Short Cruise Report
R/V Maria S. Merian: Leg MSM05-2
St. John's, Canada to Nuuk, Greenland
May 30 to June 12, 2007

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Research Program

The Labrador Sea is an important region for the thermohaline circulation of the oceans. In this area, the two North Atlantic Deep Water (NADW) components from the Nordic Seas merge, and the shallowest NADW component, the Labrador Sea Water (LSW) is formed by deep convection in the Labrador Sea. The NADW is then exported southward and for compensation warm surface waters are carried northward with the North Atlantic current. These processes, formation, transformation of water masses and the export of newly formed water masses show significant interannual variability. The objectives of the research program are to investigate and quantify the components that contribute to the variability. On the research cruise MSM05-2 this is done by a combination of shipboard observations with CTD, current observations, and by collecting water samples for CFC's, Methane and PCO2. These observations are accomplished by moored stations that are recovered and re-deployed. Most of the activities are imbedded in the BMBF Program ''Nordatlantik'', of which this cruise is the first seagoing activity.

The cruise focuses on investigations of processes in the Labrador Sea. In this region large heat fluxes in winter cause deep ocean convection concentrated in the central Labrador Sea. This usually occurs in February / March, and is measured by ADCP's and T/S sondes in moored stations. A large number of convective "plumes" will then form a larger scale convective patch and the integral properties (e.g., its mean temperature and salinity) can be observed by CTD and tracer measurements in the successive summer.

The most important part of the cruise was dedicated to the boundary current system which plays an important role in exporting newly formed water masses from their formation region to the open North Atlantic and farther toward the subtropical regime. Following earlier investigations a boundary current array with current meters and T/S probes is installed to determine the transport of deep water masses at the exit of the Labrador Sea near 53°N. These long term records are supplemented by boundary current sections with LADCP and underway measurements of upper ocean currents (Maria S. Merian's Ocean Surveyor).

CTD/LADCP station work and Mooring activities are summarized in Figure 1, and in Tables 1 and 2, respectively. Three boundary current sections were surveyed with dense station coverage. These are located off the Labrador shelf break near 53°N, and at 56°N (WOCE AR7W-Line) and near Nuuk (Greenland) which represents the inflow part into the Labrador Sea.

Altogether, we recovered 3 current meter (sound source) moorings, and deployed 4 moorings, as planned. The rest of the planned program was hampered by the fact that the cruise duration had to be shortened by 10 days, caused by problems with the ships propulsion system. We experienced normal data return and only marginal instrument losses in the moorings; summarizing, the mooring work was successful.

