PS93.1

29 June 2015 – 18 July 2015

Longyearbyen - Tromsø

Coordinator
Rainer Knust

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Contents

1. ÜBERBLICK UND FAHRTVERLAUF

R. Stein (AWI)

Das wissenschaftliche Ziel der marin-geologischen Arbeiten an Bord und der anschließenden Probenbearbeitung und Auswertung ist die Untersuchung der Veränderlichkeit wichtiger Umwelteigenschaften in der Framstraße während Warmzeiten der Vergangenheit. Von besonderem Interesse sind das letzte Interglazial (Eem, ca. 130-120 ka) und das Holozän (letzte 12 ka). Die Untersuchungen betreffen Ausdehnung, Dichte und Zusammensetzung der Eisdecke, Wassermassenparameter (Temperatur, Salzgehalt, Schichtung), Ursachen und Geschwindigkeiten von Veränderungen und die Kopplung der Veränderlichkeit in der Framstraßen an das Nordpolarmeer und den Nordatlantik. Diese Veränderlichkeit ist auf kurzen Zeitskalen (Jahrzehnte bis Jahrhunderte) bisher unerforscht, außer für das Holozän am westlichen Kontinentalrand von Svalbard. Für die Untersuchungen sollen lange Sedimentkerne aus Gebieten mit potenziell hohen Sedimentakkumulationsraten gewonnen werden. Die Bearbeitung und Auswertung bzgl. diverser paläozeanographischer und paläoklimatischer Proxydaten soll in den Labors der beteiligten Institute und deren Kooperationspartner erfolgen. Zielgebiete der Expedition liegen an den Kontinentalrändern von NE Grönland und W Svalbard sowie in der zentralen Framstraße (Abb. 1.1).

Neben dem marin-geologischen Schwerpunktprogramm der Expedition sollen ergänzende Nebenprogramme durchgeführt werden: Einholen von ozeanographischen Verankerungsketten in der zentralen Fram-Straße, die aufgrund der extremen Eisverhältnisse und fehlender Schiffszeit im Sommer 2014 zurückgelassen werden mussten, und Aussetzen von SeaGlidern (Physikalische Ozeanographie); Planktonfänge für spätere Kulturexperimente (Biologie) und Messungen von Wasserdampf und dessen Isotopenzusammensetzung (Atmosphärenchemie/Glaziologie).

Neben dem wissenschaftlichen Arbeitsprogramm wird auf der Expedition PS87 eine „Floating University“ im Rahmen des deutsch-kanadischen Graduierten-Kollegs “Processes and impacts of climate change in the North Atlantic Ocean and the Canadian Arctic - ArcTrain” durchgeführt werden. In diesem Programm werden ca. 20 kanadische und deutsche PhD-Studenten eine Einführung in wissenschaftliche Arbeitsmethoden an Bord eines Forschungsschiffes, Teamarbeit, internationale und multidisziplinäre Zusammenarbeit und Management erhalten.

Polarstern wird am 29.06.15 aus Longyearbyen nach Westen auslaufen. Zunächst werden im Hauptarbeitsgebiet der Fram-Straße bathymetrische (Hydrosweep) und sedimentechographische (Parasound) Vermessungen durchgeführt (Abb. 1.1). Anhand der Hydrosweep- und Parasound-Profile werden dann die geologischen Kernstationen ausgewählt und mit unterschiedlichen Geräte (Großkastengreifer, Multicorer, Schwerelot und Kastenlot) beprobt werden. Begleitend werden weiterhin ozeanographische, biologische und atmosphärische Arbeiten/Beprobungen durchgeführt. Die Expedition endet am 18.07.2015 in Tromsø/Norwegen.

