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Cruise Report
HEINCKE HE451-2
Longyearbyen-Bremerhaven
September 30 – October 12 2015

On citing this report in a bibliography, the reference should be followed by the words *unpublished manuscript*.

Aims of the cruise

The aim of the cruise was to complete the hydrographic mooring array in the eastern Fram Strait (West Spitzbergen Current) and recover two Seagliders in the Greenland Sea on the way back to Germany (fig. 1).

The moorings belong to 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. 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 between the Arctic Ocean and the Nordic Seas.

The glider program aims to observe whether the increasing amount of freshwater, flowing into the Nordic Seas from the Arctic Ocean with the East Greenland Current, reaches the inner basins of the Nordic Seas and dampens vertical mixing and intermediate to deep water renewal during winter. In 2015 the gliders conducted for 3 months repeated hydrographic sections in the western Nordic Seas across the Polar Front. The program started in 2014 in the framework of the DFG research group FOR1740, TP 1.1.

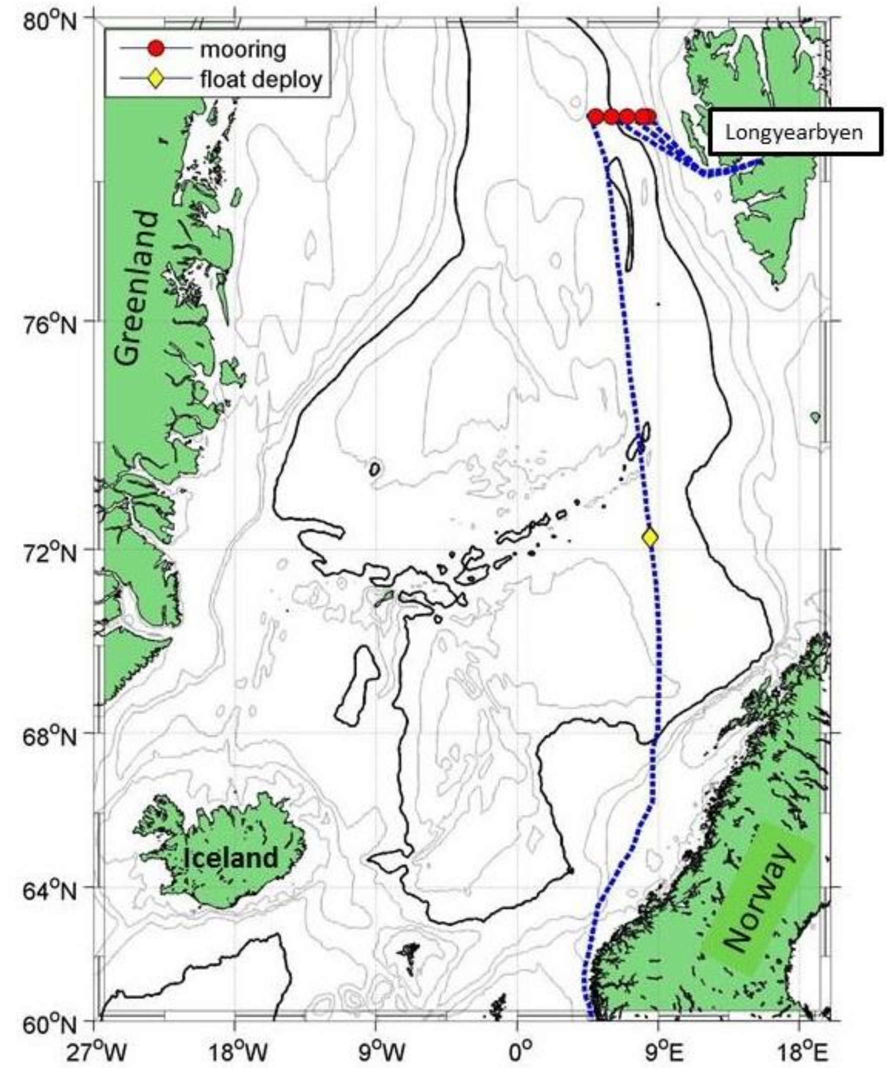

Figure 1: Cruise track of HE 451-2, Nordic Seas, October 2015.
The 2000 m depth contour is highlighted.

