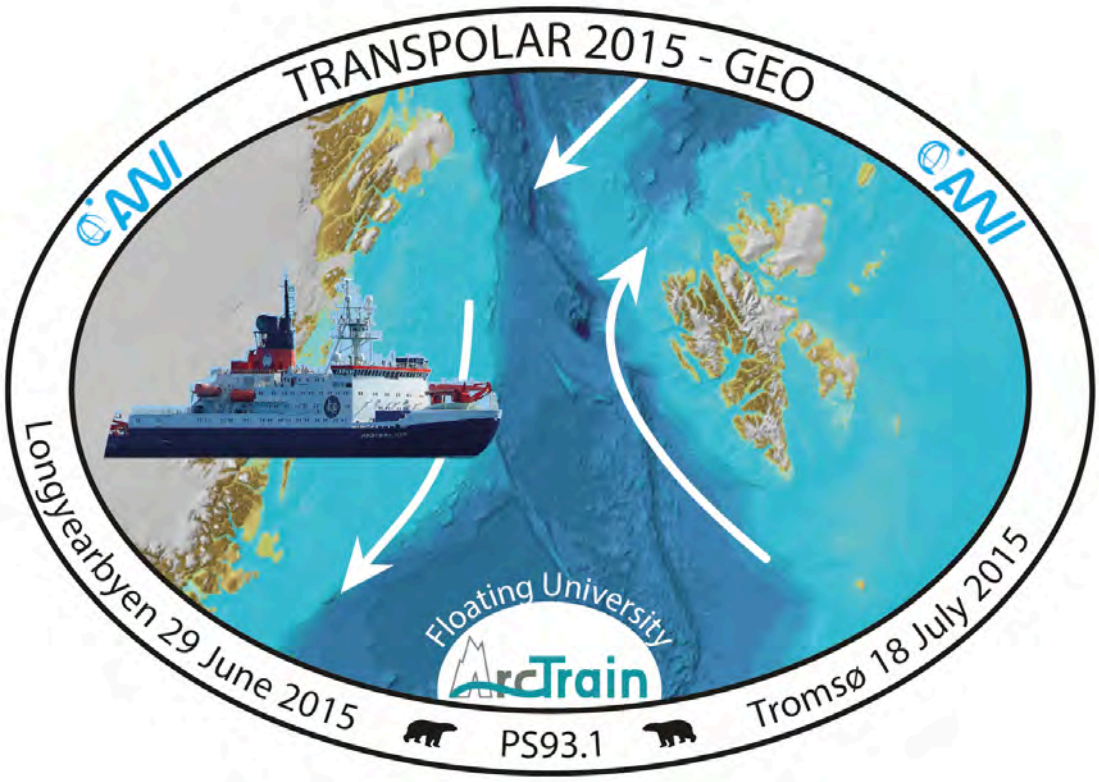
PS93.1

29 June – 18 July 2015

Longyearbyen - Tromsø



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Reference:
Stein, R. (Ed.), 2016. The Expedition PS93.1 of the Research Vessel *Polarstern* to the Northern North Atlantic/Fram Strait in 2015, Reports on Polar and Marine Research xxx, Bremerhaven, Alfred Wegener Institute for Polar and Marine Research, xxx pp.
(online available end of February 2016; http://epic.awi.de/xxxxx/x/BzPM_0xxx_2016.pdf)

1. SUMMARY AND ITINERARY

Summary
Target areas of Expedition PS93.1 were the NE Greenland continental margin, the central Fram Strait and the western Svalbard margin (Fig. 1). The overall scientific goal of the marine-geological research program is to investigate the variability of key environmental parameters during warm periods (interglacials) of the geological past. Of special interest are the last interglacial (Eemian, ca. 130-120 ka) and the Holocene (last ca. 12 ka). For this purpose, long sediment cores from potential areas with high sediment accumulation are needed. Besides the main geological program, some complementary oceanographic, biological and air-chemical programs as well as a "Floating University" were carried out.

