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# Fluxes of sedimenting material from sediment traps in the Atlantic Ocean

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## Abstract

We provide a data set assemblage of directly observed and derived fluxes of sedimenting material (total mass, POC , PON , $BSiO_2$, $CaCO_3$, PIC and lithogenic/terrigenous fluxes) obtained using sediment traps. This data assemblage contains over 5900 data points distributed across the Atlantic, from the Arctic Ocean to the Southern Ocean. Data from the Mediterranean Sea are also included. Data were compiled from a variety of sources: data repositories (e.g., BCO-DMO, PANGAEA), time series sites (e.g., BATS, CARIACO), published scientific papers and data provided by originating PI's. All sources are specified within the combined data set. Data from the World Ocean Atlas 2009 were extracted to coincide with flux data to provide additional environmental information where available. Specifically, contemporaneous data were extracted for temperature, salinity, oxygen (concentration, AOU and percentage saturation), nitrate, phosphate and silicate. Data show a broad range of flux estimates, with marked differences between ocean domains. Data also reveal important differences in the contribution that a given variable provides to the total mass flux, which is relevant towards understanding the factors that control the strength of the biological carbon pump. The dataset is archived on the data repository PANGAEA® (http://www.pangaea.de) under doi:10.1594/PANGAEA.807946.


## 1 Introduction

The export of particulate organic carbon (POC) from the sunlit upper layers to the ocean interior is an important component of the global carbon cycle. It represents a natural means of mitigating the increasing levels of atmospheric $CO_2$ via the long term storage of carbon (particulate and dissolved) in the deep waters of the ocean and in deep ocean sediments. However, the global biological carbon pump (BCP) is not well constrained, with estimates of carbon transport ranging from 3.4–4.7 Gt C $yr^{-1}$ (Eppley and Peterson, 1979) to ~ 20 Gt C $yr^{-1}$ depending on the method used (e.g., Laws et al.,





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2000). In the North Atlantic alone, estimates of the BCP range 4-fold from 0.55 to 1.94 $Gt\,C\,yr^{-1}$, representing 10–20 % of global export fluxes (Sanders et al., 2013). The uncertainty of these estimates reflects the sparseness of observations and to a smaller extent the variety of methods employed.

Currently, several independently compiled datasets of export fluxes exist but they reside in separate data repositories as individual datasets. Given the importance of the BCP for carbon sequestration and the need to further constrain its magnitude, we have attempted to bring together into a single compilation, all data currently available on POC fluxes (and related variables) obtained from sediment trap deployments in the Atlantic Ocean, which includes the adjacent Arctic Ocean, the Atlantic sector of the Southern Ocean, and data from the Mediterranean Sea (as an adjacent sea). This data set assemblage was put together by the Ocean Biogeochemistry and Ecosystems Research Group (OBE) of the National Oceanography Centre, (NOC, UK) as part of the EU FP7 EuroBASIN Programme (Work Package 2). Data were obtained from a variety of sources including: data repositories (e.g., BCO-DMO, PANGAEA), time series sites (e.g., BATS, CARIACO), published scientific papers and directly from originating PI's. All sources are specified within the data set.

## 2 Data

Observational studies of export production often make use of sediment traps. These are deployed at depths of interest in order to collect particles sinking through the water column. Upon recovery, particles are then analysed primarily to determine their carbon content, but additionally the nitrogen content is also easily obtained. The quantities of ballasting material such as calcium cabonate and opal are also increasingly important parameters. The flux rate of material captured by a trap can be calculated from knowledge of the duration a trap is deployed for and the aperture of the trap itself. By obtaining export fluxes at different depths, the efficiency of the carbon pump can be





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evaluated simply as the fraction of the flux leaving the surface that makes it to a given depth.

### 2.1 Data sources

The data assemblage presented here includes variables commonly measured in studies concerning export production. These include total mass (Tot_Mass) flux, particulate organic carbon (POC) flux, particulate organic nitrogen (PON) flux, biogenic silica ($BSiO_2$) flux, calcium carbonate ($CaCO_3$) flux, particulate inorganic carbon (PIC) flux, and terrigenous/lithogenic (Terr/Litho) material flux. Most data were obtained from data repositories and individual time series websites. 2679 data points (45 % of total) were derived from 32 smaller data sets obtained from the Data Publisher for Earth and Environmental Science (PANGAEA) at http://www.pangaea.de. 111 data points (1.9 %) were obtained from the Biological and Chemical Oceanography Data Management Office (BCO-DMO) at http://bcodmo.org (Lee et al., 2009a, b). 1755 data points (29.5 %) were obtained from the Carbon Retention In A Colored Ocean Project Ocean Time Series (CARIACO) at http://www.imars.usf.edu/CAR (Montes et al., 2012) and 784 data points (13.2 %) from the Bermuda Atlantic Time Series (BATS) at http://bats.bios.edu. Data (428 data points, 7.2 %) were also obtained from published journal articles (e.g., Fischer et al., 2000; Bory et al., 2001; Hwang et al., 2009). Finally, a few data sets (190 data points, 3.2 %) were directly obtained from Principal Investigators (Bauerfeind et al., 2009; Lampitt et al., 2010). These combined data sets provide 5947 observations of export. The full data set is organised in columns as indicated in Table 1. The names and acronyms of variables as presented in this table are the most commonly used and less ambiguous terms. Not all individual data sets, though, contain all the variables listed in Table 1. The total number of data points per variable are presented in Table 2. POC flux contains the largest number of observations (5206 data points) and PIC flux the lowest (1048 data points).





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## 2.2 Methods commonly employed

A major challenge involved in the compilation of this data set was the inconsistency with which authors refer to the same variable. Sometimes metadata make use of an acronym that is not consistent with the acronym used in a given column data-header, particularly on data sets submitted to the PANGAEA data repository. While briefly describing the generalities of the methods commonly employed in the study of export fluxes, we also comment on the different terms used to refer to a given variable, which hopefully will provide some clarity.

