Near-bottom fluxes and composition of suspended matter in the Pomeranian Bay*

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Abstract

The quality and composition of suspended organic matter in near-bottom fluxes was determined at a mooring station (Odas Tonne) 20 km north-north-west of the Odra river mouth from June to December 1997. Salinity data and high concentrations of suspended matter near the bottom showed that the material entering the Pomeranian Bay from the Odra flood was recognisable for about three weeks. Vertical sediment fluxes, however, were low (~ 40 g m^{-2} d^{-1}) compared to those measured later in the year (~ 60 g m^{-2} d^{-1}). On the other hand, average molar CNP ratios in sediment trap material decreased from June to December 1997. These results may have been a combined effect of dilution and material transport in a layer close to the sediment surface. Fluff layers sampled at Odas Tonne in August 1997 contained a very high proportion of branched fatty acids of bacterial origin, indicating high rates of bacterial degradation. Long-chain fatty acids indicated an origin from higher terrestrial plants. The saturated fatty acid content was high in the surface sediment and the traps, increasing towards the top trap. The percentage composition of fatty acids indicated that the lowest trap was fed mainly by material from the underlying sediment. Low salinities, variability in molar ratios for major elements, higher than usual bacterial activities and detection of fatty acids characteristic of land plants during the June-August deployment show a relationship with the Odra flood of summer 1997.

1. Introduction

The River Odra (Oder) provides the fifth-largest river runoff into the Baltic Sea, annually discharging about 18 km^3 of water from a drainage area of 119 000 km^2 through the Szczecin Lagoon and the three river branches Peene, wina and Dziwna into the Pomeranian Bay. In contrast to the Szczecin Lagoon, where the phytoplankton biomass is high throughout the growing season, phytoplankton blooms in the Pomeranian Bay occur only in spring, when the nutrient inputs via the three river branches of the lagoon combine with sufficient light conditions and complete vertical mixing processes in favour of algal blooming (Humborg *et al.* in press). The flood of summer 1997, however, produced a discharge pattern which differed from the normal spring discharges: the major Odra discharges entered the Baltic Sea after only three days, resulting in decreased water residence times in the intermediate lagoon and river branches. It was expected that upon reaching the Pomeranian Bay some of this turbid water would form a shallow freshwater layer overlying the seawater body, whereas heavier material would be transported at near-bottom levels.

Studies of near-bottom sediment transport have focused on the role of fluff – unconsolidated material composed of aggregated biogenic and abiogenic particles (Emeis *et al.* 1998). Fluff accumulates during calm weather on sandy sea floors and is easily resuspended by waves and currents. This fluffy material is the main transport agent for biogenic material, pollutants and riverine nutrients from the shallow environment near the Odra mouth to the deeper and calmer sedimentary basins of the southern Baltic Sea.

Fatty acids (FAs) are major lipid compounds. Their distribution in recent sediments and near-bottom waters results from direct inputs of autochthonous and allochthonous components coming from the water column, from diagenetic processes occurring in the water column and in sediments, and from benthic organisms and bacteria (Lee & Wakeham 1992, Najdek 1993). Analysis of FAs gives information on the origin and changes of organic matter in seawater and sediments (Saliot *et al.* 1991, Scribe *et al.* 1991). Of particular interest are polyunsaturated FAs, because their specific occurrence in different planktonic organisms is an indicator of their planktonic origin (Sargent *et al.* 1980, Marty *et al.* 1988, Scribe *et al.* 1991). Detection of long-chain saturated (> 22 carbon atoms per molecule) and monounsaturated FAs (C 20:1 and C 22:1), found in the cuticular waxes of higher plants, indicates a land source (Matsumoto 1981, Cassagne *et al.* 1994). The presence of branched aliphatic FAs containing an odd number of carbon atoms in a molecule is an indicator of microbiological degradation (Perry *et al.* 1979).

The impact of the Odra flood on the fate of dissolved nutrients and particulate organic matter in the water column of the Pomeranian Bay has already been studied (Humborg *et al.* in press). However, no work has so far been published on the particulate matter fluxes and the composition of this material at near-bottom levels at the Odas Tonne BASYS (Baltic Sea System Study) station before, during and after the flood. Our objectives were therefore

- to perform time-series measurements of salinity and light attenuation near the surface of the seabed,
- to quantify the vertical sediment flux and the major composition and sources of the suspended organic matter collected at different near-bottom levels at the Odas Tonne BASYS station.

2. Materials and Methods

Study area

Field work was carried out at Odas Tonne (54°03.00 N; 14°08.00 E) (Fig. 1) a BASYS mooring station at 15 m water depth where sand ripples are occasionally overlain by thin fluff (Emeis *et al.* 1998). This station displays great variability in conditions at the seafloor and has a high variability in sediment type, benthic communities and sedimentary features.

