Maria Sybilla MERIAN- MSM02-1

Observatoire de la variabilité Interannuelle à Décennale en Atlantique Nord

MERIAN CRUISE
No. 2, Leg 1

Lisbon (Portugal) – Thorshavn (Faroes)

May 21 to June 28, 2006

Principal Scientist
Pascale Lherminier

Herlé Mercier, Thierry Huck, Bruno Ferron, Pascal LeGrand, Nathalie Daniault, Fiz F. Perez, Marcos Vazquez-Rodriguez, Claire Gourcuff, Anne-Sophie Kremeur, Jean-Pierre Gouillou, Philippe Le Bot, Stéphane Leizour, Olivier Ménage, Nolwenn Carn, Nicolas Ducousso, Pierre Branellec, Johanna Lerebours, Pascal Morin, Boris Cocquempot, Thierry Cariou, Essyllt Louarn, Eric Macé, Guy Thoumelin

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1.1.Participants MSM02/1

NAME	POSITION, INSTITUTE	FUNCTION
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Pierre Branellec	Technician Ifremer	Salinity et O_2 analyses
Thierry Cariou	Technician, CNRS	CFCs et nutrients
Nolwenn Carn	Technician, Ifremer	CTD 8-12
Boris Cocquempot	Technician, CNRS	CFCs et nutrients
Nathalie Daniault	Assistant Professor, LPO/UBO	CTD 4-8
Nicolas Ducousso	Student, LPO	CTD 4-8
Bruno Ferron	Researcher, CR1 CNRS	CTD 8-12+ VMP profiler
Jean-Pierre Gouillou	Engineer, Ifremer	CTD, LADCP hardware
Claire Gourcuff	Student, LPO	SADCP&LADCP data
Thierry Huck	Researcher, CR1 CNRS	CTD 0-4
Anne-Sophie Kremeur	Student, LOCEAN	CTD 0-4
Philippe Le Bot	Technician, Ifremer	CTD 4-8
Stéphane Leizour	Technician, Ifremer	CTD 0-4, moor., glider, floats
Olivier Ménage	Technician, Ifremer	CTD 8-12, moor, VMP, floats
Pascal Le Grand	Researcher Ifremer	Salinity et O_2 analyses
Johanna Lerebours	Etudiante Intechmer (internship)	Salinity et O_2 analyses
Essyllt Louarn	Student, LOC/IUEM	CFCs et nutrients
Eric Macé	Technician CNRS	CFCs et nutrients
Pascal Morin	Researcher CR1 CNRS	CFCs et nutrients
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1.2.Research Program

Cruise MSM02/1 is the third occurrence of the Ovide hydrological section that was performed in 2002 and 2004, as part of the CLIVAR programme under the name of A25. The Ovide Principal Investigator is Herlé Mercier. A Greenland-Portugal section was previously performed in 1997 under the leadership of S. Bacon (NOCS), slightly south of the Ovide path. The Ovide route crosses Reykjanes Ridge 300 miles north of Charlie-Gibbs Fracture Zone and runs through the West European Basin without having to sample on top of the complex Mid-Atlantic Ridge.

The objective of this repeated hydrological section is to monitor the variability of water mass properties and main current transports in the basin, complementing the international observation array relevant for climate studies. The western part of the Ovide section is redundant with AR7E (called also A1) which was done on the odd years and will allow a better analysis of the inter annual variability.

The hydrological section includes a hundred surface-bottom stations from coast to coast, collecting profiles of temperature, salinity, oxygen and currents. From the 28 bottles closed at various depth at each stations, samples of sea water are used for salinity and oxygen calibration, and for measurements of biogeochemical components, including tracers, isotopes, nutrients and carbon.

From the thermal wind equations, geostrophic transports are deduced from temperature and salinity. Then, direct current observations, preferentially those measured by the ship ADCP, are used to constrain the velocity at the chosen reference level. This is particularly important in the Irminger Sea, where bottom currents are very energetic. This way, the contribution in heat and fresh water of the major currents crossed (mostly perpendicularly) by the Ovide line can be estimated. From north to south, the major currents are the East Greenland/Irminger Current (about 20 Sv southward, 1 Sv = 10^6 m^3s^{-1}), the Deep Western Boundary Current (about 10 Sv southward), the Irminger Current (about 10 Sv northward), and the North Atlantic Current (about 20 Sv northward). Between 1997 and 2004, we already observed a significative variability of these transports (about 30%).

The Meridional Overturning Circulation reflects the equilibrium between the warm and salty waters flowing poleward near surface and the cold and relatively fresh water flowing equatorward near the bottom. Measured across Ovide, it is mainly the balance between the North Atlantic Current and the Deep Western Boundary Current. The simple sketch is however complicated by the export into the Labrador Sea and around the Subpolar Gyre of part of the highly variable East Greenland Current. This is why an array of four currentmeter moorings and one ADCP lander was deployed on the East Greenland slope and shelf in 2004, for two year.
While temperature and salinity are often the basic parameters to identify water masses, it is useful to use tracers like CFCs to determine when they were ventilated. Oxygen is also a good indicator near the sources, but not conservative. Combining oxygen with nutrients gives useful information on the biological activity and on the remineralization processes. CFCs and nutrients are analysed by the Roscoff team led by Pascal Morin (LCM).

The measurements and analyses of pH, alkalinity and pCO_2 are performed by a Fiz Perez and Aida Rios from Vigo (IIMV) at every Ovide cruise. In 2006, it was officially part of the CARBO-OCEAN international program, and the objective is to better quantify the role of the North Atlantic in the storage and transport of anthropogenic carbon accumulated in the atmosphere.

In 2006, samples were taken to measure isotopes of oxygen (18) and carbon (13) after the cruise. Oxygen isotopes are very useful to determine the proportion of fresh water from different origin (rain/snow, runoff, sea ice).

1.3.Narrative of the Cruise

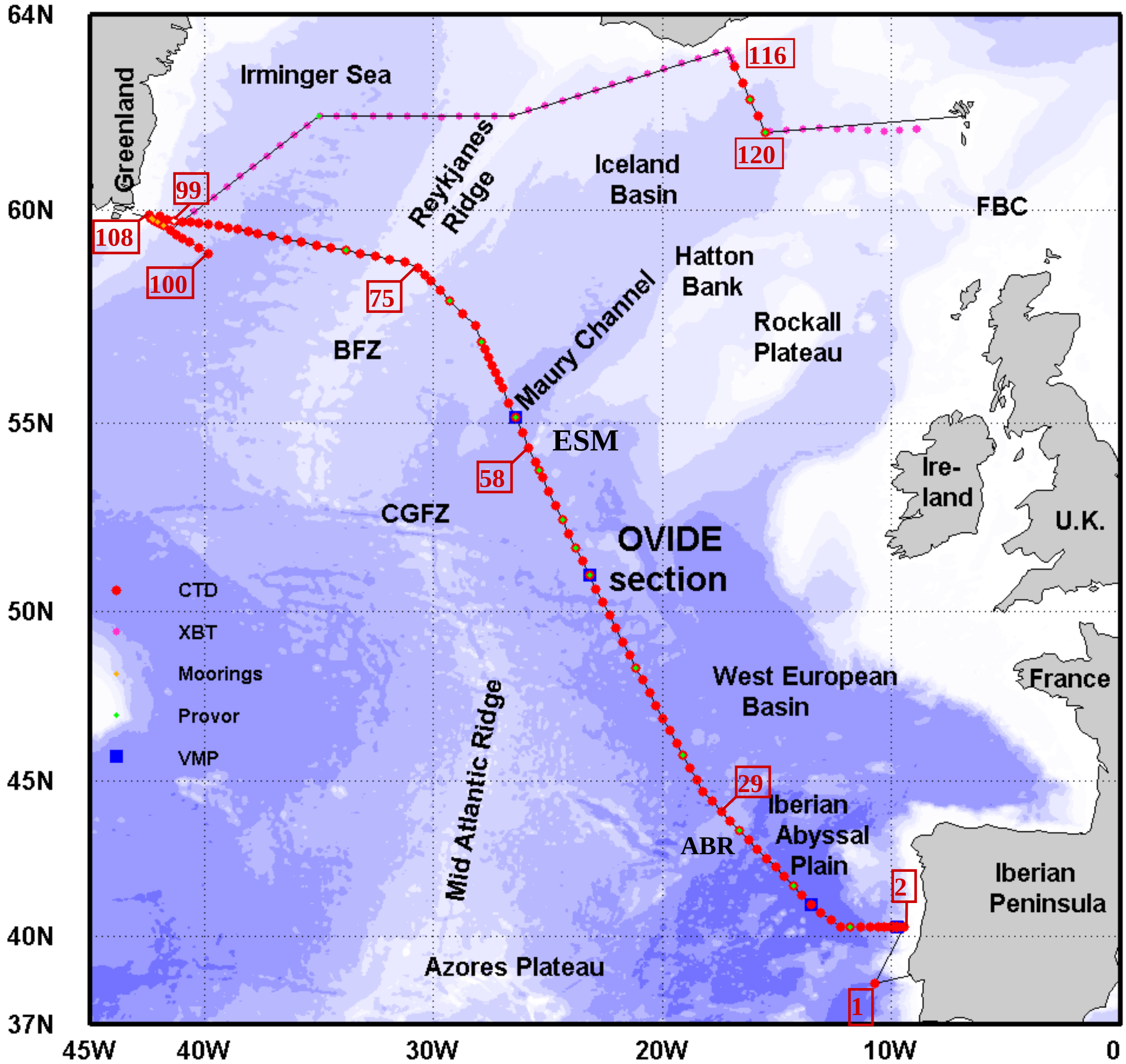


Figure 1*: Ovide section in 2006.* *Red dots indicate the hydrological stations, and smaller pink dots for XBTs. The blue squares are the stations where we added a VMP profile, and the green dots, the stations where we also deployed a profiling float. The 4 orange dots near Greenland are where we recovered our moorings. Abbreviated topographic features: Bight Fracture Zone (BFZ), Charlie-Gibbs Fracture Zone (CGFZ), ESM (Eriador Sea Mount), ABR (Azores-Biscay Rise).*

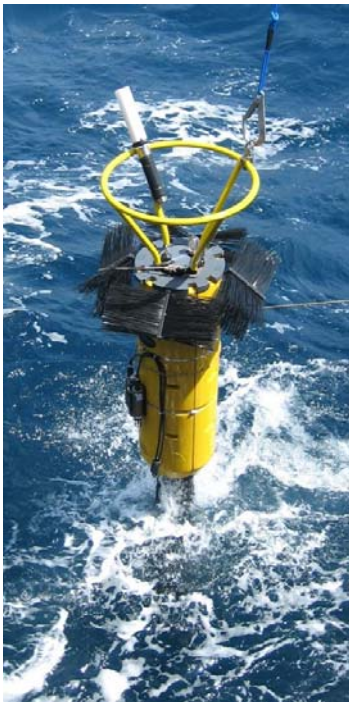
During the 120 stations of this cruise, 2740 seawater bottles were sampled for measuring the different biogeochemical quantities detailed above. In addition to the 100 stations required for the Ovide section, 15 stations are localized along the mooring array line south east of Greenland, and 5 south of Iceland, where Iceland-Scotland Overflow Water can be found near its main source (the Faeroe Bank Channel). For all stations, LADCP data were successfully collected to determine the current profiles.
The ship ADCP, a RDI 75kHz, ran nicely from the beginning to the end of the cruise. The data until station 18 are unfortunately noisy due to interferences with the DoLog at 78kHz. The problem was found and then solved after 6 days.

