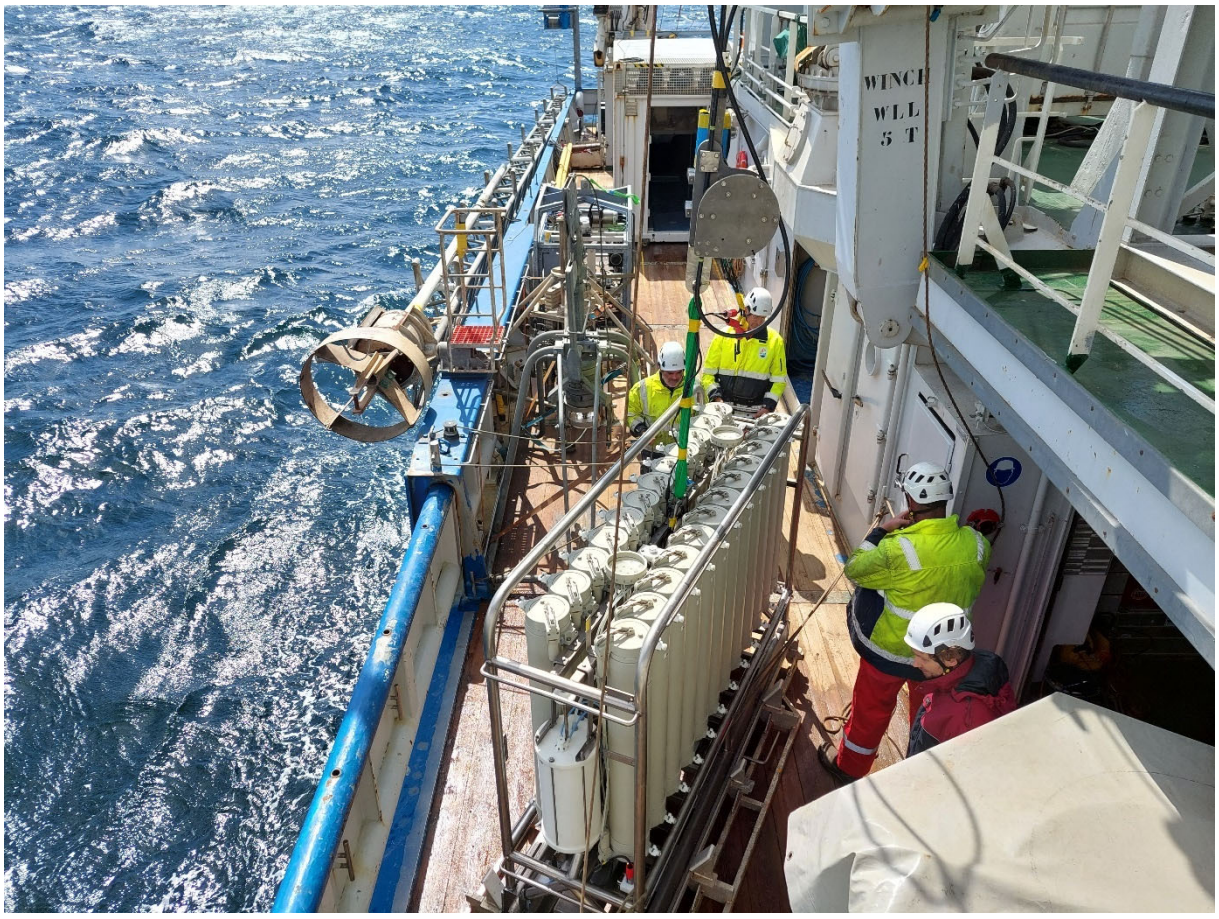
CRUISE REPORT RV Pelagia 64PE517
NoSE-North Sea Atlantic Exchange

26 May – 14 June 2023
Texel-Texel



With contributions of: Furu Mienis, Peter Kraal, Rick Hennekam, Rob Middag, Matthew Humphreys, Marina Adler, Anna Enge, Cecile Hilgen, Cuun Koek, Lucia Kranawetter, Daan Temmerman, Sharyn Ossebaar, Dave Huijsman, Marieke Bos

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Acknowledgements: The shipboard scientific party would like to thank the captain and crew of the *RV Pelagia* and the NIOZ technicians and NIOZ logistics and administrative departments (NIOZ-NMF) for their help with cruise preparations and at sea. The NoSE project is funded by NWO, grant agreement OCENW.XL21.XL21.075.

Contents

Introduction

Cruise 64PE517 was carried out in the framework of the NoSE (North Sea Atlantic Exchange) project funded by NWO (OCENW.XL21.XL21.075). In the NoSE project we aim to constrain the past, present and future exchange of carbon and other essential nutrients between the North Sea and the Atlantic Ocean. Continental shelf seas are dynamic regions with high biological primary production (15-30% of the global total), efficient carbon pumps, and intense water-sediment coupling. Therefore, even though shelf seas represent a small fraction of the ocean's surface area (<10%), they are disproportionally important in global nutrient and carbon cycles and play a crucial role in the coupled ocean climate system by virtue of their high CO_2 uptake capacity. The North Sea is a highly productive continental shelf sea and a globally significant CO_2 sink. However, the processes that govern the transport and eventual fate of carbon and associated major and trace nutrients (i) cycling and burial in North Sea sediments and (ii) their transport into the Atlantic Ocean are poorly constrained. This lack of understanding restricts our ability to predict the responses of North Sea biogeochemistry, biological

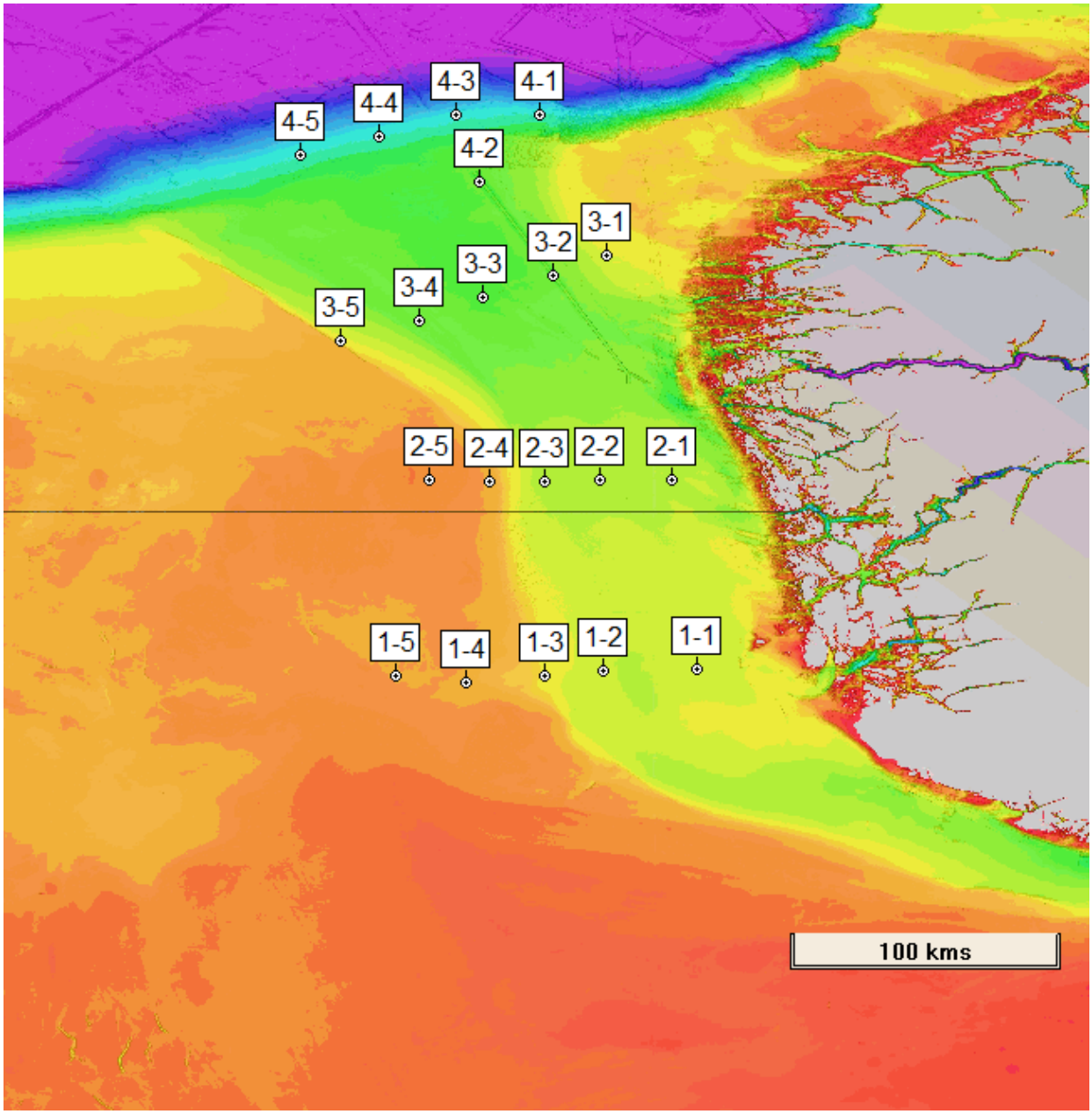

Figure 1. Map with sampling transects in the Norwegian Trench and along the Atlantic frontier. At each station water column data and samples, video data and seafloor samples were collected.

productivity and CO_2 uptake to ongoing environmental change and anthropogenic pressures (particularly important due to its proximity to densely populated coastal areas and intensive use), as well as the consequences of this response for the surrounding Atlantic Ocean. It is therefore essential to quantify the processes that export carbon from the North Sea more accurately, and their drivers and variability, because each export pathway is likely to respond differently to future environmental change. In NoSE we focus on the Norwegian Trench, recognizing it as the main export route of North Sea carbon and nutrients into the Atlantic Ocean and the most important area of sediment accumulation. Acting as the final filter for waters flowing out into the Atlantic Ocean and as a major depositional area, biogeochemical cycling and sediment deposition in the Norwegian Trench likely controls North Sea nutrient and organic matter budgets and export.

During the *RV Pelagia* 64PE517 expedition data and samples were collected along 3 cross transects in the Norwegian Trench and one at the Atlantic frontier (Figure 1) with the aim to characterize the biogeochemical cycling within, and water flow through, the Norwegian Trench and to determine how carbon and nutrient fluxes in North Sea waters are shaped by pelagic processes (WP1) and assess the impact of benthic processing on the transport and burial of carbon and nutrients in(to) the Norwegian Trench (WP2). In addition, long sediment cores have been taken at selected locations to assess biogeochemical variability over decadal to millennial timescales (WP3). At the end of the expedition moored observatories were deployed for long-term monitoring of water column characteristics and particle fluxes. An overview of all activities is presented in Table 1.

Table 1. Stationlist with action names and metadata of RV Pelagia cruise 65PE517.

Date/Time (GMT)	Lat	Lon	Name	Device name	Action	EA600|m	EM302|m	Alias
26/05/2023 10:04	53.0928	4.5252			START	25		
28/05/2023 06:04	59.1328	4.46	1	Ultra Clean CTD	BEGIN	258		1-1
28/05/2023 07:22	59.1328	4.4602	1	Ultra Clean CTD	BOT	258		1-1
28/05/2023 07:30	59.1332	4.46	1	Ultra Clean CTD	END	258		1-1
28/05/2023 07:55	59.1327	4.46	2	HD Video	BEGIN	259		1-1
28/05/2023 09:56	59.1323	4.4505	3	Boxcore d=300	BOT	260		1-1
28/05/2023 11:33	59.1325	4.4497	4	Boxcore d=300	BOT	259		1-1
28/05/2023 12:02	59.1327	4.4498	5	Boxcore d=300	BOT	261	253	1-1
28/05/2023 15:17	59.1178	3.8448	6	HD Video	BEGIN	271	272	1-2
28/05/2023 17:43	59.1173	3.8532	7	Multibeam	BEGIN	311	275	
28/05/2023 19:56	59.1022	3.4988	7	Multibeam	COCH	219	218	
28/05/2023 20:04	59.0953	3.5025	7	Multibeam	COCH	219	219	
28/05/2023 22:15	59.1103	3.8468	7	Multibeam	COCH	272	272	
28/05/2023 22:23	59.1053	3.8505	7	Multibeam	COCH	272	273	
29/05/2023 00:37	59.0875	3.5013	7	Multibeam	COCH	219	219	
29/05/2023 00:49	59.0983	3.5047	7	Multibeam	COCH	219	219	
29/05/2023 01:44	59.1023	3.6503	7	Multibeam	COCH	256	255	
29/05/2023 02:30	59.0977	3.8623	7	Multibeam	COCH	275	281	
29/05/2023 06:06	59.1177	3.8432	8	Ultra Clean CTD	BEGIN	272	272	1-2
29/05/2023 06:30	59.1175	3.8432	8	Ultra Clean CTD	BOT	271	272	1-2
29/05/2023 07:15	59.118	3.8408	8	Ultra Clean CTD	END	270	272	1-2
29/05/2023 07:33	59.1178	3.843	9	Boxcore d=300	BOT	272	273	1-2
29/05/2023 08:26	59.1178	3.8438	10	Boxcore d=300	BOT	272	280	1-2
29/05/2023 08:52	59.1182	3.8442	11	Multi Corer	BOT	273	273	1-2
29/05/2023 09:40	59.1173	3.844	12	Multi Corer	BOT	272	272	1-2
29/05/2023 11:29	59.0875	3.4913	13	HD Video	BEGIN	215	216	1-3

Date/Time (GMT)	Lat	Lon	Name	Device name	Action	EA600|m	EM302|m	Alias
29/05/2023 13:14	59.0872	3.468	14	Ultra Clean CTD	BEGIN	209	210	1-3
29/05/2023 13:26	59.0872	3.4682	14	Ultra Clean CTD	BOT	210	209	1-3
29/05/2023 13:57	59.0875	3.467	14	Ultra Clean CTD	END	209	209	1-3
29/05/2023 15:00	59.0873	3.4677	15	Boxcore d=300	BOT	209	209	1-3
29/05/2023 15:38	59.0873	3.4677	16	Multi Corer	BOT	209	209	1-3
29/05/2023 17:25	59.118	3.8362	17	Lander ALBEX	DEP	271	272	1-2
29/05/2023 19:21	59.1022	3.5027	18	Multibeam	BEGIN	219	219	
30/05/2023 00:26	59.1072	2.7033	18	Multibeam	COCH	125	125	
30/05/2023 00:32	59.101	2.7047	18	Multibeam	COCH	125	126	
30/05/2023 06:15	59.0875	3.492	19	Ultra Clean CTD	BEGIN	216	217	1-3
30/05/2023 06:24	59.0875	3.4913	19	Ultra Clean CTD	BOT	216	217	1-3
30/05/2023 07:05	59.0887	3.4907	19	Ultra Clean CTD	END	216	216	1-3
30/05/2023 09:12	59.0423	2.9505	20	HD Video	BEGIN	141	141	1-4
30/05/2023 10:05	59.0422	2.9322	20	HD Video	END	139	140	1-4
30/05/2023 11:13	59.0423	2.932	21	Boxcore d=300	BOT	139	140	1-4
30/05/2023 11:55	59.0422	2.9323	22	Multi Corer	BOT	139	140	1-4
30/05/2023 12:19	59.0422	2.9323	23	Multi Corer	BOT	139	140	1-4
30/05/2023 12:53	59.0422	2.9512	24	Ultra Clean CTD	BEGIN	140	141	1-4
30/05/2023 13:17	59.0423	2.9512	24	Ultra Clean CTD	BOT	140	142	1-4
30/05/2023 13:44	59.043	2.9495	24	Ultra Clean CTD	END	140	140	1-4
30/05/2023 15:39	59.0877	2.485	25	HD Video	BEGIN	126	126	1-5
30/05/2023 16:55	59.0872	2.4667	25	HD Video	END	125	126	1-5
30/05/2023 17:53	59.0987	2.7007	26	Multibeam	BEGIN	126	126	
30/05/2023 22:46	59.0912	3.5033	26	Multibeam	COCH		219	
30/05/2023 22:54	59.0857	3.5078	26	Multibeam	COCH		222	
31/05/2023 05:14	59.0877	2.4823	26	Multibeam	END	126	126	
31/05/2023 06:09	59.0873	2.4832	27	Ultra Clean CTD	BEGIN	126	126	1-5
31/05/2023 06:17	59.0875	2.4832	27	Ultra Clean CTD	BOT	126	126	1-5
31/05/2023 06:49	59.0875	2.482	27	Ultra Clean CTD	END	126	126	1-5
31/05/2023 07:11	59.087	2.4823	28	Boxcore d=300	BOT	126	127	1-5
31/05/2023 07:46	59.0872	2.483	29	Multi Corer	BOT	126	127	1-5
31/05/2023 07:57	59.0872	2.4827	30	Multi Corer	BOT	126	126	1-5
31/05/2023 12:47	59.1185	3.8368	31	Lander ALBEX	REC		271	1-2
31/05/2023 13:32	59.1177	3.8373	32	Pistoncorer d=110	BOT	271	271	1-2
31/05/2023 15:20	59.1177	3.8368	33	Boxcore d=300	BOT	272	271	1-2
31/05/2023 15:49	59.1177	3.8367	34	Boxcore d=300	BOT	272	271	1-2
01/06/2023 06:04	60.3672	2.7085	35	Ultra Clean CTD	BEGIN	105	231	2-5
01/06/2023 06:12	60.3677	2.7082	35	Ultra Clean CTD	BOT	105	231	2-5
01/06/2023 06:36	60.369	2.7088	35	Ultra Clean CTD	END	104	231	2-5
01/06/2023 06:59	60.3672	2.7447	36	HD Video	BEGIN	106	231	2-5
01/06/2023 08:27	60.3675	2.723	36	HD Video	END	104	231	2-5
01/06/2023 08:52	60.3675	2.7233	37	Boxcore d=300	BOT	104	231	2-5
01/06/2023 09:10	60.3672	2.724	38	Boxcore d=300	BOT	104	104	2-5
01/06/2023 09:31	60.3677	2.7238	39	Boxcore d=300	BOT	104	104	2-5
01/06/2023 11:15	60.3622	3.104	40	Ultra Clean CTD	BEGIN	127	128	2-4

Date/Time (GMT)	Lat	Lon	Name	Device name	Action	EA600|m	EM302|m	Alias
01/06/2023 11:25	60.3622	3.1037	40	Ultra Clean CTD	BOT	127	128	2-4
01/06/2023 11:52	60.3632	3.1033	40	Ultra Clean CTD	END	127	127	2-4
01/06/2023 12:41	60.3623	3.1402	41	HD Video	BEGIN	138	138	2-4
01/06/2023 13:49	60.3623	3.1223	41	HD Video	END	130	132	2-4
01/06/2023 14:15	60.3625	3.1218	42	Boxcore d=300	BOT	131	131	2-4
01/06/2023 14:33	60.3627	3.1227	43	Boxcore d=300	BOT	132	132	2-4
01/06/2023 14:50	60.3628	3.1227	44	Boxcore d=300	BOT	131	132	2-4
01/06/2023 15:23	60.3665	3.1198	45	Multibeam	BEGIN	132	131	
01/06/2023 17:45	60.3678	2.7082	45	Multibeam	COCH	105	105	
01/06/2023 20:16	60.363	3.1192	45	Multibeam	COCH	133	269	
01/06/2023 20:22	60.3587	3.12	45	Multibeam	COCH	132	267	
01/06/2023 22:36	60.3613	2.7085	45	Multibeam	COCH	104	104	
01/06/2023 22:44	60.3557	2.7083	45	Multibeam	COCH	104	104	
02/06/2023 01:03	60.3562	3.1202	45	Multibeam	COCH	130	131	
02/06/2023 01:09	60.3502	3.1287	45	Multibeam	COCH	133	133	
02/06/2023 02:12	60.3565	2.9383	45	Multibeam	END	108	108	
02/06/2023 06:05	60.366	3.4583	46	Ultra Clean CTD	BEGIN	302	302	2-3
02/06/2023 06:17	60.3657	3.4593	46	Ultra Clean CTD	BOT	302	302	2-3
02/06/2023 06:58	60.3657	3.4583	46	Ultra Clean CTD	END	301	302	2-3
02/06/2023 07:16	60.3657	3.4573	47	HD Video	BEGIN	302	302	2-3
02/06/2023 09:11	60.3657	3.4403	47	HD Video	END	301	301	2-3
02/06/2023 09:54	60.3657	3.4405	48	Boxcore d=300	BOT	301	301	2-3
02/06/2023 11:18	60.366	3.4402	49	Multi Corer	BOT	300	300	2-3
02/06/2023 12:56	60.3688	3.8315	50	Ultra Clean CTD	BEGIN	296	297	2-2
02/06/2023 13:07	60.369	3.8315	50	Ultra Clean CTD	BOT	296	296	2-2
02/06/2023 13:50	60.3693	3.8308	50	Ultra Clean CTD	END	296	296	2-2
02/06/2023 14:08	60.3688	3.8312	51	HD Video	BEGIN	297	297	2-2
02/06/2023 15:24	60.3665	3.814	51	HD Video	END	297	297	2-2
02/06/2023 15:47	60.3663	3.8143	52	Boxcore d=300	BOT	295	303	2-2
02/06/2023 16:47	60.3662	3.8145	53	Boxcore d=300	BOT	296	296	2-2
02/06/2023 17:12	60.3665	3.815	54	Boxcore d=300	BOT	297	296	2-2
02/06/2023 17:40	60.3672	3.8133	55	Multibeam	BEGIN	296	296	
02/06/2023 22:01	60.3613	2.991	55	Multibeam	COCH	115	115	
02/06/2023 22:08	60.3648	2.9948	55	Multibeam	COCH	115	115	
03/06/2023 02:40	60.3543	3.8362	55	Multibeam	COCH	297	296	
03/06/2023 02:40	60.354	3.8362	55	Multibeam	COCH	296	300	
03/06/2023 04:13	60.3475	3.5533	55	Multibeam	END	303	303	
03/06/2023 06:15	60.3668	3.8167	56	Multi Corer	BOT	297	298	2-2
03/06/2023 06:56	60.3668	3.8145	57	Multi Corer	BOT	297	298	2-2
03/06/2023 07:55	60.3673	3.8157	58	Pistoncorer d=110	BOT	297	298	2-2
03/06/2023 11:11	60.3777	4.3	59	Ultra Clean CTD	BEGIN	292	294	2-1
03/06/2023 11:23	60.3775	4.2997	59	Ultra Clean CTD	BOT	292	292	2-1
03/06/2023 12:04	60.3773	4.2988	59	Ultra Clean CTD	END	292	292	2-1
03/06/2023 12:24	60.3777	4.3	60	HD Video	BEGIN	292	299	2-1
03/06/2023 13:49	60.3778	4.2758	60	HD Video	END	290	290	2-1

Date/Time (GMT)	Lat	Lon	Name	Device name	Action	EA600|m	EM302|m	Alias
03/06/2023 14:12	60.3777	4.2758	61	Boxcore d=300	BOT	290	291	2-1
03/06/2023 14:43	60.3777	4.276	62	Multi Corer	BOT	290	291	2-1
04/06/2023 06:04	61.417	2.6325	63	Ultra Clean CTD	BEGIN	377	377	3-4
04/06/2023 06:19	61.417	2.6327	63	Ultra Clean CTD	BOT	377	378	3-4
04/06/2023 07:04	61.4183	2.6332	63	Ultra Clean CTD	END	377	379	3-4
04/06/2023 09:01	61.4615	2.6863	64	Glider	BEGIN	378	380	
04/06/2023 09:01	61.4615	2.6863	64	Glider	DEPL	378	382	
04/06/2023 11:20	61.4167	2.6668	65	HD Video	BEGIN	380	379	3-4
04/06/2023 12:45	61.4168	2.6463	65	HD Video	END	379	379	3-4
04/06/2023 13:09	61.4167	2.6467	66	Boxcore d=300	BOT	382	380	3-4
04/06/2023 13:47	61.4167	2.6467	67	Multi Corer	BOT	378	378	3-4
04/06/2023 16:33	61.2887	2.1175	68	HD Video	BEGIN	217	218	3-5
04/06/2023 18:27	61.2767	2.0912	68	HD Video	END	186	186	3-5
04/06/2023 18:43	61.2775	2.0945	69	Multibeam	BEGIN	190	190	
05/06/2023 00:43	61.5768	3.056	69	Multibeam	END	0	403	
05/06/2023 06:06	61.2887	2.1175	70	Ultra Clean CTD	BEGIN	218	218	3-5
05/06/2023 06:31	61.2887	2.1172	70	Ultra Clean CTD	BOT	217	218	3-5
05/06/2023 07:01	61.2897	2.117	70	Ultra Clean CTD	END	219	219	3-5
05/06/2023 07:19	61.2887	2.1178	71	Boxcore d=300	BOT	218	219	3-5
05/06/2023 07:49	61.2887	2.1175	72	Boxcore d=300	BOT	218	219	3-5
05/06/2023 08:08	61.2883	2.1173	73	Boxcore d=300	BOT	218	218	3-5
05/06/2023 11:52	61.5755	3.059	74	Ultra Clean CTD	BEGIN	0	402	3-3
05/06/2023 11:52	61.5755	3.059	74	Ultra Clean CTD	BEGIN	332	402	3-3
05/06/2023 11:53	61.5755	3.059	74	Ultra Clean CTD	END	0	402	3-3
05/06/2023 13:07	61.5773	3.0592	75	HD Video	BEGIN	0	407	3-3
05/06/2023 14:34	61.5688	3.047	75	HD Video	END	0	406	3-3
05/06/2023 14:58	61.5687	3.0465	76	Boxcore d=300	BOT	0	404	3-3
05/06/2023 15:35	61.5685	3.0468	77	Boxcore d=300	BOT	0	403	3-3
05/06/2023 16:02	61.5685	3.047	78	Boxcore d=300	BOT	403	403	3-3
05/06/2023 17:06	61.5687	3.0465	79	Multi Corer	BOT	404	403	3-3
05/06/2023 17:33	61.576	3.0593	80	Lander ALBEX	DEP	402	401	3-3
06/06/2023 06:03	62.3302	3.0332	81	Ultra Clean CTD	BEGIN	384	383	4-2
06/06/2023 06:16	62.3302	3.034	81	Ultra Clean CTD	BOT	383	384	4-2
06/06/2023 06:55	62.3305	3.0327	81	Ultra Clean CTD	END	383	384	4-2
06/06/2023 07:21	62.348	3.0365	82	HD Video	BEGIN	383	385	4-2
06/06/2023 08:44	62.335	3.0328	82	HD Video	END	383	383	4-2
06/06/2023 09:11	62.3348	3.0328	83	Boxcore d=300	BOT	384	384	4-2
06/06/2023 09:50	62.3352	3.0328	84	Multi Corer	BOT	385	385	4-2
06/06/2023 10:15	62.3355	3.0333	85	Multi Corer	BOT	385	384	4-2
06/06/2023 13:15	62.7467	2.877	86	Ultra Clean CTD	BEGIN	444	596	4-3
06/06/2023 13:33	62.7467	2.8762	86	Ultra Clean CTD	BOT	597	597	4-3
06/06/2023 14:20	62.7468	2.8733	86	Ultra Clean CTD	END	597	597	4-3
06/06/2023 14:43	62.7742	2.8767	87	HD Video	BEGIN	623	621	4-3
06/06/2023 17:11	62.7548	2.8767	87	HD Video	END	602	598	4-3
06/06/2023 17:45	62.7547	2.8713	88	Multibeam	BEGIN	604	600	

