ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

EXPEDITION PROGRAMME PS114

Polarstern

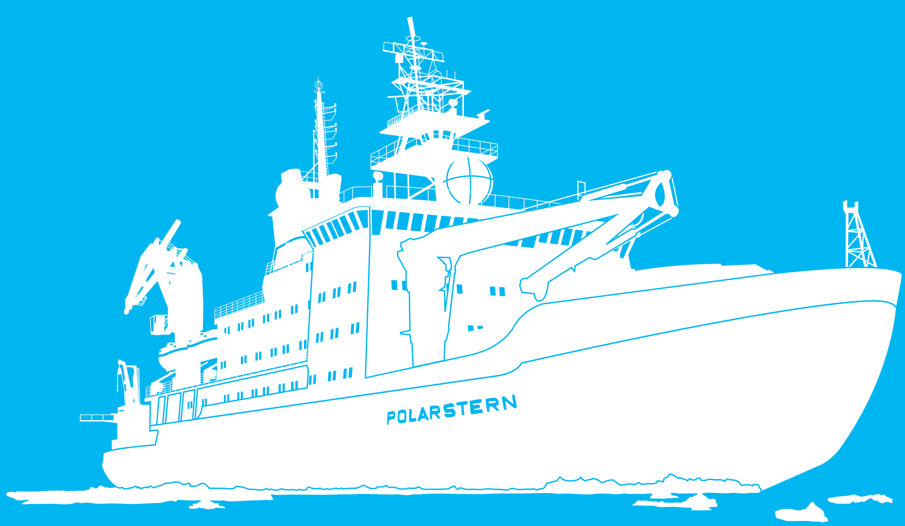
PS114

Bremerhaven - Tromsø

10 July 2018- 03 August 2018

Coordinator: Rainer Knust

Chief Scientist: Wilken-Jon von Appen



Bremerhaven, July 2018

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FRAM2018

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Contents

1. ÜBERBLICK UND FAHRTVERLAUF

Wilken-Jon von Appen
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Nach dem Auslaufen aus Bremerhaven am 20. Juli wird *Polarstern* Reise PS114 mit einem ca. 5 Tage langen Transit ins Arbeitsgebiet beginnen: die Fram-Straße zwischen Svalbard und Grönland. Die Reise wird um eine große Anzahl an Verankerungsaufnahmen und Verankerungsauslegungen, die mit der Helmholtz Infrastruktur Initiative FRAM in Verbindung stehen, herum strukturiert sein. Die Reise wird von Ost nach West das Arbeitsgebiet abfahren, um Verankerungen zu bedienen, die Teil sind von

(i) Langzeitbeobachtungen der Temperatur und des Transports im West Spitzbergen Strom,
(ii) Langzeitbeobachtungen der der Stoffflüsse ins Sediment an der Meereiskante,
(iii) einer Prozessstudie, die die Primärproduktion in der euphotischen Zone an der Eiskante zum Ziel hat,
(iv) einer Prozessstudie um die saisonalen Eigenschaften der Rezirkulation in der Fram-Straße einzugrenzen und
(v) einer Prozessstudie um die saisonalen Strömungen von warmem Atlantikwasser auf dem Ostgrönlandschelf und unter den 79N Gletscher einzugrenzen.

An den meisten Tagen im Arbeitsgebiet werden zu den Tageszeiten der Mannschaft Verankerungsaufnahmen oder Verankerungsauslegungen stattfinden. In den Nachtstunden werden stationsbasierte Messungen u.a. mit der CTD-Rosette, dem Multinetz, dem LOKI, dem kameragesteuerten Mehrkernsammler und dem Ozeanbodenbeobachtungssystem stattfinden. Diese Instrumente messen verschiedene hydrographische und biologische Parameter und sammeln Wasser-, Exemplar- und Sedimentproben für biologische und chemische Analysen. Hydrographische und Strömungs-Eigenschaften werden auch mit Unterwegssystemen gemessen, und biologische und chemische Proben werden in regulären Zeitabständen aus den Seewasser-Systemen von *Polarstern* genommen werden. Größen, die untersucht werden sind, u.a.

(i) Phytoplankton, Zooplankton und Bakterien Häufigkeit, Artenverteilung, und molekulare und genetische Variabilität,
(ii) Primärproduktion,
(iii) epibentische Megafauna,
(iv) gelöste und partikuläre inorganische und organische Nährstoffe und Kohlenstoff und
(v) Transportwege und Emissionen von Spurengasen N_2O, CH_4, DMS und CO.

Inkubationen werden die Transportraten der Spurengase unter sich ändernden Antriebsszenarien abschätzen. Während des Transits und in dem Arbeitsgebiet werden Luftproben genommen werden für die Analyse von neuartigen organischen Schadstoffen. Im westlichen Teil des Arbeitsgebiets, wo Meereis zu erwarten ist, werden Helikoptereinsätze Schneeproben von Meereisschollen sammeln für die Analyse von neuartigen organischen Schadstoffen und die Helikopter werden auch über Meereis fliegen, um ein neues Mikrowellerückstreumessgerät für Eis und Schnee Fernerkundung zu testen. Nach einem kürzeren Transit wird die Reise in Tromsø am 3. August enden.

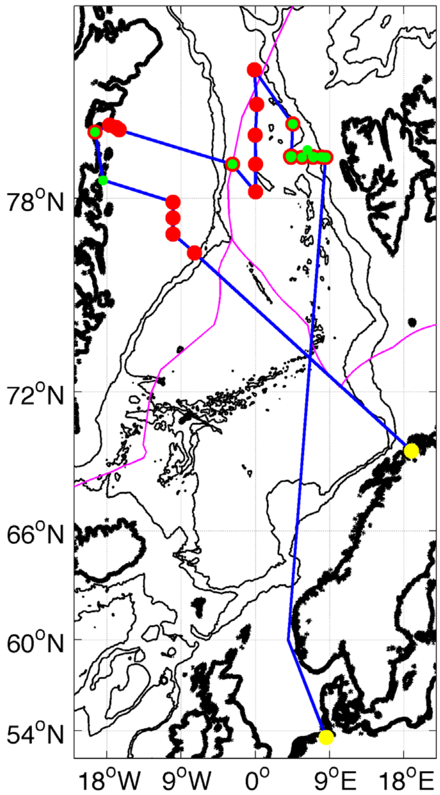

Abb. 1.1: Vorläufiger Fahrtverlauf der PS114 von Bremerhaven nach Tromsø
Fig. 1.1: Preliminary cruise track of PS114 from Bremerhaven to Tromsø

SUMMARY AND ITINERARY

Wilken-Jon von Appen
Alfred Wegner Institute, Helmholtz Centre for Polar and Marine Research

After leaving Bremerhaven on July 10th, *Polarstern* cruise PS114 will start with a roughly 5-day transit to the working area: Fram Strait between Svalbard and Greenland. The cruise will be structured around a large number of mooring recoveries and deployments associated with the Helmholtz Infrastructure Initiative FRAM. The cruise will progress from east to west across the working area to service moorings that are part of

(i) long-term observations of the West Spitsbergen Current temperature and transport,
(ii) long-term observations for sedimentary fluxes to the sea-floor,
(iii) a process study aiming at primary production in the euphotic zone at the ice-edge,
(iv) a process study to constrain the seasonal properties of the recirculation in Fram Strait, and

(v) a process study to constrain the seasonal flow patterns of warm Atlantic Water on the East Greenland shelf and underneath the 79 North Glacier.

On most days in the working area, mooring recoveries or deployments will take place during day time ship working hours. During night hours station-based sampling will take place including the deployment of the CTD rosette, multinet, LOKI, TV multi-corer, and ocean floor observation system. These instruments will measure various hydrographic and biological parameters and retrieve water, specimen, and sediment samples for biological and chemical analyses. Hydrographic and current properties will also be monitored with underway systems and biological and chemical samples will be taken at regular intervals from sea-water intakes of *Polarstern*. Properties to be investigated include

(i) phytoplankton, zooplankton, and bacteria abundance, species distribution, and molecular and genetic variability,

(ii) primary production,

(iii) epibenthic megafauna,

(iv) dissolved and particulate inorganic and organic nutrients and carbon, and

(v) pathways and emissions of trace gases N_2O, CH_4, DMS, and CO.

Incubations will assess rates of trace gas exchanges under varying forcing. During the transit and in the working area, air samples will be collected for analyses of emerging organic contaminants. In the western part of the working area, where sea-ice is expected, helicopter operations will retrieve snow samples from sea-ice floes for analyses of emerging organic contaminants and the helicopters will fly over sea-ice to test a new scatterometer for ice and snow remote sensing. After a shorter transit, the cruise will end in Tromsø on August 3rd.

2. FLOW OF ATLANTIC WATER IN FRAM STRAIT AND ON THE EAST GREENLAND SHELF

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Objectives and scientific programme

West Spitsbergen Current

This cruise supports a long-term effort to monitor and quantify the variability of oceanic fluxes through the Fram Strait with a particular emphasis on the physical oceanography.

The Arctic Ocean is a semi-enclosed marginal sea with the Bering Strait, the Canadian Arctic Archipelago, and the Barents Sea being three shallow connections to the world oceans. The Fram Strait is the only deep strait (2,700 m), thereby allowing for the exchange of intermediate and deep waters between the Arctic Ocean and the Nordic Seas, which are in turn a marginal sea of the North Atlantic. Atlantic origin water is cooled throughout the cyclonic boundary current circulation in the Nordic Seas and enters the Arctic through the Barents Sea and the eastern Fram Strait. The temperature and other properties of the inflowing warm and salty Atlantic Water change in response to interannual variability (Beszczynska-Möller et al, 2012), to large scale-, multi-year climate patterns, such as the North Atlantic Oscillation, and to global climate change. The sum of these effects can be measured in the Fram Strait before it enters the Arctic Ocean, where it participates in the formation of the halocline north of Svalbard and forms a mid-depth cyclonic boundary current. Cooling, freezing, sea-ice melt, mixing with Pacific origin water, and the addition of large amounts of river runoff in the Arctic modifies the inflowing water (Rudels et al, 2005) before it exits through the western Fram Strait (de Steur et al, 2014). Thus observations of the outflow from the Arctic make it possible to monitor the effects of many processes in the Arctic Ocean.

The complicated topography in the Fram Strait leads to a horizontal splitting of the inflowing branches of Atlantic Water. Additionally, some of the Atlantic Water participates in a westward flow called the recirculation that then turns southward to exit the Fram Strait back to the Nordic Seas. The southward flowing cold and very fresh East Greenland Current is responsible for a large part of the liquid freshwater export from the Arctic and most of the solid freshwater export in the form of sea-ice. This freshwater has the potential to impact convection in the Nordic Seas and the northern North Atlantic and in turn the meridional overturning circulation.

Since 1997, AWI and the Norwegian Polar Institute have maintained a mooring array across the Fram Strait to monitor the fluxes of volume flux, and the temperature and salinity of the flow into and out of the Arctic Ocean through this gateway.

