4. Sediment Trap Investigations in the Kara Sea

A. C. Gebhardt[1], N. Lahajnar[1], B. Gaye-Haake[1], I. Fetzer[2] & Hendrik Deubel[2]
[1]Institute for Biogeochemistry and Marine Chemistry, University of Hamburg
[2]Alfred Wegener Institut, Bremerhaven

Introduction

When studying the global biogeochemical cycle of elements such as carbon, silica, nitrogen and phosphorus, the transfer of particulate matter from the surface layer through the water column to the sediment-water interface as well as its incorporation into the sediment play a major role. Sediment traps provide a reliable means to sample sinking particulate matter and to calculate flux rates. Sediment trap investigations carried out in numerous regions of the world ocean have contributed to the better understanding of processes and factors controlling the formation, amount and composition of sinking particles (e.g. Honjo 1996; Ittekkot 1996). This information is essential for interpretation of the sedimentary record. Unfortunately, flux measurements from the high latitudes are scarce especially over longer periods because of logistical problems due to the ice coverage. The observed range of flux rates varies from only a few mg m^{-2} d^{-1} in permanently ice-covered regions (Hargrave et al. 1993) to values >300 mg m^{-2} d^{-1} under the influence of ice-rafted material near the ice edge (Hebbeln and Wefer 1991).

The sediment trap recovered during the "Akademik Boris Petrov" is the first longtime sinking particle record from the Kara Sea and therefore provides essential information about the processes and fluxes in this area. Two new systems were deployed in order to prolong this record; one at the previous position near the Yenisey estuary and the other in the open Kara Sea (Fig. 4.1).

Methods

Recovery of Sediment Trap YEN02

During the "Akademik Boris Petrov" Cruise 2000 into the Kara Sea a cylindrical sediment trap mooring was deployed in the Yenisey river mouth (see Fig. 4.1) in order to record an annual cycle of the vertical particle flux and its saisonality. For sediment trap parameters refer to (Unger et al. 2001).

The sediment trap mooring was easily retrieved at the BP00-24a site. While all bottles could be recovered, the sediment trap itself was in a desolate status: the funnel was lost, probably during the recovery procedure. Nevertheless, the trap had turned to bottle 24 which was not closed as it was recovered during the last sampling interval. Data from the sediment trap timer board could be read after changing the batteries which were exhausted at time of recovery. Fortunately, the batteries had not been exhausted until the last turning process, meaning the system had turned correctly throughout the investigated time span (Tab. 4.1).