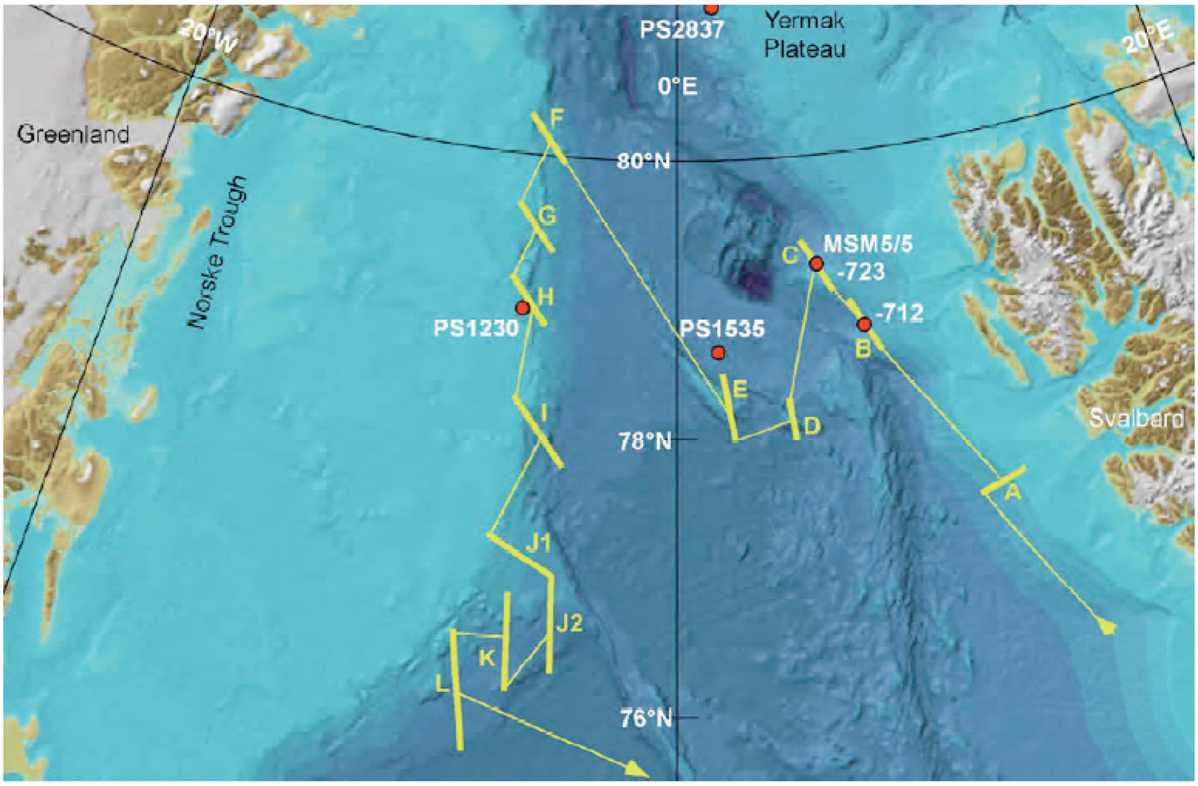

Abb. 1.1: Bathymetrische Karte der region Grönland-Framstraße-Svalbard. Dicke gelbe Linien markieren die beabsichtigten Transekte für detaillierte Hydrosweep und Parasound Surveys, feine Linien markieren mögliche Transitstrecken zwischen den Survey Transeten. Rote Punkte markieren Orte von denen bereits Sedimentkerne mit paläoozeanographischen Aufzeichnungen existieren. Die Reihenfolge der Transsekte kann ggf. dem Fahrtverlauf angepasst werden.

Fig. 1.1: Bathymetrical map of the Greenland-Fram Strait-Svalbard area. Thick yellow lines mark proposed transects for detailed Hydrosweep and Parasound surveys, fine lines mark possible transits between survey transects. Red dots mark locations of already existing sediment cores with paleoceanographic records. The order of transects may be freely changed according to the cruise plan.

SUMMARY AND ITINERARY

The overall scientific goal of the marine-geological shipboard work and the following onshore work is to investigate the variability of key environmental parameters in the Fram Strait during warm periods (interglacials) of the geological and historical past. Of special interest are the last interglacial (Eemian, ca. 130-120 ka) and the Holocene (last ca. 12 ky). Key environmental parameters are the extent, density, and nature (sea ice, icebergs) of the ice cover, the properties of water masses (temperature, salinity, stratification), the rates and causes of changes of these parameters, and the coupling of Fram Strait variability to the Arctic Ocean and the North Atlantic. On short (multidecadal to centennial) time scales details of this variability are unexplored so far, except for the Holocene in the eastern Fram Strait.

To analyze the short-term climate variability, long sediment cores will be obtained from potential areas with high sediment accumulation during Expedition PS93.1 and analyzed for a large variety of paleoceanographic and paleoclimatic proxies in home laboratories and with international partners. Target areas were selected on the NE Greenland continental margin, in the central Fram Strait and on the western Svalbard margin (Fig. 1.1).

In addition to the marine-geological programme, the major focus of this expedition, several supplementary programmes will be carried out: Recovery of oceanographic mooring systems and deployment of seagliders in the central Fram Strait (Physical Oceanography), sampling of phytoplankton for cultural experiments (biology), and measurements of water vapour and its isotope signature (atmosphere chemistry/glaciology)

Besides the the scientific research programme, a “Floating University” will be held onboard *Polarstern* under the umbrella of the International Research Training Group “Processes and impacts of climate change in the North Atlantic Ocean and the Canadian Arctic - ArcTrain”. Within this programme, about 20 Canadian and German PhD students will be introduced to technical aspects of field work in marine sciences as well as to the concepts of teamwork, interdisciplinary and international collaboration and project leadership.

Polarstern Expedition PS93.1 will start on June 29, 2015, in Longyearbyen/Svalbard. Key research area is the Fram Strait (Fig. 1.1). In this area, first Hydrosweep bathymetry and Parasound sediment echosounder surveys will be conducted. Based on these surveys, stations for sediment coring will be selected. Of special interest will be regions characterized by high sedimentation rates. Sediment coring will de done using the Giant Box Corer, Multicorer, Gravity Corer, and Kastenlot Corer. In addition, supplementary oceanographic, biological and atmospheric sampling and station work will be carried out. The expedition will end in Tromsø/Norway on July 18, 2015.

2. MARINE GEOLOGY: RECONSTRUCTION OF PAST ARCTIC CLIMATIC CONDITIONS

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Objectives and background

On multimillennial and longer timescales the history of sea ice coverage and water mass distributions in the Fram Strait, as well as the linkages to terrestrial environmental variability (e.g., ice sheet growth and decay) seem quite well understood (see Stein 2008 for review). The rapid changes observed in the Arctic in the last 100 years, however, have opened questions about past natural Arctic climate variabilty within warm periods on much shorter timescales (centennials to decades). Almost all the sedimentary sequences obtained in the Fram Strait since the early 1980s had sedimentation rates in the range of 1-5 cm/1000 yr in interglacials and are thus not suitable for high-resolution paleoclimatic studies. For the Holocene history of the eastern Fram Strait (western Svalbard margin), high-resolution records have been established in the last few years by our working groups (see below). So far, no high-resolution sedimentary sequences have ever been obtained from the western Fram Strait (NE Greenland margin and shelf). Therefore, details on short-term variabilities in sea ice coverage and water mass distributions in this area remain unexplored. The same accounts for the history of last interglacial (Eemian) variability in the entire Fram Strait and Arctic Ocean.