Narrative

September 29 in the afternoon we loaded the first part of our equipment. As the aquarium container from the last cruise leg was still on board we were not able to load all of our equipment at once.

We left Longyearbyen not earlier than in the morning of October 1 because on the previous day 8 m high waves were reported from our research area. On October 2 we deployed the moorings F2, F3 and F4 and afterwards stem back to Longyearbyen. We arrived in the morning of October 3, loaded the second part of the mooring equipment and immediately left the harbor again. On October 4 F5 and F6 were deployed. It was then decided to skip the recovery of the two Seagliders as the weather forecast predicted heavy winds of 25 m/s and more for the next day. These conditions would have prevented to water the rubber boat in the Greenland Sea for the recovery and to manage the transit back to Bremerhaven in time. Luckily RV Polarstern was able to take over and successfully recovered both instruments during October 5. On the way to the Norwegian Coast two Argo-floats from the BSH (Bundesamt für Seeschifffahrt und Hydrographie, Hamburg) were deployed in the Lofoten Basin. Sheltered against strong winds from the east we smoothly steam home. Only in the Skagerak we were affected by heavy winds and rough sea. We arrived in Bremerhaven about noon on October 11.

Station list

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Wind [m/s]	
Moorings							
001-1	2015/10/02	07:45	78°49.45’N	008°18.97’E	789	NNE 9	F2*
002-1	2015/10/02	09:38	78°49.85’N	008°00.80’E	1006	NNE 4	F3
003-1	2015/10/02	12:57	78°49.82’N	007°02.81’E	1407	NW 7	F4
004-1	2015/10/04	08:18	78°50.00’N	006°00.58’E	2434	E 10	F5
005-1	2015/10/04	11:43	78°50.72’N	004°38.46’E	2751	E 9	F6*
Argo floats							
#1	2015/10/05	23:50	72°15.34’N	008°28.84‘E	2633		WMO6902617
#2	2015/10/06	00:05	72°13.875’N	008°29.94‘E	2644		WMO6902616

* mooring from last deployment on original position is not recovered

Crew List

Name	Given Name	Rank	Nationality	Institute
von Staa	K. Friedhelm	Master	German	
Nannen	Rainer	1. Officer	German	
Franke	Remo	2. Officer	German	
Klinder	Klaus	Chief Eng.	German	
Nana-Hackman	Aboubakar	Electrician	German	
Sieber	Norbert	Cook	German	
Riedel	Kai	Bosun	German	
Heeren	Derk	AB	German	

Dräger	Martin	AB	German	
Lewin	Günter	AB	German	
Constapel	Andre	AB	German	
Science				
Latarius	Katrin	Chief scientist	German	AWI, Oz
Krieten	Guide	technician	German	AWI, Bio
Machnik	Marcel	Technician, Azubi	German	AWI, Bio
Spiesecke	Stefanie	Technician	German	AWI, Oz
Strothmann	Olaf	Technician	German	AWI, Oz
Swoboda	Steffen	Scientist, Hiwi	German	AWI, Bio
von Appen	Wilken Jon	Scientist	German	AWI, Oz

Technical Information

For the deployment of the moorings a portable winch was mounted on the afterdeck behind the fishing winch (fig.2). The up to 3000 m long mooring lines were deployed backwards with the weight put outboard at the very end.

