Vertical flux of particulate organic matter in a High Arctic fjord: Relative importance of terrestrial and marine sources

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Abstract

Vertical flux of particulate matter was recorded using a moored sediment trap during 2002-03 in the outer region of the 90 km long NE Greenland fjord Young Sound (74°18'N, 20°18'W). Sea ice covered the fjord for c. 9 months during the deployment. At 65 m depth total flux of material was 1420 g dry weight m^{-2} and annual fluxes of carbonate (g m^{-2}), chlorophyll (mg m^{-2}), particulate organic carbon (POC, g C m^{-2}) and nitrogen (PON, g N m^{-2}), were, 9, 53, 17 and 1.2 respectively. A steep increase in fluxes was observed during the summer thaw when sea ice broke up and water discharge from land began. Within the two months (July and August), >90% of the total annual vertical flux occurred. Isotopic ($\delta^{13}C$ & $\delta^{15}N$) analysis of particulate organic material (POM) in the sediment trap, in phytoplankton and in the river material indicated that a maximum of c. 50% of the POM material originated from land. This is supported by the high C:N ratio (by atoms) of up to 22 found in the trapped organic material during the summer thaw as compared with 7–9 during winter and spring, when no discharge from land occurred. Seasonal measurements of the POC discharge from rivers to the outer region of the fjord corresponded to c. 40% of the vertical POC flux measured in the sediment trap, which further indicates a significant terrestrial contribution to the settling material in the outer fjord area.

Besides POC, dissolved organic carbon (DOC) is discharged in an equal amount to the fjord from rivers, resulting in a total organic carbon (TOC) input from land to the outer region of Young Sound of 13 g C m^{-2} yr^{-1}. This corresponds to c. 40% of the net TOC input from the Greenland Sea and to the outer part of the fjord during the ice-free productive period underlining the significant terrestrial contribution to sedimentation in the outer part of the fjord.

Mean permanent accumulation rates based on the depth distributions of ^{210}Pb, ^{137}Cs and TOC in sediments at 60 m water depth in the outer fjord area revealed a burial of carbon within the sediment of 7.9 g C m^{-2} yr^{-1}. In agreement with the sediment trap measurements, $\delta^{13}C$ values within the sediment suggest that a substantial amount (c. 40%) of the POC in the sediment was of terrestrial origin. At the same sites, previous studies have reported an annual release of dissolved inorganic carbon (DIC) due to mineralization from the sediment of 12.6 g C m^{-2} yr^{-1}. The sum of the annual DIC release and the burial within the sediment represents an expected total input to the sediment of 20.5 g C m^{-2} yr^{-1} and compares well with the vertical flux measurement from the sediment trap of 17.0 g C m^{-2} yr^{-1} during the present study.

6.1 Introduction

The vertical flux of organic matter from the pelagic environment determines the input of food to benthic animals, rates of benthic mineralization as well as the burial of material in sediments below the photic zone. In the Arctic marine environment, the amount of particulate organic matter originating from primary production is strongly influenced by the presence or absence of sea ice, which is the main factor controlling the availability of light for primary producers. Thus, a strong seasonal variation in the vertical export of particulate organic matter has been observed in Arctic waters with low export rates during sea-ice cover and elevated export rates during the open-water period (Atkinson & Wacasey, 1987; Bauerfeind et al., 1997). A peak in sedimentation is often associated with sea-ice break-up due to the release of ice-algal material from the sea-ice matrix (Fortier et al., 2002). Ice algae live in and on the underside of sea ice and are present primarily during April through June until sea-ice break-up (Horner & Schrader, 1982; Chapter 4). Prior to, or in association with, the break-up of sea ice and the development of the spring phytoplankton bloom, copepods ascend from wintering depths to surface waters to graze on the bloom (Madsen et al., 2001). Grazing by copepods leads to production of fecal pellets that sink rapidly in the water column and thus enhance the vertical export to the sea floor (Sampei et al., 2002). Due to release of dissolved organic matter from copepod fecal pellets (Urban-Rich, 1999) and degradation of sinking aggregates (Ploug & Grossart, 2000) the amount of particulate organic matter reaching the sediment is expected to decrease with depth.

In addition to the marine sources of organic matter, Arctic rivers discharge 30×10^6 tons of total organic carbon (TOC) into the Arctic Ocean on an annual basis (Rachold et al., 2004). River discharge is particularly important in the Arctic Ocean, as it receives 11% of global runoff while containing only 1% of the world ocean water (Shiklomanov, 1998). The content of POC relative to POC + DOC in river water varies greatly between the Arctic rivers from 4% in the Yenisei river to 62% in the Mackenzie River (Rachold et al., 2004).