The data compiled here include observations from a range of named sediment trap designs: moored automatic Kiel Sediment Traps (Bauerfeind et al., 2009; Bauerfeind and Nöthig, 2011), cone-shaped SMT 230 Kiel and Mark VI/V traps (Wefer and Fischer, 1993), Cone-shaped multi-sampling SMT 230 KMU traps (Romero et al., 2002; Fahl and Nöthig, 2007), Conical particle interceptor traps (Antia et al., 1999), Conical sediment McLane Mark-7 traps (Hwang et al., 2009), drifting Technicap PPS 5 sediment traps (Goutx et al., 2000), Kiel HDW traps (Jonkers et al., 2010), Large Aperture Time-Series Kiel type traps (Fischer et al., 2000, 2002; Iversen et al., 2010), Mark-VII automated sediment trap (CARIACO), McLane Mark 78G-21 (Jonkers et al., 2010), Multisample moored conical traps (Bory et al., 2001), PARAFLUX Mark 7G-13 time series sediment trap (Honjo and Manganini, 1993; Jickells, 2003a, b, c, d; Lampitt et al., 2001, 2010), Aquatec Kiel type sediment trap (Neuer et al., 1997, 2007), Indented Rotary Sphere (IRS) settling velocity and time-series mode sediment traps (Peterson et al., 2005; Goutx et al., 2007; Lee et al., 2009a, b), SMT 234 Aquatec Meerestechnik Kiel trap (Helmke et al., 2005), Surface-Tethered Particle Interceptor Traps (BATS), PPS-5 traps (Jonkers et al., 2010). Some of these may be identical. However, there is insufficient information to ascertain this from the source and so, all are listed. Traps are left open to collect material for a range of periods, from a minimum of few hours or a day, to more than a year.





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Before deployment, collecting cups of sediment traps are filled with ambient seawater. NaCl is typically added to increase the salinity to 40 (Antia et al., 1999; Bory and Newton, 2000; Fischer et al., 2002; Fahl and Nöthig, 2007; Neuer et al., 1997). Formalin to yield 2–3 % formaldehyde (wt vol$^{-1}$) or mercuric chloride (0.14 % final solution) are commonly added to poison the sample to preserve the content (Antia et al., 1999; Fischer et al., 2002; Fahl and Nöthig, 2007; Helmke et al., 2005; Bauerfeind et al., 2009). Following recovery of sediment traps, swimmers (i.e., zooplankton that feed on sedimenting material) are identified and removed from collecting cups (Antia et al., 1999; Bory et al., 2001; Lampitt et al., 2010). Sometimes the samples are sieved (1 mm mesh) to remove large swimmers (e.g., Fischer et al., 2000). Also, samples are sometimes centrifuged following the removal of swimmers and the supernatant is then analysed in order to take into account of any possible dissolution of the material collected (e.g., Waniek et al., 2005). Samples from trap-cups are typically split to generate subsamples for the different types of analysis and filtered through pre-weighed filters which are rinsed with ammonium formate to remove salt and excess formalin (e.g., Bory et al., 2001). The reader is referred to the source references for details of a particular deployment.

#### 2.2.1 Total mass flux

Total mass is obtained by weighing the dried matter collected on a filter. As such, it is sometimes reported as dry mass. Total Mass Flux (Tot_Mass$_{\text{flux}}$, mg m$^{-2}$ d$^{-1}$) is calculated as $\text{Tot\_Mass}_{\text{flux}} = \frac{M_\text{w} - F_\text{w}}{T \cdot A}$, where $M_\text{w}$ is the mass dry weight (mg), $F_\text{w}$ is the filter weight (mg), $T$ is the deployment time (days), and $A$ is the aperture trap area (m$^2$) (e.g., Bahr et al., 1997).

#### 2.2.2 POC and PON fluxes

POC and PON are measured using an elemental CHN analyser (e.g., Fischer et al., 2000; Bahr et al., 1997). The fraction of C and N in a given sample is multiplied by



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Tot_Mass flux to yield POC and PON fluxes ($mg\,m^{-2}\,d^{-1}$). Aliquots destined for the determination of POC and PON are filtered onto combusted (6 h 400 °C GF/F) filters (e.g., Goutx et al., 2000), or polycarbonate filters (25 mm or 47 mm) (e.g., Hwang et al., 2009). Before drying for CHN analysis, samples are rinsed with 1–6 N HCl to remove carbonate (Fischer et al., 2000; Goutx et al., 2000; Bory et al., 2001; Helmke et al., 2005; Iversen et al., 2010). Filters are then dried at 40 °C (e.g., Goutx et al., 2000), 60 °C (e.g., Hwang et al., 2009), or 80 °C (e.g., Wefer and Fischer, 1993; Helmke et al., 2005). Some authors use freeze drying instead (e.g., Fischer et al., 2002; Waniek et al., 2005). As a term, POC is frequently used interchangeably with "organic carbon ($C_{org}$)" (e.g., Fischer et al., 1996; Lampitt et al., 2001), total organic carbon (Wefer and Fischer, 1991; Jonkers et al., 2010) or just "total carbon". POC, is sometimes estimated using $C_{org} = C_{total} - C_{CaCO_3}$ (e.g., Romero et al., 2002), where $C_{total}$ is the total carbon content of a sample and $C_{CaCO_3}$ is the carbon content in calcium carbonate. Similarly PON is also sometimes referred to as total nitrogen (e.g., Lampitt and Antia, 1997; Jonkers et al., 2010).

### 2.2.3 Calcium carbonate flux

In the literature, $CaCO_3$ flux is estimated in a variety of ways. It has been estimated as particulate inorganic carbon (PIC) flux times 8.34 (Lampitt et al., 2010) or times 8.33 (Lampitt et al., 2001; Fischer et al., 2002), based on the ratio of the molecular masses of carbon and calcium carbonate (though this is not usually explicitly stated). It is also sometimes calculated as $(C_{total} - C_{org}) \times 8.33$ (e.g., Wefer and Fischer, 1991; Helmke et al., 2005) following CHN analysis, or through mass loss following acidification and then weighing (e.g., Fahl and Nöthig, 2007). Hwang et al. (2009) refer to "biogenic $CaCO_3$", which they estimated by multiplying the "biogenic Ca" by 2.5. It is unclear however, where the factor of 2.5 comes from. In turn, they obtained "biogenic Ca" as the difference between total Ca and lithogenic-Ca ($0.5 \times Al$). Total inorganic carbon is determined by coulometric titration (Hwang et al., 2009). $CaCO_3$ flux is sometimes





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corrected if organisms containing calcium carbonate, such as pteropods, are present in the sample (e.g., Bauerfeind et al., 2009).

### 2.2.4 Particulate Inorganic Carbon (PIC) flux

PIC is estimated in different ways too. It is calculated as 12 % carbonate by weight (Antia et al., 1999; Bauerfeind et al., 2009), implying C-$CaCO_3$ (i.e., the carbon content in calcium carbonate). PIC content is sometimes calculated from total Ca concentrations in samples as $CaCO_3$ (Bory et al., 2001). It is also estimated as $C_{total}$-$C_{org}$; i.e., the difference between the C measured in filtered samples without removal of carbonate, and the C measured in samples treated with HCl. The term "inorganic carbon" is sometimes used in the literature too (e.g., Lampitt and Antia, 1997; Lampitt et al., 2001), which seems to be used as equivalent of PIC.