Key activities of the expedition can be summarized as follows:

- A detailed geological coring program (4 x Kastenlot corer, 22 x gravity corer, 29 x Giant Box Corer, 11 x Multicorer) was carried out in Fram Strait, Greenland Sea and East Greenland continental shelf (Fig. 1; Table 1). High-quality long sediment cores were recovered that will allow detailed reconstructions of the Greenland ice sheet history, the sea-ice variability and changes in water mass circulation on different time scales including the Holocene and the Eemian.
- During transit and within the main working areas, Hydrosweep and Parasound were running continuously, resulting in about 4000 km of high-quality profiles that were the basis for the precise selection of coring stations.
- The geoscientific program was supplemented by additional activities related to oceanography (recovery and deployment of moorings systems, deployment of sea gliders and underway CTD) (Fig. 2; Table 2), biology (collecting 123 phytoplankton samples that will be further isolated and analysed at the AWI to assess the biodiversity and biogeography of Arctic phytoplankton species), and atmosphere-chemistry (continuous and automatic measurements of isotopic signatures of water vapour over the Arctic Ocean).
- As major part of Expedition PS93.1, a "Floating University" was 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 program, 20 Canadian and German PhD students were introduced to all technical aspects of field work in marine sciences as well as to the concepts of teamwork, interdisciplinary and international collaboration. All the ArcTrain students have done an excellent job and contributed significantly to the success of this expedition.

Itinerary
Polarstern left Longyearbyen on June 29 around noon, onboard 44 crew members and 50 scientists, helicopter pilots, and technicians from twelve different countries. First target area was the central Fram Strait where several oceanographic mooring systems were left behind last summer because of extreme sea-ice conditions and lack of ship time. We reached the first station on June 30. The search for the first mooring system remained unsuccessful, however, a new mooring was deployed at the same location. 10-20 miles towards the west, the search activities were more successful, and at the end of the day three mooring systems were recovered. Around midnight, the first geological coring station was carried-out, and a 7.5 m long kastenlot core was recovered (Fig. 2; Station PS93/006: 79°12.2'N, 04°40.0'W; water depth 1570 m).

In the early morning of July 01, we sighted the first sea ice at 79°14'N, 04°30'E, four hours later we encountered the first sea ice directly (Fig. 3). Steaming towards the west we carried

out a Hydrosweep and Parasound site survey. On July 03 we reached the East Greenland continental shelf. Based on Parasound data from last year's cruise we selected some locations where very old sediments or rocks might outcrop at the seafloor. Coring activities by means of a gravity corer, however, remained unsuccessful. Thus, we steamed further towards the north, and reached the polynya east of NE Greenland on July 04, where several geological, biological and oceanographic stations were carried-out.

On July 05, we reached the northern edge of the polynia, the northernmost part of our study area, where we met "old friends: Yngve Kristoffersen and Audun Tholfson, two Norwegian colleagues, whom along with their hovercraft we took to the central Arctic Ocean where we left them on 30 August 2014 on a large ice floe near the Lomonosov Ridge (Fig. 4). Within the last ten months – during the winter in complete darkness – the ice floe with the camp, hovercraft and its two passengers on board drifted through the entire Arctic Ocean (Fig. 4). After intense discussions, phone calls, etc. we agreed to recover all the dangerous goods and that Yngve Kristoffersen and the hovercraft will continue the drift experiment, and Audun Tholfson will come onboard *Polarstern* (Yngve Kristoffersen ended the FRAM-2014/15 Ice Drift Experiment on August 18 successfully; Fig. 4).

July 07 to July 09 were dominated by intense coring and sampling activities of the geologists along the East Greenland continental margin between 81° and 79°N. On July 10, we were steaming towards the east, the central Fram Strait, to recover and deploy, respectively, three mooring systems (Fig. 2; Stations PS93/033 to /035). After having finished the oceanographic station work, we started the way back towards the west, towards the ice edge. During this transit we shortly stopped for one gravity corer run on Hovgaard Ridge, a location where we failed last year (Fig. 2; Station PS93/037). This time we were successful and recovered a short but good core. During transit, we successfully used the "Underway CTD" to get continuous temperature and salinity profiles.

