SHORT CRUISE REPORT

RV MERIAN: cruise MSM12-3

by : Prof. Dr. Monika Rhein, chief scientist

Institut für Umweltphysik
Abt. Ozeanographie, Universität Bremen

from Reykjavik, Iceland to Bremerhaven, Germany
July 14 to August 22, 2009

Wolfgang Böke, Lena Brinkhoff, Klaus Bulsiewicz, Antje Buß, Gerhard Fraas, Torben Frost, Arne Kaspar, Dagmar Kieke, Robert Meissner, Harald Poigner, Patrick Schmidt, Reiner Steinfeldt, Ilaria Stendardo, Uwe Stöber, Achim Ströh, Sandra Vogel, Andreas Vogel, Jenny Wendt

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1.2 Research Program

The objectives of the cruise are (i) to estimate the deepwater formation rate in the Labrador Sea from inventories of the anthropogenic trace gases chlorofluorocarbons (CFCs) and sulphurhexafluoride (SF_6), (ii) to infer the transport variability of the subpolar gyre through combined data from moored Inverted Echo Sounders (PIES), moored instruments, shipboard measurements, float profiles from the ARGO program, and satellite altimetry, (iii) to study the transports and water mass characteristics in the Flemish Pass, and in the deep western boundary current off Newfoundland using shipboard measurements and time series from moored sensors (velocity, temperature and salinity), and (iv) to study the changes in water mass characteristic in the eastern Atlantic along the former WOCE section A2. The cruise is part of the German joint research project 'Nordatlantik' and is supported by the German Ministry of education and research, BMBF

1.3 Narrative of the Cruise

The MERIAN left Reykjavik (Iceland) as scheduled (July 15, 8 UTC), and – after calibrating the compass - headed south into the Irminger Sea. The weather was favourable, and the MERIAN reached the first CTD station at 61°45'N, 30°26'W at July 16, 9 UTC. The station was only partly successful. About half of the bottles didn't close. The failure was due to the malfunctioning of the electronic release unit. After exchange of the unit, the system worked without failure during the following stations. The weather remained calm. The station distance was between 70 and 100nm till 57°21'N, 41°48'W, where the MERIAN shifted course towards Greenland and the boundary section started at July 18, 8 UTC. The station spacing was reduced to 23nm. Unfortunately, several technical problems prevented the onboard measurements of the tracers Sulphurhexafluoride SF_6 and Chlorofluorocarbon component CFC-12. Instead, offline samples were taken, and will be analysed in the home lab. The boundary section towards Greenland was finished at 59°34'N, 44°15'W at July 19, 10 UTC. The MERIAN headed afterwards along the Greenland coast to Cap Desolation at 60°22'N, 48°24'W.

On July 19, 23 UTC, the research was abandoned due to a medical emergency, and the MERIAN set course to Paamiut (61°59'N, 49°40'W), where the patient was delivered to the hospital. The ship had to stay in Paamiut for several hours, since the water preparation unit had a malfunction, and freshwater had to be filled in one of the ballast tanks. Before filling could start, the tank had to be cleaned. The MERIAN left Paamiut at July 20, 20 UTC. In order to minimize the time loss, the station plan was altered and the MERIAN sailed to the next station at 62°04'N, 50°44.5'W close to Paamiut, where the research was resumed with CTD 17. The SF_6 / CFC analysis directly on board started and replaced the offline sampling done in the Irminger Sea.

MERIAN set course to reach the WOCE A1W section at 58°13'N, 50°53'W. The station spacing was between 5 and 15nm at the continental shelf and increased in the basin interior to 30nm. The vm-ADCP velocities showed a strong northward West Greenland Current (up to 40cm/s) hugging the continental slope The MERIAN

reached the WOCE A1W section at 58°13'N, 50°53'W on July, 22, 12 UTC, and changed course towards Canada. The weather remained calm, and the working conditions were excellent.