Atlantic Water Recirculation

The recirculation of Atlantic Water (AW) in Fram Strait controls how much of the warm nutrient rich AW flowing northward in the West Spitsbergen Current enters the Arctic Ocean. This determines the oceanic heat input and therefore the extent of the partially ice-free halocline formation area north of Svalbard (Rudels et al, 2005). The inflow also impacts the light and nutrient distribution in the Arctic and therefore habitat distribution and biogeography in the Arctic Ocean (Metfies et al, 2016) as well as their future evolution.

The part of the AW that does not enter the Arctic Ocean follows distinct, but poorly understood, pathways in Fram Strait and is then exported southward in the East Greenland Current. Special to Fram Strait is also that the southward advection of sea-ice and the northward advection of AW balance such that the ice-edge location varies very little. Hence, the region where frontal dynamics associated with the meltwater front at the interface between the two can affect the physics (e.g. von Appen et al, 2018) and biology (e.g. Wulff et al, 2016) is confined to a relatively small area. The Polar Water outflow is also located vertically above the AW. While it remains to be explained how that happens, it is clear that the large stratification associated with that transition leads to a similar situation to the halocline of the Arctic Ocean where the vertical nutrient supply to the shallow euphotic zone is inhibited and the primary production has to adapt accordingly. The meridional extent over which the recirculation takes place has not been constrained. A recent numerical model study (Hattermann et al, 2016) has suggested that there are in fact two branches of the recirculation. A southern branch is thought to be comparatively steady, while a northern branch essentially can be considered as an extended region in which eddies are propagating westwards. The recirculation also likely has a baroclinic geostrophic and a barotropic wind-driven component, but it has only been possible to show that both contribute to the recirculation between 78°50'N and 79°0'N (de Steur et al, 2014). It is also known that the West Spitsbergen Current is unstable at 78°50'N, especially in winter (von Appen et al, 2016), but it is not known whether there is even more eddy generation further north. The large seasonality in the region (e.g. de Steur et al, 2014, von Appen et al, 2016) also mean that an understanding solely based on the summer time situation (calmest season) will inherently be incomplete. The dynamics that lead to the splitting of the AW inflow are essential to other regions of the ocean as well. For example, the Irminger Current splits at Denmark Strait and only some of the warm water flows northward through that strait. The lacking dynamical understanding of the present day recirculation also currently makes it impossible to predict how the recirculation and the processes influenced by it will evolve in the future under changing forcing conditions associated with e.g. climate change.

In order to improve the understanding of the recirculation in Fram Strait, it is crucial to measure several physical and biological parameters over the presumed meridional extension of the recirculation including during the winter months. The temperature and salinity distribution in space and time can be used to track the water of the recirculation and determine its modification and vertical motion reflected in the depth of the temperature maximum. The meridional gradient of the density can be used to elucidate the location of baroclinic geostrophic flows and combination with direct velocity measurements can reveal the full current structure. The short term variability of the currents gives information on the eddy field and its possible contribution to the flow. Vertical velocity shear can highlight the interface between the lighter Polar outflow water and the AW. The horizontal motion of those two layers is likely quite different in some regions and possibly also decoupled from the overlying ice motion. The vertical migration of the interface between the two water masses in response to external factors can be tracked even in the absence of profiling temperature and salinity measurements. The oxygen distribution provides insights on the primary productivity while acoustic backscatter elucidates the presence and migration of zooplankton which possibly responds to changes in the physical environment.

The ideal location to measure these properties is along the prime meridian (0°EW). This is outside of the West Spitsbergen Current and the East Greenland Current and what happens there is therefore not due to the boundary currents, but rather due to the recirculation. The prime meridian also avoids the 5,500 m deep Molloy Hole whose likely topographic steering would add an additional level of complexity to this already complex question. The prime meridian also cuts across the ice-edge (near 79°N at 0°EW) such that the influence of the recirculation on the ice-edge can be studied there. Additionally, the small amount of data that exist on the meridional structure of the recirculation is located along the prime meridian (Marnela et al 2013) and it is hence valuable to collect new data at a comparable location. Mooring data will also be used for validation of and assimilation into a numerical model of the region around the Fram Strait.

For these reasons, in 2016 during PS100 five equally spaced moorings were deployed at the following locations along the prime meridian (0°EW): 78°10'N, 78°50'N, 79°30'N, 80°10'N, and 80°50'N which is in water depths between 2,000 m and 3,000 m. Velocity as well as temperature, salinity, and oxygen are being measured in the upper 750 m on the moorings.

East Greenland Shelf Circulation

Mass loss from the Greenland Ice Sheet presently accounts for a third to a quarter of sea- level rise (Milne et al 2009) and the rate of mass loss is increasing (Velicogna 2009). The dominant mechanism is increased mass discharge along the marine margins where numerous major outlet glaciers have undergone a nearly simultaneous retreat, acceleration and thinning (Rignot and Kanagaratnam 2006; Howat et al 2008; Stearns and Hamilton 2007; Dietrich et al 2007). Both data and models indicate that this acceleration was triggered by a change at the tidewater margins of these glaciers (Thomas 2004; Nick et al 2009; Pritchard et al 2009), suggesting that the ocean plays a key role in modulating the ice sheet's mass balance (Vieli and Nick 2011; Straneo et al 2012).

The proposed oceanic trigger is supported by recent studies showing that warm Atlantic waters are present and circulating in Greenland's glacial fjords (Holland et al 2008; Straneo et al 2010; Murray et al 2010; Straneo et al 2011) and by the observation that these waters were warming and accumulating in the subpolar North Atlantic at the same time as the glaciers started to retreat (e.g. Bersch et al 2007).

Greenland's glacier acceleration has been concentrated along the southeastern and western margins terminating in the subpolar North Atlantic. Only recently, Helm et al (2014) observed a general reduction in ice sheet elevation near the margins in the northeast of Greenland. Here, mainly two glaciers Nioghalvfjerdsfjorden glacier and Zachariae Isstrom drain the Northeast Greenland Ice Stream (NEGIS) whose drainage basin contains more than 15 % of the Greenland Ice Sheet area (Rignot and Kanagaratnam 2006). Zachariae Isstrom lost about 5 Gt/yr of its mass since 2003 and was observed to retreat at an accelerated rate since fall 2012, whereas no mass loss but an increased bottom melting was found at Nioghalvfjerdsfjorden glacier (Mouginot et al 2015). Khan et al (2014) observed an acceleration of the ice flow of Nioghalvfjerdsfjorden glacier and a sustained dynamic thinning of NEGIS which they linked to a regional warming. The fact that a warming and thickening of the Atlantic layer has recently been observed in the Nordic Seas (e.g. in Fram Strait; Beszczynska-Möller et al 2012) raises the question of whether the ocean changes may have triggered the fast retreat of Zachariae Isstrom (as suggested by Mouginot et al 2015) and will trigger unstable behaviour of Nioghalvfjerdsfjorden glacier.

Warm Atlantic water is carried to the North by the North Atlantic Current - Norwegian Atlantic Current - West Spitsbergen Current system. In Fram Strait a sizable fraction of the Atlantic water recirculates to the south on the East Greenland continental slope. Studies on the eastern Greenland shelf in the 1980s and 1990s found this recirculating Atlantic water (RAW) to penetrate through sea bed troughs onto the East Greenland shelf (e.g. Bourke et al 1987) below the fresh and cold polar waters (PW).

The Atlantic water mass found on the shelf was described by Bourke et al (1987) as Atlantic Intermediate Water (AIW) with temperatures ranging between 0°C and 3°C and salinities between 34.5 and 34.9. Budeus et al (1997) found two distinct types of Atlantic waters in the trough system. They found 1°C warm Atlantic waters with salinities of 34.9 to be present throughout the southern Norske Trough, which cooled and freshened towards 79N glacier, and 0.5°C warm Atlantic waters with salinities of 34.8 in the northern Westwind Trough. An anticyclonic surface circulation on the continental shelf following the trough axis was found based on hydrographic observations (Bourke et al 1987, Schneider and Budeus 1995), moored (Topp and Johnson 1997) and ship based (Johnson and Niebauer 1995) velocity measurements. In addition, Topp and Johnson (1997) proposed an anticyclonic subsurface circulation from moored measurements in Westwind Trough, in contrast to Budeus et al. (1997), who proposed that there is no one-directional flushing of the trough system. In the trough area east of the outlet glaciers, i.e. between Westwind and Norske Trough, Budeus and Schneider (1995) suggested a sill depth of 250 m causing the differences in water properties. This part of the shelf has rarely been studied due to a perennially fast sea ice cover (e.g. Schneider and Budeus 1995; Schneider and Budeus 1997), but is of strong interest when studying warm water pathways towards the outlet glaciers. Between 1979-1999 and 2000-2016, the temperature in the deep part of Norske Trough increased by more than 0.5°C (Schaffer et al, 2017).

A survey of Nioghalvfjerdsfjorden glacier in the mid-1990s led to very high estimates of submarine melt rates (about 40 m/yr locally, with a mean basal melt rate of 8 m/yr), which account for the bulk of the ice shelf mass loss (Mayer et al 2000). The melting was attributed to the presence of AIW in the 600 m to 800 m deep subglacial cavity as observed in several conductivity, temperature and depth (CTD) profiles collected at the glacier's margins (Thomsen et al 1997; Mayer et al 2000). A more recent survey conducted in the summer of 2009 (Straneo et al 2012) confirmed that the AIW found under the floating ice tongue still contains large amounts of heat to drive melting. Based on three CTD sections taken north of the main glacier front, Wilson and Straneo (2015) discussed that warm AIW cannot enter the cavity through Dijmphna Sund due to a sill of 170 m depth but needs to pass the eastern pinned glacier front.

They proposed that the exchange of warm Atlantic waters between the continental shelf and the cavity through Norske Trough occurs on timescales of less than a year. Fast hydraulically controlled flow into the cavity was recently observed to supply warm AIW to the overturning circulation in the cavity (Schaffer 2017).

Nonetheless these implications are not based on sufficient observations towards the east/southeast of Nioghalvfjerdsfjorden glacier, and aspects of a direct pathway of warm AIW from the shelf break, through Norske Trough towards Nioghalvfjerdsfjorden glacier are still missing.

Work at sea

Moorings had been deployed in the Fram Strait and on the East Greenland shelf by the Alfred Wegener Institute in 2016 (PS100), and 2017 (PS107, PS109). It is planned that the 24 moorings currently still in the water (Fig. 2.1, Table 2.1) shall be recovered during PS114.

Another large part of the work will be to deploy 15 moorings (Fig. 2.2, Table 2.1).

Conductivity-Temperature-Depth (CTD) measurements will be carried out with the ship-board SBE 9/11+ CTD system, which is combined with a SBE 32 Carousel Water Sampler (Seabird). In addition, current measurements of the upper ~200 m along the cruise track will be collected with the vessel mounted ADCP.