Date/Time (GMT)	Lat	Lon	Name	Device name	Action	EA600|m	EM302|m	Alias
06/06/2023 22:18	62.3308	3.0332	88	Multibeam	COCH	386	384	
06/06/2023 22:24	62.3325	3.0225	88	Multibeam	COCH	387	389	
07/06/2023 03:01	62.7538	2.8315	88	Multibeam	END	616	610	
07/06/2023 06:01	62.6307	2.3735	89	Ultra Clean CTD	BEGIN	588	584	4-4
07/06/2023 06:17	62.6308	2.3733	89	Ultra Clean CTD	BOT	588	585	4-4
07/06/2023 07:02	62.6307	2.3712	89	Ultra Clean CTD	END	585	585	4-4
07/06/2023 07:24	62.6312	2.3733	90	HD Video	BEGIN	584	584	4-4
07/06/2023 08:44	62.621	2.3817	90	HD Video	END	539	573	4-4
07/06/2023 09:16	62.6208	2.3822	91	Boxcore d=300	BOT	573	573	4-4
07/06/2023 10:00	62.621	2.3822	92	Multi Corer	BOT	574	574	4-4
07/06/2023 12:10	62.5118	1.8555	93	Ultra Clean CTD	BEGIN	583	583	4-5
07/06/2023 12:28	62.5117	1.8557	93	Ultra Clean CTD	BOT	583	582	4-5
07/06/2023 13:22	62.5118	1.855	93	Ultra Clean CTD	END	583	583	4-5
07/06/2023 13:47	62.491	1.8827	94	HD Video	BEGIN	554	554	4-5
07/06/2023 15:15	62.4818	1.8913	94	HD Video	END	544	543	4-5
07/06/2023 15:41	62.4812	1.892	95	Boxcore d=300	BOT	542	542	4-5
07/06/2023 17:03	62.482	1.8922	96	Multi Corer	BOT	542	542	4-5
07/06/2023 17:32	62.4833	1.8922	97	Multibeam	BEGIN	543	543	
07/06/2023 23:50	62.3312	3.0258	97	Multibeam	END	386	385	
08/06/2023 06:00	62.775	3.4273	98	Ultra Clean CTD	BEGIN	568	568	4-1
08/06/2023 06:17	62.7747	3.4268	98	Ultra Clean CTD	BOT	567	568	4-1
08/06/2023 07:05	62.7755	3.4252	98	Ultra Clean CTD	END	569	569	4-1
08/06/2023 07:42	62.725	3.3672	99	HD Video	BEGIN	501	501	4-1
08/06/2023 09:01	62.7163	3.3517	99	HD Video	END	495	493	4-1
08/06/2023 09:26	62.7167	3.3522	100	Boxcore d=300	BOT	494	494	4-1
08/06/2023 09:58	62.7165	3.352	101	Boxcore d=300	BOT	493	494	4-1
08/06/2023 13:50	62.3297	3.033	102	Mooring	DEP	384	384	4-2
08/06/2023 17:07	62.7563	2.8763	103	Boxcore d=300	BOT	602	602	4-3
08/06/2023 17:54	62.7562	2.8767	104	Multi Corer	BOT	601	601	4-3
08/06/2023 18:20	62.7562	2.8765	105	Ultra Clean CTD	BEGIN	601	601	UCC test
08/06/2023 18:51	62.7563	2.8778	105	Ultra Clean CTD	END	601	601	UCC test
09/06/2023 09:48	62.4495	6.0033	106	Crew change				
09/06/2023 17:49	61.8485	3.8687	107	HD Video	BEGIN	263	552	3-1
09/06/2023 19:02	61.8582	3.8683	107	HD Video	END	258	552	3-1
09/06/2023 19:55	61.8577	3.8642	108	Multibeam	BEGIN	262	262	
10/06/2023 01:34	61.5762	3.059	108	Multibeam	COCH	371	400	
10/06/2023 05:36	61.5935	3.0448	108	Multibeam	END	405	405	
10/06/2023 06:24	61.5767	3.0622	109	Lander ALBEX	REC		403	3-3
10/06/2023 08:29	61.5758	3.0598	110	Pistoncorer d=110	BOT	400	401	3-3
10/06/2023 09:55	61.5318	2.9152	111	Glider	RECOV	390	393	
10/06/2023 12:28	61.7133	3.5237	112	Ultra Clean CTD	BEGIN	368	370	3-2
10/06/2023 12:40	61.7132	3.524	112	Ultra Clean CTD	BOT	368	370	3-2
10/06/2023 13:22	61.7123	3.5255	112	Ultra Clean CTD	END	368	370	3-2
10/06/2023 13:44	61.7147	3.5238	113	HD Video	BEGIN	368	369	3-2
10/06/2023 14:56	61.7115	3.5227	113	HD Video	END	370	372	3-2

Date/Time (GMT)	Lat	Lon	Name	Device name	Action	EA600|m	EM302|m	Alias
10/06/2023 15:18	61.7115	3.522	114	Boxcore d=300	BOT	370	371	3-2
10/06/2023 15:49	61.712	3.5225	115	Multi Corer	BOT	369	372	3-2
10/06/2023 16:30	61.7158	3.5312	116	Multibeam	BEGIN	368	371	
10/06/2023 18:58	61.8515	3.8725	116	Multibeam	COCH	259	261	
10/06/2023 23:57	61.5965	3.168	116	Multibeam	COCH	393	393	
11/06/2023 05:17	61.843	3.9057	116	Multibeam	END	261	259	
11/06/2023 06:00	61.8487	3.8682	117	Ultra Clean CTD	BEGIN	263	263	3-1
11/06/2023 06:13	61.8488	3.8685	117	Ultra Clean CTD	BOT	264	264	3-1
11/06/2023 06:45	61.8485	3.8705	117	Ultra Clean CTD	END	260	261	3-1
11/06/2023 07:12	61.8585	3.869	118	Boxcore d=300	BOT	257	257	3-1
11/06/2023 07:33	61.8585	3.8698	119	Boxcore d=300	BOT	257	257	3-1
11/06/2023 07:54	61.8585	3.8698	120	Boxcore d=300	BOT	257	257	3-1
11/06/2023 08:14	61.8583	3.8698	121	Boxcore d=300	BOT	257	257	3-1
11/06/2023 09:04	61.8582	3.8692	122	Multi Corer	BOT	259	257	3-1
11/06/2023 09:24	61.8583	3.8695	123	Multi Corer	BOT	257	257	3-1
11/06/2023 09:54	61.8585	3.8685	124	Gravity Core	BOT	258	257	Failed
11/06/2023 12:54	61.7125	3.5237	125	Gravity Core	BOT	368	369	3-2
11/06/2023 14:38	61.7172	3.528	126	Ultra Clean CTD	BEGIN	367	369	UCC test
11/06/2023 14:50	61.7173	3.5285	126	Ultra Clean CTD	BOT	367	368	UCC test
11/06/2023 15:00	61.7175	3.529	126	Ultra Clean CTD	END	367	368	UCC test
11/06/2023 15:34	61.7353	3.5333	127	HD Video	BEGIN	365	366	3-2
11/06/2023 16:56	61.7227	3.5363	127	HD Video	END	365	366	3-2
12/06/2023 06:38	60.3777	4.2998	128	Mooring	DEP	293	293	
12/06/2023 06:49	60.3707	4.2995	129	Lander ALBEX	DEP	293	293	

Multibeam mapping

The Kongsberg EM 302 multibeam echosounder as presently installed on board the RV Pelagia is a 30 kHz echo sounder with a one degree opening angle for the transmitter and a 2° angle for the receiver. It uses 288 beams with 2-3 depth measurements per beam. The system is equipped with a dual swath, resulting in a maximum number of depth measurements of 864 per ping. The maximum swath opening angle is 150°. The transmit fan is split into at maximum 9 individual sectors that can be steered independently to compensate for ships roll, pitch and yaw to get a best fit of the ensonified line perpendicular to the ships track and thus a uniform coverage of the seabed. The transducers are mounted in a gondola which is placed at the port site of the vessel at about one quarter to one third of the ships length from the bow. The motion of the vessel is registered by a Kongsberg MRU-5 motion reference unit. Ships position and heading is determined with two GPS antennas. The motion and position information is combined in a Seapath 380 ships attitude processing unit and send to the Transmit and Receiver Unit (TRU). The system is synchronized by means of a 1 pulse per second (1PPS) signal produced by the Seapath 380 which is send to the TRU. The data from the receiver transducer and the ships attitude are sent through an ethernet connection to the acquisition computer (Kongsberg HWS 10). Data acquisition is done using the Kongsberg SIS (Seafloor Information System) software. The sound velocity profile is calculated from salinity, pressure and temperature data recorded by a Seabird CTD system. During the cruise the Reson SVP 70 sound velocity probe that is normally mounted on the gondola containing the transducers and measures the sound velocity near the transducers was not available. The near-transducer sound velocity was taken from the calculated velocity profile. The processing PC is connected to a display on the bridge of the Pelagia through a KVM switch and an ethernet connection allowing operation of the system from the bridge if desired.

Multibeam data were collected along the transects crossing the sampling sites. We collected a total of 33 lines of multibeam data (Table 1), to identify seafloor features as well as backscatter to determine differences in sedimentology. New sound velocity profiles were uploaded at each transect.

3.5 kHz echosounder (*Rick Hennekam*)

We also once used the 3.5 kHz echosounder available on *RV Pelagia*, which potentially can be used to observe layering in the sub-surface. To test the echosounder results, a recording was started during the evening of the 6th of June 2023. Although following the careful instructions by Henk de Haas and considering several settings for the TVG (Time Variable Gain), we did not find the right settings to observe the layering and/or the seafloor was not suitable for this device. Hence, we refrained from using this device the rest of the cruise.

Ultra Clean CTD

During this expedition, the UCC (Ultra Clean CTD) was used for water column sampling. This system was designed and built by the NIOZ in the Netherlands, comprising of a rectangular Titanium metal frame, holding 24 vertically mounted polypropylene sampling bottles. Each bottle holds 23 liters of water and is activated via a water based hydraulic system, closing butterfly valves at both the upper and lower ends of the sampling bottles. This system is deployed using a Kevlar (non-metallic) conductive cable and after deployment, the complete CTD sampling system was placed in a cleanroom environment inside a modified high cube shipping container where subsamples can be collected without contamination of trace metals (Middag et al., 2015; Rijkenberg et al., 2015).
Instrumentation attached to the frame consisted of Sea Bird SBE 9 plus underwater control unit, with Sea bird SBE 3 temperature sensor, SBE 4 conductivity sensor, SBE 43 dissolved oxygen sensor, using an SBE 5 underwater pump to continually circulate new water along the sensors. Further instrumentation comprised of a Chelsea Aqua 3 fluorescence sensor, Satlantic PAR-sensor, Valeport VA-500 altimeter, combined Wetlabs FLNTU fluorescence and turbidity sensor, a pH sensor, and an in house designed and built multivalve triggering system for the closing the sampling bottles and accumulator for storage of the hydraulic pressure required.

Water sampling (Marieke Bos, Cuun Koek, Rob Middag and Daan Temmerman)

At 20 stations water column samples were collected at up to 12 depths for concentrations of oxygen, macronutrients, DIC, pH, Alkalinity, $\delta^{13}C$, DOC, salinity, HPLC pigment analysis, FrrF (photosynthetic parameters), POC and PON, biogenic silica, SPM, dissolved metals (1 sample for analysis and 1 for archiving) and particulate metals.
At 20 stations water column samples were collected for dissolved metals (0.2 µm filtered) and particulate metals (Table 2). Samples were collected at all depths except the shallowest sampling depth of 5 m to avoid contamination of the ship.

Table 2. Stations and sampled depths for dissolved and particulate metals.

station	Bottle	Depth (intented, m)	station	Bottle	Depth (intented, m)	station	Bottle	Depth (intented, m)	station	Bottle	Depth (intented, m)
1	22	12	40	22	12	70	22	12	89	4	520
1	20	25	40	15	30	70	20	20	89	2	571
1	18	40	40	11	50	70	18	55	93	22	12
1	16	70	40	8	70	70	16	90	93	20	20
1	13	100	40	5	100	70	12	130	93	18	35
1	10	170	40	2	118	70	6	170	93	16	70
1	7	200	46	22	12	70	2	207	93	14	150
1	4	225	46	20	25	74	22	12	93	12	225
1	1	242	46	18	40	74	20	20	93	10	300
8	22	12	46	16	60	74	18	30	93	8	400
8	20	25	46	14	100	74	16	45	93	6	500
8	18	40	46	11	150	74	14	90	93	4	535
8	16	70	46	8	200	74	12	170	93	2	570
8	12	90	46	5	250	74	10	210	98	22	10
8	8	120	46	2	292	74	8	250	98	20	40
8	6	180	50	22	12	74	6	310	98	18	80
8	4	240	50	20	25	74	4	360	98	16	150
8	2	261	50	18	40	74	2	391	98	14	250
19	22	12	50	16	55	81	22	12	98	12	290
19	20	20	50	14	80	81	20	25	98	10	330
19	18	30	50	12	100	81	18	50	98	8	380
19	14	60	50	10	150	81	16	80	98	6	440
19	10	100	50	8	200	81	13	120	98	4	500
19	6	140	50	5	240	81	10	200	98	2	557
19	4	180	50	2	286	81	7	280	112	22	12
19	2	205	59	22	12	81	4	360	112	20	22
24	22	12	59	20	25	81	2	373	112	18	40
24	20	25	59	18	35	86	22	12	112	16	70
24	16	40	59	16	60	86	20	20	112	14	100
24	12	60	59	14	80	86	18	50	112	10	200
24	8	80	59	12	100	86	16	150	112	6	300
24	4	110	59	10	150	86	14	250	112	4	325
24	2	130	59	8	200	86	12	325	112	2	357
27	22	12	59	5	240	86	10	370	117	22	12
27	20	25	59	2	281	86	8	450	117	20	24
27	18	38	63	22	12	86	6	480	117	18	37
27	15	45	63	20	25	86	4	540	117	14	70
27	12	60	63	18	50	86	2	581	117	10	120
27	9	80	63	16	75	89	22	12	117	6	200
27	6	100	63	14	100	89	20	50	117	2	251
27	2	115	63	12	170	89	18	75			
35	22	12	63	10	170	89	14	100			
35	15	25	63	8	250	89	12	200			
35	9	40	63	6	300	89	10	300			
35	6	60	63	4	340	89	8	430			
35	2	95	63	2	366	89	6	460			

Dissolved metals (Rob Middag and Cuun Koek)

For dissolved metals, samples were filtered over a 0.2 µm PES Acropak filter under 0.5 bar inline filtered nitrogen pressure directly from the Pristine polypropylene samples into acid cleaned (following the GEOTRACES Protocol (Middag et al., 2023)) 125 ml LDPE bottles (Nalgene) for analysis and into 1 L LDPE bottles (Nalgene) for achieving. Samples were acidified to 0.024 M HCl shortly after filtration using ultra pure HCL (Normatom Ultrapure, VWR), resulting in a pH of ~1.8. Samples will be transported back to the shore-based laboratory for Multi-Element determination that will give the concentrations of Cd, Co, Cu, Fe, Mn, Ni, Zn, Ti, Y, La, Pb, and Ga (Middag et al., 2023). This analysis will be done using a SeaFAST system and a High-Resolution Sector Field Inductively Coupled Plasma Mass Spectrometer (HR-ICP-MS) (Gerringa et al., 2020). The seaFAST pico system is an ultra-clean, in-line, automated, low-pressure ion chromatography system that utilises a three-step process in order to pre-concentrate an acidified seawater sample. The seaFAST system takes up a 20 mL volume of acidified seawater (0.024 M HCl) into a sample loop using a vacuum and subsequently transports the sample over a chelating resin (Nobias PA1) using a syringe pump. Directly before the sample is passed over the resin, it is mixed with an ammonium acetate buffer (~pH 6.2), to raise the pH of the acidified seawater sample to 5.8. At this pH, the trace metals of interest in the sample complex with the resin and are quantitatively removed from the seawater and its matrix. The second step in the pre-concentration process is the resin wash with 'ultra pure' milliQ water. This second rinse aims to remove any loosely bound major constituent ions from the resin, such as Na^+, Cl^-, and Ca^{2+}, and to flush the small amount of seawater present after pre-concentration out of the column. The third and final step in the pre-concentration process of a sample is the elution of the trace metals from the resin. This step is achieved by passing 0.5 mL of eluent acid (~1.7 M HNO_3), using a syringe pump, over the resin to elute the trace metals from the resin, resulting in a pre-concentration factor of 40. The eluate is transferred into a destination vial using N_2 gas as a carrier gas. Subsequently samples will be analysed on the Element 2 HR-ICP-MS at NIOZ.

Particulate metals (Rob Middag, Cuun Koek)

For particulate metals sampling, up to 8 liters (i.e., up to 8 liters for deep waters and less for surface waters, see Table 3) of unfiltered seawater was collected from a maximum of 12 depths on all 20 stations. These unfiltered samples were collected in 10L, acid cleaned, carboys (VWR Collection) and stored close to the ambient seawater temperature until the moment of filtration. Before the expedition, 25 mm poly-ether-sulfone (PES) disc filters (0.45 µm PAll Supor) and polypropylene filter holders (Advantec) were cleaned by heating them at 60°C for 24h in 3x sub-boiled distilled 1.2M HCl (VWR Chemicals – AnalaR NORMAPUR) and rinsing them 5 times with MQ water (18.2 MΩ) (Ohnemus et al., 2014). Filters were stored in MQ water (18.2 MΩ) until use. Filtrations should be started within a maximum of two hours after sampling (Cutter et al., 2017), and on this expedition were stared within 30 minutes. Before the start of the filtrations, samples were gently homogenized (i.e., by shaking the carboys) and the PES filters were placed on the filter holders. Filter holders were placed on the caps (Nalgene) of the carboys using polypropylene luer-locks (Cole-Palmer). Carboys were then hung upside down onto the CTD frame using a custom-made polypropylene carboy frame. Filtration was done under nitrogen gas pressure (0.3 bar overpressure). Samples were filtered for a maximum of 2 hours and checked regularly for leaks. For each filter, filtered water was collected into a waste container for subsequent quantification of the amount of seawater that passed the filter. After filtration excess seawater on top of the filters was removed by gentle air pressure. In the clean laboratory, the filters were removed from the filter holders and were placed in a clean Eppendorf tube and stored frozen (-20°C) until analysis. Particulate metals analysis will be subjected to acid digestion at NIOZ and elemental composition will be quantified using the Element 2 HR-ICP-MS following van Manen et al. (2022).

Table 3. Filtered volumes for particulate metals for the different stations and Pristine samplers.

Station	1	8	19	24	27	35	40	46	50	59
Date	28/05/23	29/05/23	30/05/23	30/05/23	31/05/23	01/06/23	01/06/23	02/06/23	02/06/23	03/06/23
Bottle	Volume	Volume	Volume	Volume	Volume	Volume	Volume	Volume	Volume	Volume
1										5560
2	4600	4660	5100	3180	2480	3500	4140	5040	5100	4940
3										
4	4950	4820	4400	4100						4880
5							4840	6100	4840	5760
6		5690	6400		2050	3700				
7	6350									
8		5670		3640			4320	5280	6620	6460
9					3200	3480				
10	5650		6480						5560	5880
11							3740	5860		
12		1570		3620	2490				3760	5740
13	5620									
14			4900					4140	4460	4740
15					1640	3680	2540			
16	1540	5680		3340				3700	2730	4920
17										
18	3450	4120	3150		820			2000	3530	4160
19										
20		3160	2200	2800	2340			2360	3560	3360
21	5310									
22		3170	1970		860	3430	1500	2780	4130	2900
23	2600			1240						
24										
Station	63	70	74	81	86	89	93	98	112	117
Date	04/06/23	05/06/23	05/06/23	06/06/23	06/06/23	07/06/23	07/06/23	08/06/23	10/06/23	11/06/23
Bottle	Volume	Volume	Volume	Volume	Volume	Volume	Volume	Volume	Volume	Volume
1										
2	5540	4080	5800	5800	5000	4580	5460	2800	5560	5240
3										
4	5660		6450	5940	5220	4080	5260	5240	5540	6720
5										6600
6	6520	3660	5540		5640	4260	4520	4740	6400	5780
7				5240						
8	6820		4740		5420	5200	5940	4680	6150	5960
9									5460	5760
10	5180		5460	6540	5240	5000	6360	5080	6000	5340
11	4480								4980	
12	5960	3720	4980		5780	5180	5360	5560		
13				5340						
14	5920		5040		4580	5000	3120	5560	5280	4900
15										
16	5780	3200	3120	5280	4900	3760	3560	5480	5180	
17						4660				
18	4740	2520	2980	3760	3000	3580	2680	4960	3700	3240
19										
20	4920	1480	3650	3420	3140	2960	1900	4700	1880	2460
21										
22	2560	1520	1560	2060	1160	1740	1840	1180	1520	2780

Phytoplankton pigments (Marieke Bos, Rob Middag, Willem van de Poll, Cuun Koek)

Water was sampled from the UCC (ultra clean CTD) at multiple stations for phytoplankton biology and physiology. The goal was to link biology and physiology to water column physics and geochemical conditions.

3-4 L of seawater were filtered on 47 mm GF/F filters under mild vacuum (<0.2 mBar), samples were snap frozen in liquid nitrogen and stored at -80°C. Pigments can resolve phytoplankton composition roughly to the taxonomic level. Furthermore, their abundance is a useful estimate for algal biomass (e.g., chlorophyll a). Pigment samples were collected at 1, 2 or 3 depths between 10 and 50 m at all UCC stations (Table 4). Analysis will be by high performance liquid chromatography (HPLC).

Fast Repetition Rate Fluorometry (Marieke Bos, Rob Middag, Willem van de Poll, Cuun Koek)

Fast repetition rate fluorometry (FRRf) samples were collected from 1, 2 or 3 depths between 10 and 50 m at all UCC stations. FRRf measures photosynthetic characteristics related to the efficiency of electron transport by photosystem 2. The characteristics were measured after 10-30 min dark incubation and during a series of irradiance exposures (photosynthesis vs irradiance curves; 8 levels of 40 sec, each up to 1000 µmol photons m^{-2} s^{-1}. Some samples were diluted (Table 4) to obtain accurate measurements (5 mL filtered seawater, 2 mL sample). Changes in PSII characteristics are indicative for nutrient limitation (particularly iron limitation) and taxonomic composition.

Incubation experiments under manipulated conditions (Bio assays)

Water from 10-12 m depth, collected from the UCC (4 L) at 13 stations was spiked under trace metal clean conditions with Fe (0.5 nM final concentration), ammonium (2 µM final concentration and/or nitrate (10 µM final concentration) and after station 35 phosphate (0.625 µM), and incubated under constant irradiance (20 µmol photons m^{-2} s^{-1}) for 72 h or 66 h in a temperature controlled room adjusted to ambient water temperature (Table 5). Triplicates of 200 mL were used for all conditions. The goal was to identify responses in photosynthetic characteristics and changes in biomass to the iron and nutrient additions. After incubation the experiment was sampled for FRRf (photosynthetic characteristics) and for pigments (filtration on 25 mm GF/F).

*Table 4. Bio-assay conditions with dilution volume for FRRf analysis *All conditions consist of 3 replicas, except T0.*

Station	Condition *	Sample volume (mL)	Sea water dilution (mL)
1	T0	3,5	0
1	C	3,5	0
1	Fe	3,5	0
1	NO_3	3,5	0
1	NO_3+Fe	3,5	0
19	T0	3,5	0
19	C	3,5	0
19	Fe	3,5	0
19	NO_3	3,5	0
19	NO_3+Fe	3,5	0
27	T0	3,5	0
27	C	3,5	0
27	Fe	3,5	0
27	NO_3	3,5	0
27	NO_3+Fe	3,5	0
35	T0	3,5	0
35	C	3,5	0
35	Fe	3,5	0
35	NO_3	3,5	0
35	NO_3+Fe	3,5	0
40	T0	3,5	0
40	C	2	5
40	Fe	2	5
40	PO_4+NO_3	2	5
40	PO_4+NO_3+Fe	2	5
46	T0	3,5	0
46	C	3,5	0
46	Fe	3,5	0
46	PO_4+NO_3	2	5
46	PO_4+NO_3+Fe	2	5
59	T0	3,5	0
59	C	3,5	0
59	Fe	3,5	0
59	PO_4+NO_3	2	5
59	PO_4+NO_3+Fe	2	5
70	T0	3,5	0
70	C	2	5
70	Fe	2	5
70	PO_4+NO_3	2	5
70	PO_4+NO_3+Fe	2	5
74	T0	3,5	0
74	C	3,5	0
74	Fe	3,5	0
74	PO_4+NO_3	3,5	0
74	PO_4+NO_3+Fe	Replica 1: 3,5 Replica 2&3: 2	Replica 1: 0 Replica 2&3: 5
86	T0	2	5
86	C	2	5
86	Fe	Replica 1&3: 3,5 Replica 2: 2	Replica 1&3: 0 Replica 2: 5
86	PO_4+NO_3	2	5
86	PO_4+NO_3+Fe	2	5

Station	Condition *	Sample volume (mL)	Sea water dilution (mL)
93	T0	3,5	0
93	C	3,5	0
93	Fe	2	5
93	PO_4+NO_3	2	5
93	PO_4+NO_3+Fe	2	5
98	T0	3,5	0
98	C	2	5
98	Fe	2	5
98	PO_4+NO_3	Replica 1&3: 3,5 Replica 2: 2	Replica 1&3: 0 Replica 2: 5
98	PO_4+NO_3+Fe	2	5
112	T0	3,5	0
112	C	3,5	0
112	Fe	3,5	0
112	PO_4+NO_3	2	5
112	PO_4+NO_3+Fe	2	5

*Table 5. Overview stations and bio-assay stations *HPLC depth includes the upper water layer (around 12 m) and chlorophyll maximum, determined by the UCC-CTD.*

Date	Station	Latitude	Longitude	BA depth	HPLC depth
May 28 2023	1	59 07.97 N	004 27.65 E	12 m	12 m 25 m
May 29 2023	8	59 07.05 N	003 50.59 E	-	12 m 25 m
May 30 2023	19	59 05.25 N	003 29.49 E	12 m	12 m 20 m
May 30 2023	24	59 02.54 N	002 57.06 E	-	12 m 25 m
May 31 2023	27	59 05.25 N	002 28.99 E	12 m	12 m 45 m
Jun 01 2023	35	60 22.05 N	002 42.49 E	12 m	12 m 25 m
Jun 01 2023	40	60 21.73 N	003 06.24 E	12 m	12 m 30 m
Jun 02 2023	46	60 21.94 N	003 27.54 E	12 m	12 m 25 m
Jun 02 2023	50	60 22.14 N	003 49.89 E	-	12 m 25 m
Jun 03 2023	59	60 22.66 N	004 17.99 E	12 m	12 m 25 m
Jun 04 2023	63	61 25.03 N	002 37.95 E	-	12 m 25 m
Jun 05 2023	70	61 17.33 N	002 07.04 E	12 m	12 m 20 m 55 m
Jun 05 2023	74	61 34.56 N	003 03.57 E	12 m	12 m 30 m 45 m
Jun 06 2023	81	62 19.82 N	003 02.02 E	-	12 m 25 m
Jun 06 2023	86	62 44.81 N	002 52.61 E	12 m	12 m 20 m
Jun 07 2023	89	62 37.84 N	002 22.41 E	12 m	12 m

Jun 07 2023	93	62 30.70 N	001 51.33 E	12 m	12 m 20 m 35 m
Jun 08 2023	98	62 46.50 N	003 25.63 E	10 m	10 m
Jun 10 2023	112	61 42.79 N	003 31.42 E	12 m	12 m 22 m
Jun 11 2023	117	61 50.93 N	003 52.09 E	-	12 m 24 m 37 m

Seawater chemistry (Marina Ádler and Matthew P. Humphreys)

Introduction

Seawater chemistry analysis during expedition 64PE517 (NoSE) included analysis of the marine carbonate system, specifically total alkalinity and pH, and oxygen at sea, as well as sample collection for $\delta^{13}C_{DIC}$ for later analysis (Table 7). Samples were also collected separately for later dissolved inorganic carbon analysis as described elsewhere in this report. All analyses at sea were conducted in NIOZ laboratory container 53, positioned in the ship's hold.

Seawater sampling and measurements from the ultra-clean CTD system

Total alkalinity

Motivation: Total alkalinity (TA) (Dickson, 1981) controls the capacity of seawater to store CO_2 in equilibrium with the atmosphere as well as its ability to chemically buffer against pH changes (Frankignoulle, 1994; Humphreys et al., 2018). Together with a second parameter, it can be used to solve the marine carbonate system and thus calculate all other parameters (Lewis and Wallace, 1998; Humphreys et al., 2022).

Sample collection: Samples for TA were collected from the ultra-clean water sampling bottles following the best-practice protocol for DIC described by Dickson et al. (2007a). Specifically, 250 ml borosilicate glass bottles were rinsed with excess sample before being filled and allowed to overflow, taking care not to trap any air bubbles within the bottle. The bottles were then shut completely full of seawater with ground glass stoppers and stored in the dark until analysis, which was always on the same day as sample collection.

Analysis

TA was measured using two VINDTA 3C instruments (Marianda, Kiel, Germany) from NIOZ Texel, #14 (R2-CO2) and #17 (Furious George). Before analysis, samples were warmed to 25 °C in a water bath. A c. 100 ml subsample was then drawn from each bottle by the VINDTA for analysis. The subsample was titrated potentiometrically with titrant (c. 0.1 M HCl + 0.6 M NaCl) added in steps of 0.15 ml up to a total of 4.2 ml. One large batch (10 L) of titrant had been prepared before the expedition and subdivided into 1 L bottles for use during the analyses on both VINDTAs. The 1 L titrant bottles connected to the instruments needed to be topped up once during the expedition.

The titrant concentration was calibrated based on daily measurements of certified reference material (CRM) obtained from Prof A. G. Dickson (Scripps Institute of Oceanography). CRM from batches 189, 198 and 205 were measured during the expedition. A 25 L substandard of filtered seawater was also analysed regularly throughout the expedition as a check on consistency between analysis sessions. This was initially filled from the seawater tap at NIOZ Texel but was refilled half-way through the expedition with filtered seawater from station 35.

Total alkalinity will be determined from the titration data by a least-squares fitting procedure (Dickson, 1981) as implemented by the Python package Calkulate (Humphreys and Matthews, 2022). Finalised

TA data will become available after the expedition once nutrient and salinity analyses have been completed.

Dissolved oxygen

Sampling

Samples for measuring the dissolved oxygen in the water column were collected in c. 120 ml glass bottles from the UCC water sampling bottles with Tygon tubing in the ultraclean container. After the bottles were filled and let overflow three times the volume of the sampling bottle they were transferred on deck where the temperature was measured immediately. Then two reagents were added to each bottle: (a) 1 ml of manganese chloride ($MnCl_2$) and (b) 2 ml of sodium hydroxide and potassium iodide (NaOH/KI) mixture. After the addition of the reagents the samples were shaken for 15 seconds, then the lids secured with elastic bands. After 15 minutes a second shaking took place and the samples were stored until analysis at room temperature (c. 20.0 °C) water in the dark.