The performance of the used winch (ELW1) deteriorated with each station, although the wire had been replaced in Reykjavik. Starting with CTD 24, the winch ELW2 was used and the system worked excellently. On the morning of July, 22, the system had to be switched back to the ELW1 winch due to a technical problem, but was switched back to ELW2 after one station (CTD 26). On CTD 27, several stops on the way up were done in order to calibrate the Microcats (T/S sensors), which will be deployed off Flemish Cap. At the CTD stations 32 and 33 two acoustic releasers respectively were fixed at the wire several meters above the rosette and tested when the package was at the bottom. The WOCE section was finished at July 24, 2 UTC at 54°38'N, 53°56'W, and the MERIAN turned north into the northern central Labrador Sea. The calibration of the Microcats to be moored at the western boundary off Newfoundland continued as well as the testing of the releasers. The section north into the central Labrador Sea was finished at July 25, 14 UTC, (58°50'N, 54°22'W, CTD 44) and the weather continued to provide comfortable working conditions. The testing of the releasers and calibration of the Microcats for the boundary current moorings was finished before reaching that position.

The MERIAN is now bound southeast on the section along the central Labrador Sea, and the southern end was reached on July 28, 6:15 UTC at 53°20'N, 46°13'W (CTD 58). During the whole time period the weather and sea stayed calm, and the MERIAN proceeded with 13kn. The last 6 CTD stations in the Labrador Sea were carried out on a boundary section to 51°25'N, 50°17'W, and were finished at July 29, 10 UTC. Afterwards, the MERIAN headed towards the Flemish Pass at 47°06'N, 47°16'W. The Flemish Pass was sampled with 7 CTD/LADCP casts including tracer sampling in order to estimate the transport of newly formed Labrador Sea Water through that channel. The Flemish Pass might be a shortcut for LSW on the way to the subtropics. Also nutrient, and alkalinity samples were taken on 4 profiles in the centre of the Pass.

On July 31, the three Bremen boundary current moorings were deployed east of the Flemish Cap at the continental slope at the positions 47°06'N, 43°25'W, 43°13'W, and 43°07'W. The two outer moorings are 12nm apart, and the bottom slopes from 1300m to 3500m depth. The relatively steep slope focuses the deep western boundary current and allows to measure transports and T/S characteristics with these moorings. The moorings were successfully deployed between 8 and 18 UTC. Towards the end of the deployment, the weather conditions deteriorated, and for the first time during that cruise, the winds reached 7-8 Bft. After the topography near the moorings have been surveyed by the ship's multibeam echo sounder, the CTD station work resumed at July 1, 2 UTC at 47°06'N. Near the continental slope, the station spacing was between 3 and 6nm, and increased gradually to 48nm in the interior of the Newfoundland basin. The LSW found here were fresher than the LSW found in the Flemish Pass, indicating a younger age.

On August 1, 16:40 UTC, a PIES (No. B24) was deployed in 3500m depth at 47°06'N, 42°53.5'W. On August 2, wind reached again 8 Bft, but the CTD stations could be carried out without problems and without time delay. Between the stations, the speed of the MERIAN went up to 14kn due to the westerlies and the strong

eastward flowing North Atlantic Current (NAC). When the current direction reversed, the speed decreased to 12kn. On August 4, at about 5UTC, the propulsion system on the port side malfunctioned. Lowering a camera to the propulsion showed that the damage was not caused by an obstacle which might also endanger the starboard propulsion. So the research was resumed, but with only the starboard pod functional. The MERIAN proceeded with reduced speed between the stations of 9-10 kn. This speed reduction has serious consequences for the future station planning, loosing about 20-30% of the allocated station time to transit.

