SHORT CRUISE REPORT

Circulation and Variability in the Subpolar North Atlantic

RV Meteor Cruise No. 59, Leg 3

August, 31st - October, 5th 2003, St. John's - Bremerhaven

by Dr. Jürgen Fischer

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Research Program

The western subpolar North Atlantic 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 M59/3 this is done by a combination of shipboard observations with CTD, current observations, and by analyzing water samples for different tracers. These observations are accomplished by moored stations and drifting autonomous floats. All investigations are imbedded in the SFB-460 'Dynamics of thermohaline circulation variability.

The first part of the cruise focuses on processes in the Labrador Sea. In this region large heat fluxes in winter cause deep ocean convection concentrated in small scale convective plumes. This usually occurs in February / March, and is measured by ADCPs and T/S sondes in moored stations. A large number of these "plumes" will then form a larger scale convective patch and the integral properties (e.g., its mean temperature) are observed by acoustic tomography and by the hydrographic and tracer measurements during the cruise. Profiling and neutrally buoyant floats deployed during M59/3 complement these measurements.

The second 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. Two boundary current arrays with current meters and T/S probes are used to determine the transport of deep water masses at the exit of the Labrador Sea, and at the transition of the subpolar to the subtropical regime (at the Tail of the Grand Banks). These long term records are supplemented by boundary current sections with LADCP and underway measurements of upper ocean currents (shipboard ADCPs). Profiling floats seeded into the Deep Western Boundary Current off the Grand Banks will give additional information regarding the Deep Water export.

Narrative of the Cruise

METEOR departed from the port of St. John's, Canada, in the morning of Sunday, 31 August 2003. Sunny weather and little wind made this a pleasant start. The ship was heading NW for the central Labrador Sea. Underway recording systems, e.g. the PCO_2 pump system, were switched on after being well outside the 12 nm limits of Canadian waters. On our way north Meteor passed an impressive ice berg from which hundreds of pictures were taken.
On September 1st we had a first test station with CTD and Lowered ADCP (LADCP) and water samples were taken. The CTD showed severe data distortions, indicating that the CTD might have a problem. However, to exclude that the CTD wire was causing this misbehaviour, we switched to winch 3 (W3) and tried again with the same result. Changing the CTD and another test showed then proper results. Preparations for the first mooring recovery were finished and we hoped to arrive at favourable conditions at the first mooring location.

Tuesday, Sept. 2nd we reached the southern end of the WOCE AR7W section, and covered the near shore part out to the first mooring location with the shipboard ADCPs. Recovery of mooring K62 began at 13:15 UTC; westerly winds at 6 Bft, fair visibility with showers were the conditions. Both releases responded well, when interrogated by the (University of Bremen) UB-deck unit, but not with ours, and at 15:45 all components were safely recovered. The next task was to recover the three bottom transponders which took a while until 20:00. The station work was completed by a CTD cast (#2). Overnight we made two CTD/LADCP stations on our way to K61 to support the tomographic measurements of the moorings.

Wednesday, Sept. 3rd we arrived at mooring K61 in the central Labrador Sea and began to interrogate K61 releases while approaching the station. Release commands were sent to both releases at 09:25, and the top element was spotted soon after (the uppermost part with the telemetry was lost). At 12:36 all components were recovered. At this location only two transponders were of the recoverable type, and both were recovered. About four miles west of the mooring we deployed three RAFOS floats (parked). These were launched using a cradle at

about 19:05 - 19:25 UTC; the deployment went well. Afterwards a CTD cast was performed at this location (giving some space to avoid conflicts with the parked floats).

Overnight CTD casts were performed on our way to mooring K63, at which we arrived at about 11:00 UTC on Sept. 4th At the mooring location we tried to interrogate the releases; but no response. Release code was sent at about 11:20 and the mooring surfaced at 11:26. Later we found that one release had not responded and was still closed. It took some time to get the top float due to unfavourable location of the floatation strings. However, at 12:10 the top was on deck and at 12:57 the releases came on deck. From the three transponders at this location we were able to recover two. The third one did not respond to the release command and after several trials (also with different deck units) we decided to leave and declared this one a loss.

During the night Meteor steamed northward to deploy the next float park early morning of Sept. 5th . This park (P1) was installed and later during the day we arrived at the AR7W section where we deployed the third float park (P2). At this location we performed a release test at 1500 m which showed good responses with the UB deck-unit but with none of ours. All 5 releases worked properly. CTD work carried us southward toward the RAFOS mooring location (RF01). On Sept. 6th we deployed the RAFOS mooring; winds were weak from 215°, and visibility was good. Magnetic deviation at the mooring location was 28.4°, and water depth is 3535m uncorrected. At 11:15 UTC we began to deploy at 57° 6.94'N, 52° 4.89'W. At 11:40 the release went in and at 12:56 all Meteor rope was fed out and the anchor slipped. We were not able to watch the submersion. Final Position was determined at 57° 04.76' N, 52° 06.01' W. The cruise continued with some CTD's and Microcat calibrations scheduled to arrive at the location of mooring K71 early next morning.

On Sept. 7th we lost some time during the night due to high winds. However, winds were favourable in the morning and the mooring deployment simulation told us to deploy in southward direction. All wires were spooled top to bottom and that had to be reversed first. Later during the deployment there was a 10m length instead of 100m in the plans. We began about 6 nm north of the target position, and the deployment went well. At 12:29 UTC the deployment began with the surface telemetric part, which took some time because of inductive links that had to be installed. However, the tomographic transceiver went in at 13:19 and the rest was routine, except that the tension remained high due to towing speeds near and above 1.5kn. The anchor launch position was 56° 33.5'N, 52° 40.0'W at 16:43. Water depth at the target position was 3489m (3507m uncorrected at 1500m/s). The submersion was observed at 17:08 but 20 Minutes later the telemetry reappeared as planned. The 20:30 Argos data reception showed the "Chemistry Frame" at 48dbar. The next activity at this location was the deployment of three acoustic transponders and their subsequent survey. After the third transponder drop three profiling floats were launched. The floats were started shortly before deployment and should stay for about 5 hours at the surface (at least the APEX). The PROVOR float was launched first, and while slowly swung out, it slipped out of the deployment rope. On a video clip one could clearly see that the plastic damper disc was torn off and so was the conductivity cell. The float stayed for a minute or so at the surface and then sank. The two APEX floats went in smoothly.