Reagents:

a. Reagent A: 600 g $MnCl_2$ x 4 H_2O in 1 L of Milli-Q (demineralized) water
b. Reagent B: 350 g KI + 250 g NaOH in 1 L Milli-Q water
c. Reagent C: 10 M H_2SO_4

Analysis

Six calibration solutions were prepared from filtered seawater (junk carboy in the lab container) with the addition of the three reagents (C, B and A) in reverse order. To each solution, different volumes of KIO_3 (70.07 mM) stock solution was added indicated in Table 6. Each analysis started with running Milli-Q (zero) and then the calibration solutions through the system.

Table 6. List of calibration solutions.

	$V_{pipette}$ (ml)	Bottle no.	V_{bottle} (ml)	c_{O2} (µM)
C0	0	262	116.323	0
C1	0.1	146	122.032	57.323
C2	0.25	159	122.346	142.770
C3	0.35	192 / 260	122.347 / 121.588	199.707 / 200.951
C4	0.45	237	122.475	256.290
C5	0.65	215	121.591	372.269

Three sets of standards were used during the expedition. Calibration bottle 192 (C3) broke after the first set of standards had been measured so the second and third sets used bottle 260 instead for C3.

The samples were analysed on board the day after collection, as follows. We added 1 ml of H_2SO_4 (10 M) to each bottle, covered them with light protection, and stirred them with a magnetic stirrer. After the precipitation dissolved we covered the lid with parafilm and immediately started the analysis. Sample was drawn from the bottles through a flow-through cell for spectrophotometric measurement by a peristaltic pump. The absorbances at 466 nm were measured by a Cary 60 UV-Vis spectrophotometer (Agilent Technologies).

Seawater pH

Samples were collected from the UCC water sampling bottles in the ultraclean container with Tygon tubing into 250 ml borosilicate glass bottles. The bottles were filled until overflowing with three times

the volume of the sampling bottle and sealed with ground glass stoppers. After sampling but always later on the same day, they were transferred into quartz cells, avoiding contact with the atmosphere. After filling the cells they were incubated at 25.0 °C for at least 2 hours in a warming box attached to a circulating water bath.

Each filled sample cell was placed in the spectrophotometer and a blank reading made. Then, 10 µl of purified meta-cresol purple (mCP) dye was added into the cell, which was then shaken for at least 45 seconds to ensure that the dye was uniformly mixed with the sample. The cell was then returned to the Cary 8454 UV-Vis spectrophotometer (Agilent Technologies) for measurement at 434, 578 and 730 nm. pH on the total scale was calculated following Dickson et al. (2007b).

At least one bottle of tris buffer solution was measured during each analysis session. This tris had been prepared at NIOZ Texel before the expedition following Paulsen and Dickson (2020).

We added a second10 µl mCP dose to a few samples after their initial measurement and then measured them again. This was in order to be able to correct the results for the pH change due to dye addition, following Dickson et al. (2007b).

Stable isotopes of DIC ($\delta^{13}C_{DIC}$)

Motivation: The stable isotope ratio of dissolved inorganic carbon in seawater ($\delta^{13}C_{DIC}$) is a tracer that can help to disentangle the drivers of variability in DIC and the wider the marine carbonate system, including air-sea CO_2 exchange, anthropogenic CO_2 accumulation and biological activity (Lynch-Stieglitz et al., 1995; Eide et al., 2017).

Sample collection: Samples for $\delta^{13}C_{DIC}$ were collected from the ultra-clean water sampling bottles following the best-practice protocol for DIC described by Dickson et al. (2007a) and previously used for $\delta^{13}C_{DIC}$ (Humphreys et al., 2015, 2016). Specifically, 100 ml borosilicate glass bottles were rinsed with excess sample before being filled and allowed to overflow, taking care not to trap any air bubbles within the bottle. The bottles were then shut completely full of seawater with ground glass stoppers. To sterilise the sample and thus prevent biological activity from changing the $\delta^{13}C_{DIC}$, the bottles were re-opened, a 1 ml air headspace introduced, and 20 µl of saturated mercuric chloride ($HgCl_2$) solution was then added, before greasing the stopper (Apiezon L) and sealing the bottle shut again. The lids were held in place with elastic bands or electrical tape.

Measurements: The samples will be analysed after the expedition at either NIOZ Texel or the University of Groningen.

Underway seawater supply

Surface pH

Sea surface pH contains the signal of multiple physical and biogeochemical processes (Takahashi et al., 2014). Also, pH is closely related to seawater pCO_2 which is needed to determine air-sea CO_2 fluxes (Wanninkhof, 2014).

The sensor system

Surface seawater pH on the total scale was measured with an optode system (Pico pH from Pyroscience). The optode sensor was submerged in a flow-through cell connected to the Aquaflow underway water system (photo right). A thermometer connected to the optode sensor was also submerged within the flow-through cell. The entire system was housed in a laboratory container on the aft deck (port side).

A new sensor cap was used (PHCAP-PK8T-SUB, sensor code FCD7-687-975, serial number 224558044). The sensor cap was calibrated around 1130 UTC on Friday 26th May using Pyroscience pH buffers (pH 2 – lot number 118267348 and pH 11 – lot number 020288653) and tris solution made in-house at NIOZ. The sensor was submersed in each calibration solution for 15–20 minutes before reading.

Measurements of pH were conducted throughout the expedition from the afternoon of 26th May until the morning of 14th May, every 30 seconds for pH and every 10 seconds for temperature.

Accuracy check

The accuracy of the sensor results will be checked after the expedition by comparison with the spectrophotometric pH measurements from the shallowest depth (5 m) at each CTD station.

Table 7. Samples collected for Oxygen, pH, DIC and total alkalinity.

Station	Bottle	Depth (m)	Oxygen	pH	Total alkalinity	$\delta^{13}C_{DIC}$
1	3	242	x	x	xx	x
1	6	225	xx	x	x	
1	9	200	x	xx	x	
1	12	170	x	x	x	xx
1	15	100	x	xx	x	
1	17	70	x	x	x	x
1	19	40	xx	x	x	
1	21	25	x	x	x	
1	23	12	x	x	x	x
1	24	5	x	x	xx	x
8	3	261	x	x	x	x
8	5	240	x	xx	x	
8	7	180	x	x	xx	
8	9	120	x	x	x	
8	13	90	x	xx	x	
8	17	70	x	x	xx	x
8	19	40	x	x	x	
8	21	25	x	x	x	
8	23	12	xx	x	x	x
8	24	5	xx	x	x	x
19	3	205	x	xx	x	x
19	5	180	x	x	xx	
19	9	140	x	x	xx	
19	13	100	xx	x	x	x
19	17	60	x	xx	x	
19	19	30	x	x	xx	
19	21	20	xx	x	x	x
19	23	12	xx	x	x	
19	24	5	x	xx	x	x

Station	Bottle	Depth (m)	Oxygen	pH	Total alkalinity	$\delta^{13}C_{DIC}$
24	3	130	x	xx	x	x
24	5	110	x	x	xx	
24	11	80	xx	x	x	
24	15	60	x	x	x	
24	19	40	x	x	xx	
24	21	25	x	xx	x	x
24	23	12	xx	x	x	
24	24	5	x	x	x	x
27	3	115	x	x	x	x
27	7	100	x	x	x	
27	10	80	x	x	x	
27	13	60	x	x	x	
27	16	45	x	x	x	xx
27	19	38	x	x	x	x
27	21	25	x	x	x	x
27	23	12	x	x	x	
27	24	5	x	x	x	x
31	1	0.397	x	x	x	
31	2	0.456	x	x	x	
31	3	0.238	x	x	x	
31	4	0.11	x	x	x	
31	5	0.425	x	x	x	
31	6	0.281	x	x	x	
35	3	95	x	xx	x	
35	7	60	x	x	xx	
35	10	40	xx	x	x	
35	16	25	x	x	x	
35	20	12				x
35	21	12				x
35	23	12	x	x	x	
35	24	5	x	x	x	
40	3	118	x	xx	x	x
40	6	100	xx	x	x	
40	9	70	x	x	xx	
40	12	50	x	x	x	
40	16	30	xx	x	x	
40	23	12	xx	xx	x	x
40	24	5	x	x	x	x
46	3	292	x	x	xx	x
46	6	250	x	xx	x	x
46	9	200	xx	x	x	
46	12	150	x	x	x	x

Station	Bottle	Depth (m)	Oxygen	pH	Total alkalinity	$\delta^{13}C_{DIC}$
46	15	100	x	x	x	
46	17	60	x	x	x	x
46	19	40	x	xx	x	
46	21	25	xx	x	x	x
46	23	12	x	x	xx	
46	24	5	x	x	x	x
50	3	286	x	x	x	x
50	6	240	xx	x	x	
50	9	200	x	x	x	
50	11	150	x	x	x	
50	13	100	x	xx	x	
50	15	80	x	x	x	
50	17	55	x	x	x	
50	19	40	x	x	xx	
50	21	25	x	x	x	x
50	23	12	x	x	x	
50	24	5	x	x	x	x
59	3	281	xx	x	x	x
59	6	240	x	xx	x	
59	9	200	x	x	xx	
59	11	150	x	x	x	
59	13	100	x	x	x	
59	14	80	x	x	x	
59	17	60	x	x	x	
59	19	35	x	x	x	xx
59	21	25	x	x	x	x
59	23	12	x	x	x	
59	24	5	x	x	x	x
63	3	366	x	x	x	x
63	5	340	x	x	x	
63	7	300	x	x	x	
63	9	250	x	x	x	
63	11	170	x	x	x	
63	13	170	x	x	x	x
63	15	100	x	x	x	
63	17	75	x	x	x	
63	19	50	x	x	x	
63	21	25	x	x	x	x
63	23	12	x	x	x	
63	24	5	x	x	x	x
70	3	207	xx	x	x	x
70	7	170	x	xx	x	

Station	Bottle	Depth (m)	Oxygen	pH	Total alkalinity	$\delta^{13}C_{DIC}$
70	13	130	x	x	xx	
70	17	90	x	xx	x	
70	19	55	xx	x	x	x
70	21	20	x	x	xx	
70	23	12	x	x	x	
70	24	5	x	x	x	x
74	3	391	x	x	x	x
74	5	360	x	x	x	
74	7	310	x	x	x	
74	9	250	x	x	x	
74	11	210	x	x	x	
74	13	170	x	x	x	
74	15	80	x	x	x	
74	17	45	x	x	x	
74	19	30	x	x	x	
74	21	20	x	x	x	
74	23	12	x	x	x	x
74	24	5	x	x	x	x
81	3	373	x	xx	x	x
81	5	360	x	x	xx	
81	8	280	x	xx	x	
81	11	200	x	x	xx	
81	13	120	x	x	x	
81	17	80	xx	x	x	
81	19	50	x	x	x	
81	21	25	x	x	x	
81	23	12	x	x	x	
81	24	5	x	x	x	x
86	3	581	x	x	x	x
86	5	540	x	x	x	x
86	7	480	x	x	x	x
86	9	450	x	x	x	x
86	11	370	x	x	x	x
86	13	325	x	x	x	x
86	1	250	x	x	x	
86	17	150	x	x	x	
86	19	50	x	x	x	
86	21	20	x	x	x	
86	23	12	x	x	x	x
86	24	5	x	x	x	x
89	3	571	x	x	x	x
89	5	520	x	x	x	

Station	Bottle	Depth (m)	Oxygen	pH	Total alkalinity	$\delta^{13}C_{DIC}$
89	7	460	x	x	x	x
89	9	430	x	x	x	x
89	11	300	xx	x	x	
89	13	200	x	xx	x	
89	15	100	x	x	xx	
89	19	75	x	x	x	
89	21	50	x	x	x	
89	23	12	x	x	x	
89	24	5	x	x	x	x
93	3	570	x	xx	x	
93	5	535	x	x	x	
93	7	500	x	x	x	
93	9	400	x	x	xx	
93	11	300	x	x	x	
93	15	150	x	x	x	
93	17	70	x	x	x	
93	19	35	x	x	x	
93	21	20	x	x	x	
93	23	12	x	x	x	
93	24	5	xx	x	x	
98	3	557	xx	x	x	
98	5	500	x	x	x	
98	7	440	x	x	xx	
98	9	380	x	x	x	x
98	11	330	x	x	x	x
98	15	250	x	x	x	x
98	17	150	x	x	x	
98	19	80	x	x	x	
98	21	40	x	xx	x	
98	23	10	x	x	x	
98	24	5	x	x	x	
109	L1	0.01	x	x	x	
109	L2	0.02	x	x	x	
109	L3	0.04	x	x	x	
109	L4	0.08	x	x	x	
109	L5	0.16	x	x	x	
109	L6	0.32	x	x	x	
112	3	357	x	x	x	
112	5	325	x	x	xx	
112	7	300	x	xx	x	
112	11	200	xx	x	x	
112	15	100	xx	x	x	

Station	Bottle	Depth (m)	Oxygen	pH	Total alkalinity	$\delta^{13}C_{DIC}$
112	17	70	x	xx	x	
112	19	40	x	x	xx	
112	21	22	x	x	x	
112	23	12	x	x	x	
112	24	5	x	x	x	
117	3	251	xx	x	x	
117	7	200	x	xx	x	
117	11	120	x	xx	x	
117	15	70	x	x	xx	
117	19	37	x	x	x	
117	21	24	x	x	x	
117	23	12	x	x	xx	
117	24	5	xx	x	x	

Dissolved organic matter (DOC) (Daan Temmerman)

To obtain water samples for DOC analysis (Table 8), seawater was directly extracted from the polypropylene sampling bottles of the Ultra Clean CTD with 60 ml syringes and silicon tubing in a cleanroom environment inside a modified high cube shipping container. Before every UCC deployment, all syringes were rinsed 2 times with 0.1M HCl and 3 times with Milli-Q water and stored in the filtration lab container (6°C to 10°C). Before extraction of the sample, every syringe was rinsed three times with seawater from the respective sampling bottle. Special care was taken to prevent air bubble formation inside the syringe while sampling. Protective attire (i.e., a hair net, clean boots, a lab-overall and nitrile gloves) was worn during sample collection. Samples were always kept out of direct sunlight and stored at temperatures similar to in-situ ocean conditions (6°C to 10°C).

Immediately after collection, the syringes were brought to a different lab container (10°C), where their contents were transferred under a fume hood to 40 ml glass vials using attachable filter holders containing GFF membranes (25mm, 0.7µm pore size). A lab coat and nitrile gloves were worn during filtration and acidification steps. Before and after the filtration of exactly 40 ml seawater into the glass vial, 10 ml of the sample was pushed through the filter and discarded to avoid contamination of the subsample with residual water from other subsamples still inside the filter. The same filter was used for all subsamples from one UCC-station and immediately discarded after processing. On completion of the filtration, the subsamples were acidified by adding 3 drops of 0.1M HCl using a pre-combusted glass pipette, after which the vials were sealed with caps, wrapped in aluminum foil and put inside an airtight plastic bag. The labeled bags were then stored in a fridge in the ship's hull at 4°C.

Table 8. List of DOC samples.

Date	Station	Bottle Number	Volume filtrated (mL)	Remarks
2023-05-28	1	24	40	sampled in clean container, directly from Niskin (no syringes used for station 1)
2023-05-28	1	23	40	sampled in clean container, directly from Niskin (no syringes used for station 1)
2023-05-28	1	21	40	sampled in clean container, directly from Niskin (no syringes used for station 1)
2023-05-28	1	17	40	sampled in clean container, directly from Niskin (no syringes used for station 1)
2023-05-28	1	15	40	sampled in clean container, directly from Niskin (no syringes used for station 1)
2023-05-28	1	9	40	sampled in clean container, directly from Niskin (no syringes used for station 1)
2023-05-28	1	6	40	sampled in clean container, directly from Niskin (no syringes used for station 1)
2023-05-28	1	3	40	sampled in clean container, directly from Niskin (no syringes used for station 1)
2023-05-29	8	24	40	not under fumehood
2023-05-29	8	23	40	not under fumehood
2023-05-29	8	21	40	not under fumehood
2023-05-29	8	19	40	not under fumehood
2023-05-29	8	17	40	not under fumehood
2023-05-29	8	7	40	not under fumehood
2023-05-29	8	5	40	not under fumehood
2023-05-29	8	3	40	not under fumehood
2023-05-30	19	24	40	not under fumehood
2023-05-30	19	23	40	not under fumehood
2023-05-30	19	21	40	not under fumehood
2023-05-30	19	19	40	not under fumehood
2023-05-30	19	17	40	not under fumehood
2023-05-30	19	13	40	not under fumehood
2023-05-30	19	5	40	not under fumehood
2023-05-30	19	3	40	not under fumehood
2023-05-30	24	24	40	
2023-05-30	24	23	40	
2023-05-30	24	21	40	
2023-05-30	24	19	40	
2023-05-30	24	11	40	
2023-05-30	24	3	40	
2023-05-31	27	24	40	
2023-05-31	27	23	40	
2023-05-31	27	21	40	
2023-05-31	27	16	40	
2023-05-31	27	13	40	
2023-05-31	27	10	40	
2023-05-31	27	3	40	
2023-05-31	31	p1	40	lander deployment

Date	Station	Bottle Number	Volume filtrated (mL)	Remarks
2023-05-31	31	p2	40	lander deployment
2023-05-31	31	p3	40	lander deployment
2023-05-31	31	p4	40	lander deployment
2023-05-31	31	p5	40	lander deployment
2023-05-31	31	p6	40	lander deployment
2023-06-01	35	24	40	
2023-06-01	35	23	40	
2023-06-01	35	16	40	
2023-06-01	35	7	40	Vial label says 6 in stead of 7
2023-06-01	35	3	40	
2023-06-01	40	24	40	
2023-06-01	40	23	40	
2023-06-01	40	16	40	
2023-06-01	40	12	40	
2023-06-01	40	9	40	
2023-06-01	40	6	40	
2023-06-01	40	3	40	
2023-06-02	46	24	40	
2023-06-02	46	23	40	
2023-06-02	46	21	40	
2023-06-02	46	19	40	
2023-06-02	46	17	40	
2023-06-02	46	15	40	
2023-06-02	46	6	40	
2023-06-02	46	3	40	
2023-06-02	50	24	40	
2023-06-02	50	23	40	
2023-06-02	50	21	40	
2023-06-02	50	19	40	
2023-06-02	50	17	40	
2023-06-02	50	15	40	
2023-06-02	50	6	40	
2023-06-02	50	3	40	
2023-06-03	59	24	40	
2023-06-03	59	23	40	
2023-06-03	59	23	40	duplo
2023-06-03	59	21	40	
2023-06-03	59	19	40	
2023-06-03	59	17	40	
2023-06-03	59	13	40	
2023-06-03	59	13	40	duplo
2023-06-03	59	9	40	
2023-06-03	59	6	40	
2023-06-03	59	6	40	duplo

Date	Station	Bottle Number	Volume filtrated (mL)	Remarks
2023-06-03	59	3	40	
2023-06-04	63	24	40	
2023-06-04	63	23	40	
2023-06-04	63	21	40	
2023-06-04	63	19	40	
2023-06-04	63	13	40	
2023-06-04	63	7	40	
2023-06-04	63	5	40	
2023-06-04	63	3	40	
2023-06-05	70	24	40	
2023-06-05	70	23	40	
2023-06-05	70	23	40	duplo
2023-06-05	70	21	40	
2023-06-05	70	19	40	
2023-06-05	70	17	40	
2023-06-05	70	13	40	
2023-06-05	70	13	40	duplo
2023-06-05	70	3	40	
2023-06-05	70	3	40	duplo
2023-06-05	74	24	40	
2023-06-05	74	23	40	
2023-06-05	74	23	40	duplo
2023-06-05	74	19	40	
2023-06-05	74	17	40	
2023-06-05	74	17	40	duplo
2023-06-05	74	15	40	
2023-06-05	74	11	40	
2023-06-05	74	5	40	
2023-06-05	74	3	40	
2023-06-05	74	3	40	duplo
2023-06-06	81	24	40	
2023-06-06	81	23	40	
2023-06-06	81	19	40	
2023-06-06	81	14	40	
2023-06-06	81	8	40	
2023-06-06	81	3	40	
2023-06-06	86	24	40	
2023-06-06	86	23	40	
2023-06-06	86	23	40	duplo
2023-06-06	86	21	40	
2023-06-06	86	19	40	
2023-06-06	86	11	40	
2023-06-06	86	15	40	
2023-06-06	86	15	40	duplo

Date	Station	Bottle Number	Volume filtrated (mL)	Remarks
2023-06-06	86	9	40	
2023-06-06	86	7	40	
2023-06-06	86	7	40	duplo
2023-06-06	86	3	40	
2023-06-07	89	24	40	
2023-06-07	89	23	40	
2023-06-07	89	21	40	
2023-06-07	89	19	40	
2023-06-07	89	11	40	
2023-06-07	89	7	40	
2023-06-07	89	5	40	
2023-06-07	89	3	40	
2023-06-07	93	24	40	
2023-06-07	93	23	40	
2023-06-07	93	21	40	
2023-06-07	93	17	40	
2023-06-07	93	11	40	
2023-06-07	93	7	40	
2023-06-07	93	3	40	
2023-06-08	98	24	40	
2023-06-08	98	24	40	duplo
2023-06-08	98	23	40	
2023-06-08	98	21	40	
2023-06-08	98	15	40	
2023-06-08	98	15	40	duplo
2023-06-08	98	9	40	
2023-06-08	98	7	40	
2023-06-08	98	5	40	
2023-06-08	98	3	40	
2023-06-08	98	3	40	duplo
2023-06-10	109	p1	40	lander deployment
2023-06-10	109	p2	40	lander deployment
2023-06-10	109	p3	40	lander deployment
2023-06-10	109	p4	40	lander deployment
2023-06-10	109	p5	40	lander deployment
2023-06-10	109	p6	40	lander deployment
2023-06-10	112	24	40	
2023-06-10	112	23	40	
2023-06-10	112	21	40	
2023-06-10	112	19	40	
2023-06-10	112	11	40	
2023-06-10	112	5	40	
2023-06-10	112	3	40	
2023-06-11	117	24	40	

Date	Station	Bottle Number	Volume filtrated (mL)	Remarks
2023-06-11	117	23	40	
2023-06-11	117	23	40	duplo
2023-06-11	117	21	40	
2023-06-11	117	19	40	
2023-06-11	117	15	40	
2023-06-11	117	15	40	duplo
2023-06-11	117	11	40	
2023-06-11	117	7	40	
2023-06-11	117	3	40	
2023-06-11	117	3	40	duplo

Particulate matter (Daan Temmerman and Furu Mienis)

Seawater was directly transferred from the polypropylene sampling bottles of the Ultra Clean CTD in the 'clean' container to 5 L bottles using silicon tubing. Again, protective attire (i.e., a hair net, clean boots, a lab-overall and nitrile gloves) was worn during sample collection. After extraction, the bottles were brought to the filtration lab container and stored their until further processing at temperatures similar to in-situ ocean conditions (6 °C to 10 °C). To determine the concentrations, stocks and fluxes as well as age, bioreactivity and origins of the suspended (organic) matter throughout the water-column. Samples (GF/F and Polycarbonate filters) will be analyzed after the expedition using an autoanalyzer (for obtaining data on POC, PON, PIN), a wet oxidation method (POP), isotope ratio-mass spectrometry ($\delta^{13}C$, $\delta^{15}N$), high-performance liquid chromatography (phytopigments), SEM imagery (SPM) and a NaOH-digestion method (biogenic Si).

Warm clothing which does not produce a lot of airborne fibers was worn to minimize contamination of the samples during the filtration process in the filtration lab container. Three separate vacuum filtration set-ups were used, equipped with 6 glass funnels of 1 L, 6 plastic funnels of 500 ml and 4 plastic funnels of 300 ml. All beakers were precleaned with both 0.1M HCl and Milli-Q rinses, which were repeated at the beginning of every transect. During filtration, the beakers were covered with alu foil lids, which were likewise often replaced. Pre-combusted (4h at 450°C) and pre-weighted 47 mm and 25 mm GF/F filters (0.7 µm pore size) and 47 mm Polycarbonate membranes (0.4 µm pore size) were used to filter suspended particulates from the seawater. The set-up with the 300 ml funnels was only used for 47 mm Polycarbonate membrane filtration (meant for post-expedition biogenic Si) while the set-up with the 500 ml funnels could only hold 25 mm GF/F membranes. The set-up with the 1 L funnels was used for both 47 mm GF/F and 47 mm Polycarbonate filtration. See Figure 2 for examples of the vacuum filtration set-up.

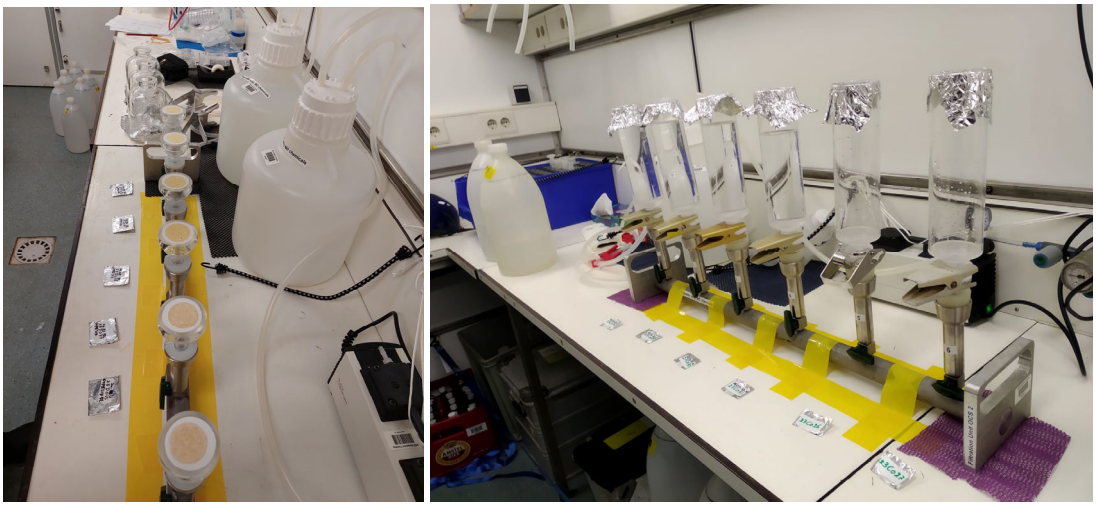

Figure 2. Photo 1 (left) shows samples after filtration. Photo 2 (right) shows the set-up during filtration.

After 5 L of seawater was filtered through (or less if the filter was saturated up to the point where the flow had almost halted completely), the beaker was rinsed with a small amount of Milli-Q and the larger zooplankton that remained was carefully removed with tweezers. The GF/F filters were folded once and placed in labeled aluminum envelopes, while the Polycarbonate filters were placed in coded petri dishes, sealed with tape. All samples were then sealed in plastic bags and stored at -20 °C in the dark. All activities were carefully recorded in sampling sheets (Table 9-11) and were digitized every evening. Notification was based upon the type of filters and the post-cruise analysis. Filter blanks were likewise taken roughly every 20 to 30 filters and recorded in the sampling sheets. The whole filtration process for one UCC deployment took approximately 2 to 4 hours, depending on the amount of depths allocated for sampling to a given station. Before the next UCC deployment, the beakers were again thoroughly rinsed with Milli-Q and the entire work area was cleaned. The 5 L bottles also received a double Milli-Q rinse in between every deployment.

Tabel 9. List of suspended particulate organic matter samples.