The environmental changes in the Arctic observed over the last two decades have increased the interest in discharge of freshwater and organic matter from land to ocean (Benner et al., 2004). Although the Greenland Ice Sheet represents a huge freshwater source that potentially may have a profound influence on river discharge, erosion and organic matter transport to Greenland fjords and offshore areas, very little is known of this transport. In 1995, a research and monitoring station ZERO (Zackenberg Ecological Research Operations) was established in NE Greenland to increase knowledge about climate-ecosystem interactions. As part of an extensive monitoring program, the discharge of water and organic matter from the Zackenberg River has been monitored since 1995 (Rasch et al., 2000; Hasholt & Hagedorn, 2000; Chapter 2). The total freshwater discharge takes place over a 3-month period during June–August, when air temperatures exceed 0°C, and 65% of the discharge often occurs within a few weeks. The very pulsed freshwater discharge greatly affects the physical circulation in the fjord. The outer parts of the fjord are minimally influenced by discharge from glaciers, but pulsed terrestrial runoff occurs during the short summer thaw generating an estuarine circulation in which lighter low-salinity water is moved seaward above denser incoming water from the Greenland Sea (Rysgaard et al., 2003; Chapter 3). Previous studies have shown that the net TOC input to the outer fjord area during the productive ice-free period is 15–50 t d^{-1} (Rysgaard et al., 2003).

In order to determine the annual vertical flux of particulate organic matter and to evaluate the relative importance of marine and terrestrial sources in a NE Greenland fjord, a mooring equipped with a time-series sediment trap was deployed in the outer region of Young Sound. Sedimenting particles were collected at c. 65 m water depth during 2002-03 at 20 individually programmed time intervals. The material was analyzed for its content of total dry weight, carbonate, chlorophyll, POC, PON and isotopic signal ($\delta^{13}C$ & $\delta^{15}N$). In parallel, water samples of the Zackenberg River were collected frequently during May–September 2003 to determine the flux of POC and DOC as well as the isotopic signal from the catchment area. Finally, we compare the vertical flux from the sediment trap with the sediment mineralization processes and discuss the relative importance of terrestrial and marine sources of carbon for permanent burial in the sediment.

6.2 Methods

6.2.1 Study area

The study was carried out in 2002-03 in Young Sound, a NE Greenland fjord (74°18’N, 20°18’W) situated in the Northeast Greenland National Park. The fjord is c. 90 km long and 2–7 km wide with a 40-50-m deep sill at the entrance (Fig. 6.1). Mean air temperature is below freezing 9 months of the year, and only the months of June through August have positive mean air temperatures of up to 4°C (Cappelen et al.,