The morning of Sept. 8th saw Meteor at the location of mooring K72, which was deployed between 10:16 UTC (08:16 local) and 13:27 when the anchor was launched. Correct water depth at mooring location was 2765 m and the mooring was towed into position. Submersion was observed to happen at 13:42 UTC. In the following we deployed three transponders and surveyed their position. Meteor then turned shoreward and began station work toward the shelf edge at 500m. Then we turned toward the 53°N section (mooring K37, RAFOS).

The recovery of K37 on Sept. 10. was the first action at the 53° N section and was released 12:24. At 13:05 the top elements were on deck. Only the top two flotation groups were visible and after we had these on board the wire was straight down. When we recovered the last two floatation groups the first one had 4 out of 6 glass balls imploded (all 4 were Nautilus), and the last group of 6 was totally lost by implosion. Thereby the mooring lost about half of its total backup flotation, but all instruments were recovered safely.

After the recovery winds had increased to 8-9 Bft and heavy swell from NW hindered us to go to the shelf first and continue with K38. Instead we slowly progressed to K39, and the next morning when winds were considerably weaker we first recovered K39. At 9:04 UTC the release

code was sent, and the top element was on deck at 09:45. All instruments were safely recovered at 11:17 UTC. The 32" top was very difficult to pick up, and it was recommended to use a floating line etc. for better recovery. Then we proceeded to mooring K38 and recovered that as well (13:05 release to 14:39 UTC). Then we steamed to the 500m line and made CTD casts beyond the mooring position of K49.

Sept. 11th saw us early morning at the location of K49. Winds were strong (7 Bft), but we decided to begin with mooring work after breakfast. First we made a deployment simulation and while that was performed the ship was quite stable with almost no water on deck. However, during the deployment which began 10:35 UTC winds increased and occasionally water entered over the stern. This was certainly the limit for any mooring work, but all went well and by 13:13 UTC the anchor was dropped at 53° 08.09'N, 50° 51.95'W. Water depth was 2895 m (corrected for sound speed), thus 35 m deeper than planned. Submersion of the top element was observed at 13:31 UTC. Meteor proceeded to the end of the 53°N section with several more CTD stations and one KISP cast. While the KISP cast was performed, wind speeds increased again and CTD casts were almost impossible. We could not wait for calmer weather as any delay would have consequences for the final mooring operations at the Grand Banks, and after one more station at this leg we decided to head towards Flemish Cap (FC) for another boundary current section.

The morning of September 12th saw us steaming SE towards the CTD station north of FC, at which we arrived Sept. 13 at 16:00 UTC for the northernmost station of the FC-section, i.e., for the first of 10 CTD/LADCP stations (32 to 41). The first stations were rather deep and at station #633/36 on Sept. 14th another set of Sea / Microcats was calibrated. A release test was performed at that station with four releases tied together. Station work continued at shorter distances as the water became shallower. With station 41 finished, Meteor headed towards the final CTD section (the former WOCE section A2) with heavy mooring work waiting for us.

On Sept. 16th we arrived at the location of mooring K104_2 and released it at 13:17 (UTC) with the horizontal distance being around 0.8nm. There was sunshine, low winds and excellent visibility. It took quite a while for the top element to rise to the surface. The top was spotted at 14:06 UTC. More Benthos float groups surfaced close by and it was decided to use the rubber boat to separate the top. This went well, and at 15:15 (UTC) the top was on deck. At 15:15 we recovered all instruments at once, and there was only one Benthos group left. We had to haul in 10 pieces of wire at once which went relatively smooth after unraveling the floatation and instruments. At 16:30 the last float group was recovered and the rest of the wires came on board at 16:32 UTC. After the mooring work a CTD cast was performed and with it we sent 8 T/C probes down for calibration. This ended at 20:15UTC, giving us plenty of time to steam to K103_2 and for two underway CTD casts.

On Sept. 17th we reached mooring K103_2 in the morning and by 09:00 UTC the release command was sent. The mooring surfaced at 09:13, but even after waiting for some time no more than 3 Benthos groups were at the surface. During the recovery it became clear, that a problem with the lower floatation had occurred. In fact, from the six glass balls at 3000m depth four were imploded (2 Benthos and 2 Nautilus). The remaining float group was then ok, and by 11:06 the mooring was recovered.

On our way to the next mooring (K102_2) we crossed the North Atlantic Current front at the cold wall where water temperatures dropped from more than 20°C to 15° C; approximate location was 42° 52'N, 48° 06'W. At station K102_2 visibility was much improved and winds were rather weak. We were sending several interrogate commands, but nothing was heard. At 14:05 UTC the release commands were sent for several times, but with no response. Changing release deck-units did not help either. We then tried to release by hanging a hydrophone over the side (again with no success). As time progressed we prepared for dredging, but it was soon clear,

that we would run out of time (daylight). Instead we decided to steam to K101_2 and recover that mooring first. The dredging operation was then scheduled for the next morning. At 17:00 UTC we were at K101_1, and the releases could be contacted immediately, and already at 17:04 the release command was sent. This smooth operation gave us additional confidence, that the board-units were properly functioning (as it was on the other releases before; except those at K102). The preparation for the dredge-operation went on, but we then found in the nautical chart that several cables were marked at or nearby the mooring site. This circumstance and the risk to damage one of these cables led to the decision not to dredge. Instead we planned a systematic release survey around the mooring location for the following morning.

The morning of Sept. 18th saw Meteor again at the position of K102_2. From all 4 directions the releases were first interrogated and then released. This took about two hours. A final trial was then performed with the active hydrophon lowered over the side. But again, not a single reply. We then decided to stay in the area and re-deploy K102_3 first. Position was chosen about 2 nm toward the topography where there is some gap in the cable density. After a simulation of the deployment we determined the start position for the deployment to be 4.5 nm in 102° from the target position. At 14:18 UTC the top went in, and 17:00 UTC the anchor was launched. At the target position (which is equal to the final position) the water depth was 2947m (PN) and corrected to 2935m using CTD sound-speed. At 17:15 the mooring went under and the radio signal could not be heard further.

The next mooring to re-deploy was K101_3 (Sept. 19th). The same procedure was carried out, and the start position was determined to be 2.5 nm away from the target. (Water depth was 2027 m). The deployment began early morning at 10:00 UTC and about an hour later we had all but one instrument in the water. However, we had to tow the mooring into position for quite a while. Anchor drop was then at 11:40 UTC, and the top element could be observed until 11:49 UTC. We then steamed to K103_3 to deploy that mooring on the same day. Deployment begin was at 17:28 UTC, and by 19:40 the anchor was dropped. At the target a water depth of 3666m, 3651m corrected, was observed. We were not able to observe the top to sink, but it was seen shortly before. (there was too much sun glitter on the surface).