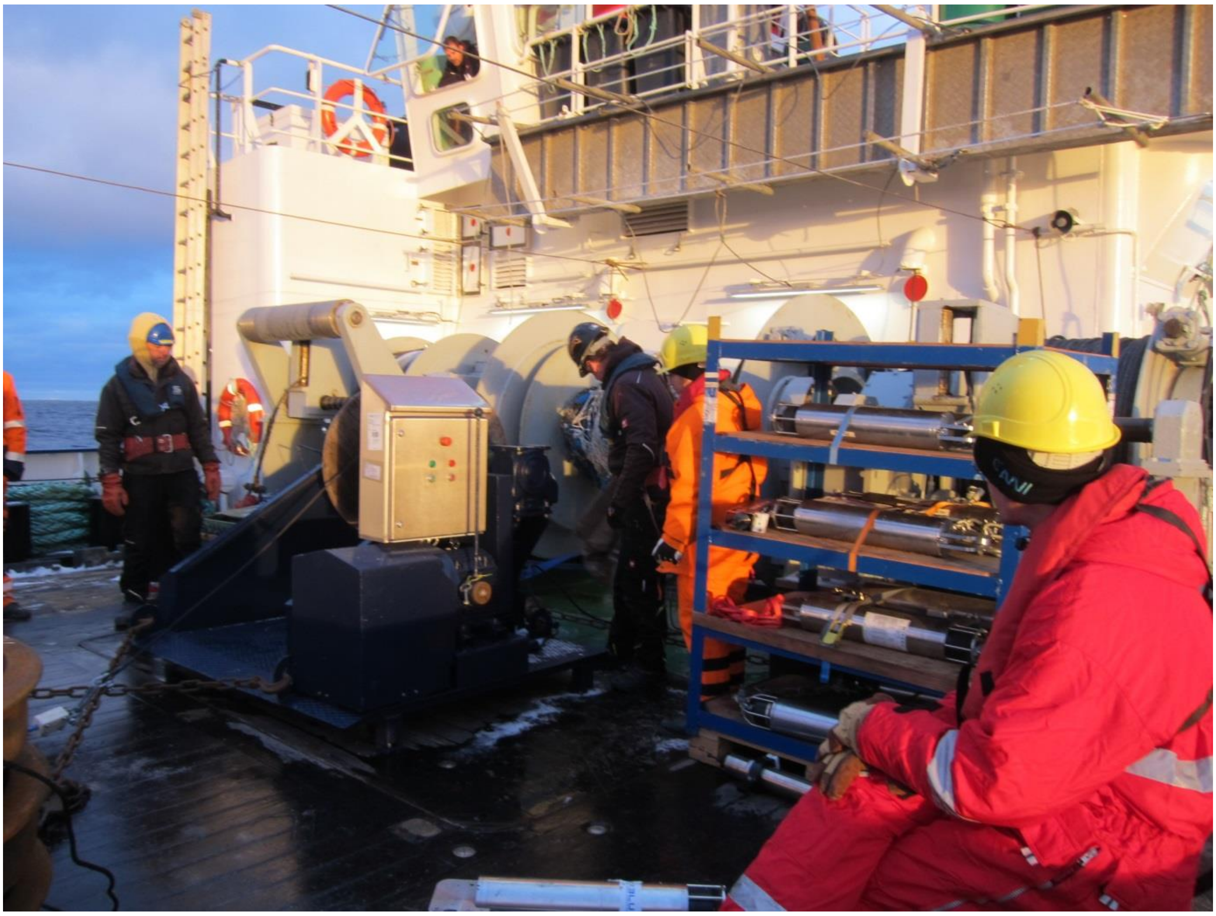

Figure 2: Mooring work with the portable winch from the section of physical oceanography of the AWI Bremerhaven on the afterdeck of Heincke.

First results

Fram Strait mooring array

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 (2700m), 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.

The mooring array in Fram Strait is shown in figure 3.

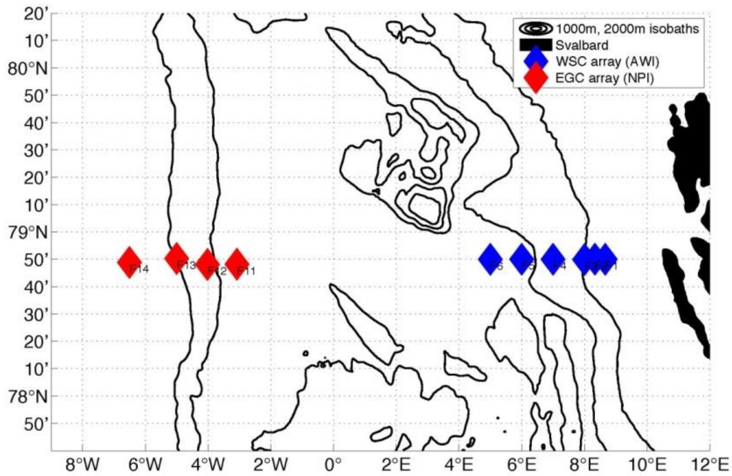

Figure 3: The Fram Strait mooring array maintained by the Alfred Wegener Institute, Bremerhaven, and the North Polar Institute, Tromsø.