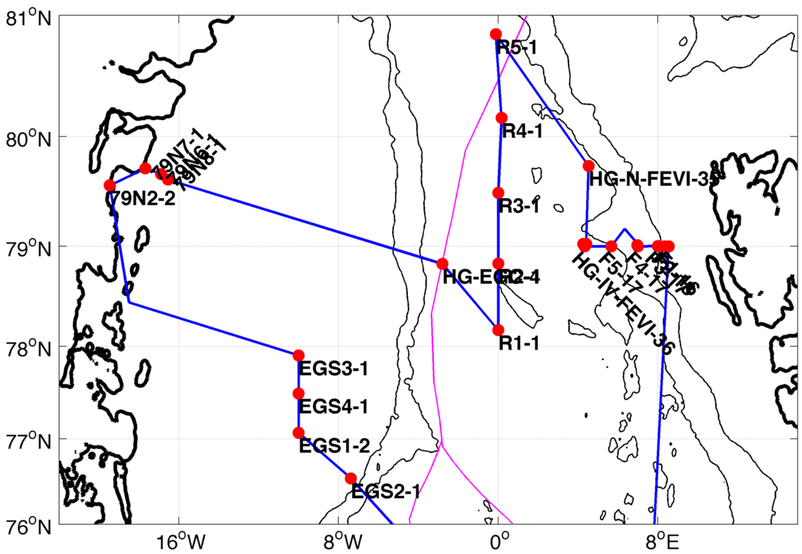

Fig. 2.1: Positions of the moorings to be recovered in Fram Strait and on the East Greenland shelf

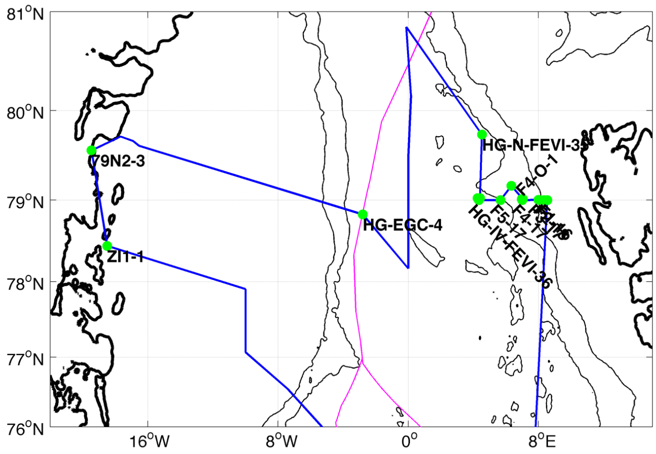

Fig. 2.2: Positions of the moorings to be deployed in Fram Strait and on the East Greenland shelf

Tab. 2.1: Mooring recoveries and deployments planned for PS114

Name	Longitude Degrees	Longitude Minutes	Latitude Degrees	Latitude Minutes	Deployment time Year	Month	Day	Hour	Minute	Depth Meters	Top Meters	Deployment station
Recoveries												
HG-IV-FEVI-36	4	20.02 E	79	0.00 N	2017	8	11	6	4	2609	52	PS107/038-1
HG-IV-S-2	4	15.71 E	79	1.36 N	2017	8	11	8	14	2599	20	PS107/038-2
HG-IV-SWIPS-2017	4	24.31 E	79	1.39 N	2017	8	11	12	12	2535	138	PS107/038-4
F4-S-2	6	57.86 E	79	0.70 N	2017	8	15	10	16	1260	18	PS107/049-1
HG-N-FEVI-35	4	31.44 E	79	44.49 N	2017	8	9	16	37	2692	48	PS107/035-1
HG-EGC-4	2	47.53 W	78	49.86 N	2017	8	4	13	3	2589	55	PS107/025-2
F1-16	8	32.51 E	79	0.01 N	2016	7	24	9	0	345.9	238	PS100/0023-1
F2-18	8	19.84 E	79	0.02 N	2016	7	23	6	57	785.2	43	PS100/0016-1
F3-17	7	59.84 E	79	0.12 N	2016	7	23	8	44	1075	44	PS100/0017-1
F4-17	7	0.03 E	79	0.01 N	2016	7	23	13	44	1219	47	PS100/0018-1
F5-17	5	40.12 E	79	0.02 N	2016	7	23	17	53	2100	64	PS100/0019-1
R1-1	0	0.04 E	78	10.21 N	2016	8	9	13	54	3013	64	PS100/0106-1
R2-1	0	0.09 E	78	50.01 N	2016	7	27	13	48	2597	48	PS100/0039-2
R3-1	0	0.03 W	79	30 N	2016	7	28	23	25	2778	63	PS100/0045-1
R4-1	0	10.19 E	80	9.75 N	2016	7	29	18	14	3034	60	PS100/0047-1
R5-1	0	7.23 W	80	51.18 N	2016	7	31	12	34	3140	76	PS100/0053-1
79N6-1	16	53.36 W	79	40.15 N	2016	8	27	14	59	256.6	249	PS100/0263-3
79N7-1	17	40.4 W	79	43.23 N	2016	8	28	8	38	404.1	394	PS100/0272-1
79N8-1	16	32.61 W	79	37.15 N	2016	8	28	11	41	287	186	PS100/0273-1
79N2-2	19	27.83 W	79	34.01 N	2017	9	23	15	20	476	83	PS109/071-1
EGS4-1	10	0.15 W	77	29.98 N	2017	10	3	19	25	262	103	PS109/133-1
EGS3-1	9	59.79 W	77	54.40 N	2017	10	3	16	27	233	98	PS109/132-2
EGS2-1	7	22.58 W	76	32.76 N	2017	10	6	11	8	763	81	PS109/148-1
EGS1-2	10	0.10 W	77	3.97 N	2017	10	4	14	34	425	92	PS109/138-2
Deployments												
HG-IV-FEVI-36	4	20.02 E	79	0.00 N	2018					2609	52	
HG-IV-S-2	4	15.71 E	79	1.36 N	2018					2599	20	
HG-IV-SWIPS-2017	4	24.31 E	79	1.39 N	2018					2535	138	
F4-S-2	6	57.86 E	79	0.70 N	2018					1260	18	
F4-W-1	7	2.50 E	79	0.70 N	2018					1260	150	
F4-O-1	6	20.00 E	79	10.00 N	2018					1260	95	
HG-N-FEVI-35	4	31.44 E	79	44.49 N	2018					2692	48	
HG-EGC-4	2	47.53 W	78	49.86 N	2018					2589	55	
F1-16	8	32.51 E	79	0.01 N	2018					345.9	238	
F2-18	8	19.84 E	79	0.02 N	2018					785.2	43	
F3-17	7	59.84 E	79	0.12 N	2018					1075	44	
F4-17	7	0.03 E	79	0.01 N	2018					1219	47	
F5-17	5	40.12 E	79	0.02 N	2018					2100	64	
79N2-3	19	27.83 W	79	34.01 N	2018					476	83	

Expected results

The planned mooring recoveries will prolong the time series of Atlantic Water temperature and velocity in the West Spitsbergen Current. It is expected that the deployment years 2016-2018 will elucidate some of the impacts of the Arctic air temperature warming events. The moorings along 0°EW will allow for the first ever assessment of the dynamics of the Atlantic Water recirculation in winter. Furthermore, it is expected that the moorings to be recovered on the East Greenland shelf will provide insights how Atlantic Water gets underneath 79NG. The CTD measurements will improve the understanding of the interaction of Atlantic Water and Polar Water and how they flow into the Arctic Ocean, towards the Nordic Seas overflows and towards Greenland's glaciers.

Data management

The data recorded by the moored instruments that will be recovered on PS1114 will be processed after the cruise at AWI and submitted to the PANGAEA data publisher. Some of the moorings that will be deployed on PS1114 will be recovered in 2019 and the rest will be recovered in 2020. The data recorded on those instruments will accordingly be processed after recovery and submitted to the PANGAEA data publisher at that time. Likewise, the data collected during PS1114 from the CTD will be processed at AWI and afterwards submitted to the PANGAEA data publisher.

References

Bersch, M., I. Yashayaev, and K. P. Koltermann (2007), Recent changes of the ther- mohaline circulation in the subpolar north atlantic, Ocean Dynamics, 57(3), 223–235, doi:10.1007/s10236-007-0104-7.

Beszczynska-Möller, A., E. Fahrbach, U. Schauer, and E. Hansen (2012), Variability in atlantic water temperature and transport at the entrance to the arctic ocean, 1997-2010, ICES Journal of Marine Science: Journal du Conseil, 69(5), 852–863, doi: 10.1093/icesjms/fss056.

Bourke, R. H., J. L. Newton, R. G. Paquette, and M. D. Tunnicliffe (1987), Circulation and water masses of the east greenland shelf, Journal of Geophysical Research: Oceans, 92(C7), 6729–6740, doi:10.1029/JC092iC07p06729.

Budeus, G., and W. Schneider (1995), On the hydrography of the northeast water polynya, Journal of Geophysical Research: Oceans, 100 (C3), 4287–4299, doi:10.1029/94JC02024. Budeus, G., W. Schneider, and G. Kattner (1997), Distribution and exchange of water masses in the northeast water polynya (greenland sea), Journal of Marine Systems, 10(14), 123 – 138, doi:http://dx.doi.org/10.1016/S0924-7963(96)00074-7.

de Steur, L., E. Hansen, R. Gerdes, M. Karcher, E. Fahrbach, and J. Holfort (2009), Freshwater fluxes in the East Greenland Current: A decade of observations, Geophysical Research Letters, 36(23).

de Steur, L., E. Hansen, C. Mauritzen, A. Beszczynska-Möller, and E. Fahrbach (2014), Impact of recirculation on the East Greenland Current in Fram Strait: Results from moored current meter measurements between 1997 and 2009, Deep Sea Research, 92, 26–40.

Dietrich, R., H.-G. Maas, M. Baessler, A. Ru ̈lke, A. Richter, E. Schwalbe, and P. West- feld (2007), Jakobshavn isbræ, west greenland: Flow velocities and tidal interaction of the front area from 2004 field observations, J. Geophys. Res., 112(F03S21), doi: 10.1029/2006JF000601.

Hattermann, T., P. E. Isachsen, W.-J. von Appen, J. Albretsen, and A. Sundfjord (2016), Where eddies drive recirculation of Atlantic Water in Fram Strait, Geophysical Research Letters, 43, 1-9.

Helm, V., A. Humbert, and H. Miller (2014), Elevation and elevation change of greenland and antarctica derived from cryosat-2, The Cryosphere, 8 (4), 1539–1559, doi:10.5194/tc- 8-1539-2014.

Holland, D. M., R. H. Thomas, B. de Young, M. H. Ribergaard, and B. Lyberth (2008), Acceleration of jakobshavn isbrae triggered by warm subsurface ocean waters, Nature Geosci, 1(10), 659–664.