The next mooring deployment was already planned for Sept. 20th (K104_3). It was quite windy, with heavy showers. Visibility was generally good. After the usual deployment simulation we began 5 miles away from the target (bearing 148° target to start position). At 13:03 UTC the top went in. Winds were up to 17m/s and there was some water washing on deck; very unpleasant conditions. At 15:02 the anchor was dropped and the final position determined at 42° 31.06'N, 46° 46.82'W; WT=4322m (PN), or 4314m corrected for sound-speed. The last ARGOS watchdog transmission was heard 15:19 UTC, about 17 Minutes after anchor drop.

The weather prognosis for the next two days was not favourable, only a short period with relatively low winds was expected for the next morning, thus offering the only chance for deploying the McLane profiler with mooring K105. This was the reason why we began the deployment already before breakfast at 08:02 UTC with all the other procedures finished beforehand. This mooring with the delicate profiler was not easy to handle, and there should be some alterations made in the deployment procedure for the next one. However, 2500m wire in one piece is deployed rather fast, and at 10:03 UTC the anchor was dropped at 42° 20.75'N, 46° 14.68'W at a water depth of 4672m (corrected) at the final mooring position. Mooring position is 42° 20.39'N, 46° 14.51'W. Wire length was adjusted to water depth by removing 220 m of wire.

In between all this mooring work we completed the CTD station net, performed a release test, calibrated all remaining Microcats/Seacats and made one KISP station. The dogleg part of the WOCE A2 section was complete by Sept. 22nd and we crossed the Newfoundland basin eastward with CTD's every 30nm. In progressing eastward we crossed intense northward surface

currents which made CTD casts rather difficult. The combination of surface currents up to 3 kn and strong winds led to temporarily large wire angles at CTD casts (#58-60). Farther east the currents reversed with comparable southward velocities. On some stations we were not able to reach the bottom even though there was substantially more cable paid out than the depth of the CTD.

On Sept. 23rd we decided to put one of the two remaining APEX floats into the southward flowing current band. The deployment went rather well, but then the float was drawn under the ship and was not seen anymore. This led to an alteration of the deployment procedure, that should be done with slow (2kn) speed ahead. This went very well with the last float that we deployed at the location of mooring K106.

Meteor reached the target position of K106 late morning, with winds up to 18m/s. During the mooring simulation it became clear that the deployment would be possible, and we began to deploy at 13:29 UTC on September, 24th . At 13:50 the CTD profiler went in smoothly, and at 15:22 the anchor was dropped. We were not able to see the submersion of the mooring, but the radio on the mooring was heard until 15:39 UTC. Final position was the target position at 43° 30.00'N, 40° 00.00'W. This was the last mooring operation (9 recovered and 10 deployed) during M59/3.

A CTD cast was made near the mooring location and it turned out to be the last one for some time. The speed of Meteor was only 6 to 7kn due to strong winds and currents. The wind came from an almost stationary low south of our track. We decided to increase station spacing, but at the next morning (Sept. 25th) even stronger winds and heavy waves made station work impossible. Weather prognosis was 8-9 Bft. and during the day the wind speed was more than 22m/s. Meteor slowed down to less than 6 kn and the fourth diesel was switched on. We decided to move eastward as fast as possible, as farther east somewhat lower wind speeds should allow a few more stations.

The morning of Sept. 26th was somewhat calmer and it was possible to perform a CTD cast about 40nm west of the BSH Mooring K3. The next station was in the vicinity of that mooring which we surveyed after the CTD (late afternoon). The releases responded well and when Meteor ran slowly across the mooring position the acoustic ranging showed a minimum; thus confirming that the releases had not moved. As this was only the bottom part of the mooring there was not enough floatation (negative buoyancy) to let it rise to the surface when released or dredged. Release diagnostics confirmed that they are not vertically oriented. Releases were set to sleep modus again and Meteor headed to the next station.

The following CTD stations were carried out at 25nm distance to resolve any deep water flow along the edge of the Mid Atlantic ridge. The last CTD station (72) was in close proximity to the M59/2 cruise track, as it was planned beforehand. After the last station late night of September 27th, 2003 Meteor began the long transit to the ship yard in Bremerhaven.

Once on transit, Meteor steamed ahead with good speed for two days, but then was slowed down to almost 5kn because of strong head winds and heavy seas. The weather calmed down on the afternoon of October 1st and Meteor entered the English Channel with tidal help at 14kn on the 2nd. The cruise ended Sunday, October 5th in Bremerhaven.

Summarizing, on RV Meteor cruise M59/3 we made 72 CTD/LADCP casts. Water samples for salinity, oxygen, CFCs, and SF6 were taken at almost each station (see station Table 1). Shipboard ADCP data were collected along the track giving about 7000km of current data of the upper ocean ranging from the surface to 600-1000m. We recovered 9 current meter moorings

and deployed 10 (Table 2). In addition 9 neutrally buoyant floats (Table 3) and 10 profiling floats (Table 4) were laid out.

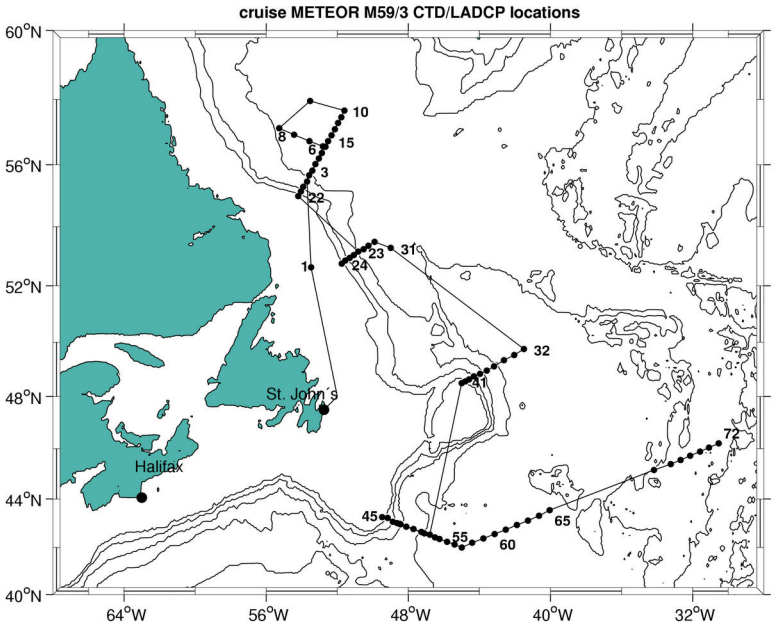

Fig. 1: CTD-station distribution of METEOR cruise M59/3, August 31 to October 5, 2003.