The data return of the instruments from the last recovery (July 2015 with RV Polarstern, PS93.1) was very successful. Preliminary calibration of the data was possible and did not exhibit any major problems with the data. The seasonal cycle of temperature and salinity (fig.4) across the West Spitsbergen Current agreed with previous results. However, the moorings experienced major vertical mooring motions associated with very strong horizontal currents on the upper continental slope. Specifically, the microcat that was moored at a nominal depth of 75 m on mooring F3 at a water depth of 1040 m was blown down to 500-650 m depth for short periods every deployment year between December and February (fig.4). The ADCP records indicated that the velocities at those times exceeded 0.5 m/s through a significant part of the water column. This information should be considered in the mooring design.

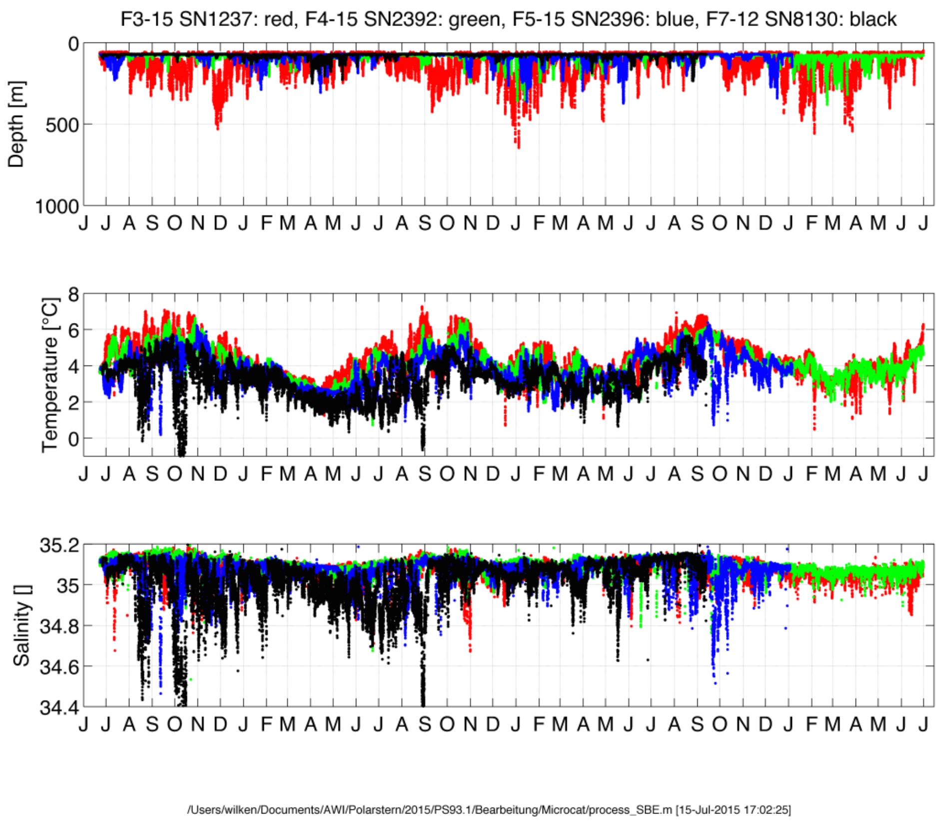

Figure 4: Mooring records of instrument depth, temperature, and salinity at the nominal 75 m depth level of the four recovered moorings F3-15, F4-15, F5-15, and F7-12.

Atlantic Water in the eastern Fram Strait defined as water warmer than 2°C was found to have increased in temperature by ~1°C between 1997 and 2010 with a maximum in 2007 (Beszczynska-Möller et al, 2012). That analysis was based on a gridded field derived from data from all six moorings F1 to F6. Since F1 and F2 could not be recovered on PS93.1, a slightly different representation of the temperature evolution in the West Spitsbergen Current is given (fig.5). It again becomes clear that the temperature increased from 1997 until reaching a maximum in 2007. The temperatures after 2007, however, were lower than in 2007, but higher than before such that 2007 appears to be an anomalous maximum. The temperature over the recent 8 years was relatively stable at elevated levels compared to the mid 1990s.