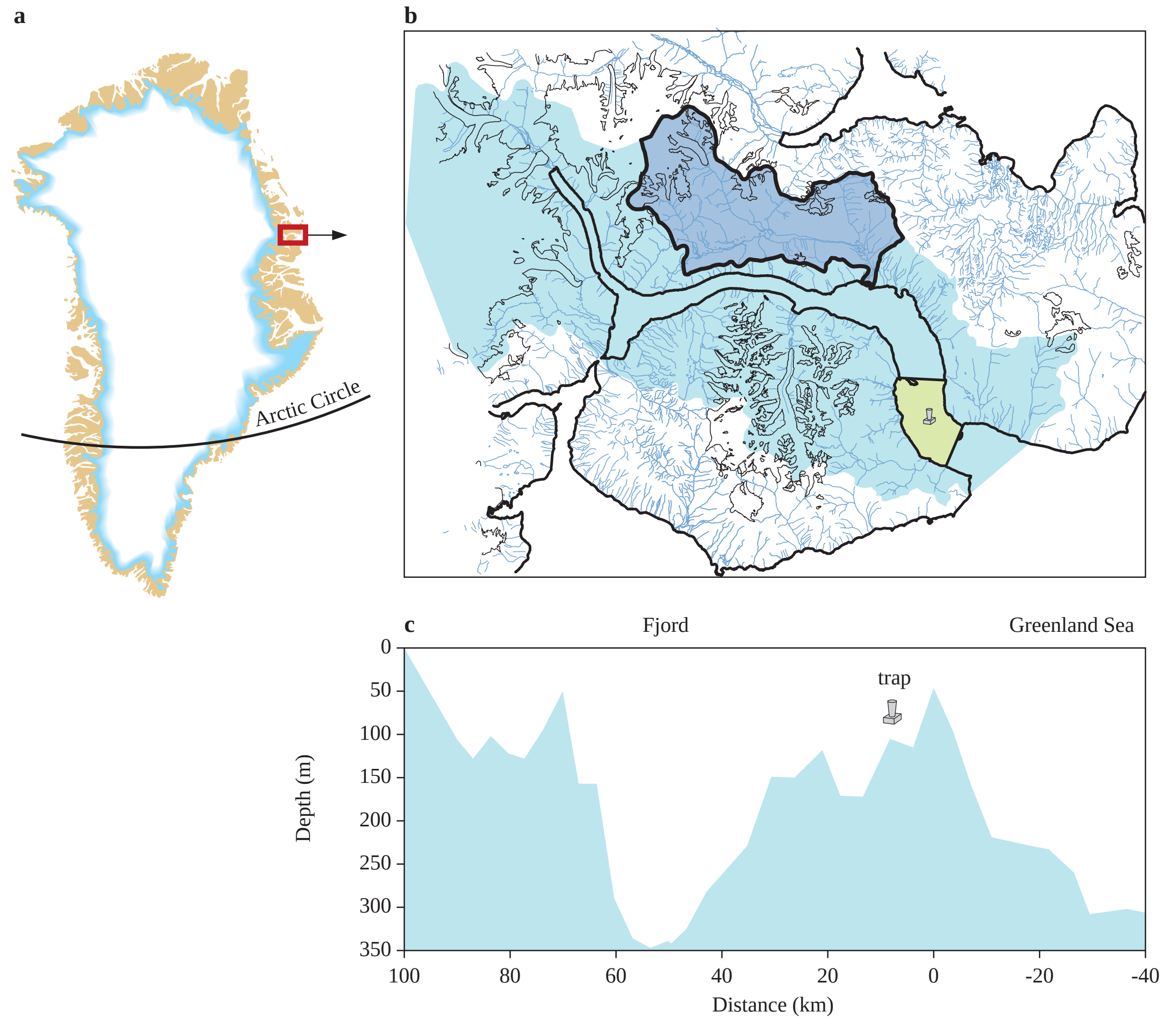


Figure 6.1 (a) The study site is located 1000 kilometers north of the Arctic Circle. **(b)** Catchment area of the Young Sound/Tyrolerfjord system (shaded area) showing the drainage basin of the Zackenberg River (blue area) and the study area "Region 1" (light green area) with the position of the sediment trap. **(c)** Length section of the fjord showing the site of the moored sediment trap.

2001). Sea ice covers the fjord for 9–10 months of the year. During summer, a surface layer (0–10 m) of low salinity (<30) and with a temperature of 2–4°C is present due to melting sea ice and freshwater input from land. Below this layer, salinity increases to >33 with sub-zero temperatures forming a stable halocline at 15–20 m (Rysgaard et al., 1999, 2003; Chapter 3). The thick sea-ice and snow cover regulates activity in the light-limited Young Sound ecosystem. Primary production of sea ice algae in Young Sound is low due to the poor light conditions below the snow cover and because river discharge removes and/or inhibits algae at the sea ice/water interface through physical disturbance and exposure to freshwater (Rysgaard et al., 2001; Chapter 4). After the break-up of sea ice, however, phytoplankton bloom in the surface water and rapidly deplete nutrients above the well-established halocline, causing maximum photosynthesis to occur in a subsurface layer at 15–20 m depth (Rysgaard et al., 1999). Phytoplankton primary production is tightly coupled to the grazer community in Young Sound and it has been estimated earlier that copepods account for >80% of the grazing pressure upon phytoplankton during the short productive ice-free period (Rysgaard et al., 1999; Chapter 5). When sea ice breaks up, benthic mineralization is immediately stimulated (Rysgaard et al., 1998; Berg et al., 2003; Chapter 8), presumably due to a peak in vertical export from the water column.

6.2.2 Sediment trap measurements

In September 2002, a mooring equipped with a time-series Kiel sediment trap (opening 0.5 m^2, K/MT 320, K.U.M, Kiel GmbH, Germany) was deployed in the outer region of Young Sound (74°18.93'N, 20°16.70'W) (Fig. 6.1). The trap was positioned at c. 65 m water depth to collect material vertically exported from the productive photic zone of the upper c. 40 m. To prevent icebergs from removing or destroying the trap the upper buoyancy was positioned at c. 40 m water depth. A sill 45 m deep at the entrance to the fjord prevents larger icebergs from entering the fjord and no icebergs are released from the inner parts of Young Sound. Water depth at the position was c. 100 m. Sedimenting particles were collected from 15 September 2002 to 20 September 2003 at 20 individually programmed time intervals.