Specific objectives will be

- to survey potential areas along the NE Greenland continental margin, on the NE Greenland shelf, and in the central Fram Strait for sites with high sediment accumulation
- to identify the most suitable sites with unusually high sediment accumulation and obtain undisturbed long and short large-volume sediment cores from these sites
- to obtain a set of young (recent) sediment surface samples as a reference for the reflection of modern environmental oceanic parameters (ice coverage, temperature, salinity, stratification) in shelf, slope, and deep-sea sediments.

Work at sea

Site preselection

To identify core sites with relatively high sediment accumulation rates a survey with the Parasound system of RV *Polarstern* is essential. A preselection of potential survey areas is made on the basis of experience with previous work in the Arctic and especially on the western Svalbard continental margin. Most earlier expeditions (including RV *Polarstern* cruises to the western Fram Strait and Greenland Sea) had concentrated on the recovery of sediment cores from morphologic highs (e.g., ridges) in the deep-sea or plateaus on continental margins. However, we are now aware that boundary currents and deep-sea currents in the relatively narrow Fram Strait lead to a non-uniform deposition. Because of these current activities, fine-grained sediment material (e.g., much of the sediment made available by (sub)glacial erosion) often does not settle uniformly (i.e., as a blanket). This results in relatively low average Holocene sedimentation rates of 3 - 5 cm/ky on the western Svalbard margin and on morphologic highs in the central Fram Strait and in relatively coarse (5 - 20 % >63 µm) interglacial deposits (e.g. Köhler and Spielhagen 1990; Hebbeln and Wefer 1997). In contrast, deposition of fines is found preferentially in lee positions of morphologic protrusions along the continental margins, often only at very specific water depths (Fig. 2.1). Sites selected on the basis of above described considerations yielded cores with 20 - 30 cm/ky and very fine-grained sediments (<2 % >63 µm), sufficient for paleoceanographic records with multidecadal resolution (Spielhagen et al. 2011; Müller et al. 2012). No evidence was found for a significant bottom transport and redistribution of sand-sized microfossils.

For the PS93.1 cruise, we propose to survey areas on the lee side (southern or southeastern flank) of similar protrusions along the NE Greenland continental margin with the Parasound sediment echosounder to locate high-sediment accumulation rate sites. Analogue to what is found along the Svalbard margin, we expect to find several sites where fine-grained sediment exported from the NE Greenland glacier systems is accumulating and diluting the otherwise relatively slowly settling coarser hemipelagic sediment components (e.g., foraminifers, coarse ice-rafted debris) which are used in paleoceanographic research. In the central Fram Strait, a similar strategy will be applied to the flanks of 3 - 4 submarine ridges and plateaus to identify sites with higher sediment accumulation than those presently available.

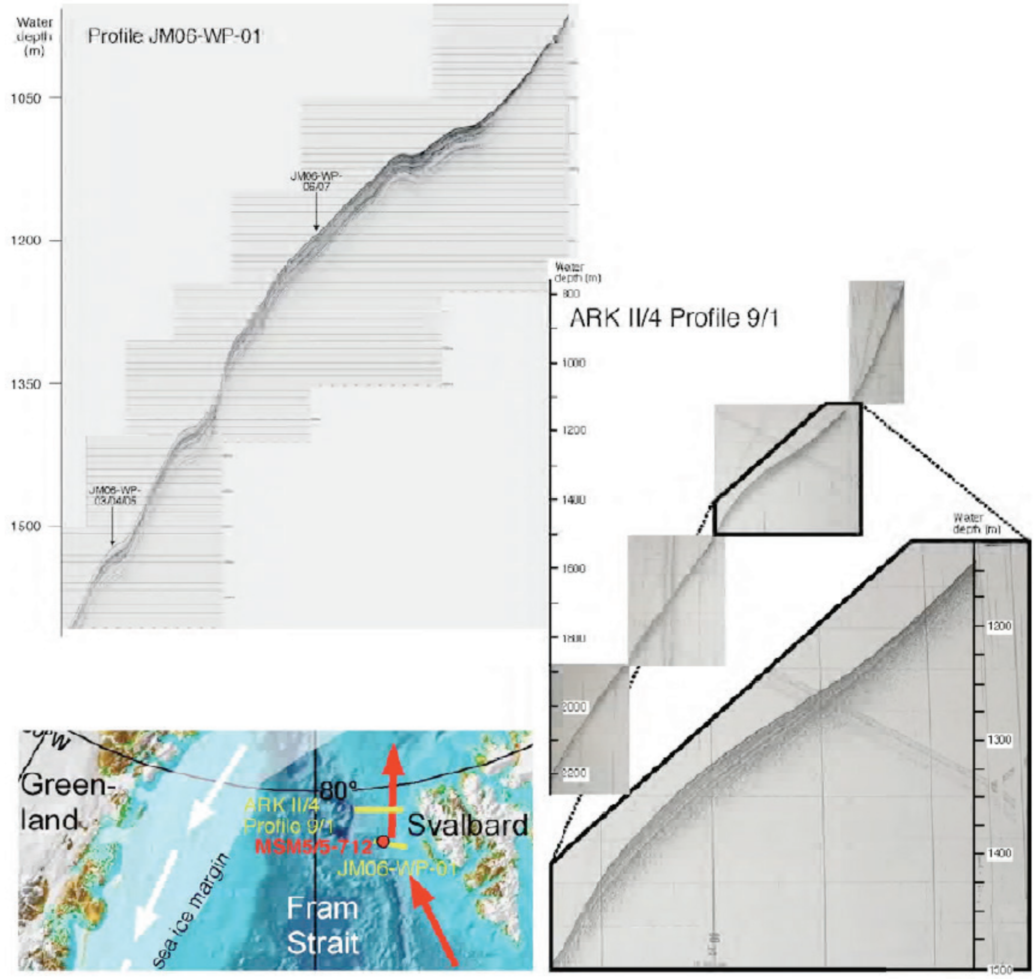

Fig. 2.1: Sediment echosounder profiles from selected areas at the western Svalbard continental margin with high sediment accumulation (thickened profile with individual layers visible). Sediment cores taken at site MSM5/5-712 on profile JM06-WP-01 (see Fig. 1.1) revealed sedimentation rates of >20 cm/ky.