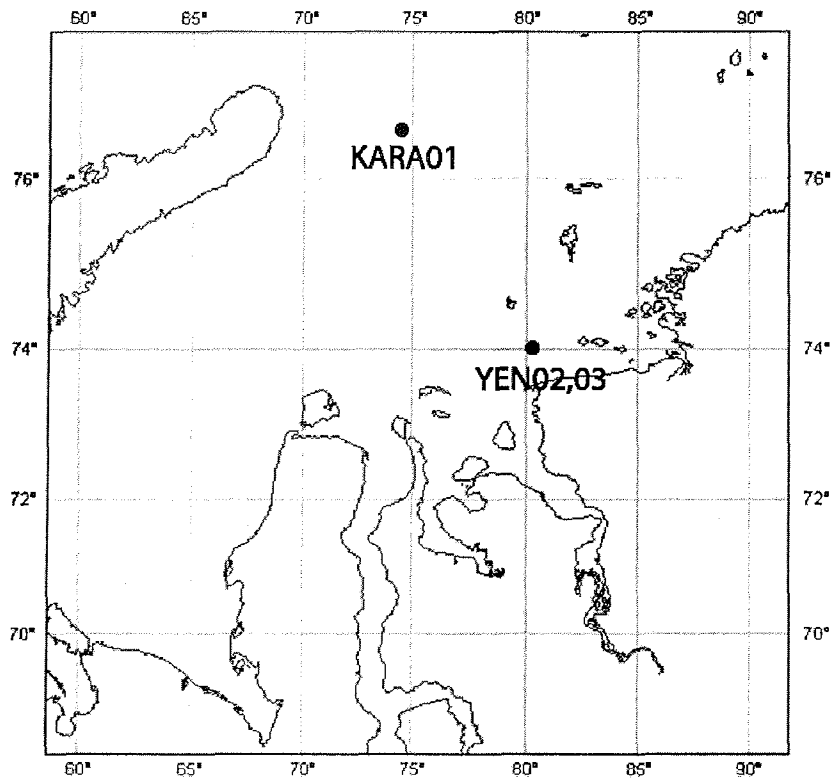

Fig. 4.1: Positions of sediment traps YEN02, YEN03 and KARA01

Deployment of Sediment Trap YEN03

In order to extend the particle flux measurements over a longer period and to get a better insight into the flux in the Yenisey river mouth, the sediment trap mooring was deployed for another year (YEN03). This time, the mooring was equipped with a current meter allowing to determine current direction and velocity as well as temperature of the water masses delivering the trap with particulate matter.

Sediment trap YEN02 which was recovered in desolate status was repaired onboard and equipped with a new funnel made primarily of a gravity core liner (diameter 120 mm) and a laboratory funnel. The new funnel system was covered by a mesh to avoid fish and other animals to swim actively into the funnel. Additionally, in order to stabilize the funnel, the trap was furnished with extra holding rods by the ship's mechanics.

To get a reasonable record resolution, the 24 sediment trap bottles were programmed to rotate weekly in arctic summer and river runoff maximum, respectively, whereas the sampling intervals were prolonged to 14 days in spring and autumn and to 28 days in

To get a reasonable record resolution, the 24 sediment trap bottles were programmed to rotate weekly in arctic summer and river runoff maximum, respectively, whereas the sampling intervals were prolonged to 14 days in spring and autumn and to 28 days in winter (Tab. 4.2). All bottles were filled with sea water (surface water from station BP01-01) poisoned with 3,3 g $HgCl_2$ and 35 g NaCl per liter to avoid bacterial activity.

The sediment trap mooring was deployed on August, 23, 10:06 UTC at station BP01-27 (74°00,07'N, 80'19,87'E), water depth 36 m. The trap was deployed on open hole; the first sampling intervall was started on August, 24, 00:00 UTC in order to avoid sampling particles whirled up by the deployment procedure. The sediment trap itself was stationed 25 m below sea surface and 11 m above sea bottom, respectively. For detailed deployment information refer to Table 4.3.

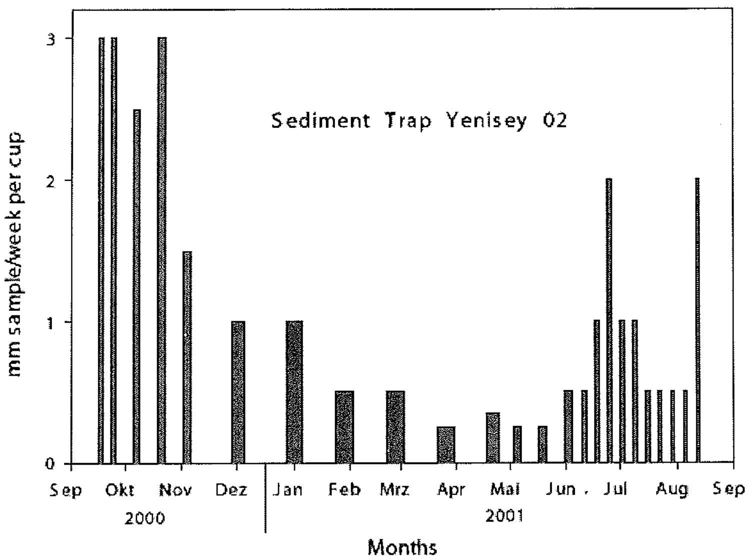

Fig. 4.2: Bulk collected material of YEN02 (in mm sample/week per bottle)