Prior to launching, the collector cups of the sediment trap were filled with GF/F-filtered bottom water and poisoned with $HgCl_2$ (1 ml saturated solution per 100 ml water). NaCl was also added to the cup solution to increase salinity to c. 40. The mooring was acoustically released from its position after 1 year of sampling. After recovery, another 0.5 ml of the $HgCl_2$ solution was added to each 100-ml cup and samples were stored at 4°C. In the laboratory, zooplankton "swimmers" were removed from all samples prior to further treatment. Samples were then freeze-dried and weighed to determine total fluxes (dry weight, dw), and homogenized sub-samples of known weight were taken for analyses of particulate organic carbon (POC), particulate organic nitrogen (PON), chlorophyll (Chl) and calcium carbonate ($CaCO_3$). Total carbon contents (TC) were determined on an elemental analyzer (Europa Scientific RoboPrep). The POC and PON contents were obtained by analyses of decalcified samples. Decalcification was achieved by H_2SO_3 treatment and heating to 80°C. The $CaCO_3$ content was calculated as TC - POC. Stable isotopic composition of the decalcified samples was analyzed on an elemental analyzer in line with a mass spectrometer (Triple Collector Europa Scientific 20-20 IRMS). Isotope measurements are presented using the conventional $\delta^{13}C$ notation relative to PDB, and the $\delta^{15}N$ notation relative to air. The chlorophyll content (total pigments) of the cup material was analyzed by spectrophotometry on acetone extractions of freeze-dried samples (Dalsgaard et al., 2000).

Launching sediment trap mooring in Young Sound.

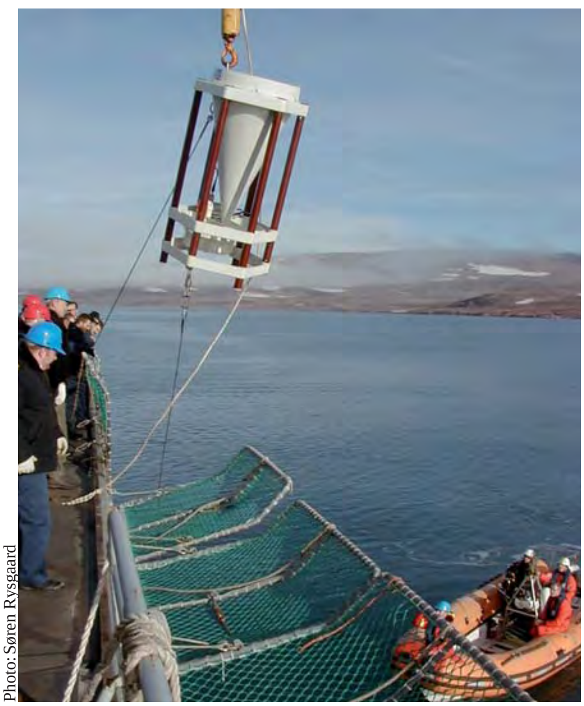


Photo: Søren Rysgaard

6.2.3 Sediment analysis

The upper 0–5 cm of sediment cores collected at 60 m water depth was freeze-dried, treated with H_2SO_3 and heated to 80°C to remove $CaCO_3$, homogenized and weighed into sample boats. The total carbon content and the stable isotopic signal of $\delta^{13}C$ were analyzed as described above. Data on carbon burial in the sediment was taken from earlier measurements reported in Chapter 8.

6.2.4 Sea ice measurements

The Danish Military Patrol Sirius collected data on sea ice thickness during 2002–03, using an ice-drill and a measuring stick at a position (74°18.59'N, 20°15.04 W) close to the sediment trap. These data are part of the long-term monitoring program at Zackenberg (Rysgaard et al., 2005; Chapter 4).

6.2.5 River discharge measurements

The drainage basin for the largest river in the area, Zackenberg River, covers an area of 514 km^2 (Fig. 6.1; Chapter 2). A hydrometric station at the outer part of the river recorded the water level every 15 minutes via sonic range and pressure sensors. The measured water level was converted to meters above sea level, which in turn was converted to discharge,

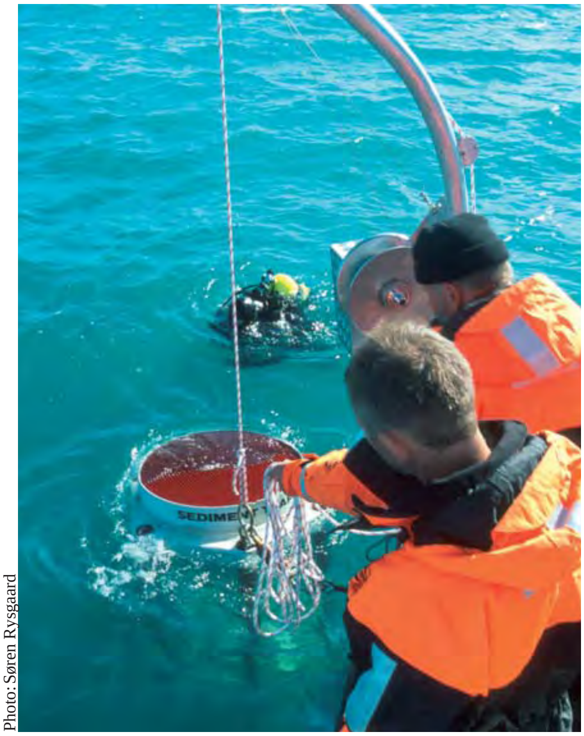


Photo: Søren Rysgaard

Retrieving sediment trap mooring 1 year after launching.

using an established relationship between water level and discharge. Water samples were collected daily from the river during May–September 2003 using a depth-integrated sampler. The collected water (0.8 l) was filtered (combusted GF/C) and filters frozen and decalcified before analyzing for POC and PON as described above. The DOC concentration in the filtered water samples was analyzed with a Shimadzu TOC-5000A Analyzer. These data are part of the long-term monitoring program Zackenberg Basic (www.Zackenberg.dk).