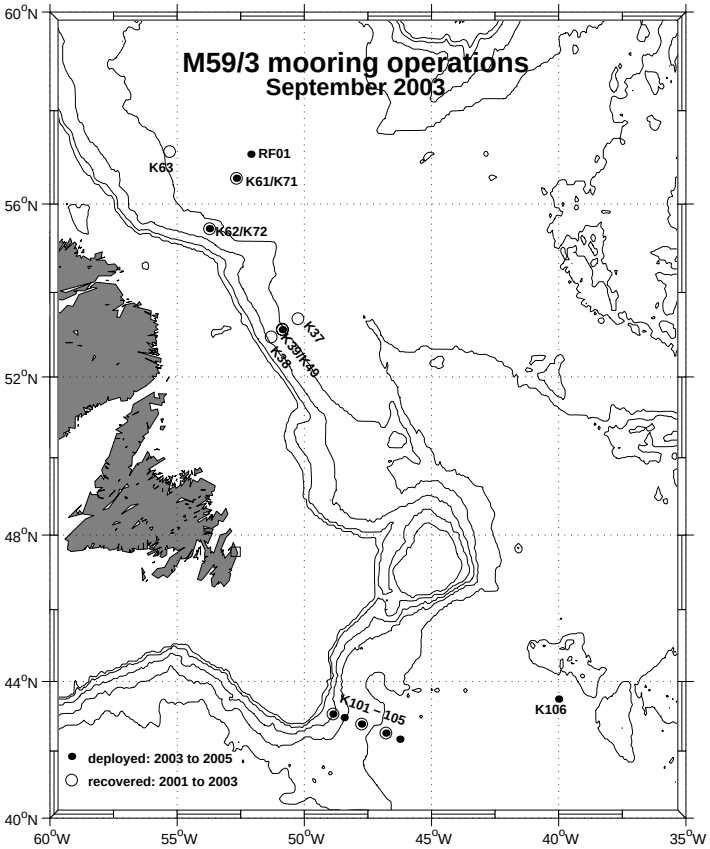

Fig. 2: Mooring operations during M59/3

Station Lists M59/3

Table 1: METEOR M59/3 CTD/LADCP Stations

R/V Meteor cruise M59/3 CTD-stations

SHIP	Station	Profile	DATE	UTC		POSTION						Uncorr.	MAX	NO. OF	
EXPOCODE	No.	No.	mmddyy	TIME	CODE	LATITUDE			LONGITUDE			DEPTH	PRESS	BOTTLES	PAR.
06ME59/3	590	1	090103	15:15	BE	52 12,66	N		53 21,06	W		367	CTD		
06ME59/3	590	1	090103	15:30	BO	52 12,55	N		53 20,99	W		369	330	21	3,4
06ME59/3	590	1	090103	15 :40	EN	52 12,50	N		53 20.95	W		368			
06ME59/3	592	2	090203	2011	BE	55 28,06	N		53 42,05	W		2820			
06ME59/3	592	2	090203	2107	BO	55 27.67	N		53 41,53	W		2815	2801	20	1,2,3,4
06ME59/3	592	2	090203	2204	EN	55 27,39	N		53 41,23	W		2798			
06ME59/3	593	3	090303	0121	BE	55 48,97	N		59 52,02	W		3118			
06ME59/3	593	3	090303	0224	BO	55 49,23	N		53 24,63	W		3122	3129	21	1,2,3,4
06ME59/3	593	3	090303	0323	EN	55 49,28	N		53 25,66	W		3125			
06ME59/3	594	4	090303	0630	BE	56 11,87	N		53 0206	W		3411			
06ME59/3	594	4	090303	0733	BO	56 11,85	N		53 01,98	W		3410	3429	21	1,2,3,4
06ME59/3	594	4	090303	0838	EN	56 11,88	N		53 02,01	W		3409			
06ME59/3	596	5	090303	1939	BE	56 34,34	N		52 48,30	W		3494			
06ME59/3	596	5	090303	2050	BO	56 34,25	N		52 48,64	W		3491	3510	21	1,3,4
06ME59/3	596	5	090303	2159	EN	56 34,05	N		52 48,88	W		3494			
06ME59/3	597	6	090403	0057	BE	56 43,98	N		53 34,02	W		3348			
06ME59/3	597	6	090403	0202	BO	56 43,66	N		53 35,40	W		3342	3359	20	1,2,3,4
06ME59/3	597	6	090403	0309	EN	56 43,40	N		53 36,15	W		3338			
06ME59/3	598	7	090403	0613	BE	56 55,94	N		54 25,95	W		3267			
06ME59/3	598	7	090403	0717	BO	56 55,75	N		54 26,34	W		3270	3279	21	1,2,3,4
06ME59/3	598	7	090403	0820	EN	56 55,55	N		54 26,91	W		3261			
06ME59/3	599	8	090403	1706	BE	57 08,92	N		55 17,18	W		3099			
06ME59/3	599	8	090403	1808	BO	57 08,43	N		55 16,93	W		3099	3108	16	1,2,3,4
06ME59/3	599	8	090403	1909	EN	57 08,05	N		55 16,80	W		3097			
06ME59/3	600	9	090503	0511	BE	57 57,17	N		53 31,73	W					
06ME59/3	600	9	090503	0620	BO	57 57,18	N		53 31,84	W		3471	3496	21	1,3,4
06ME59/3	600	9	090503	0726	EN	57 57,05	N		53 31,92	W		3475			
06ME59/3	601	10	090503	1347	BE	57 40,06	N		51 35,99	W		3519			
06ME59/3	601	10	090503	1458	BO	57 40,00	N		51 36,23	W		3539	3536	18	1,2,3,4
06ME59/3	601	10	090503	1629	EN	57 39,60	N		51 37,10	W		3539			
06ME59/3	602	11	090503	2022	BE	57 27,95	N		51 46,50	W		3560			
06ME59/3	602	11	090503	2132	BO	57 27,98	N		51 46,70	W		3560	3562	21	1,2,3,4
06ME59/3	602	11	090503	2242	EN	57 28,07	N		51 46,69	W		3560			
06ME59/3	603	12	090603	0001	BE	57 17,50	N		51 56,95	W		3582			
06ME59/3	603	12	090603	0108	BO	57 17,59	N		51 56,95	W		3581	3583	21	1,2,3,4
06ME59/3	603	12	090603	0218	EN	57 17,32	N		51 57,10	W		3555			
06ME59/3	604	13	090603	0348	BE	57 05,94	N		52 08,10	W		3522			
06ME59/3	604	13	090603	0459	BO	57 05,13	N		52 09,31	W		3534	3550	21	1,2,3,4
06ME59/3	604	13	090603	0608	EN	57 04,50	N		52 10,38	W		3527			
06ME59/3	605	14	090603	0722	BE	56 54,91	N		52 19,11	W		3523			
06ME59/3	605	14	090603	0828	BO	56 54,82	N		52 19,92	W		3533	3550	20	1,2,3,4
06ME59/3	605	14	090603	0935	EN	56 54,64	N		52 20,59	W		3523			
06ME59/3	607	15	090603	1556	BE	56 44,06	N		52 30,90	W		3525			
06ME59/3	607	15	090603	1705	BO	56 43,85	N		52 30,26	W		3533	3547	21	1,2,3,4,5
06ME59/3	607	15	090603	1813	EN	56 43,70	N		52 29,87	W		3546			
06ME59/3	608	16	090603	1953	BE	56 33,75	N		52 39,91	W		3525			
06ME59/3	608	16	090603	2103	BO	56 33,61	N		52 93,88	W		3521	3528	21	1,2,3,4
06ME59/3	608	16	090603	2232	EN	56 33,45	N		52 39,65	W		3521			
06ME59/3	609	17	090703	0009	BE	56 21,96	N		52 51,88	W		3513			
06ME59/3	609	17	090703	0116	BO	56 21,76	N		52 51,59	W		3526	3545	21	1,3,4
06ME59/3	609	17	090703	0224	EN	56 21,51	N		52 52,14	W		3556			
06ME59/3	610	18	090703	0522	BE	56 01,20	N		53 13,45	W		3279			
06ME59/3	610	18	090703	0622	BO	56 00,91	N		53 13,12	W		3260	3273	21	1,3,4
06ME59/3	610	18	090703	0722	EN	56 00,65	N		53 13,07	W		3257			
06ME59/3	612	19	090803	0203	BE	55 39,94	N		53 35,01	W		2995			
06ME59/3	612	19	090803	0307	BO	55 40,00	N		53 35,62	W		2998	2995	21	1,2,3,4