On August 5, 3:40 UTC the position of the southernmost Bremen PIES array (B20) at 47°40'N, 31°09'W was reached, and the data of the PIES should be recovered by acoustic telemetry. Although the instrument reacted to the acoustic commands and first provided reliable ranging estimates, telemetry failed on all positions the MERIAN could occupy without using the pumpjet continually. The use of the pumjet creates too much noise on the PIES frequencies. Therefore the PIES was released at 6:27 UTC. The PIES reacted to this command by pinging every 4 seconds, and two pings should be received on board, i.e. the direct ping and the ping first reflected at the bottom. Some pings were received, but without a recognizable pattern, which would reflect the ascent. Most likely the PIES did not leave the bottom. The PIES should have reached the surface at 7:40 UTC. No visual or radio contact was detected in the next hours, and neither could the few acoustic pings which the PIES might have sent be interpreted. The active search was abandoned at 11:30, and a CTD at the location of the PIES was carried out. Starting at August 5, 14 UTC, the remaining active propulsion unit was tested. It turned out that its condition required an immediate stop of the research and the MERIAN steamed to Bremerhaven, supported by favourable winds conditions. The MERIAN arrived at August 12, 7UTC, i.e. 10 days sooner than planned.

Table 1 PIES activities

Name	PIESNo	Latitude	Longitude	Depth	Deployment
B24	235	47°06.00‘N	52°53.36‘W	3440m	01.08.2009,16:42

Name	PIESNo	Latitude	Longitude	Depth	Telemetry
B20	186	47°40.26‘N	31°08.97‘W	4084m	5.8.09 3:50-6:20, failed

Name	PIESNo	Latitude	Longitude	Depth	Recovery
B20	186	47°40.26‘N	31°08.97‘W	4084m	5.8.09 6:30-11:20, failed

PIES: Inverted Echo Sounder with Pressure sensor
Time in UTC

Table 2 Boundary Current Moorings

Name	Latitude	Longitude	Depth	Deployment	*Recovered*
B21	47°06.01‘N	43°25.06‘W	1290m	31.7.2009, 17:46	
	with radio beacon, flashlight				
B22	47°06.45’N	43°14.47’W	2985m	31.7.2009, 15:22	
	with radio beacon, flashlight, Argos-watchdog				
B23	47°06.07’N	43°07.21’W	3500m	31.7.2009, 11:32	
	with radio beacon, flashlight				