### 2.2.5 Biogenic silica flux

Biogenic silica is typically measured with colorimetric methods following extraction from particulate material either following the alkaline digestion method of Mortlock and Froelich (1989) (e.g., Antia et al., 1999; Bory et al., 2001) or the sequential leaching method of DeMaster (1981) as modified by Müller and Schneider (1993) (e.g., Wefer and Fischer, 1991, 1993; Romero et al., 2002; Helmke et al., 2005). In some cases, dissolved silica is first measured in the water used for the collecting cups. Dissolved silica is then measured again following the trap's recovery in order to correct for any opal dissolution (e.g., Jonkers et al., 2010). However, we note that not all the biogenic silica data in this compilation includes such a correction or its application to the data was not clear.

Hwang et al. (2009) report opal as the result of multiplying "biogenic Si" by 2.4, where "biogenic Si" is the difference between the total Si and the lithogenic-Si (3.5 × Al). Bauerfeind et al. (2009) define "biogenic particulate silica (bPSi)" in their abstract, which suggests the compound "silicon dioxide" ($SiO_2 \cdot nH_2O$) is being dealt with. How-





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ever, in the methods section, it is redefined as "biogenic particulate silicon (bPSi)". Hence it is the chemical element Si that seems to be dealt with. Further, Opal is defined as 2.1 × bPSI; i.e., the mass ratio $\frac{SiO_2}{Si}$ multiplied by bPSi (Bauerfeind et al., 2009). Whether the terms "$PSiO_2$" (von Bodungen et al., 1995; Peinert et al., 2001; Bauerfeind and Nöthig, 2011), "$PSiO_2$ and $BSiO_2$" (Fischer, 2003), "PSi" (Fischer, 2005), "$BSiO_2$" as the sum of $PSiO_2$ and $DSiO_2$ (e.g., Antia et al., 1999; Lampitt et al., 2001; Honjo and Manganini, 2003a, b, c), "$BSiO_2$" (Lampitt and Antia, 1997), "Opal" (Neuer et al., 1997, 2007), "bPSi or biogenic particulate silicon" (opal = 2.1 × bPSi) (Bauerfeind et al., 2009), "opaline silica" (Lampitt et al., 2010) or "biogenic silica (opal)" (Antia et al., 1999; Fischer et al., 2002; Waniek et al., 2005), are dealt with as one and the same variable, is unfortunately unclear. In this data compilation we attempted to identify whether $SiO_2$ or Si was the variable being reported. When enough information was available, values of Si were converted to $SiO_2$ using the appropriate mass ratio. The data compilation contains a column of notes where we point out the variable reported in the original data source.

### 2.2.6 Lithogenic and/or terrigenous material flux

Lithogenic fluxes are typically estimated as the difference between the total mass flux and what is termed either "biogenic flux", "biogenic matter" or "organic matter flux"; i.e., $CaCO_3$ + POC + $BSiO_2$ fluxes (e.g., Antia et al., 1999; Bauerfeind et al., 2009). For this purpose, in deriving "organic matter", POC is sometimes multiplied by 2 (Fischer et al., 2002; Bauerfeind et al., 2009) or 2.5 (e.g., Hwang et al., 2009), as this is considered to give a more representative flux of organic matter, but in the literature, this adjustment would benefit from a fuller explanation. Thus, biogenic flux ($Bio_{flux}$) is $Bio_{flux} = 2 \times POC_{flux} + CaCO_{3flux} + Opal_{flux}$. Lithogenic flux (Litho) is thus given by $Litho = Tot\_Mass_{flux} - Bio_{flux}$. Some researchers estimate the lithogenic mass as a fraction (8.4 %) from Al concentrations (Bory et al., 2001) or by multiplying the Al concentration by 12.15 (e.g., Hwang et al., 2009). In the latter case, however, it is unclear where the factor of 12.15 comes from.



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## 2.3 Data standardisation

This data assemblage contains fluxes from short duration deployments (hour to days) to longer duration deployments lasting months to a year, or over a year. Hence, in order to standardise the data set, all values from long term deployments, typically reported in $g\,m^{-2}\,yr^{-1}$ (e.g., Wefer and Fischer, 1991, 1993; Fischer et al., 2000; Fischer, 2005; Peinert et al., 2001), were converted to daily values, i.e., $mg\,m^{-2}\,d^{-1}$, which is the unit most commonly reported. Long term deployments, however, can be easily identified. A column is provided which specifies the duration of the deployment. A few daily values were reported in $g\,m^{-2}\,d^{-1}$, and these were also converted to $mg\,m^{-2}\,d^{-1}$ for consistency. In a few instances, POC, PIC, and $BSiO_2$ were reported in $mol\,m^{-2}\,yr^{-1}$ (e.g., Antia et al., 1999; Dymond and Lyle, 2003a, b; Honjo and Manganini, 2003d, e, f; Fahl and Nöthig, 2007) or $mmol\,m^{-2}\,d^{-1}$ (Martin, 2003a, b, c). Again, for consistency, these were converted to $mg\,m^{-2}\,d^{-1}$. A column of notes is included, and where unit conversions were done, these are pointed out.

# 3 Quality control

Given that the data compiled here derives from research already published, we assume that the originating authors have already undertaken steps necessary to assure data quality. Here we have tried to as best as possible, and to the best of our knowledge, to put the data together in a self consistent manner, allowing users to trace original data sources should issues arise, in particular in light of the different deployment duration and traps used, different analytical methods employed, different calculation approaches, different units reported and the confusion generated by using multiple terms for a given variable and/or not clarifying whether a chemical element or a compound is being dealt with.





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## 4 Ancillary data

Where possible, data from the World Ocean Atlas 2009 (WOA09) were extracted to coincide with flux data to provide additional environmental information (http://www.nodc.noaa.gov/OC5/WOA09/pr_woa09.html). Specifically, data were extracted for temperature, salinity, oxygen (concentration, AOU and percentage saturation), nitrate, phosphate and silicate. The extraction involves linear interpolation of WOA09 data to the latitude, longitude and depth of the flux data. Each environmental variable is a weighted average over the period of deployment. Note that as WOA09 is a climatology it cannot provide data for specific years. For example, if a mooring collected flux data from 1 November 1990 until 15 January 1991, the WOA data at the relevant point is averaged over the 76 days comprising the annual climatologies for November (for 30 days), December (for 31 days) and January (15 days). For temperature, salinity and oxygen variables, monthly climatologies are used above 1500 m and annual ones below. For nutrients, monthly climatologies are only available and used above 500 m. The distribution of WOA09 climatologies does not extend close to the coasts. Hence, given the proximity of the CARIACO time series station to the mainland, ancillary data is not available for this site from WOA09.