Hopkins, T. S. (1991), The GIN seas synthesis of its physical oceanography and literature review 19721985, Earth-Science Reviews, 30(34), 175 – 318, doi: http://dx.doi.org/10.1016/0012-8252(91)90001-V.

Howat, I. M., I. Joughin, M. Fahnestock, B. E. Smith, and T. A. Scambos (2008), Synchronous retreat and acceleration of southeast Greenland outlet glaciers 2000- 06: ice dynamics and coupling to climate, Journal of Glaciology, 54, 646–660, doi: 10.3189/002214308786570908.

Johnson, M., and H. J. Niebauer (1995), The 1992 summer circulation in the northeast water polynya from acoustic doppler current profiler measurements, Journal of Geo- physical Research: Oceans, 100(C3), 4301–4307, doi:10.1029/94JC01981.

Khan, S. A., K. H. Kjær, M. Bevis, J. L. Bamber, J. Wahr, K. K. Kjeldsen, A. A. Bjørk, N. J. Korsgaard, L. A. Stearns, M. R. van den Broeke, L. Liu, N. K. Larsen, and I. S. Muresan (2014), Sustained mass loss of the northeast greenland ice sheet triggered by regional warming, Nature Clim. Change, 4 (4), 292–299.

Mayer, C., N. Reeh, F. Jung-Rothenhusler, P. Huybrechts, and H. Oerter (2000), The sub- glacial cavity and implied dynamics under nioghalvfjerdsfjorden glacier, ne-greenland, Geophysical Research Letters, 27(15), 2289–2292, doi:10.1029/2000GL011514.

Metfies, K., W.-J. von Appen, E. Kilias, A. Nicolaus, and E.-M. N ̈othig (2016), Biogeography and Photosynthetic Biomass of Arctic Marine Pico-Eukaroytes during Summer of the Record Sea Ice Minimum 2012, PLOS ONE, 11(2), doi: doi:10.1371/journal.pone.0148512.

Milne, G. A., W. R. Gehrels, C. W. Hughes, and M. E. Tamisiea (2009), Identifying the causes of sea-level change, Nature Geosci, 2 (7), 471–478.

Mouginot, J., E. Rignot, B. Scheuchl, I. Fenty, A. Khazendar, M. Morlighem, A. Buzzi, and J. Paden (2015), Fast retreat of zachariæ isstrøm, northeast greenland, Science, doi:10.1126/science.aac7111.

Murray, T., K. Scharrer, T. D. James, S. R. Dye, E. Hanna, A. D. Booth, N. Selmes, A. Luckman, A. L. C. Hughes, S. Cook, and P. Huybrechts (2010), Ocean regulation hypothesis for glacier dynamics in southeast greenland and implications for ice sheet mass changes, Journal of Geophysical Research: Earth Surface, 115 (F3), doi: 10.1029/2009JF001522, f03026.

Nick, F. M., A. Vieli, I. M. Howat, and I. Joughin (2009), Large-scale changes in greenland outlet glacier dynamics triggered at the terminus, Nature Geosci, 2 (2), 110–114.

Pritchard, H. D., R. J. Arthern, D. G. Vaughan, and L. A. Edwards (2009), Extensive dynamic thinning on the margins of the greenland and antarctic ice sheets, Nature, 461(7266), 971–975.

Rignot, E., and P. Kanagaratnam (2006), Changes in the velocity structure of the green- land ice sheet, Science, 311 (5763), 986–990, doi:10.1126/science.1121381.

Rudels, B., G. Bjo ̈rk, J. Nilsson, P. Winsor, I. Lake, and C. Nohr (2005), The interaction between waters from the Arctic Ocean and the Nordic Seas north of Fram Strait and along the East Greenland Current: results from the Arctic Ocean-02 Oden expedition, Journal of Marine Systems, 55(1), 1–30.

Schaffer, J., W.-J. von Appen, P. A. Dodd, C. Hofstede, C. Mayer, L. de Steur, and T. Kanzow (2017), Warm water pathways toward Nioghalvfjerdsfjorden Glacier, Northeast Greenland, J. Geophys. Res. Oceans, 122, doi:10.1002/ 2016JC012462.

Schaffer, J. (2017), Ocean impact on the 79 North Glacier, Northeast Greenland, PhD thesis, University of Bremen, http://nbn-resolving.de/urn:nbn:de:gbv:46-00106281-12

Schneider, W., and G. Budeus (1997), A note on norske ø ice barrier (northeast green- land), viewed by landsat 5, Journal of Marine Systems, 10(14), 99 – 106, doi: http://dx.doi.org/10.1016/S0924-7963(96)00076-0.

Schneider, W., and G. Budeus (1995), On the generation of the northeast water polynya, Journal of Geophysical Research: Oceans, 100 (C3), 4269–4286, doi:10.1029/94JC02349. Stearns, L. A., and G. S. Hamilton (2007), Rapid volume loss from two east greenland outlet glaciers quantified using repeat stereo satellite imagery, Geophysical Research Letters, 34(5), doi:10.1029/2006GL028982, l05503.

Straneo, F., G. S. Hamilton, D. A. Sutherland, L. A. Stearns, F. Davidson, M. O. Hammill, G. B. Stenson, and A. Rosing-Asvid (2010), Rapid circulation of warm subtropical waters in a major glacial fjord in east greenland, Nature Geosci, 3(3), 182–186.

Straneo, F., R. G. Curry, D. A. Sutherland, G. S. Hamilton, C. Cenedese, K. Vage, and L. A. Stearns (2011), Impact of fjord dynamics and glacial runoff on the circulation near helheim glacier, Nature

Geosci, 4 (5), 322–327. Straneo, F., D. A. Sutherland, D. Holland, C. Gladish, G. S. Hamilton, H. L. Johnson, E. Rignot, Y. Xu, and M. Koppes (2012-11-01T00:00:00), Characteristics of ocean waters reaching greenland's glaciers, Annals of Glaciology, 53(60), 202–210, doi: doi:10.3189/2012AoG60A059.

Thomas, H. R. (2004), Force-perturbation analysis of recent thinning and accel- eration of Jakobshavn Isbrae, Greenland, Journal of Glaciology, 50, 57–66, doi: 10.3189/172756504781830321.

Thomsen, H. H., N. Reeh, O. B. Olesen, C. E. Bøggild, W. Starzer, A. Weidick, and A. K. Higgins (1997), The nioghalvfjerdsfjorden glacier project, north-east greenland: a study of ice sheet response to climatic change, Geology of Greenland Survey Bulletin, 176, 95–103.

Topp, R., and M. Johnson (1997), Winter intensification and water mass evolution from yearlong current meters in the northeast water polynya, Journal of Marine Systems, 10(14), 157 – 173, doi:http://dx.doi.org/10.1016/S0924-7963(96)00083-8.

Velicogna, I. (2009), Increasing rates of ice mass loss from the greenland and antarctic ice sheets revealed by grace, Geophysical Research Letters, 36(19), doi: 10.1029/2009GL040222, l19503.

Vieli, A., and F. M. Nick (2011), Understanding and modelling rapid dynamic changes of tidewater outlet glaciers: Issues and implications, Surveys in Geophysics, 32(4), 437– 458, doi:10.1007/s10712-011-9132-4.

von Appen, W.-J., U. Schauer, T. Hattermann, and A. Beszczynska-Möller (2016), Seasonal cycle of mesoscale instability of the West Spitsbergen Current, Journal of Physical Oceanography, 46 (4), 1231-1254, doi:10.1175/JPO-D-15-0184.1.

von Appen, W.-J., C. Wekerle, L. Hehemann, V. Schourup-Kristensen, C. Konrad, and M. Iversen, 2018: Observations of a submesoscale cyclonic filament in the marginal ice zone, Geophysical Research Letters, in press, doi:10.1029/2018GL077897

Wilson, N. J., and F. Straneo (2015), Water exchange between the continental shelf and the cavity beneath nioghalvfjerdsbr (79 north glacier), Geophysical Research Letters, 42(18), 7648–7654, doi:10.1002/2015GL064944, 2015GL064944.

Wulff, T., E. Bauerfeind, and W.-J. von Appen (2016), Physical and ecological processes at a moving ice edge in the Fram Strait as observed with an AUV, Deep Sea Research, 115, 253-264.

3. HAUSGARTEN: IMPACT OF CLIMATE CHANGE ON ARCTIC MARINE ECOSYSTEMS

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Objectives and scientific programme

While always fluctuating, the global climate is presently experiencing a period of rapid change, with a warming trend amplified in the Arctic region. Results of large-scale simulations of the future Earth's climate by several global climate models predict a further increase in temperatures, also leading to further reduction in ice cover. Moreover, there has been a significant thinning of the sea ice by approx. 50 % since the late 1950s.

The shift from a white cold ocean to a darker, warmer ocean will have severe impacts on the polar marine ecosystem. Thinner ice may permit better growth of ice algae, but more rapid spring melting may reduce their growing season. The timing and location of pelagic primary production will generally alter. Whether sea ice retreat generally leads to an increase in primary productivity is under debate, but biogeochemical models predict no or even negative changes in productivity and export flux. Altered algal abundance and composition will affect the zooplankton community structure and subsequently the flux of particulate organic matter to the seafloor, where the quantity and quality of this matter will impact benthic communities. Changes in the predominance of certain trophic pathways will have cascading effects propagating through the entire marine community. Generally, arctic marine organisms will be compromised by temperature regimes approaching the limits of their thermal capacity. As a consequence, warmer waters in the Arctic will allow a northward expansion of sub-arctic and boreal species. Besides an increasing water temperature, expanding ocean acidification will pose another threat to pelagic and benthic life in the Arctic Ocean.

To detect and track the impact of large-scale environmental changes in the transition zone between the northern North Atlantic and the central Arctic Ocean, and to determine experimentally the factors controlling deep-sea biodiversity, the Alfred-Wegener-Institute Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) established the LTER (Long-Term Ecological Research) observatory HAUSGARTEN. Regular sampling as well as the deployment of moorings and different free-falling systems (bottom-lander), which act as local observation platforms, has taken place since the observatory was established back in 1999. Since 2014, this observatory is successively extended within the frame of the HGF financed infrastructure project FRAM (Frontiers in Arctic marine Monitoring) and currently covers 21 permanent sampling sites on the West-Spitsbergen and East-Greenland slope at water depths between 250 and 5,500 m.

Ongoing climate change will impact marine ecosystems in a variety of ways, and polar environments are believed to be particularly sensitive to these changes. Increasing atmospheric CO_2 concentration will lead to a reduction of ocean pH, which is expected to exert a significant impact on marine calcifying organisms. Reductions in sea-ice cover and warming of water masses will modify ocean stratification and restrict the supply of nutrients to the euphotic zone. Taken together with anticipated changes in light conditions, net phytoplankton growth is expected to change with important ramifications for Arctic ecosystem structure and biogeochemical fluxes. In particular the quantity of photosynthetically produced organic matter exported from the surface ocean is likely to change under these conditions.