On July 12, two long cores with several metres of Holocene sediments were recovered that will allow a detailed study of short- und long-term climate-variability during the last about 12000 years. With this successful coring event we finished our research program in the western ice-covered East Greenland shelf area and steamed towards the SE, about 120 nm through the partly heavy ice. On July 14, early in the morning, we reached our next station, since long time the first again out of the ice. Besides geological and biological sampling activities, two "sea gliders" were deployed (Fig. 2). These instruments are able to actively dive up and down and measure temperature, pressure and salinity. A final multidisciplinary station with all gears, i.e., CTD, multinet, giant box corer, multicorer, and gravity corer was carried out, followed by a 12-hours hydrosweep survey, the absolute end of the PS93.1 research!

On July 18 at 10:30 am, *Polarstern* arrived in Tromsø.

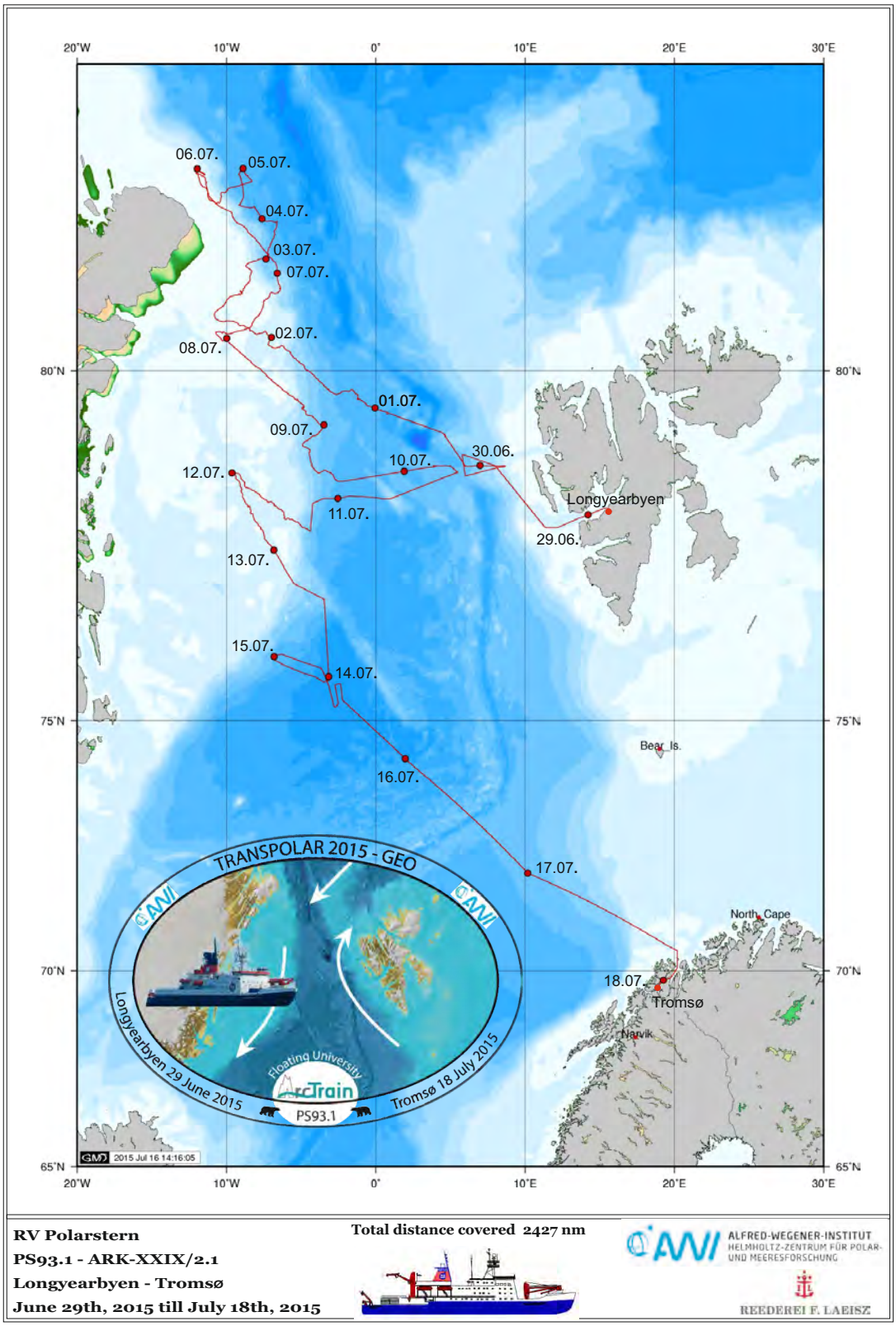

Fig. 1: Cruise track of Expedition PS93.1

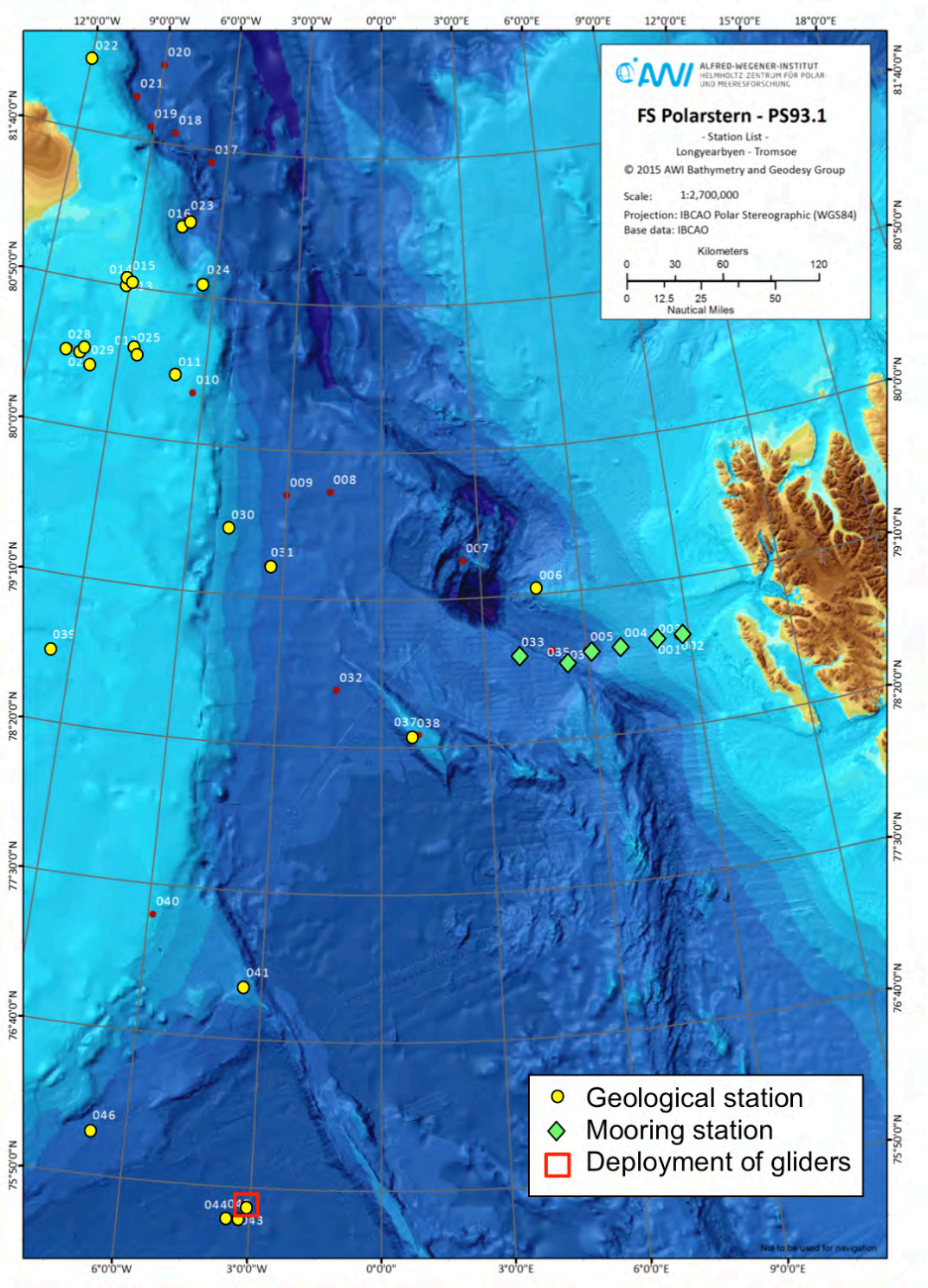

Fig. 2: Stations of Expedition PS93.1. Geological stations, moorings stations and the area of deployment of the sea gliders are indicated. In addition, biological and oceanographic stations were carried-out that are not indicated here (For details and station numbers see Chapters 4 and 5).