R/V METEOR cruise M59/3 CTD-stations

SHIP EXPOCODE	Station No.	Profile No.	DATE mmddyy	UTC TIME	POSTION CODE	LATITUDE		LONGITUDE		Uncorr. DEPTH	MAX PRESS	NO. OF BOTTLES	PAR.
06ME59/3	612	19	090803	0406	EN	55 40,23 N		53 36,27 W		3013			
06ME59/3	614	20	090803	1753	BE	55 17,93 N		53 54,98 W		2294			
06ME59/3	614	20	090803	1840	BO	55 17,82 N		53 54,97 W		2297	2269	21	1,2,3,4,5
06ME59/3	614	20	090803	1926	EN	55 17,80 N		53 55,03 W		2297			
06ME59/3	615	21	090803	2042	BE	55 09,00 N		54 02,83 W		1348			
06ME59/3	615	21	090803	2114	BO	55 09,08 N		54 02,31 W		1397	1351	13	1,2,3,4
06ME59/3	615	21	090803	2142	EN	55 09,09 N		54 01,99 W		1421			
06ME59/3	616	22	090803	2301	BE	54 59,97 N		54 11,84 W		493			
06ME59/3	616	22	090803	2314	BO	54 59,88 N		54 11,62 W		494	466	9	1,3,4
06ME59/3	616	22	090803	2328	EN	54 59,81 N		54 11,42 W		494			
06ME59/3	618	23	091003	0636	BE	53 10,00 N		50 48,99 W		2973			
06ME59/3	618	23	091003	0737	BO	53 09,39 N		50 48,91 W		2943	2951	21	1,2,3,4
06ME59/3	618	23	091003	0835	EN	53 08,92 N		50 49,07 W		2920			
06ME59/3	620	24	091003	1648	BE	52 45,85 N		51 44,80 W		473			
06ME59/3	620	24	091003	1707	BO	52 45,73 N		51 44,53 W		469	433	7	1,3,4
06ME59/3	620	24	091003	1721	EN	52 45,66 N		51 44,53 W		468			
06ME59/3	621	25	091003	1834	BE	52 51,94 N		51 32,92 W		1454			
06ME59/3	621	25	091003	1908	BO	52 51,77 N		51 32,82 W		1453	1414	12	1,2,3,4
06ME59/3	621	25	091003	1940	EN	52 51,59 N		51 32,94 W		1423			
06ME59/3	622	26	091003	2056	BE	52 57,54 N		51 18,06 W		2269			
06ME59/3	622	26	091003	2142	BO	52 57,44 N		51 18,23 W		2263	2237	17	1,2,3,4
06ME59/3	622	26	091003	2230	EN	52 57,37 N		51 17,98 W		2266			
06ME59/3	623	27	091103	0116	BE	53 02,97 N		51 03,84 W		2641			
06ME59/3	623	27	091103	0207	BO	53 02,73 N		51 04,04 W		2617	2625	18	1,2,3,4
06ME59/3	623	27	091103	0251	EN	53 02,22 N		51 04,62 W		2595			
06ME59/3	624	28	091103	0535	BE	53 15,08 N		50 30,99 W		3202			
06ME59/3	624	28	091103	0642	BO	53 14,71 N		50 31,68 W		3202	3226	21	1,2,3,4,5
06ME59/3	624	28	091103	0744	EN	53 14,63 N		50 32,10 W		3215			
06ME59/3	626	29	091103	1604	BE	53 22,11 N		50 14,94 W		3428			
06ME59/3	626	29	091103	1711	BO	53 22,07 N		50 14,81 W		3441	3456	21	1,2,3,4
06ME59/3	626	29	091103	1817	EN	53 21,90 N		50 15,69 W		3407			
06ME59/3	627	30	091203	0019	BE	53 29,67 N		49 54,33 W		3584			
06ME59/3	627	30	091203	0127	BO	53 30,01 N		49 54,63 W		3570	3591	21	1,2,3,4
06ME59/3	627	30	091203	0237	EN	53 30,48 N		49 54,77 W		3563			
06ME59/3	628	31	091203	0626	BE	53 17,84 N		48 59,92 W		3736			
06ME59/3	628	31	091203	0742	BO	53 18,29 N		49 00,17 W		3733	3766	20	1,2,3,4
06ME59/3	628	31	091203	0852	EN	53 18,46 N		49 00,60 W		3733			
06ME59/3	629	32	091303	1533	BE	49 45,30 N		41 29,76 W		4389			
06ME59/3	629	32	091303	1701	BO	49 46,16 N		41 31,47 W		4386	4448	21	1,2,3,4
06ME59/3	629	32	091303	1832	EN	49 47,12 N		41 33,17 W		4385			
06ME59/3	630	33	091303	2055	BE	49 32,41 N		42 02,86 W		4459			
06ME59/3	630	33	091303	2222	BO	49 32,48 N		42 03,41 W		4489	4563	21	1,2,3,4
06ME59/3	630	33	091403	0005	EN	49 32,05 N		42 03,69 W		4518			
06ME59/3	631	34	091403	0230	BE	49 20,90 N		42 37,44 W		4208			
06ME59/3	631	34	091403	0352	BO	49 19,70 N		42 37,26 W		4199	4258	21	1,2,3,4
06ME59/3	631	34	091403	0515	EN	49 18,63 N		42 37,45 W		4214			
06ME59/3	632	35	091403	0736	BE	49 07,41 N		43 10,28 W		3914			
06ME59/3	632	35	091403	0855	BO	49 08,03 N		43 12,18 W		3909	3956	21	1,2,3,4
06ME59/3	632	35	091403	1015	EN	49 08,61 N		43 13,44 W		3930			
06ME59/3	633	36	091403	1205	BE	48 58,02 N		43 35,51 W		3469			
06ME59/3	633	36	091403	1310	BO	48 58,49 N		43 35,73 W		3465	3474	18	1,2,3,4
06ME59/3	633	36	091403	1442	EN	48 59,17 N		43 35,67 W		3452			
06ME59/3	634	37	091403	1752	BE	48 50,95 N		43 57,97 W		2414			
06ME59/3	634	37	091403	1842	BO	48 50,99 N		43 57,65 W		2444	2407	21	1,2,3,4,5
06ME59/3	634	37	091403	1927	EN	48 51,00 N		43 57,51 W		2444			
06ME59/3	635	38	091403	2106	BE	48 45,05 N		44 18,46 W		1792			
06ME59/3	635	38	091403	2142	BO	48 45,02 N		44 18,30 W		1801	1782	14	1,2,3,4
06ME59/3	635	38	091403	2221	EN	48 45,15 N		44 17,99 W		1823			
06ME59/3	636	39	091403	2345	BE	48 38,35 N		44 35,07 W		1394			
06ME59/3	636	39	091503	0015	BO	48 38,34 N		44 34,74 W		1399	1368	12	1,2,3,4