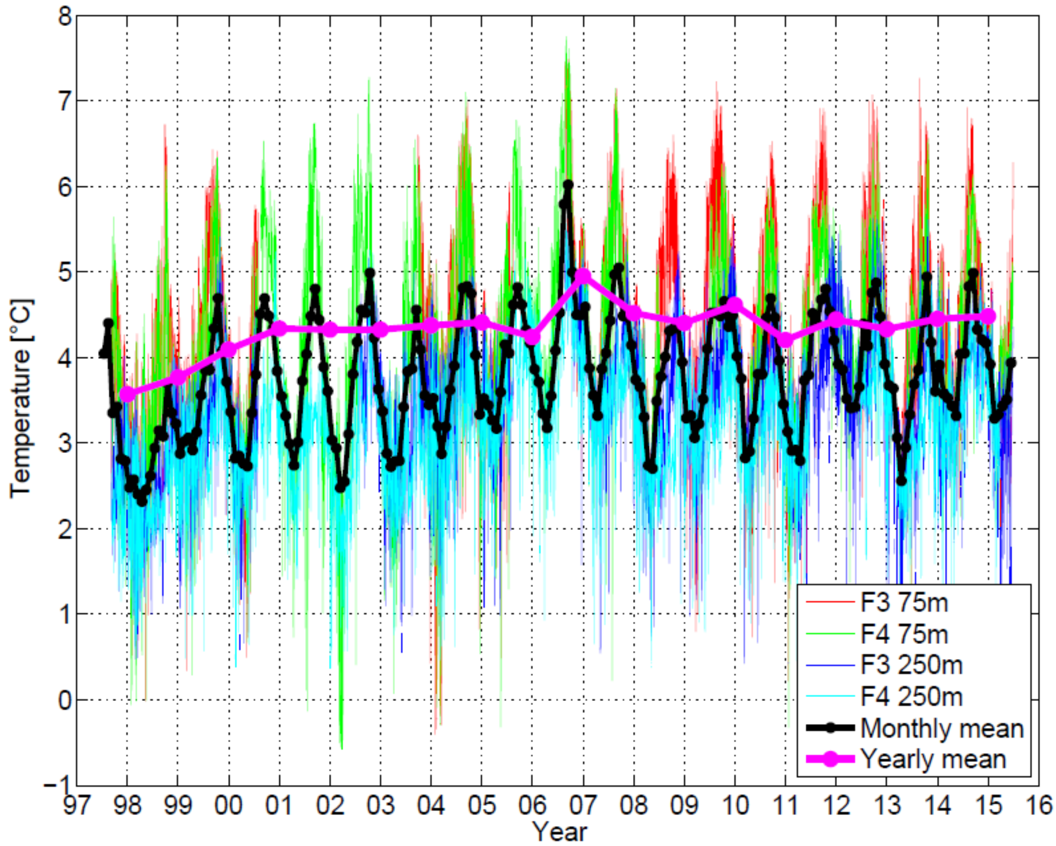

Figure 5: Temperatures recorded at 75 m and 250 m depth on moorings F3 and F4 from 1997 to 2015. The monthly means of those four records are also shown as are the July to June yearly means. This figure shows similar information to Figure 6a of Beszczynska-Möller et al (2012).

Further publications about analyses based on the mooring array in Fram Strait can be found in the references.

Glider missions

Next to the dramatic retreat of sea ice, the strongest climatic signals 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 freshwater has been observed in the past decades in the Arctic Ocean. The aim of a glider program, 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 to deep water renewal during winter. This might lead to a slow-down of the northern branch of the AMOC.

In summer 2015 the gliders capture hydrographic sections between the inner Greenland Sea Basin and the East Greenland Current. Along the section dives of 500 to 1000 m depth are carried out continuously to record temperature and salinity profiles. The data is transmitted via Iridium satellites when the gliders return to the surface after each dive. The gliders are monitored and remotely steered by glider pilots at the AWI in Bremerhaven.