6.2.6 Horizontal carbon transport

During 2000–2001, a net carbon budget for the outer fjord area (Region 1) was established based on total organic carbon (TOC) measurements in the water column and a volume-mass model (Rysgaard et al., 2003). In short, the carbon export towards the sea was estimated along two separate transects enclosing Region 1 (76 km^2) during the ice-free period. During the investigation period, the TOC concentration in the water column ranged from 60 to 110 µM. Elevated concentrations were found in the upper 10–25 m in association with the pycnocline in the period 2–12 August. A total net retention of 28 t C d^{-1} (range 15–50 t C d^{-1}) in Region 1 during the ice-free period was reported.

6.3 Results & discussion

6.3.1 Seasonal variation in sea ice cover and river discharge

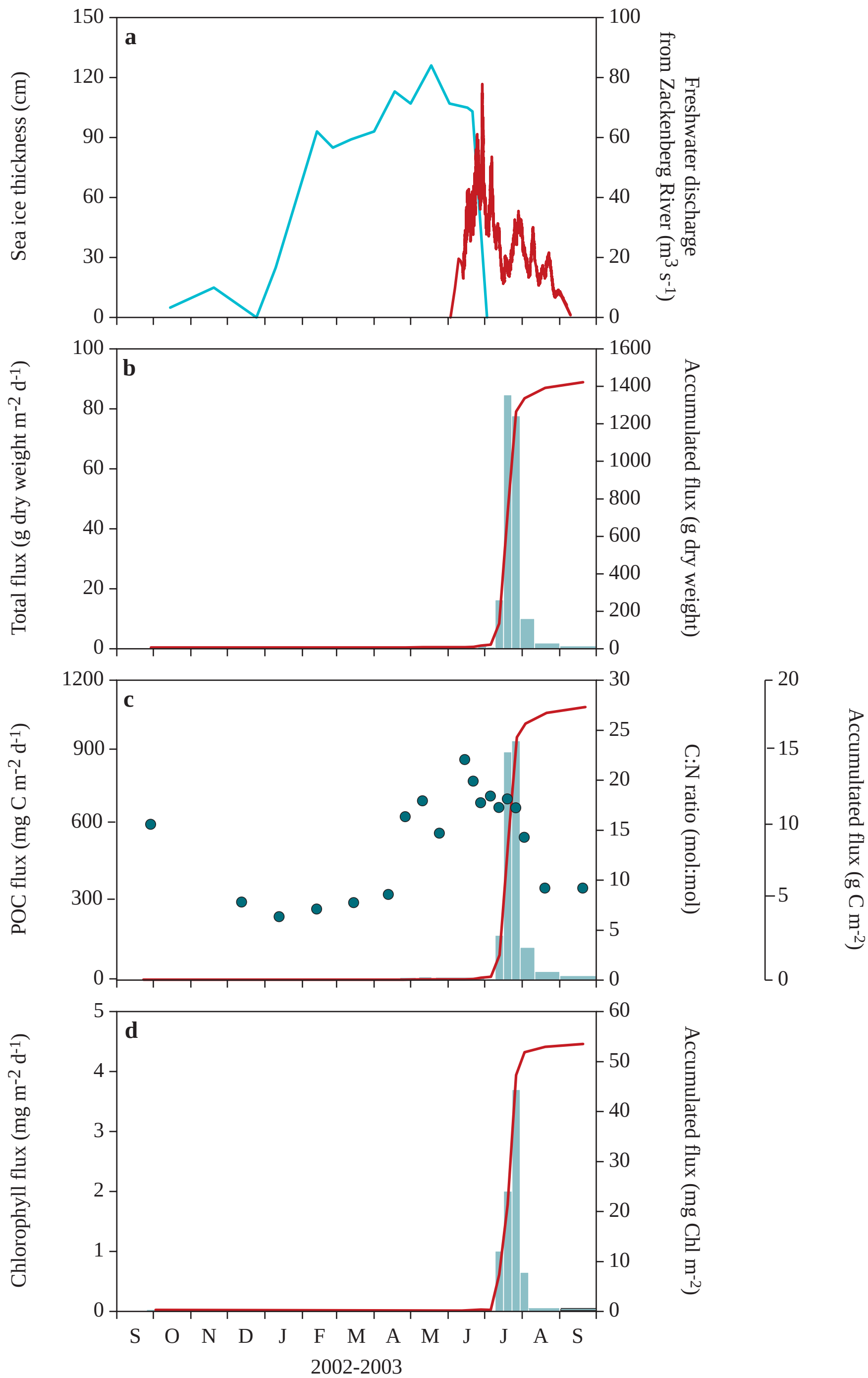
Normally, sea ice forms in late September or early October and stays until the following summer thaw (Rysgaard et al., 2005; Chapter 4). However, in 2002, sea ice suddenly broke on 25 December and was exported to the Greenland Sea due to high wind speeds from the north and lack of sea ice outside the fjord. New ice reached a maximum thickness of 120 cm with a 40-cm snow cover on top in April–May 2003. Sea ice broke on 3 July 2003 in outer Young Sound, 3 weeks earlier than normal (Fig. 6.2a).