R/V METEOR cruise M59/3 CTD-stations

SHIP	Station	Profile	DATE	UTC		POSTION						Uncorr.	MAX	NO. OF	
EXPOCODE	No.	No.	mmddyy	TIME	CODE	LATITUDE			LONGITUDE			DEPTH	PRESS	BOTTLES	PAR.
06ME59/3	636	39	091503	0046	EN	48	38,36	N	44	34,88	W	1386			
06ME59/3	637	40	091503	0150	BE	48	33,99	N	44	47,85	W	1034			
06ME59/3	637	40	091503	0214	BO	48	33,90	N	44	47,84	W	1024	1001	09	1,2,3,4
06ME59/3	637	40	091503	0236	EN	48	33,80	N	44	47,89	W	1025			
06ME59/3	638	41	091503	0343	BE	48	30,05	N	45	00,01	W	804			
06ME59/3	638	41	091503	0403	BO	48	30,06	N	45	00,01	W	804	783	09	1,2,3,4,5
06ME59/3	638	41	091503	0420	EN	48	30,08	N	45	00,12	W	812			
06ME59/3	639	42	091603	1648	BE	42	31,91	N	46	47,89	W	4271			
06ME59/3	639	42	091603	1809	BO	42	31,81	N	46	48,38	W	4270	4337	15	1,2,3,4
06ME59/3	639	42	091603	2007	EN	42	31,57	N	46	49,26	W	4262			
06ME59/3	640	43	091603	2214	BE	42	39,10	N	47	15,96	W	4073			
06ME59/3	640	43	091603	2332	BO	42	39,50	N	47	15,90	W	4096	4131	21	1,2,3,4
06ME59/3	640	43	091703	0057	EN	42	39,35	N	47	15,98	W	4082			
06ME59/3	641	44	091703	0302	BE	42	46,10	N	47	42,68	W	3655			
06ME59/3	641	44	091703	0413	BO	42	46,31	N	47	42,39	W	3656	3688	21	1,2,3,4
06ME59/3	641	44	091703	0523	EN	42	46,39	N	47	42,15	W	3658			
06ME59/3	644	45	091703	2152	BE	43	15.49	N	49	28,37	W	334			
06ME59/3	644	45	091703	2205	BO	43	15,48	N	49	28,24	W	326	309	06	1,2,3,4
06ME59/3	644	45	091703	2216	EN	43	15,50	N	49	28,21	W	321			
06ME59/3	645	46	091703	2348	BE	43	13,48	N	49	10,14	W	1006			
06ME59/3	645	46	091803	0011	BO	43	13,27	N	49	10,22	W	999	964	09	1,2,3,4
06ME59/3	645	46	091803	0035	EN	43	13,24	N	49	10,21	W	999			
06ME59/3	646	47	091803	0409	BE	42	57,87	N	48	26,19	W	2937			
06ME59/3	646	47	091803	0507	BO	42	57,91	N	48	26,64	W	2927	2933	21	1,2,3,4
06ME59/3	646	47	091803	0604	EN	42	57,86	N	48	27,26	W	2897			
06ME59/3	647	48	091803	1753	BE	42	58,73	N	48	28,07	W	2862			
06ME59/3	647	48	091893	1850	BO	42	58,24	N	48	28,19	W	2880	2864	16	1,2,3,4
06ME59/3	647	48	091803	2013	EN	42	57,84	N	48	28,72	W	2851			
06ME59/3	648	49	091903	0057	BE	43	00,76	N	48	38,23	W	2547			
06ME59/3	648	49	091903	0147	BO	43	00,65	N	48	38,88	W	2537	2522	18	1,2,3,4
06ME59/3	648	49	091903	0238	BE	43	00,52	N	48	39,52	W	2523			
06ME59/3	649	50	091903	0357	BE	43	03,95	N	48	52,49	W	2027			
06ME59/3	649	50	091903	0439	BO	43	03,91	N	48	52,59	W	2007	2003	18	1,2,3,4
06ME59/3	649	50	091903	0520	EN	43	03,69	N	48	52,83	W	1971			
06ME59/3	651	51	091903	2328	BE	42	52,00	N	48	06,92	W	3407			
06ME59/3	651	51	092003	0037	BO	42	52,34	N	48	07,12	W	3404	3400	21	1,2,3,4
06ME59/3	651	51	092003	0152	EN	42	52,60	N	48	07,63	W	3397			
06ME59/3	653	52	092003	0719	BE	42	35,34	N	47	05,79	W	4037			
06ME59/3	653	52	092003	0837	BO	42	35,75	N	47	06,27	W	4039	4085	21	1,2,3,4
06ME59/3	653	52	092003	1001	EN	42	36,18	N	47	06,72	W	3992			
06ME59/3	654	53	092003	1706	BE	42	25,97	N	46	29,94	W	4591			
06ME59/3	654	53	092003	1837	BO	42	26,80	N	46	30,73	W	4551	4637	21	1,2,3,4
06ME59/3	654	53	092003	2010	EN	42	27,73	N	46	31,51	W	4538			
06ME59/3	655	54	092003	2151	BE	42	21,48	N	46	14,82	W	4657			
06ME59/3	655	54	092003	2322	BO	42	22,81	N	46	14,88	W	4680	4744	21	1,2,3,4
06ME59/3	655	54	092103	0116	EN	42	23,96	N	46	15,81	W				
06ME59/3	657	55	092103	1222	BE	42	14,46	N	45	49,02	W	4709			
06ME59/3	657	55	092103	1349	BO	42	14,43	N	45	49,77	W	4697	4774	21	1,2,3,4
06ME59/3	657	55	092103	1553	EN	42	14,47	N	45	51,48	W	4681			
06ME59/3	658	56	092103	1815	BE	42	07,53	N	45	24,01	W	4739			