These changes have clear implications for the sequestration of atmospheric CO_2 and the structure and function of benthic ecosystems that principally rely on this energy source from the pelagic. Considering the importance of these processes, reliably detecting the effects of climate change and understanding the influence of anthropogenic forcing on Arctic ecosystems is a clear priority. As part of our efforts to observe and detect long-term changes in Arctic Ocean ecosystems, we deployed a network of fixed- point moorings in the Fram Strait. On the one hand these moorings reflect a continuation of the well-established and long-term efforts of monitoring particle flux in the Fram Strait as part of the LTER Observatory HAUSGARTEN. In addition to this, new mooring arrays were designed to sample biogeochemical and physical properties in the upper water column to link with particle flux observations. These arrays include autonomous water samplers and autonomous particle samplers that are capable of collecting discrete samples with weekly resolution and preserving them for detailed analysis upon recovery. This work is part of the Frontiers in Arctic marine Monitoring (FRAM) infrastructure project.

To determine the transfer of organic matter from the upper productive layer in the water column to the bottom of the ocean, measurements of settling particles are performed by means of year-round moored sediment traps that provide information on the quantity and seasonality of vertical particle flux. The moorings are also equipped with current meters (RCMs) and self-recording CTDs, to gain information on the hydrographic conditions in the study area. Results obtained by these instruments are of major importance for the interpretation of the results derived by the sediment traps, as the settling particles can be transported over long distances before arriving at the seabed.

To determine the seasonal changes in nutrient concentrations in the euphotic zone, water samplers were deployed in 2017 (PS107) at approximately 20 m and 80 m depth. In total, 24 discrete samples are being taken with weekly to monthly resolution (depending on season) to follow the biological drawdown of nutrients. The moorings are also equipped with a physical and biogeochemical sensor package including SBE37-SMP-ODO (temperature, salinity, oxygen), SAMI pH, SAMI pCO_2, Wetlabs PAR (photosynthetically active radiation), Wetlabs Ecotriplet (Chlorophyll and CDOM fluorescence plus scattering), SUNA Deep Nitrate, current meters, and Acoustic Doppler Current Profilers. The combination of these sensors and the water samplers, in combination with the deployment of a profiling winch facilitates the assessment of seasonal stratification and nutrient concentrations above and below the pycnocline. The nutrient drawdown enables an estimate of new production. Furthermore, the samples will be used for DNA sequencing to examine seasonal changes in bacterial community structure. The particle samplers collect and preserve filters for DNA extraction and sequencing that together with the fluorescence sensors allow us to track the progression of phytoplankton biomass and community composition over different seasons. These efforts give us a novel year-round description of biological, chemical, and physical processes in the Fram Strait.

In addition, water samplers were deployed at ~80 m water depth in the anticipated cores of the West Spitsbergen and East Greenland Currents. Together with detailed measurements of physical parameters, these samples will be used to measure the nutrient composition of water masses flowing into and out of the Arctic Ocean through the Fram Strait.

During *Polarstern* expedition PS114, multidisciplinary research activities will be conducted at a sub-set of stations mainly in the northern and western HAUSGARTEN area (Fig. 3.1).

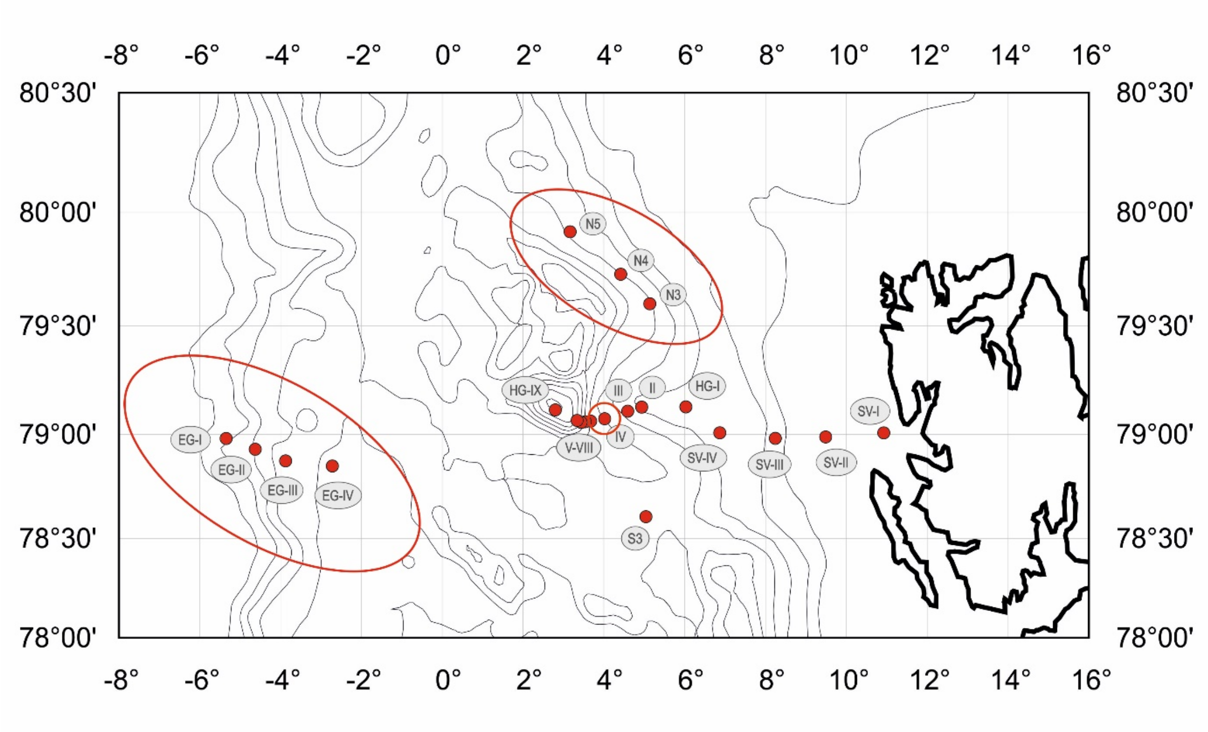

Fig. 3.1: Permanent sampling sites of the LTER Observatory HAUSGARTEN in Fram Strait; red circles indicate stations to be visited during Polarstern expedition PS114

Work at sea

Surface water characteristics and vertical flux of particulate organic matter

At the central HAUSGARTEN site HG-IV (see Fig. 3.1), we will recover and re-deploy a special mooring with a prototype profiling winch system carrying a sensor package. This device has been developed within the BMBF funded project ICOS-D (Integrated Carbon Observation System, Germany) and shall conduct measurements within the upper 200 m of the water column at regular preprogramed intervals. At present, the sensor package consists of instruments for measuring carbon dioxide, oxygen, conductivity, temperature, pressure, and chlorophyll fluorescence.

Measurements of the vertical flux of particulate matter at HAUSGARTEN have been conducted since the establishment of the observatory. By means of these measurements we are able to quantify the export of organic matter from the sea surface to the deep sea, and trace changes in these fluxes over time. The organic material which is produced in the upper water layers or introduced from land is the main food source for deep-sea organisms. Estimations of organic matter fluxes are conducted by bottom-tethered moorings carrying sediment traps (Fig. 3.2) at ~200 m and ~1,000 m below sea-surface, and about 180 m above the seafloor. In addition, HAUSGARTEN moorings carry autonomous McLane RAS 500 water samplers that are programmed to collect and preserve water samples (~0.5 L) with approximately weekly resolution, as well as particle samplers that filter and preserve ~10 L water samplers with approximately bi-weekly resolution. Besides these instruments, the moorings are equipped with Aanderaa currentmeters (RCM11, Seaguard) and self-recording CTDs (Seabird MicroCATs).

During the *Polarstern* expedition PS114, we will recover moorings and instruments that were deployed (see Fig. 3.1, Table 2.1) during the *Polarstern* expedition PS107 in 2017 and redeploy moorings according to Table 2.1.

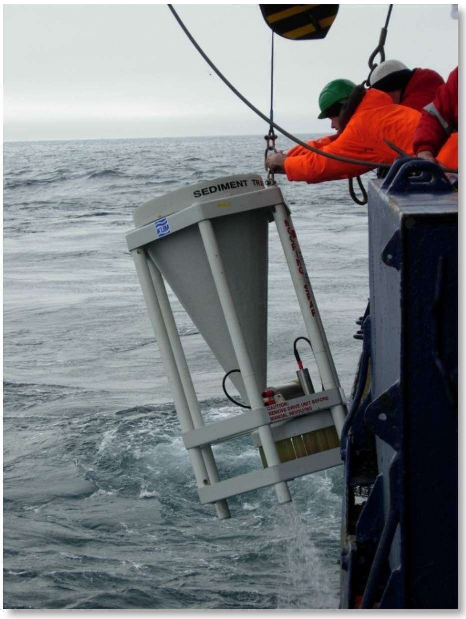

Fig. 3.2: Deployment of a sediment trap to assess particle fluxes to the seafloor

Sediment properties and the benthic biota

Virtually undisturbed sediment samples will be taken using a video-guided multicorer (TV-MUC; Fig. 3.3). Various biogenic compounds from these sediments will be analysed to estimate the input of organic matter from phytodetritus sedimentation (indicated by sediment-bound chloroplastic pigments) and to assess activities (i.e. bacterial exoenzymatic activity) and the total biomass (i.e. particulate proteins, phospholipids) of the smallest sediment-inhabiting organisms. Results will help to describe ecosystem changes in the benthal of the Arctic Ocean. Sediments retrieved by the TV-MUC will also be analysed for the quantitative and qualitative assessment of the small benthic biota (size range: bacteria - meiofauna).

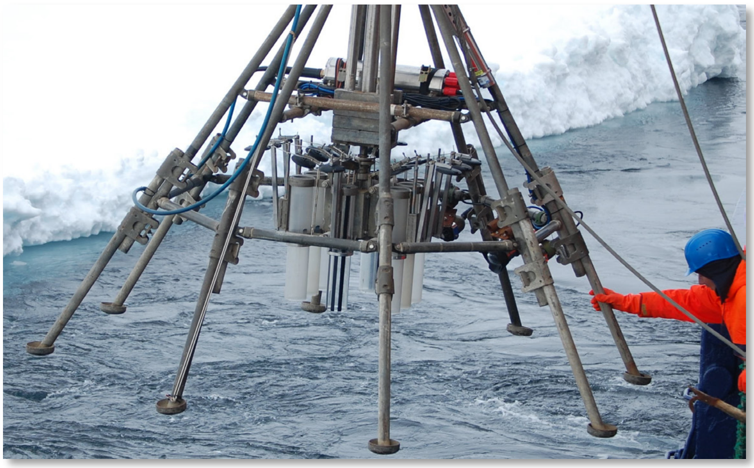

Fig. 3.3: Sediment sampling using a video-guided multicorer (TV-MUC)

Epibenthic megafauna, defined as the group of organisms ≥1 cm, considerably contribute to the continuous redistribution of organic matter, oxygen and other nutrients in surficial sediments. Megafaunal organisms create pits, mounds and traces that enhance habitat heterogeneity and thus diversity of smaller sediment-inhabiting biota in otherwise apparently homogenous environments. In this way, erect biota enhances 3D habitat complexity and provides shelter from predation.