Deployment of Sediment Trap KARA01

During the "Akademik Boris Petrov" cruise in 2001 a second sediment trap mooring (KARA01) was deployed in the northwestern part of the investigated area (Fig. 4.1) in order to record the vertical particle flux in the distal part of the Ob and Yenisey estuaries as well as in the open Kara Sea. The position of the sediment trap was chosen primarily in order to get an open Kara Sea signal, i.e. at a site which is north enough not to be directly influenced by Ob and Yenisey. Nevertheless, the trap position could not be chosen farther north than 76°N because of often occurring pack and sea ice in that region.

be chosen farther north than 76°N because of often occurring pack and sea ice in that region.

Contrary to the YEN03 mooring, KARA01 consists of 12 bottles. The 12 bottle configuration was chosen as in this distal part a rather low vertical particle flux is expected. For better comparison the rotation scheme was synchronized to the YEN03 scheme by simply doubling the sampling intervals (Tab. 4.2). Likewise to YEN03, KARA01 was equipped with a current meter. This current meter not only records current direction, current velocity and temperature of the water masses delivering the trap with the particle flux in question, but also its turbidity. Likewise to YEN03, all bottles were filled with sea water (filtered surface water from station BP01-58) poisoned with 3,3 g $HgCl_2$ and 35 g NaCl per liter to avoid bacterial activity. The sediment trap mooring was deployed on September, 03, 12:53 UTC at station BP01-61a (76°31,16'N, 74°30,95'E), water depth 73 m. The trap was deployed on open hole; the first sampling intervall was started at September, 04, 00:00 UTC in order to avoid sampling particles whirled up by the deployment procedure. The sediment trap itself was stationed 53 m below sea surface and 20 m above sea bottom, respectively.
For detailed deployment information refer to Table 4.3.

Tab. 4.1: Rotation/recovery scheme for sediment trap YEN02

Bottle	Start of Interval	Moscow Time	Duration of Interval	Recovery Status
Bottle 1	09/16/2000	0:00	7 days	done
Bottle 2	09/23/2000	0:00	7 days	done
Bottle 3	09/30/2000	0:00	14 days	done
Bottle 4	10/14/2000	0:00	14 days	done
Bottle 5	10/28/2000	0:00	14 days	done
Bottle 6	11/11/2000	0:00	28 days	done
Bottle 7	12/09/2000	0:00	28 days	done
Bottle 8	01/06/2001	0:00	28 days	done
Bottle 9	02/03/2001	0:00	28 days	done
Bottle 10	03/03/2001	0:00	28 days	done
Bottle 11	03/31/2001	0:00	28 days	done
Bottle 12	04/28/2001	0:00	14 days	done
Bottle 13	05/12/2001	0:00	14 days	done
Bottle 14	05/26/2001	0:00	14 days	done
Bottle 15	06/09/2001	0:00	7 days	done
Bottle 16	06/16/2001	0:00	7 days	done
Bottle 17	06/23/2001	0:00	7 days	done
Bottle 18	06/30/2001	0:00	7 days	done
Bottle 19	07/07/2001	0:00	7 days	done
Bottle 20	07/14/2001	0:00	7 days	done
Bottle 21	07/21/2001	0:00	7 days	done
Bottle 22	07/28/2001	0:00	7 days	done
Bottle 23	08/04/2001	0:00	7 days	done
Bottle 24	08/11/2001	0:00	7 days	active

First Results

The amount of sinking particles (in mm sample per cup and week, Fig. 4.2) shows two distinct peaks, one in June/July and one in September/October. The first peak most likely reflects the maximum river discharge, whereas the second peak reflects the Arctic summer and therefore a period with enhanced primary productivity. Furthermore, during the Arctic winter months (December to Mai), almost no sample was collected. As the Ob and the Yenisey are throughly frozen during this time span and the Kara Sea is ice covered, this material most likely must be resuspended matter.