06ME59/3	658	56	092103	1949	BO	42	07,92	N	45	24,90	W	4740	4847	21	1,3,4
06ME59/3	658	56	092103	2128	EN	42	08,26	N	45	25,89	W	4751			
06ME59/3	659	57	092103	2347	BE	41	59,98	N	44	59,86	W	4843			
06ME59/3	659	57	092203	0121	BO	42	00,77	N	44	59,42	W	4842	4916	21	1,2,3,4
06ME59/3	659	57	092203	0321	EN	42	01,54	N	44	58,96	W	4815			
06ME59/3	660	58	092203	0637	BE	42	12,11	N	44	24,53	W	4815			
06ME59/3	660	58	092203	0817	BO	42	14,09	N	44	27,58	W	4815	4457	21	1,2,3,4
06ME59/3	660	58	092203	1010	EN	42	15,93	N	44	31,24	W	4815			
06ME59/3	661	59	092203	1430	BE	42	22,54	N	43	46,56	W	4814			
06ME59/3	661	59	092203	1608	BO	42	24,38	N	43	47,45	W	4878	4880	21	1,2,3,4

R/V METEOR cruise M59/3 CTD-stations

SHIP EXPOCODE	Station No.	Profile No.	DATE mmddyy	UTC TIME	CODE	POSTION LATITUDE			LONGITUDE			Uncorr. DEPTH	MAX PRESS	NO. OF BOTTLES	PAR.
06ME59/3	661	59	092203	1842	EN	42	26,14	N	43	48,60	W	4815			
06ME59/3	662	60	092203	2205	BE	42	33,78	N	43	08,79	W	4879			
06ME59/3	662	60	092203	2336	BO	42	34,73	N	43	08,76	W	4859	4919	21	1,2,3,4
06ME59/3	662	60	092303	0202	EN	42	34,62	N	43	07,08	W	4854			
06ME59/3	663	61	092304	0518	BE	42	44,69	N	42	31,17	W	4719			
06ME59/3	663	61	092303	0653	BO	42	43,64	N	42	29,75	W	4740	4897	21	1,2,3,4
06ME59/3	663	61	092303	0834	EN	42	42,48	N	42	28,72	W	4814			
06ME59/3	664	62	092303	1215	BE	42	55,99	N	41	53,68	W	4850			
06ME59/3	664	62	092303	1344	BO	42	54,22	N	41	52,86	W	4826	4909	21	1,3,4
06ME59/3	664	62	092303	1543	EN	42	51,88	N	41	52,59	W	4810			
06ME59/3	665	63	092303	2025	BE	43	07,06	N	41	16,45	W	4807			
06ME59/3	665	63	092303	2159	BO	43	06,76	N	41	16,56	W	4827	4905	21	1,2,3,4
06ME59/3	665	63	092303	2354	EN	43	06,67	N	41	16,99	W	4821			
06ME59/3	666	64	092403	0450	BE	43	18,69	N	40	39,03	W	4791			
06ME59/3	666	64	092403	0628	BO	43	20,52	N	40	40,46	W	4793	4874	21	1,2,3,4
06ME59/3	666	64	092403	0814	EN	43	22,37	N	40	41,65	W	4793			
06ME59/3	667	65	092403	1615	BE	43	32,61	N	40	02,90	W	4665			
06ME59/3	667	65	092403	1748	BO	43	32,65	N	40	04,35	W	4665	4888	20	1,2,3,4
06ME59/3	667	65	092403	1943	EN	43	33,14	N	40	06,18	W	4664			
06ME59/3	668	66	092603	0857	BE	45	09,36	N	34	10,75	W	3827			
06ME59/3	668	66	092603	1007	BO	45	09,88	N	34	10,16	W		3875	21	1,2,3,4
06ME59/3	668	66	092603	1137	EN	45	10,66	N	34	09,38	W	3855			
06ME59/3	669	67	092603	1618	BE	45	23,36	N	33	13,98	W	3695			
06ME59/3	669	67	092603	1730	BO	45	23,47	N	33	13,83	W	3683	3716	21	1,2,3,4
06ME59/3	669	67	092603	1841	EN	45	23,70	N	33	13,95	W	3688			
06ME59/3	670	68	092603	2202	BE	45	33,09	N	32	41,12	W	3867			
06ME59/3	670	68	092603	2319	BO	45	32,97	N	32	40,49	W	3961	3995	21	1,2,3,4
06ME59/3	670	68	092703	0055	EN	45	32,84	N	32	39,28	W	3995			
06ME59/3	671	69	092703	0344	BE	45	43,20	N	32	08,54	W	3143			
06ME59/3	671	69	092703	0448	BO	45	42,95	N	32	08,48	W	3153	3193	20	1,2,3,4
06ME59/3	671	69	092703	0547	EN	45	42,83	N	32	08,58	W	3125			
06ME59/3	672	70	092703	0904	BE	45	52,96	N	31	35,14	W	3562			
06ME59/3	672	70	092703	1012	BO	45	53,08	N	31	35,27	W	3572	3593	21	1,2,3,4
06ME59/3	672	70	092703	1127	EN	45	53,14	N	31	35,25	W	3576			
06ME59/3	673	71	092703	1759	BE	46	02,49	N	31	05,16	W	3370			
06ME59/3	673	71	092703	1905	BO	46	03,23	N	31	05,73	W	3357	3394	21	1,2,3,4
06ME59/3	673	71	092703	2015	EN	46	03,75	N	31	06,09	W	3342			
06ME59/3	674	72	092703	2259	BE	46	12,38	N	30	32,28	W	3305			
06ME59/3	674	72	092803	0008	BO	46	12,55	N	30	31,78	W	3306	3327	20	1,2,3,4
06ME59/3	674	72	092803	0121	EN	46	12,93	N	30	31,73	W	3268			