May 22-23: On Monday morning, while scientists are settling down in their 6-week home, our six containers are loaded aboard. Then 36 hours are dedicated to connect the different waters, the

electricity and network between the ship and the 3 containers that are used as laboratories, and to initialize the experiments. A few of us immediately concentrate our efforts on the configuration of the ship ADCP, helped by Catherine Kermabon from Ifremer. In the deck lab, Thierry Terre (Ifremer) and Breck Owens (WHOI) are also finishing the preparation of the 2 SPRAY gliders, teaching us the last steps before deployment that should occur mid June near Greenland. A group of 4 people, Stephen Dye, Neil Needham (both from CEFAS, UK), Ulrich Drübbisch and Andreas Welsch (from IfM Geomar), come aboard to prepare their 2 pipe moorings that we plan to deploy at 63°N east of Greenland.
MERIAN left the port of Lisbon at 10 pm on May 23, after some repair works on the engines. Six containers were embarked, including 3 laboratories. Objective: the deep test station at 38° 26' N 10° 42'W. The long Atlantic swell welcomes us as soon as we exit from the Tage.

May 24: a day dedicated to tests of the different systems around 2 CTD stations. We learn to work together. A few days will be needed to determine procedures necessary to smooth the operations. During the CTD descent, the EM120 is used to listen to the rosette pinger, helping in the bottom approach. The signal is sometimes noisy. All the stations were performed down to 5 to 15m from the bottom, as confirmed by the signal of a contacter. The Posidonia system was also used at all stations to get the 3D position of the rosette under the water.
Using the ship sounders for detecting actual depth is not trivial. The objective is naturally to avoid hitting the CTD at the bottom of the downcast. It turns out that most of them work around 12kHz. So we must check the possible interferences between the EM120 (we only need the vertical beam of this multi-beam), the EA600, our own pinger mounted on the CTD, and the Posidonia system. We finally choose to use the EA600 as a receiver of our pinger, so that we can monitor the distance between our rosette and the sea-floor. The EM120 is used to evaluate the depth at the beginning of the station and during the upcast, but we have to switch it off during the downcast because it blurs the signal of our pinger. Then, we observe that Posidonia has no effect on all this. A backup system consists in a 15-meter chain attached at one end under the rosette, the "contacter", that rings in the container whenever the apparent weight of the chain decreases.

May 25: We are back on the Iberian shelf, at 150m depth. This is the first station of the Ovide section (fig. 1). Apart from a little surprise on the depth shallower than expected, everything turns out to be good. The upward looking 300kHz ADCP refusing to communicate, we have to install a spare for the following stations. Fortunately, our old downward looking BB150kHz is faithfully fulfilling our expectations.
First chemical analyses give satisfactory results. The team from the Université de Bretagne Occidentale measure CFCs and nutrients, while the team from CSIC Vigo gather information to better understand the carbon cycle.
The 4th station is placed on the upper continental slope at 800m depth. Therefore, the favorable meteorological conditions give us an excellent opportunity to test our new Vertical Microstructure Profiler. Deployed at 14:35 local time, it pops up half an hour later, and is easily localized by both VHF and captain's eyes. After a very smooth approach, the VMP is recovered with the starboard crane without difficulty. 3 hydrological stations close this very active day.

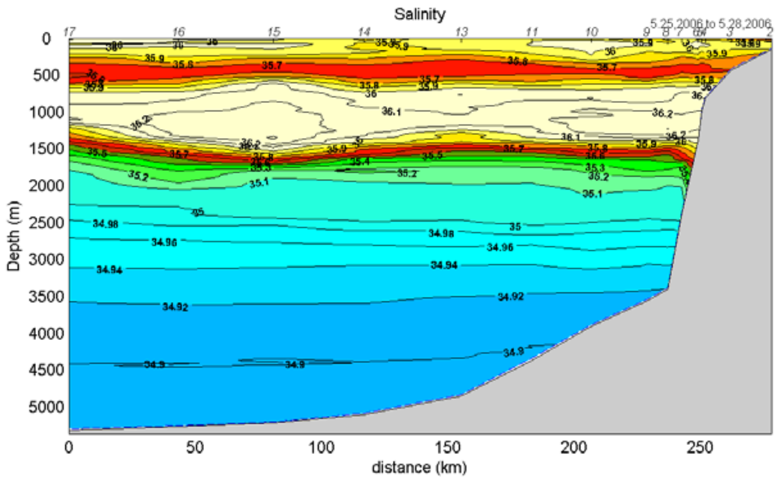


***Vertical Microstructure Profiler** deployment of the on May 25.*

May 26: Night station work begins, and we are now more than 3000m deep. In the middle of the night, a failure occurs in the steering gear of a pumpjet, preventing any dynamical positioning. After a discussion with the scientists, the captain decides to come back to land to be delivered a spare part the following day. Meanwhile, we keep on working, until midnight, achieving five hydrological stations held manually at the bridge.

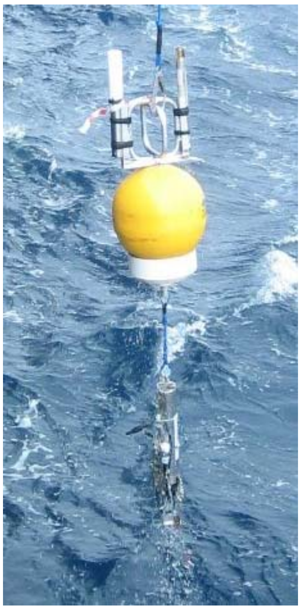
May 27: Figuera da Foz looks nice from the sea, but we will not have a chance to visit it: the spare part is delivered by the pilot at 12:00, and we "immediately" return to the last station. By the time we reach it, the pumpjet is repaired. After measuring this profile again to check its variability, we resume our course a little before midnight. This day is also special. Franck Riedel finally discovered why the 75 kHz ship ADCP signal showed interferences: the DoLog is pinging at 78… and cannot be legally switched off. A short test in station confirms the diagnosis, and shows the remarkable potential of this ADCP. Even with the DoLog pinging, we can get some information on the currents, but the calculated errors are big.

May 28: The influence of Mediterranean Water decreases slowly as we are steaming westward; but at station 15, a relative maximum of salinity at 1000 meters surprises us. Immediately warned by Nathalie, I make a careful comparison with the last 2 profiles and decide to launch a profiling float that is programmed to drift at 1000m depth. Following stations tend to confirm that we were dealing with a Meddy. Let's hope we will be able to follow its path with the float in the following months.



Salinity section *showing the Meddy at station 15 and the Mediterranean vein flowing northward along the Portuguese west coast, centered around 1000 meter depth.*

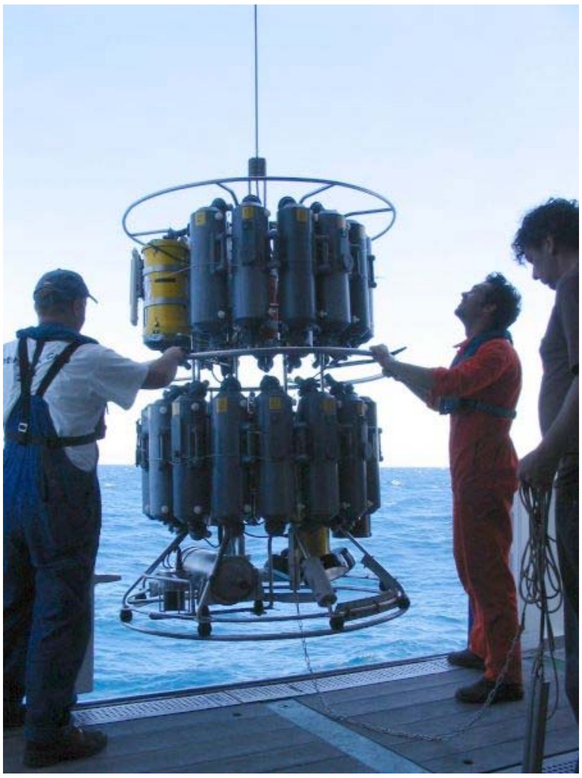
May 29: CTD measurements show a noisy signal, usually attributed to a default in the CTD-wire connection. However, a more serious issue stops our progression: the steering gear of the yellow winch breaks, while the CTD is hanging 4000 meters under our feet (upcast of station 19). After the replacement of the broken piece, we can slowly come back to the surface and recover all the equipment. The time for repairing is used for instrument trials: the VMP is sent down to 5300m depth, while a new type of free-fall CTD (SBE 19, on the left) is tried twice on 500m deep profiles. All the instruments behave as expected, and the 3 recoveries are perfectly performed.
Meanwhile, the CTD is connected to the violet winch that we will use now on.



The free-fall CTD *(SBE 19) conceived by P. Le Grand, O. Peden, O. Ménage and S. Leizour.*

May 30: Five stations and one Provor deployment. Despite the increasing swell and wind, we keep on working hard, and the winch and cable too. Due to the important rolling of the ship, the cable endures several chocks at deployment and recovery of the CTD. We must also interrupt the up-cast several times to correct the spooling on the winch. But data are collected, saved, calibrated, compared. The DoLog is finally switched off and the SADCP data get immediately better in range and precision.