Megafaunal predators control the population dynamics of their prey and therefore shape benthic food webs and community structure. Sunken organic matter that is not converted into benthic biomass and forwarded along food chains might be actively transported from the water column-sediment interface into the sediment by bioturbation. Organic matter is then degraded/recycled into nutrients and CO_2. Mega- and macrofaunal species thus actively influence biogeochemical processes at the sediment–water interface. An understanding of megafaunal dynamics is therefore vital to our understanding of the fate of carbon at the deep seafloor, Earth's greatest carbon repository.

During the *Polarstern* expedition PS114, we will continue to study interannual dynamics of megafaunal organisms using our towed camera system (Ocean Floor Observation System, OFOS; Fig. 3.4). The OFOS will be towed along an established track at HAUSGARTEN station EG-IV on the Eastern Greenland rise.
The new footage will extend our image time series that started already in 2002.

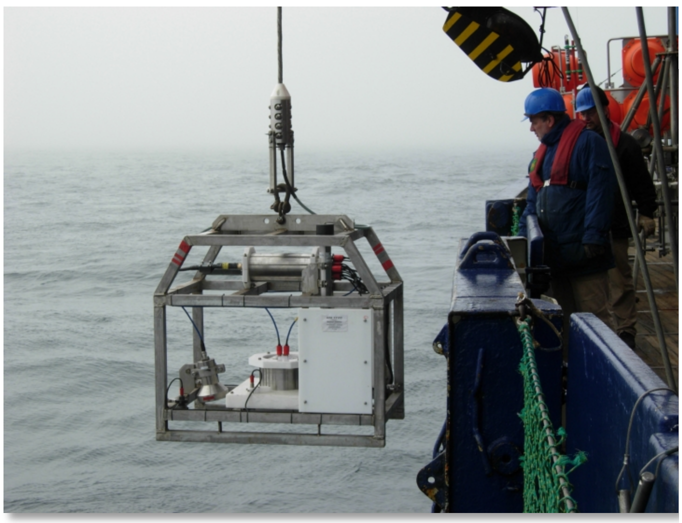

Fig. 3.4: Deployment of the Ocean Floor Observation System (OFOS)

Data and sample managment

Sample processing will be carried out at AWI. Data acquisition from the several types of investigation will be differently time-consuming. The time periods from post processing to data provision will vary from one year maximum for sensor data, to several years for organism related datasets. Until then preliminary data will be available to the cruise participants and external users after request to the senior scientist. The finally processed data will be submitted to the PANGAEA data library. The unrestricted availability from PANGAEA will depend on the required time and effort for acquisition of individual datasets and its status of scientific publication.

4. PLANKTON ECOLOGY AND BIOGEOCHEMISTRY IN THE CHANGING ARCTIC OCEAN (PEBCAO, FRAM MICROBIAL OBSERVATORY)

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Objectives and scientific programme

The Arctic Ocean has gained increasing attention over the past years because of the drastic decrease in sea ice and increase in temperature, which is about twice as fast as the global mean rate. In addition, the chemical equilibrium and the elemental cycling in the surface ocean will alter due to ocean acidification. These environmental changes will have consequences for the biogeochemistry and ecology of the Arctic pelagic system. The effects of changes in the environmental conditions on the polar plankton community can only be detected through long-term observation of the species and processes. Our studies on plankton ecology have started in 1991 and sampling has been intensified since 2009 in the Fram Strait at ~79°N. Since then our studies are based on combining a broad set of analysed parameters. This includes e.g. classical bulk measurements and microscopy, optical measurements, satellite observations, molecular genetic approaches, or cutting edge methods for zooplankton observations to study plankton ecology in a holistic approach. Over the past 9 years we have compiled complementary information on annual variability in plankton composition, primary production, bacterial activity and zooplankton composition. Since 2014 the PEBCAO group is a member of the FRAM (Frontiers in Arctic Monitoring) Ocean Observatory Team providing ground truthing information for water column monitoring of plankton ecological, biogeochemical parameters and microbial (prokaryotic and eukaryotic) biodiversity. We are also involved in the development of automatic platforms and sampling technology for long-term observation in the Arctic Ocean with main focus on the AWI HAUSGARTEN situated in the Fram Strait.

Climate induced changes will impact the biodiversity in pelagic ecosystems with concomitant changes in carbon cycling and sequestering. At the base of the food web, we expect small algae to gain more importance in mediating element and matter turnover as well as matter and energy fluxes in future Arctic pelagic systems. In order to examine changes, including the smallest fractions, molecular methods are applied to complement traditional microscopy. The characterization of the communities with molecular methods is independent of cell-size and distinct morphological features. The assessment of the biodiversity and biogeography of Arctic phyto- and bacterioplankton and associations between the two domains, will be based on the analysis of ribosomal genes with next generation sequencing technology, and quantitative PCR. Zooplankton organisms are affected by the changes at the base of the food web, and this may alter the transport and modification of organic matter. Also, the zooplankton community composition may shift due to the warmer Atlantic water in the Fram Strait. Most of our knowledge on zooplankton species composition and distribution has been derived from traditional multiple net samplers, which allow to sample depth intervals of several hundred meters. Newly developed optical methods, such as the zooplankton recorder LOKI (Lightframe On-sight Key species Investigations), and acoustic methods such as the high-frequency acoustic device AQUAscat now continuously detect organisms floating in the water column during vertical tows from 1,000 m depth to the surface. Simultaneously, hydrographical parameters (i.e. pressure, salinity, temperature, oxygen concentration and fluorescence) are being recorded. This allows the exact identification of zooplankton distribution patterns in relation to environmental conditions.

Global change increasingly affects also pelagic microbial biogeochemistry in the Arctic Ocean. Thus we will continue to monitor concentrations of organic carbon, nitrogen and phosphorus as well as specific compounds like gel particles, amino acids and carbohydrates. Additionally, we will perform rate measurements of heterotrophic bacterial production and phytoplankton primary production. The latter will be distinguished into particulate primary production (carbon remaining in the cells) and dissolved primary production (organic carbon subsequently released by cells). Overall, primary production is expected to increase in the changing Arctic Ocean, however, it is currently unclear if this leads to increased export of particulate organic carbon or if dissolved primary production will remain at the surface fuelling heterotrophic bacteria. By linking compound dynamics, rate measurements and bacteria, phyto- and zooplankton community structure we will gain further insights into the flow of carbon through Arctic food webs. Our overarching goal is to improve the mechanistic understanding of biogeochemical and microbiological feedback processes in the Arctic Ocean and to assess the potential for changes in the near future.

In summary during PS 114 the following topics are covered:

- Monitoring phyto-, zoo- and bacterioplankton species composition and biomass distribution
- Monitoring biogeochemical parameters
- Investigations of selected phytoplankton groups and related biogeochemical parameters
- Composition of organic matter in a changing Arctic Ocean

Work at sea

Biogeochemical & biological parameters from rosette samples, including the automated filtration system for marine microbes AUTOFIM, and from remote sampling devices (RAS, PPS)

We will sample Arctic seawater by CTD/rosette sampler at the main HAUSGARTEN/FRAM stations at about 3-10 depths, with a focus on the photic zone.

In addition to this we will collect particulate organic matter close to the surface (~ 10 m) with the **auto**mated **fil**tration system for marine **m**icrobes AUTOFIM (Fig. 4.1) that is coupled to the ship's pump system. Using AUTOFIM we will collect seawater at regular intervals and in parallel to the sampling via CTD. AUTOFIM allows filtration of a sampling volume up to 5 litres.

In total 12 filters can be taken and stored in a sealed sample archive. Prior to the storage a preservative can be applied to the filters to prevent degradation of the sample material, that can be used for molecular or biochemical analyses. Furthermore, samples for molecular microbiological analyses will be retrieved from remote sampling devices (RAS, PPS) to investigate seasonal patterns in bacterial and eukaryotic community structure at unprecedented temporal resolution.

Primary and bacterial production measurements will be performed on board using ^{14}C bicarbonate and ^{3}H leucin.

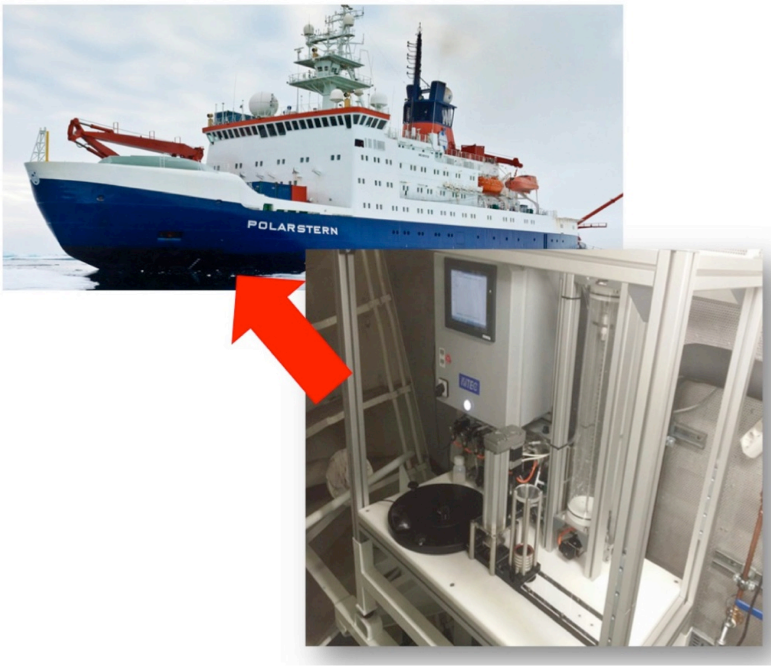

Fig. 4.1: The fully automated filtration module AUTOFIM is installed on Polarstern in the bow thruster room close to the inflow of the ships-pump system. AUTOFIM is suited to collect samples with a maximum volume of 5 liters. Filtration can be triggered on demand or after fixed intervals.