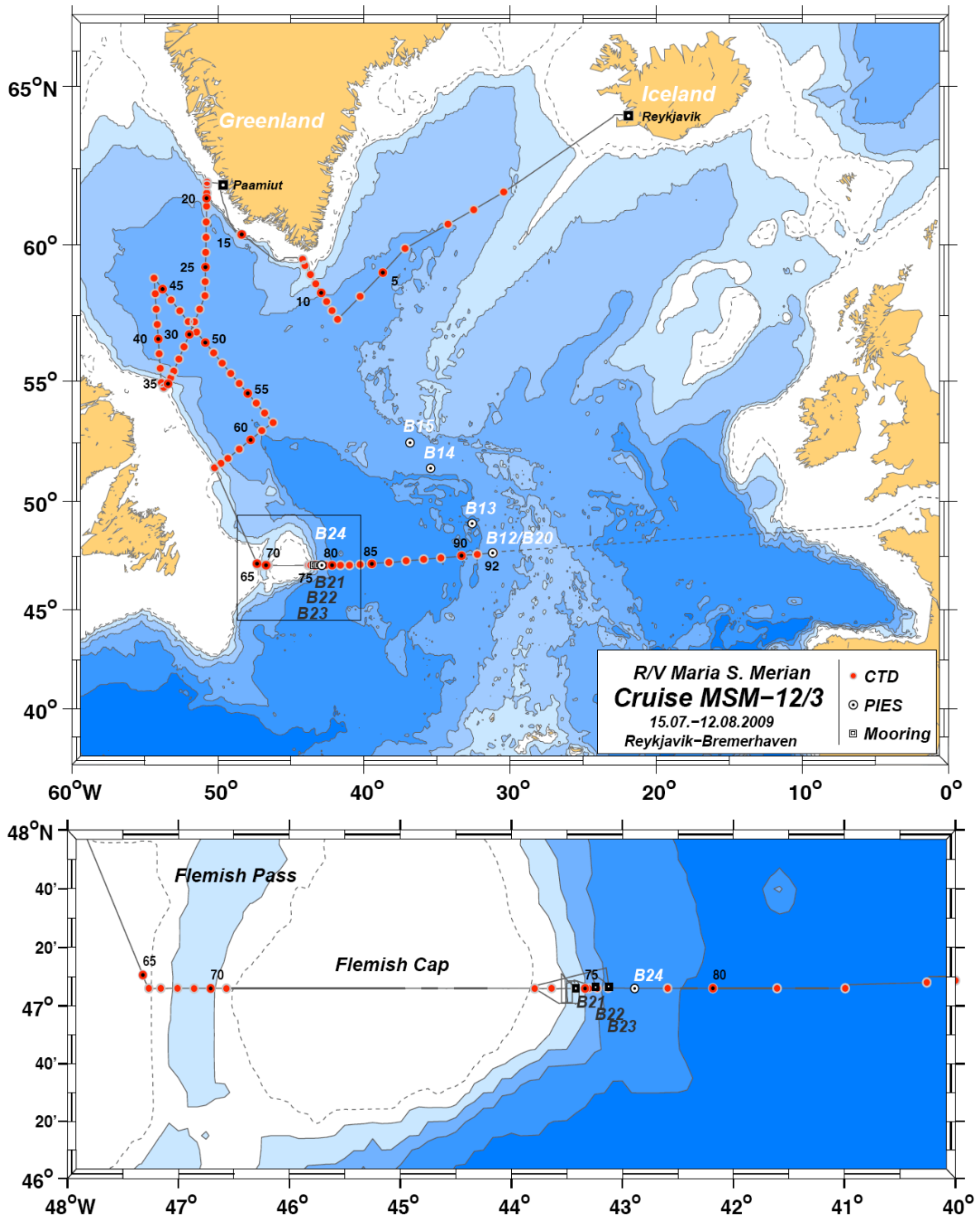

Fig. 1 Cruise track MERIAN cruise MSM12/3

Prof.	Sta.	Date	Time	Latitude	Longitude	Water Depth	Prof. Depth	CFC	SF_6	O_2	Nuts	Alk., DIC, ^{13}C	LADCP	Comments
1	658	2009/07/16	08:39	61° 45.48' N	30° 26.04' W	2067	2063	-	-	x	-	-	x	
2	659	2009/07/16	15:52	61° 10.92' N	32° 29.15' W	2640	2624	-	-	x	-	-	x	
3	660	2009/07/16	22:18	60° 42.00' N	34° 14.51' W	2996	2988	x	-	x	-	-	x	
4	661	2009/07/17	08:15	59° 52.51' N	37° 11.58' W	3104	3097	x	-	x	-	-	x	
5	662	2009/07/17	16:19	59° 2.14' N	38° 42.59' W	3096	3087	x	-	x	-	-	x	
6	663	2009/07/18	00:04	58° 11.53' N	40° 15.52' W	3163	3156	x	-	x	-	-	x	
7	664	2009/07/18	07:57	57° 20.99' N	41° 48.48' W	3279	3273	x	-	x	-	-	x	
8	665	2009/07/18	12:00	57° 40.55' N	42° 11.15' W	3305	3295	x	-	x	-	-	x	
9	666	2009/07/18	16:00	57° 59.99' N	42° 33.53' W	3204	3196	x	-	x	-	-	x	
10	667	2009/07/18	19:52	58° 18.96' N	42° 55.51' W	2918	2909	x	-	x	-	-	x	
11	668	2009/07/18	23:45	58° 38.49' N	43° 18.00' W	2162	2153	x	-	x	-	-	x	
12	669	2009/07/19	03:07	58° 57.99' N	43° 40.01' W	1626	1616	x	-	x	-	-	x	
13	670	2009/07/19	06:12	59° 16.99' N	44° 2.51' W	1642	1640	x	-	x	-	-	x	
14	671	2009/07/19	08:37	59° 30.20' N	44° 12.32' W	196	184	x	-	x	-	-	x	
15	672	2009/07/19	20:48	60° 21.45' N	48° 21.88' W	526	524	x	x	x	-	-	x	
16	673	2009/07/19	21:49	60° 20.54' N	48° 27.21' W	1900	1814	x	x	x	-	-	x	
17	674	2009/07/20	23:23	62° 4.49' N	50° 44.45' W	340	327	x	x	x	-	-	x	
18	675	2009/07/21	00:31	61° 59.20' N	50° 45.04' W	1608	1604	x	x	x	-	-	x	
19	676	2009/07/21	03:13	61° 43.46' N	50° 45.97' W	1707	1707	x	x	x	-	-	x	
20	677	2009/07/21	05:50	61° 33.57' N	50° 46.63' W	1587	1695	x	x	x	-	-	x	
21	678	2009/07/21	08:30	61° 17.76' N	50° 46.53' W	2914	2901	x	x	x	-	-	-	
22	679	2009/07/21	13:01	60° 46.48' N	50° 48.02' W	3077	3031	x	x	x	-	-	x	