Parasound sediment echosounder survey and site selection

In the areas identified as described above, Parasound sediment echosounder surveys will be conducted, in most cases perpendicular to the isobaths. The Parasound system usually has a penetration of 50 - 100 m in hemipelagic Arctic sediments. This is sufficient for tracing key reflectors and determining those water depths on the profile which show a maximum thickness of the uppermost layers (which are supposed to be of Late Quaternary age). After termination of each upslope or downslope profile, the ship will return to the selected optimal sites for coring operations. Along the western Svalbard continental margin, several sites with enhanced Holocene deposition are known. We plan to revisit these sites to obtain Eemian sequences which may be found at <10 m sediment depth.

Sediment coring

At the selected sites long and short sediment cores will be obtained. Short cores (giant box cores and/or multicores, 30-50 cm long) ensure the availability of sediments from the sediment-water interface which ideally reflect the modern environment at the site. Depending on sedimentation rates, the undisturbed sedimentary sequences in short cores cover the last few kiloyears (or ideally less) of environmental history. To obtain long sedimentary records, square-barrel gravity corers ("kastenlot corers", 30x30 cm, up to 17 m long) and conventional gravity corers (12 cm in diameter, up to 15 m long) will be used. Similar attempts will be made also at potentially suitable sites on the NE Greenland margin.

Sediment core treatment and analyses in home laboratories

Before openening, sediment cores will be logged using the MSCL system. Selected gravity cores will be opened and – as the kastenlot cores - described and photographed on board. Continuous sampling of selected cores will be performed in various ways and for various purposes, including several large-volume archive boxes (parallel sampling). Samples will be stored cool or frozen for further analyses in the home laboratories in Bremerhaven and Kiel. This work will comprise a huge set of analyses and proxy investigations like, e.g., XRF-scanning, grain sizes, biomarkers, stable carbon and oxygen isotopes of foraminifers, microfossil associations, Mg/Ca ratios of carbonate microfossils, clay and bulk mineralogy, etc.

Expected results and objectives of post-cruise research

- Stratigraphic analyses of the sediment sequences, using a multi-proxy-approach (AMS^{14}C, oxygen and carbon stable isotopes, biostratigraphy, natural radionuclides, physical properties, XRF scanning, cyclostratigraphy, and correlation to other existing Arctic Ocean records)
- Quantification and characterization of terrigenous sediment fraction in order to reconstruct transport processes, oceanic currents, and circum-Arctic ice-sheet history (Proxies/approach: grain size, clay minerals, heavy minerals, major, minor, trace and rare earth elements, organic carbon fractions, and physical properties; analytical techniques: X-ray diffraction (XRD), X-ray fluorescence (XRF), inductivity-coupled plasma mass spectrometry (ICP-MS), and microscopy of coarse fraction as well as MSCL-logging and XRF-scanning.
- Reconstruction of surface-water sub-surface and deep-water characteristics: paleo-sea-ice distribution, surface-water productivity, sea-surface and deep-water temperature, deep-water ventilation, etc., using specific biomarkers (e.g., n-alkanes, sterols, alkenones; U^{k}_{37} Index, IP_{25} Index), micropaleontological proxies (dinoflagellates, foraminifers, etc.), and inorganic-geochemical proxies (stable isotopes, radiogenic isotopes, etc.). Analytical techniques to be used include LECO ($CaCO_3$, TOC, C/N), Rock-Eval pyrolysis, gas chromatography (GC), gas chromatography/ mass spectrometry (GC/MS), and high-performance liquid chromatography/mass spectrometry (HPLC/MS), XRF, ICP-MS, and microscopy as well as XRF scanning.
- Studies of sea ice and sea-ice sediments (biomarkers, mineralogy, geochemistry, biology, etc.).

Data management

All data will be uploaded to the PANGAEA data repository. Unrestricted access to the data will be granted after about three years, pending analysis and publication.

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3. BATHYMETRY

L. Radig, M. Winkler, B. Maiyegun (AWI)

Objectives

If you are going somewhere and you do not want to get lost – you need a map. Accurate knowledge of the seafloor topography, hence high-resolution bathymetry data, is key, basic information necessary to understand many marine processes. It is of particular importance for the interpretation of scientific data in a spatial context. Especially in barely surveyed areas like the ice-covered high-latitude ocean, the bathymetry often provides the first view on the seafloor thus providing valuable information on the nature of the seafloor. Bathymetry, hence geo-morphology, is furthermore a basic parameter for the understanding of the general geological setting of an area and many geological processes such as for example erosion, sediment transport and deposition. Even information on tectonic processes can be inferred from the bathymetry. Supplementing the bathymetric data, high-resolution sub-bottom data of the top 10s of meters below the seabed provide information on the sediments at the seafloor, the shallow sediment architecture and on the lateral extension of sediment successions. In this way, the sub-bottom data add the 3rd dimension to the bathymetric maps.