Tab. 4.2: Rotation scheme for sediment traps YEN03 and KARA01

Trap YEN03				**Trap KARA01**			
Bottle	Start of Interval	Moscow Time	Duration of Interval	Bottle	Start of Interval	Moscow Time	Duration of Interval
Bottle 1	08/24/2001	0:00	7 days				
Bottle 2	08/31/2001	0:00	7 days	Bottle 1	09/04/2001	0:00	17 days
Bottle 3	09/07/2001	0:00	14 days				
Bottle 4	09/21/2001	0:00	14 days	Bottle 2	09/21/2001	0:00	42 days
Bottle 5	10/05/2001	0:00	28 days				
Bottle 6	11/02/2001	0:00	28 days	Bottle 3	11/02/2001	0:00	56 days
Bottle 7	11/30/2001	0:00	28 days				
Bottle 8	12/28/2001	0:00	28 days	Bottle 4	12/28/2001	0:00	56 days
Bottle 9	01/25/2002	0:00	28 days				
Bottle 10	02/22/2002	0:00	28 days	Bottle 5	02/22/2002	0:00	56 days
Bottle 11	03/22/2002	0:00	28 days				
Bottle 12	04/19/2002	0:00	28 days	Bottle 6	04/19/2002	0:00	42 days
Bottle 13	05/17/2002	0:00	14 days				
Bottle 14	05/31/2002	0:00	7 days	Bottle 7	05/31/2002	0:00	14 days
Bottle 15	06/07/2002	0:00	7 days				
Bottle 16	06/14/2002	0:00	7 days	Bottle 8	06/14/2002	0:00	14 days
Bottle 17	06/21/2002	0:00	7 days				
Bottle 18	06/28/2002	0:00	14 days	Bottle 9	06/28/2002	0:00	28 days
Bottle 19	07/12/2002	0:00	14 days				
Bottle 20	07/26/2002	0:00	7 days	Bottle 10	07/26/2002	0:00	14 days
Bottle 21	08/02/2002	0:00	7 days				
Bottle 22	08/09/2002	0:00	7 days	Bottle 11	08/09/2002	0:00	14 days
Bottle 23	08/16/2002	0:00	7 days				
Bottle 24	08/23/2002	0:00	7 days	Bottle 12	08/23/2002	0:00	7 days

Most of the material in the bottles contained, besides detritus, many fecal pellets of animal origin (Tab. 4.4). There was a clear size grouping showing many small pellets probably from microplankton and small copepods (e.g. *Microcalanus* sp., *Drepanopus bungei*, *Pseudoclanus* spp.), medium sized pellets of bigger copepod species (*Calanus* spp.) and large ones mostly originating from Appendicularia (bottles 4-7, 13, 19-24). Many gelatinous housings of the Appendicularia *Larvacea* spp. (bottles 6, 7, 11, 19, 22, 23) and some comb jellies (*Ctenophoras* spp.) (bottles 6, 8, 12) were also transported into the cups. Active swimmers as copepods and pteropods *Limacina* spp. (bottle 14) were also trapped.

Several bottles contained quite large amounts of copepods. Single individuals of *Pareuchaeta glacialis* and *Calanus glacialis/hyperboreus* were caught. Interestingly some bottles contained many small copepods of the genus *Pseudocalanus* (bottles 1-5).

Probably the environmental conditions in this time of the year were such that they were transported to the vicinity of the trap in great numbers.

The presence of organic matter, copepods and fecal pellets correlates in time. During high occurrence of organic matter, which originates most likely from dying phytoplankton or riverine imported material, there is also a high concentration of copepods feeding on this material (bottles 24, 1-7). This may as well explain the abundant fecal pellets afterwards (bottles 4-7).