## 5 Data distribution

Figure 1 shows the distribution of the sediment trap deployments compiled in this data set. Data coverage spans from the early 1980's to the beginning of the 2010's, with the largest amount of observations between 1990 and 2010 (Fig. 2). Figure 3 shows the number of observations per station. The most abundant contributions to this dataset derive from established time series stations: BATS (31°40′ N, 64°10′ W) as pointed out above (Sect. 2.1); CARIACO (10.5° N, 64.4° W) as pointed out above (Sect. 2.1); DYnamique des Flux Atmosphériques en MEDiterranée et leur évolution dans la colonne d'eau (DYFAMED) 43°25′ N, 07°52′ E, 401 data points, 6.7 % of total (Miquel et al.,





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2011); The Porcupine Abyssal Plain (PAP), 49° N, 16°30′ W, 366 data points, 6.2 % of total (Lampitt et al., 2001, 2010); The North Atlantic Bloom Experiment (NABE), 34° N, 21° W to 48° N, 21° W, 170 data points, 2.9 % of total (Honjo and Manganini, 1993; Martin, 2003a, b, c); and the European Station for Time-Series in the Ocean (ESTOC, 29° N, 15.5°W, 124 data points, 2.1 % of total (Neuer et al., 1997). Missing in this compilation are data from the Progamme Océan Multidisciplinaire Méso Echelle (POMME, 30 to 60° N and 0 to 30° W), which are not yet publicly available. We are also aware of a few more recent datasets from the ESTOC, but these have copy right restrictions (e.g., Neuer et al., 2007).

Observation depths span from 15 m down to 5031 m (Table 2). Tot_Mass, $CaCO_3$ and Terr/Litho exhibit the broadest range of export fluxes, while PON and PIC exhibit the narrowest range (Table 2). The largest number of observations, with higher vertical resolution, have been made within the first 1000 m of the water column, particularly in the upper 500 m (Figs. 4 and 5). At depths greater than 1000 m a preference for sampling at 3000 m is apparent in the data. With the exception of the PIC flux and lithogenic/terrigenous flux, which contain the lowest number of data points (Table 2), all other variables of particle export have been sampled at similar vertical resolution (Figs. 4 and 5).

The overall pattern of particle export fluxes is the expected decrease from upper layers to depth (Figs. 6 and 7). This is particularly clear in the Atlantic Ocean and Mediterranean Sea data (red and orange symbols in Figs. 6 and 7). POC, PON, $BSiO_2$ and $CaCO_3$ show a similar structure; the range of values at a given depth decreases from surface to depth. In the upper 1000 m, the largest fluxes of POC and PON occur in the Atlantic and the Arctic domains. Within the Arctic domain, the broad range of POC and PON fluxes in the upper 200 m derive from trap deployments off the northwest coast of Norway (∼ 17° E, ∼ 70° N). Largest fluxes of $BSiO_2$ in the upper 1000 m are found in the Atlantic and Southern Ocean domains. PIC fluxes are largest in the Atlantic and the Mediterranean Sea. In the Atlantic, PIC data show maximum values at 1400 m, which then decrease at greater depths (Fig. 7). These maximum values at 1400 m,





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though, derive from trap deployments north of Ireland and may result from the supply of PIC from the shelf or shelf break front. $CaCO_3$ fluxes are rather comparable among ocean domains, though a larger range is found at about 150 m in the Atlantic. Terr/Litho fluxes show a broad range of values within the upper 1250 m which reduce substantially at greater depths.

The proportion each export variable makes to total mass flux is shown in Fig. 8. The largest contributions of up to 80 % are provided by the Terr/Litho, $CaCO_3$ and $BSiO_2$ fractions but there is a broad range in the contribution each fraction makes to the total mass flux at all sampled depths and within the four ocean domains. In the case of $CaCO_3$ and terr/litho the range in the contribution from these fractions to total mass flux appears to narrow with depth which may reflect the attenuation of other variables with depth rather than any systematic change to terr/litho and $CaCO_3$ contributions. The largest contribution (up to 90 %) made by $BSiO_2$ to total mass flux derive from trap deployments in the Southern Ocean with apparent peaks at depths of 500 m and 4500 m; elsewhere the $BSiO_2$ contribution is smaller but nevertheless a major component of the downward particle flux. The contribution made by POC to total mass flux is broadly similar within all four ocean domains and decreases from ~ 80 % in the upper 500 m to < 20 % at 5000 m revealing a marked attenuation with depth. Both PON and PIC typically contribute < 20 % to total mass flux, but, whilst the contribution from PIC remains fairly constant with depth, there is vertical attenuation of PON with depth such that at depths > 500 m the PON contribution is < 10 %.

## 6 Conclusions

We have assembled a dataset of over 5900 observations of particle flux across the wider Atlantic Ocean and adjacent seas which will be invaluable in determining seasonal and geographical variability in the BCP. Our initial examination of this dataset already indicates important differences in the flux estimates between ocean domains and in the contribution particular flux variables make to the total mass flux, which may in turn





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indicate important differences in the strength of the BCP due to local environmental and ecosystem level forcing. Exploring the reasons for such differences remains a major scientific and societal problem particularly given projected changes to the future ocean and this dataset will help in this endeavour. The dataset is archived on the data repository PANGAEA® (http://www.pangaea.de) under doi:10.1594/PANGAEA.807946.

## 7 List of data sets compiled

- Antia, Avan N (2003): Particle fluxes of L2-B-92_trap. doi:10.1594/PANGAEA.92747

- Antia, Avan N (2003): Particle fluxes of OMEX2_trap. doi:10.1594/PANGAEA.92749

- Antia, Avan N (2003): Particle fluxes of OMEX3_trap. doi:10.1594/PANGAEA.92748

- Antia, Avan N (2003): Particle fluxes of SEEP-7_trap. doi:10.1594/PANGAEA.92746

- Antia, Avan N (2003): Particle Flux of SEEP-10_trap. doi:10.1594/PANGAEA.92745

- Bahr, Fred; Bates, Nicolas R (2013): Total flux, particulate carbon and nitrogen from surface-tethered sediment traps at time series station BATS in 1988 and 1989. doi:10.1594/PANGAEA.805543





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– Bahr, Fred; Bates, Nicolas R (2013): Total flux, particulate carbon and nitrogen from surface-tethered sediment traps at time series station BATS in 1990. doi:10.1594/PANGAEA.805545

– Bahr, Fred; Bates, Nicolas R (2013): Total flux, particulate carbon and nitrogen from surface-tethered sediment traps at time series station BATS in 1991. doi:10.1594/PANGAEA.805546

– Bahr, Fred; Bates, Nicolas R (2013): Total flux, particulate carbon and nitrogen from surface-tethered sediment traps at time series station BATS in 1992. doi:10.1594/PANGAEA.805547

– Bahr, Fred; Bates, Nicolas R (2013): Total flux, particulate carbon and nitrogen from surface-tethered sediment traps at time series station BATS in 1993. doi:10.1594/PANGAEA.805548

– Bahr, Fred; Bates, Nicolas R (2013): Total flux, particulate carbon and nitrogen from surface-tethered sediment traps at time series station BATS in 1994. doi:10.1594/PANGAEA.805549

– Bahr, Fred; Bates, Nicolas R (2013): Total flux, particulate carbon and nitrogen from surface-tethered sediment traps at time series station BATS in 1995. doi:10.1594/PANGAEA.805550

– Bahr, Fred; Bates, Nicolas R (2013): Total flux, particulate carbon and nitrogen from surface-tethered sediment traps at time series station BATS in 1996.