Although intensively investigated, areas without high-resolution swath bathymetry coverage still exist in the Fram Strait. For those areas, the bathymetry is modelled from satellite altimetry with according low resolution. Satellite altimetry derived bathymetry lack the resolution necessary to resolve small- to meso-scale geo-morphological features (e.g. iceberg ploughmarks, sediment waves, and erosional escarpments). Ship-borne multibeam data provide bathymetry information in a resolution sufficient to resolve those features.

In the Fram Strait, geo-morphological features on the upper continental slopes can provide important information on the maximum advance of ice sheets across the continental shelves. For the reconstruction of the environmental parameters in the Fram Strait, also the pathways of icebergs can provide information on prevailing winds and ocean currents in the past. The abundance of icebergs ploughmarks can be used as a proxy for the amount and sizes of icebergs release into the Arctic Ocean. In addition, the bathymetry is a key data set for the selection of target sites for sediment and rock sampling. In combination with sub-bottom information, these data can be used to optimise the on-site sampling strategy. For example areas of outcropping older strata and areas of reduced or enhanced sediment accumulation can be identified. Furthermore, these data provide information on the adjacent and regional context of the sediment and rock samples.

Work at sea

Bathymetric data will be recorded with the hull-mounted multibeam echosound Atlas Hydrosweep DS3 and. The main task of the bathymetry group is to plan and run bathymetric surveys in the survey areas and during transit. The raw bathymetric data will be corrected for sound velocity changes in the water column and will be further processed and cleaned for erroneous soundings and artefacts. Detailed seabed maps derived from the data will provide information on the general and local topographic setting in the study areas. High-resolution seabed and sub-bottom data recorded during the survey will be made available for site selection and cruise planning. During the survey, the acoustic measurement will be carried out be three operators in a 24/7 shift mode.

Preliminary (expected) results

Expected results are high-resolution seabed maps along the cruise track and from the target research sites. The bathymetric and sediment acoustic data will be analysed to provide geomorphological information for the seabed in the Fram Strait. Expected outcomes aim towards a better understanding of the geological and particularly the sedimentological processes in the research area.

Data management

Bathymetric data collected during the expedition will be stored in the PANGAEA data repository at the AWI. Furthermore, the data will be provided to mapping projects and included in regional data compilations such as IBCAO (International Bathymetric Chart of the Arctic Ocean) and GEBCO (General Bathymetric Chart of the Ocean).

4. VARIABILITY OF OCEANIC FLUXES THROUGH FRAM STRAIT

W.-J. von Appen (AWI), O. Strothmann (AWI), U. Schauer (AWI, not on board)

Background and objectives

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 (2,700m), 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, 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 before it exits through the western Fram Strait. 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 and heat, and, in the western part of the strait, freshwater into and out of the Arctic Ocean through this gateway.

Next to the dramatic retreat of sea ice, the strongest climatic signal of the Arctic Ocean and the Nordic Seas in the past decade are changes in temperature and salinity. While additional heat and salt are advected northwards from the subpolar North Atlantic into the Nordic Seas, a strong accumulation of fresh water has been observed in the past decades in the Arctic Ocean. The aim of a glider programme, started in summer 2014 in the western Nordic Seas, is to observe whether the increasing amount of freshwater reaches the inner basins of the Nordic Seas and thus dampens vertical mixing and intermediate as well as deep water renewal during winter. This might lead to a slow-down of the northern branch of the AMOC.

Work at sea

The work at sea of this group will focus on recovering as many moorings as possible. The original plan had been to recover the moorings of the array along 78°50’N during PS85 (summer 2014). However, the majority of the mooring service work of that cruise, particularly in the eastern Fram Strait could not be achieved due to the additional time that *Polarstern* spent in the shipyard in spring 2014. The priority is to recover moorings F1 and F3-F7 during PS93.1. They generally contain tempeature and ocean current velocity recorders at 75m, 250 m, 750 m, 1,500 m, and at the bottom (unless the water depth is shallower than the standard depths). Salinity is also measured at 75 m and 250 m depth. The top flotation of F2 was damaged (the Argos beacon started sending data while drifting in June 2014) and this mooring cannot be recovered during PS93.1. Seven moorings with sound sources were deployed between 5°W and 0° during previous expeditions to the region. We will attempt to recover as many of them as possible, but this is limited by the available time and possible complications in case some of the releasers might not work properly anymore. An overview of the mooring locations is shown in Fig. 4.1.

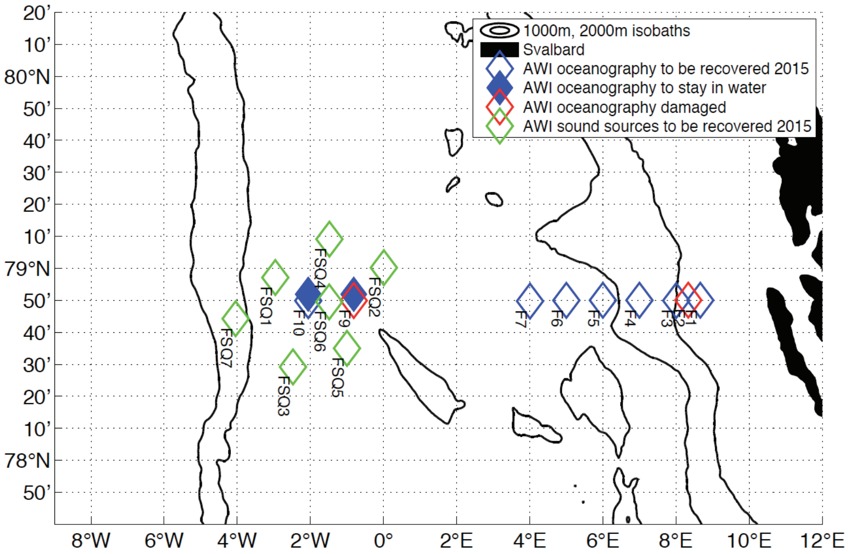

Fig. 4.1: Positions of the moorings to be recovered in Fram Strait during Expedition PS93.1 (number depends on time available)

Not enough time is available for re-deployment of the moorings F1-F6 during PS93.1, but this task should be achieved during another cruise with a smaller research vessel to the Fram Strait in 2015.