Break-up of the Zackenberg River occurred on 30 May 2003, resulting in a steep increase in freshwater discharge to 78 m^3 s^{-1} at the end of June, after which it gradually decreased and ceased in September (Fig. 6.2a). This is in agreement with earlier observations that the annual runoff generally peaks in the beginning of June to July, mainly due to melting snow from the catchment area (Chapter 2).

6.3.2 Flux of particulate matter

A steep increase in the vertical flux of material was observed in association with the break-up of sea ice and peak in freshwater discharge from the River Zackenberg (Fig. 6.2). Within two months (July and August), more than 90% of the total annual vertical flux occurred. Our data support previous reports of a strong seasonal variation in the vertical flux of particulate material in Arctic waters, with low flux rates under sea ice cover and elevated export rates during sea-ice break-up and during open-water conditions. In the Northeast Water Polynya and in Baffin Bay, 40–70% of the annual vertical particle flux was observed from June–October (Bauerfeind et al., 1997; Hargrave et al., 2002), and in Frobisher Bay, Arctic Canada, 45% of the annual POC flux occurred during July–August (Atkinson & Wacasey, 1987). During spring, a pronounced signal in the vertical flux has sometime been observed in seasonally ice-covered seas due to ice-edge production (Hebbeln & Wefer, 1991; Wassmann et al., 1991) or ice-algal material released from sea ice (Fortier et al., 2002; Bauerfeind et al., 2005). In Young Sound, however, sea-ice-algal primary production and biomass were very low due to thick snow cover (40 cm) in 2002–03 (Chapter 4; Rysgaard et al., 2005). Furthermore, previous stud-

Figure 6.2 (a) Sea ice thickness (blue line) and freshwater discharge (red line) at the investigation site. **(b)** Vertical flux rate of particulate matter (bars) and accumulated flux (red line). **(c)** Vertical flux of particulate organic carbon (bars), accumulated flux (red line) and C:N ratio in organic matter (dots). **(d)** Vertical flux of chlorophyll (bars) and accumulated flux (red line).



ies have suggested that sea-ice-algal biomass is very low in the fjord due to extreme dynamics in sea-ice appearance, structure and brine percolation, which is driven primarily by the large but variable freshwater input during snow melt and breaking of frozen rivers, transforming the sea ice matrix into a hostile environment for sea ice algae, despite good light and nutrient availability (Rysgaard et al., 2001; Chapter 4). Thus, the very large vertical POC flux following sea ice break-up made the winter and spring vertical POC fluxes insignificant, although detectable (0.07–0.2 mg C m^{-2} d^{-1}) (Fig. 6.2).

In Young Sound, the annual vertical flux rate at 65 m water depth was 1420 g dry weight material m^{-2} and 17 g POC m^{-2} (Fig. 6.2bc). This is lower than rates from Frobisher Bay (33 m) but higher than rates further offshore from East Greenland (245 m), from the Northeast Water Polynya (150–350 m), Baffin Bay (>200 m) and several offshore localities (>500 m) in the Greenland Sea, the Fram Strait, the Barents Sea and the Norwegian Sea (Honjo et al., 1988; Hebbeln & Wefer 1991; Hebbeln, 2000; Wassmann et al., 1991; Bauerfeind et al., 1997; Hargrave et al., 2002; Bauerfeind et al., 2005). On an annual basis, the vertical flux of POC in the sediment trap material, in Young Sound corresponded to 1.2% of the total dry weight flux. This agrees well with the measured organic carbon content in the sediments at 36–163 m water depth in the same area, which ranged from 1.1 to 1.4% (Glud et al., 2000). Furthermore, the vertical flux of calcium carbonate accounted for less than 1% of the flux of dry weight material, which supports earlier measurements of low calcium carbonate contents in the sediment of the outer part of the fjord (Chapter 8). However, it differs strongly from observations further offshore from East Greenland that c. 30% of the annual particle flux could be ascribed to calcium carbonate (Bauerfeind et al., 2005).