Code: BE = begin, BO = bottom, EN = end
Parameters (Par.): 1= salinity, 2 = oxygen, 3 = CFC, 4 = SF6, 5 = CO2

Table 2: **Mooring recoveries and deployments during cruise M59/3**

Mooring Recoveries:

Mooring	Date	Latitude			Longitude		
K61	3-Sep-2003	56°	33.50'	N	052°	39.50'	W
K62	2-Sep-2003	55°	27.20'	N	053°	43.89'	W
K63	4-Sep-2003	57°	8.00'	N	055°	17.50'	W
K37	9-Sep-2003	53°	23.50'	N	050°	15.40'	W
K38	10-Sep-2003	52°	57.50'	N	051°	18.10'	W
K39	10-Sep-2003	53°	8.50'	N	050°	52.10'	W
K101_2	17-Sep-2003	43°	4.00'	N	048°	52.50'	W
K102_2	(lost)	42°	57.00'	N	048°	23.50'	W
K103_2	17-Sep-2003	42°	46.80'	N	047°	45.20'	W
K104_2	16-Sep-2003	42°	31.80'	N	046°	47.35'	W

Mooring Deployments

Mooring	Date	Latitude			Longitude		
RF01	6-Sep-2003	57°	4.76'	N	052°	6.01'	W
K71	7-Sep-2003	56°	33.70'	N	052°	40.00'	W
K72	8-Sep-2003	55°	27.10'	N	053°	43.80'	W
K49	11-Sep-2003	53°	7.78'	N	050°	51.80'	W
K101_3	19-Sep-2003	43°	4.00'	N	048°	52.50'	W
K102_3	18-Sep-2003	42°	58.00'	N	048°	26.00'	W
K103_3	19-Sep-2003	42°	46.80'	N	047°	45.20'	W
K104_3	20-Sep-2003	42°	31.06'	N	046°	46.82'	W
K105_1	21-Sep-2003	42°	20.39'	N	046°	14.51'	W
K106_1	24-Sep-2003	43°	30.00'	N	040°	40.00'	W

Table 3: **RAFOS Float deployments during cruise M59/3**

Float	Time	Latitude	Longitude	Start Mission	End Mission	ARGOS ID
#500	2003/09/03, 19:04	56°34.458	52°47.997	2004/02/29	2005/06/30	19861
#503	2003/09/03, 19:13	56°34.433	52°48.110	2004/03/15	2005/07/15	19913
#506	2003/09/03, 19:24	56°34.399	52°48.212	2004/03/30	2005/07/30	19969
#501	2003/09/05, 07:50	57°56.922	53°32.012	2004/02/29	2005/06/30	19878
#504	2003/09/05, 08:02	57°56.832	53°32.037	2004/03/15	2005/07/15	19917
#507	2003/09/05, 08:10	57°56.777	53°32.125	2004/03/30	2005/07/30	19980
#502	2003/09/05, 16:40	57°39.610	51°37.209	2004/02/29	2005/06/30	19885
#505	2003/09/05, 16:48	57°39.661	51°37.422	2004/03/15	2005/07/15	19924
#508	2003/09/05, 16:56	57°39.678	51°37.529	2004/03/30	2005/07/30	19981

Table 4: **Deployments of profiling floats (type: APEX and PROVOR)**

S/N	*Argos dec.*	*Argos hex.*	*WMO No.*	*Park depth*	*Profile depth*	*Cycle (days)*	*Depl. Date/Time(UTC)*	*Dpl. Latitude*	*Dpl. Longitude*
1101	22795	642C4	4900349	1500	2000	10	2003/09/19 00:41	43° 00.60'N	48° 37.57'W
1102	22797	6437D	4900350	1500	2000	10	2003/09/19 00:44	43° 00.59'N	48° 37.72'W
1103	22798	64388	4900351	1500	2000	10	2003/09/23 15:55	42° 51.43'N	41° 52.61'W
1104	23227	6AECC	4900352	1500	2000	10	2003/09/24 19:45	43° 33.28'N	40° 06.39'W
1105	23233	6B06C	4900353	1500	2000	10	2003/09/19 08:04	43° 03.93'N	48° 52.58'W
1106	23239	6B1D5	4900354	1500	2000	10	2003/09/20 02:00	42° 52.75'N	48° 07.63'W
1107	23242	6B2A7	4900355	1500	2000	10	2003/09/18 23:45	42° 57.07'N	48° 29.08'W
1099	42699	35476BE	none	800	2000	6	2003/09/07 19:22	56° 33.10'N	52° 41.70'W
1100	42700	35476C7	none	800	2000	6	2003/09/07 19:15	56° 33.10'N	52° 41.50'W
P202	na	na	none	800	2000	6	2003/09/07 18:53	56° 33.10'N	52° 41.70'W