At the end of the cruise on the transit back to Tromsø, SeaGliders SG127 and MK558 will be deployed in the Greenland Sea. This requires a small boat operation and monitoring of the gliders during their first short dive to assess whether their buoyancy is sufficient. The gliders will capture hydrographic sections between the inner Greenland Sea Basin and the East Greenland Current. Every 4km they will dive to 1000m depth and thereby record temperature and salinity profiles. These data will be transmitted via Iridium satellites when the gliders return to the ocean surface after each dive. The gliders will be monitored and remotely steered along standard sections by glider pilots at the AWI in Bremerhaven.

Data management

The data recorded by the moored instrumentation will be processed after the cruise at AWI and submitted to the PANGAEA data repository. The gliders are piloted from AWI in real time. The uncalibrated data will be provided in near-real time to the Coriolis data centre for use in operational applications. The calibration and final processing will take place after completion of the mission and the data will be delivered to the PANGAEA data repository.

5. PLANKTON ECOLOGY AND BIOGEOCHEMISTRY IN THE CHANGING ARCTIC OCEAN (PEBCAO GROUP)

S. Gäbler-Schwarz (AWI)
not on board: K. Metfies (AWI), E.-M. Nöthig (AWI), I. Peeken (AWI)

Objectives

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.

Climate induced changes will also impact the biodiversity in pelagic ecosystems. A shift in species composition is expected to occur in all plankton size classes, however smallest algae may thrive the phytoplankton in the future Arctic Ocean. Besides diatoms, other smaller planktonic algae will gain more importance in mediating elemental- and matter- as well as export fluxes. One of them, *Phaeocystis pouchetii*, having an intermediate position regarding size, can play a key role in the cycle of sulphur and carbon. Little is know about the diversity distribution, occurrence and physiology of this species in Arctic pelagic regions.

The prymnesiophyte *Phaeocystis* is a cosmopolitan genus of the phytoplankton. It is ecologically important because it can develop large blooms. Two colony-forming cold water species are known: *P. pouchetii* in the Arctic and *P. antarctica* in the Southern Ocean. Preliminary molecular biological analyses of the ribosomal RNA (rRNA) and ITS (Internal Transcribed Spacer) sequences indicated substantial inter- and intraspecific diversity as well as the possibility of a species complex in the Arctic *P. pouchetii*. Based on these results, a detailed analysis of the population structure is intended to link genetic data to environmental parameters as well as to ecophysiological response patterns. An aim is to experimentally evaluate whether genetic differences are reflected in different ecophysiological response patterns which could explain specific biogeographic distribution patterns. Moreover, this new approach offers also the opportunity to relate population genetics to predicted climatic changes.

In order to examine changes, including the smallest fractions, molecular methods are well to complement traditional microscopy to assess composition and biogeography of marine protists here with the focus on the key species *Phaeocystis pouchetii*. 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 phytoplankton will be based on the analysis of ribosomal genes, taking advantage next generation sequencing technology, Automated Ribosomal Intragenic Sequence Analysis (ARISA), and quantitative PCR.

Work at sea

In order to gain enough material to isolate *Phaeocystis* cells a small plankton hand-net (20µm) will be towed down to ~10m water 5-10 times at ship stations. We also intend to sample arctic seawater by the shipborne snorkel system and hand-net hauls along the cruise track to catch phytoplankton for isolation of clonal cultures of *P. pouchetii*; with these clonal cultures genetic and physiological analyses will be carried out back at the AWI.

All samples will be haltered in the cooling culture lab container on board for later clonal culturing and physiological experiments in the home laboratory at AWI and may be transferred to the shipborne cooling room for transfer back to Bremerhaven.

Preliminary (expected) result

We expect to gain clonal cultures at various isolation stages.

Data management

Cultures will be kept at AWI cool laboratories until genetic work and physiological experiments have been carried out. 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 or even later).

6. PROJECT ISO-ARC: ISOTOPE SIGNATURE OF WATER VAPOUR OVER THE ARCTIC OCEAN

J.-L. Bonne (AWI),
not on board: S. Kipfstuhl (AWI), H. Meyer (AWI), B. Rabe (AWI), Hans-Christian Steen-Larsen (LSCE), M. Werner (AWI)

Objectives

For several decades, isotope research was focussed on precipitation samples as end member products of the hydrological cycle, only, as vapour measurement in the field were most difficult to perform. Since very recently, $H_2^{18}O$ and HDO in water vapour can be measured with necessary precision by commercially available light-weighted cavity-ring-down spectrometers (CRDS). The CRDS allow for the first time in the water isotope research history that the isotopic content of the water vapour in the air can be analysed directly under *in-situ* conditions on any place or platform almost autonomously, thus also on board of ships or planes or on remote stations in the Arctic or Antarctic.