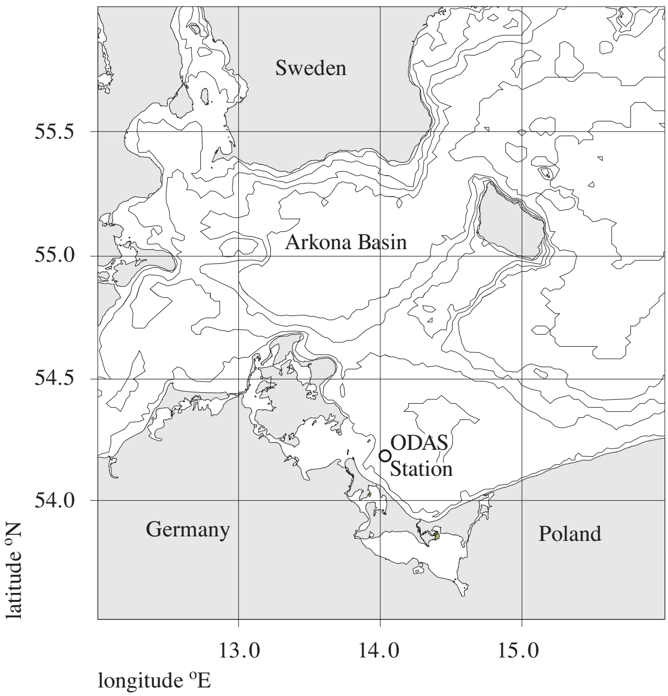

Fig. 1. The geographical location of the Odas Tonne station

Fig. 2. The tripod trap system used in this study

Sediment trap tripod

A tripod trap system, consisting of a stainless steel frame equipped with sediment traps, transmissometer and Aanderaa current meter (Fig. 2), was deployed on 11 June and recovered on 19 August. A second tripod deployment covered the period from 21 August to 14 October and a third deployment covered the period from 14 October to 6 December. The transmissometer (DST 9202) measured attenuation of a 630 nm wavelength beam over a distance of 0.5 m at 15-minute intervals at 0.5 m above the seabed. Measurements of light attenuation were converted into a light attenuation coefficient ($C - C_w$) by

$$C - C_w = [-\ln(F/F_0)]/r, \tag{1}$$

where C_w is the ambient light attenuation coefficient in the water, F is the measured light intensity [V], F_0 is the initial light intensity, and r is the distance [m] between light emitter and receiver (Wells & Seok-Yun 1991). The Aanderaa current meter measured current speed, conductivity and temperature every 10 minutes 1 m above the seabed. Current direction was not measured in the present set-up. The sediment traps consisted of stainless tubes closed at the lower end, and trap openings were placed 0.35, 0.70, 1.05, 1.40 and 1.75 m above the seabed for measuring vertical fluxes. The cylindrical traps are 25 cm long with an inner diameter of 5 cm giving an aspect ratio of 5. This is considered the optimal aspect ratio for measuring vertical fluxes in horizontal flows with moderate current speeds of up to *ca* 20 cm s^{-1} (Hargrave & Burns 1979). Under such moderate conditions, an aspect ratio of 5 has been found optimal both to avoid overtrapping and to prevent resuspension from the traps (Knauer & Asper 1989, White 1990). The contents of the sediment traps were carefully emptied and stored in 2 l plastic flasks at 4°C. In the laboratory the material was filtered (Whatman 540) and dried at 60°C for 24 hours. Dried weight was recorded and the material was ground prior to analysis.

Fluff layer and surface sediment sampling

Samples of fluff were collected at the Odas Tonne station in October 1996, March 1997, June 1997, August 1997 and October 1997 by divers using a vacuum pump system operated on board ship. The water was removed using a flow-through centrifuge, the particulates were deep-frozen on board and stored at −18°C. Undisturbed sediment cores were taken manually by divers. The water overlying the sediment was carefully discarded and the 0–0.5 cm layer was scooped off and stored at −18°C. All samples were freeze-dried prior to analysis.

Extraction of fatty acids

Fluff layers, suspended matter in traps and sediment were extracted three times with a 2:1 chloroform : methanol mixture. The solutions were combined and then extracted three times with water buffered to pH 2 with potassium carbonate. Following this, the aqueous solutions were combined, adjusted to pH 3 and extracted with hexane to isolate free fatty acids. Finally, the combined hexane extracts were dried over 4 Å molecular sieves and evaporated. The derivatives were formed by the addition of 4–bromo–methyl–7–methoxycoumarin solution in acetonitrile, in accordance with Pazdro & Falkowski (1994).

Analyses

Samples for total phosphorus determination were combusted at 550°C for 12 h and extracted with 1 M HCl for 20 minutes at 80°C (Svendsen *et al.* 1993). These acid samples were filtered and phosphorus was measured in the supernatants using the molybdate method (Murphy & Riley 1962). Total organic nitrogen was measured by titration using a Tecator Kjeltec Analyser. Organic carbon was determined gravimetrically from CO_2 evolution (Nørnberg & Dalsgaard 1996). Fatty acids were analysed by high performance liquid chromatography (HPLC) of their coumaryl esters. A Lichrospher 100 RP–18e column and methanol : water system at linear gradient were applied for reversed phase chromatography. A Hypersil SI 60 column and hexane : chloroform : isopropanol (88 : 10 : 2) isocratic solvent were applied for normal phase chromatography. The fluorescence detection parameters used were $\lambda_{\text{excitation}} = 312$ nm and $\lambda_{\text{emission}} = 399$ nm. The recoveries of individual compounds varied from 70 to 80%. The precision of the method, expressed as the standard deviation for three sample replicates, varied from 5.7 to 10%, depending on the individual compound. The detection limit for coumaryl fatty acid derivatives was 20 pmol per one 20 μl injection.