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-05-28	1	24	23D001	47	5	
2023-05-28	1	24	23D002	47	5	
2023-05-28	1	23	23D003	47	5	
2023-05-28	1	23	23D004	47	5	
2023-05-28	1	21	23D005	47	5	
2023-05-28	1	21	23D006	47	5	
2023-05-28	1	19	23D007	47	5	
2023-05-28	1	19	23D008	47	5	
2023-05-28	1	17	23D009	47	5	
2023-05-28	1	17	23D010	47	5	
2023-05-28	1	11	23C005	25	5	
2023-05-28	1	11	23C006	25	5	
2023-05-28	1	5	23C003	25	5	
2023-05-28	1	5	23C004	25	5	
2023-05-28	1	2	23C001	25	5	
2023-05-28	1	2	23C002	25	5	

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-05-29	8	24	23D011	47	5	
2023-05-29	8	24	23D012	47	5	
2023-05-29	8	23	23D013	47	5	
2023-05-29	8	23	23D014	47	5	
2023-05-29	8	21	23D015	47	5	
2023-05-29	8	21	23D016	47	5	
2023-05-29	8	19	23D017	47	5	
2023-05-29	8	19	23D018	47	5	
2023-05-29	8	15	23D019	47	5	
2023-05-29	8	15	23D020	47	5	
2023-05-29	8	7	23C007	25	5	
2023-05-29	8	7	23C008	25	5	
2023-05-29	8	5	23C009	25	5	
2023-05-29	8	5	23C010	25	5	
2023-05-29	8	3	23C011	25	5	
2023-05-29	8	3	23C012	25	5	
2023-05-30	19	24	23D022	47	5	
2023-05-30	19	24	23D023	47	5	
2023-05-30	19	23	23D024	47	5	
2023-05-30	19	23	23D025	47	5	
2023-05-30	19	21	23D026	47	5	
2023-05-30	19	21	23D027	47	5	
2023-05-30	19	19	23D028	47	5	
2023-05-30	19	19	23D029	47	5	
2023-05-30	19	17	23D020	25	5	
2023-05-30	19	17	23D021	25	5	
2023-05-30	19	13	23C018	25	5	23C019 is blank
2023-05-30	19	13	23C017	25	5	
2023-05-30	19	5	23C016	25	5	
2023-05-30	19	5	23C015	25	5	
2023-05-30	19	3	23C014	25	5	
2023-05-30	19	3	23C013	25	5	
2023-05-30	24	24	23D030	47	5	
2023-05-30	24	24	23D031	47	5	23D032 is blank
2023-05-30	24	23	23D033	47	5	
2023-05-30	24	23	23D034	47	5	
2023-05-30	24	21	23D035	47	5	
2023-05-30	24	21	23D036	47	5	
2023-05-30	24	19	23D037	47	5	
2023-05-30	24	19	23D038	47	5	
2023-05-30	24	11	23C022	25	5	
2023-05-30	24	11	23C023	25	5	

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-05-30	24	3	23C024	25	4.48	Stopped by accident too early with filtering (there was still +-0,5L water left in the bottle). Volume is right.
2023-05-30	24	3	23C025	25	4.48	Stopped by accident too early with filtering (there was still +-0,5L water left in the bottle). Volume is right.
2023-05-31	27	24	23D039	47	5	
2023-05-31	27	24	23D040	47	5	
2023-05-31	27	23	23D041	47	5	
2023-05-31	27	23	23D042	47	5	
2023-05-31	27	21	23D043	47	5	
2023-05-31	27	21	23D044	47	5	
2023-05-31	27	16	23D045	47	5	
2023-05-31	27	16	23D046	47	5	
2023-05-31	27	13	23D047	47	5	
2023-05-31	27	13	23D048	47	5	
2023-05-31	27	10	23C030	25	5	
2023-05-31	27	10	23C031	25	5	
2023-05-31	27	3	23C028	25	4.7	
2023-05-31	27	3	23C029	25	4.6	
2023-05-31	31	p1	23C032	lander	3.6	
2023-05-31	31	p2	23C033	lander	2.3	
2023-05-31	31	p3	23C034	lander	3.3	
2023-05-31	31	p4	23C035	lander	2.75	
2023-05-31	31	p5	23C026	lander	2.6	
2023-05-31	31	p6	23C027	lander	3	
2023-06-01	35	24	23D049	47	5	
2023-06-01	35	24	23D050	47	5	
2023-06-01	35	23	23D051	47	5	
2023-06-01	35	23	23D052	47	5	
2023-06-01	35	16	23D053	47	5	
2023-06-01	35	16	23D054	47	5	
2023-06-01	35	7	23C038	25	5	
2023-06-01	35	7	23C039	25	5	
2023-06-01	35	3	23C036	25	5	
2023-06-01	35	3	23C037	25	5	
2023-06-01	40	24	23D055	47	5	
2023-06-01	40	24	23D056	47	5	
2023-06-01	40	23	23D057	47	5	
2023-06-01	40	23	23D058	47	5	
2023-06-01	40	16	23D059	47	5	

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-01	40	16	23D060	47	5	
2023-06-01	40	12	23D062	47	5	23D061 is blank
2023-06-01	40	12	23D063	47	5	
2023-06-01	40	9	23C040	25	5	
2023-06-01	40	9	23C041	25	4.88	23C042 is blank
2023-06-01	40	3	23C043	25	4.44	
2023-06-01	40	3	23C044	25	4.9	
2023-06-01	40	6	23C045	25	5	
2023-06-01	40	6	23C046	25	5	
2023-06-02	46	24	23D064	47	5	
2023-06-02	46	24	23D065	47	5	
2023-06-02	46	23	23D066	47	5	
2023-06-02	46	23	23D067	47	5	
2023-06-02	46	21	23D068	47	5	
2023-06-02	46	21	23D069	47	5	
2023-06-02	46	19	23D070	47	5	
2023-06-02	46	19	23D071	47	5	
2023-06-02	46	17	23D072	47	5	
2023-06-02	46	17	23D073	47	5	
2023-06-02	46	15	23C047	25	5	
2023-06-02	46	15	23C048	25	5	
2023-06-02	46	6	23C049	25	5	
2023-06-02	46	6	23C050	25	5	+-500ml of b24 with b6
2023-06-02	46	3	23C051	25	5	
2023-06-02	46	3	23C052	25	5	
2023-06-02	50	24	23D074	47	5	
2023-06-02	50	24	23D075	47	5	
2023-06-02	50	23	23D076	47	5	
2023-06-02	50	23	23D077	47	5	
2023-06-02	50	21	23D078	47	5	
2023-06-02	50	21	23D081	47	5	23D079 and 23D080 discarded
2023-06-02	50	19	23D082	47	5	
2023-06-02	50	19	23D083	47	5	
2023-06-02	50	17	23D084	47	5	
2023-06-02	50	17	23D085	47	5	23D086 is blank
2023-06-02	50	15	23C057	25	3.7	
2023-06-02	50	15	23C058	25	4.02	23C059 is blank
2023-06-02	50	6	23C053	25	5	
2023-06-02	50	6	23C054	25	5	
2023-06-02	50	3	23C055	25	5	
2023-06-02	50	3	23C056	25	5	
2023-06-03	59	24	23D088	47	5	
2023-06-03	59	24	23D090	47	5	

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-03	59	23	23D089	47	5	
2023-06-03	59	23	23D093	47	5	
2023-06-03	59	21	23D091	47	5	
2023-06-03	59	21	23D092	47	5	
2023-06-03	59	19	23D094	47	5	
2023-06-03	59	19	23D095	47	5	
2023-06-03	59	17	23D096	47	5	
2023-06-03	59	17	23D097	47	5	
2023-06-03	59	13	23D066	47	5	
2023-06-03	59	13	23D067	47	5	
2023-06-03	59	9	23C060	25	5	No quick rinse
2023-06-03	59	9	23C061	25	5	No quick rinse
2023-06-03	59	6	23C062	25	5	No quick rinse
2023-06-03	59	6	23C063	25	5	No quick rinse
2023-06-03	59	3	23C064	25	5	
2023-06-03	59	3	23C065	25	5	
2023-06-04	63	24	23D098	47	5	2x quick rinse
2023-06-04	63	24	23D099	47	5	2x quick rinse
2023-06-04	63	23	23D100	47	5	2x quick rinse
2023-06-04	63	23	23D104	47	5	2x quick rinse
2023-06-04	63	21	23D105	47	5	
2023-06-04	63	21	23D106	47	5	
2023-06-04	63	19	23D107	47	5	
2023-06-04	63	19	23D108	47	5	
2023-06-04	63	13	23D109	47	5	
2023-06-04	63	13	23D110	47	5	
2023-06-04	63	7	23C068	25	5	
2023-06-04	63	7	23C069	25	5	
2023-06-04	63	5	23C070	25	5	
2023-06-04	63	5	23C071	25	5	
2023-06-04	63	3	23C072	25	5	
2023-06-04	63	3	23C073	25	5	
2023-06-05	70	24	23A116	47	5	
2023-06-05	70	24	23A117	47	5	Lot of macro zoopl.
2023-06-05	70	23	23A118	47	5	Lot of macro zoopl.
2023-06-05	70	23	23A119	47	5	Lot of macro zoopl.
2023-06-05	70	21	23A120	47	5	
2023-06-05	70	21	23A121	47	5	23A122 is blank
2023-06-05	70	19	23A123	47	5	
2023-06-05	70	19	23A124	47	5	
2023-06-05	70	3	23C074	25	5	
2023-06-05	70	3	23C075	25	5	
2023-06-05	70	13	23C076	25	5	
2023-06-05	70	13	23C077	25	5	

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-05	70	17	23C078	25	5	
2023-06-05	70	17	23C079	25	5	23C080 is blank
2023-06-05	74	24	23A125	47	5	
2023-06-05	74	24	23A126	47	5	
2023-06-05	74	23	23A127	47	5	
2023-06-05	74	23	23A128	47	5	
2023-06-05	74	19	23A129	47	5	
2023-06-05	74	19	23A130	47	5	
2023-06-05	74	17	23A163	47	5	
2023-06-05	74	17	23A164	47	5	
2023-06-05	74	15	23A162	47	5	
2023-06-05	74	15	23A161	47	5	
2023-06-05	74	3	23C081	25	5	
2023-06-05	74	3	23C082	25	5	
2023-06-05	74	5	23C083	25	5	
2023-06-05	74	5	23C084	25	5	
2023-06-05	74	11	23C085	25	5	
2023-06-05	74	11	23C086	25	5	2x MQ
2023-06-06	81	24	23A131	47	5	Little macro zooplankton, but slow flow. (check bioassays)
2023-06-06	81	24	23A132	47	5	
2023-06-06	81	23	23A133	47	5	
2023-06-06	81	23	23A134	47	5	
2023-06-06	81	19	23A135	47	5	
2023-06-06	81	19	23A136	47	5	
2023-06-06	81	14	23C087	25	5	
2023-06-06	81	14	23C088	25	5	
2023-06-06	81	8	23C089	25	5	
2023-06-06	81	8	23C090	25	5	
2023-06-06	81	3	23C091	25	5	
2023-06-06	81	3	23C092	25	5	23C094 is blank
2023-06-06	86	24	23A165	47	4.24	
2023-06-06	86	24	23A166	47	4.5	
2023-06-06	86	23	23A167	47	5	
2023-06-06	86	23	23A168	47	4.58	
2023-06-06	86	21	23A169	47	5	
2023-06-06	86	21	23A170	47	5	23A171 is blank
2023-06-06	86	19	23A172	47	5	
2023-06-06	86	19	23A173	47	5	23C093 is blank
2023-06-06	86	11	23C095	25	5	
2023-06-06	86	11	23C096	25	5	
2023-06-06	86	7	23C097	25	5	
2023-06-06	86	7	23C098	25	5	

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-06	86	3	23C099	25	5	
2023-06-06	86	3	23C100	25	5	
2023-06-06	86	15	23C162	25	5	
2023-06-06	86	9	23C163	25	5	
2023-06-06	86	15	23C161	25	5	
2023-06-06	86	9	23C164	25	5	
2023-06-07	89	24	23A174	47	5	
2023-06-07	89	24	23A175	47	5	
2023-06-07	89	23	23A176	47	5	
2023-06-07	89	23	23A177	47	5	
2023-06-07	89	21	23A178	47	5	
2023-06-07	89	21	23A179	47	5	
2023-06-07	89	19	23A149	47	5	
2023-06-07	89	19	23A150	47	5	
2023-06-07	89	11	23C141	25	5	
2023-06-07	89	11	23C142	25	5	
2023-06-07	89	7	23C101	25	5	
2023-06-07	89	7	23C102	25	5	
2023-06-07	89	5	23C103	25	5	
2023-06-07	89	5	23C104	25	5	
2023-06-07	89	3	23C105	25	5	
2023-06-07	89	3	23C106	25	5	
2023-06-07	93	24	23A181	47	5	
2023-06-07	93	24	23A182	47	5	
2023-06-07	93	23	23A183	47	5	
2023-06-07	93	23	23A184	47	5	
2023-06-07	93	21	23A185	47	5	
2023-06-07	93	21	23A186	47	5	
2023-06-07	93	17	23A187	47	5	
2023-06-07	93	17	23A188	47	5	
2023-06-07	93	11	23C165	25	5	
2023-06-07	93	11	23C166	25	5	
2023-06-07	93	7	23C167	25	5	
2023-06-07	93	7	23C168	25	5	
2023-06-07	93	3	23C169	25	5	
2023-06-07	93	3	23C170	25	5	
2023-06-08	98	24	23A151	47	5	
2023-06-08	98	24	23A152	47	5	
2023-06-08	98	23	23A153	47	5	
2023-06-08	98	23	23A154	47	5	
2023-06-08	98	21	23A155	47	5	
2023-06-08	98	21	23A156	47	5	
2023-06-08	98	15	23C107	25	5	
2023-06-08	98	15	23C108	25	5	

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-08	98	9	23C109	25	5	
2023-06-08	98	9	23C110	25	5	
2023-06-08	98	7	23C143	25	5	
2023-06-08	98	7	23C144	25	5	
2023-06-08	98	5	23C145	25	5	
2023-06-08	98	5	23C146	25	5	
2023-06-08	98	3	23C147	25	5	
2023-06-08	98	3	23C148	25	5	
2023-06-10	112	24	23A197	47	5	many macro zoopl.
2023-06-10	112	24	23A198	47	5	many macro zoopl.
2023-06-10	112	23	23A199	47	5	
2023-06-10	112	23	23A157	47	5	
2023-06-10	112	21	23A158	47	5	
2023-06-10	112	21	23A159	47	5	
2023-06-10	112	19	23D102	47	5	
2023-06-10	112	19	23D101	47	5	
2023-06-10	112	11	23C111	25	5	
2023-06-10	112	11	23C112	25	5	
2023-06-10	112	5	23C113	25	5	
2023-06-10	112	5	23C114	25	5	
2023-06-10	112	3	23C115	25	5	
2023-06-10	112	3	23C116	25	5	
2023-06-11	117	24	23D103	47	5	
2023-06-11	117	24	23D104	47	5	
2023-06-11	117	23	23D105	47	5	
2023-06-11	117	23	23D106	47	5	
2023-06-11	117	21	23D107	47	5	
2023-06-11	117	21	23D108	47	5	
2023-06-11	117	19	23D109	47	5	
2023-06-11	117	19	23D110	47	5	
2023-06-11	117	15	23D111	47	5	
2023-06-11	117	15	23D112	47	5	
2023-06-11	117	11	23C171	25	5	
2023-06-11	117	11	23C172	25	5	
2023-06-11	117	7	23C173	25	5	
2023-06-11	117	7	23C174	25	5	
2023-06-11	117	3	23C175	25	5	
2023-06-11	117	3	23C176	25	5	

Table 10. List of suspended particulate Si samples.

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-05-28	1	24	23F001	47	2.6	
2023-05-28	1	23	23F002	47	2.02	
2023-05-28	1	21	23F003	47	2.52	
2023-05-28	1	19	23F005	47	2.800	
2023-05-28	1	12	23F007	47	2.180	
2023-05-28	1	6	23F008	47	2.360	
2023-05-28	1	3	23F009	47	2.120	
2023-05-29	8	24	23F010	47	2.14	
2023-05-29	8	23	23F011	47	2.86	
2023-05-29	8	21	23F012	47	2.6	
2023-05-29	8	19	23F013	47	3.2	
2023-05-29	8	15	23F014	47	5	
2023-05-29	8	7	23F015	47	5	
2023-05-29	8	5	23F016	47	4.3	
2023-05-29	8	3	23F017	47	4.610	
2023-05-30	19	24	23F018	47	2	
2023-05-30	19	23	23F019	47	1.7	
2023-05-30	19	21	23F020	47	2.3	
2023-05-30	19	19	23F021	47	2.86	
2023-05-30	19	17	23F022	47	5	
2023-05-30	19	13	23F023	47	5	
2023-05-30	19	5	23F024	47	4.6	
2023-05-30	19	3	23F025	47	5	23F026 is blank
2023-05-30	24	24	23F027	47	1.86	
2023-05-30	24	23	23F028	47	1.83	
2023-05-30	24	21	23F029	47	2.58	
2023-05-30	24	19	23F030	47	3.34	
2023-05-30	24	11	23F031	47	2.26	
2023-05-30	24	3	23F032	47	2.66	2.34 or 3.34 still in bottle
2023-05-31	27	24	23F033	47	1	
2023-05-31	27	23	23F034	47	1	
2023-05-31	27	21	23F035	47	1.8	
2023-05-31	27	16	23F036	47	1.4	
2023-05-31	27	13	23F037	47	1.66	
2023-05-31	27	10	23F038	47	2.24	
2023-05-31	27	3	23F041	47	1.9	23F039 fell on the ground, continued with 23F041 because 23F040 is blank
2023-06-01	35	24	23F042	47	1.8	
2023-06-01	35	23	23F043	47	1.75	
2023-06-01	35	16	23F044	47	2.1	
2023-06-01	35	7	23F045	47	2.58	
2023-06-01	35	3	23F046	47	3.42	

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-01	40	24	23F047	47	1.2	
2023-06-01	40	23	23F048	47	1	
2023-06-01	40	16	23F049	47	1.5	
2023-06-01	40	12	23F050	47	2.2	
2023-06-01	40	9	23F051	47	3.04	No MQ quick.rinse
2023-06-01	40	6	23F052	47	3.4	Counting mistake while measuring water in box? Not sure, 2,6 or 1,6 was still in the bottle.
2023-06-01	40	3	23F054	47	2.16	23F053 fell on ground; 23F055 is blank
2023-06-02	46	24	23E047	47	2.7	
2023-06-02	46	23	23E048	47	2.3	
2023-06-02	46	21	23E049	47	1.5	
2023-06-02	46	19	23E050	47	1.7	
2023-06-02	46	17	23E140	47	2.2	
2023-06-02	46	15	23E139	47	3.6	
2023-06-02	46	6	23E051	47	5	
2023-06-02	46	3	23E052	47	5	
2023-06-02	50	24	23E054	47	2.8	
2023-06-02	50	23	23E053	47	2.8	
2023-06-02	50	21	23E055	47	2.34	
2023-06-02	50	19	23E056	47	2.7	
2023-06-02	50	17	23E057	47	2.26	
2023-06-02	50	15	23E058	47	3.06	
2023-06-02	50	6	23E059	47	2.96	
2023-06-02	50	3	23E060	47	3.08	
2023-06-03	59	24	23F072	47	2.3	
2023-06-03	59	23	23F073	47	2.2	
2023-06-03	59	21	23F074	47	2.12	
2023-06-03	59	19	23F075	47	2.74	
2023-06-03	59	17	23F076	47	3.64	
2023-06-03	59	13	23F077	47	3.42	
2023-06-03	59	9	23F080	47	3.5	
2023-06-03	59	6	23F079	47	3.28	
2023-06-03	59	3	23F078	47	3.5	
2023-06-04	63	24	23F101	47	2.16	
2023-06-04	63	23	23F102	47	2.22	
2023-06-04	63	21	23F103	47	3.52	
2023-06-04	63	19	23F104	47	3.54	
2023-06-04	63	13	23F105	47	3.6	
2023-06-04	63	7	23F106	47	3.46	
2023-06-04	63	5	23F107	47	3.54	
2023-06-04	63	3	23F108	47	3.22	

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-05	70	24	23E077	47	1.66	No quick rinse; 23E076 is blank
2023-06-05	70	23	23E078	47	1.48	
2023-06-05	70	21	23E079	47	1.4	
2023-06-05	70	19	23E080	47	2.4	
2023-06-05	70	17	23E101	47	2.62	
2023-06-05	70	13	23E102	47	3	
2023-06-05	70	3	23E103	47	3.12	
2023-06-05	74	24	23F091	47	2.12	
2023-06-05	74	23	23F092	47	1.52	
2023-06-05	74	19	23F093	47	1.96	
2023-06-05	74	17	23F094	47	2.54	
2023-06-05	74	15	23F095	47	4	
2023-06-05	74	11	23F096	47	3.5	
2023-06-05	74	5	23F097	47	3.54	
2023-06-05	74	3	23F109	47	2.64	deepest bottle has often more macro zoopl. then layers directly above it
2023-06-06	81	24	23F110	47	1	
2023-06-06	81	23	23F111	47	1.46	
2023-06-06	81	19	23F112	47	1.86	
2023-06-06	81	14	23F113	47	2.84	
2023-06-06	81	8	23F114	47	2.64	
2023-06-06	81	3	23F115	47	2.62	
2023-06-06	86	24	23F116	47	0.8	
2023-06-06	86	23	23F117	47	1	
2023-06-06	86	21	23F118	47	3.84	
2023-06-06	86	19	23F119	47	1.8	
2023-06-06	86	11	23F120	47	2.9	
2023-06-06	86	15	23F141	47	3.2	
2023-06-06	86	9	23F142	47	5	
2023-06-06	86	7	23F143	47	5	
2023-06-06	86	3	23F144	47	5	
2023-06-07	89	24	23F145	47	1.4	
2023-06-07	89	23	23F146	47	1.4	
2023-06-07	89	21	23F147	47	2.6	
2023-06-07	89	19	23F148	47	2.8	
2023-06-07	89	11	23F149	47	4.32	
2023-06-07	89	7	23F150	47	3	
2023-06-07	89	5	23F099	47	3.3	
2023-06-07	89	3	23F100	47	3.84	
2023-06-07	93	24	23E181	47	1.36	
2023-06-07	93	23	23E185	47	1.16	
2023-06-07	93	21	23E183	47	1.2	
2023-06-07	93	17	23E184	47	3.26	

Date	Station	Bottle nr	Filter nr	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-07	93	11	23E186	47	5	
2023-06-07	93	7	23E187	47	4.22	
2023-06-07	93	3	23E188	47	3	
2023-06-08	98	24	23F191	47	0.8	
2023-06-08	98	23	23F192	47	1	
2023-06-08	98	21	23F193	47	3.1	
2023-06-08	98	15	23F194	47	4	
2023-06-08	98	9	23F195	47	3.48	
2023-06-08	98	7	23F196	47	3.84	
2023-06-08	98	5	23F197	47	3.72	
2023-06-08	98	3	23F198	47	3.8	
2023-06-10	112	24	23F088	47	1.3	
2023-06-10	112	23	23F089	47	1	
2023-06-10	112	21	23F090	47	1	
2023-06-10	112	19	23F151	47	2.4	
2023-06-10	112	11	23F152	47	4.62	
2023-06-10	112	5	23F154	47	4.16	23F155 is blank
2023-06-10	112	3	23F153	47	4.64	
2023-06-11	117	24	23F156	47	1.28	
2023-06-11	117	23	23F157	47	1.38	
2023-06-11	117	21	23F158	47	1.6	
2023-06-11	117	19	23F159	47	2.08	
2023-06-11	117	15	23F199	47	3.76	
2023-06-11	117	11	23F160	47	4.62	
2023-06-11	117	7	23F161	47	4.82	
2023-06-11	117	3	23F162	47	4.2	

Table 11. List of suspended particulate matter samples.

Date	Station	Niskin Number	Filter number	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-05-28	1	24	23E001	47	2.7	Filter had moved while attaching glass beaker so not the whole area of the filter holder was covered by the filter.
2023-05-28	1	23	23E002	47	1.9	
2023-05-28	1	21	23E003	47	2.7	
2023-05-28	1	19	23E004	47	2.6	
2023-05-28	1	12	23E005	47	2.14	
2023-05-28	1	6	23E006	47	1.86	
2023-05-28	1	3	23E008	47	1.14	
2023-05-29	8	24	23E011	47	2.2	
2023-05-29	8	23	23E012	47	3.28	
2023-05-29	8	21	23E013	47	4	

Date	Station	Niskin Number	Filter number	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-05-29	8	19	23E014	47	4.7	
2023-05-29	8	15	23E015	47	5	
2023-05-29	8	7	23E016	47	5	
2023-05-29	8	5	23E017	47	5	
2023-05-29	8	3	23E018	47	5	
2023-05-30	19	24	23E010	47	1.7	23D009 is blank
2023-05-30	19	23	23E019	47	1.5	
2023-05-30	19	21	23E020	47	2.38	
2023-05-30	19	19	23E021	47	2.9	
2023-05-30	19	17	23E022	47	3	
2023-05-30	19	13	23E023	47	3	
2023-05-30	19	5	23E024	47	3.4	
2023-05-30	19	3	23E025	47	3.66	
2023-05-30	24	24	23E026	47	1.6	3L in bottle + 400 mL sucked out again
2023-05-30	24	23	23E027	47	1.46	3.16L in bottle + 380mL sucked out again
2023-05-30	24	21	23E028	47	2.5	
2023-05-30	24	19	23E029	47	2.94	2.06L or 3.06L still in bottle (lost count). likely 2.06L
2023-05-30	24	11	23E030	47	2.2	
2023-05-30	24	3	23E031	47	2.08	2.82L in bottle + 100mL sucked out again -> I initially wrote down 2.17!
2023-05-31	27	24	23E132	47	1	
2023-05-31	27	23	23E133	47	0.8	Filter moved when inserted
2023-05-31	27	21	23E134	47	1.9	
2023-05-31	27	16	23E135	47	0.98	
2023-05-31	27	13	23E136	47	1.22	
2023-05-31	27	10	23E137	47	3.32	This is a lot? Check the volume of water (2.68L of 3.68L still in bottle?).
2023-05-31	27	3	23E138	47	1.6	
2023-06-01	35	24	23E031	47	2.4	
2023-06-01	35	23	23E032	47	2.24	
2023-06-01	35	16	23E033	47	3.1	
2023-06-01	35	7	23E034	47	3.28	
2023-06-01	35	3	23E035	47	2.86	
2023-06-01	40	24	23E036	47	2.74	-1L from bottle. so 4L to start with in the bottle
2023-06-01	40	23	23E037	47	1.48	
2023-06-01	40	16	23E038	47	2.28	
2023-06-01	40	12	23E039	47	2.86	
2023-06-01	40	9	23E040	47	2.2	
2023-06-01	40	6	23E041	47	1.9	23E042 is blank
2023-06-01	40	3	23E043	47	2.76	

Date	Station	Niskin Number	Filter number	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-02	46	24	23F056	47	2.9	
2023-06-02	46	23	23F057	47	2.3	
2023-06-02	46	21	23F058	47	1.9	
2023-06-02	46	19	23F059	47	2.04	
2023-06-02	46	17	23F060	47	2.32	
2023-06-02	46	15	23F061	47	2.7	
2023-06-02	46	6	23F062	47	2.48	
2023-06-02	46	3	23F063	47	1.74	
2023-06-02	50	24	23F064	47	2.34	
2023-06-02	50	23	23F065	47	2.34	
2023-06-02	50	21	23F066	47	2.6	
2023-06-02	50	19	23F067	47	2.62	
2023-06-02	50	17	23F068	47	2.18	
2023-06-02	50	15	23F069	47	2.64	
2023-06-02	50	6	23F070	47	2.86	
2023-06-02	50	3	23F071	47	2.9	
2023-06-03	59	24	23E044	47	2.68	
2023-06-03	59	23	23E045	47	2.7	
2023-06-03	59	21	23E046	47	3.92	
2023-06-03	59	19	23E061	47	1.48	got some of bottle 17 (+-500ml)
2023-06-03	59	17	23E062	47	4.82	got some of bottle 13 (+-500ml)
2023-06-03	59	13	23E063	47	4.4	
2023-06-03	59	9	23E067	47	1.7-2.2	processing went wrong (calculation volume: 5-(1.5->2L)-1.28=1.72->2.22) between 1.72 and 2.22 L filtered
2023-06-03	59	6	23E065	47	2.8	Started with +-1L less (4L iso 5L)
2023-06-03	59	3	23E066	47	3.4	
2023-06-04	63	24	23E068	47	2.6	
2023-06-04	63	23	23E069	47	2.24	
2023-06-04	63	21	23E070	47	3.78	
2023-06-04	63	19	23E071	47	3.42	
2023-06-04	63	13	23E072	47	3.78	
2023-06-04	63	7	23E073	47	3.88	
2023-06-04	63	5	23E074	47	3.76	
2023-06-04	63	3	23E075	47	3.68	
2023-06-05	70	24	23E081	47	1.56	
2023-06-05	70	23	23E082	47	1.74	
2023-06-05	70	21	23E083	47	2.28	
2023-06-05	70	19	23E084	47	2.6	
2023-06-05	70	17	23E085	47	3.16	
2023-06-05	70	13	23E086	47	3.44	bioluminiscentie macro zoopl.