May 31: Rolling speaking, the worse day of the week, consequence of 5m waves and force 7 to 8 winds. We occasionally oscillate on more than 20° on each side. Sometimes, despite our efforts to fix it, the 1-ton rosette jumps on the deck. The Posidonia system cannot locate the rosette while profiling. Meal times are not especially relaxing. The scientists working in the containers located on the outside deck take the closest indoor corridor to avoid the salty shower. But it is quite sunny though …



At station 25, the end of the CTD upcast profile is missing: 2 bulbs show the damage of the bad weather on the last 20 meters of the wire. The cable is cut, and the connection rebuilt. Next station is fine. *Alles klar*.

We all clearly observe that the Merian rolling behaves as if she was resonating at a period of about 10s. When she begins to roll at this rhythm, the movement slowly builds up for several periods before decaying suddenly.

Only 3 CTD stations today … fortunately, the weather forecasts bring hope of better days.

June 1: 5 CTD stations and a Provor deployment. A sane routine finally settles down despite the 3 meter swell. Chemical analysis are performed in real time, with no major failure or delay.

June 2: better meteorological conditions. 4 CTD stations and a Provor deployment today. We pass 46°N and 19°W. From station 37, we decide to start to collect data before immerging the CTD, so that we won't be obliged to replay the stations after the cruise.

June 3: In the afternoon of this beautiful day, the BB150kHz LADCP refuses to wake up for station 38. To make a long story short: we will have to rely on a smaller, but less efficient, 300kHz LADCP for stations 38 and 39, while the old fellow is repaired in the night, after blowing up 3 fuses… 4 CTD casts were performed today.

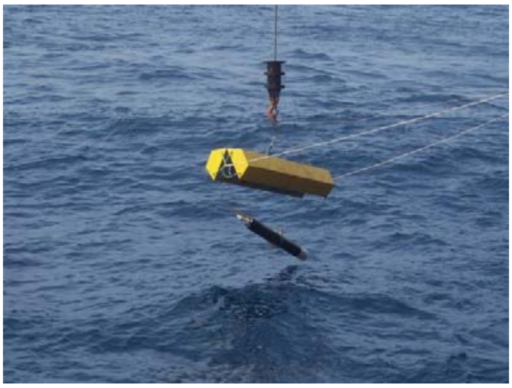
June 4: Early morning, the chain of the violet winch breaks during the down-cast of station 40, at 3200m. One and a half hour later, the winch is repaired and the cast resumed, but interrupted several times until the bottom. After some work on the data, we should be able to recover a correct profile of temperature, salinity and oxygen. Later in the evening, alarming messages oblige the crew to stop one of the two pods. Transit speed between stations is reduced from 12 to 9 knots, while engineers and electricians are working hard on the problem. We still gather 4 more profiles of 28 bottles each, and as usual, a Provor is deployed. At the end of the day, we pass north of Brest latitude: 49°N.

June 5: Work progresses well. No diagnostic for the pod is given yet, so we keep a speed of 9-10 knots between the stations. At 8 p.m., a group of pilot whales is observed during station 46. Jean-Pierre celebrated his 60th birthday.

June 6: The sky is grey but wind and sea are quiet. While the VMP is profiling, the cable of the yellow winch is deployed with a weight at the back of the ship and rolled back up properly so that it can be used again. During this operation, we cover a distance of 8nm to the NNW along the section,

and when it's over, we come back to recover the VMP at 1:15pm. The instrument signals are well received both on radio and Argos.
Some problems arise on nutrients experiment (instability in electric power?). We also note difficulties with the pump that provides the water for Gaspar (pCO2) and surface alkalinity analysis.
At 7:30pm, an unfortunate hit on the C key lauches the recalibration of the compass of the glider Spray 010, which now shows unacceptable values and cannot be deployed.

June 7: since the weather is freshening, we decide delay station 53 and to perform a calibration of the Spray 010 in the zodiac (which is mostly magnetic). After two tries, each implying the zodiac performing a full circle in a not so quiet sea at half a mile from the Merian, we finally get some acceptable values from the glider's software, and decide to come back aboard. We take this opportunity to calibrate also the zero of the goniometer case (for Argos reception).



June 8: still no diagnostic on the port pod. Weak wind, turning from north to west. Work is progressing well in the Iceland Basin.

*A **PROVOR profiling float** is deployed.*

June 9: a bright blue sky for a terrible day. At 0:30am, winches don't answer to commands. The solution is found one hour later. Then, the worse verdict is pronounced in the morning: the port pod is definitely dead. It is decided to pursue the mission, but we won't try anything in the ice and the speed will not exceed 10 kn.
Finally, the last but not the least, the VMP does not come back from its 3km-deep profile after station 61. We wait for 2 hours 2nm north of the deployment position with no result. We finally proceed to station 62 with a 3 hour delay. Since all safety procedures (chemical and electronical) are supposed to release the VMP weight within the next 24 hours, I decide to double the spatial sampling (to slow us down) so that the VMP could be recovered if a signal is received.

June 10: on land, Herlé is watching closely any Argos signal that would come from the VMP. Stations 63, 65 and 67 were added at mid distance from the 2002 station positions.

June 11: the weather is freshening (force 7, NNW), leading to a difficult progression at 6kn. The forecast is worse. Since the VMP did not emit, we decide to proceed. In the evening, the wind slows down unexpectedly.

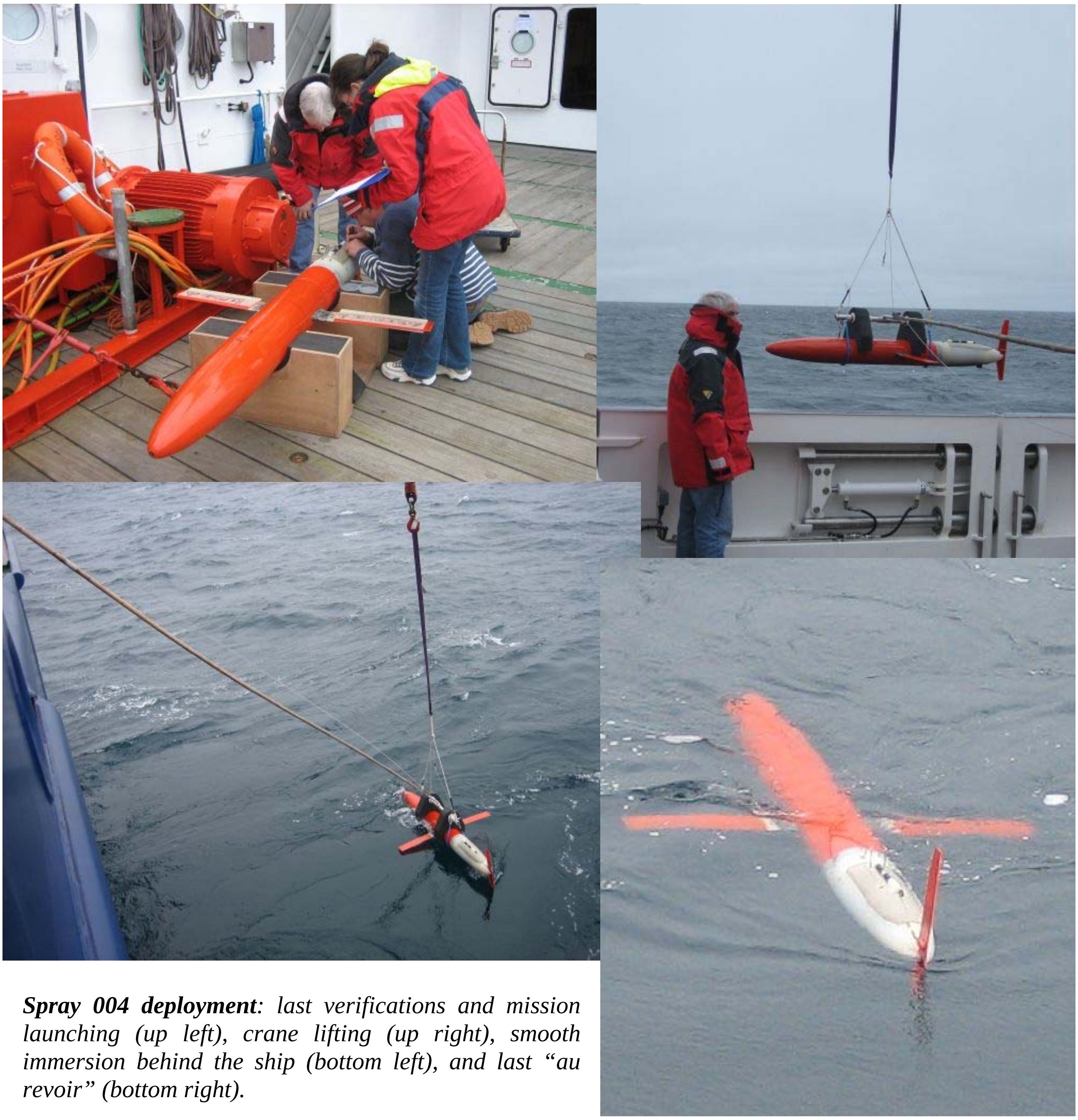
June 12: moderate sea and wind. We enter the Irminger realm. As usual, LADCP on Reykjanes Ridge are well sheared. It would be nice to perform a 24h repeated station here to determine the exact nature of the internal waves here, although internal tide is probably the best candidate. Too bad that we don't have the VMP anymore to estimate the mixing there. The ballast in the bow of the ship are cleaned during station 77. During this 3-hour operation, the ship ADCP is at 6.3m under the surface, instead of 7m.

June 13: a strong crossed swell adds to 30kn winds (ESE). From station 79 to 82, many spur data are noticed in the oxygen profiles, resulting from the important rolling. At station 83, the cable jumps out from the pulley.

June 14: the 35kn wind slow us down, but we keep working. And we are not in a hurry, since these westerlies push the ice off of the Greenland coast, blocking our progression in a near future. 9pm: the forecast gives force 8+ after midnight, so we decide to stop working until the next morning after station 88 since we have only one pod. Actually, the last recovery of the rosette proves how wise this decision is …

June 15: work resumes at 9am. Still 30 knots of South Westerlies the whole day, but the sea is not too rough. Only 4 CTD stations today.