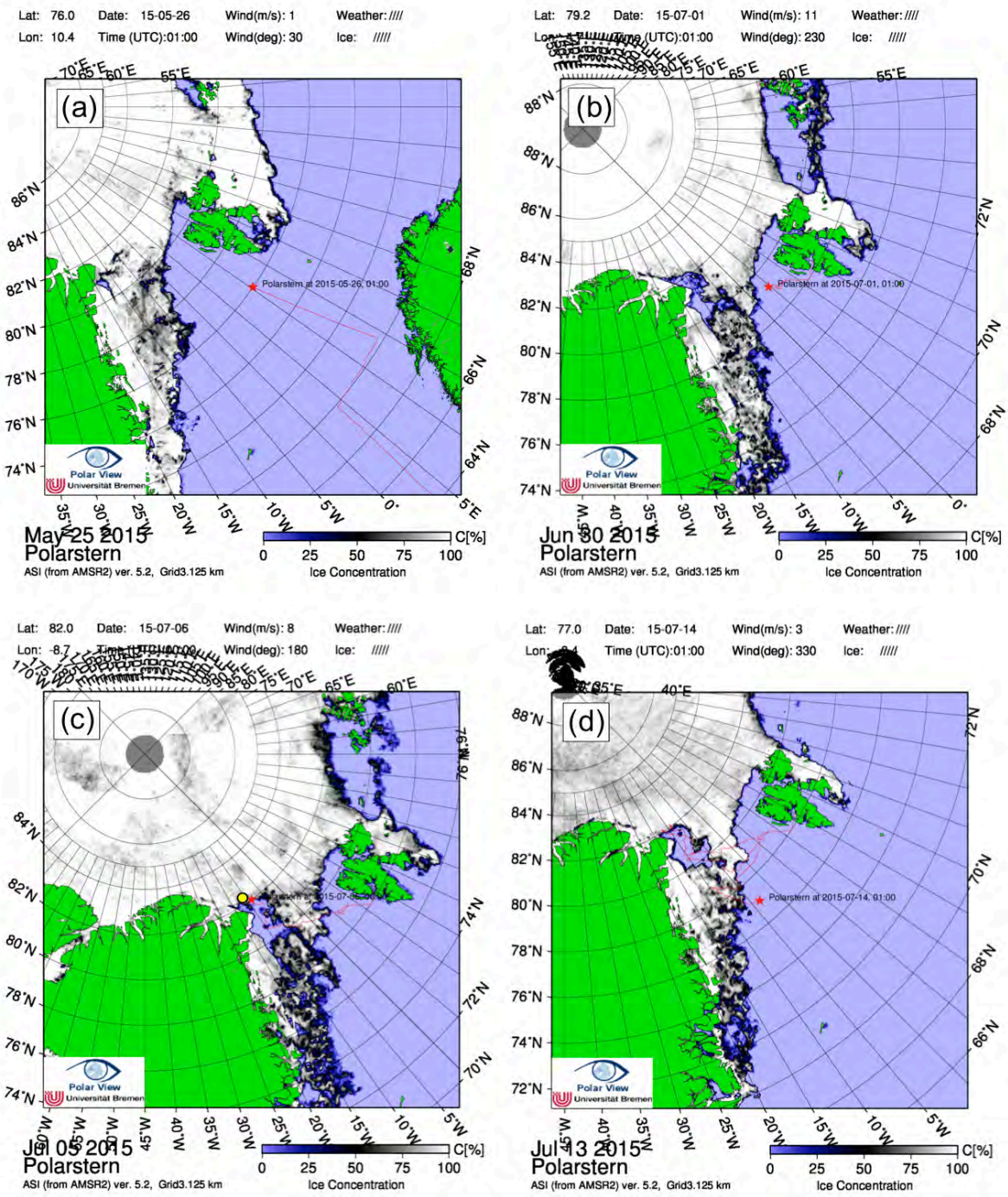

Fig. 3: Sea-ice concentration on (a) 25 May, (b) 30 June, (c) 05 July, and (d) 13 July 2015. The position of Polarstern (red star) at the specific day is indicated. Yellow circle in (c) indiactes position of the FRAM-2014/15 Ice Drift Station.

Fig. 4: FRAM-2014/15 Ice Drift Experiment. Arrival/landing of helicopter at the FRAM-2014/15 Ice Drift Station on 05 July 2015. Red circle marks hovercraft, red rectangle the ice camp (Photo: R. Stein/AWI); (b) Hovercraft Sabvabaa (Photo: R. Stein/AWI); (c) Drift track of FRAM-2014/15 Ice Drift Station from 30 August 2014 to 18 August 2015 (sabvabaa.nersc.no).