Date	Station	Niskin Number	Filter number	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-05	70	3	23E087	47	3.64	
2023-06-05	74	24	23E088	47	2.8	
2023-06-05	74	23	23E089	47	2.04	
2023-06-05	74	19	23E090	47	3	
2023-06-05	74	17	23E104	47	3.4	
2023-06-05	74	15	23E105	47	4.88	
2023-06-05	74	11	23E106	47	4.14	
2023-06-05	74	5	23E107	47	4.5	
2023-06-05	74	3	23E108	47	3.84	
2023-06-06	81	14	23E232	47	2.9	
2023-06-06	81	3	23E233	47	3.2	
2023-06-06	81	8	23E234	47	2.8	
2023-06-06	81	19	23E231	47	2.8	
2023-06-06	81	23	23E110	47	2.3	
2023-06-06	81	24	23E109	47	1.6	
2023-06-06	86	24	23E111	47	1.2	
2023-06-06	86	23	23E112	47	1.04	
2023-06-06	86	21	23E113	47	1.76	
2023-06-06	86	19	23E114	47	1.44	
2023-06-06	86	15	23E115	47	2.48	
2023-06-06	86	11	23E116	47	2.36	
2023-06-06	86	9	23E117	47	3.16	
2023-06-06	86	7	23E118	47	3.24	
2023-06-06	86	3	23E119	47	3.44	
2023-06-07	89	24	23E235	47	1.06	
2023-06-07	89	23	23E236	47	1.22	
2023-06-07	89	21	23E237	47	2.64	
2023-06-07	89	19	23E238	47	2.56	
2023-06-07	89	11	23E239	47	2.4	
2023-06-07	89	7	23E240	47	2.36	
2023-06-07	89	5	23E189	47	2.3	
2023-06-07	89	3	23E190	47	2.16	
2023-06-07	93	24	23F081	47	1	
2023-06-07	93	23	23F082	47	1	
2023-06-07	93	21	23F083	47	0.84	
2023-06-07	93	17	23F084	47	1.44	
2023-06-07	93	11	23F085	47	2.36	
2023-06-07	93	7	23F086	47	2.36	
2023-06-07	93	3	23F087	47	2.3	
2023-06-08	98	24	23E091	47	1.16	
2023-06-08	98	23	23E092	47	1	
2023-06-08	98	21	23E093	47	3.6	
2023-06-08	98	15	23E094	47	4.4	
2023-06-08	98	9	23E095	47	4	

Date	Station	Niskin Number	Filter number	Filter diameter (mm)	Volume filtrated (L)	Remarks
2023-06-08	98	7	23E096	47	4	
2023-06-08	98	5	23E097	47	2.22	
2023-06-08	98	3	23E098	47	5	
2023-06-10	112	24	23E141	47	1.32	
2023-06-10	112	23	23E142	47	1.06	
2023-06-10	112	21	23E143	47	1	
2023-06-10	112	19	23E144	47	2.56	
2023-06-10	112	11	23E145	47	4.6	
2023-06-10	112	5	23E146	47	4.62	
2023-06-10	112	3	23E147	47	2.44	23E148 is blank
2023-06-11	117	24	23E099	47	1.46	
2023-06-11	117	23	23E100	47	1.46	
2023-06-11	117	21	23E150	47	1.78	
2023-06-11	117	19	23E149	47	1.88	
2023-06-11	117	15	23E197	47	2.56	
2023-06-11	117	11	23E198	47	3.28	
2023-06-11	117	7	23E199	47	3.12	
2023-06-11	117	3	23E200	47	2.72	

Nutrients (Sharyn Ossebaar)

Summary

The availability of sunlight and nutrients play a crucial role for the production of oceanic phytoplankton which form the base of the marine food web. Knowing the variability in macronutrients (Phosphate Ammonium, Nitrite, Nitrate and Silicate) can help understand requirements between species, environmental conditions and the role of nutrient cycling. At all stations and from various experiments, samples were collected for shipboard macronutrient determination. The macronutrient measurements were made simultaneously on four channels for Phosphate Ammonium, Nitrite and Nitrate, using a continuous gas-segmented flow QuAAtro Auto-Analyser produced by SEAL Analytical. In total 1127 samples were measured on board during the research cruise. Samples for Silicate, Dissolved Inorganic Carbon (DIC) and Total Nitrogen & Total Phosphate (TNTP) were also taken and will be stored in a refrigerator and freezer until further analysis back at the NIOZ, The Netherlands. All results were reported as concentrations in micro mole per litre (µmol/L).

Equipment and Methods

Sample water was obtained from the Ultra-Clean 'Titan' CTD (UCC) from all depths. All samples were collected in high-density polyethylene syringes (Terumo®) with a three way valve directly after the oxygen sampling. The UCC nutrient samples were sub-sampled over a 0.8/0.2 µm Acrodisc® filter and transferred into 5 ml polyethylene vials (known as ponyvials) after rinsing three times with the sample before being capped. DIC and pCO_2 samples were transferred into 5ml glass vials already containing 15µl of mercury(II)chloride and filled with a miniscus before being screw capped and stored upside down in the refrigerator. Care was taken that no air was in the filled glass vial. These two samples were filled first before the nutrient, TNTP and silicate sub-samples. Samples from the bioassays were drawn into a 20ml syringe and filtered over a 0.8/0.2 µm Acrodisc® filter into a ponyvial. Incubation experiment samples were also filtered over a 0.2 µm Acrodisc® filter with a syringe into a ponyvial. Samples from the multicore porewaters were obtained and sub-sampled filtered into ponyvials. Samples from the Lander equipped with 6 sample bags were collected into the sampling bags and were

sub-sampled using a syringe and filter into ponyvials. Samples that weren't analysed within two to four hours of sampling were stored in the refrigerator at 4 °C and analysed in the following analytical run. All analyses (PO_4, NH_4 and NO_3 plus NO_2) were generally made within 2-14 hours of sampling and very occasionally up to a maximum of 20 hours later. Samples for Silicate, DIC, pCO_2 and TNTP were also taken and will be stored in a refrigerator and freezer until further analysis back at the NIOZ, The Netherlands.

Analytical Methods

All measurements were calibrated with standards diluted in low nutrient seawater (LNSW) in the salinity range of the stations at approximately 35‰ to ensure that analysis remained within the same ionic strength. Calibration standards were diluted from stock solutions of the different nutrients in 0.2 µm filtered LNSW and were freshly prepared every day. The LNSW is surface seawater depleted of most nutrients; it is also used as baseline water for the analysis between the samples. Each run of the system had a correlation coefficient of at least 0.9999 for 10 calibration points, but typically 1.0000 for linear chemistry was achieved. The samples were measured from the lowest to the highest concentration in order to keep carry-over effects as small as possible, i.e. from surface to deep waters. Prior to analysis, all samples and standards were brought to an average lab temperature of 22.4 °C (container temperature range 21.9-22.8 °C) in about one to two hours in a dark draw.
Before analysis the caps were removed and the ponyvials covered with parafilm under tension against exchange of ammonium from the and air and evaporation and placed in the sampler. The QuAAtro manufactured by SEAL Analytical, uses an LED instead of a lamp as a light source as it is not affected by the movement of the ship giving a stable reading. A sampler rate of 60 samples per hour was also used. Concentrations were recorded in µmol per liter (µmol/L) at the average container temperature of 22.4 °C. During every run a daily freshly diluted mixed nutrient standard, containing silicate, phosphate and nitrate (a so-called nutrient cocktail), was measured in triplicate. Additionally, a natural sterilized Reference Material Nutrient Sample from Kanso Technos Co., Ltd., Japan, containing known concentrations of silicate, phosphate, nitrate and nitrite in Pacific Ocean water, was analysed in triplicate for multiple days during the cruise. The cocktail and the CRM were both used to monitor the performance of the analyser. From every station the deepest sample bottle was sub-sampled for nutrients in duplicate, the duplicate sample-vials were all stored dark at 4 °C, and measured again in the following run with the upcoming stations for statistical purposes. In total 1127 samples were analysed for phosphate, ammonium, nitrate and nitrite during the cruise. The breakdown of samples was 402 samples at nineteen UCC stations, 169 samples for the thirteen bioassays (Middag et.al.), 18 samples from the two lander stations (Mienis et.al), 126 samples for eight flux incubation experiments (Kraal et.al), 147 samples for four 15N incubation experiments and 516 analyses were performed on the 265 porewater samples for the work of Kraal et al. The porewater samples were diluted 11 times for NO_3 and NO_2 analysis and diluted 101 times for NH_4 analysis. The porewater PO_4^- and Si sample will be analysed back at the NIOZ in a combined 1.0 ml sample that contains 10 µml of suprapur 5N HCl to ensure that iron hydroxides don't sorb PO_4^-.
The following is a brief overview of the colorimetric methods used on the QuAAtro auto-analyser;

Ortho-Phosphate (PO_4) reacts with ammonium molybdate at pH 1.0 and potassium antimonyltartrate is used as a catalyst. The yellow phosphate-molybdenum complex is reduced by ascorbic acid and forms a blue reduced molybdophosphate-complex which is measured at 880nm (Murphy & Riley, 1962).

Ammonium (NH_4) reacts with phenol and sodiumhypochlorite at pH 10.5 to form an indo-phenolblue complex. Citrate is used as a buffer and complexant for calcium and magnesium at this pH. The blue colour is measured at 630nm (Koroleff, 1969 and optimized by W. Helder and R. de Vries, 1979).

Nitrate plus Nitrite (NO_3+NO_2) is mixed with an imidazol buffer at pH 7.5 and reduced by a copperized cadmium column to Nitrite. The Nitrite is diazotated with sulphanylamide and naphtylethylene-

diamine to a pink coloured complex and measured at 550nm. Nitrate is calculated by subtracting the Nitrite value measured on the Nitrite channel from the 'NO3+NO2' value (Grasshoff et al, 1983).

Nitrite (NO_2) is diazotated with sulphanylamide and naphtylethylene-diamine to form a pink colored complex and measured at 550nm. (Grasshoff et al, 1983).

Back at the NIOZ;
Silicate (Si) reacts with ammonium molybdate to a yellow complex and after reduction with ascorbic acid, the obtained blue silica-molybdenum complex is measured at 820nm. Oxalic acid is added to prevent formation of the blue phosphate-molybdenum complex (Strickland & Parsons, 1968).
Dissolved Inorganic Carbon (DIC); Samples are acidified online after being oxidised by H_2O_2 to prevent H_2S being released before entering the silicon dialyser whereby the formed CO_2 is dialysed to a secondary flow. This secondary flow contains a slightly alkaline phenolphthalein solution giving a pink colour. The more CO_2 that is dialysed, the lower the pH and therefore some discolouration of the pink reagent is observed. This decolouring is measured at 520nm and is an inverse chemistry spectrophotometer method described by Stoll, Bakker, Nobbe and Haesse, 2001.

Calibration and Standards

Nutrient primary stock standards were prepared at the NIOZ as follows;
Ortho-Phosphate (PO_4): by weighing Potassium dihydrogen phosphate in a calibrated volumetric polypropylene (PP) flask to make 1mM PO_4 stock solution.
Ammonium: by weighing Ammonium Chloride in a calibrated volumetric PP flask to make 1mM NH_4 stock solution.
Nitrate (NO_3): by weighing Potassium nitrate in a calibrated volumetric PP flask set to make a 10mM NO_3 stock solution.
Nitrite (NO_2): by weighing Sodium nitrite in a calibrated volumetric PP flask set to make a 0.5mM NO_2 stock solution.
Silicate: by weighing Na_2SiF_6 in a calibrated volumetric PP flask to 19.84mM Si stock solution.
DIC: by weighing $NaHCO_3$ stock in a calibrated volumetric PP flask set to make a 200mM stock solution.

All standards were stored at room temperature in a 100% humidified box. The calibration standards were prepared daily by diluting the separate stock standards, using three electronic pipettes, into four 100ml PP volumetric flasks (calibrated at the NIOZ) filled with diluted LNSW. The blank values of the diluted LNSW were measured and added to the calibration values to get the absolute nutrient values.
Data Management & Statistics
The standards are continuously being monitored by participating in inter-calibration exercises organised by external organisations such as ICES, Quasimeme and the inter-comparison exercise organised by MRI, Japan.

To gain some accuracy, the NIOZ made an in-house 'Cocktail' standard which contains PO4, NO3 and Si to monitor the performance of the analyser throughout the cruise. This cocktail standard has been used for analytical performance monitoring since 2008. The following values were obtained from the cocktail which was diluted 250 times in a calibrated PP volumetric flask, being measured in triplicate and sometimes twice in triplicate in every analytical run.

	Average value	±STDEV	N	Dilution Factor
Cocktail-1008				
PO_4	0.914 µM	0.007	203	250
NO_3+NO_2	14.018 µM	0.081	203	250

The cocktail measurements showed that there were no trends observed, thus concluding that the calibration standards were stable during the cruise.

Mean Detection Limits (M.D.L)

The method detection limit was calculated during the cruise using the standard deviation of ten samples containing 2% of the highest standard used for the calibration curve and multiplied with the student's value for n=10, thus being 2.82.(M.D.L = Standard Deviation of 10 samples x 2.82)

	2% Standard STDEV	M.D.L µM/L	Used measuring ranges µM/L
PO_4	0.003	0.007	0.005 - 1.505
NH_4	0.002	0.006	0.050 - 2.050
NO_3+NO_2	0.002	0.007	0.010 - 26.005
NO_2	0.001	0.001	0.000 - 1.500

Precision at different concentration levels

The third standard was measured ten times to calculate the precision of a specific concentration level in µM/l with the respective standard deviation of that concentration:

	Conc. µM/L	±STDEV
PO_4	1.005	*0.001*
NH_4	1.550	*0.004*
NO_3	17.505	*0.004*
NO_2	0.750	*0.001*

Certified Reference Material

For further management of analysis precision and verifying analytical performance, Kanso Technos Co., LTD. from Japan have made a macro-nutrient certified reference material (CRM). The CRM is produced using treated natural seawater. Batch BU with salinity 34.991 psu was analysed in triplicate for consecutive analysis runs during the cruise.

The average value of measurements (n=116) of CRM "CH" with sub-batch numbers 2290,1926 and 0424 at 22.4°C are as follows:

	Average ± STDEV	Converted to µM/kg	Assigned by *KANSO*
Lot CH	µM/l	22.4°C	µM/kg ± Expanded Uncertainty
PO_4	1.210 ± 0.008	1.181	1.172 ± 0.015
NH_4	1.509 ± 0.105	1.474	not reported
NO_3	17.358 ± 0.107	16.951	*16.94*± 0.15
NO_2	0.183 ± 0.003	0.178	*0.159* ± 0.015

The CRM values obtained are in equitable agreement with the assigned values and in good agreement with previously analysed data produced by the NIOZ, therefore no post cruise adjustments are needed.

All raw data will be stored on the NIOZ-server for secured back-up and is available to collaborators via F. Mienis, P. Kraal, R. Middag and M.P. Humphreys.

HD-video transects *(Furu Mienis, Marina Adler, Matthew Humphreys)*

The tethered HD- video system was a 2x1.5x1 m, 700 kg video frame, connected via a Kevlar cable to the ship. The frame was equipped with two HD cameras, one forward facing to determine the oncoming landscape and potential obstacles and one downward facing camera aimed at the seafloor for habitat and substrate classification and faunal quantification. Two green lasers, 30 cm apart, were placed in the middle of the downward facing camera view for scale. A SeabirdSBE37 CT-ODO was attached to the frame, as well as a forward-facing sonar system (Kongsberg Mesotech, frequency of 675 kHz) to navigate the terrain. The system was deployed from the side of the ship and down to station depth hoovering approximately 1-2 m above the seafloor, controlled by a winch, and towed after the ship downwards along a predetermined transect. A USBL transponder was attached to the frame for accurate positioning. USBL and CT-ODO data were saved in separate files with the Pelnav program. At each site on average one hour of video footage was collected to determine substrate type, water column properties (turbidity/current), megafaunal community composition and abundance. Based on video data sites for sediment sampling and moored observatory deployments were selected. Throughout five video transects (Station 2, Station 13, Station 87, Station 90, Station 94) an AquapHOx-LX® Logger (Pyroscience GmBH, S/N: 21410016) equipped with a high-precision fixed NTC temperature sensor and a PyroScience pH sensor (FCD7-687-945, S/N: 224558044) was attached with yellow tape to the metal video frame (Table 12).

Table 12. Calibration data for the video frame sensor.

Buffer	T (°C)	Reading	Calibration time (min)
pH 2	18.70	21.95	15
pH 11	17.98	55.77	15
TRIS (pH 8.281)	17.93	36.70	20

Settings for the stand-alone logging:

a. Maximum low noise measurements
b. T and pH logging every 10 seconds
c. Measurement dates: 28-05-2023, 29-05-2023, 06-06-2023, 07-06-2023

A short description of each transects is provided here, station numbers are shown in Figure 3 and site numbers along transects are indicated in Figure 1.

Transect 64PE517-02: Short transect (15 minutes) at the westernmost station (site1-1) along transect1. Mainly soft substrate was observed. The most common megafauna consisted of sponges, soft corals and crustaceans. The transect was aborded due to malfunctioning of the forward-facing camera. No CTD data were collected due to a configuration error with Pelnav.

Transect 64PE517-06: Ninety minute transect at site1-2 along transect1. The sediment consisted of soft sediment with lebensspuren. The water just above the seafloor was very turbid throughout the entire survey. The most common fauna consisted of seapens, starfish and anemones. Several trawl tracks were observed. No CTD data were collected due to a configuration error with Pelnav.

Transect 64PE517-13: Transect (50 minutes) along the western slope of the trench (site1-3) showing soft sediment with multiple trawl tracks. Most common fauna observed were different fish species and ophiuroids. No CTD data were collected due to configuration error with Pelnav. CT-ODO was replaced by another instrument.

Transect 64PE517-20: Transect at site1-4 along transect 1. The sediment was coarser with a lot of shell debris. Most common fauna were urchins, starfish, anemones and different fish species.

Transect 64PE517-25: Video data (~1 hour) collected at the shallowest site1-5 of transect 1. The sediment showed a lot of bioturbation tracks and shell debris (likely *Arctica islandica*). At the beginning of the transect occasional boulders were observed covered with anemones. The transect was characterised by high abundance of tube worms, as well as crustaceans, star fish and flat fish. The water column was characterised by a lot of marine snow, including large aggregates.

Transect 64PE517-36: Westernmost and shallowest site2-5, characterised by a sandy bottom with shell debris. The fauna consisted of anemones, sea urchins and starfish. Again a lot of marine snow was observed in the benthic boundary layer.

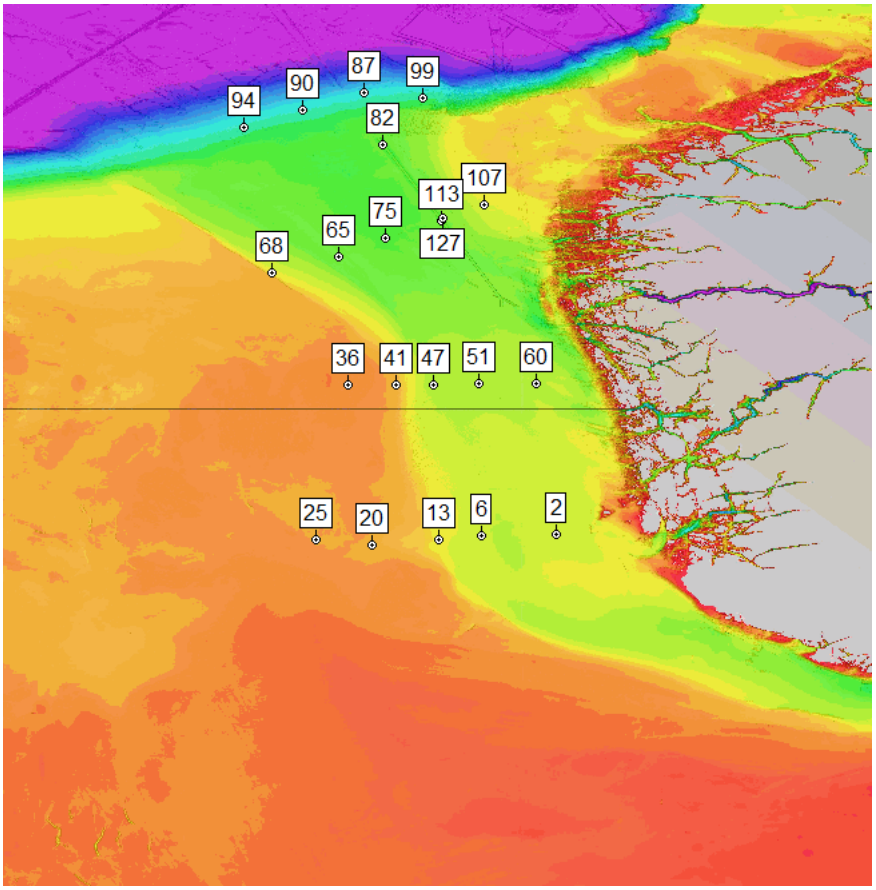

Figure 3. Video stations during the NoSE expedition (64PE517).

Transect 64PE517-41: Transect at site2-4 showing a sandy bottom with shell debris. Current ripples were observed throughout the entire transect, indicating the presence of strong bottom currents. Most common fauna observed were anemones, urchins and starfish.

Transect 64PE517-47: Transect at the slope of the trench at site2-3, characterised by soft sediment. The entire transect was characterised by the presence of trawl marks. Most common fauna were seapens, anemones, starfish and occasional sharks were observed.

Transect 64PE517-51: Transect characterised by soft sediment at site2-2. Trawl tracks were occasionally observed. Most common fauna were seapens, starfish, and sea urchins.

Transect 64PE517-60: Easternmost transect at site2-1 characterised by soft sediment with seapens, holothurians, anemones and starfish. Note that camera did not move into the current, but moved sideways.

Transect 64PE517-65: Transect at site3-4 characterised by soft sediment with sponges, sea urchins, holothurians and occasional trawl tracks. At the beginning of the transect a lot of zooplankton was observed.

Transect 64PE517-68: Transect at site 3-5 along the westernmost edge of the trench. Sediments were coarser compared to the other stations along this transect. Most common megafauna observed were anemones, sea stars, hermit crabs, sea urchins and flat fish.

Transect 64PE517-75: Video transect in the middle of the Trench (site3-3), characterised by soft sediment with seapens, anemones, urchins, ophiurids and different fish species.

Transect 64PE517-82: Transect (site4-2) along the North Sea outflow route south of the Atlantic boundary, characterised by soft sediments. Most common megafauna observed were seapens, holothurians, urchins and seastars.
Transect 64PE517-87: First transect (Site4-3) in the Atlantic Ocean, showing large numbers of drop stones and current ripples, indicative of strong currents. On hard substrate mainly anemones, soft corals and sponges were observed. A certain rock fish species was also often found. Water temperatures along this transect were extremely cold, being around zero degrees.
Transect 64PE517-90: Transect at site4-4 showing the presence of coarser sand with current ripples and areas with drop stones. Megafauna was mainly characterised by the presence of anemones, sponges, seastars and soft corals.
Transect 64PE517-94: Westernmost transect in the Atlantic (site4-5) with a lot of drop stones on sandy sediment. Most common megafauna found were sponges, soft corals, seastars and fish (Figure 4). During this transect no USBL data were recorded due to an issue with the transponder.
Transect 64PE517-99: Easternmost site along transect 4 (site4-1) characterised by the presence of a lot of drop stones, current ripples and trawl tracks. Most common species were sponges, corals and seastars. An occasional fishing line was also observed.
Transect 64PE517-107: Easternmost site along transect 3 (site3-1) showing the presence of boulders on soft sediment seafloor. Most common fauna observed were sponges, holothurians, urchins and fish.
Transect 64PE517-113: Transect at site3-2 characterised by a soft sediment with an occasional drop stone. Most common fauna observed were ophiurids, urchins and holothurians.
Transect 64PE517-127: Same site as 64PE517-113 characterised by soft sediment. Most common species observed were sponges, ophiurids, holothurians and urchins.

Figure 4. Examples of benthic megafauna (e.g., porifera, echinodermata) observed.

Sediment

Sediment material for paleoceanography (Cecile Hilgen and Rick Hennekam)

We aimed to obtain several short and long sediment cores in the Norwegian Trench during the NoSE 2023 expedition to determine the drivers of variability in nutrients, primary productivity, and carbon fluxes in the Trench/North Atlantic systems from recent times back into the past, beyond the observational record. For this purpose we will focus to acquire sediment material for short-lived isotopes, palynology, biomarkers, and inorganic geochemical tools. It is well-known that marine sediments function as valuable paleorecords, with the surface sediment layers being a potential indicator of human impact. The deeper sediments, providing a longer temporal perspective, will unveil the natural climate variability preceding human influence. To evaluate human-induced climate change we will eventually integrate the surface sediment cores with the deeper sediment cores in order to obtain a long, comprehensive composite record. To achieve this, we retrieve the surface sediments using a different coring device, ensuring their preservation and enabling high-resolution sampling. Moreover, we are interested into the correlation between direct measurements (other work packages)

and indirect measurements (our work package), which can serve as a valuable calibration for our analytical approaches. By examining the relationship between these two types of measurements, we aim to refine and validate our proxy data. To obtain long records which go further back in time then other studies done in this region, we carefully selected the deepest points along the transects where sediment deposition is highest (depocenter) in low energetic environment, facilitating the preservation of undisturbed sequences of past climate variability. Through the analysis of bottom sediment maps and seismic data, we made preliminary assessments of the composition of the underlying material and the bathymetry. The sediment cores were recovered with 4 distinct coring devices: box core (BC) and multicore (MC) for collecting surface sediments, and piston core (PC) and gravity core (GC) for obtaining deeper sediment samples. Sampling was carried out at a total of 20 sites, distributed among four west-east transects (consisting of five locations per transect) within the Norwegian Trench. The geographic coordinates of the transects spanned from 1.8922 to 4.4497 °E longitude and 59.0422 to 62.7562 °N latitude (Figure 5).

Sediment - Composition and structure

The sediment composition varied across the transects, with the outer west sites containing sand and large shells/shell fragments, and the outer east sites containing sand and larger stones/pebbles. The grain size varies within these cores from fine silt to very coarse sand. Bioturbation was occasionally observed up to a depth of 10 cm on average. The sites located in the middle of the trench consisted of homogeneous organic muds with occasional foraminifera lenses. These sediment cores exhibited a general pattern of transitioning from soft, organic-rich brown material to wetter and thinner light grey mud, eventually progressing to denser and stiffer darker grey mud. In certain cores, black carbon-rich spots and borrowings filled with coarser grained material were also observed. The sediment cores exhibited minimal to negligible bioturbation below a depth of 2 cm, with no observable presence of macro-fauna on the sediment surfaces. Since small graine sized material (clay/silt) is essential for palynology, it is crucial to analyse the surface sediment cores before retrieving the deeper sediment cores.

Paleo-reconstruction proxies - Determining the chemical footprint of climate variability

Inorganic proxies

Short-lived radio isotopes, i.e., ^{210}Pb and ^{234}Th, will be used to obtain high resolution age control. Hence, combined with high sampling resolution (see below), these radioisotopes allow high-temporal

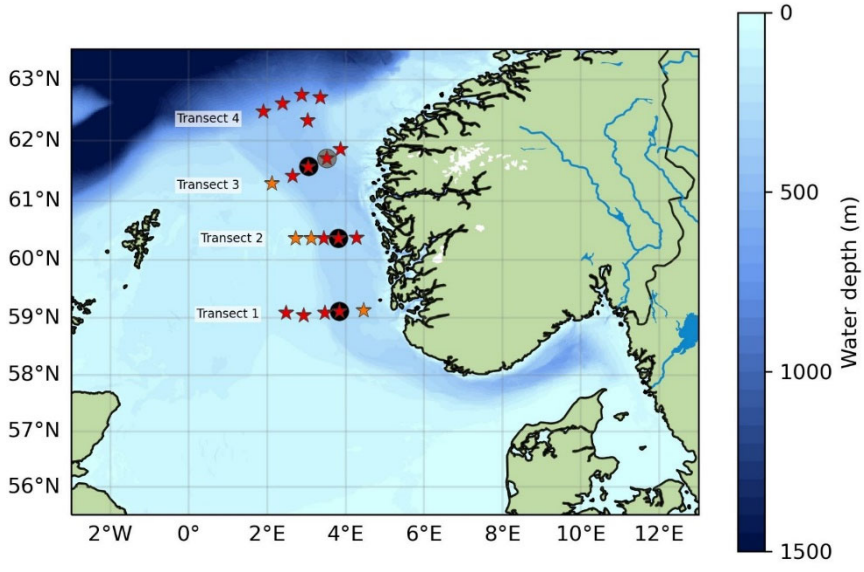

Figure 5: Map of the 4 transects including station locations (paleo-records). Red stars indicate multicores, orange stars indicate box cores, black circles indicate piston cores and the grey circle indicates a gravity core.

resolution age control for multiple time-scales over the past ~120 years (^{210}Pb), while also indicating how fresh the top sediment material is (^{234}Th). The latter isotope is crucial for acquiring a comprehensive understanding of the degree to which post-depositional processes, such as bioturbation, impact the chemical composition of the sediment cores. As biological processes tend to blend sediments and disrupt the sequential paleorecord, comprehending their influence is essential. Other inorganic geochemical tools will include XRF core scanning, which will be used to obtain high resolution (<1 mm) data on the cores collected. XRF core scanning is an efficient and non-destructive method to rapidly acquire long timeseries of several important proxies that can be used to reconstruct water and sediment properties (e.g., Ba and Ca/Al for (primary) productivity, Br for total OC, several redox-sensitive elements for dissolved oxygen). Applying XRF core scanning to all cores will provide a basin-scale first overview of carbon and nutrient cycling in high resolution. XRF data will then be used to identify (dis)similarities between core records in space and time. Based on core matching and preliminary sediment dating, we will select key sediment intervals of interest for further analyses (dinoflagellate and organic or other inorganic proxies). Note that we will also apply other inorganic geochemical tools, such as oxygen isotopes of foraminifera, if deemed necessary.

Organic proxies

Sedimentary marine palynomorphs (dinoflagellates cysts) will be used to (qualitatively) reconstruct past environmental conditions of the water column: salinity (freshwater input), nutrients availability and productivity, upper water stratification and sea surface temperature. Palynology samples will be processed with the standard palynological technique in use in the GEO laboratory at Utrecht University. The palynomorph extraction technique acquires a particular type of sediment, therefore, line-scans and core description will be performed prior to sampling. Besides dinoflagellate cysts, pollen and spores and other palynomorphs will be counted. Pollen and spore results will help to reconstruct vegetation changes on land and river input. Moreover, biomarkers will be used to deduce several interesting environmental parameters in the Norwegian Trench. Sea Surface Temperature (SST) will be reconstructed using alkenones (UK'37), glycerol dialkyl glycerol tetraether lipids (TEX86), and the Long-chain Diol Index (LDI). Salinity will be derived by seawater stable isotopes of both hydrogen and oxygen. To deduce variations in OM (marine vs terrestrial) and input from land, we will use a suite of tools such as C/N ratio, carbon isotopic signature of OM, soil input (BIT), and riverine input (fraction C32 1,15 diol).