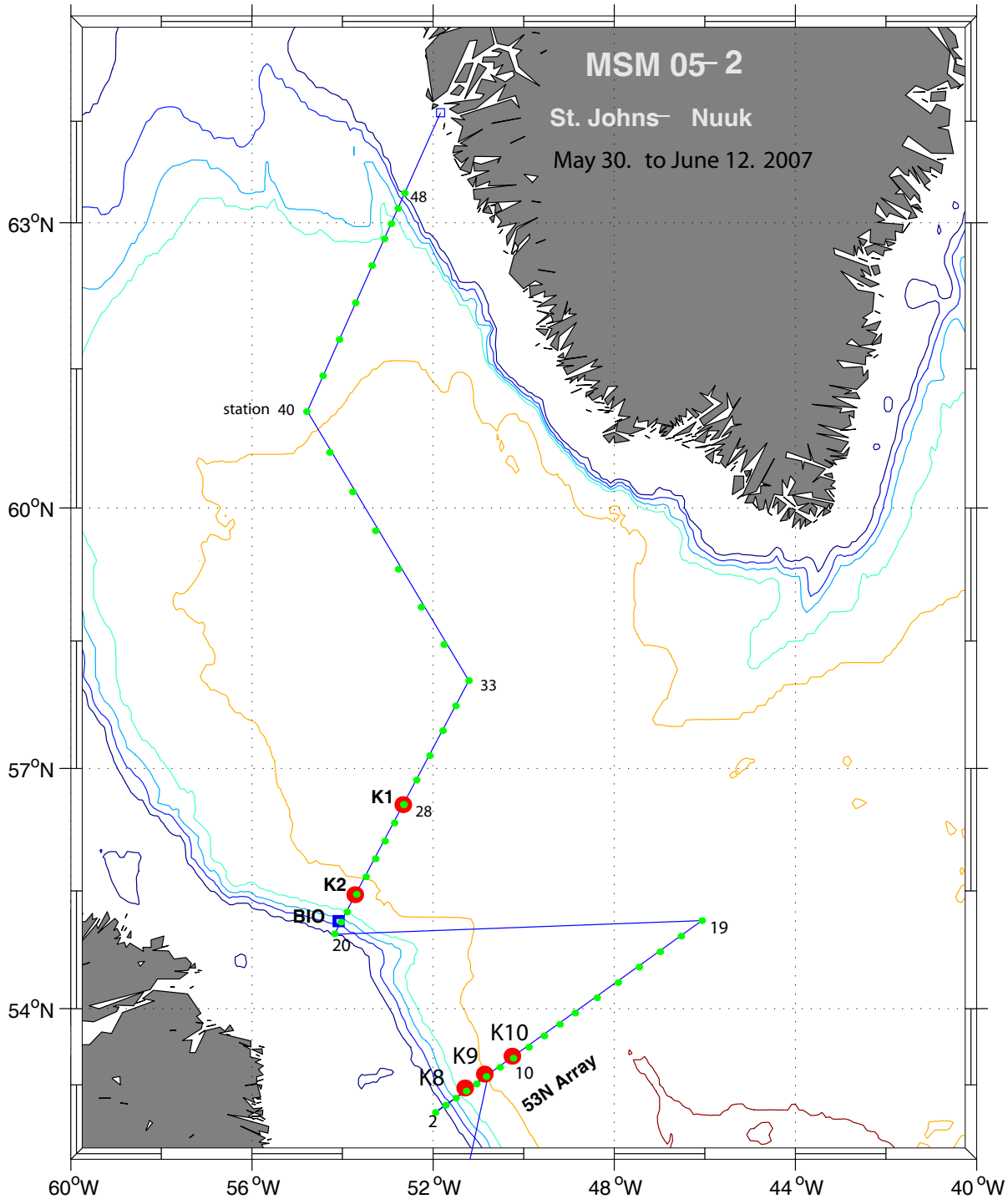

Figure 1: *MSM05-2 cruise track, station data and mooring locations.*

Narrative of the cruise

May 19 The last group of the science party arrived at RV Merian in the middle (02:00 LT) of the night. The disappointment was large, when it became clear, that the departure of Maria S. Merian will be significantly delayed beyond expectation – 7 to 10 days -- meaning that there will be only two weeks left for the proposed work. Basically this meant that mooring work and boundary current sections are the only parts left over.

May 20 – May 29
We began to unload containers and install equipment in labs; this was followed by preparing the moored equipment. We wrote an email to local university director –and some visits to the local institutions and a presentation of our work were arranged. The hospitality of the people from the University was excellent. In the evening of May 28 the POD's were repaired and a sea-trial was arranged for the next morning with a GL representative on board. This trial was successful. In the evening we went to the bunker pier and finally left St. John's in the night of May 29/30.

May 30 --- at sea. After the bunker station we left St. John's in the middle of the night to arrive at the working area early morning. During daylight Merian passed several ice bergs and smaller floes and arrived during the morning of May 31st at mooring site K9 which was there since 2005. This mooring was recovered after lunch, when the visibility became favourable. A CTD station was made before and after the mooring work, with the second one for calibration and test purposes. During the evening we steamed toward shallow water to begin with the 53°N-section.

June 1st, overnight we made some shallow CTD stations and encountered problems with both CTD's we had with us. So, the mooring deployment of K8 was the opportunity to sort that out, and finally the CTD worked again. Mooring work went very well in favourable conditions (westerly wind at 3 Bft and slow south eastward surface drift with little swell). The visibility became better during the morning and we were able to watch the top buoy when submerging. The anchor was dropped at 13:20 UTC, and the final mooring position was as planned at 52° 57.5'N, 51° 18.0' W (see Table 2).

June 2nd , for this day we planned to deploy the two remaining moorings of the 53°N – Array, K9_07 and K10_07. We were at position K9 very early in the morning and performed a drift test at 06:00 in very favourable conditions; visibility was good and the winds were blowing at 2-3 Bft only. At 08:00 we were at the start position and began to deploy mooring K9 which was completed about two hours later. We were also able to watch the top element of the mooring as it submerged. We repeated the procedure in the afternoon in deploying mooring K10 located about 30nm along the section. Again we were able to watch the mooring top submerging. During the deployments the wind speed increased and at the morning of

June 3rd; we experienced strong winds increasing to 9 Bft in the evening. CTD station work had to be stopped as it appeared too dangerous with heavy waves and intense roll-events of the ship. The next morning showed a little less wind, but CTD work was still hampered by rolling of the ship. On two of the stations we had severe data dropouts when a burst of heavy ship motion accelerated the CTD. The CTD

cable showed defective kinks about 10-20m above the CTD. As a consequence we had to cut the wire and renew the termination. Further, the LADCP data were not usable on these stations due to strong inclinations and high vertical velocities. Therefore, and due to the lack of time we decided to finish the section and to steam westward to the shelf edge north of Hamilton Bank for beginning with the AR7W section and additional mooring work. We expected to arrive there about 24 h later on the evening of June 5.