3. Results and discussion

Salinity and light attenuation coefficient

Times series measurements of the light attenuation coefficient showed strong variations especially during the later part of the June–August deployment, when the upper limit of the instrument measuring range was reached, for instance between 19 and 25 July (Fig. 3). The increase in the light attenuation coefficient during this period was related to a three-day period of high current speeds where a maximum of 16.2 cm s^{-1} was reached on 19 July (not shown). This period was dominated by fairly high winds

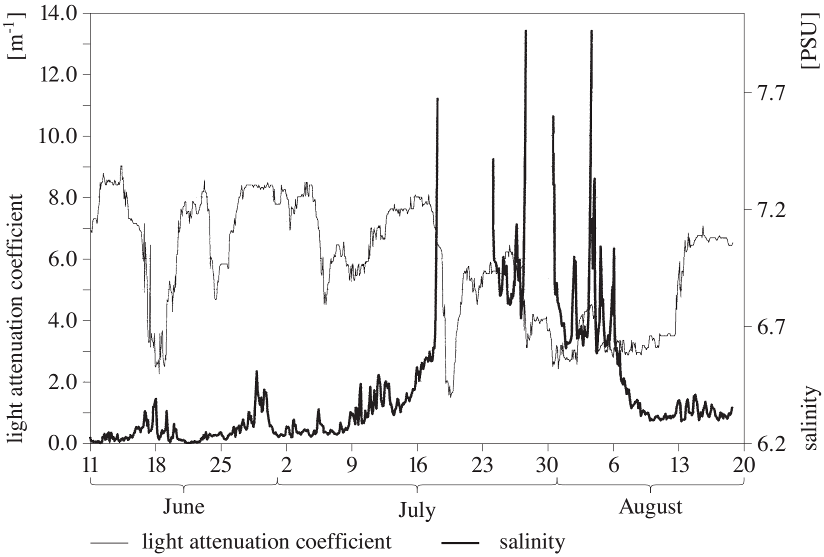

Fig. 3. Time series measurements of salinity [PSU] and light attenuation [m^{-1}] between 11 June and 20 August 1997 at the seabed at the Odas Tonne station

($\sim$15 m s^{-1}) from a north-easterly direction (Siegel & Matthäus, in press) as a result of which salinity decreased at this position. A similar salinity decrease also occurred around 18 June, when the current speed reached 10.2 cm s^{-1} during a period of high westerly winds ($\sim$13 m s^{-1}). The upper limit of the measuring range was again reached for a shorter period (Fig. 3). The freshwater plume related to the Odra flood entered the Pomeranian Bay on 28 July (Mohrholz *et al.* 1998), concurrently with the decrease in salinity. The low salinity remained quite constant until about 13 August. The discharge through the Świna, the main Odra river outlet, started to decrease around 14 August (see Fig. 6; Mohrholz *et al.* 1998) and may have been related to the increase in bottom salinity.

Sediment fluxes

The vertical sediment flux varied between 19.6 and 82.9 g m^{-2} day^{-1} at 1.75 and 0.35 m above the seabed between 11 June and 19 August 1997 (Fig. 4). The sediment flux was 114.3 g m^{-2} day^{-1} at 0.35 m above the seabed during the second deployment (August–October) and 86.6 g m^{-2} day^{-1} during the third deployment (October–December). A sediment flux measured by sediment traps is a gross sedimentation rate comprising a primary flux (Lund-Hansen 1991) and a resuspended flux (Lund-Hansen *et al.* 1997). The resuspended flux is the result of sediment

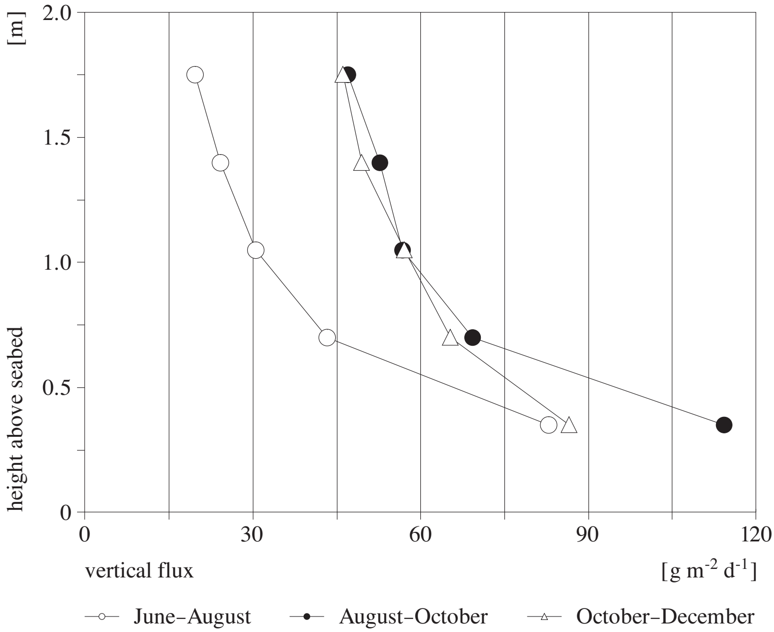

Fig. 4. Vertical sediment fluxes [$g\,m^{-2}\,d^{-1}$] at various sediment trap heights during three deployment periods at the Odas Tonne Station in 1997