23	680	2009/07/21	17:33	60° 15.50' N	50° 48.98' W	3160	3155	x	x	x	-	-	x	
24	681	2009/07/21	22:00	59° 44.49' N	50° 50.00' W	3405	3398	x	x	x	-	-	x	
25	682	2009/07/22	02:31	59° 13.97' N	50° 50.97' W	3499	3463	-	-	x	-	-	x	
26	682	2009/07/22	07:16	58° 42.95' N	50° 51.99' W	3341	3507	x	x	x	-	-	x	
27	684	2009/07/22	11:58	58° 12.96' N	50° 52.99' W	3613	3538	x	x	x	-	-	x	Microcat calib.
28	685	2009/07/22	17:59	57° 43.49' N	51° 14.57' W	3583	3628	x	x	x	-	-	x	
29	686	2009/07/22	22:40	57° 15.49' N	51° 36.00' W	3545	3540	x	x	x	-	-	x	
30	687	2009/07/23	03:14	56° 47.49' N	51° 57.51' W	3500	3526	-	-	x	-	-	x	
31	688	2009/07/23	07:55	56° 19.46' N	52° 18.98' W	3552	3548	x	x	x	-	-	x	
32	689	2009/07/23	12:35	55° 51.49' N	52° 40.00' W	3287	3279	-	-	x	-	-	x	
33	690	2009/07/23	17:22	55° 23.46' N	53° 1.48' W	3176	3093	x	x	x	-	-	x	
34	691	2009/07/23	20:57	55° 7.97' N	53° 13.54' W	2560	2547	x	x	x	-	-	x	
35	692	2009/07/23	23:56	54° 53.65' N	53° 24.51' W	1200	1152	x	x	x	-	-	x	
36	693	2009/07/24	02:05	54° 44.79' N	53° 42.43' W	366	353	x	x	x	-	-	x	
37	694	2009/07/24	03:50	54° 56.47' N	53° 52.49' W	538	521	-	-	x	-	-	x	Microcat calib.
38	695	2009/07/24	07:06	55° 29.94' N	53° 56.46' W	2767	2721	-	-	x	-	-	x	
39	696	2009/07/24	11:41	56° 3.48' N	54° 1.02' W	3258	3250	-	-	x	-	-	x	
40	697	2009/07/24	17:57	56° 36.96' N	54° 4.99' W	3296	3232	x	x	x	-	-	x	
41	698	2009/07/24	23:14	57° 9.92' N	54° 9.00' W	3324	3316	x	x	x	-	-	x	
42	699	2009/07/25	03:59	57° 43.50' N	54° 13.47' W	3354	3350	x	x	x	-	-	x	
43	700	2009/07/25	08:58	58° 16.98' N	54° 17.51' W	3401	3385	-	-	x	-	-	x	
44	701	2009/07/25	13:46	58° 50.48' N	54° 21.96' W	3432	3373	x	x	x	-	-	x	
45	702	2009/07/25	18:14	58° 26.93' N	53° 46.99' W	3644	3402	x	x	x	-	-	x	
46	703	2009/07/25	22:41	58° 3.48' N	53° 12.01' W	3536	3465	x	x	x	-	-	x	

