is the longest and most continuous particle flux time-series of its kind. Through collaboration with nearby upper ocean time-series programs, facilities, and other Bermuda-based sampling programs, OFP will continue to be a valuable resource for the oceanographic community in the effort to answer questions about the intricate relationship between deep ocean particle flux and climate, as well as biological, physical, and chemical oceanographic processes. Looking to the future, OFP will use increasingly advanced instrumentation and state-of-the-art analytical tools to investigate the nature and patterns of the material that sinks from the surface to deep ocean and the mechanisms that drive that process. The OFP provides education and training for students from high school to Ph.D. levels and supports early career researchers. OFP data and samples are broadly available to other researchers across the scientific disciplines.

Two overarching goals drive core activities funded under the OFP grant. The first is to extend the time-series by collecting new samples of the highest quality, while ensuring they have a comprehensive oceanographic context. The second is to elucidate the processes that drive oceanic particle flux through comparative studies of flux magnitude and composition with concurrent observations of external forcing (e.g., synoptic scale meteorology, climate patterns), surface water physics and biology (e.g., mesoscale features, blooms), and interior processes (e.g., biological particle aggregation/disaggregation, elemental scavenging, authigenic mineralization). The specific grant objectives are: (1) to provide for continuity of the particle flux measurements at 500, 1500 and 3200 m depths and continue to refine the quality of the time-series record and expand its oceanographic context, (2) to update/calibrate OFP sample processing and analytical methods to enhance the time-series data record, and to curate the time-series sample archives for future study, (3) to promote collaborative research to maximize interdisciplinary information obtained from the samples, (4) to conduct focused studies to identify deep flux temporal trends and their coherence with upper ocean forcing, to elucidate causal flux generation processes, and to develop proxies for climate studies,
(5) to provide education and training opportunities. A particular focus of this funding cycle will be to analyze the extensive OFP digital image archive with an automated (and/or semi-automated) approach, including classical methodologies and Deep Learning (DL) based tools for image classification, segmentation and archive, and a Graphical User Interface (GUI). The development of these new tools for identification, quantification, and characterization of the flux material will better exploit the image archive's potential, as fuller characterization of biological components will contribute new information on the ecosystem dynamics and responses to environmental forcing that drive flux generation.

October 2023 through September 2025
NSF Award OCE-2414704 Abstract:

This award provides an additional three years of support for the Oceanic Flux Program (OFP). This program

was first established in 1978 to measure the export flux of particles from the surface to the deep ocean in the deep Sargasso Sea and represents the longest and most continuous particle flux time-series of its kind. This program and the time-series record will continue to help the oceanographic community to answer questions about the relationship between deep ocean particle flux and climate and biological, physical, and chemical oceanographic processes. In the past, the OFP has provided evidence for coupling between the upper and deep ocean processes linked to seasonal, episodic (e.g., physical and meteorological forcing) and climate patterns. Looking to the future, this program will utilize increasingly advanced instrumentation and analytical tools to address questions about the material that sinks from the surface to deep ocean and its controls. The OFP provides education and training for students from the high school to Ph.D. level and supports early career researchers.

The OFP time-series represents a 43-year, nearly continuous record focused on particle fluxes in the deep ocean. With increasingly more data available from the lengthening record, investigators can put observed biogeochemical patterns into perspective to understand the interplay between climate and ocean functioning. The availability of data from complementary nearby Hydrostation S, the Bermuda Atlantic Time-Series (BATS), the Bermuda Testbed Mooring (1994-2007), the Tudor Hill atmospheric tower and other Bermuda sampling programs provide additional opportunities to study upper ocean physics and biogeochemistry coupled with deep ocean biogeochemical processes. The OFP record is becoming long enough to study deep flux linkages with gyre circulation and advective processes. The OFP's archive is an unparalleled resource for retrospective studies of temporal trends and the biogeochemical consequences of a changing ocean, including future impacts of ocean acidification. As the OFP heads into the future, increasingly sophisticated OFP mooring instrumentation (ADCP current profiling and backscatter; MicroCAT temperature, salinity, and oxygen measurements) and advances in digital imaging and analytical tools (both chemical and genomic) to probe the recovered flux materials continue to reveal novel, fundamental information about the oceanic particle flux and its controls

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Program Information

Oceanic Flux Program (OFP)

Website: http://www.mbl.edu/ecosystems/conte/ofp/

Coverage: Sargasso Sea

(Adapted from the NSF Project Summary)

Since 1978, the Oceanic Flux Program (OFP), originally founded and managed by at the Woods Hole Oceanographic Institution and now managed by the Bermuda Institute of Ocean Science (BIOS), has continuously measured particle fluxes in the deep Sargasso Sea. The 35+ year OFP time-series is, by far, the longest of its kind and unique in its focus on the deep ocean. OFP has produced a unique, albeit "edited", record of temporal variability in the "biological pump", a term loosely applied here to material transfer from the surface to the deep ocean. The OFP provided the first direct evidence for seasonality in the deep ocean and the tight coupling between deep fluxes and upper ocean processes. It has provided clear evidence of the intensity of biological reprocessing of flux and scavenging of suspended material in mesopelagic waters. The record has documented interannual and longer variations in deep fluxes and shorter term fluctuations driven by the interactions between mesoscale physical variability, meteorological forcing and ecosystem responses.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2421112
NSF Division of Ocean Sciences (NSF OCE)	OCE-2414704
NSF Division of Ocean Sciences (NSF OCE)	OCE-2122619

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