June 16: Wonderful weather: 8kn W-SW winds and flat sea. 6 hopeful stations until a sea-ice wall 35 miles from the Greenland coast. Neither sea-ice charts nor weather forecasts allow some optimism. We call the Greenland station, we radio the fishermen nearby : it seems to be a quite exceptional situation compared to last years, but maybe not so exceptional 20 years ago … good to know. We seek a path through the ice more to the north to reach at least the shelf. No way. At 63°N, we learn that everything is blocked down to the 1000m isobath. Operations there are really compromised. We have a week ahead of us.



***Spray 004 deployment**: last verifications and mission launching (up left), crane lifting (up right), smooth immersion behind the ship (bottom left), and last "au revoir" (bottom right).*

June 17: we arrive near mooring A (the most offshore mooring) at 5 am. It is covered by sea-ice! So we come back on station 96 to do it again (station 98) since CFC could not be sampled. The ice front moved 1/2nm within 1 hour, so we retreat to former station 95 to measure it again (station 99) and deploy the Spray glider (#004). The deployment is easy and nominal at 11:25. We are in contact with Thierry Terre on shore to verify the data status. At 2pm, after 2 dives at 100m and 200m depth, we leave the glider to Thierry's control and try to penetrate into the ice pack (more or less loose) with much cautiousness, but it turns out that it would have been faster to skirt the edge to the north-west. After exiting the pack, we head towards mooring A that is finally in an area free of ice. It is released at 8pm. At least we suppose so, but we'll learn later from the data that it was actually accidentally released during our first visit. That is why we have to run after it for 1 hour helped with our Argos beacon, to finally discover it nearly embedded in a growler (fortunately not under it). We recover a pack of knots and all our instruments (5 RCM8 and a Seacat). A CTD near mooring A position is performed, and we escape further offshore for the night since the weather is supposed to freshen again.

Mooring A recovery*: the mooring A is finally seen, embedded in a big growler (up left). The first currentmeter to come is the deepest one (up center), quickly followed by a mass of cables (right) and a huge ball of steel cable (up right).*

June 18: 50kn of South-Westerlies. Nothing we can do, and sea ice expands. Fortunately, the glider goes faster. Everybody relax a little while the ship goes back and forth. Trying to hold a station is hopeless. A new CTD section along the NOCS mooring line is defined. The winds pushed the Kap Farvel ice tongue south of our position. Today is Sunday. Weather forecast indicate possibly weak North-Easterlies for Tuesday. By performing the new 13 stations from offshore, we should arrive on mooring B position by Tuesday. And if it is free of ice, we push as far as we can on the shelf to finish the section.

June 19: was yesterday just a bad dream? No wind, no wave. We begin the new section by station 101 at 8am. The journalist from Thalassa, who was planning to come aboard by helicopter, is very disappointed: the small helicopter has only a 10nm autonomy, and the big one is too expensive. He is in Narsassuaq and tries to find good pictures there while waiting. But if we can get as close as 15nm from the coast, I consider that we will be lucky.
8pm: 30kn westerlies slow us again. The captain changed the attitude of the ship with the ballasts: she is now at 6.6m under the water at the bow, and 6.8m at the stern. The ADCP (near the bow) is at a depth of 6.5m.

June 20: 1am: parse growlers appear, half way between stations 104 and 105. Slaloming among the growlers, we finally reach station 105, that we perform non conventionally with port to the wind so that the reinforced bow of the ship could face the ice drift. At this latitude, the night of the Summer solstice is not totally dark and it helps the monitoring.

3am: an accident occurs. At the end of the CTD profile, while he is trying to close the heavy sliding door on starboard side, Ronald Kuhn, alias Kuhno, has his right index tip crushed. The electric command of this door (for the CTD) is broken, and it has been opened and closed manually for a few days. The captain immediately called for help and a frigate is on her way from Reykjavick to transfer Kuhno to a hospital asap. We steam in its direction as fast as we can, hoping that Kuhno could recover his finger. 10pm: Kuhno is transferred by helicopter (lifted). He seems to be alright. A depression is passing south of Greenland, that should create the expected easterlies. Since the situation is not so clear at 63°N, we decide to come back to the mooring site at 60°N.

June 21 : a long day. We decide not to deploy the Spray glider #010, since our last try for calibration in the main shelter is not satisfying (although other compasses show that the magnetic field is quite good there, probably because the hangar is so big).
In the evening, it is a patience game for all of us. Ice backed off, but not enough for mooring B. A CTD station help us to wait. Then, we can finally recover mooring B, but we loose the Seacat near the head of the mooring: the collar was obviously weakened with some corrosion, and a shock with the shell at the recovery broke it: we literally saw it sink. The 5 currentmeters are fine, and we did not have to run after the mooring after release. Then we proceed to mooring D position: no ice, but a thick fog that prevent us to see what's ahead. Helped with the radar, we keep going to the NW, and miraculously end up on the shelf.

June 22: 1am: CTDs 107 and 108 on the shelf (near the shelf break). The fog disappears suddenly with the dawn, and suddenly the sharp white peaks of Greenland appears under a bright orange sky, so close that it surprises us (still 23nm away …). We recover mooring D. And finally C. Relief sighs. All the instruments are aboard. It is 7:20am. We use 4 hours to get a bathymetric map of the mooring site with the EM120 multibeam sounder. And finally, we finish the secondary hydrological section, hoping that both segments connect well enough.

June 23: the section is finished at 3am. It's too late to go to deploy the pipe moorings on the shelf at 63°N: due to the missing pod, the transit time is uncertain, as are the winds that begin to turn to the west again. We have to go back to the Faeroes, and if the weather is favorable, we will sample the ISOW with 5 stations south of Iceland. While turning off the Aanderaa ADCP of the pipe mooring, we realize that batteries are empty. We inform Stephen Dye immediately in case he deploys the mooring during the following cruise.
During the transit to Thorshavn, an 700m XBT is launched every other hour (i.e. 20nm apart approx.). Helped with the ADCP, we may be able to calculate sub surface heat fluxes.

June 24: we cross Reykjanes Ridge at 62°N. Just before, aligned on the 200nm Islandic EEZ line, we cross an impressive fleet of large trawlers. On the radar, we can count 28 of them dispatched on 12 miles. Knowing that each has a 1km deep net that is dragged 1/2nm behind the ship, I wonder how a fish could survive. A Red Fish to be precise. The captain explains that they are here the whole year long. We have to remember to absolutely avoid this area for autonomous platforms …

June 25: First look at the whole dataset during a scientific meeting aboard. TA, pH, Cant, Nitrates, Phosphates, Silicates, and even CCl_4 sections are shown, in addition to the classical T, S, O_2 data. The harvest is promising.

June 26: Our day is filled with 5 CTD stations south of Iceland (probably the last stations of our 20 year-old Neil-Brown CTD), + 2 test stations for our new Seabird CTD system. The ISOW is well sampled.

June 28: we arrive in Thorshavn at 3am local time, in time for the final ASOF meeting.

1.4.Observations, Analysis Methods and Preliminary results

1.4.1. Water masses and variability compared to previous years

1.4.1.1.Calibrations and data quality of CTD and oxygen measurements

The CTD used on all hydrographic stations on this cruise leg (MSM02/1) was a Neil-Brown Mark III B (#2782), in conjunction with a 28 (8-liter) bottle carousel PASH 6000. The CTD was systematically lowered at less than 15m from the bottom, as attested by the signal of a contacter. The Neil-Brown temperature and pressure sensors were calibrated on March 30, 2006 and January 18, 2007. 2738 salinity bottle samples were drawn from the whole water column of the 120 stations. A PORTASAL salinometer (serial number: 62302) was standardized using standard seawater batch P146 (K15=0.99979, labelled S=34.992, bottles filled in May 2005). No mentionable drift in the salinometer was observed during the calibration work which was performed during the cruise. After calibration, the accuracy for conductivity (respective salinity) is better than 0.003 (see Figure 2), consistently with the statistics calculated of 59 duplicates. The median filter used for calibration discarded 273 samples that are not shown on Figure 2.
The oxygen was measured with a SeaBird SBE43 probes (#526). The calibration is presently quite crude and data should not be used before a more precise processing based on the 98 duplicates and 2793 samples. First results show that we can expect an accuracy better than 3 µmol.kg^{-1}.