June 5th. Maria S. Merian steamed toward the shallowest station on the second (AR7W) section, and we arrived there in again favourable weather conditions, as overnight wind and swell decreased considerably. At that station we could see the ice edge near by and decided for a short visit to prove Maria S. Merian's ice capabilities --- very impressive when she steamed through the ice pack in sunlight. With stations overnight we reached mooring K2 with early daylight at June 6.

June 6th. Winds were moderate, at 5-6 Bft, but visibility was bad. The mooring work was scheduled after breakfast, but we waited about one hour for better conditions. With no improvements on the visibility, we released the mooring at 08:49 LT. A few minutes later the top element surfaced, but was not visible. Later with the aid of Gonio-bearings from the Argos watchdog, we approached the mooring position and finally spotted it drifting at the surface. Soon after we had the first element of K2_05 on board and finished the recovery by 11:30 LT we had all components recovered (see table 2). CTD stations were made during the approach of mooring K1 which will be recovered and re-deployed at June 7.

June 7th. We were at mooring K1 early morning, but dense fog did not allow for recovery of that mooring. We surveyed the mooring and found the releases in a place just 0.1 nm north of the estimated mooring position. However, visibility remained less than 100m and we therefore first deployed the new mooring about 6 nm north of the former position. Then we went back to the mooring site, but still had low visibility. A short window in the fog led us to release the mooring in the afternoon, but when the mooring surfaced the fog was dense again. With the Argos beacon not working, we slowly approached the determined site and finally found the mooring right in place where we expected it to be. The mooring recovery then went very well and by 18:15 LT we had all instruments on board. This action marked the end of the mooring operations which were carried out as planned.

June 8th – June 11th: The rest of the program was dedicated to CTD/LADCP work in the northern Labrador Sea and across the West-Greenland Current off Nuuk. Altogether we made 50 CTD casts which is a quite large number bearing in mind the limited amount of time. After the last station at the shelf edge, Maria S. Merian steamed across the wide West Greenland shelf toward the extensive fjord system near Nuuk, where we used the remaining few hours to visit the impressive scenery of Greenland's Fjord and Glacier landscape.

June 12th: Maria S. Merian steamed through Fjords and rocky islands toward the port of Nuuk, at which we arrived at 10:00 LT. This was the end of a rather short, but nevertheless successful cruise with Maria S. Merian. We thank Captain Holtschmidt, officers and crew of the Maria S. Merian for their professional and friendly work that makes this cruise a success and a pleasure for us to be on board.

Summary of cruise:

The research cruise MSM05-2 was hampered by a severe defect of Maria S. Merian's propulsion system that led to a delay of almost 11 days. Consequently, the time at sea was only 13 days instead of 24 days. The program had to be restricted to a few core activities, i.e., the mooring work and boundary current sections at the Labrador shelf break.
The remaining work went quite well, and all of the mooring activities were successful. CTD/LADCP worked quite well, except for a short period when the sea state caused the ship to roll intensively. This led to cable damages (single conductor cable of the CTD), CTD data drop-outs and unusable LADCP data caused by large inclinations and vertical accelerations of the package.
Two other deficits should be mentioned: the first was the quality of the oxygen measurements, which appeared to be unstable due to strong oxygen fluctuations in the water supplied by the ship's water system; the second deficit was in the LADCP data in the northern area of the cruise, where the flux gate compasses of the LADCP's apparently suffered from the proximity to the magnetic North pole.

For a quick glance at one of the scientific highlights we show the temperature evolution of the deep Labrador Sea from moored records of the time period 2005 to 2007 (Figure 2). At all three locations we see a continuation of the warming of the Labrador Sea, in the centre of the basin (mooring K1) and in the boundary current (K2 and K9).