Table 1. *Geological stations of Expedition PS93.1*

Station	PositionLat	PositionLon	Depth [m]	Gear Abbreviation	Recovery [cm]
PS93/006-1	79° 12.22' N	4° 40.13' E	1593.3	KAL-12m	786 cm
PS93/006-2	79° 12.20' N	4° 40.08' E	1605.2	GKG	
PS93/011-4	80° 23.13' N	6° 56.49' W	258.4	MUC	
PS93/012-1	80° 27.88' N	8° 26.33' W	295.4	GKG	
PS93/012-2	80° 27.37' N	8° 25.83' W	296.9	GC-5m	223 cm
PS93/013-1	80° 50.81' N	9° 6.17' W	58.8	GC-5m	empty
PS93/014-1	80° 51.27' N	9° 11.44' W	56.7	GC-3m	empty
PS93/015-1	80° 52.83' N	9° 2.95' W	74.9	GC-3m	empty
PS93/016-4	81° 13.02' N	7° 20.44' W	1549.8	GKG	
PS93/016-5	81□13.04' N	7°20.48' W	1568.9	MUC	
PS93/016-6	81□13.01' N	7° 20.46' W	1548.3	KAL-12m	746 cm
PS93/022-1	82° 4.12' N	11° 57.72' W	217.6	GKG	empty
PS93/022-2	82° 4.02' N	11° 57.15' W	216.5	GKG	empty
PS93/023-2	81° 15.79' N	7° 14.68' W	1500.9	GKG	empty
PS93/023-3	81° 15.43' N	7° 11.37' W	1505	GKG	
PS93/023-4	81° 15.96' N	7° 12.60' W	1509	MUC	
PS93/023-5	81° 15.11' N	7° 14.79' W	1508.2	GC-10m	624
PS93/024-4	80° 54.62' N	6° 23.43' W	1307.3	GKG	
PS93/024-5	80° 54.49' N	6° 25.09' W	1295.8	GKG	
PS93/024-6	80° 54.58' N	6° 22.90' W	1308.3	MUC	
PS93/025-1	80° 28.84' N	8° 29.24' W	291.3	GKG	
PS93/025-2	80° 28.90' N	8° 29.40' W	290.2	KAL-6m	260
PS93/026-1	80° 26.42' N	10° 13.36' W	292.5	GC-5m	168
PS93/027-1	80° 25.64' N	10° 16.64' W	284.7	GC-5m	120
PS93/028-1	80° 26.27' N	10° 40.64' W	289.3	GC-5m	229
PS93/029-1	80° 22.19' N	9° 58.50' W	307.6	GC-5m	124
PS93/029-2	80° 22.19' N	9° 58.54' W	318.2	GKG	
PS93/029-3	80° 22.18' N	9° 58.62' W	318.2	GKG	
PS93/030-4	79° 33.66' N	4° 48.84' W	1305.7	MUC	
PS93/030-5	79° 33.83' N	4° 49.36' W	1294.9	GKG	