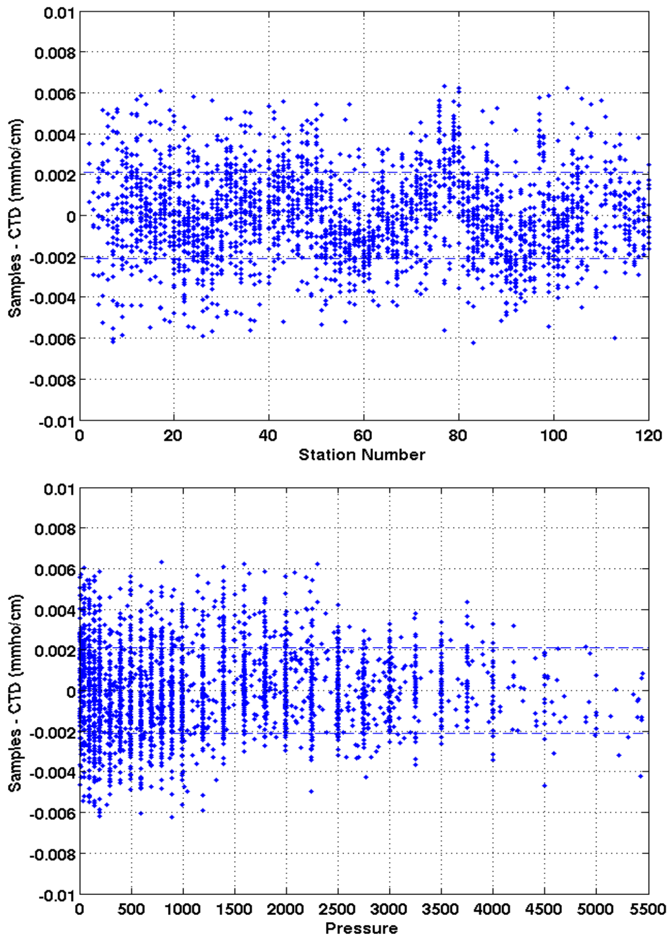
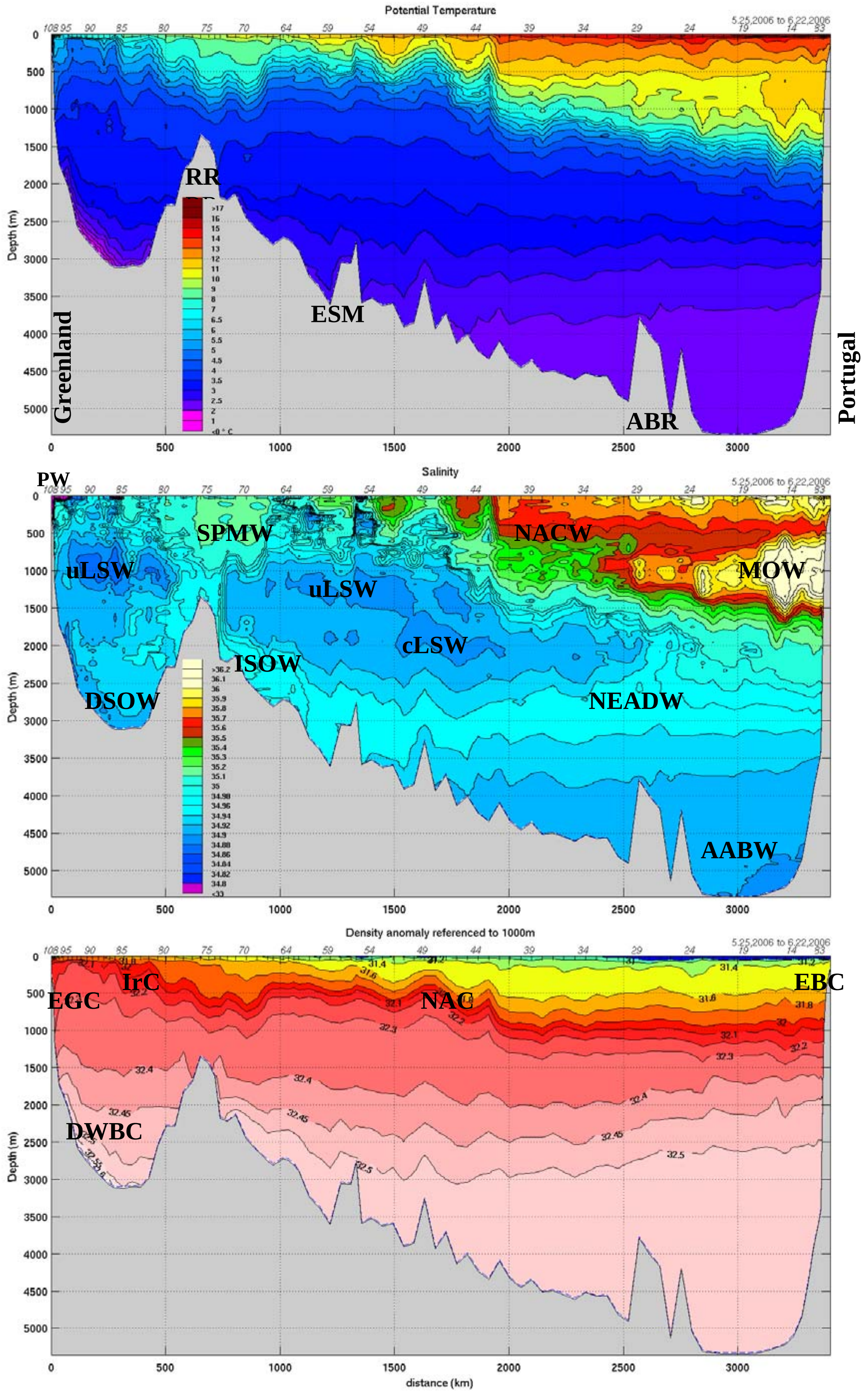


**Figure 2*: Differences between sample and probe conductivity measurements in mmho/cm*, *as a function of station number or pressure, after calibration. The standard deviation of 0.0021 is plotted.*

1.4.1.2.Hydrological sections from Greenland to Portugal



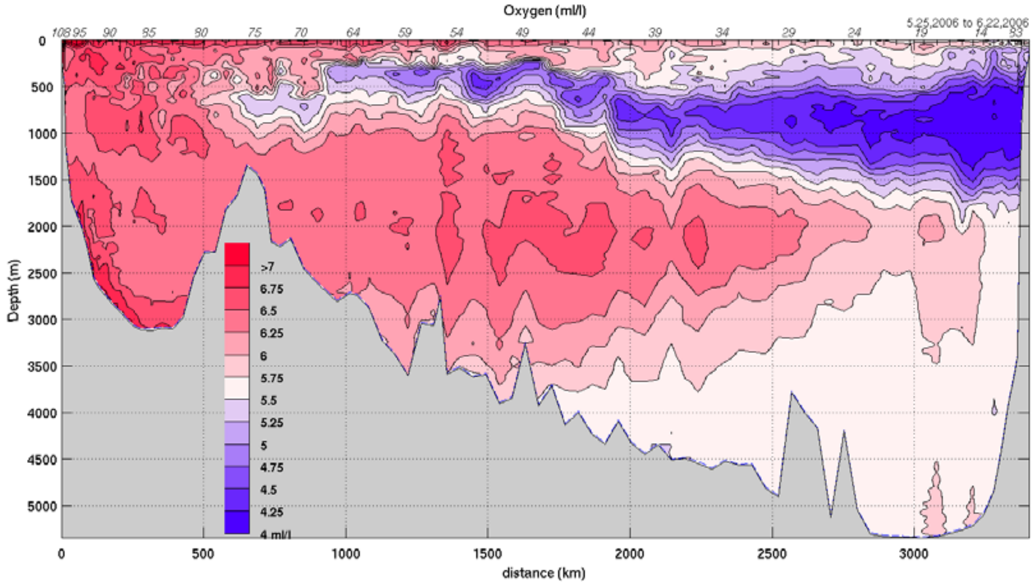


Figure 3 : ***Hydrological sections.*** *From top to bottom : potential temperature (°C), salinity, potential density anomaly referenced to 1000m, oxygen (ml/l).*

All the hydrological sections are plotted on Figure 3 (temperature, salinity, potential density and oxygen). Main topographic features also shown on Figure 1 are localized: Reykjanes Ridge (RR), Eriador Sea Mount (ESM), Azores-Biscay Rise (ABR).

Main water masses are shown on the salinity section:
PW: Polar Water (PW),
uLSW & cLSW: upper and classical Labrador Sea Water,
SPMW: SubPolar Mode Water,
DSOW: Denmark Strait Overflow Water,
ISOW: Iceland-Scotland Overflow Water,
NACW: North Atlantic Central Water,
MOW: Mediterranean Overflow Water,
NEADW: North-East Atlantic Deep Water,
AABW: Antarctic Bottom Water.

Main currents are shown on the density section
EGC: East Greenland Current,
DWBC: Deep Western Boundary Current,
IrC: Irminger Current (the part that circulates around the Reykjanes Ridge),
NAC: North Atlantic Current (at least 2 branches embedded in eddies cross the section),
EBC: Eastern Boundary Current.

1.4.1.3. θ-S plots of the different basins: comparison with 2002 and 2004

The Antarctic Bottom Water is seen in the Iberian Abyssal Plain and presents a remarkable linear relation between temperature and salinity documented by Saunders (1986), as shown on the different θ-S diagrams on Figure 4. A freshening of 0.003 in 2004 could not be explained after calibration and is considered as potentially real, although θ-S characteristics are back on the Saunders line in 2006.

Geostrophic transports are calculated with a box inverse model that includes additional constraints derived from the SADCP (Ship Acoustic Doppler Current Profiler) plus a net mass transport of 1+/-3Sv flowing to the north through the section. The method and results for Fourex 1997 and Ovide 2002 are detailed in Lherminier et al. (2007). On Figure 4, transports are binned with a resolution of 0.02 in salinity and 0.2°C in temperature. As expected, about 1 Sv of AABW flows systematically to the north in the Iberian Abyssal Plain.