resuspension either by waves (Aalderlink *et al.* 1984) or by currents (Sanford *et al.* 1991). Compared to the net flux rates of $3\,g\,m^{-2}\,day^{-1}$ measured in the deep water Arkona Basin (Neumann *et al.* 1996), the present data (Table 1 and Fig. 4) indicate a strong resuspension rate at the shallow water Odas Tonne station. That resuspension does actually take place is evidenced

Table 1. Current speeds [$cm\,s^{-1}$], variability of near-bottom vertical sediment fluxes [$g\,m^{-2}\,d^{-1}$] and CNP molar ratios of the trapped material. Mean values and SDs (parentheses) are shown ($n = 5$). Redfield ratios are given for comparison. Odas Tonne, 1997

Deployment period 1997	Current speed* mean	max	Vertical sediment flux	C:N molar ratio	N:P molar ratio	C:P molar ratio
11.06–19.08	4.5	16	40.1 (22.8)	3.4 (2.6)	13.7 (6)	38.3 (17.8)
21.08–14.10	4.3	16	68.0 (24.3)	2.5 (0.7)	13.0 (1)	33.2 (11.9)
14.10–06.12	5.4	19	60.9 (14.4)	2.7 (0.8)	9.9 (2)	25.0 (4.5)
redfield ratio				6.6	16	106

* average current speed measured 1.0 m above the seabed

by the fact that the average current speed was $5.2\,\mathrm{cm\,s^{-1}}$ measured 1 m above the bottom during June–August. On average, this is very close to the $5.9\,\mathrm{cm\,s^{-1}}$ needed to resuspend fluffy material from the bottom at this station (Lund-Hansen *et al.* 1999). During the June–August period two major resuspension events took place. Using wave prediction formulae (Christiansen *et al.* 1997) it can be estimated that the local north-easterly winds of up to $15\,\mathrm{m\,s^{-1}}$ (data from the Danish Meteorological Institute) in the days around 19 July resulted in near-bottom orbital velocities of about $20–25\,\mathrm{cm\,s^{-1}}$. At the same time measured current speeds were up $16\,\mathrm{cm\,s^{-1}}$. The combined effects or current- and wave-induced resuspension resulted in near-bottom suspended matter concentrations above the upper limit of the measuring range (Fig. 3). The other major resuspension event in the June-August period occurred on 28 July. Then, near-bottom current speeds had risen to $10\,\mathrm{cm\,s^{-1}}$. In spite of westerly winds of about $13\,\mathrm{m\,s^{-1}}$, the computed wave-induced orbital velocity did not exceed the resuspension threshold due to the short fetch from this direction. But again, resuspension was strong enough to induce suspended matter concentrations above the instrument's upper measuring limit. Similar maximum current speeds of $19.4\,\mathrm{cm\,s^{-1}}$ (August–October) and $19.1\,\mathrm{cm\,s^{-1}}$ (October–December) were measured during the following periods. These data indicate that the gross sedimentation flux at the Odas Tonne station was no greater during the Odra flood event than at other periods. Instead, the fluxes were comparatively low in the traps above 0.35 m between 11 June and 19 August. Increasing water masses during floods transport greater amounts of suspended matter from the catchment area, but this is not necessarily reflected in higher suspended matter concentrations in the recipient, for instance, because of a dilution effect. Another explanation could be that the suspended material entering the Pomeranian Bay during the flood event was transported in a near-bottom layer less than 0.35 m thick and resulted in higher fluxes in the lowest trap. Evidence in support of near-bottom transport was observed after the August–October deployment: when the traps were emptied for suspended matter it was observed that the tripod was overgrown with *Balanus balanus*. An exception was the bottom 50 cm of the tripod legs, which looked as if they had been scoured with sand. The presence of near-bottom lateral transport may also help to explain the high trapping rate f in the lowest trap during the August–October deployment. However, it must be emphasised that the June-August deployment comprised a period of 71 days and effects of the Odra flood event (low salinities) were only detected for a maximum period of 21 days (Fig. 3).