PS93/030-6	79° 33.99' N	4° 50.54' W	1277.5	GC-10	535
PS93/031-1	79° 21.10' N	3° 28.39' W	2145.7	GKG	empty
PS93/031-2	79° 20.63' N	3° 32.03' W	2123.8	MUC	
PS93/031-3	79° 21.09' N	3° 28.36' W	2144.0	GKG	empty
PS93/031-4	79° 21.08' N	3° 28.24' W	2147.3	KAL-12	825
PS93/031-5	79° 20.97' N	3° 31.43' W	2134.5	GKG	
PS93/037-1	78° 24.09' N	1° 2.78' E	1168.9	GC-10m	413
PS93/039-4	78° 44.91' N	9° 35.73' W	400.3	GKG	empty
PS93/039-5	78° 44.92' N	9° 35.53' W	401	GKG	
PS93/039-6	78° 44.94' N	9° 35.35' W	402.4	GKG	
PS93/039-7	78° 44.97' N	9° 35.30' W	403.3	MUC	
PS93/039-8	78° 44.97' N	9° 35.12' W	402.8	GC-10m	502
PS93/039-10	78° 45.08' N	9° 35.23' W	403.4	GC-10m	681
PS93/039-11	78° 45.31' N	9° 34.95' W	400.9	GC-10m	556
PS93/041-1	76° 57.79' N	3° 26.85' W	1768.3	GKG	
PS93/041-2	76° 57.81' N	3° 26.94' W	1746.8	MUC	
PS93/041-3	76° 57.81' N	3° 26.92' W	1718.3	GC-5m	493
PS93/042-1	75° 44.39' N	3° 9.05' W	3625.8	GKG	
PS93/042-2	75° 44.39' N	3° 9.03' W	3622.3	GC-10m	empty
PS93/043-1	75° 40.20' N	3° 16.32' W	3614.3	GC-10m	352
PS93/044-1	75° 39.48' N	3° 31.52' W	3605.8	GC-10m	535
PS93/046-3	76° 5.08' N	6° 48.72' W	2457.2	GKG	
PS93/046-4	76°5.10' N	6° 48.76' W	2457.9	MUC	
PS93/046-5	76° 4.33' N	6° 49.07' W	2461.7	GC-10m	829

Table 2. *Mooring deployments and recoveries during PS93.1. The different instruments on the moorings are given and it is indicated what the instruments measured when. The abbreviations for the variables are "vel"=velocity, "T"=temperature, "S"=salinity, "P"=pressure and the abbreviations for the instruments are "ADCP QM"=Quarter Master (150kHz) acoustic Doppler current profiler, "SBE 37"=Seabird microcat, "RCM"=Aanderaa Rotor Current Meter.*