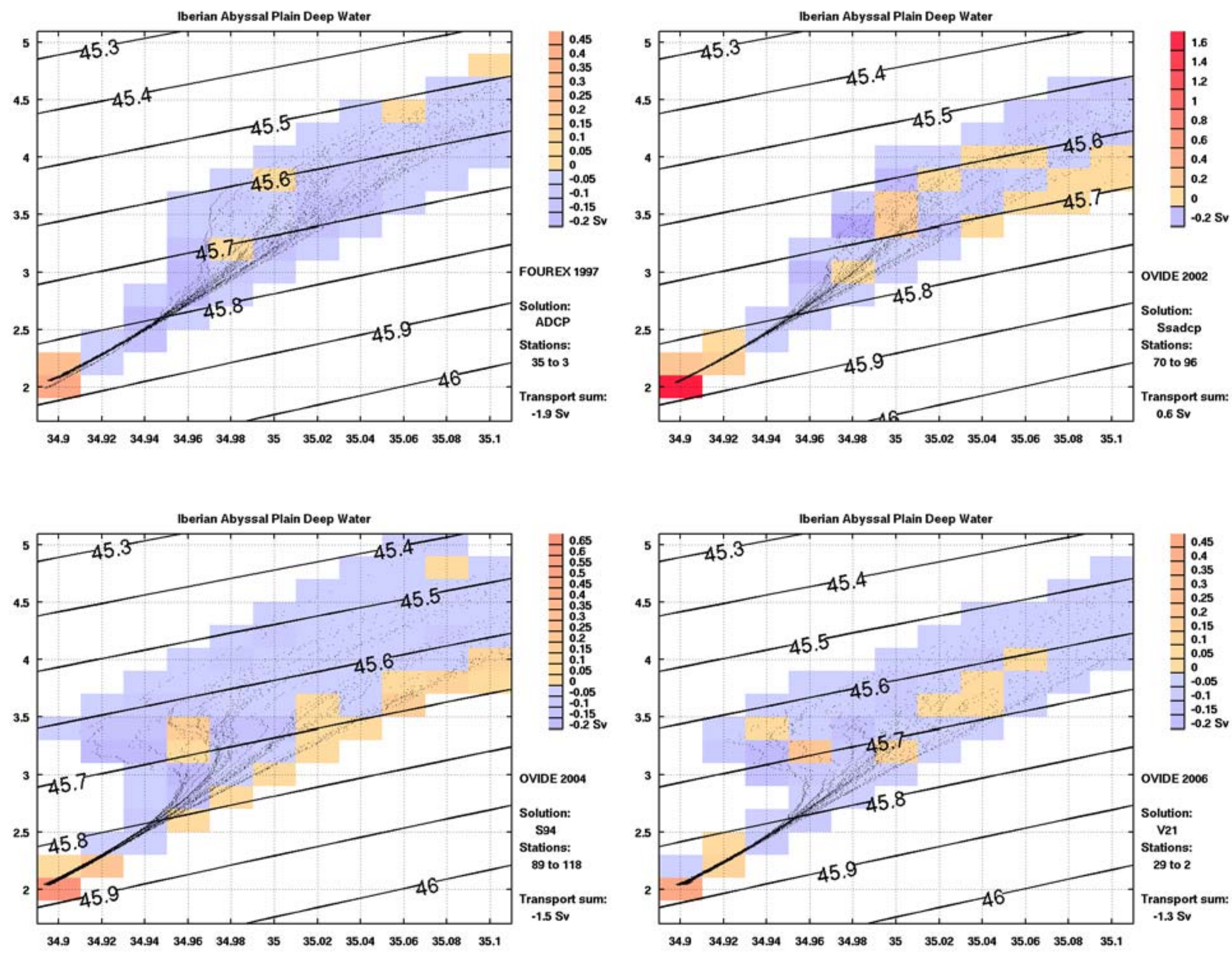


Figure 4 : ***Potential temperature versus salinity in the Iberian Abbyssal Plain*** *as measured in 1997 (FourEx cruise led by S. Bacon), 2002 (Ovide cruise led by H. Mercier), 2004 (Ovide cruise led by T. Huck) and 2006 (this cruise).Isopycnal lines referenced to 4000m are drawn. Color square indicate binned transports.*

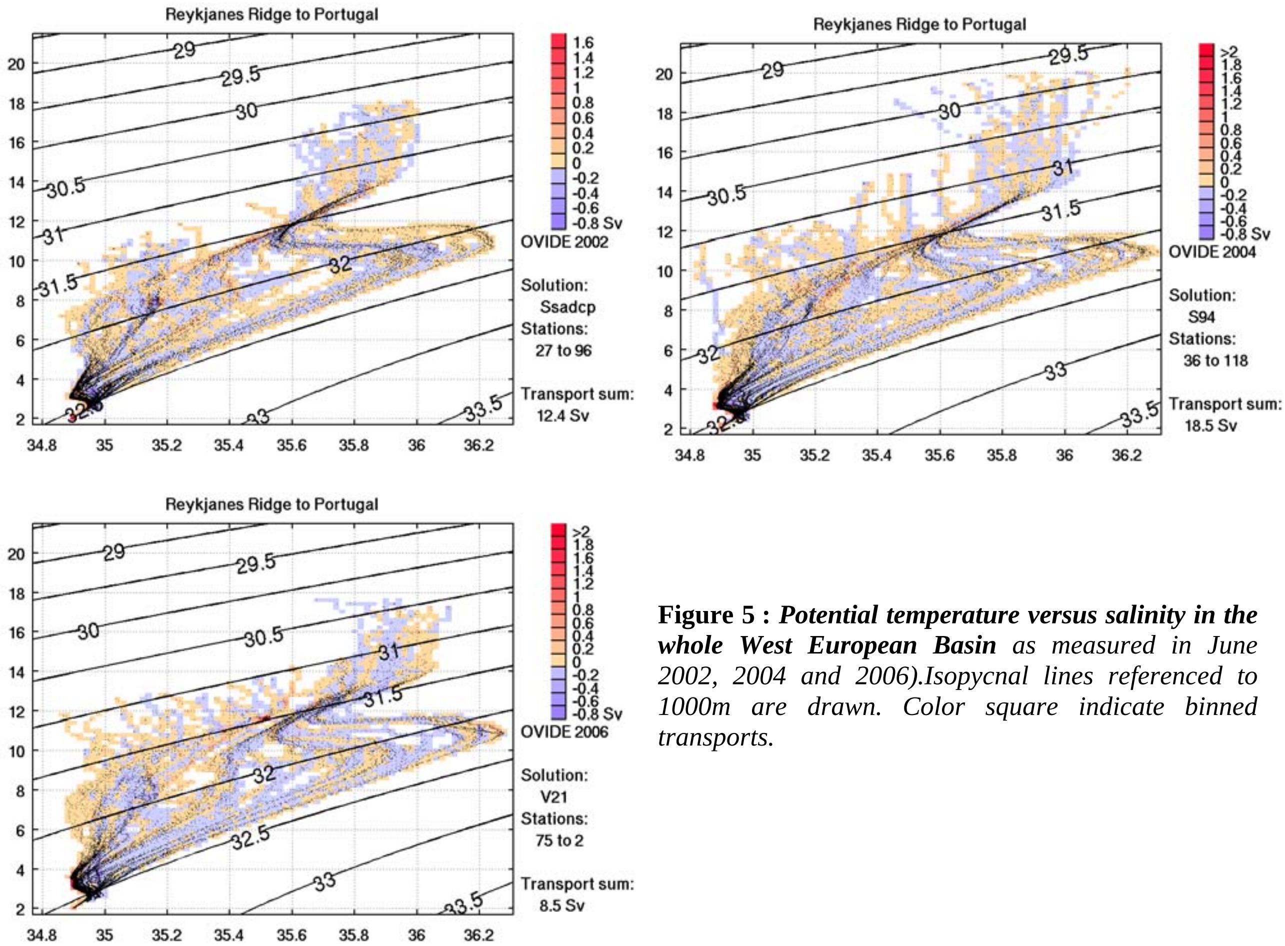


Figure 5 : ***Potential temperature versus salinity in the whole West European Basin*** *as measured in June 2002, 2004 and 2006).Isopycnal lines referenced to 1000m are drawn. Color square indicate binned transports.*

The same plotting exercise is done in the whole Western European Basin, from Reykjanes Ridge to Portugal (Figure 5). Surface water in 2006 show a better agreement with 2002. It is not surprising since 2004 cruise was slightly later in the year (finishing on July 18) and followed a particularly warm Spring.

Another striking feature is the progressive appearance of the upper Labrador Sea Water west of Reykjanes Ridge (the warmest deep minimum in salinity).

In 2006, the Mediterranean Water show a peak in salinity that is intermediate between 2002 and 2004 (when it reached 36.3).

In the Irminger Sea, the characteristics are this time plotted against oxygen (Figure 6). While 2002 and 2004 showed quite scattered properties in the deep waters, 2006 data show a surprising "purity" of the Denmark Strait Overflow Water, with quite salty and warm properties. This contrasts with the very fresh and scattered values of 2004. First inversions suggest that the Deep Western Boundary Current would be only about 6 Sv in 2006, while it was 11 Sv in 2004. Such a weak value would suggest a much weaker entrainment in 2006 and would then partly explain the observed differences.

We observed also a sensible erosion of the elbow that marked the cLSW, while the uLSW is very well sampled for all 3 sections. This observations corroborates the formation and export of the 2000s shallower vintage of LSW in the Labrador Sea.

Studying the possible ventilation of the uLSW in the Irminger Basin requires other tracers.

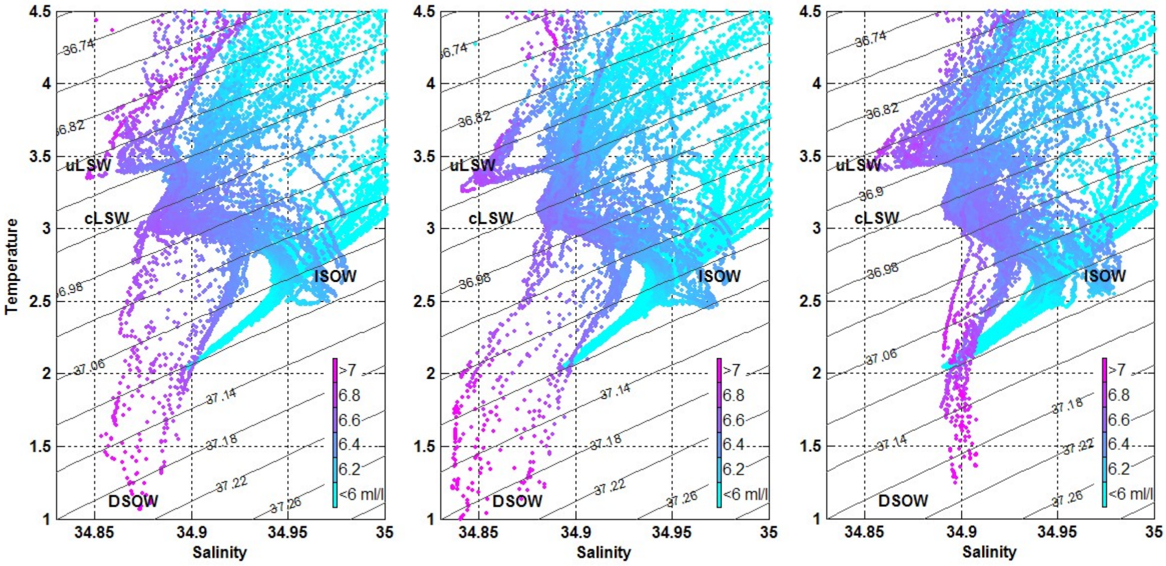


Figure 6 : ***Potential temperature versus salinity in the Irminger Basin*** *as measured in June 2002, 2004 and 2006 (from left to right). Isopycnal lines referenced to 2000m are drawn. Profiles were decimated with a 10-meter resolution and colored by oxygen measurements.*