All other samples will be filtered (partly fractionated using pore sizes of 10, 3 and 0.4/0.2 µm) and preserved or frozen at - 20°C or - 80° C for further analyses. At the home laboratories at AWI, MPI and GEOMAR we will determine the following parameters to describe the biogeochemistry and the abundance and biomass distribution of eukaryotic, bacterial and archaeal plankton groups:

- Chlorophyll a concentration (total and fractionated)
- Dissolved organic carbon (DOC)
- Particulate organic carbon (POC)
- Total dissolved nitrogen (TDN)
- Particulate organic nitrogen (PON)
- Dissolved organic phosphorus (DOP)
- Particulate biogenic silica (PbSi)
- Transparent exopolymer particles (TEP)

- Coomassie-stainable particles (CSP)
- Dissolved combined carbohydrates and amino acids
- Phytoplankton, protozooplankton and bacterial abundance
- Molecular based information (Next Generation Sequencing, quantitative PCR) on community structure, diversity and distributional patterns of protists
- Quantification of selected bacterial groups by fluorescence in situ hybridization (FISH)
- Information on the quality of automated sampling and sample preservation using AUTOFIM

Zooplankton sampling

The composition and depth distribution of the mesozooplankton community will be determined by vertical tows with a Multinet Type Midi (Hydrobios; mesh size: 150 µm; Fig. 4.2a), covering five depth strata (0-50-200-500-1,000-1,500 m). Samples will be preserved in buffered formalin for later analyses under a stereo microscope. In addition, surveys with the optical plankton recorder LOKI (iSiTEC; 6.1 mpix camera, 19.8 frames $second^{-1}$) and the acoustic device AQUAscat (Aquatec; 0.5, 1, 2 and 4 MHz transducers) will be conducted from 1,000 m depth to the surface to determine the small-scale distribution of zooplankton (Fig. 4.2b).

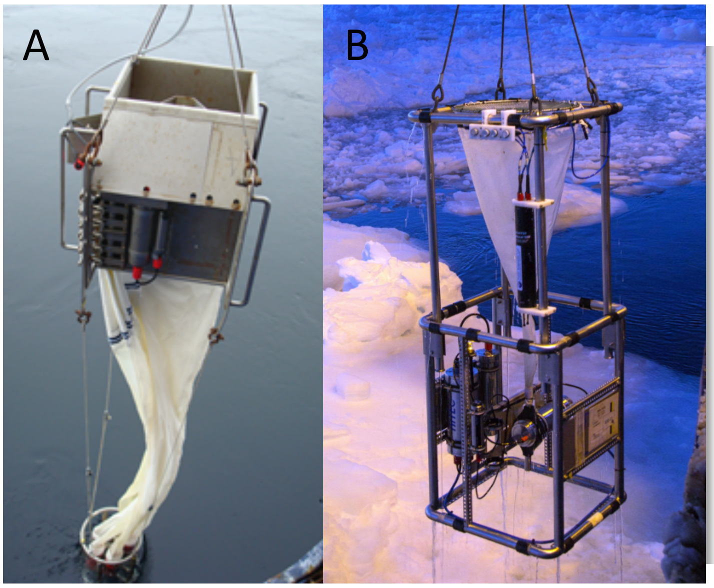

Fig. 4.2: The Multinet (A) and the LOKI system (B) during deployment. The AQUAscat is mounted to the upper half of the LOKI frame, the transducers facing sideward.

Data and sample management

During our cruises, we sample a large variety of interconnected parameters. Many of the samples (i.e. pigment analyses, particulate matter in the water column, etc.) will be analysed at AWI and at GEOMAR within about a year after the cruise. We plan that the full data set will be available and submitted to the PANGAEA data publisher at latest about two years after the cruise. Most of the species samples and samples which will not be analysed immediately, will be stored at the AWI at least for another 10 years and will be available for other colleagues.

Molecular sequencing data will be deposited in public repositories such as NCBI and ENA. Environmental data will be made available to the public via PANGAEA after publishing (depending on how many comparisons will be made, long-term study 2 to 5 years after the cruise).

5. TEMPORAL VARIABILITY OF NUTRIENT AND CARBON TRANSPORTS INTO AND OUT OF THE ARCTIC OCEAN

S. Torres-Valdés (AWI), D. Scholz (AWI), A. Morische (Uni Oldenburg), W.J. von Appen (AWI), R. Stiens (AWI), J. Bäger (AWI), E. Price (Uni Liverpool), L. Wischnewski (AWI, not on board)

Objectives

Current gaps in knowledge concerning nutrient and carbon biogeochemical cycles at the pan-Arctic scale stem from the lack of information necessary to constrain their budgets. Available computations (MacGilchrist et al., 2014; Torres-Valdés et al., 2013, 2016) indicate the Arctic Ocean (AO) is a net exporter of phosphate, dissolved organic phosphorus, silicate, dissolved organic nitrogen and dissolved inorganic carbon (DIC). Net nitrate transports appear to be balanced despite known large losses due to denitrification. With the exception of silicate, whose export results from riverine inputs, there are still unknowns with regards to understanding sources and sinks of the other variables. Under ongoing and predicted climate change, identifying and quantifying sinks and sources becomes relevant to:

i) generate baseline measurements against which future change can be evaluated,

ii) assess the impact of climate change on biogeochemical processes (e.g., primary production, organic carbon export, remineralisation),

iii) understand the complex interaction between biogeochemical and physical processes, and how such interactions affect the transport of nutrients downstream and the capacity of the Arctic Ocean to function as a sink of atmospheric CO_2,

iv) determine whether long-term trends occur. Available AO nutrient and carbon budgets derive from transport calculations across the main gateways (Fram Strait, the Barents Sea Opening, Bering Strait and Davis Strait).

However, these are mostly based on summer time measurements. Hence, it is necessary to generate continuous observations in order to evaluate budgets over seasonal and longer times scales.

We aim to address the above issue by deploying FRAM sensors and remote access samplers to generate continuous observations of nutrients and DIC in Fram Strait, targeting core (~250 m) and surface waters on the West Spitsbergen Current and the East Greenland Current.

Work at sea

We will prepare and deploy sensors and remote access samplers (RAS). Each package will consist of a RAS with a SUNA nitrate, pH, pCO2, CTD-O2, PAR and Eco-triplet sensors attached (PAR and Eco-triplet are in surface deployments only).

We will also collect seawater samples for later analysis of DIC and dissolved organic nutrients, and for onboard analysis of inorganic nutrients.

Expected results

Although this will be our team's first original deployment, from which we will obtain results only in 2019, we will be recover nutrient sensors previously deployed and collect samples from previously deployed RAS. We expect results from these previous deployments to be generated within roughly six months, following the expedition.

Data management

Our aim is to compile data from the different devices in a single file once individual data sets have been retrieved, quality controlled and analysed. Data will then be submitted to PANGAEA.

References

MacGilchrist GA, Naveira-Garabato AC, Tsubouchi T, Bacon S, Torres-Valdés S, Azetsu-Scott K (2014) The Arctic Ocean carbon sink. Deep Sea Research I, 86:39-55, doi: 10.1016/j.dsr.2014.01.002

Torres-Valdés S, Tsubouchi T, Bacon S, Naveira-Garabato AC, Sanders R, McLaughlin FA, Petrie B, Kattner G, Azetsu-Scott K, Whitledge TE (2013) Export of nutrients from the Arctic Ocean. Journal of Geophysical Research: Oceans, 118(4): 1625-1644, doi: 10.1002/jgrc.20063

Torres-Valdés S, Tsubouchi T, Davey E, Yashayaev I, Bacon S (2016) Relevance of dissolved organic nutrients for the Arctic Ocean nutrient budget. Geophysical Research Letters, 43(12): 6418-6426

6. PATHWAYS AND MISSIONS OF CLIMATE-RELEVANT TRACE GASES IN A CHANGING ARCTIC OCEAN - PETRA

D. Arévalo-Martínez (GEOMAR), M. Baumann (GEOMAR), I. Brown (PML), H. Campen (GEOMAR), J. Maud (PML), G. Tarran (PML), H. Bange (GEOMAR, not on board), A, Rees (PML, not on board)

Objectives

During PETRA we will investigate the impact of three stressors (temperature, ocean acidification and elevated irradiation) on the production and consumption of the climatically active trace gases nitrous oxide (N_2O), methane (CH_4), dimethyl sulphide (DMS) and carbon monoxide (CO) in the marine environment. Each stressor is directly or indirectly associated with the anthropogenic CO_2 burden to the atmosphere and will be investigated individually and in combination with the other two. Observational and experimental procedures will be undertaken in the Arctic Ocean, with fieldwork east of Svalbard in the Barents Sea and east of Greenland in the region of the Fram Strait. The Arctic Ocean provides an important region for the exchange of these important trace gases with the atmosphere, and factors controlling their release have been demonstrated to be sensitive to the impacts of climate change. This study will include the disciplines of trace gas analyses, carbon and nitrogen biogeochemistry and molecular biology. An integrated modelling component will utilise ecosystem models to further our understanding of the impact of these stressors on mechanisms of consumption and production.

The overall objective of PETRA is to investigate the role of (multiple) stressors for future trace gas (i.e. N_2O, CH_4, DMS, CO) cycling in the Arctic Ocean. Specific objectives to be addressed are:

- to determine the surface ocean and depth distributions of the trace gases listed above,
- to determine the relevance of air/sea gas emissions for the regional (Arctic) and global atmospheric trace gas budgets,
- to determine how stressors (warming, acidification, light) will affect future trace gas production and consumption pathways and
- to provide improved models of the mechanistic understanding of stressors on trace gas fluxes, which will provide the basis for increased understanding of the regional and global importance of these gases.

In order to address these objectives we have designed a comprehensive research programme which includes two research cruises to the Arctic Ocean, numerical modelling and an integral pathway-to-impact component. Our research programme is thus divided into four complimentary work packages (WP), each with specific objectives which are outlined below.

WP1 has the specific objectives to a) characterise the horizontal and vertical distribution of climatically active gases N_2O, CH_4, DMS and CO in waters of the Arctic Ocean and to b) determine their co-variability with natural conditions of the physical environment (e.g. temperature, pCO_2, pH, irradiance), the phytoplankton community composition and trace gas-relevant microbial processes.

WP2 has the specific objective to determine the air-sea exchange of climatically active trace gases in the Arctic Ocean by improving understanding of the control of these fluxes by sea-ice.

WP3 has the specific objective to perform ship-based experimental manipulations over policy relevant conditions (RCP 4.5 and 8.5) in order to assess the impact of increasing temperature, ocean acidification and irradiance on the production and consumption of climatically active gases N_2O, CH_4, DMS and CO.

WP4 has the specific objectives to a) perform process based modelling of multiple stressors impacts on the production and consumption of climatically active gases, b) to assess the relative importance of single and combined stressors on trace gas production.

Work at sea

- Continuous underway measurements of N_2O, CH_4, O_2 and gas tension
- Depth profiles of N_2O, CH_4, DMS/O/P, CO and O_2(Winkler).
- Incubation experiments: experimental manipulations (temperature, pH, light) with seawater from the surface and the base of the euphotic zone/mixed layer
- Measurement of the carbonate system (TA, DIC, pH) and NH_4^+ in the upper 100 m
- Collecting samples for the determination of nitrification
- Collecting filter samples for the determination of the phytoplankton composition and POC
- Taking filter samples for functional gene microarrays for amoA, nirS, norB and nosZ (lab work done by PETRA's project partner Bess Ward from Princeton Univ.)
- Collecting samples for N_2 fixation, N_2O production and C fixation rates from selected depths (lab work done by PETRA's project partner Carolin Löscher, SDU, Denmark)

Expected results

The deployment of novel high-resolution laser-based trace gas analysers will vastly increase the number of trace gas measurements from the Arctic Ocean and, therefore, improve our understanding of their spatial and temporal distributions and air/sea fluxes. The comprehensive set of incubation experiments together with the results of the ecosystem modelling is expected to yield new insights into the impact of environmental stressors on future oceanic trace gas cycling and emissions. Our results are expected to provide an improved understanding of future trace gas cycling in the Arctic Ocean and its relevance for regional (Arctic) and global atmosphere and climate.