Table 13. Overview of retrieved cores: box cores (BC), multi cores (MC), piston cores (PC) and gravity cores (GC). Transect 1 is most southern transect and site 1 is most eastern site on transect.

Date	Transect	Site	Station	Type	Storage	(-20℃)	(4℃)	Purpose	Resolution	Remarks
28/05/2023	1	1	4	BC	Core		x	XRF		PVC
28/05/2023	1	1	5	BC	Core		x	Archive		PVC
28/05/2023	1	1	4	BC	Bags	x		Palynology, biomarkers	0.5 cm	0 - 32 cm
29/05/2023	1	2	11	MC	Core		x	XRF		PVC
29/05/2023	1	2	12	MC	Core		x	Archive		PVC

Date	Transect	Site	Station	Type	Storage	(-20℃)	(4℃)	Purpose	Resolution	Remarks
29/05/2023	1	2	11	MC	Vials		x	Short-lived isotopes	0.5 cm	1-68 nr vials (0-34 cm) - sediment from palynology core
29/05/2023	1	2	11	MC	Bags	x		Palynology	0.5 cm	0 - 34 cm
29/05/2023	1	2	11	MC	Bags	x		Biomarkers	0.5 cm	0 - 34.5 cm
31/05/2023	1	2	32	PC	Tubes		x		1 meter	8 subsections: 767 cm, released at wrong time
29/05/2023	1	3	16	MC	Core		x	XRF		PVC
29/05/2023	1	3	16	MC	Core		x	Archive		PVC
29/05/2023	1	3	16	MC	Vials		x	Short-lived isotopes	0.5 cm	69-100 nr vials (0-16 cm) - sediment from palynology core
29/05/2023	1	3	16	MC	Bags	x		Palynology	0.5 cm	0 - 16 cm
29/05/2023	1	3	16	MC	Bags	x		Biomarkers	0.5 cm	0 - 16 cm
30/05/2023	1	4	22	MC	Core		x	XRF		PVC
30/05/2023	1	4	22	MC	Core		x	Archive		PVC
30/05/2023	1	4	22	MC	Vials		x	Short-lived isotopes	0.5 cm	101-140 nr vials (0-20 cm) - sediment from palynology core
30/05/2023	1	4	22	MC	Bags	x		Palynology	0.5 cm	0 - 26.75 cm
30/05/2023	1	4	22	MC	Bags	x		Biomarkers	0.5 cm	0 - 27 cm
31/05/2023	1	5	30	MC	Core		x	XRF		PVC
31/05/2023	1	5	30	MC	Core		x	Archive		PVC
31/05/2023	1	5	30	MC	Vials		x	Short-lived isotopes	0.5 cm	141-161 nr vials (0-10.3 cm) - sediment from palynology core
31/05/2023	1	5	30	MC	Bags	x		Palynology	0.5 cm	0 - 10.3 cm
31/05/2023	1	5	30	MC	Bags	x		Biomarkers	0.5 cm	0 - 10 cm
03/06/2023	2	1	62	MC	Core		x	XRF		PVC
03/06/2023	2	1	62	MC	Core		x	Archive		PVC
03/06/2023	2	1	62	MC	Vials		x	Short-lived isotopes	0.5 cm	275 - 294 nr vials (0-10 cm) - sediment from palynology core
03/06/2023	2	1	62	MC	Bags	x		Palynology	0.5 cm	0 - 39.5 cm
03/06/2023	2	1	62	MC	Bags	x		Biomarkers	0.5 cm	0 - 32 cm
03/06/2023	2	2	57	MC	Core		x	XRF		PVC
03/06/2023	2	2	57	MC	Core		x	Archive		PVC

Date	Transect	Site	Station	Type	Storage	(-20C)	(4C)	Purpose	Resolution	Remarks
03/06/2023	2	2	57	MC	Vials		x	Short-lived isotopes	0.5 cm	222 - 274 nr vials (0-25 cm) - sediment from palynology core
03/06/2023	2	2	57	MC	Bags	x		Palynology	0.5 cm	0 - 25 cm
03/06/2023	2	2	57	MC	Bags	x		Biomarkers	0.5 cm	0 - 26.5 cm
03/06/2023	2	2	58	PC	Tubes		x		1 meter	8 subsections: 732 cm, core catcher is 24 cm
02/06/2023	2	3	49	MC	Core		x	XRF		PVC
02/06/2023	2	3	49	MC	Core		x	Archive		PVC
02/06/2023	2	3	49	MC	Vials		x	Short-lived isotopes	0.5 cm	202 - 221 nr vials (0-10 cm) - sediment from palynology core
02/06/2023	2	3	49	MC	Bags	x		Palynology	0.5 cm	0 - 20 cm
02/06/2023	2	3	49	MC	Bags	x		Biomarkers	0.5 cm	0 - 17 cm
01/06/2023	2	4	44	BC	Core		x	XRF		PVC
01/06/2023	2	4	43	BC	Core		x	Archive		PVC
01/06/2023	2	4	44	BC	Vials		x	Short-lived isotopes	0.5 cm	182 - 201 nr vials (0-10 cm) - sediment from palynology core
01/06/2023	2	4	44	BC	Bags	x		Palynology	0.5 cm	0 - 18 cm, ± 7-9 cm huge shell
01/06/2023	2	4	44	BC	Bags	x		Biomarkers	0.5 cm	0 - 16.5 cm
01/06/2023	2	5	37	BC	Core		x	XRF		PVC
01/06/2023	2	5	39	BC	Core		x	Archive		PVC
01/06/2023	2	5	37	BC	Vials		x	Short-lived isotopes	0.5 cm	162-181 nr vials (0-10 cm) - sediment from palynology core
01/06/2023	2	5	37	BC	Bags	x		Palynology	0.5 cm	0 - 16 cm
01/06/2023	2	5	37	BC	Bags	x		Biomarkers	0.5 cm	0 - 18 cm
11/06/2023	3	1	122	MC	Core		x	XRF		PVC
11/06/2023	3	1	122	MC	Core		x	Archive		PVC
11/06/2023	3	1	122	MC	Vials		x	Short-lived isotopes	0.5 cm	1! - 20! (top 10 cm - unweighed vials) - sediment from palynology core
11/06/2023	3	1	122	MC	Bags	x		Palynology	0.5 cm	0 - 32 cm
11/06/2023	3	1	122	MC	Bags	x		Biomarkers	0.5 cm	0 - 30.5 cm
10/06/2023	3	2	115	MC	Core		x	XRF		PVC
10/06/2023	3	2	115	MC	Core		x	Archive		PVC

Date	Transect	Site	Station	Type	Storage	(-20C)	(4C)	Purpose	Resolution	Remarks
10/06/2023	3	2	115	MC	Vials		x	Short-lived isotopes	0.5 cm	491 - 500 & 277 - 284 (Peter) & 115A - 115B nr vials (0-10 cm) - sediment from palynology core
10/06/2023	3	2	115	MC	Bags	x		Palynology	0.5 cm	0 - 35 cm
10/06/2023	3	2	115	MC	Bags	x		Biomarkers	0.5 cm	0 - 30.5 cm
05/06/2023	3	3	79	MC	Core		x	XRF / archive		PVC
05/06/2023	3	3	79	MC	Vials		x	Short-lived isotopes	0.5 cm	335 - 403 nr vials (0-32.5 cm), also oxic slicing - sediment from palynology core
05/06/2023	3	3	79	MC	Bags	x		Palynology	0.5 cm	0 - 32.5 cm
05/06/2023	3	3	79	MC	Bags	x		Biomarkers	0.5 cm	0 - 34.5 cm
10/06/2023	3	3	110	PC	Tubes		x		1 meter	8 subsections: 723 cm, core catcher = 24 cm, trigger core = 38 cm
04/06/2023	3	4	67	MC	Core		x	XRF		PVC
04/06/2023	3	4	67	MC	Core		x	Archive		PVC
04/06/2023	3	4	67	MC	Vials		x	Short-lived isotopes	0.5 cm	295 - 314 nr vials (0-10 cm) - sediment from palynology core
04/06/2023	3	4	67	MC	Bags	x		Palynology	0.5 cm	0 - 27.5 cm
04/06/2023	3	4	67	MC	Bags	x		Biomarkers	0.5 cm	0 - 27.5 cm
11/06/2023	3	2	125	GC	Tubes		x		1 meter	4 subsections: 397 cm, shell fragments at top, core catcher = 18 cm
05/06/2023	3	5	73	BC	Core		x	XRF		PVC
05/06/2023	3	5	73	BC	Core		x	Archive		PVC
05/06/2023	3	5	73	BC	Vials		x	Short-lived isotopes	0.5 cm	315 - 334 nr vials (0-10 cm) - sediment from palynology core
05/06/2023	3	5	73	BC	Bags	x		Palynology	0.5 cm	0 - 20 cm
05/06/2023	3	5	73	BC	Bags	x		Biomarkers	0.5 cm	0 - 20.5 cm
11/06/2023	3	5	124	GC	Tubes					Failed! Bended core.
06/06/2023	4	2	84	MC	Core		x	XRF		PVC
06/06/2023	4	2	84	MC	Core		x	Archive		PVC
06/06/2023	4	2	84	MC	Vials		x	Short-lived isotopes	0.5 cm	404 - 423 nr vials (0-10 cm) - sediment from palynology core

Date	Transect	Site	Station	Type	Storage	(-20C)	(4C)	Purpose	Resolution	Remarks
06/06/2023	4	2	84	MC	Bags	x		Palynology	0.5 cm	0 - 22.5 cm
06/06/2023	4	2	84	MC	Bags	x		Biomarkers	0.5 cm	0 - 26 cm
08/06/2023	4	1	100	BC	Core		x	XRF / archive		
08/06/2023	4	1	100	BC	Vials		x	Short-lived isotopes	0.5 cm	464 - 486 nr vials (top 11.5 cm) - sediment from palynology core
08/06/2023	4	1	100	BC	Bags		x	Palynology & biomarkers	0.5 cm	0 - 11.5 cm
09/06/2023	4	3	104	MC	Core		x	XRF		PVC
09/06/2023	4	3	104	MC	Core		x	Archive		PVC
09/06/2023	4	3	104	MC	Vials		x	Short-lived isotopes	0.5 cm	487 - 490 & 285 - 300 (Peter) nr vials (0-10 cm) - sediment from palynology core
09/06/2023	4	3	104	MC	Bags	x		Palynology	0.5 cm	0 - 35.5 cm
09/06/2023	4	3	104	MC	Bags	x		Biomarkers	0.5 cm	0 - 33.5 cm
07/06/2023	4	4	92	MC	Core		x	XRF / archive		PVC
07/06/2023	4	4	92	MC	Vials		x	Short-lived isotopes	0.5 cm	424 - 443 nr vials (0-10 cm) - sediment from palynology core
07/06/2023	4	4	92	MC	Bags	x		Palynology	0.5 cm	0 - 26.5 cm
07/06/2023	4	4	92	MC	Bags	x		Biomarkers	0.5 cm	0 - 25 cm
07/06/2023	4	5	96	MC	Core		x	XRF		PVC
07/06/2023	4	5	96	MC	Core		x	Archive		PVC
07/06/2023	4	5	96	MC	Vials		x	Short-lived isotopes	0.5 cm	444 - 463 nr vials (0-10 cm) - sediment from palynology core
07/06/2023	4	5	96	MC	Bags	x		Palynology	0.5 cm	0 - 28 cm
07/06/2023	4	5	96	MC	Bags	x		Biomarkers	0.5 cm	0 - 25.5 cm

Short sediment cores using the box- and multi corer (Peter Kraal, Anna Enge, Cecile Hilgen, Lucia Kranawetter, Furu Mienis, Rick Hennekam)

After a video transect on every site, an appropriate location to deploy the box corer was chosen; a location with relatively low amount of rocks and undisturbed surface (no trawling tracks). In general, from the box core a sample was taken for gust experiments by Anna Enge and macro fauna (after sieving) and sediment surface material (mainly for organic carbon) for Furu Mienis. Moreover, the box core material was photographed using the identifier card. Dependent on the sediment material it was then decided if the multi corer was deployed at the same site. In most cases this was possible, but some locations were too sandy and/or rocky to allow multi corer deployment (Figure 6). See Table 13 for the detailed information on taken cores.

Multicores with a diameter of approximately 10 cm were collected with an Oktopus multicoring apparatus (www.oktopus-mari-tech.de) during the expedition (Figure 6). The weighing system of the multi corer was adjusted at each site to achieve optimum sediment recovery. With this device, 12 cores are recovered per cast. Each core contains in general ~25-35 cm of sediment plus overlying water, but for some, especially sandy, stations this was less. After core collection, the multicores were either stored (at 4 °C and/or -20 °C) or sampled using the hydraulic push-up device in appropriate resolution. See Figure 5 and Table 13 for box- and multicores locations and core designations.

From every station we at least took cores for several paleo-purposes: short-lived isotopes, palynology, biomarkers, and inorganic geochemistry (XRF core scanning among other things). Besides the inorganic geochemistry core (called “XRF” core in fridge; in a grey PVC tube), we retrieved a core for long-term storage (called “Archive” core in fridge; in a grey PVC tube). Both were capped with plastic red caps, labeled and stored upright at 4°C to allow for later sampling / analyses (Figure 6B). The palynology and biomarker cores were immediately sampled using a hydraulic slicer, while the short-lived isotope

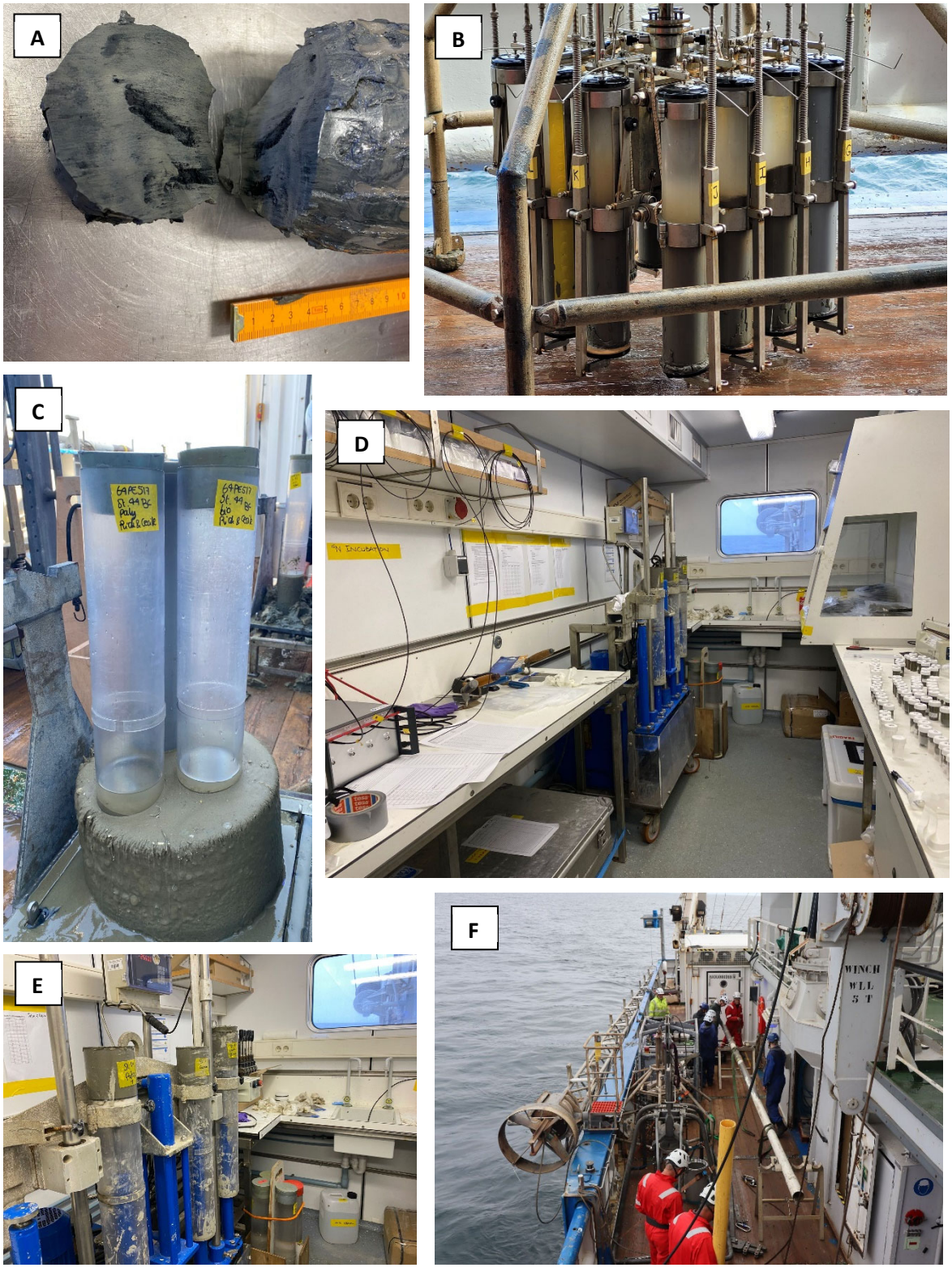

Figure 6. A: The bottom part of the core catcher including carbon rich black spots (station 110). B: Multi coring device including 12 cores. C: Since we were not able to take multicores, bottom material was too sandy/coarse grained, we used the box cores to retrieve our cores for paleo purposes (station 44). D: Our paleo container. E: Hydraulic slicer. F: Piston core deployment.

samples were taken from the palynology core as well and transferred into pre-weighed vials. Moreover, we retrieved from only a few stations, cores which were immediately frozen stored (-20°C).

After freezing these cores for at least 48 hours, the sediment was removed from the core liner and the core was rinsed quickly to remove smeared material on the outside. The exposed fresh material from the intact cores was photographed, packed in aluminum plastic bags which were sealed and returned to storage at -20 °C. The stations from which we have collected a frozen core are: 5, 11, 16, 22, 30, 39 43, 49, 57, 62, 67, 71, and 84.

Oxic sediment slicing using the hydraulic slicer (Cecile Hilgen and Rick Hennekam)

Upon arrival on deck, the sediment cores were labelled and brought to the container (Figure 6D) in which the sediment material from every station (either Box Core or Multi Core, depending on sediment availability and hardness of sub-surface) was sliced into sample bags at 7 °C. The sample bags, which are organic geochemistry proof plastic bags, were labelled with: 64PE517, station number, type of core, and the depth interval. Generally, from every station, a total of three cores were sliced using a hydraulic slicer (Figure 6E), fish wire, and metal spatulas. Most of the remaining bottom water was siphoned off using a plastic tube and any remaining water was removed with a 20 ml syringe prior to slicing. One core was sliced for palynology, one core for biomarkers, and one core for "oxic" (i.e., not processed under anoxic conditions) samples for various biogeochemical analysis for Lucia Kranawetter and Peter Kraal. We also sampled, in separate pre-weighed vials instead of sampling bags, for porosity and short-lived isotopes from the palynology core. To ensure the integrity of short-lived isotopes analysis, we specifically collected the inner sediment from the core. This measure was taken to avoid potential contamination from younger material that may have smeared at the inner walls of the sampling tubes. Clearly, the sampling resolution is important for this method and during the NoSE cruise we therefore sampled at high 5-mm resolution for at least the top 10 cm and for several cores the complete core (see Table 13). We first aimed to sample at an even higher 2-mm resolution for the top 2 cm, but this was deemed impossible due to the liquid nature of the top sediment. Note that we will aim to preferably use the samples for palynology also for biomarkers to allow for an optimal comparison. The Palynology and Biomarker cores were sampled at 0.5-cm resolution throughout the entire cores. Besides these cores, we sliced Br (at certain key stations) and Oxic cores (for porosity and other measurements done by Lucia Kranawetter and Peter Kraal) following a different sampling scheme (0.5-cm resolution for the top 2 cm, 1-cm resolution from 2-10 cm, 2-cm resolution from 10-20 cm, and 4-cm resolution for the rest of the cores). Prior to the Br core slicing we took a bottom water sample with a syringe. We did not include the outer 0.5 cm of the material to avoid contamination from other material leaking through the sides of the tubes and filled small tubes which were used to centrifuge them immediately after the slicing. The Oxic cores were transferred into pre-weighed vials and the remaining part was transferred into the sample bags and stored at -20 °C.

Long sediment cores using the piston- and gravity corer (Cecile Hilgen, Anna Enge, Cuun Koek, Furu Mienis, Rick Hennekam)

Four successful long cores were recovered for the purpose of paleo-reconstructions in this region (Fig. 2F). Three cores at transect 1, 2 and 3 (stations 32, 58, 110) were recovered using the piston corer (9-m long liner; longer was not possible due to positioning of the UItraclean CTD container); where the core is brought into free fall for several meters when the trigger/trip core touches the sediment. Besides the piston cores, the trigger core and core catcher were occasionally also retrieved (Figure 6A; Table 13). The first piston core (station 32) triggered at the wrong time, when the piston core was already pulled back upwards to the surface, meaning it remains uncertain whether it penetrated just once or more. One core (station 125) was recovered using the gravity core device (9-m long liner); where the long steel tube is lowered into the sediment using the winch at a speed of about ~50m/minute. One other Gravity Core station (station 124) failed (bend pipe), probably due to a too

rocky terrain. No material was stored from this core. We generally opted for piston cores instead of gravity cores to obtain a maximum amount of material. The gravity core station was done to compare the length of the two coring devices. In this case the gravity core was about half the size of the piston cores, however, we did see a perfect preservation of the top material in the last gravity core section, while this was clearly disturbed for the piston cores.

On deck, the cores were split into 1-m sections. After cutting the core sections, the top sections were filled up with foam and paper until the sediment surface, to avoid movement of the sediment material when transported in a horizontal position. The core sections were stored in 4°C storage together with the core catcher material (Figure 7). The core catcher material was sampled on a resolution of 2 to 4 cm in sample bags. The trip core of the piston core was only stored in one occasion (station 110), as it was either empty or clearly penetrated too deep into the sediment on other occasions. Upon arrival at NIOZ, further processing, such as XRF-core-scanning, will be organized. At NIOZ, the core sections will first be opened, photographed in high resolution with the XRF core scanner ("linescanning"), and described in detail. See Table 13 for more detailed information on the piston cores and gravity core, such as locations, length, and at which condition it was stored on the research vessel Pelagia and at NIOZ.

Figure 7: A. Fridge (4 °C) with stored gravity and piston cores (yellow tubes), multicores and box-cores (archive and XRF) and vials from the palynology cores. B: Fridge (4 °C) with stored box- and multicores.

Sedimentary burial and recycling of nutrients (Lucia Kranawetter and Peter Kraal)

In work package two, the overall aim is to quantify benthic burial and recycling processes and their role in carbon and nutrient transport into and through the Norwegian Trench, eastern deep North Sea. For this reason, different methods were applied to collect water and sediment-samples, sediment profiles and experimental data which can be used to calculate nutrient fluxes across the sediment-water interface (SWI).

Box-cores and multi-cores were used to collect sediment cores. The recovered sediment was checked for absence of disturbance during sampling. Below follows a description of the samples processing and/or analysis that was applied to sediment from selected cores. To see which selected cores for the various activities, please consult Table 14 (64PE517 core overview).

Micro-profiling

Micro-scale gradients in dissolved species control exchange across the sediment-water interface and reveal the impact of processes at the micro-scale, for instance pH as affected by respiration and possible oxidation of reduced species in the uppermost sediment. Therefore, micro-scale profiles of

Table 14. Core overview.

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	28/05/2023 09:56	1	1-1	3	BC		GUST		Sediment discarded
64PE517	28/05/2023 09:56	1	1-1	3	BC		GUST		Sediment discarded
64PE517	28/05/2023 09:56	1	1-1	3	BC		Micro-profiling		Sediment discarded
64PE517	28/05/2023 09:56	1	1-1	3	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	28/05/2023 11:33	1	1-1	4	BC		Anoxic slicing		Sediment stored under N2 at -20°C
64PE517	28/05/2023 11:33	1	1-1	4	BC		Oxic slice		Sediment stored at -20°C
64PE517	28/05/2023 11:33	1	1-1	4	BC		Paly		
64PE517	28/05/2023 11:33	1	1-1	4	BC		XRF		
64PE517	28/05/2023 12:02	1	1-1	5	BC		Archive -20C		
64PE517	28/05/2023 12:02	1	1-1	5	BC		Archive 4C		
64PE517	29/05/2023 08:26	1	1-2	10	BC		GUST		Sediment discarded
64PE517	29/05/2023 08:26	1	1-2	10	BC		GUST		Sediment discarded
64PE517	29/05/2023 08:26	1	1-2	10	BC		Micro-profiling		Sediment discarded
64PE517	29/05/2023 08:26	1	1-2	10	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	29/05/2023 08:52	1	1-2	11	MC	Anoxic slicing			Sediment samples stored under N_2 at -20°C
64PE517	29/05/2023 08:52	1	1-2	11	MC	Archive -20C			
64PE517	29/05/2023 08:52	1	1-2	11	MC	Bio			
64PE517	29/05/2023 08:52	1	1-2	11	MC	CH_4 sampling			Sediment preserved in NaCl at room temperature
64PE517	29/05/2023 08:52	1	1-2	11	MC	Oxic slice			Sediment stored at -20°C
64PE517	29/05/2023 08:52	1	1-2	11	MC	Paly		Isotopes	
64PE517	29/05/2023 08:52	1	1-2	11	MC	XRF			

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	29/05/2023 09:40	1	1-2	12	MC	Archive 4C			
64PE517	29/05/2023 09:40	1	1-2	12	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	29/05/2023 09:40	1	1-2	12	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	29/05/2023 09:40	1	1-2	12	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	29/05/2023 09:40	1	1-2	12	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	29/05/2023 09:40	1	1-2	12	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	29/05/2023 09:40	1	1-2	12	MC	Micro-profiling			Sediment discarded
64PE517	29/05/2023 15:00	1	1-3	15	BC			Fauna, OC	
64PE517	29/05/2023 15:38	1	1-3	16	MC	Archive -20C			
64PE517	29/05/2023 15:38	1	1-3	16	MC	Archive 4C			
64PE517	29/05/2023 15:38	1	1-3	16	MC	Bio			
64PE517	29/05/2023 15:38	1	1-3	16	MC	Paly		Isotopes	
64PE517	29/05/2023 15:38	1	1-3	16	MC	XRF			
64PE517	30/05/2023 11:13	1	1-4	21	BC			Fauna, OC	
64PE517	30/05/2023 11:55	1	1-4	22	MC	Anoxic slicing			Samples stored under N_2 at -20°C
64PE517	30/05/2023 11:55	1	1-4	22	MC	Archive -20C			
64PE517	30/05/2023 11:55	1	1-4	22	MC	Archive 4C			
64PE517	30/05/2023 11:55	1	1-4	22	MC	Bio			
64PE517	30/05/2023 11:55	1	1-4	22	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	30/05/2023 11:55	1	1-4	22	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	30/05/2023 11:55	1	1-4	22	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	30/05/2023 11:55	1	1-4	22	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	30/05/2023 11:55	1	1-4	22	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	30/05/2023 11:55	1	1-4	22	MC	Oxic slice			Sediment stored at -20°C
64PE517	30/05/2023 11:55	1	1-4	22	MC	Paly		Isotopes	
64PE517	30/05/2023 11:55	1	1-4	22	MC	XRF			
64PE517	30/05/2023 12:19	1	1-4	23	MC		GUST		Sediment discarded
64PE517	30/05/2023 12:19	1	1-4	23	MC		GUST		Sediment discarded
64PE517	30/05/2023 12:19	1	1-4	23	MC		Micro-profiling		Sediment discarded
64PE517	31/05/2023 07:11	1	1-5	28	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	31/05/2023 07:46	1	1-5	29	MC FAILED				
64PE517	31/05/2023 07:57	1	1-5	30	MC	Archive -20C			
64PE517	31/05/2023 07:57	1	1-5	30	MC	Archive 4C			
64PE517	31/05/2023 07:57	1	1-5	30	MC	Bio			
64PE517	31/05/2023 07:57	1	1-5	30	MC	Oxic slice			Sediment stored at -20°C
64PE517	31/05/2023 07:57	1	1-5	30	MC	Paly		Isotopes	
64PE517	31/05/2023 15:20	1	1-2	33	BC		$^{15}NO_3$ incubation		10 subcores taken from BC
64PE517	31/05/2023 15:49	1	1-2	34	BC		$^{15}NO_3$ incubation		10 subcores taken from BC