1.4.2. Current profiling sections

1.4.2.1.VMADCP

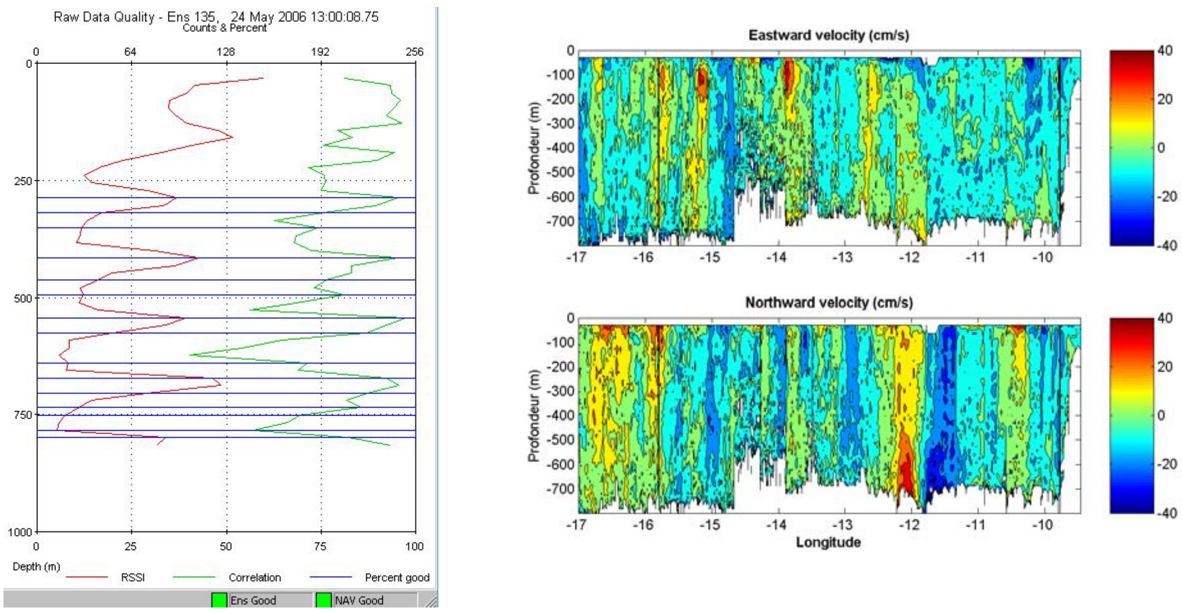


Figure 7 : ***SADCP raw and processed data.*** *On the left, the result of one ping that shows interferences. 80% of the raw profiles looked like this before May 30 when the78kHz DoLog was finally switched off. On the right, the velocities after processing. The ship is progressing eastward. The weather deteriorates at about 14°W. At 14°35'W, the DoLog is switched off.*

The Ship ADCP is a RDI Ocean Surveyor 75kHz. The configuration was chosen based on our experience on the Pourquoi pas? and also helped by Andreas Lehmann experience. These data are very important for Ovide cruises since they are used to determine the velocity at the reference level (indirectly) and allow a quite precise determination of the western boundary currents.

Until we reached the longitude of 14°30’W, interferences were observed on the SADCP raw data (Figure 7). Although less precise, we chose the Narrow Band mode since the signal was better recovered despite the numerous holes in the raw data. After realizing that the DoLog (78kHz) was responsible for this default, the Captain took the responsibility to shut it off although it gives the official speed of the ship.

The dataset is remarkable, with validated velocities down to more than 800m most of the time. It was processed using our Cascade Software written in Matlab language. A complete report was written, in which details on the configuration and the processing can be found (Gourcuff et al., 2006).

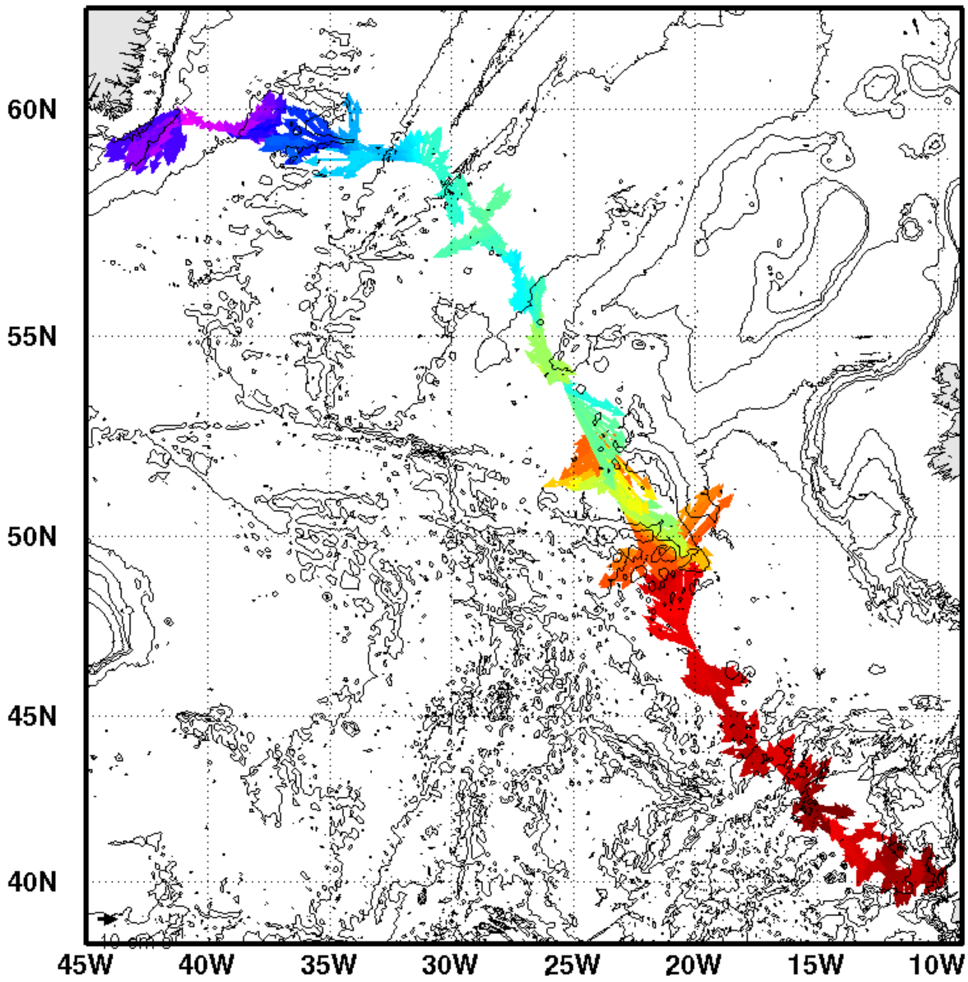


Figure 8 : ***Mean current between 100 and 400m depth*** *as measured by the SADCP. Colors indicate the temperature interpolated from CTD data in the same layer.*

1.4.2.2.LADCP

The rosette is equipped with a downward-looking RDI BB150kHz (Broad Band), one of the last of its generation. Its 200m range is enough to get a good profile without additional information from another LADCP. However, a 300kHz Work-Horse was mounted on the rosette, looking upwards, to be combined with the BB150 in the processing, but it was not possible to synchronize both ADCP and using both of them does not always lead to a more accurate result.

The data were processed with the LDEO software version 7e (Visbeck, 2002), and compare well with the SADCP data in the first 800m (Gourcuff et al., 2006). Stations 38 and 39 were performed with only one down-looking 300kHz (the 150kHz blew a fuse twice in a row on its comm. card), and as anticipated, the profiles are less reliable. The whole Ovide section is plotted on Figure 9.

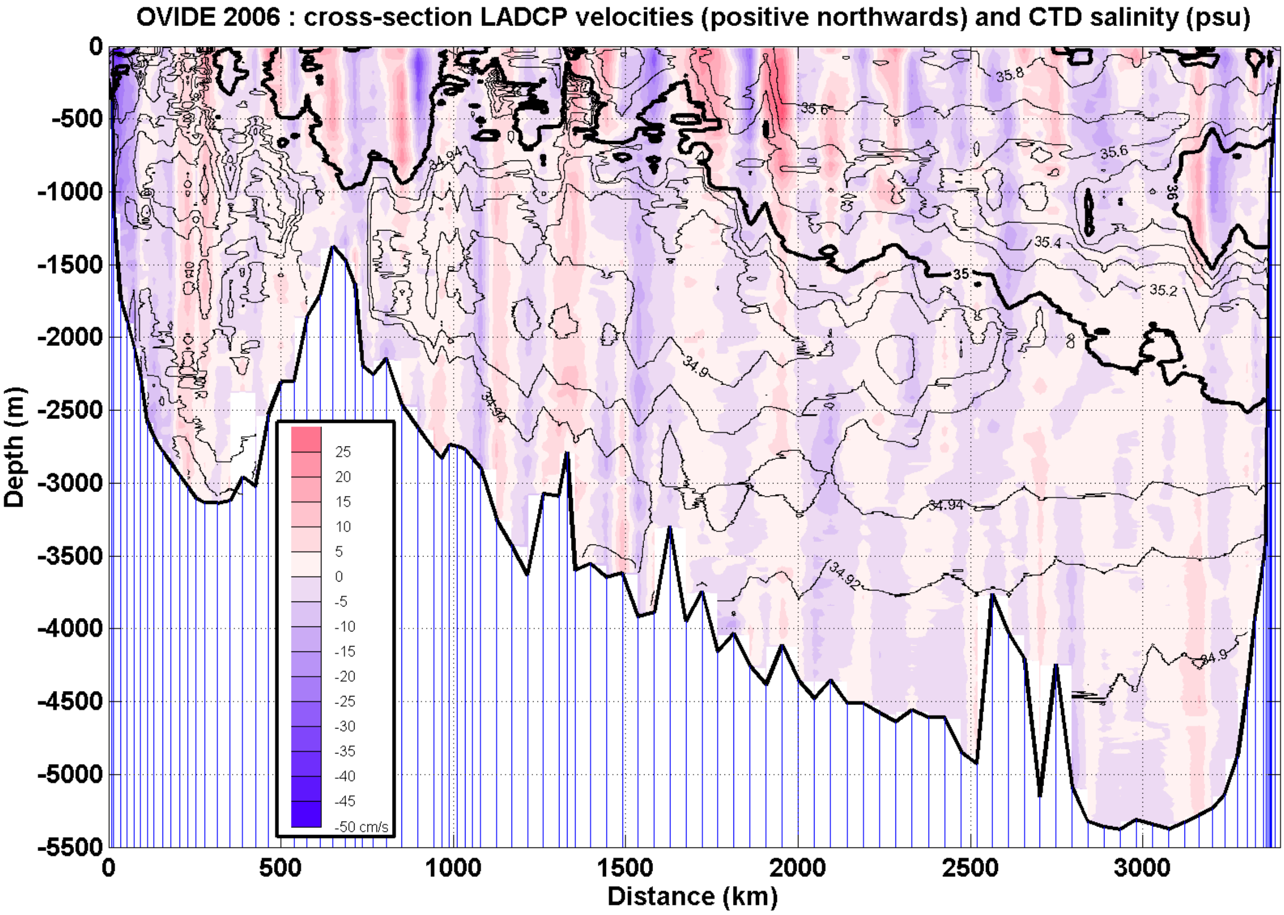


Figure 9 : ***the LADCP section with salinity contours.***

1.4.3. Nutrients, Chlorofluorocarbon (CFC), and carbon measurements

1.4.3.1.Nutrients

Nutrients were sampled in 125ml polyethylene bottles and analyzed following the protocols given in Aminot et Chaussepied (1983) and using a Auto Analyser II Bran et Luebbe. Procedures and results for this cruise are described in details in Morin et al. (2007). 2722 samples were analysed, leading to 10888 measurements of nitrates, nitrites, silicates and phosphates.