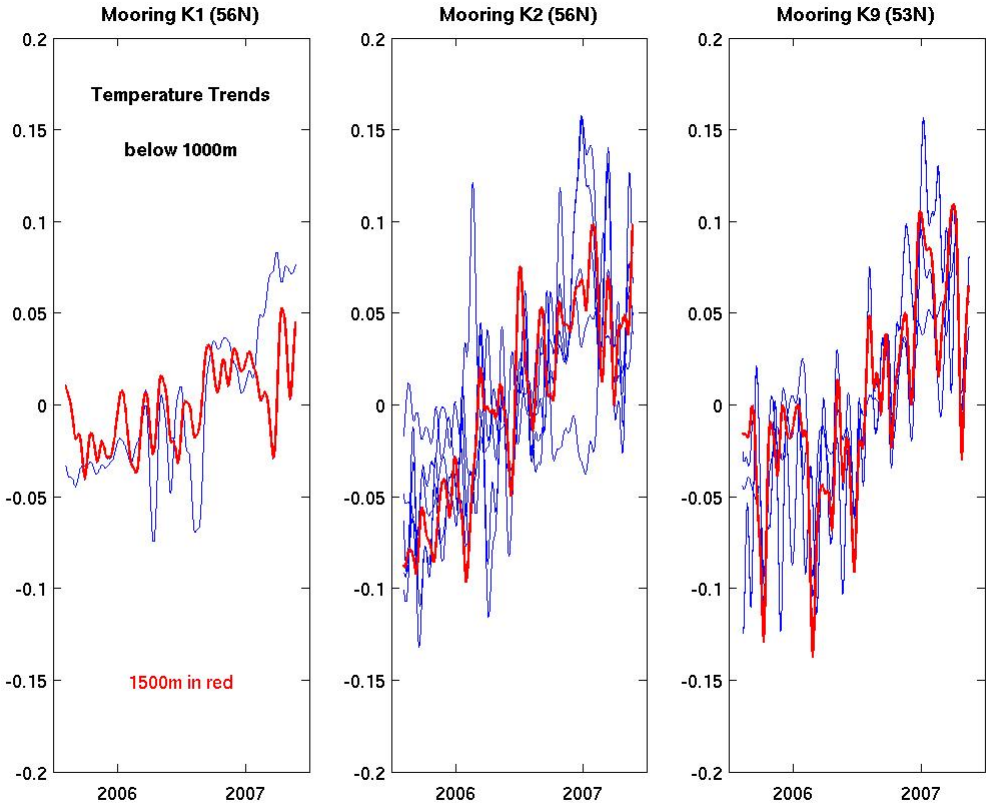

Figure 2: *Temperature trends of approximately 0.05°C/year as observed by moored instruments in the central Labrador Sea (K1) and at two locations in the Deep Labrador Current (K2 and K9). Mean temperatures are subtracted.*