Within the project Iso-Arc, funded by AWI's strategy fond, the installation of such an instrument on board of *Polarstern* in combination with surface water sampling will allow a unique simultaneous data set of $H_2^{18}O$ and HDO in both ocean surface and the atmosphere directly above the ocean surface. Thus, the imprint of marine boundary conditions (e.g. temperature variations, circulation changes, or meltwater input) to the isotopic composition of the atmospheric water cycle will be directly measured for the first time with a focus on North Atlantic and Arctic oceans. In combination with simultaneous water isotope measurements at Iceland (by Hans Christian Steen-Larsen, LSCE), Svalbard (by Valérie-Masson Delmotte, LSCE), and Samoylov, North Siberia, (by AWI) and paired with complementing climate simulations enhanced by water isotope diagnostics, a combined analyses of model results and data from all sites, covering an approx. 6,000 km transect of the eastern Arctic, will allow a quantitative assessment of the Eurasian Arctic water cycle, its isotopic variations and imprint in various climate archives. The results of these analyses will also be of relevance for the interpretation of isotope signals found in ice cores and on terrestrial Arctic sites in terms of past climate change.

As a pilot study, continuous isotopic measurements of specific humidity, $H_2^{18}O$ and HDO have been performed with success over 1 month, with a Los Gatos Research (LGR) CRDS during ARK-XXVIII/4 in Aug/Sep 2014. This instrument has been removed from the ship after the cruise and will now be replaced by a new water vapour analyser system within the framework of the Iso-Arc project.

Work at sea

During the cruise the Picarro water vapour analyser system, a light-weighted CRDS, will be installed. Besides the CRDS the system includes a heated inlet to measure ambient water vapour (this inlet has been already installed during ARK-XXVIII/4) as well as a newly designed calibration unit. After successful installation the analyser system will continuously and autonomously measure water vapour and its isotopic composition during this cruise and future *Polarstern* expeditions.

Data management

All humidity and isotope data of this project will be uploaded to the PANGAEA database after processing and post-operative calibration. Unrestricted access to the data will be granted within 2-3 years, pending analysis and publication.

7. THE „ARCTRAIN“ FLOATING UNIVERSITY

R. Stein (AWI), A. Paul (UoB), A. Criscitiello (UoC), A. Slavin (McGill), and the PS93.1 ArcTrain PhD students
not on board: M. Kucera (UoB), M. Walter (UoB), A. de Vernal (UQAM)

Background and objectives

Due to a complex set of feedback processes collectively known as “polar amplification”, the Arctic realm is expected to experience a greater-than-average response to global climate forcing. The cascades of feedback processes that connect the Arctic cryosphere, ocean and atmosphere remain incompletely constrained by observations and theory and are difficult to simulate in climate models. Our capacity to predict the future of the region and assess the impacts of Arctic change processes on global and regional environments hinges on the availability of interdisciplinary experts with strong international experience and understanding of the science/society interface. This is the basis of the International Research Training Group “Processes and impacts of climate change in the North Atlantic Ocean and the Canadian Arctic - ArcTrain“, which was initiated in 2013. ArcTrain aims to educate PhD students in an interdisciplinary environment that combines paleoclimatology, physical oceanography, remote sensing and glaciology with comprehensive Earth system modelling, including sea-ice and ice-sheet components. The qualification programme for the PhD students includes joint supervision, mandatory research residences at partner institutions, field courses on land and on sea (Floating University), annual meetings and training workshops and a challenging structured training in expert skills and transferrable skills. Its aim is to enhance the career prospects and employability of the graduates in a challenging international job market across academic and applied sectors.

ArcTrain is a collaborative project at the University of Bremen and the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven. The German part of the project is designed to continue for nine years and educate three cohorts of twelve PhD students each. The Canadian partners comprise a consortium of eight universities led by the GEOTOP cluster at the Université du Québec à Montréal and including Dalhousie University, McGill University, Memorial University of Newfoundland, University of Alberta, University of British Columbia, University of Calgary and Université du Québec à Rimouski.

Further details about ArcTrain are available at: https://www.marum.de/ArcTrain.html

Work at sea

As part of the ArcTrain qualification programme, a “floating University” will be held onboard *Polarstern* during the PS93.1 Expedition. About 20 Canadian and German PhD students with very different scientific backgrounds (i.e., oceanography, geosciences and modelling) will be introduced into the different technical aspects of field work in marine sciences. The students will assist the different working in all kind of activities on the aft deck and in the laboratories, and they will be involved in the evaluation and interpretation of the shipboard scientific data. Besides the practical work, seminars will be carried out with presentations by the ArcTrain PhD students as well as the senior scientists involved in the PS93.1 scientific programme.

Preliminary (expected) results

Reports about the shipboard activities shall be written by the ArcTrain students.

Data management

Provided by the other research groups.

8. TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

	Address
AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
BPRC	Byrd Polar Research Center The Ohio State University, 108 Scott Hall 1090 Carmack Road, Columbus, OH 43210, USA
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard-Nocht-Str. 76 20359 Hamburg Germany
GEOMAR	Helmholtz-Zentrum für Ozeanforschung (GEOMAR) Wischhofstr. 1-3 24148 Kiel Germany
HeliService	HeliService International GmbH Am Luneort 15 27572 Bremerhaven Germany
McGill	Department of Atmospheric and Oceanic Sciences, McGill University, 805 Sherbrooke Street West, Montreal, Quebec, H3A 0B9, Canada
KOPRI	Korea Polar Research Institute 6 Songdomirae-ro, Yeonsu-gu 406-840 Incheon Korea