Data management

Data generated during the PETRA project will form four basic types: 1) Environmental data, 2) Bio- and chemical-assay type experimental data, 3) Molecular biology/Genetic information on microbial populations and 4) Model code.

1) Environmental data on the concentrations of N_2O, CH_4, DMS and CO will be lodged with BODC, BADC and PANGAEA, MEMENTO (-> N_2O, CH_4 concentration data) and the PMEL DMS database (-> DMS concentration data) as appropriate.
2) Bio- and chemical-assay data generated in PETRA on the concentrations of N_2O, CH_4, DMS and CO will be lodged with BODC.
3) Molecular data originated by PETRA's collaborator Bess Ward (Princeton) will be deposited at Gene Expression Omnibus (http://www.ncbi.nlm.nih.gov/projects/geo/).
4) Model code developed in PETRA will be made publicly available through the ERSEM webpage (www.ersem.com) and connected code repository under GNU General Public License v. 3.

Throughout the project, a project-specific website will be set up, which will be maintained by GEOMAR and PML. All the data mentioned above will be also duplicated and deposited to this project website, which will be made available to the scientific community and the general public. It is anticipated that all data will be publicly available within 6-12 months upon completion of PETRA in 2021, or as soon as the publication of the results in scientific journals.

7. INVESTIGATION OF EMERGING ORGANIC CONTAMINANTS IN THE NORTH ATLANTIC AND THE ARCTIC

Z. Xie (HZG), H. Joerss (HZG)

Objectives

Along with the rapid increasing of the world pollutions and the fast developments of the economy and industry, many kinds of chemical pollutants have been and continue to be poured into the environment in considerable amounts. Therefore, analysis and evaluation of these contaminants in the marine environment is a critical issue nowadays. Besides the notorious Persistent Organic Pollutants (POPs), the emerging organic contaminants (EOCs), although not on the list of POPs under scrutiny by Stockholm Convention currently, are attracting more and more concerns on their occurrence and transport behaviours from the local sources to the remote regions. Additionally, climate change may significantly influence the transport and environmental fate of EOCs in the polar regions.

During PS114, this project is focused on studies of the distribution and atmospheric transport of emerging organic contaminants (EOCs), e.g. halogenated flame retardants (HFRs) including brominated flame retardants (BFRs), Dechlorane Plus (DP) and organophosphate esters (OPEs), phthalate esters (PEs) and per- and polyfluoroalkyl substances (PFASs) in the Atlantic and the Arctic. The aims of the project are:

(1) characterization of the concentrations of EOCs in the atmosphere, sea water and snow pack in the Arctic;

(2) evaluation of the air–water and air-snow exchange process intervening in the transport of EOCs in the Arctic;

(3) modeling the input of EOCs into the Arctic via atmospheric dry and wet deposition.

The results will contribute to the filling of data gaps regarding fluorinated alternatives. The data will be used to estimate the transport path of EOCs from high concentrated region (European continent, Asian and American Arctic) to relatively low contaminated region (European Arctic), and discover the flow of persistent organic pollutants via air-water or air-snow interaction in the Arctic summer.

Work at sea

Air samples are collected using a high-volume air sampler equipped with a PUF/XAD-2 column for gas-phase compounds and a glass fiber filter (GFF) (Pore size: 0.70 µm) for atmospheric particles, respectively. The ship-borne air samples are collected on the upper deck of the research vessel. Field blanks are prepared by espousing the PUF/XAD-2 column shortly to the sampling site.

Different sampling procedures for determination of EOCs in water phase will be applied and compared. High volume water samples are collected using Kiel In-Situ Pump (KISP) equipped with XAD-2 resin column, which is optimal for neutral substances. 2 L surface water samples will be collected in polypropylene bottles from the ship's seawater intake system (stainless steel pipe) at regular intervals along the route. Water samples are preconcentrated with solid-phase extraction, which is used for determination of alternative PFASs. A glass fibre filter (GF/F, diameter, 47 mm; pore size, 0.7 µm) is used to collect suspended particular matters (SPM). Surface snow samples will be collected in a 10-L stainless steel barrel by landing on sea-ice with *Polarstern*'s helicopters. Snow samples will be stored at -20°C on board.

Expected results

By combining integrated atmospheric samples and the collections of reprehensive seawater as well as snow samples across different regions of the Arctic, findings are sought as to determine air-water/snow exchange and what sets flux of these organic pollutants. Data and feedback from this project may improve models to predict the environmental progression and assess the effect of climate change on the long-range transport and the fate of the EOCs in the marine and Arctic ecosystem.

Data management

Sample processing will take place at HZG, Geesthacht, within about a year after the cruise. Processed data will be submitted to the open access databases PANGAEA and coastMap. The unrestricted availability from PANGAEA and coastMap will depend on the required time and effort for achievement of individual datasets and its status of scientific publication.

8. TRIAL RUN OF A NEW HELICOPTER BORNE SCATTEROMETER FOR ICE AND SNOW REMOTE SENSING

M. Fischer (Uni Hamburg), T. Schlick (Uni Hamburg), KW Gurgel (Uni Hamburg, not on board), D. Stammer (Uni Hamburg, not on board)

Objectives

The objective of the project is to test the newly developed Microwave Scatterometer HeliScat of the University of Hamburg in the field over sea ice conditions. This includes the test of the additional sensors flown simultaneously with the scatterometer (infrared and visual camera). All instruments will be flown on the Eurocopter BK117 under Arctic field conditions. It is intended to assess the handling of the new system during installation and operation, and on the other hand the quality of the registered data as preparation for the MOSAiC expedition.

Work at sea

The HeliScat instrument will be flow several times over sea ice conditions, each flight being about 1h in duration. In detail, various ice and snow formations are to be observed along previously defined flight tracks. The altitude and speed as well as the beam angle of the antenna will be varied from within the helicopter during flight as part of the test setup.

Expected results

Expected are new microwave observations of sea ice and snow at five microwave frequencies in the range 1 to 15 GHz (L, S, C, X and Ku) and four polarization combinations (VV, VH, HH, HV), together with visual and infrared observations, providing information on various surface properties at high spatial and temporal resolutions. Those measurements will be used to characterize sea ice conditions and to detect snow on sea ice (if available). The subsequent analysis will follow Kern et al. (2009).

Data management

All raw data streams from all sensors are synchronized and recorded at the same time. About 7 GByte per minute of raw data is stored on SSD during flight operation. Later, after returning on board, the data can be transferred to mass storage and backup devices. Data will be evaluated during a first scientific analysis. The main purpose is, however, to test the new system and to evaluate its noise characteristic in preparation of subsequent expeditions. Since these data amounts are prohibitively large for PANGAEA, the data will only be made available upon request directly by the PI and will not be submitted to PANGAEA.

References

Kern, S., Brath, M., Fontes, R., Gade, M., Gurgel, K.-W., Kaleschke, L., Spree, G., Schulz, S., Winderlich, A., Stammer, D. (2009):Multi^3Scat - A Helicopter-Based Scatterometer for Snow-Cover and Sea-Ice Investigations, IEEE Geoscience And Remote Sensing Letters, Vol. 6, No. 4, pp. 703-707.

9. TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

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10. FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung/ Discipline
Arevalo-Martinez	Damian	GEOMAR	Scientist	Chemical oceanography
Bäger	Jana	AWI	Technician	Deep sea ecology
Baumann	Moritz	GEOMAR	Scientist	Chemical oceanography
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Campen	Hanna	GEOMAR	Scientist	Chemical oceanography
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Gischler	Michael	HeliService	Heli technician	
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Rentsch	Harald	DWD	Meteorologist	Meteorology
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Richter	Roland	HeliService		Pilot
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Specht	Mia Sophie	AWI	Student	Physical oceanography
Staufenbiel	Benjamin	GEOMAR	Student	Plankton ecology
Stiens	Rafael	AWI	Technician	Deep sea ecology

Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung/ Discipline**
Tarran	Glen	PML	Scientist	Chemical oceanography
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von Appen	Wilken-Jon	AWI	Scientist	Physical oceanography
von Jackowski	Anabel	AWI	Student	Plankton ecology
Wulf	Jörg	MPI	Technician	Plankton ecology
Xie	Zhiyong	HZG	Scientist	Air chemistry

11. Schiffsbesatzung / Ship's Crew

	Name	Rank
1.	Schwarze, Stefan	Master
2.	Langhinrichs, Moritz	EO
3.	Farysch, Bernd	Ch. Eng.
4.	Kentges, Felix	EO Ladun
5.	Fallei, Holger	2.Offc.
6.	Neumann, Ralph Peter	2.Offc.
7.	Rudde-Teufel	Doctor
8.	Christian, Boris	Comm.Off
9.	Grafe, Jens	2.Eng.
10.	Krinfeld, Oleksandr	2.Eng.
11.	Haack, Michael	2. Eng.
12.	Redmer, Jens Dirk	Elec.Tech
13.	Ganter, Armin	Electron.
14.	Hüttebräucker, Olaf	Electron.
15.	Nasis, Ilias	Electron.
16.	Himmel,Frank	Electron
17.	Loidl, Reiner	Boatsw.
18.	Reise, Lutz	Carpenter
19.	Hans, Stefan	A.B.
20.	Domeyer, Uwe Hans	A.B.
21.	Scheel, Sebastian	A.B.
22.	Bäcker, Andreas	A.B.
23.	Brück, Sebastian	A.B.
24.	Wende, Uwe	A.B.
25.	Klee, Philipp	A.B.
26.	Neubauer, Werner	A.B.
27.	Preußner, Jörg	Storek. G
28.	Teichert, Uwe	Mot-man
29.	Rhau, Lars-Peter	Mot-man
30.	Lamm, Gerd	Mot-man
31.	Gebhardt, Norman	Mot-man
32.	Schwarz, Uwe	Mot-man
33.	Schnieder, Sven	Cook
34.	Silinski, Frank	Cooksmat
35.	Möller, Wolfgang	Cooksmat
36.	Czyborra, Bärbel	1.Stwdess
37.	Wöckener, Martina	Stwdss/KS

	Name	Rank
38.	Dibenau, Torsten	2.Steward
39.	Silinski, Carmen	2.Stwdess
40.	Golla, Gerald	2.Steward
41.	Arendt, Rene	2.Steward
42.	Hu, Guo Yong	2.Steward
43.	Chen, Dan Sheng	Laundrym.