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doi:10.1594/PANGAEA.805551

– Bahr, Fred; Bates, Nicolas R (2013): Total flux, particulate carbon and nitrogen from surface-tethered sediment traps at time series station BATS in 1997. doi:10.1594/PANGAEA.805552

– Bahr, Fred; Bates, Nicolas R (2013): Total flux, particulate carbon and nitrogen from surface-tethered sediment traps at time series station BATS in 1998. doi:10.1594/PANGAEA.805553

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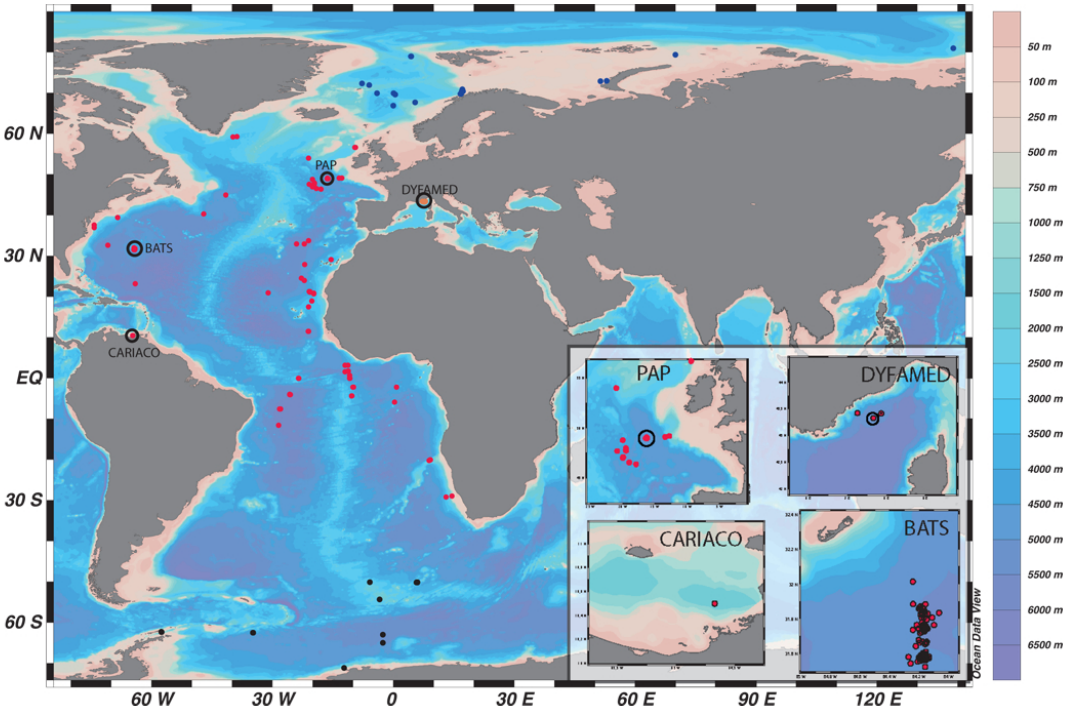


**Fig. 1.** Map showing the location of sediment trap deployments. Inset figures show expanded maps of regions where the CARIACO, BATS, PAP and DYFAMED time series are located. Locations are colour-coded per ocean domain; Atlantic (red •), Mediterranean (orange •), Arctic (blue •), and Southern Ocean (black •).





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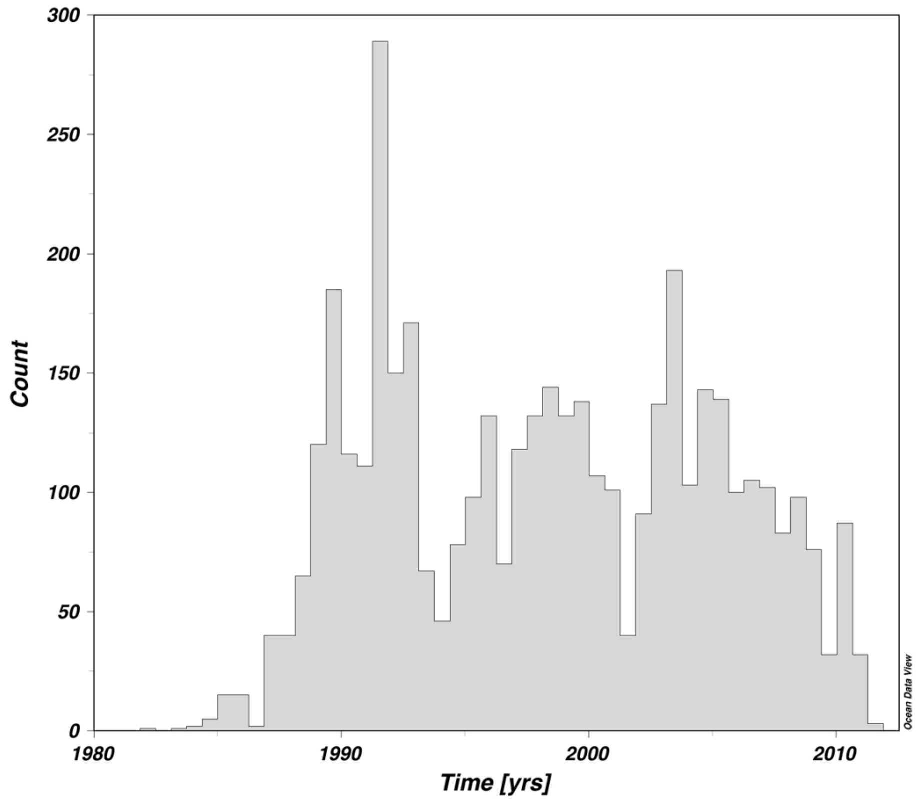