	Address
UoAE	Department of Earth & Atmospheric Sciences, 1-26 Earth Sciences Building University of Alberta Edmonton Edmonton, Alberta, T6G 2E3 Canada
UoB	Center for Marine Environmental Sciences (MARUM), University of Bremen Leobener Strasse, 28359 Bremen Germany
UoC	University of Calgary, 200 Glacier Dr., #27 Canmore, AB T1W 1K6 Canada
UoK	Institute for Geosciences, University of Kiel Otto-Hahn-Platz 1 24118 Kiel Germany
UoT	Institute of Geology, University of Tromsø Dramsveien 201 9037 Tromsø Norway
UQAM	GEOTOP & Département des sciences de la Terre et de l'atmosphère, Université du Québec à Montréal, CP 8888, succ. Centre-Ville, Montréal, Québec, H3C 3P8, Canada

9. FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Name	First name	Institute	Profession
Aubry	Aurélie	UQAM	PhD student ArcTrain
Bartels	Martin	UoB	PhD student ArcTrain
Bauch	Henning	GEOMAR	Geology
Bonne	Jean-Louis	AWI	Glaciology/Chemistry
Bouchat	Amélie	McGill	PhD student ArcTrain
Breckenfelder	Tilia	UoB	PhD student ArcTrain
Criscitiello	Alison	UoC	Postdoc ArcTrain
Davin	Sam	UQAM	PhD student ArcTrain
Falardeau	Jade	UQAM	PhD student ArcTrain
Forwick	Matthias	UoT	Geology
Gäbler-Schwarz	Steffi	AWI	Biology
Garcia	Yarisbel	UoAE	PhD student ArcTrain
Gillard	Laura	UoAE	PhD student ArcTrain
Hata	Yukie	McGill	PhD student ArcTrain
Hegstad	Sigrun	UoT	Geology
Hörner	Tanja	AWI	Geology
Jutras	Mathilde	McGill	PhD student ArcTrain
Kirillova	Valeriia	UoB	PhD student ArcTrain
Klus	Andrea	UoB	PhD student ArcTrain
Krandick	Annegret	UoB	PhD student ArcTrain
Kremer	Anne	AWI	Geology
Kretschmer	Kerstin	UoB	PhD student ArcTrain
Leng	Wei	UoB	PhD student ArcTrain
Maiyegun	Babajide	AWI	Bathymetry
Miller	Max	DWD	Meteorologist
Niessen	Frank	AWI	Parasound/Logging
Olsen	Ingrid	UoT	Geology
Paul	Andre	UoB	PI ArcTrain
Petersen	Florian	UoK	Parasound
Plante	Mathieu	McGill	PhD student ArcTrain
Quatmann-Hense	Anna	UoB	Geology
Radig	Lars	AWI	Bathymetry
Scarlat	Raul	UoB	PhD student ArcTrain
Schreck	Michael	KOPRI	Geology
Slavin	Alexander	McGill	Postdoc ArcTrain
Sonnabend	Hartmut	DWD	Met. Technician
Spielhagen	Robert	GEOMAR	Geology
Stein	Ruediger	AWI	Chief scientist/Geology

Name	**First name**	**Institute**	**Profession**
Strothmann	Olaf	AWI	Oceanography
Telesinski	Maciej	GEOMAR	Geology
von Appen	Wilken-Jon	AWI	Oceanography
Werner	Kristin	BPRC	Geology
Wildau	Antje	UoK	Geology
Williams	James	McGill	PhD student ArcTrain
Winkler	Maria	AWI	Bathymetry
Zorzi	Coralie	UQAM	PhD student ArcTrain
NN		HeliService	
NN		HeliService	
NN		HeliService	
NN		HeliService	

10. SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
01.	Wunderlich, Thomas	Master
02.	Lauber, Felix	1.Offc.
03.	Westphal, Henning	Ch.Eng.
04.	Kentges, Felix	2.Offc.
05.	Stolze, Henrik	2.Offc.
06.	Fallei, Holger	2.Offc.
07.	Spilok, Norbert	Doctor
08.	Hofmann, Jörg	Comm.Offc.German
09.	Schnürch, Helmut	2.Eng.
10.	NN	2.Eng.
11.	Rusch, Torben	2.Eng.
12.	Brehme, Andreas	Elec.Tech.
13.	Ganter, Armin	Electron.
14.	Dimmler, Werner	Electron.
15.	Winter, Andreas	Electron.
16.	Feiertag, Thomas	Electron.
17.	Schröter, Rene	Boatsw.
18.	Neisner,Winfried	Carpenter
19.	Clasen, Nils	A.B.
20.	Burzan, Gerd-Ekkehard	A.B.
21.	Schröder, Norbert	A.B.
22.	Leisner, Bert	A.B.
23.	Hartwig-L., Andreas	A.B.
24.	Kretzschmar, Uwe	A.B.
25.	Müller, Steffen	A.B.
26.	Gladow, Lothar	A.B.
27.	Sedlak, Andreas	A.B.
28.	Beth, Detlef	Storekeep.
29.	Plehn, Markus	Mot-man
30.	Klein, Gert	Mot-man
31.	Krösche, Eckard	Mot-man
32.	Dinse, Horst	Mot-man
33	Watzel, Bernhard	Mot-man
34.	Meißner, Jörg	Cook
35.	Tupy,Mario	Cooksmate
36.	Völske, Thomas	Cooksmate
37.	Luoto, Eija	1.Stwd.
38.	Schwitzky-S., Carmen	Stwdss/KS
39.	Mack, Ulrich	2.Steward
40.	Hischke, Peggy	2.Stwdess
41.	Wartenberg, Irina	2.Stwdess
42.	Hu, Guo Yong	2.Steward
43	Chen, Quan Lun	2.Steward
44.	Ruan, Hui Guang	Laundrym.