Ongoing work

The sediment trap samples will be split and the aliquots will be analyzed for opal, organic carbon and nitrogen, carbon and nitrogen isotopes, amino acids, biomarkers and pigments; plankton counts will be done.

Acknowledgements

We would like to express our thanks to the Captain and crew of R/V "Akademik Boris Petrov" for their excellent work during the recovery and deployment of the sediment traps. We would also like to thank all colleagues on board "Akademik Boris Petrov" for their assistance during the cruise.

	YEN03	KARA01
Date of Deployment:	08/23/2001	09/03/2001
Time of Deployment:	10:06 UTC	12:53 UTC
Position of Anchor Drop:	74°00,07'N, 80°19,87'E	76°31,16'N, 74°30,95'E
Water Depth:	36 m	73 m
Trap:	Hydro-Bios Multi Sediment Trap MST24 Funnel: Height 570mm, Diameter 120mm	Hydro-Bios Multi Sediment Trap MST12 Funnel: Height 760 mm, Diameter 138 mm
Acoustic Release:	Benthos Release Model 865-A Receive Frequency: 10 kHz Transmit Frequency: 12 kHz Enable Code: 1B Release Code: 1D	Benthos Release Model 865A Receive Frequency: 10 kHz Transmit Frequency: 12 kHz Enable Code: 1C Release Code: 1A
Current Meter:	**Aanderaa RCM9 Current Meter**	**Aanderaa RCM9 MkII Current Meter**
Topfloat:	none	Novatech (Canada) Frequency: 156,475 MHz or Channel 69 Transmission rate: continious (ON/OFF pressure dependent) Transmission distance: approx. 5-10 nm
Cup Water:	Surface Water from Station BP01-01 Addition of env. 3.3g HgCl2/lt and 35g NaCl/lt	Filtrated surface water from Station BP01-58 Addition of env. 3.3g HgCl2/lt and 35g NaCl/lt

Tab. 4.3: Deployment Protocol for YEN03/KARA01

Bottle	Interval	OM	CP	AM	FP	PC	AP	CT	MY	ME	CH	CU	PT	IA
1	09/06/2000-09/23/2000	xx	xx											
2	09/23/2000-09/30/2000	xx	xx											
3	09/30/2000-10/14/2000	xx	xx											
4	10/14/2000-10/28/2000	xx	xx	x	x									
5	10/28/2000-11/11/2000	x	xx	x	x									
6	11/11/2000-12/09/2000	x	x		xxx	x	x	x						
7	12/09/2000-01/06/2001	x		x	xxx		x		x					
8	01/06/2001-02/03/2001	x	x	xx				x		x	x	x		
9	02/03/2001-03/03/2001	x												x
10	03/03/2001-03/31/2001	x												x
11	03/31/2001-04/28/2001	x	x				x							
12	04/28/2001-05/12/2001		x					x						
13	05/12/2001-05/26/2001		xx	x	x				x		x			
14	05/26/2001-06/09/2001		x	x							xx		x	
15	06/09/2001-06/16/2001		xx								x			
16	06/16/2001-06/23/2001	x	xx											
17	06/23/2001-06/30/2001	x												
18	06/30/2001-07/07/2001		x											
19	07/07/2001-07/14/2001	x			x		x				x			
20	07/14/2001-07/21/2001		x		x									
21	07/21/2001-07/28/2001	x			x									
22	07/28/2001-08/04/2001		x		x		x							
23	07/04/2001-08/11/2001		x		x		x							
24	08/11/2001-08/23/2001	x			x									

Tab. 4.4: Sample composition for recovered sediment trap YEN02 (macrofauna). OM: organic matter; CP: copepods; AM: amphipods; FP: fecal pellets; PC: polychaets; AP: apendiculariens; CT: ctenophores; MY: mysidaceens; ME: medusae; CH: chaetognaths; CU: cumaceens; PT: pteropods; IA: ice algae; x: sparse; xx: abundant; xxx: very abundant.