**Fig. 2.** Data time distribution histogram.





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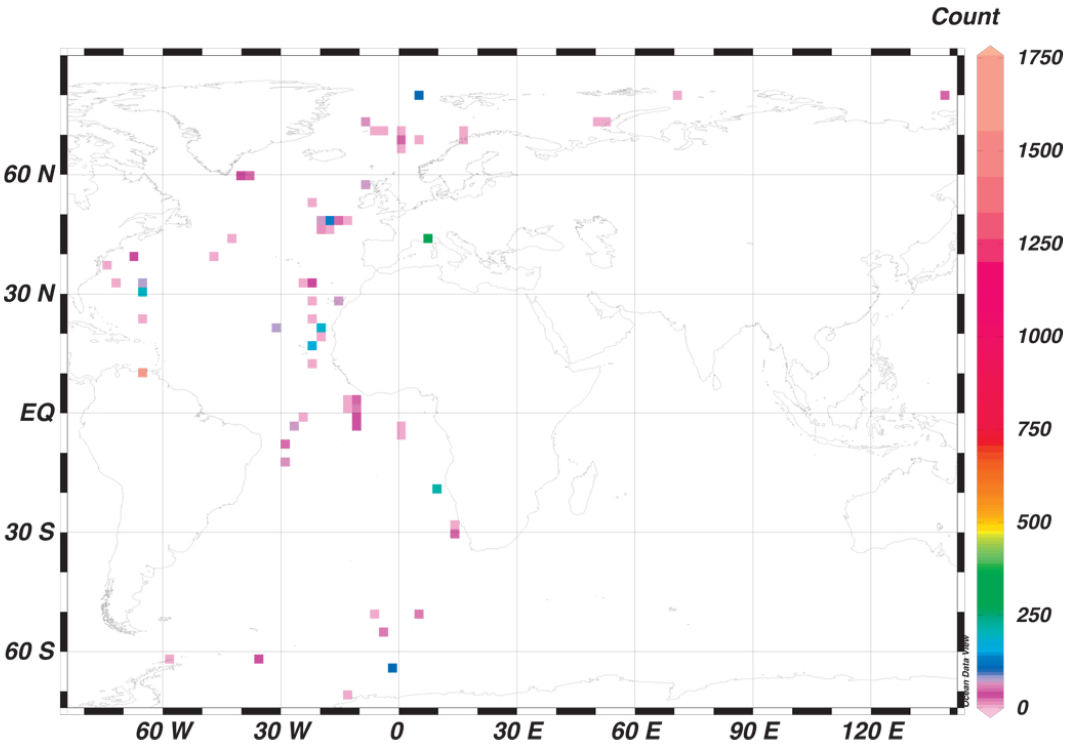


**Fig. 3.** Map showing observation counts (colour bar) per trap-deployment site.





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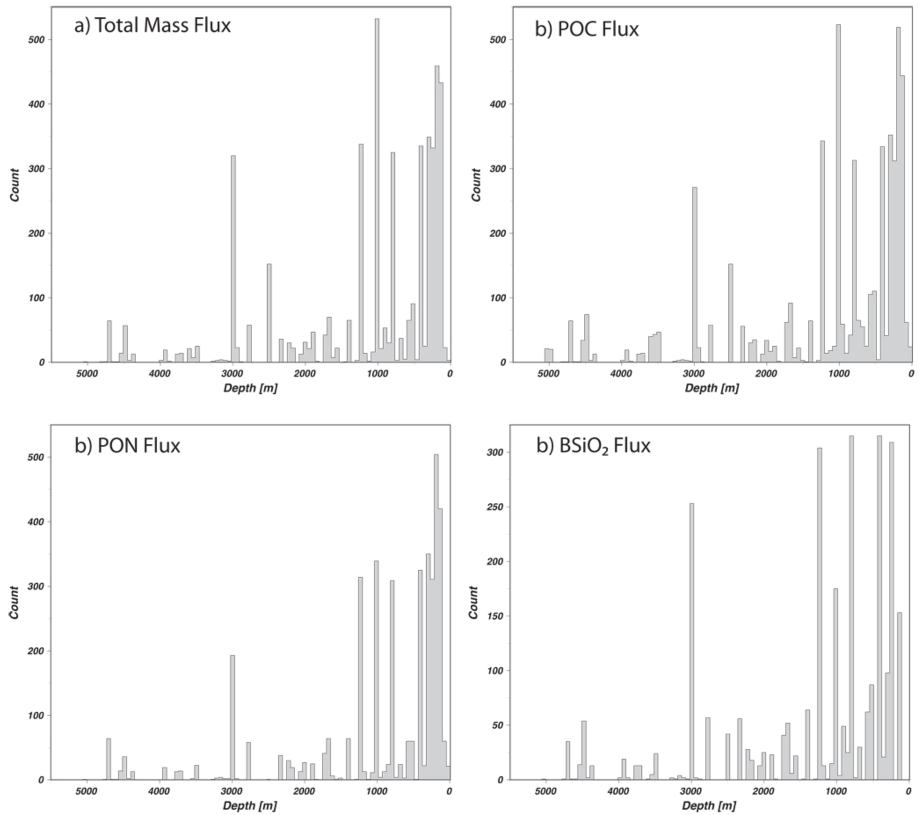


**Fig. 4.** Observation counts relative to depth.



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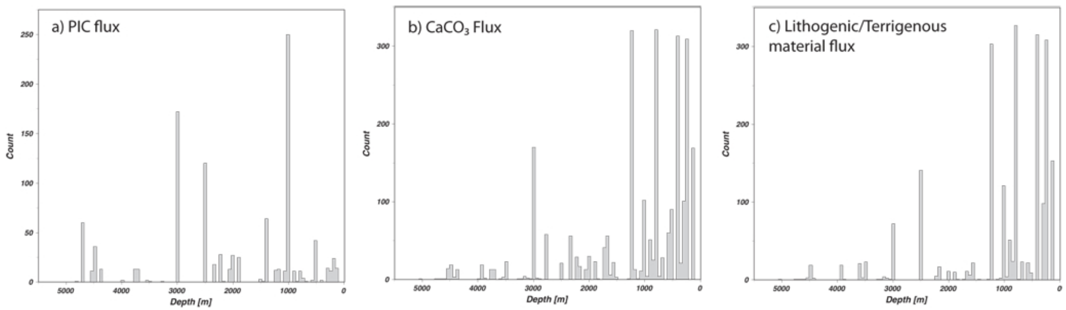