Table 1: CTD/LADCP station Table

Profile	Time (UTC) Date (UTC)	Latitude	Longitude	Samples	Remarks
1	May 31 2007 10:45:03	53 05.96 N	050 52.32 W	L/C/G/S/O	Spikes
2	May 31 2007 19:41:41	53 05.84 N	050 49.59 W	L	Calib.
3	Jun 01 2007 01:38:24	52 42.81 N	051 45.39 W	L/C/ /S/O	SBE-2
4	Jun 01 2007 02:55:13	52 45.91 N	051 38.21 W	L/C/G/S/O	Spikes
5	Jun 01 2007 05:11:47	52 50.17 N	051 28.77 W	L/C/ /S/	Spikes
6	Jun 01 2007 07:40:32	52 57.50 N	051 17.99 W	/C/ /S/O	Spikes
7	Jun 01 2007 13:53:15	52 57.20 N	051 19.91 W	L/ /G/ /	W.f.Kiel
8	Jun 01 2007 16:30:15	53 00.68 N	051 02.67 W	/C/ /S/O	
9	Jun 01 2007 19:30:29	53 08.00 N	050 51.99 W	L/C/ /S/O	
10	Jun 01 2007 23:50:13	53 13.91 N	050 31.74 W	L/C/ /S/O	
11	Jun 02 2007 04:09:38	53 00.69 N	051 02.67 W	L/ / / /	Rpt of 8
12	Jun 02 2007 18:49:54	53 23.30 N	050 15.95 W	L/C/ /S/O	
13	Jun 02 2007 23:02:01	53 29.77 N	049 53.33 W	L/C/G/S/O	
14	Jun 03 2007 03:03:19	53 38.75 N	049 32.96 W	L/C/ /S/O	
15	Jun 03 2007 06:59:39	53 47.70 N	049 12.49 W	L/C/ /S/O	
16	Jun 03 2007 10:47:29	53 56.62 N	048 52.05 W	L/C/G/S/O	
17	Jun 03 2007 15:18:04	54 08.38 N	048 23.00 W	L/C/ /S/O	
18	Jun 03 2007 19:41:56	54 20.13 N	047 55.39 W	L/C/ /S/O	
19	Jun 04 2007 01:02:37	54 32.07 N	047 27.31 W	L/C/G/S/O	Spikes
20	Jun 04 2007 10:10:16	54 43.90 N	046 59.60 W	L/C/G/S/O	
21	Jun 04 2007 14:56:47	54 55.78 N	046 31.74 W	L/ / / /	Spikes
22	Jun 05 2007 15:23:49	54 57.62 N	054 10.64 W	L/C/G/S/O	
23	Jun 05 2007 18:07:46	55 06.31 N	054 02.30 W	L/C/ /S/O	
24	Jun 05 2007 20:11:57	55 14.02 N	053 54.20 W	L/C/G/S/O	Calib.
25	Jun 06 2007 00:41:07	55 40.57 N	053 29.05 W	L/C/ /S/O	
26	Jun 06 2007 04:03:52	55 28.86 N	053 41.90 W	L/C/G/S/O	
27	Jun 06 2007 16:18:47	55 53.82 N	053 16.48 W	L/C/ /S/O	
28	Jun 06 2007 19:48:09	56 07.03 N	053 04.01 W	L/C/ /S/O	
29	Jun 06 2007 23:31:27	56 20.30 N	052 51.38 W	L/C/G/S/O	
30	Jun 07 2007 02:57:01	56 29.84 N	052 40.91 W	L/C/ /S/O	CO2
31	Jun 07 2007 22:20:33	56 51.59 N	052 21.98 W	L/C/ /S/O	
32	Jun 08 2007 02:34:23	57 09.32 N	052 04.70 W	L/C/ /S/O	
33	Jun 08 2007 06:39:27	57 27.00 N	051 47.40 W	L/C/G/S/O	
34	Jun 08 2007 10:34:43	57 44.56 N	051 30.08 W	L/C/ /S/O	
35	Jun 08 2007 14:39:20	58 02.34 N	051 12.84 W	L/C/G/S/O	
36	Jun 08 2007 19:34:53	58 27.49 N	051 45.79 W	L/C/ /S/O	
37	Jun 09 2007 00:50:11	58 53.23 N	052 16.04 W	L/C/ /S/O	
38	Jun 09 2007 05:53:28	59 19.03 N	052 46.34 W	L/C/G/S/O	Calib.
39	Jun 09 2007 10:50:20	59 44.80 N	053 16.61 W	L/C/ /S/O	Calib.
40	Jun 09 2007 16:21:48	60 10.62 N	053 46.93 W	L/C/ /S/O	Calib.
41	Jun 09 2007 21:42:47	60 36.51 N	054 17.43 W	L/C/ /S/O	
42	Jun 10 2007 03:20:57	61 02.74 N	054 47.78 W	L/C/ /S/O	
43	Jun 10 2007 07:32:24	61 25.60 N	054 26.21 W	L/C/ /S/O	
44	Jun 10 2007 11:38:18	61 48.81 N	054 04.60 W	L/C/ /S/O	Calib.
45	Jun 10 2007 16:14:16	62 11.21 N	053 42.99 W	L/C/ /S/O	
46	Jun 10 2007 20:19:01	62 34.05 N	053 21.34 W	L/C/ /S/O	
47	Jun 10 2007 23:47:01	62 50.19 N	053 04.73 W	L/C/ /S/O	

48	Jun 11 2007	02:17:47	62 59.42 N	052 55.69 W	L/C/ / /O
49	Jun 11 2007	04:47:45	63 08.54 N	052 46.83 W	L/C/ / /O
50	Jun 11 2007	07:07:51	63 17.60 N	052 37.80 W	L/C/ / /O

L: Lowered ADCP Profile
C: CFC sample
G: Trace gas samples (CH4,NO2)
S: Salinity sample
O: Oxygen sample
CO2: CO2 sample
Calib.: Moored instrument calibration
W.f.Kiel: 20l water canister for use with Autosal in Kiel

Table 2: Mooring deployment and recovery Table MSM05-2 June 2007

Mooring	Date/time (UTC) deployed	Water depth	latitude	longitude
K1_07	7 June / 15:00	3490m	56° 37.60’ N	52° 36.70’ W
K8_07	1 June / 13:30	2200m	52° 57.50’ N	51° 18.00’ W
K9_07	2 June / 12:29	2860m	53° 08.00’ N	50° 52.00’ W
K10_07	2 June / 18:22	3300m	53° 22.90’ N	50° 15.70’ W

Mooring	Date/time (UTC) recovered	Water depth	latitude	longitude
K1_05	7 June / 17:58	3490m	56° 31.50’ N	52° 39.00’ W
K2_05	6 June / 10:49	2860m	55° 27.10’ N	53° 43.80’ W
K9_05	31 May / 14:05	2860m	53° 08.00’ N	50° 52.00’ W