Major elements

Variability patterns at different near-bottom levels and surface sediments are shown for the three periods of 1997 (Fig. 5). Carbon concentration in the top trap (1.75 m.a.b.) was high during June–August relative to August–October and October–December. No clear distribution pattern

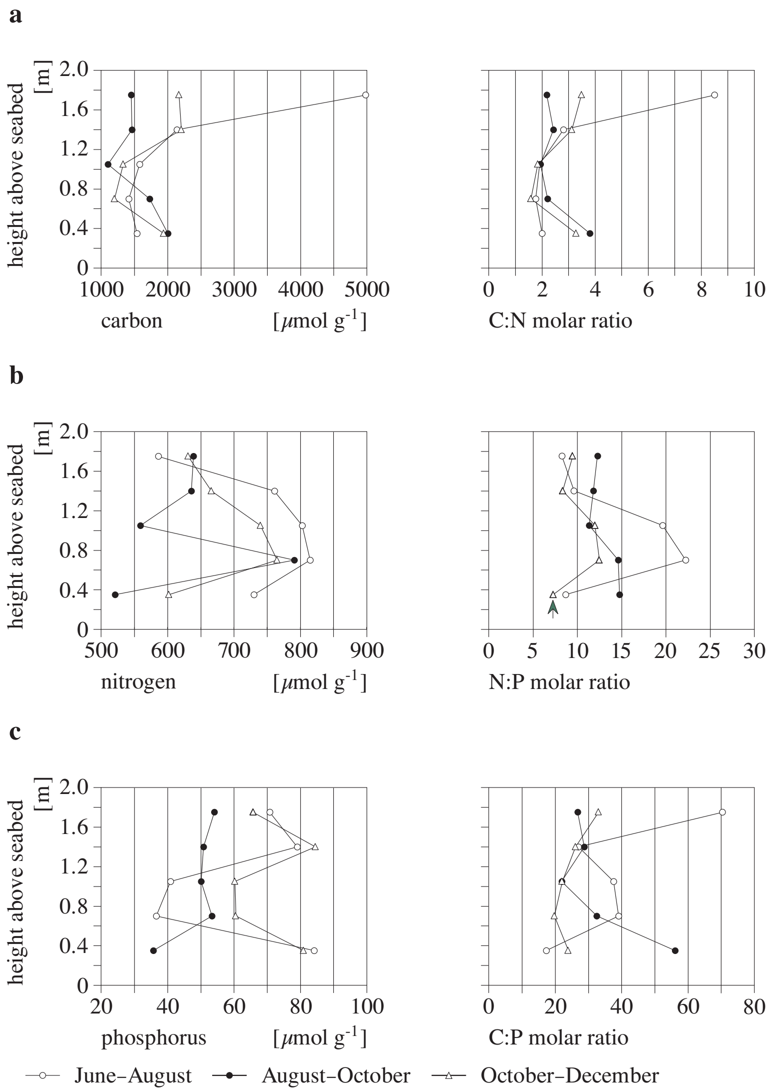

Fig. 5. Average CNP content and molar ratios in the sediment traps (a–c) at the Odas Tonne station during three deployment periods in 1997. Contents in the 0–1/2 cm of surficial sediment (d) and fluff layers (e) for a longer period are shown for comparison

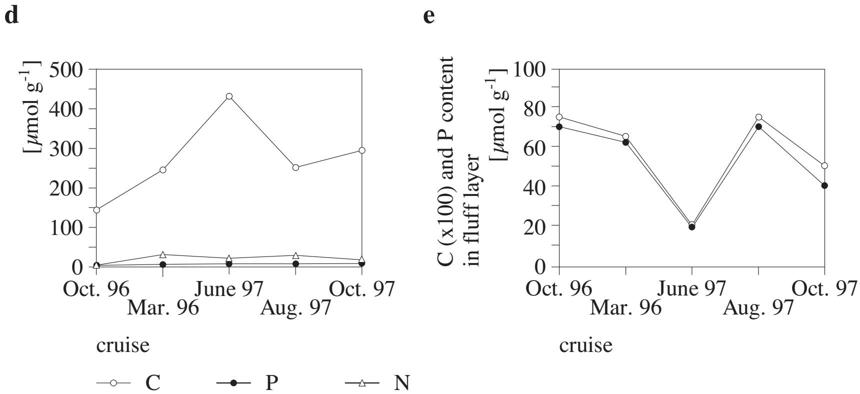

Fig. 5. (continued)

was seen for phosphorus in traps or shallow sediment horizons, but the nitrogen concentration was highest in the intermediate traps and lowest at the sediment surface. The C:N molar ratio of the trapped material was essentially constant with time (Fig. 5). The N:P molar ratio at intermediate levels increased during June–August and decreased during August–October and October–December. The average CNP molar ratios decreased from summer to winter (Table 1). Humborg *et al.* (in press) suggests that the summer flooding event caused enhanced nitrogen retention by land vegetation within the drainage area, resulting in a nitrogen-limited algal biomass growth. Indeed, a comparison of measured CNP molar ratios with Redfield ratios suggests a decrease in phytoplankton biomass production during and after the Odra flood (Table 1). This is a regular phenomenon in the summer-autumn seasons, except for the presence of *Cyanophyta* in hot summers. The carbon content in the 0 to 0.5 cm of surficial sediment decreased in August compared to previous measurements. Moreover, the organic content of the fluff layer was higher in August compared to previous or later measurements in 1997 (Fig. 5e). Hence, these results suggest the predominance of transport mechanisms in a layer close to the seabed surface sometime between June and August 1997.