**Fig. 5.** Observation counts relative to depth.

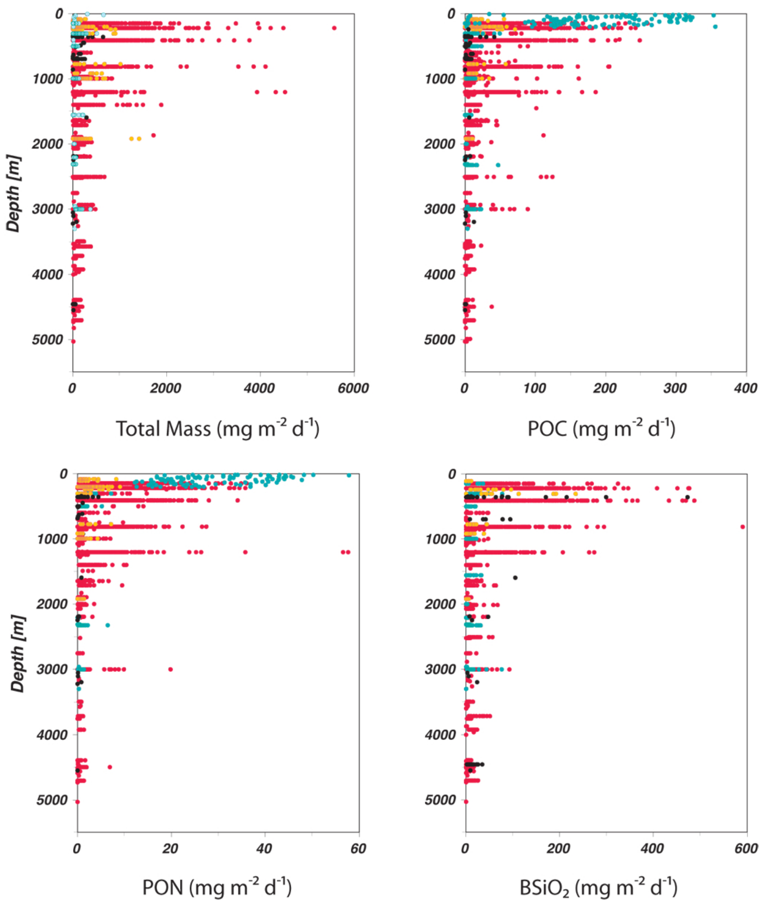


**Fig. 6.** Tot_Mass, POC, PON, and $BSiO_2$ downward fluxes plotted against depth. Data points are colour-coded per ocean domain; Atlantic (red •), Mediterranean (orange •), Arctic (blue •), and Southern Ocean (black •).





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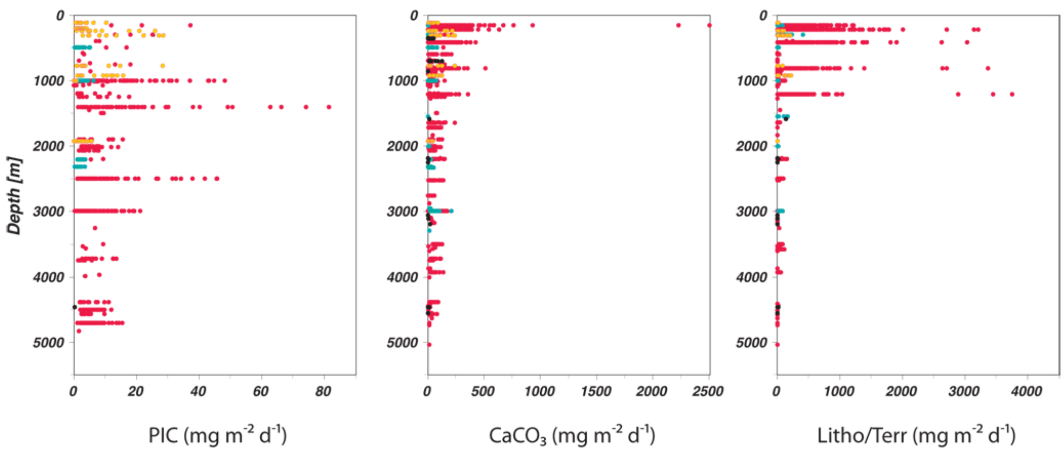


**Fig. 7.** PIC, $CaCO_2$ and Litho/Terr downward fluxes plotted against depth. Data points are colour-coded per ocean domain; Atlantic (red •), Mediterranean (orange •), Arctic (blue •), and Southern Ocean (black •).

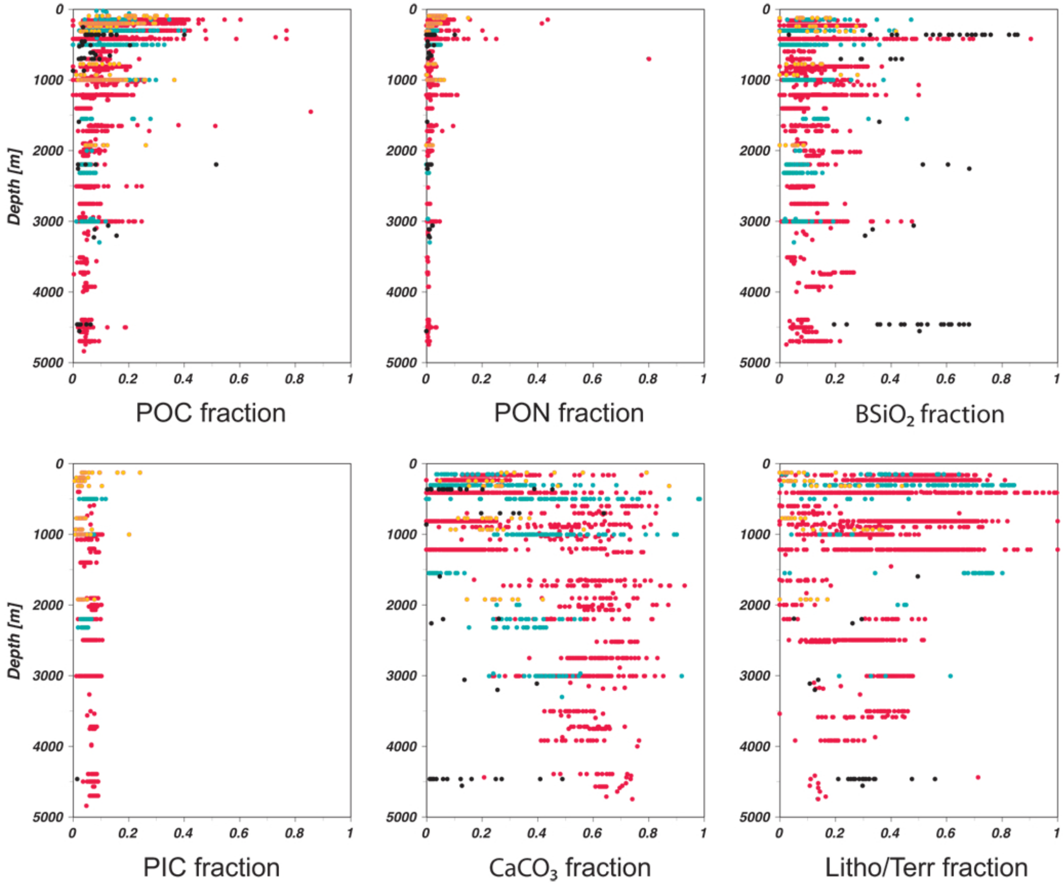


**Fig. 8.** Fraction of POC, PON, and $BSiO_2$, PIC, $CaCO_2$ and Litho/Terr downward fluxes relative to Tot_Mass flux. Data points are colour-coded per ocean domain; Atlantic (red •), Mediterranean (orange •), Arctic (blue •), and Southern Ocean (black •). Few outliers (fraction > 1) were excluded from the graphs.