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	06/01/2023 08:52	2	2-5	37	BC		Bio		
64PE517	06/01/2023 08:52	2	2-5	37	BC		GUST		Sediment discarded
64PE517	06/01/2023 08:52	2	2-5	37	BC		Paly	Isotopes	
64PE517	06/01/2023 08:52	2	2-5	37	BC		XRF		
64PE517	06/01/2023 08:52	2	2-5	37	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	06/01/2023 09:10	2	2-5	38	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	06/01/2023 09:31	2	2-5	39	BC		Archive -20C		
64PE517	06/01/2023 09:31	2	2-5	39	BC		Archive 4C		
64PE517	06/01/2023 09:31	2	2-5	39	BC		Oxic slice		Sediment stored at -20°C
64PE517	06/01/2023 14:15	2	2-4	42	BC		GUST		Sediment discarded
64PE517	06/01/2023 14:33	2	2-4	43	BC		Archive -20C		
64PE517	06/01/2023 14:33	2	2-4	43	BC		Archive 4C		
64PE517	06/01/2023 14:33	2	2-4	43	BC		Oxic slice		Sediment stored at -20°C
64PE517	06/01/2023 14:50	2	2-4	44	BC		Bio		
64PE517	06/01/2023 14:50	2	2-4	44	BC		Paly		
64PE517	06/01/2023 14:50	2	2-4	44	BC		XRF		
64PE517	06/01/2023 14:50	2	2-4	44	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	06/02/2023 09:54	2	2-3	48	BC		GUST		Sediment discarded
64PE517	06/02/2023 09:54	2	2-3	48	BC		Micro-profiling		Sediment discarded
64PE517	06/02/2023 09:54	2	2-3	48	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	06/02/2023 11:18	2	2-3	49	MC	Anoxic slicing			Sediment samples stored under N_2 at -20°C

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	06/02/2023 11:18	2	2-3	49	MC	Archive -20C			
64PE517	06/02/2023 11:18	2	2-3	49	MC	Archive 4C			
64PE517	06/02/2023 11:18	2	2-3	49	MC	Bio			
64PE517	06/02/2023 11:18	2	2-3	49	MC	Oxic slice			Sediment stored at -20°C
64PE517	06/02/2023 11:18	2	2-3	49	MC	Paly		Isotopes	
64PE517	06/02/2023 15:47	2	2-2	52	BC				No sampling
64PE517	06/02/2023 16:47	2	2-2	53	BC		$^{15}NO_3$ incubation		10 subcores taken from BC
64PE517	06/02/2023 17:12	2	2-2	54	BC		$^{15}NO_3$ incubation		10 subcores taken from BC
64PE517	06/03/2023 06:15	2	2-2	56	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/03/2023 06:15	2	2-2	56	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/03/2023 06:15	2	2-2	56	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/03/2023 06:15	2	2-2	56	MC	GUST			Sediment discarded
64PE517	06/03/2023 06:15	2	2-2	56	MC	GUST			Sediment discarded
64PE517	06/03/2023 06:15	2	2-2	56	MC	Rhizon			
64PE517	06/03/2023 06:56	2	2-2	57	MC	Micro-profiling			Sediment discarded
64PE517	06/03/2023 06:56	2	2-2	57	MC	Anoxic slicing			Sediment samples stored under N_2 at -20°C
64PE517	06/03/2023 06:56	2	2-2	57	MC	Archive -20C			
64PE517	06/03/2023 06:56	2	2-2	57	MC	Archive 4C			
64PE517	06/03/2023 06:56	2	2-2	57	MC	Bio			
64PE517	06/03/2023 06:56	2	2-2	57	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	06/03/2023 06:56	2	2-2	57	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	06/03/2023 06:56	2	2-2	57	MC	CH_4 sampling			Sediment preserved in NaCl at room temperature
64PE517	06/03/2023 06:56	2	2-2	57	MC	Oxic slice			Sediment stored at -20°C
64PE517	06/03/2023 06:56	2	2-2	57	MC	Paly		Isotopes	
64PE517	06/03/2023 06:56	2	2-2	57	MC	XRF			
64PE517	06/03/2023 14:12	2	2-1	61	BC		Micro-profiling		Sediment discarded
64PE517	06/03/2023 14:12	2	2-1	61	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	06/03/2023 14:43	2	2-1	62	MC	$^{35}SO_4$ sampling			Sediment samples stored under N_2 at -20°C
64PE517	06/03/2023 14:43	2	2-1	62	MC	Archive -20C			
64PE517	06/03/2023 14:43	2	2-1	62	MC	Archive 4C			
64PE517	06/03/2023 14:43	2	2-1	62	MC	Bio			
64PE517	06/03/2023 14:43	2	2-1	62	MC	CH_4 sampling			Sediment preserved in NaCl at room temperature
64PE517	06/03/2023 14:43	2	2-1	62	MC	GUST			Sediment discarded
64PE517	06/03/2023 14:43	2	2-1	62	MC	GUST			Sediment discarded
64PE517	06/03/2023 14:43	2	2-1	62	MC	GUST			Sediment discarded
64PE517	06/03/2023 14:43	2	2-1	62	MC	Oxic slice			Sediment stored at -20°C
64PE517	06/03/2023 14:43	2	2-1	62	MC	Paly		Isotopes	
64PE517	06/03/2023 14:43	2	2-1	62	MC	Rhizon			
64PE517	06/03/2023 14:43	2	2-1	62	MC	XRF			
64PE517	06/04/2023 13:09	3	3-4	66	BC		GUST		Sediment discarded

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	06/04/2023 13:09	3	3-4	66	BC		GUST		Sediment discarded
64PE517	06/04/2023 13:09	3	3-4	66	BC			Fauna, OC	
64PE517	06/04/2023 13:47	3	3-4	67	MC	Micro-profiling			Sediment discarded
64PE517	06/04/2023 13:47	3	3-4	67	MC	Anoxic slicing			Sediment samples stored under N_2 at -20°C
64PE517	06/04/2023 13:47	3	3-4	67	MC	Archive -20C			
64PE517	06/04/2023 13:47	3	3-4	67	MC	Archive 4C			
64PE517	06/04/2023 13:47	3	3-4	67	MC	Bio			
64PE517	06/04/2023 13:47	3	3-4	67	MC	Paly		Isotopes	
64PE517	06/04/2023 13:47	3	3-4	67	MC	Rhizon			Sediment stored under N_2 at -20°C
64PE517	06/05/2023 07:19	3	3-5	71	BC		Archive -20C		
64PE517	06/05/2023 07:19	3	3-5	71	BC		GUST		Sediment discarded
64PE517	06/05/2023 07:19	3	3-5	71	BC		GUST		Sediment discarded
64PE517	06/05/2023 07:19	3	3-5	71	BC		Micro-profiling		Sediment discarded
64PE517	06/05/2023 07:19	3	3-5	71	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	06/05/2023 07:49	3	3-5	72	BC		Archive 4C		
64PE517	06/05/2023 07:49	3	3-5	72	BC		GUST		Sediment discarded
64PE517	06/05/2023 07:49	3	3-5	72	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	06/05/2023 08:08	3	3-5	73	BC		Bio		
64PE517	06/05/2023 08:08	3	3-5	73	BC		Oxic slice		Sediment stored at -20°C
64PE517	06/05/2023 08:08	3	3-5	73	BC		Paly	Isotopes	
64PE517	06/05/2023 08:08	3	3-5	73	BC		XRF		
64PE517	06/05/2023 14:58	3	3-3	76	BC		GUST		Sediment discarded
64PE517	06/05/2023 14:58	3	3-3	76	BC		GUST		Sediment discarded

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	06/05/2023 14:58	3	3-3	76	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	06/05/2023 15:35	3	3-3	77	BC		$^{15}NO_3$ incubation		10 sub cores taken from BC
64PE517	06/05/2023 16:02	3	3-3	78	BC		$^{15}NO_3$ incubation		10 sub cores taken from BC
64PE517	06/05/2023 17:06	3	3-3	79	MC	Anoxic slicing			Sediment samples stored under N_2 at -20°C
64PE517	06/05/2023 17:06	3	3-3	79	MC	Bio			
64PE517	06/05/2023 17:06	3	3-3	79	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	06/05/2023 17:06	3	3-3	79	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	06/05/2023 17:06	3	3-3	79	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/05/2023 17:06	3	3-3	79	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/05/2023 17:06	3	3-3	79	MC	GUST			Sediment discarded
64PE517	06/05/2023 17:06	3	3-3	79	MC	GUST			Sediment discarded
64PE517	06/05/2023 17:06	3	3-3	79	MC	Micro-profiling			Sediment discarded
64PE517	06/05/2023 17:06	3	3-3	79	MC	Paly		Isotopes	
64PE517	06/05/2023 17:06	3	3-3	79	MC	XRF			
64PE517	06/06/2023 09:11	4	4-2	83	BC				No sampling
64PE517	06/06/2023 09:50	4	4-2	84	MC	Archive -20C			
64PE517	06/06/2023 09:50	4	4-2	84	MC	Archive 4C			
64PE517	06/06/2023 09:50	4	4-2	84	MC	Bio			
64PE517	06/06/2023 09:50	4	4-2	84	MC	CH_4 sampling			Sediment preserved in

									NaCl at room temperature
Cruise	**Date**	**Transect**	**Alias**	**Station**	**Core-type**	**Experiment**	**Sub core**	**Sample**	**Detailed information**
64PE517	06/06/2023 09:50	4	4-2	84	MC	CH_4 sampling			Sediment preserved in NaCl at room temperature
64PE517	06/06/2023 09:50	4	4-2	84	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/06/2023 09:50	4	4-2	84	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/06/2023 09:50	4	4-2	84	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/06/2023 09:50	4	4-2	84	MC	Micro-profiling			Sediment discarded
64PE517	06/06/2023 09:50	4	4-2	84	MC	Oxic slice			Sediment stored at -20°C
64PE517	06/06/2023 09:50	4	4-2	84	MC	Paly		Isotopes	
64PE517	06/06/2023 09:50	4	4-2	84	MC	XRF			
64PE517	06/06/2023 10:15	4	4-2	85	MC	Anoxic slicing			Sediment samples stored under N_2 at -20°C
64PE517	06/06/2023 10:15	4	4-2	85	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	06/06/2023 10:15	4	4-2	85	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	06/06/2023 10:15	4	4-2	85	MC	GUST			Sediment discarded
64PE517	06/06/2023 10:15	4	4-2	85	MC	GUST			Sediment discarded
64PE517	06/06/2023 10:15	4	4-2	85	MC	Test cores			
64PE517	06/07/2023 09:16	4	4-4	91	BC			Fauna, OC	
64PE517	06/07/2023 10:00	4	4-4	92	MC	$^{35}SO_4$ sampling			Sediment samples stored under N_2 at -20°C

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	06/07/2023 10:00	4	4-4	92	MC	Anoxic slicing			Sediment samples stored under N_2 at -20°C
64PE517	06/07/2023 10:00	4	4-4	92	MC	Bio			
64PE517	06/07/2023 10:00	4	4-4	92	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	06/07/2023 10:00	4	4-4	92	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/07/2023 10:00	4	4-4	92	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/07/2023 10:00	4	4-4	92	MC	GUST			Sediment discarded
64PE517	06/07/2023 10:00	4	4-4	92	MC	Micro-profiling			Sediment discarded
64PE517	06/07/2023 10:00	4	4-4	92	MC	Oxic slice			Sediment stored at -20°C
64PE517	06/07/2023 10:00	4	4-4	92	MC	Paly			
64PE517	06/07/2023 10:00	4	4-4	92	MC	Test cores			
64PE517	06/07/2023 10:00	4	4-4	92	MC	XRF			
64PE517	06/07/2023 15:41	4	4-5	95	BC			Fauna, OC	
64PE517	06/07/2023 17:03	4	4-5	96	MC	Archive 4C			
64PE517	06/07/2023 17:03	4	4-5	96	MC	Bio			
64PE517	06/07/2023 17:03	4	4-5	96	MC	Paly		Isotopes	
64PE517	06/07/2023 17:03	4	4-5	96	MC	XRF			
64PE517	06/08/2023 09:26	4	4-1	100	BC		GUST		Sediment discarded
64PE517	06/08/2023 09:26	4	4-1	100	BC		GUST		Sediment discarded
64PE517	06/08/2023 09:26	4	4-1	100	BC		Paly	Isotopes	
64PE517	06/08/2023 09:26	4	4-1	100	BC		XRF		
64PE517	06/08/2023 09:26	4	4-1	100	BC			Fauna, OC	
64PE517	06/08/2023 09:58	4	4-1	101	BC failed				

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	06/08/2023 17:07	4	4-3	103	BC		$^{35}SO_4$ sampling		Sediment samples stored under N2 at -20°C
64PE517	06/08/2023 17:07	4	4-3	103	BC		GUST		Sediment discarded
64PE517	06/08/2023 17:07	4	4-3	103	BC		GUST		Sediment discarded
64PE517	06/08/2023 17:07	4	4-3	103	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	06/08/2023 17:54	4	4-3	104	MC	Anoxic slicing			Sediment samples stored under N_2 at -20°C
64PE517	06/08/2023 17:54	4	4-3	104	MC	Archive 4C			
64PE517	06/08/2023 17:54	4	4-3	104	MC	Bio			
64PE517	06/08/2023 17:54	4	4-3	104	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	06/08/2023 17:54	4	4-3	104	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	06/08/2023 17:54	4	4-3	104	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/08/2023 17:54	4	4-3	104	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/08/2023 17:54	4	4-3	104	MC	GUST			Sediment discarded
64PE517	06/08/2023 17:54	4	4-3	104	MC	GUST			Sediment discarded
64PE517	06/08/2023 17:54	4	4-3	104	MC	Oxic slice			Sediment stored at -20°C
64PE517	06/08/2023 17:54	4	4-3	104	MC	Paly		Isotopes	
64PE517	06/08/2023 17:54	4	4-3	104	MC	XRF			
64PE517	06/10/2023 15:18	3	3-2	114	BC		GUST		Sediment discarded
64PE517	06/10/2023 15:18	3	3-2	114	BC		GUST		Sediment discarded

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	06/10/2023 15:18	3	3-2	114	BC			Fauna, OC	Sediment sieved, fauna preserved in formalin
64PE517	06/10/2023 15:49	3	3-2	115	MC	$^{35}SO_4$ sampling			Sediment samples stored under N_2 at -20°C
64PE517	06/10/2023 15:49	3	3-2	115	MC	Archive 4C			
64PE517	06/10/2023 15:49	3	3-2	115	MC	Bio			
64PE517	06/10/2023 15:49	3	3-2	115	MC	CH_4 sampling			Sediment preserved in NaCl at room temperature
64PE517	06/10/2023 15:49	3	3-2	115	MC	DGT-DET			Sediment discarded
64PE517	06/10/2023 15:49	3	3-2	115	MC	DGT-DET			Sediment discarded
64PE517	06/10/2023 15:49	3	3-2	115	MC	GUST			Sediment discarded
64PE517	06/10/2023 15:49	3	3-2	115	MC	GUST			Sediment discarded
64PE517	06/10/2023 15:49	3	3-2	115	MC	Micro-profiling			Sediment discarded
64PE517	06/10/2023 15:49	3	3-2	115	MC	Oxic slice			Sediment stored at -20°C
64PE517	06/10/2023 15:49	3	3-2	115	MC	Paly			
64PE517	06/10/2023 15:49	3	3-2	115	MC	XRF			
64PE517	06/11/2023 07:12	3	3-1	118	BC		GUST		Sediment discarded
64PE517	06/11/2023 07:12	3	3-1	118	BC		GUST		Sediment discarded
64PE517	06/11/2023 07:12	3	3-1	118	BC		Micro-profiling		
64PE517	06/11/2023 07:12	3	3-1	118	BC			Fauna, OC	
64PE517	06/11/2023 07:33	3	3-1	119	BC		$^{15}NO_3$ incubation		10 subcores taken from BC
64PE517	06/11/2023 07:54	3	3-1	120	BC failed				
64PE517	06/11/2023 08:14	3	3-1	121	BC		$^{15}NO_3$ incubation		10 subcores taken from BC
64PE517	06/11/2023 09:04	3	3-1	122	MC	Anoxic slicing			Sediment samples stored under N_2 at -20°C

Cruise	Date	Transect	Alias	Station	Core-type	Experiment	Sub core	Sample	Detailed information
64PE517	06/11/2023 09:04	3	3-1	122	MC	Archive 4C			
64PE517	06/11/2023 09:04	3	3-1	122	MC	Bio			
64PE517	06/11/2023 09:04	3	3-1	122	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	06/11/2023 09:04	3	3-1	122	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/11/2023 09:04	3	3-1	122	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/11/2023 09:04	3	3-1	122	MC	Flux incubation			Sediment sieved, fauna preserved in formalin
64PE517	06/11/2023 09:04	3	3-1	122	MC	Micro-profiling			Sediment discarded
64PE517	06/11/2023 09:04	3	3-1	122	MC	Oxic slice			Sediment stored at -20°C
64PE517	06/11/2023 09:04	3	3-1	122	MC	Paly			
64PE517	06/11/2023 09:04	3	3-1	122	MC	XRF			
64PE517	06/11/2023 09:24	3	3-1	123	MC	$^{35}SO_4$ sampling			Sediment samples stored under N_2 at -20°C
64PE517	06/11/2023 09:24	3	3-1	123	MC	Br incubation			Sediment discarded, porewater stored under N_2 at -20°C
64PE517	06/11/2023 09:24	3	3-1	123	MC	CH_4 sampling			Sediment preserved in NaCl at room temperature
64PE517	06/11/2023 09:24	3	3-1	123	MC	GUST			Sediment discarded

O_2, N_2O, redox and pH were obtained from the top few cm of the sediment to calculate gradients and rates across the SWI.

A sub-core from either the multi-cores (preferably divisible polycarbonate core tube) or the box corer (custom-made short cores) was taken and capped with a rubber stopper at the bottom. Measurements were done in dry lab (Chemistry lab). N_2 gas was blown over the water surface to establish laminar flow in the overlying water. A USB microscope and lights were used such that the SWI and the position

of the micro-electrodes were clearly seen (Figure 8). This was especially important to have 'zero' position accurately at the SWI. The Unisense motorized profiling system was used with sets of two electrodes: O_2-pH and redox-N_2O. The position of the two sensors was adjusted, so that the sensor-tips had the same vertical position (adjusted as well as possible). Duplicate profiles (at two locations in the horizontal plane) were taken for all sub-cores for each set of electrodes; using the manual part of the manipulator in the x and y direction, suitable new sediment areas were probed. For some sub-cores triplicate profiles (at three locations in the horizontal plane) were taken. The general settings were as follows:

Profiles were always started at 0.5 cm above and reached down to 2-3.5 cm below the SWI, after 0 has been set at the SWI. Usually, the step size was set to 150 µm. In total, 3 replicates were obtained for every measurement step, after 1 second waiting time for each replicate. The previous plan to place the core in a larger volume with in-situ water from CTD at in-situ temperature to buffer warming of the core was discarded after finishing Profile 1 (Station 3).

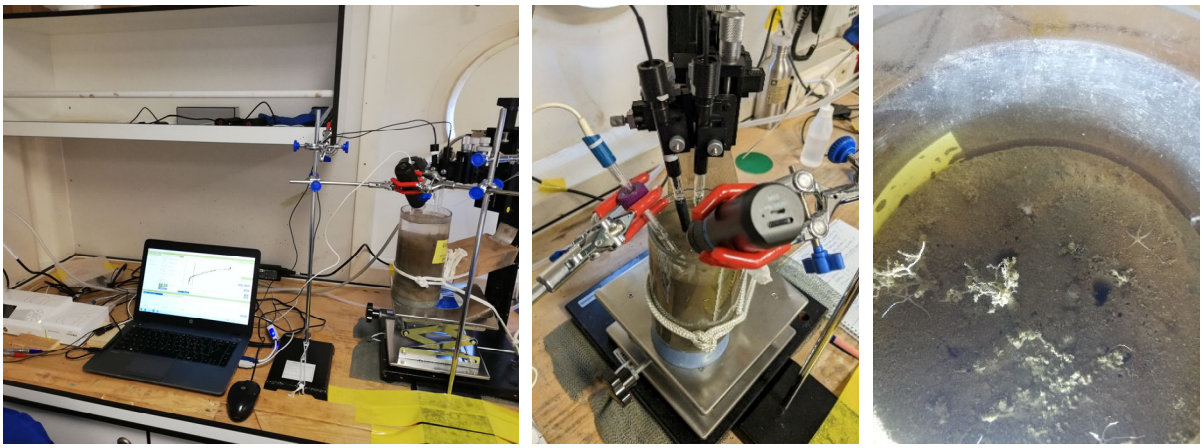

Figure 8. Micro-profiling set-up on the left; on the right sediment surface after micro-profiling (large holes caused by N_2O sensor).

N transformation rates (anammox, dentrification) by $^{15}NO_3$ whole-core incubation

Rates of denitrification and anammox can be determined to quantify N transformations and loss around in anaerobic surface sediment (Trimmer and Nicholls, 2009; Trimmer et al., 2013). The data complement sediment micro-profiling (O_2, N_2O, redox and pH), whole-core incubations for benthic fluxes (O_2, DIC, NH_4, NO_2, NO_3, DON, SRP, DOP), detailed pore-water and solid-phase analyses and DNA analysis (16S RNA) to unravel coupled biogeochemical C-N-P (re)cycling and constrain nutrient (export) budgets for the Norwegian Trench.

For this whole-core incubation experiment, sub-cores with overlying water were taken from box-cores (Figure 9) using Perspex core liners (30 cm long, 6 cm diameter; filled with sediment to about half of the length and the rest overlying bottom water). Bottom water from CTD was used to top up cores if needed. A total of 20 cores were collected for each of the four locations in the Trench where a $^{15}NO_3$ incubation experiment was performed (10 cores per box core, so two box cores per location).

The cores were capped at the bottom with a rubber stopper, topped up if needed, equipped with a small stainless steel/Teflon-coated stirrer and transferred into a holding container to a temp-controlled container at site bottom temperature. Each core was bubbled with air for equilibration overnight. Two cores were fitted with an O_2 optode sensor spot (Presens) on the inside to monitor O_2 during the incubation later on.

After equilibration, a 5-mL sample was taken from each core and filtered over 0.45-µm Nylon syringe filters for on-board analysis of total NO_3 and/or frozen storage. In 14 cores, the overlying water was amended with 15 uM $^{15}NO_3$ and 6 cores were left unamended. After adding $^{15}NO_3$, again a 5-mL sample was taken from each core for on-board analysis of total NO_3 and/or frozen storage (to obtain $^{14}NO_3/^{15}NO_3$ ratio in the overlying water, i.e. r14w). The required pre-incubation time was calculated using the measured O_2 penetration depth (cm) based on the obtained micro-profile and the diffusion properties of NO_3 (D_s) and the sediment (porosity; estimated), see Table 14. For the calculated pre-incubation time, the cores were left open with constant stirring and air bubbling gently to maintain O_2 saturation.

Figure 9. Perspex core liners in Box-corer (left); Cores with open caps and air supply equilibrating (middle); Sediment core before suspending it into a slurry (right).

After pre-incubation, 5 amended and 3 unamended cores were sacrificed as T0 measurement: the sediment was gently suspended into a slurry making sure all the sediment was in suspension; the suspension was then sampled with a large syringe and two gas-tight 12-mL Exetainers (pre-filled with 0.2 mL 37% formaldehyde) were filled up, not overflowing. This was done with PPE in a fume hood. These samples were shaken and stored upside down at 4 °C for later on-shore N_2 and N_2O analysis, respectively. The 12 remaining cores were capped with a rubber stopper and incubated under constant stirring.

The cores were incubated for ~24 h, the prescribed maximum O_2 loss of 20 % was never reached. Initial O_2 consumption was used to roughly estimate total allowed incubation duration. Four of the 12 amended cores were sacrificed over the incubation experiment at pre-determined time intervals. The 3 remaining unamended and 5 remaining amended cores were sacrificed at Tend (Table 15).

Table 15. Actual sampling scheme of ^{15}N incubation experiment with sediment cores from station 33 and 34.

Transect	Station	Estim. Sed porosity	F (Sediment resistivity)	DSed (Diffusivity SED)	O2 pen [cm]	Pre-Incubation time
1	10	0.9	1.14679222	9.68205E-06	1.1	8h40min
2	48	0.9	1.14679222	9.68205E-06	1.34	12h53min
3	76	0.9	1.14679222	9.68205E-06	2.59	48h07min
3	118	0.9	1.14679222	9.68205E-06	1.4275	14h38min

The incorporation of ^{15}N into anaerobic N transformation products (N_2O, N_2) will be quantified in collaboration with Prof. Mark Trimmer at Queen Mary University London after the expedition, from which rates of denitrification and anammox can be calculated.

Bio-irrigation rates by whole-core bromide incubation

Whole-core bromide incubation was used to calculate the bio-irrigation rate (Martin and Banta, 1992; Lenstra et al., 2019). This is a critical parameter in benthic exchange and required for proper parametrization of the small-scale reactive-transport models. For selected stations, two sediment cores (duplicates, in some instances one core due to sampling constraints) were collected from the multi-corer or the box corer. The overlying water was manipulated so that there was ~15 cm overlying water (1 L volume). To the water, 840 µL of a 5 M NaBr stock solution was added to achieve ~ 5 mM Br concentration (natural Br concentration is ~0.8 M, ~4.2 M was added). The cores were then incubated for ~ 2 days under constant bubbling with O_2, which keeps O_2 saturated and mixes the overlying water (Figure 10).

After incubation, cores were sliced at 0.5 - 4-cm resolution (Table 16) using the hydraulic slicer and pore-water was extracted by centrifugation (3000 rpm, ~20 min) and filtration using 0.45-µm Nylon filters. Pore-water samples were stored in 15-mL Falcon tubes at 4 °C for Cl and Br analysis. In some cases where sediment was relatively coarse, hanging filters were used or Rhizons were applied to the centrifuged sediment to obtain sufficient pore-water for on-shore Br analysis.

Figure 10. Set-up for whole-core bromide incubation.

Table 16. Br core sampling scheme.

Sample	Top	Bottom	Sample	Top	Bottom
1	0	0.5	14	12	14
2	0.5	1	15	14	16
3	1	1.5	16	16	18
4	1.5	2	17	18	20
5	2	3	18	20	24
6	3	4	19	24	28
7	4	5	20	28	32
8	5	6	21	32	36
9	6	7	22	36	40
10	7	8	23	40	44
11	8	9	24	44	48
12	9	10	25	48	52
13	10	12			

Benthic O_2 uptake and element fluxes with whole-core incubation

Measuring fluxes between the bottom water and the sediment are crucial to understand the role of sediment as a net source or sink of key species such as O_2, C, N and P. Changes in key parameters (DO, NH_4, NO_2, NO_3, DON, PO_4, DOP, DOC, DIC, TAlk) in the overlying water can be measured over time and from these time series fluxes into or out of the sediment can be calculated.

For selected stations, 10-cm sediment cores (divisible cores; duplicate or triplicate) were collected. The cores were measured and a stirrer and Presens O_2 sensor spot were placed. The cores were equilibrated overnight at temperatures as close to in-situ as could be achieved (5-7 °C) in an incubation tank with filtered bottom water collected by CTD that was bubbled with air using an aquarium pump (Figure 11). The cores were left open sop they could exchange with the water in the tank and remain oxygen-saturated. At the start of the incubation, cores were capped with gas-tight lids with gas-tight sampling ports. One port was connected to a jerry can with site air-purged (i.e. O_2-saturated) bottom water, the other port to a sampling port for a syringe. The cores were fitted with a holder to position the Presens fiber optic cable, which was connected to the OXY4 unit and then to the laptop, after which O_2 monitoring was started using Presens Measurement Studio 2 for continuous O_2 measurement over ~12 hours at 2-min intervals.

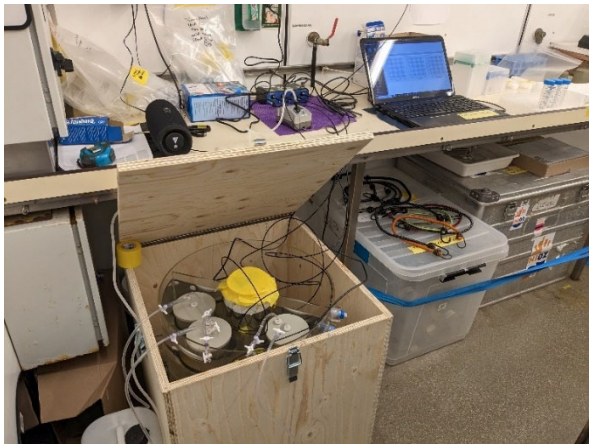

Figure 11. Set-up for whole-core incubation for benthic fluxes. Transparent tubing for sampling and water replenishment, black cables are fiber optics for O_2 monitoring.

At predetermined time intervals (6 sampling points over ~12 hours), discrete samples were taken using a 30-mL acid-washed plastic syringe, filtered over acid-washed 0.2 micrometer PES filters and sub-sampled for dissolved species (Table 17). After incubation, the sediment was sieved over 1 mm and the fauna was preserved in borax-buffered formalin in a plastic container.

Table 17. Benthic flux sub-sampling scheme.