Typical salinity sections from summer 2014 and 2015 along the same line are compared in figure 6. These sections show only the upper 55 m of the water column as the freshwater concentrates in the near-surface layer. In summer 2014 the ice coverage extend far from the continental shelf into the Greenland Sea basin. Sections were carried out to the Northwest until the ice edge is reaches. Close to the ice edge salinities below 32 were observed in the upper 10 m. Repeated sections suggest rapid vertical mixing within this layer. In summer 2015 ice was found only close to Greenland on the shallow shelfs and freshwater was observed only on top of the EGC but not in a thin surface layer in the interior basin. The interannual variability of the salinity/freshwater distribution supports the idea, that local ice melt is the source for freshwater in the inner Greenland Sea and the occurrence depends on the spreading of ice from the EGC to the interior basin. This freshwater source for the Greenland Sea basin was also observed by de Steur et al. (2015) in previous years.

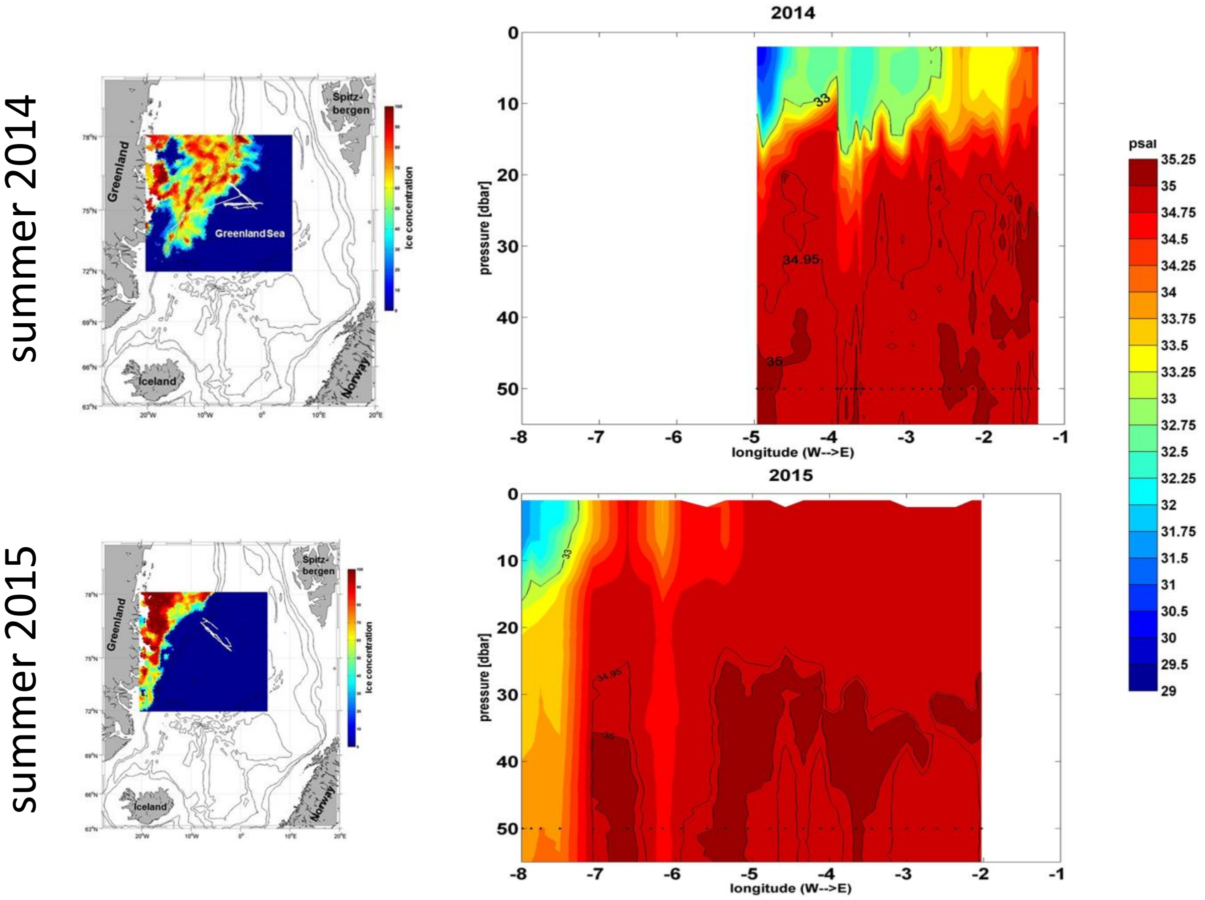

Figure 6: (left) ice coverage in the western Nordic Seas and glider tracks for the associated summer missions (right) salinity sections (upper 55 m) along the NW to SE line. The 33 and 34.95 isohalines are marked in black.