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**Table 1.** Data set column headers. All fluxes are reported as per day over the period of deployment. We note that only at BATS are samples collected in triplicate. Hence, other than BATS, data under the "replicate 1" and "average" headers contain the same information. Not applicable is denoted (NA).

| Label/Variable | Units | Description |
|---|---|---|
| ID | NA | Data point reference number. |
| Cruise/Project/Area/ STN/ Trap | NA | Cruise reference number or name, name of data, originating project, area where data was collected from, station, trap ID (depending on available information). |
| yyyymmdd1 | NA | Date in the format Year Month Day of sediment trap deployment. |
| yyyymmdd2 | NA | Date in the format Year Month Day of sediment trap recovery. |
| Duration | Days | Duration of sediment trap deployment. |
| Lat | $^\circ$N | Decimal latitude of sediment trap deployment. |
| Long | $^\circ$E | Decimal longitude of sediment trap deployment. |
| Depth | m | Depth of sediment trap deployment. |
| Samp_id1 | NA | Sample/cup ID replicate 1. |
| Samp_id2 | NA | Sample/cup ID replicate 2 (if available). |
| Samp_id3 | NA | Sample/cup ID replicate 3 (if available). |
| Tot_Mass1 | mg $m^{-2}$ $d^{-1}$ | Total mass flux replicate 1. |
| Tot_Mass2 | mg $m^{-2}$ $d^{-1}$ | Total mass flux replicate 2 (if available). |
| Tot_Mass3 | mg $m^{-2}$ $d^{-1}$ | Total mass flux replicate 3 (if available). |
| Tot_Mass_av | mg $m^{-2}$ $d^{-1}$ | Total mass flux average. |
| Tot_Mass_stdev | mg $m^{-2}$ $d^{-1}$ | Total mass standard deviation. |
| POC_1 | mg $m^{-2}$ $d^{-1}$ | Particulate organic carbon flux replicate 1. |
| POC_2 | mg $m^{-2}$ $d^{-1}$ | Particulate organic carbon flux replicate 2 (if available). |
| POC_3 | mg $m^{-2}$ $d^{-1}$ | Particulate organic carbon flux replicate 3 (if available). |
| POC_Av | mg $m^{-2}$ $d^{-1}$ | Particulate organic carbon flux average. |
| POC_stdev | mg $m^{-2}$ $d^{-1}$ | Particulate organic carbon flux standard deviation. |
| PON_1 | mg $m^{-2}$ $d^{-1}$ | Particulate organic nitrogen flux replicate 1. |
| PON_2 | mg $m^{-2}$ $d^{-1}$ | Particulate organic nitrogen flux replicate 2 (if available). |
| PON_3 | mg $m^{-2}$ $d^{-1}$ | Particulate organic nitrogen flux replicate 3 (if available). |
| PON_Av | mg $m^{-2}$ $d^{-1}$ | Particulate organic nitrogen flux average. |
| PON_stdev | mg $m^{-2}$ $d^{-1}$ | Particulate organic nitrogen flux standard deviation. |





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**Table 1.** Continued.

| Label/Variable | Units | Description |
|---|---|---|
| $BSiO_2$ | mg $m^{-2}$ $d^{-1}$ | Biogenic silica flux average. |
| $BSiO_2$_stdev | mg $m^{-2}$ $d^{-1}$ | Biogenic silica flux standard deviation. |
| $CaCO_3$ | mg $m^{-2}$ $d^{-1}$ | Calcium carbonate flux average. |
| $CaCO_3$_stdev | mg $m^{-2}$ $d^{-1}$ | Calcium carbonate flux standard deviation. |
| Terr/Litho | mg $m^{-2}$ $d^{-1}$ | Terrigenous or lithogenic (as reported) material flux average. |
| Terr_stdev | mg $m^{-2}$ $d^{-1}$ | Terrigenous or lithogenic material flux standard deviation. |
| PIC | mg $m^{-2}$ $d^{-1}$ | Particulate inorganic carbon flux average. |
| PIC_stdev | mg $m^{-2}$ $d^{-1}$ | Particulate inorganic carbon flux standard deviation. |
| Institution | NA | Affiliation institution of main author and/or data originator (when available). |
| Reference | NA | Simple ID to identify the publication where the data is reported. |
| Trap_ID | NA | Simple acronym of sediment trap type and/or characteristics of it. |
| Trap_Type | NA | Description of sediment trap type and/or characteristics of it. |
| Data source | NA | Link to data source. |
| Notes | NA | Notes. |
| WOA09_Temp | °C | Temperature from World Ocean Atlas 2009 (WOA09) Climatology. |
| WOA09_Sal | NA | Salinity from WOA09. |
| WOA09_DO | µmol $L^{-1}$ | Dissolved oxygen concentration from WOA09. |
| WOA09_$O_{2SAT}$ | % | Oxygen saturation from WOA09. |
| WOA09_AOU | µmol $L^{-1}$ | Apparent oxygen utilisation from WOA09 |
| WOA09_$NO_3^-$ | µmol $L^{-1}$ | Nitrate concentration from WOA09. |
| WOA09_$Si(OH)_4$ | µmol $L^{-1}$ | Silicate concentration from WOA09. |
| WOA09_$PO_4^{3-}$ | µmol $L^{-1}$ | Phosphate concentration from WOA09. |



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**Table 2.** Sinking material flux range, depth range distribution and number of observations available.

| Variable | Number of observations | Range $mg\ m^{-2}\ d^{-1}$ | | Depth range m | |
|---|---|---|---|---|---|
| | | Min | Max | Min | Max |
| Total mass flux | 4735 | 0.0 | 5584 | 15 | 5031 |
| POC flux | 5202 | 0.0 | 355.7 | 15 | 5031 |
| PON flux | 3996 | 0.0 | 57.9 | 20 | 5031 |
| $BSiO_2$ flux | 2895 | 0.0 | 590.5 | 117 | 5031 |
| PIC flux | 1048 | 0.04 | 81.4 | 117 | 4832 |
| $CaCO_3$ flux | 2631 | 0.0 | 2505.7 | 117 | 5031 |
| Terr/Litho flux | 2166 | 0.0 | 4528.8 | 117 | 5031 |



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