Analyte	Vial	Label	Vol	Preservation	Store	Method	Where
Metals	4 mL Nalgene AW[1]	ICPMS	4	20 uL 5N sp HNO3	4 C	ICPMS	NIOZ
NH4,NO	5 mL pony vial	NH4,NO	3	-	4 C	AA	On-board
P, Si	5 mL pony vial	P, Si	2	20 uL 5N sp HCl	4 C	AA	On-board
TAlk	5 mL pony vial	TAlk	1.5	15 uL HgCl2			NIOZ
DIC	DIC glass vial	DIC	0.5	4.5 mL 41 g/L NaCl	4 C		NIOZ
DOC	DOC glass vial	DOC	4	10 uL 5 N sp HCl	4 C		NIOZ
DOP,DON	5 mL pony vial	DOP,DON	4	-	-20 C		NIOZ
		T0,Tend	19				

[1] acid-washed

Sediment sampling for pore-water CH_4

Organic-rich sediments can host methane-producing bacteria (methanogens) that thrive under sulfate-depleted conditions. The CH_4 is mobile and can affect chemistry in the overlying sediment (e.g. sulfate-methane transition zone).

For some stations, a multi-core tube pre-drilled with 16-mm holes set ~3 cm apart was used to sample for CH_4. Before deployment, the holes were covered with yellow tape on the outside of the core liner. After retrieval, the core was capped and immediately processed (CH_4 is gaseous and will escape to the atmosphere rapidly after core retrieval). With a cut-off syringe, a 5-mL wet sediment sample was obtained and transferred into a 65-mL infusion bottle partially filled with saturated NaCl (Figure 12). The bottle was rapidly topped up with sat. NaCl and closed with a rubber stopper and screw cap (a needle was pushed through the stopper to allow some NaCl solution to escape during closing). Samples were shaken and stored upside down.

At NIOZ, a N_2 or Ar headspace will be injected and after equilibration, a sample of the headspace will be injected into the GC-FID for quantification of CH_4.

Figure 12. Core with pre-drilled holes (left); sediment sample in infusion bottle filled with NaCl (right).

Anoxic core slicing and pore-water processing

Early diagenetic processes control the balance between recycling and burial of essential elements such as C, N and P. Their fate is intimately coupled to other important elements such as Fe, Mn and S. Measuring these elements in dissolved (pore-water) and solid-phase form provides detailed information about their release and sequestration in the sediment - from which burial efficiency and burial rates can be estimated, the latter in combination with ^{210}Pb and ^{14}C profiles to obtain age models and sedimentation rates.

For selected stations (see Table 14, core overview), cores were collected for slicing and pore-water sub-sampling. The core was capped and inspected to ensure the SWI was intact and transported into the temperature-controlled lab container set to ~5 C (close to bottom temperature).

Figure 13. Glove bag with set-up for anoxic core slicing.

A 20-mL bottom water sample was taken from the water overlying the sediment, using a syringe with a stopcock and tubing, this sample was kept in the temp-controlled container until it was processed together with the sediment pore-water samples. A disc was placed in the bottom of the core and excess overlying water was siphoned off. The core was then placed in the setup for anoxic core slicing in a N_2-purged glovebag (Figure 13). The remaining overlying water was removed and sections of 0.5 - 4 cm thickness (Table 18) were extruded and transferred into pre-weighed, pre-labelled 50-mL centrifuge tubes. After anoxic core slicing, the filled centrifuge tubes were taken from glovebag, balanced in the centrifuge buckets and centrifuged at 2500-3000 rpm for 30-60 minutes. Then, samples were transferred into a different N_2-purged glovebag for filtration with 20-mL syringe and 0.45 µm acid-cleaned PES filters (3 x mQ cleaned) into 15-mL Falcon (BULK), from which the sub-samples were

taken (Table 19). Centrifuged sediment was packed in N_2-purged Al-laminate bags and stored frozen at -20C for on-shore sediment analyses.

Alternatively, for station 62 and 67 pore-water was extracted with Rhizons using specially designed cores with predrilled holes for Rhizons; sampling resolution was slightly different (1 cm top 10 cm; 2 cm > 10 cm sediment depth).

Table 18. Pore-water core sampling scheme.

Sample	Top	Bottom	Sample	Top	Bottom
1	0	0.5	14	12	14
2	0.5	1	15	14	16
3	1	1.5	16	16	18
4	1.5	2	17	18	20
5	2	3	18	20	24
6	3	4	19	24	28
7	4	5	20	28	32
8	5	6	21	32	36
9	6	7	22	36	40
10	7	8	23	40	44
11	8	9	24	44	48
12	9	10	25	48	52
13	10	12			

Table 19. Pore-water sub-sampling scheme.

Analyte	Vial	Label	Vol	Preservation	Store	Method	Where
Metals	4 mL Nalgene AW1	ICPMS	1	10 uL 5N sp HNO3	4 C	ICPMS	NIOZ
NH4,NO	5 mL pony vial	NH4,NO	1.2	-	4 C	AA	On-board
P, Si	5 mL pony vial	P, Si	1	10 uL 5N sp HCl	4 C	AA	On-board
TAlk	5 mL pony vial	TAlk	1.2	15 uL HgCl2		AA	NIOZ
DIC	DIC glass vial	DIC	0.5	4.5 mL 41 g/L NaCl	4 C	AA	NIOZ
DOC	DOC glass vial	DOC	1.2	10 uL 1M sp HCl2	4 C	Shimadzu	NIOZ
DOP,DON	5 mL pony vial	DOP,DON	2	-	-20 C	TNTP	NIOZ
Sulfide	Glass vial	HS	0.5	1 mL NaOH solution, 1 mL ZnAc solution	4 C	Spectro	NIOZ

Sediment sampling for porosity (Cecile Hilgen, Rick Hennekam)

Bulk wet sediment can be collected in pre-weighed containers (and geochemical sampling bags) and freeze-dried. These samples provide the gravimetric water content from which porosity can be estimated, and provides an oxic bulk sample that can be used for ^{210}Pb analysis.

For each station, 10-cm sediment cores were collected. The core was loaded onto the hydraulic slicer and sliced at 0.5 - 4 cm resolution as pore-water and Br core, see sampling scheme below (Table 20

and 21). Samples were partially transferred into pre-weighed, labelled 20-mL plastic containers and stored frozen at -20 C, remainder was stored in geochemical sampling bag.

At NIOZ, the containers with frozen wet sediment will be weighed. The sediment will then be freeze-dried and weighed again. The freeze-dried sediment will be suitable for bulk analyses such as ^{210}Pb.

Table 20. Porosity core sampling scheme (done for station 4 and 11).

Sample	Top	Bottom	Sample	Top	Bottom
1	0	0.5	14	12	14
2	0.5	1.0	15	14	16
3	1.0	1.5	16	16	18
4	1.5	2	17	18	20
5	2	3	18	20	22
6	3	4	19	22	24
7	4	5	20	24	26
8	5	6	21	26	28
9	6	7	22	28	30
10	7	8	23	30	34
11	8	9	24	34	38
12	9	10	25	38	42
13	10	12			

Table 21. Porosity core sampling scheme (for other stations).

Sample	Top	Bottom	Sample	Top	Bottom
1	0	0.5	14	12	14
2	0.5	1	15	14	16
3	1	1.5	16	16	18
4	1.5	2	17	18	20
5	2	3	18	20	24
6	3	4	19	24	28
7	4	5	20	28	32
8	5	6	21	32	36
9	6	7	22	36	40
10	7	8	23	40	44
11	8	9	24	44	48
12	9	10	25	48	52
13	10	12			

Sediment sampling for sulfate reduction rates with $^{35}SO_4$ - test

Sediment samples can be injected with ^{35}S-SO_4, which is used by sulfate reducing bacteria and converted into sulfide and/or elemental sulfur. The elemental sulfur and sulfide pools are extracted and the radioactivity is measured. This can be used to calculate sulfate reduction rates with much higher accuracy compared to using SO_4 gradients in pore-water (Joergensen 1978; Fossing and Joergensen 1989). Sulfate reduction is a key metabolic pathway for anoxic OM degradation.

At selected stations, sediment sampling for sulfate reduction rates was performed. A 10-cm sediment core from the multi-corer with pre-drilled 16-mm holes (~3 cm spacing; same liner as for CH_4 sampling) for 5-mL syringes was recovered from the seafloor. Before deployment, the holes were covered with yellow tape on the outside of the core liner. After recovery, as soon as possible, the overlying water was removed by siphoning, the core stabilized by inserting oasis foam downward onto the SWI and

the core was placed horizontally. The tape was removed and some of the outer sediment was carefully removed with a small spatula to avoid contamination with surface water and sediment smeared along the core liner. Then, samples were taken with a plastic 5-mL syringe, transferred into labelled 50-mL Falcons which were immediately purged with N_2 and stored in N_2-purged Al-laminate bags at 4 °C (Figure 14).

At the home laboratory ('on shore'), sediment will be injected with $^{35}S\text{-}SO_4$ and transferred into 50-mL Falcon tubes in the radiation lab with all required precautions, immediately after the cruise. The samples will be incubated at a temperature close to in-situ (in the fridge) for 24h. Afterwards, 20 mL of 20% (200 g/L) zinc acetate will be added to halt the reaction and the samples will be stored frozen prior to analysis. Sediment will be washed and a multi-step or single-step extraction method will be used to recover sulfides and measure $^{35}S\text{-}S(-II)$ activity with liquid scintillation counting.

Figure 14. Stabilized core placed horizontally for sampling for $^{35}SO_4$ experiment.

Benthic fauna (Furu Mienis)

One quarter of a box core was sieved on a 1mm sieve and stored in 5% formaldehyde for later taxonomic analysis of benthic fauna (Table 14, Figure 15). Of each of these box cores a surface sediment sample was collected for organic carbon content. Samples were stored at 4 °C.

Figure 15. Examples of benthic fauna collected with box cores during cruise 64PE517.

Sediment Transport in the Norwegian Trench (Anna Enge)

To quantify the amount of carbon that is stored in sediments the mobility of sediments is an important parameter to identify. Knowledge about the potential and rate of sediment transport into and within the Norwegian Trench is used to estimate carbon transport by sediment transport from the North Sea into the Atlantic Ocean. In general, the transport of sediment is dependent on the sediment characteristics e.g., grain size and porosity and on the near-bed current velocities. If the sediment is resuspended depends on the critical shear stress velocity which is a function of the sediments specific grain size composition and water density. All three parameters are intended to be calculated on and after the cruise.

Box-cores and Multicores were used to collect samples on the transects 1-4 for grain size and porosity analysis as well as for the erosion experiment with the Gust chamber (Table 22). Detailed information about the Gust chamber experiments in given in Table 22 in the section of Methods. On both Moorings (St. 102: 62.292, 3.0337; St. 128: 60.3777, 4.2998) an ADCP (Signature1000, Nortek instrument) was attached to collect current velocity data at 20 m above the bed. On the southern Mooring (St. 128) an ADV (Vector4000, Nortek instrument) was attached 5 m above the bed to record turbulence data. Both Moorings will be collected, programmed, and deployed again during the next cruise in spring/summer 2024.

Table 22. Sediment sample overview about origin and usage

Station	Coordinates	Box-core grain size	Gust sample	BC/MC
3	59.1323, 4.4505	x	x	BC
10	59.1178, 3.8438	x		BC
12	59.1173, 3.8440		x	MC
15	59.0873, 3.4677	x		BC
16	59.0873, 3.4677		x	MC
21	59.0422, 3.9320	x		BC
23	59.0422, 2.9823		x	MC
28	59.0870, 2.4823	x		BC
30	59.0872, 2.4827		x	MC
37	60.3675, 2.7233	x	x	BC
42	60.3675, 3.1218	x	x (failed)	BC
48	60.3657, 3.4405	x	x (failed)	BC
49	60.3660, 3.4402		x (failed)	MC
52	60.3663, 3.8143	x	x (failed)	BC
56	60.3668, 3.8167		x	MC
61	60.3777, 4.2758	x		BC
62	60.3777, 4.2760		x (failed)	MC
66	61.4167, 2.6467	x		BC
67	61.4167, 2.6467		x	MC
71	61.2887, 2.1178	x	x (failed)	BC
76	61.5687, 3.0465	x	x	BC
79	61.5687, 3.0465		x	MC
83	62.3348, 3.0328	x	x	BC
85	62.3355, 3.0333		x	MC
91	62.6208, 2.3822	x	x	BC
95	62.4812, 1.8920	x	x	BC
100	62.7167, 3.3522	x	x	BC
103	62.7563, 2.8763	x	x (failed)	BC
104	62.7562, 2.8767		x	MC
114	61.7115, 3.5220	x	x	BC
115	61.7120, 3.5225		x	MC
118	61.8585, 3.8690	x	x	BC
122	61.8582, 3.8692		x	MC

Grain-size

From each box-core a subsample was taken to sample the first 10 cm of sediment. The subsample was taken with a syringe (length = 10 cm, diameter = 2 cm). The subsample was cut into 1 cm slices for the upper 5 cm and into 2 cm slices for the lower 5 cm. The samples were cooled in a fridge (4 °C). The grain size analysis will be conducted at Deltares with a Mastersizer3000.

Gust chamber experiment

The Gust chamber is "combination of a spinning disk and a central suction to generate nearly uniform shear stress across sediments in a cylindrical container" (Green Eyes, 2015) (Figure 16 and Table 23). It allows to measure erodibility of sediment over a calibrated range from 0.01 to 0.65 Pa. On board bed shear stress intervals of 0.05 Pa and 1 Pa are applied over the range from 0.1 to 0.65Pa for 2 -3 minutes. The key features are the calibration equations from Gust which relate the disc rotation to the central suction and temperature dependence. Therefore, bottom water from the UCC is used to run most of the experiments to reproduce as accurately as possible the in-situ density conditions. The effluent water is partly analysed for total suspended solids (TSS) to determine the concentration of the eroded material. As the turbidity meters were not calibrated in advance because the maximum concentration of sediment was unknown, the TSS are needed to back-calibrate the measured voltage output.

Figure 16. Gust chamber set up with sediment at the bottom and 10 cm water column.

*Table 23. Experimental runs with the Gust chamber on board **
*1/2 bottom, 1/2 warm (15 degree) saltwater ** saltwater from tab (15 degree)*

Station	Steps [Pa]	Time [min]	Water	Filter Peter	Filter concentration	Specialities
8	0.1	3	CTD bottom			offset -0.2 V
12	0.1	2	CTD bottom	x		offset -0.2 V
16	0.1	2	CTD bottom			offset -0.02 V
23	0.1	2	CTD bottom	x		
49	0.1	2	CTD bottom			
56	0.05	2	Mixed *		225 ml, 0.6 Pa	
67	0.05	2	Warm **	x	225 ml, 0.3, 0.4, 0.6 Pa	
71	0.1	3	Warm **	x	225 ml, 0.2, 0.4, 0.6 Pa	failed
76	0.05	2	Warm **		275 ml, 0.4, 0.6 Pa	
79	0.05	2	Warm **		225 ml, 0.6 Pa	
83	0.05	2	Warm **		225 ml, 0.4, 0.6 Pa	
85	0.05	2	CTD bottom	x	225 ml, 0.4, 0.6 Pa	
91	0.05	2	CTD bottom	x	275 ml, 0.3, 0.4, 0.6 Pa	
95	0.05	2	CTD bottom	x	225 ml, 0.3, 0.4, 0.6 Pa	
100	0.05	2	CTD bottom			
104	0.05	2	Mixed *	x	225 ml, 0.3, 0.4, 0.6 Pa	
114	0.05	2	CTD bottom	x	225 ml, 0.3, 0.4, 0.6 Pa	
118	0.05	2	CTD bottom	x	225 ml, 0.3, 0.4, 0.6 Pa	

Moorings (*Anna Enge, Furu Mienis, Marina Adler, Matthew Humphreys*)

Two moorings were deployed at the end of the expedition to measure abiotic water column characteristics and their temporal variability over one year. The moorings were equipped with a similar suite of instruments, including multiple current sensors, a Seabird Microcat CTD, a PPS5/2 Technicap sediment trap with a sampling carrousel with 24 jars rotating at a 14 day interval (Figure 18). On the sediment trap a datalogger attached to a Wetlabs FLNTU, an Advantech Rinko oxygen optode and pH sensor were mounted. Below the sediment trap a Signature1000 and Vector 4000 were mounted to measure near-bed hydrodynamics.

Signature1000

The two Signature1000 (4 Beam) were deployed on the Moorings (St. 102, St. 128) at 20 m over the bed (Figure 17). The instruments measure current velocities and directions with the Doppler Effect. They emit acoustic waves that are scattered on particles in the water columns. As the particles move passively their velocities and direction represents the velocity and direction of the water in which their float. Due to the particle movement, the acoustic wave that is scattered back to the ADCP receiver feels a phase shift. Based on the phase shift, water mass movement can be calculated very accurately. The Signature1000 were programmed to measure for 370 days with a sampling Frequency of 2 Hz. The bin length is 69 s and the bin interval 10 minutes. They are programmed to record a water profile of 20 m downwards with a resolution (cell size) of 0.7 m.

Vector4000

The Vector4000 was deployed on the southern Mooring (St. 128) at 5 m over the bed (Fig. 2). Equally to the Signatures it measures current velocities with the Doppler Effect. The difference to the Signature1000 is that it can measure at high frequency and allows to measure turbulence. Therefore, the sampling volume is limited to 14 cm^3.

The ADV4000 was programmed to measure for 370 days with a sampling frequency of 16 Hz. The bin length is 327 s and the bin interval 1h. The ADV includes an Inertial Motion Unit (IMU) which allows for movement correction afterwards as it is independent from the orientation of the ADV coordinate system itself.

pH sensors

In order to investigate annual, seasonal, and diurnal patterns in the pH of the Norwegian Trench we equipped two mooring stations with an AquapHOx-LX® Logger (Pyroscience GmBH, S/N: 22350009) equipped with a fixed NTC temperature sensor and a PyroScience pH optode sensor (FCD7-687-945, S/N: 223757438).

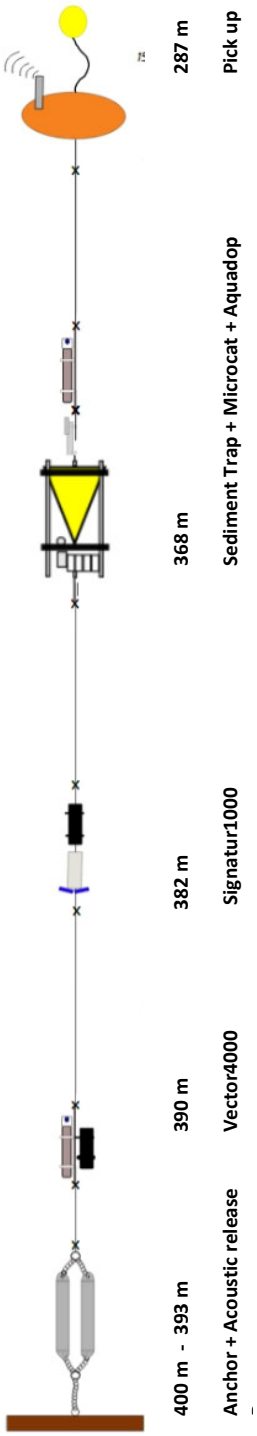

Figure 17. Modified sketch of Mooring 2 (St. 128). Depth of instruments is given with reference to 400 m bottom depth.

Figure 18. PPS5/2 sediment trap with Ph sensor attached.

Prior to deployment, the sensors were calibrated with two-point calibration and an additional pH offset-adjustment step (Table 24 and 25). First, the sensor was placed in a pH 2.0 calibration solution, then a pH 11.0 calibration solution prepared according to the manufacturer's guidelines. Last the sensor was placed in tris buffer (pH 8.281) then into filtered seawater until the deployment.

Table 24. Calibration data for the first mooring sensor.

Buffer	T (°C)	Reading	Calibration time (min)
pH 2	19.53	20.79	20
pH 11	19.00	55.87	20
Tris (pH 8.281)	19.18	35.66	15

Table 25. Calibration data for the second mooring sensor.

Buffer	T (°C)	Reading	Calibration time (min)
pH 2	17.87	21.76	20
pH 11	17.02	54.26	20
Tris (pH 8.281)	18.10	36.13	25

Settings for the stand-alone logging for the first mooring (Station 102):

a. Maximum low noise measurements
b. Temperature and pH logging every 10 minutes
c. Start of logging: 11:22 (UTC) 08-06-2023

Settings for the stand-alone logging for the second mooring (Station 128):

a. Maximum low noise measurements
b. Temperature and pH logging every 30 minutes
c. Start of logging: 19:00 (UTC) 10-06-2023

Benthic landers (*Furu Mienis*)

Two short deployments were made with aan ALBEX bottom lander (Figure 19). During the short deployments the ALBEX2 lander consisted of an alu tripod equipped with 12 glass Benthos™ floats, two IXSEA™ acoustic releasers, an Iridium beacon, radio beacon, flash light and large orange flag were attached to the frame to locate it after surfacing. Furthermore, the ALBEX2 lander was equipped with an Aquadopp profiler to measure current speed and direction at 10 m above the bottom, a combined Wetlabs FLNTU turbidity and fluorescence sensor, and an ARO-USB Advantech oxygen sensor. All sensors were programmed to collect data at 5-minute intervals. Three Advantech ATUD turbidity sensors were mounted at different heights above the bottom, at 40, 100 and 300 cm above bottom, respectively. In addition, a McLane particle pump (sample interval every 2 hours) and a NIOZ designed profile pump were attached to the frame. The profile pump was programmed to take samples at 6 depth intervals above the seafloor all at exactly the same time, which allowed for the collection of bottom water along a gradient (10-320 cm above the bottom). Samples were collected with profile sampler at the end of each short-term lander deployment. After retrieval subsamples were taken for oxygen, inorganic nutrients, DOC, DIC, total alkalinity and suspended matter (precombusted GGF filters, 25 mm).

At the end of the expedition the lander was prepared for a long-term deployment of one year. This lander was equipped with a PPS4/3 sediment trap with the aperture at 2.2 m above the bottom and a sampling carousel with 12 jars programmed to rotate every 28 days.

Figure 19. Deployment of the ALBEX lander (photo left). McLane pump on the ALBEX lander (photo right)

Ocean glider (*Matthew P. Humphreys and Furu Mienis*)

Introduction

The Norwegian Trench hosts a complex and highly variable water column which is impossible to fully characterise using traditional ship-based sampling. To better constrain continuous spatial and temporal variability, we deployed a semi-autonomous ocean glider for several days, which transited across one of the sampling transects. This marked the first deployment of an ocean glider by NIOZ (Figure 19).

Glider details

We deployed Slocum G3 Glider (Teledyne Marine/Webb Research, USA) “Mola” (unit_1034), which has rechargeable lithium batteries and an aft propellor. This glider has sensors for conductivity-temperature-depth (CTD, non-pumped), oxygen (optode), and chlorophyll fluorescence / turbidity / CDOM.

Preparations

A complete functional checkout was conducted following the protocol provided by the manufacturer on board RV Pelagia on 27th May 2023. All components of the glider were in full working order, including

the altimeter. It was difficult to obtain an Iridium signal on board, sometimes taking 20-30 minutes and requiring us to rotate the ship and/or move the glider to various different positions on deck.
A pre-water flight test was conducted on the morning before the deployment, again following the manufacturer's protocol, with no problems encountered.

Deployment

The deployment was carried out in the morning of 4th June 2023 at station 64 of the expedition (61.461°N, 002.670°E).
The glider was deployed from the side winch of Pelagia using the cart with automatic release system, such that the entry to the water was very gentle. The deployment ran very smoothly without the glider receiving any hits or shocks.
Initially the glider was deployed attached to a buoy with 20 m of neutrally buoyant line (Figure 20). Test dives to 3 m and 10 m were accomplished with Freewave control before removing the buoy and starting the glider on its transect with piloting via Iridium.

Figure 20. Photo left: Glider during preparation phase. Photo middle: glider deployment from the side winch with the auto-release module on the cart. Photo right: the glider in the man-overboard boat after recovery.

Flight

Initial dives were conducted with increasing depth down to 300 m with a single yo between surfaces. The seafloor at the deployment area was around 380 m. However, the glider did not detect the seafloor with its altimeter during the first two deeper test dives where this was supposed to happen. Instead, it appears that the glider landed on the seafloor and rested for around 5 minutes before returning to the surface. We conducted some tests via Iridium which showed that the altimeter was no longer working, for unknown reasons (presumably a loose connection inside the glider). We continued with the transect not allowing the glider to dive deeper than 300 m, as based on EMODnet bathymetry the water depth was mostly around 380 m and never shallower than 320 m. This decision to continue was made in consultation with and with the approval of a representative from the glider manufacturer. After recovery, an inspection found no damage to the glider, although a small amount of sediment had collected inside the nose cone (Figure 21).

Figure 21. Mud collected inside the nose of the glider.

The majority of the mission was conducted following a pattern of 3 dives to 300 m between each surfacing. This took around 3h10 between each surface moment. Piloting the glider was done entirely from on board Pelagia via Iridium and the manufacturer's SFMC interface. A reliable internet connection on the ship is absolutely critical for this operation.

The glider followed the planned trajectory mostly very well, using course corrections based on calculated current speeds and rarely if ever activating the propellor. The glider travelled on average at a horizontal speed of around 1 km/hour relative to the ground. The northeastern end of the transect was at 61.73°N, 003.75°E.

Recovery

The recovery was carried out in the morning of 10th June 2023 at station 111 of the expedition (61.532°N, 002.915°E).
The glider was recovered "by hand" from the man-overboard boat without any significant difficulties. There were four people on the boat: one pilot and three to recover the glider. We found that this is the exact complement required for a safe recovery – having one person fewer would have made the process challenging and potentially dangerous.
The glider was lifted back onto Pelagia from the man-overboard boat using the side winch.

Preliminary results

Figure 22 below shows the preliminary time series of seawater temperature data collected during our deployment. The vertical black line just after the start of 7th June indicates the northeastern end of the transect.

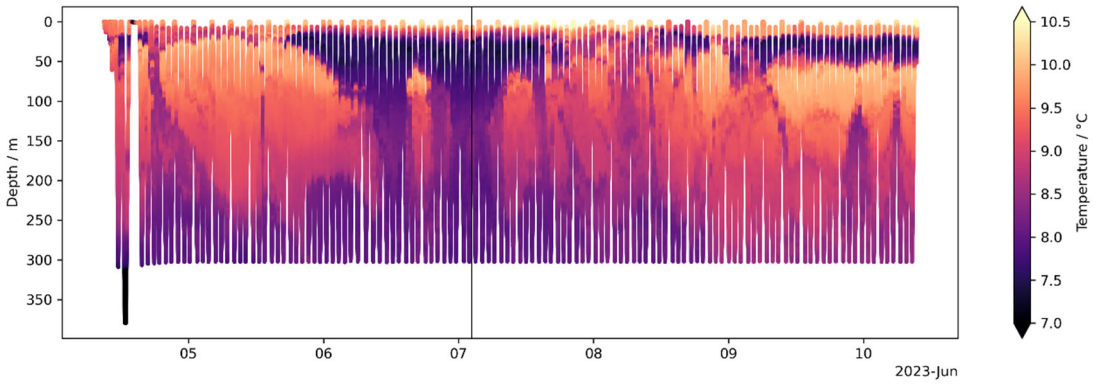

Figure 22. Seawater temperature data collected with the glider.

In figure 23 below the corresponding chlorophyll fluorescence dataset is shown. The data were nonsensical for a few hours near the start of the transect, but return to sensible values and patterns from the start of 5th June. Turbidity and CDOM data (from the same sensor) were also bad for the same period. This may have been caused by the unintended landings on the seafloor (e.g., some sediment covering the sensor), as the sensor is positioned on the underside of the glider.

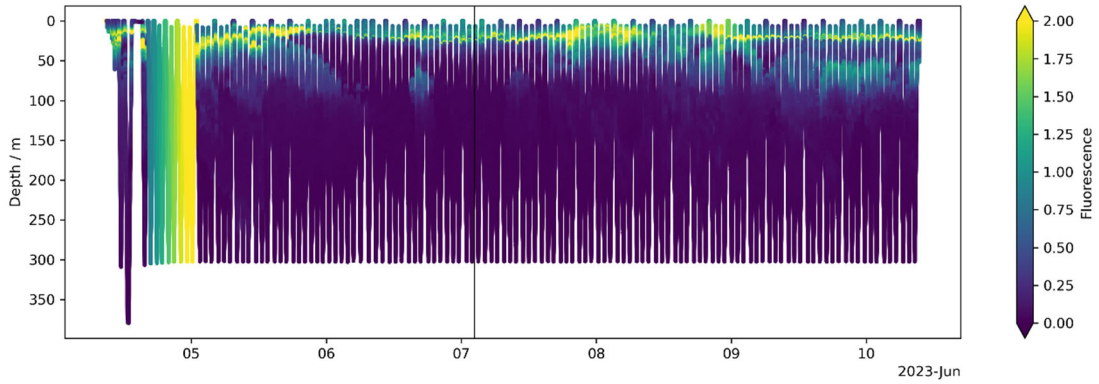

Figure 23. Seawater chlorophyll fluorescence data collected with the glider.

Outreach

Blog: 7 blog entries were made by shipboard scientific staff. These blogs written by cruise participants discussed the work done during the cruise (https://www.nioz.nl/en/blog/nose-expedition-to-the-norwegian-trench-26-may-14-june-2023).

Instagram project.NoSE2023: Instagram was used to introduce all NoSE PhDs as well as show pictures and short movies of the activities on board. Special posts were made on World Ocean Day (8 June).

Other media: On the day of arrival a radio interview at Nieuws en Co and a news item on television (NOS journal) were broadcasted, showing the link of NoSE with climate research. One week after the cruise a newspaper article in Trouw showcased the NoSE expedition.

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