Fatty acids

The magnitude of the FA flux during June–August and their proportion in the flux of organic matter are shown in Table 2. The FA flux was below 2% of the total organic matter flux. Data from sediment traps, fluff layers and surface sediments showed that saturated FAs were the dominant fraction in total FAs, consisting mainly of palmitic acid (C 16:0) (Figs. 6 and 8, Tables 3 and 4). The total FA content of the fluff layer was higher in August

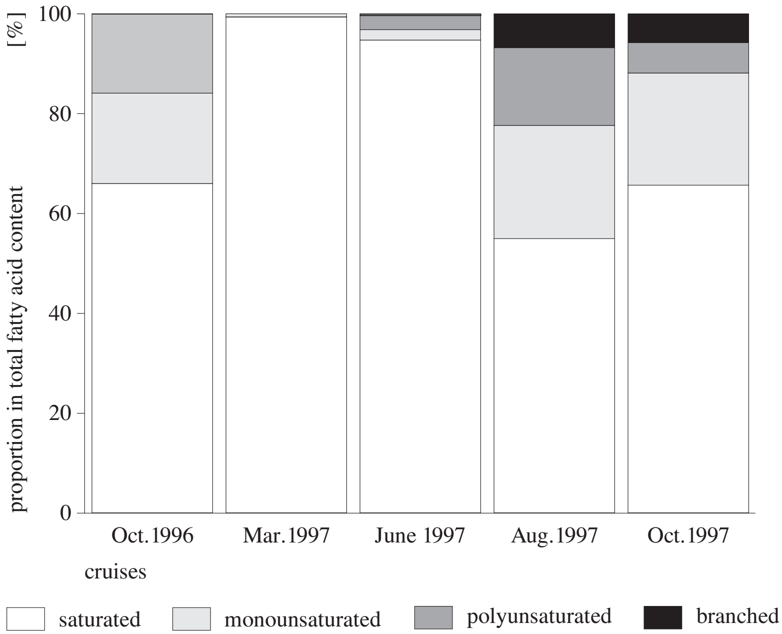

Fig. 6. Percentage composition of major groups of fatty acids in 'fluff' layers sampled at Odas Tonne at different times during 1996 and 1997. See also Tables 3 and 4

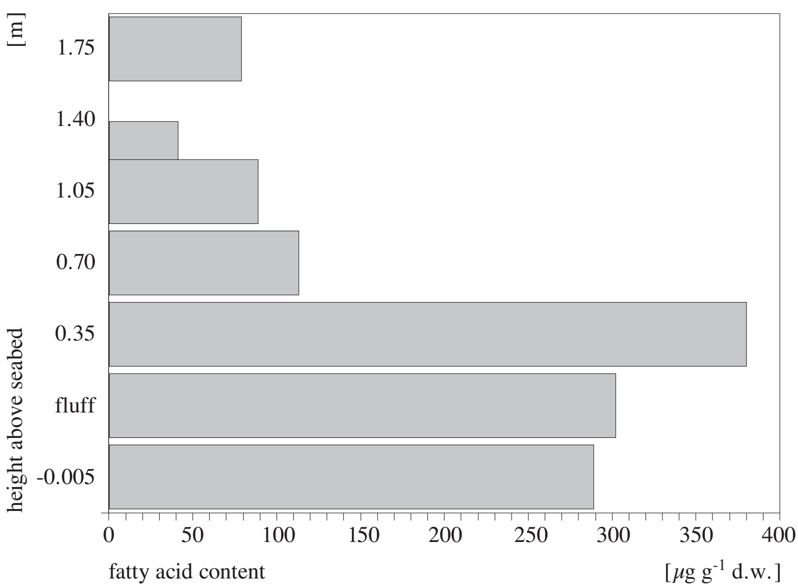

Fig. 7. Free fatty acid content at different near-bottom levels and in the surface sediment. Odas Tonne, August 1997. See also Tables 3 and 4

Table 2. Vertical fluxes [$mg\,m^{-2}\,d^{-1}$] of free fatty acids (FFA) and organic matter (expressed as CNP) at near-bottom levels during the June–August deployment at Odas Tonne

Metres above seabed	Vertical fluxes total FFA	CNP	FFA as % of of CNP flux
1.75	1.57	1395	0.11
1.40	1.00	951	0.11
1.00	2.76	957	0.29
0.75	4.97	1306	0.40
0.35	31.97	2549	1.25

Table 3. Free fatty acid content and composition in 'fluff' layers sampled by divers at the Odas Tonne station