The C:N ratio in the organic sediment trap material ranged from 7 during winter, when sea ice cover was present and very low vertical flux rates occurred, to 15–22 during May–July (Fig. 6.2c). C:N ratios in organic material close to the Redfield ratio of 7 (by atoms) is normally interpreted as sedimentation of marine phytoplankton. The vertical flux of chlorophyll peaked when sea ice broke up and was highly correlated ($r^2 = 0.9$, $P << 0.001$) with the vertical flux of POC (Fig. 6.2cd). Pennate diatoms (Naviculales, Achnanthales, Lyrellales and Bacillariales) dominated the phytoplankton in the sediment trap material but dinoflagellates (*Protoperidinium* spp., *Ceratium* spp., *Prorocentrum* spp. and *Dinophysis* spp.) were also present. Both diatoms and dinoflagellates were present in the trap material throughout the year, although low cell numbers were encountered during winter (data not shown).

6.3.3. Marine and terrestrial sources

The high C:N ratio in the sediment trap organic material of up to 22 during the summer thaw, as compared with 7–9 during winter and spring, when no discharge from land occurred, suggests that carbon sources other than marine phytoplankton are important in the outer fjord area (Fig. 6.2c). As POC:Chl ratios <100 are characteristic of seston enriched with phytoplankton, the ratio of 320 observed in the present study (calculation based on annual dataset) further indicates that carbon sources other than phytoplankton cells contribute to the vertical export in the fjord. Seasonal measurements of the POC and DOC discharge from the Zackenberg River show that large quantities of terrestrial carbon are being transported into the fjord (Fig. 6.3). Within the 3 months of June–August, 416 tons of POC and 421 tons of DOC enter the fjord from the Zackenberg River. Thus, the content of POC relative to POC+DOC in the Zackenberg River is quite high (50%) and compares with conditions in the Mackenzie River (Rachold et al., 2004). The C:N ratio in river-borne POC ranged from 10–40 with a mean value of 18 throughout the study period. The C:N ratio of DOM was not determined, but ratios of 50–60 found in other Arctic rivers (e.g. Köhler et al., 2003) suggest that the C:N ratio of river-borne total organic material (TOM) was higher than that of POM. The extent to which DOM precipitation contributed to sedimentation is not known.

Figure 6.3 (a) Particulate organic carbon (blue dotted) and dissolved organic carbon (red dotted) discharge from the Zackenberg River. Accumulated transport of POC (blue line) and of DOC (red line). **(b)** C:N ratio in river-borne particulate organic matter.

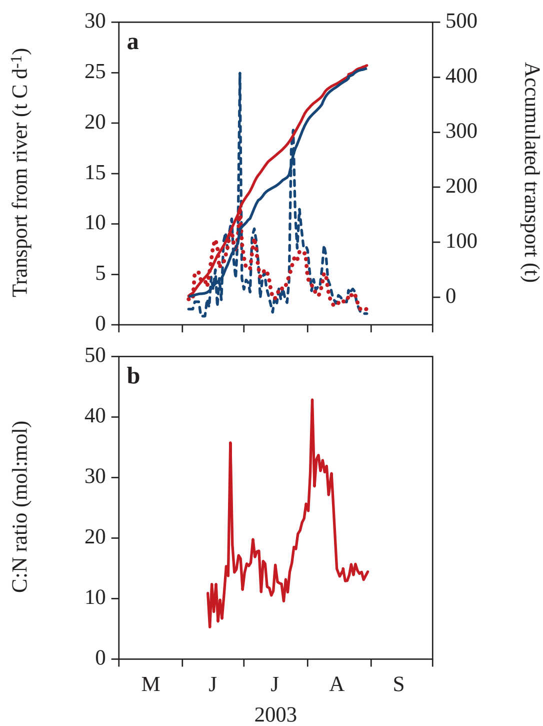


Table 6.1. Isotopic signals in organic matter from primary producers, sediment trap material, sediment and the Zackenberg River.

Sample	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	n
[a]Pelagic primary producers	-21.6 ± 0.8	5.4 ± 0.8	5
[b]POM from sediment trap (summer mean)	-23.6 ± 0.1	4.7 ± 0.2	7
[c]POM in the sediment at 60 m water depth	-23.1 ± 0.4	nd	20
[d]POM in the Zackenberg River	-25.6 ± 0.1	4.3 ± 0.3	23

[a]POM. (Hobson & Welch, 1992)
[b]Mean value of samples collected in trap through June–September.
[c]Mean value of upper 5 cm of the sediment at 60 m water depth.
[d]Mean value in suspended particulate matter of the Zackenberg River.


Photo: Magnus Elander

Preserving samples from the sediment trap system.