Argo floats

The monitoring of hydrography in the Nordic Seas was conducted with Argo floats since 2001. For maintenance of the array deployments are needed every year. Analyses of the interannual variability of hydrography and circulation as well as analyses of heat and freshwater budgets were conducted on the basis of the data set from the Argo floats (Latarius and Quadfasel, 2010; Voet et al. , 2010; Latarius and Quadfasel, 2016). Tracks from the Argo floats deployed in the Nordic Seas I 2015 are shown in figure 7.

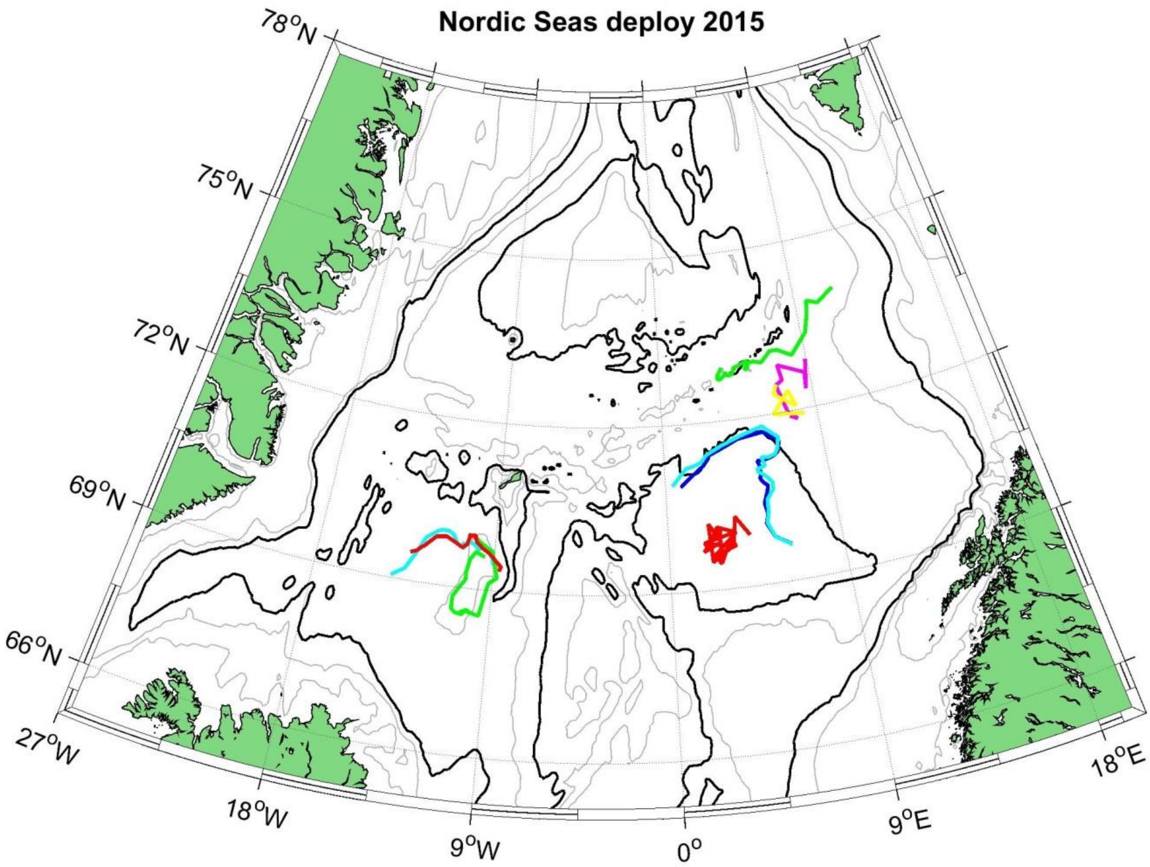

Figure 7: Tracks of Argo floats deployed in the Nordic Seas in 2015 (data until February 2016).

Acknowledgements
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