Date of sampling	Total FFA content [$\mu g\,g^{-1}$ d.w.]	Composition* [%]						
		10:0	12:0	14:0	14:1	ai 15:0	16:0	16:1
October 1996	991.0	1.2	6.9	14.1	7.1	–*	23.6	4.8
March 1997	83.0	2.0	5.2	28.9	–*	–*	32.6	0.7
June 1997	102.0	0.8	1.9	22.9	0.7	0.2	49.3	1.2
August 1997	302.0	3.1	3.4	10.4	1.1	4.2	27.9	2.8
October 1997	153.0	6.2	2.2	14.0	9.2	4.1	31.0	6.1
		ai 17:0	18:0	18:1	18:2	18:3	20:0	20:1
October 1996		–*	18.5	5.6	10.4	2.9	2.9	0.9
March 1997		–*	30.6	–*	–*	–*	–*	–*
June 1997		0.1	18.8	0.5	1.3	1.4	1.4	0.9
August 1997		2.6	9.4	15.5	3.4	3.5	0.2	0.2
October 1997		1.7	12.3	7.1	–*	4.8	–*	–*
		20:2	20:4	20:5	22:1	22:6		
October 1996		–*	1.0	1.2	–*	0.8		
March 1997		–*	–*	–*	–*	–*		
June 1997		–*	–*	0.2	–*	–*		
August 1997		1.9	5.4	1.5	2.9	1.5		
October 1997		–*	–*	1.1	–*	0.1		

* the first numerals denote the number of carbon atoms in the aliphatic chain, the second denote the number of double bonds;
ai – anteiso; i – iso. These abbreviations indicate the position of the methyl group (branch) in branched aliphatic acids, like those characteristic of bacteria.

Table 4. Free fatty acid content and composition in sediment, 'fluff' layers and sediment traps. Odas Tonne, August 1997

Sample	Date of sampling	Total FFA content	Composition* [%]									
		[μg g^{-1} d.w.]	10:0	12:0	14:0	14:1	ai 15:0	16:0	16:1	ai 17:0	18:0	18:1
surface sediment	August 1997	289.0	4.1	6.5	9.4	1.0	2.9	30.9	2.8	3.9	11.9	10.5
fluffy layer	August 1997	302.0	3.1	3.4	10.4	1.1	4.2	27.9	2.8	2.6	9.4	15.5
sediment traps												
ST – 35 cm	June–August 1997	380.0	1.8	4.6	6.8	0.7	4.7	39.0	1.9	2.4	14.1	6.5
ST – 75 cm	June–August 1997	113.0	4.3	10.9	10.1	–*	4.5	29.8	1.0	3.6	15.2	12.3
ST – 100 cm	June–August 1997	89.0	4.1	7.4	6.9	–*	1.5	33.8	1.2	2.5	20.2	12.2
ST – 140 cm	June–August 1997	41.0	0.2	9.1	15.6	0.2	2.9	31.0	11.2	0.6	14.8	8.3
ST – 175 cm	June–August 1997	79.0	2.3	9.9	9.9	1.1	2.9	34.4	3.3	1.2	16.0	8.1
			18:2	18:3	20:0	20:1	20:2	20:4	20:5	22:1	22:6	
surface sediment			4.0	4.0	1.8	0.1	1.9	2.1	0.5	0.8	0.9	
fluffy layer			3.4	3.5	0.2	0.2	1.9	5.4	1.5	2.9	1.5	
sediment traps												
ST – 35 cm			3.2	2.4	1.0	2.1	4.6	1.2	0.8	1.2	0.9	
ST – 75 cm			2.9	3.5	–*	–*	1.9	–*	–*	–*	0.1	
ST – 100 cm			8.2	2.1	–*	–*	–*	–*	–*	–*	0.2	
ST – 140 cm			3.6	2.8	–*	–*	–*	–*	–*	–*	0.4	
ST – 175 cm			2.6	2.7	1.1	0.4	2.1	0.6	0.7		0.7	

* the first numerals denote the number of carbon atoms in the aliphatic chain, the second denote the number of double bonds; ai – anteiso; i – iso. These abbreviations indicate the position of the methyl group (branch) in branched aliphatic acids, like those characteristic of bacteria.

as compared to March, June or October 1997. The fluff layer sampled in August contained 22.5% of monounsaturated FAs, 16.3% of polyunsaturated FAs, and a high proportion of branched acids of bacterial origin (C 15:0 and C 17:0) considerably in excess of the March and June values (Fig. 6 and Table 3). Branched FAs were also measured in the October fluff layer (5.8%) whereas monounsaturated FAs were also measured in the lowest trap and surface sediment (Table 4). The FA contents of the surface sediment, fluff layer and lowest trap (0.35 m.a.b.) were similar (range 289 μg g^{-1} d.w. to 380 μg g^{-1} d.w.), and decreased to 79 μg g^{-1} d.w. in the top trap (Fig. 7). FAs characteristic of higher land plants (C 22:1) were measured in the lowest trap, fluff and sediment. The most stable (saturated) FAs were the major fraction found at the different near-bottom levels (August) and their percentage values increased with height above the bottom, reaching about 80% in the top trap (Fig. 8). The opposite trend was found for unsaturated FAs, their content being highest in the lowest trap and decreasing towards the top trap. The FA compositions in the lowest trap and underlying sediment were similar. Different proportions of branched FAs ranging from 3.1 to to 7.1% were measured in the traps and also in the surface sediment.