Prof.	Sta.	Date	Time	Latitude	Longitude	Water Depth	Prof. Depth	CFC	SF_6	O_2	Nuts	Alk., DIC, ^{13}C	LADCP	Comments
47	704	2009/07/26	03:15	57° 39.98' N	52° 36.90' W	3498	3493	x	x	x	-	-	x	
48	705	2009/07/26	07:49	57° 16.01' N	52° 1.90' W	3516	3510	x	x	x	-	-	x	
49	706	2009/07/26	12:18	56° 52.49' N	51° 26.96' W	3558	3555	-	-	x	-	-	x	
50	707	2009/07/26	16:51	56° 28.95' N	50° 51.94' W	3601	3597	x	x	x	-	-	x	
51	708	2009/07/26	21:23	56° 5.49' N	50° 17.51' W	3664	3664	x	x	x	-	-	x	
52	709	2009/07/27	02:04	55° 42.01' N	49° 42.51' W	3656	3656	x	x	x	-	-	x	
53	710	2009/07/27	06:43	55° 17.97' N	49° 7.50' W	3667	3664	-	-	x	-	-	x	
54	711	2009/07/27	11:24	54° 54.50' N	48° 32.53' W	3806	3806	x	x	x	-	-	x	
55	712	2009/07/27	16:07	54° 30.98' N	47° 57.46' W	3788	3788	-	-	x	-	-	x	
56	712	2009/07/27	20:49	54° 7.51' N	47° 22.45' W	3513	3613	x	x	x	-	-	x	
57	714	2009/07/28	01:32	53° 43.50' N	46° 47.96' W	3692	3693	x	x	x	-	-	x	
58	715	2009/07/28	06:15	53° 20.00' N	46° 12.98' W	3959	3963	x	x	x	-	-	x	
59	716	2009/07/28	11:28	53° 0.51' N	46° 59.93' W	4167	3981	-	-	x	-	-	x	
60	717	2009/07/28	16:42	52° 37.52' N	47° 45.99' W	3881	3894	x	x	x	-	-	x	
61	718	2009/07/28	21:51	52° 14.50' N	48° 32.49' W	3628	3645	x	x	x	-	-	x	
62	719	2009/07/29	02:58	51° 51.01' N	49° 19.01' W	3006	3000	x	x	x	-	-	x	
63	720	2009/07/29	06:31	51° 38.54' N	49° 47.52' W	2293	2274	-	-	x	-	-	x	
64	721	2009/07/29	09:58	51° 27.25' N	50° 13.32' W	488	475	-	-	x	-	-	x	
65	722	2009/07/30	08:48	47° 10.62' N	47° 19.18' W	606	302	-	-	-	-	-	x	
66	723	2009/07/30	09:43	47° 6.01' N	47° 15.97' W	470	457	x	x	x	-	-	x	
67	724	2009/07/30	10:39	47° 6.00' N	47° 9.46' W	872	858	x	x	x	x	x	x	
68	725	2009/07/30	12:20	47° 6.01' N	47° 0.47' W	1125	1114	x	x	x	x	x	x	
69	726	2009/07/30	13:56	47° 5.98' N	46° 51.51' W	1165	1155	x	x	x	x	x	x	
70	727	2009/07/30	15:37	47° 5.98' N	46° 42.50' W	1135	1123	x	x	x	x	x	x	
71	728	2009/07/30	17:14	47° 5.99' N	46° 34.03' W	548	536	x	x	x	x	x	x	
72	733	2009/08/01	02:22	47° 5.99' N	43° 47.45' W	580	571	-	-	x	-	-	x	
73	734	2009/08/01	03:45	47° 6.02' N	43° 38.28' W	764	756	x	x	x	-	-	x	
74	735	2009/08/01	05:25	47° 6.00' N	43° 25.40' W	1265	1258	x	x	x	-	-	x	
75	736	2009/08/01	06:57	47° 5.99' N	43° 20.17' W	1890	1792	x	x	x	-	-	x	
76	737	2009/08/01	08:37	47° 5.98' N	43° 18.10' W	2495	2501	x	x	x	x	x	x	
77	738	2009/08/01	11:05	47° 6.02' N	43° 13.56' W	3002	3000	x	x	x	-	-	x	
78	739	2009/08/01	13:39	47° 6.17' N	43° 7.68' W	3409	3412	-	-	x	x	x	x	
79	741	2009/08/01	21:22	47° 6.00' N	42° 35.51' W	3656	3652	x	x	x	-	-	x	
80	742	2009/08/02	01:04	47° 6.04' N	42° 11.08' W	4098	4090	x	x	x	x	x	x	
81	743	2009/08/02	05:26	47° 6.03' N	41° 36.41' W	4285	4287	x	x	x	-	-	x	
82	744	2009/08/02	10:05	47° 6.05' N	40° 59.56' W	4475	4483	x	x	x	x	x	x	single ADCP
83	745	2009/08/02	15:09	47° 8.06' N	40° 15.42' W	4525	4546	x	x	x	-	-	x	single ADCP
84	746	2009/08/02	20:30	47° 10.05' N	39° 29.47' W	4577	807	-	-	-	-	-	x	bad CTD data
85	747	2009/08/02	21:38	47° 10.11' N	39° 27.43' W	4578	4582	x	x	x	-	-	x	
86	748	2009/08/03	04:14	47° 13.97' N	38° 17.95' W	4580	4592	x	x	x	x	x	x	
87	749	2009/08/03	10:56	47° 18.43' N	37° 6.60' W	4426	4417	x	x	x	-	-	x	
88	750	2009/08/03	17:45	47° 22.46' N	35° 55.08' W	4340	4334	-	-	x	x	x	x	
89	751	2009/08/04	00:08	47° 26.48' N	34° 43.94' W	4077	4066	x	x	x	-	-	x	
90	752	2009/08/04	12:35	47° 32.96' N	33° 19.20' W	4194	4181	x	x	x	x	x	x	
91	753	2009/08/04	19:59	47° 36.48' N	32° 14.86' W	4007	3995	x	x	x	x	x	x	
92	754	2009/08/05	11:41	47° 40.21' N	31° 8.89' W	4000	4075	x	x	x	-	-	x	