The high C:N ratios observed during May are presumably due to air-borne terrestrial material being incorporated into the sea ice and liberated to the water column as air temperatures increase during spring. Isotopic ($\delta^{13}C$ & $\delta^{15}N$) analysis of particulate organic matter (POM) showed that the composition of the sediment trap material was close to the average of the composition of phytoplankton and river material (Table 6.1). This indicates that c. 50% of the depositing POM originates from land (Table 6.1) and hence supports the high C:N ratios observed in the trap material during June–July 2003.

Previous mass and volume budgets of TOC covering the outer part of the fjord have revealed a net input of TOC of 28 t C d^{-1} to Region 1 (Fig. 6.1) from the adjacent Greenland Sea and surrounding land during the ice-free productive period (Rysgaard et al., 2003). During that study it was not possible to distinguish between marine and terrestrial carbon sources, but it appeared that the freshwater discharge from land was the primary factor determining the net TOC input through its influence on the estuarine circulation in the fjord. Thus, the net TOC input to Region 1 during the productive period is 2436 t C yr^{-1} (Table 6.2), given an annual freshwater discharge during the present investigation very similar to that in 2001 (Chapter 2; Rysgaard et al., 2003) and assuming that water-column TOC concentrations were similar in the two years. This corresponds to a net input of 32 g C m^{-2} yr^{-1} to Region 1 in the outer part of the fjord (Fig. 6.1; Table 6.2).

Assuming that the Zackenberg catchment area (512 km^2) is representative of the entire catchment area of 3109 km^2 of the Young Sound/Tyrolerfjord system, and that the discharge from the Zackenberg River can be linearly scaled to the entire catchment area, 2526 t POC yr^{-1} should enter the fjord from the terrestrial compartment (Table 6.2). Scaling this input to the outer Region 1 of the fjord, it corresponds to 6.5 g POC m^{-2} yr^{-1}, which is very similar to the carbon burial observed in the sediment in this region (see below). Besides POC, dissolved organic carbon is discharged in an equal amount to the fjord from rivers and results in a total organic carbon (TOC) input from land to the outer region of Young Sound of 20.5 g C m^{-2} yr^{-1}. This amount corresponds to c. 40% of the net TOC input from the Greenland Sea and land (Table 6.2), further supporting the conclusion that the terrestrial input to the outer part of Young Sound is significant.

6.3.4 Vertical flux, mineralization and burial

Depth distributions of ^{210}Pb, ^{137}Cs and TOC in sediments at 60 m water depth close to the sediment trap reveal that 7.9 g C m^{-2} yr^{-1} is buried within the sediment (Table 6.3; Chapter 8). This rate is in the same range as the estimated terrestrial POC transport to the outer fjord. Furthermore, the $\delta^{13}C$ values within the sediment suggest that a substantial amount (c. 40%) of the POC in the sediment is of terrestrial origin (Table 6.1).

Previous studies have reported an annual release of dissolved inorganic carbon (DIC) due to miner-

Table 6.2 The annual net input of carbon to the outer region of the fjord and the annual carbon flux from land.

Sources	C flux ($t\ C\ yr^{-1}$)	[d]C input from entire catchment area ($t\ C\ yr^{-1}$)	[e]C input to Region 1 ($g\ C\ m^{-2}\ yr^{-1}$)
[a]Net TOC input to Region 1	2436 (1300 – 4400)		32 (17 – 58)
[b]POC from the Zackenberg River	416	2526	6.5
[b]DOC from the Zackenberg River	421	2556	6.6
[c]TOC from the Zackenberg River	837	5082	13

[a]Net input to Region 1 (76 km^2) from land and the Greenland Sea.
[b]POC input from the Zackenberg River to Young Sound (the Zackenberg River catchment area is 512 km^2).
[c]POC + DOC in the Zackenberg River.
[d]Carbon input from the Zackenberg River catchment area scaled to entire catchment area (3109 km^2) of Young Sound (389 km^2) (Fig. 6.1).
[e]Carbon input scaled to Region 1 during 2002–2003.
The numbers in brackets represent the maximum range of uncertainty.

alization in the sediment of 12.6 g C m^{-2} yr^{-1} at 60 m water depth in the outer region of the fjord (Glud et al., 2000; Chapter 8). The sum of the annual DIC release and the sediment burial represent an expected total input to the sediment of 20.5 g C m^{-2} yr^{-1}, which compares reasonably well with the vertical flux measurement from the sediment trap of 17 g C m^{-2} yr^{-1} obtained in present study.

Table 6.3 Annual carbon fluxes in the water column and sediment.

	$g\ C\ m^{-2}\ yr^{-1}$
[a]Vertical POC flux	17.0
[b]DIC release from sediment (60 m)	12.6
[b]Carbon burial in sediment (60 m)	7.9
[c]Total (60 m)	20.5

[a)] This study
[b)] Glud et al. (2002) and Chapter 8).
[c)] Sum of sediment DIC release and burial

6.4 Acknowledgements

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