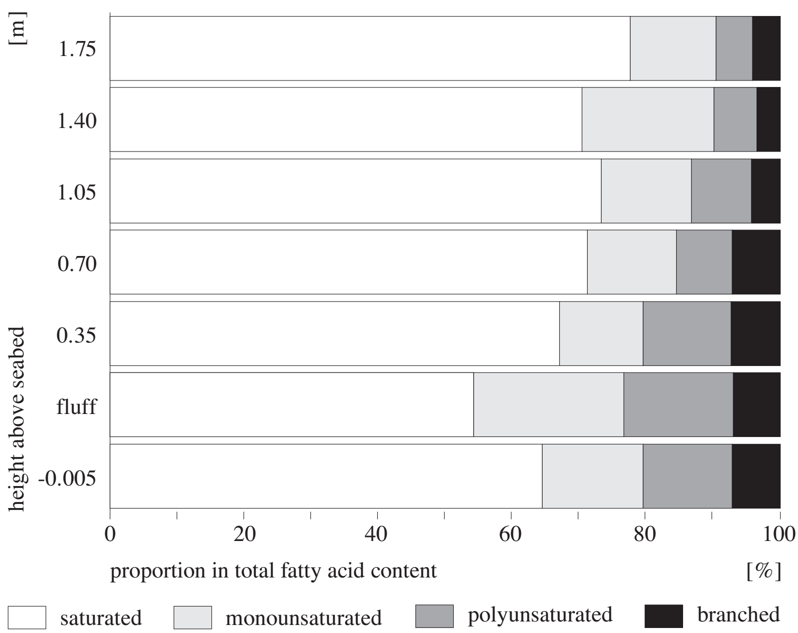

Fig. 8. Vertical distribution of different FA classes at different near-bottom levels and in the surface sediment. Odas Tonne, August 1997

The measurement of branched FAs is useful for assessing microbiological activity in water and sediments (Saliot *et al.* 1994). Data reported for surface sediments and sediment traps in different seas vary from 0.7% in Antarctic sediments to 26% in Black Sea sediments (Perry *et al.* 1979, Saliot *et al.*, 1994, Wakeham 1995). The presence of branched FAs up to 0.7% of the total content corresponds to values obtained for bacterial cultures. In August samples the contribution of branched FAs to the total content was 6.8%. This is a high value compared to earlier results at the Odas station (Fig. 6, Table 3). Similar proportions (5.8%) of branched FAs were found in the October samples, indicating that the bacterial biomass remained constantly high in the period from August to October.

Long-chain saturated and monounsaturated FAs are present in the cuticular waxes of higher plants, so their presence will give information both on the origin of the organic matter and on the transport pathways for terrigenic material in coastal environments (Reetsma *et al.* 1990). Long-chain monounsaturated FAs were exclusively present in August; hence, it was undoubtedly related to increasing river water masses entering the Pomeranian Bay during the Odra flood (Fig. 3). Owing to their higher reactivity, unsaturated FAs are more sensitive to decomposition processes than the saturated ones (Venkatesan *et al.* 1987, Reetsma *et al.* 1990). The degree of FA decomposition is directly related to the number of double chemical bonds and inversely related to their chain length. The decrease in the polyunsaturated FAs and the increase in the saturated FAs reflect an increase in the organic matter decomposition processes. A high content of unsaturated FAs is also an indicator of high biological productivity. On the other hand, an explanation for low levels of unsaturated acids in the top trap could be that these acids are more rapidly degraded than the saturated ones during the recycling and sinking of particles. The 'freshness' of labile organic matter in the lowest trap material is reflected in the high content of unsaturated FAs. Indeed, the lowest trap may well have been fed mainly by resuspended layers of surface sediment, as their FA percentage composition was similar.

In summary, these results highlight the following points:

- the decrease in bottom salinity and high variability in the light attenuation coefficient at the Odas Tonne station in the period 25 July–13 August was related primarily to the entry of the freshwater plume into the Pomeranian Bay and not by changes in wind direction and speed in this period;
- the sampling strategy for suspended matter was imposed by the practical aspects of the surveys (shipping time, weather conditions, etc) resulting in relatively long-term deployments of sediment traps

in the study area which, unfortunately, did not fully match the short duration of the Odra flood. In spite of these constraints, signs obtained from organic matter variability and composition (essentially carbon) at near-bottom levels, fluff and surficial sediment horizons were useful to assess the quality of particulate matter delivered to the Pomeranian Bay during the Odra flood;

- perhaps the most evident signs of near-bottom transport and material dilution during the flood event were the relative decrease in the June-August sediment fluxes as compared to later periods, a low FA flux compared to the total organic matter flux, a decrease in CNP ratios from June to December, and the drop in organic (especially carbon) content in surficial sediment horizons from June to August, which was followed by an increase in organic content in the overlying fluff layer (August). The variation in current speeds was comparatively low between the different deployments and the elevated sediment fluxes in the period between August and December might have been related to episodic resuspension events, as the frequency of strong winds increases during autumn and winter;
- based on the analysis of fatty acid composition in a spectrum of samples covering different seasons, there was evidence in the August 1997 samples of increased bacterial activities and of the unusual presence of fatty acids characteristic of land plants. Hence, these results are related to the Odra flood events in July 1997.

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