Mooring	Latitude	Longitude	Water depth [m]	Top float at [m]	Station number	Working date	Status	Instrument type	Instrument SN	Instrument depth [m]	Variables measured	Data start	Data end	Data comment
F1-14	78° 50.01'N	8° 39.99'E	246	245	PS93.1 002-01	20-Jun-2015	recovery failed, possibly releaser too old	ADCP QM	14090	245		-		
								SBE 37	2384	245		-		
F1-15	78° 49.80'N	8° 40.14'E	246	245	PS93.1 002-02	20-Jun-2015	deployed, recovery planned summer 2016	ADCP QM	15500	245		-		
								SBE 37	1230	245		-		
F3-15	78° 49.91'N	8° 00.29'E	1005	49	PS93.1 003-01	20-Jun-2015	recovered	RCM 11	461	59	vel, T, P	22-Jun-2012	12-Oct-2014	
								SBE 37	1237	60	T, S, P	22-Jun-2012	30-Jun-2015	
								ADCP QM	14086	240	vel profiles, T,P	22-Jun-2012	30-Jun-2015	
								RCM8	9770	242	vel, T	22-Jun-2012	9-Oct-2014	
								SBE 37	9487	243	T, S, P	22-Jun-2012	30-Jun-2015	
								Holgiphone	33	493	passive acoustics	?		Data not yet recovered
								RCM 11	506	750	vel, T, P	22-Jun-2012	20-Nov-2013	
								SBE 37	230	991	T, S	22-Jun-2012	30-Jun-2015	
								RCM 11	504	997	vel, T, P	22-Jun-2012	30-Jun-2015	
F4-15	78° 50.01'N	6° 59.99'E	1420	64	PS93.1 004-01	20-Jun-2015	recovered	RCM 8	11887	74	vel, T, P	22-Jun-2012	9-Oct-2014	
								SBE 37	2392	75	T, S, P	22-Jun-2012	30-Jun-2015	
								ADCP QM	14087	235	vel profiles, T,P	22-Jun-2012	30-Jun-2015	
								RCM 8	9783	237	vel, T, P	22-Jun-2012	4-Jul-2014	
								SBE 37	2393	238	T, S, P	22-Jun-2012	24-Mar-2015	
								RCM 7	8048	692	vel,T	22-Jun-2012	30-Jun-2015	
								SonoVault	1026	743	passive acoustics	?		Data not yet recovered
								SonoVault	1024	1410	passive acoustics	?		Data not yet recovered
								RCM 8	10497	1412	vel	22-Jun-2012	30-Jun-2015	
F5-15	78° 50.01'N	6° 00.04'E	2418	63	PS93.1 005-01	20-Jun-2015	recovered	RCM 8	9194	74	vel, T	23-Jun-2012	9-Oct-2014	
								SBE 37	2396	75	T, S, P	23-Jun-2012	5-Jan-2015	
								ADCP QM	14088	225	vel profiles, T,P	23-Jun-2012	30-Jun-2015	
								RCM 8	10002	227	vel, T, P	23-Jun-2012	9-Oct-2014	
								SBE 37	2610	228	T, S, P	-		Instrument damaged, no data
								RCM 11	462	673	vel, T, P	23-Jun-2012	4-Oct-2014	
								RCM 11	486	1424	vel, T	23-Jun-2012	29-Jun-2015	vel only till 01-Mar-2015
								RCM 8	9390	2410	vel, T	23-Jun-2012	4-Oct-2014	
F7-12	78° 49.72'N	4° 00.51'E	2292	71	PS93.1 033-01	10-Jul-2015	recovered	SBE 37	8130	78	T, S, P	25-Jun-2012	12-Sep-2014	
								ADCP QM	14951	239	vel profiles, T,P	?		Data not yet recovered
								RCM 8	9997	241	vel	25-Jun-2012	30-Apr-2014	
								SBE 37	8131	242	T, S, P	25-Jun-2012	31-May-2014	
								RCM 7	8402	742	vel, T, P	25-Jun-2012	4-Oct-2014	
								RCM 8	3517	1498	vel, T	25-Jun-2012	4-Oct-2014	
								RCM 8	9782	2284	T	25-Jun-2012	4-Oct-2014	
F8-16	78°49.99'N	5° 00.00'E	2707	51	PS93.1 034-01	10-Jul-2015	recovery failed, possibly releaser too old	RCM 11	315	61		-		
								SBE 37	2237	62		-		
								ADCP QM	14089	252		-		
								RCM 11	491	254		-		
								SBE 37	244	256		-		
								Holgiphone	34	504		-		
								RCM 11	455	751		-		
								RCM 8	9186	1553		-		
								RCM 8	9188	2636		-		
F20-5	78° 44.99'N	5° 29.98'E	2410	88/0	PS93.1 035-01	10-Jul-2015	deployed, recovery planned summer 2016	NGK Profiler		88		12-Jul-2015		Profiler comes to the sea surface once every 48 hours
								NGK Winch		89		N/A		