Table 4 Participants MERIAN, Leg MSM 12/3

1.	Monika Rhein	Chief Scientist	UniHB
2.	Klaus Bulsiewicz	SF6 – CFC - Analysis	UniHB
3.	Wolfgang Böke	CTD, PIES, moorings	UniHB
4.	Gerd Fraas*	CTD, PIES, moorings	UniHB
5.	Dagmar Kieke	CTD, Tracer, underway data	UniHB
6.	Reiner Steinfeldt	Calibration of sensors, interpretation	UniHB
7.	Uwe Stöber	vm-ADCP, LADCP	UniHB
8.	Achim Ströh	PIES	UniHB
9.	Sandra Erdmann	SF6 – CFC - Watch	UniHB
10.	Lena Brinkhoff	CTD/LADCP Watch	UniHB
11.	Antje Buß	CTD/LADCP Watch	UniHB
12.	Torben Frost	CTD/LADCP Watch	UniHB
13.	Robert Meissner	CTD/LADCP Watch, moorings	UniHB
14.	Patrick Schmidt	CTD/LADCP Watch	UniHB
15.	Harald Poigner	SF6 – CFC - Watch	UniHB
16.	Andreas Vogel	CTD/LADCP Watch	UniHB
17.	Ilaria Stendardo	oxygen, nutrients,alkalinity	ETH
18.	Jenny Wendt	oxygen, nutrients, alkalinity	UniHB
19.	Arne Kasper	oxygen, nutrients , alkalinity	IFM-GEOMAR

*left ship on July, 20 in Paamiut, Greenland due to medical reasons

UniHB: Oceanography dep. Institute of Environmental Physics, University Bremen, Germany
ETH: Eidgenössische Technische Hochschule, Zürich, Switzerland
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