[NO_3^-] : uncertainty on nitrates measurements is less than 0.11 and 0.25 µmol l-1 at 2500m and 4600m respectively (0.54 et 1.09% relatively to the measured concentrations). Relatively to the scale defined by the WHP (1991), resulting precisions (0.24 et 0.54%) are well below the limit value defined by the WHP (0.9%).

[$Si(OH)_4$] : uncertainty on silicates measurements is less than 0.32 et 0.33 µmol l^{-1} at 2500m and 4600m respectively (0.67 et 0.97% relatively to the measured concentrations). Relatively to the scale defined by the WHP (1991), resulting precision (0.13%) is well below the limit value defined by the WHP (0.20%).

[PO_4^{3-}] : uncertainty on phosphates measurements is less than 0.02 µmol l^{-1} (1.59 et 1.31% relatively to the measured concentrations). Relatively to the scale defined by the WHP (1991), resulting precision (0.36%) is below the limit value accepted by the WHP (0.40%).

Nutrients can contribute to identify the origin of specific watermasses, or even to constrain deep circulation patterns. Silicates are for example an excellent tracer of the AABW (Figure 10).

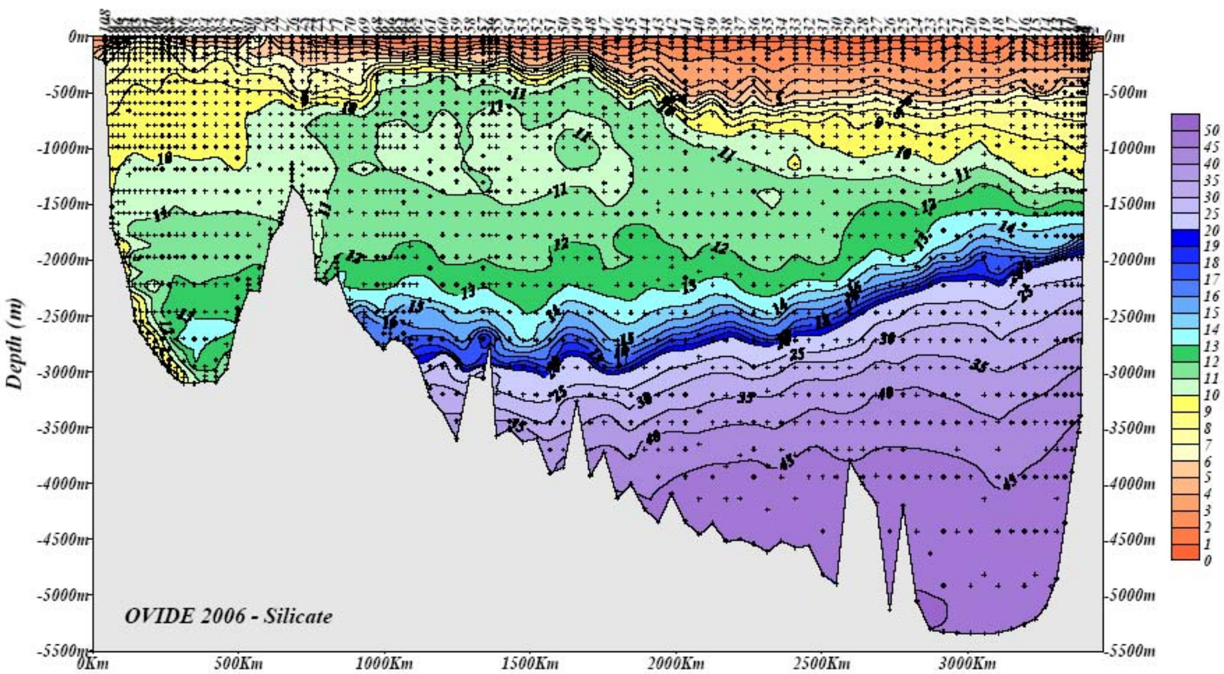


Figure 10 : ***Silicate vertical section (µmol.l^{-1}).***

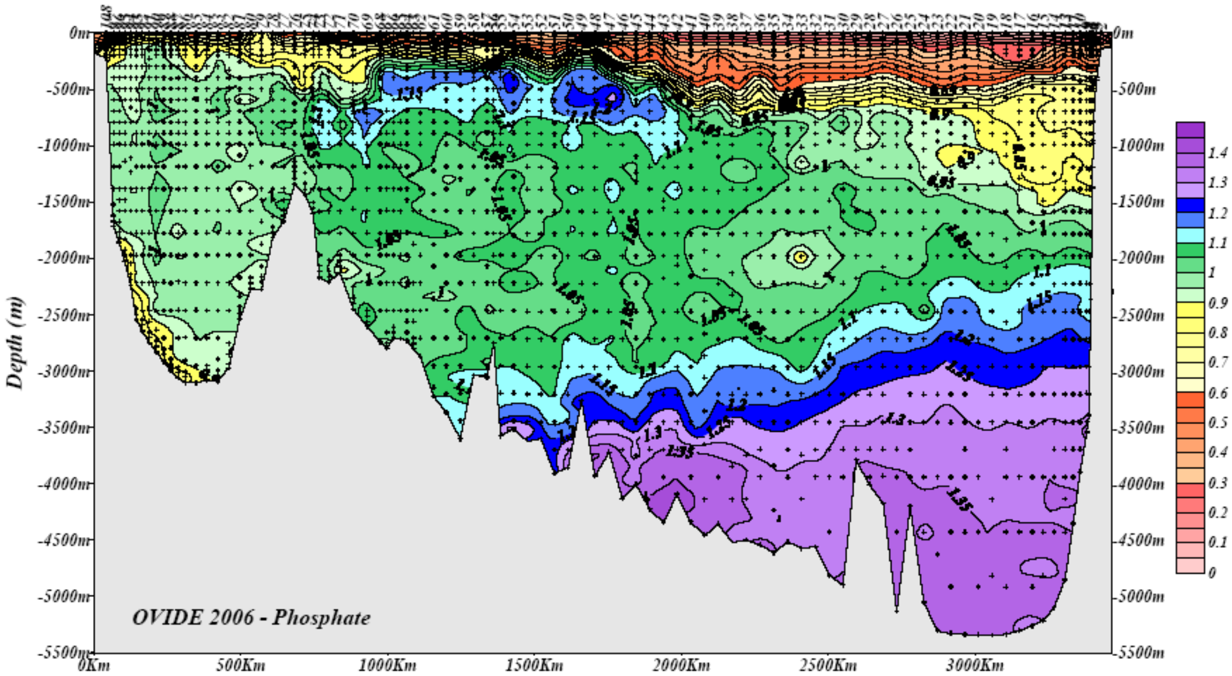


Figure 11 : ***Phosphate vertical section (μmol.l^{-1})***

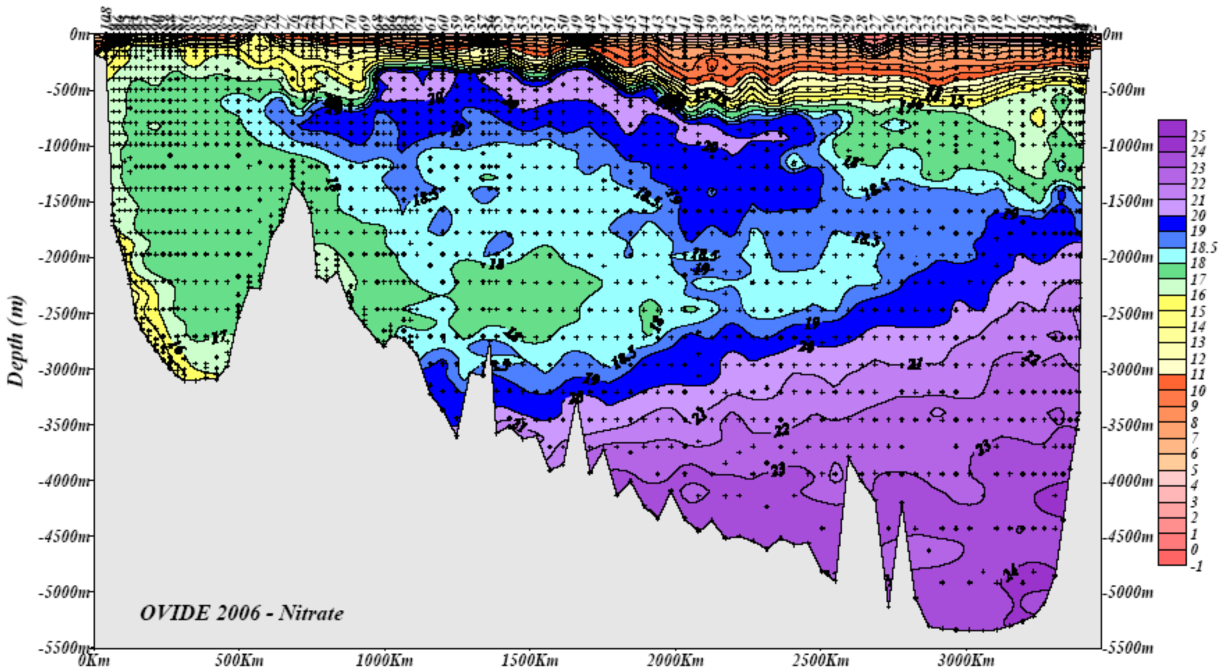
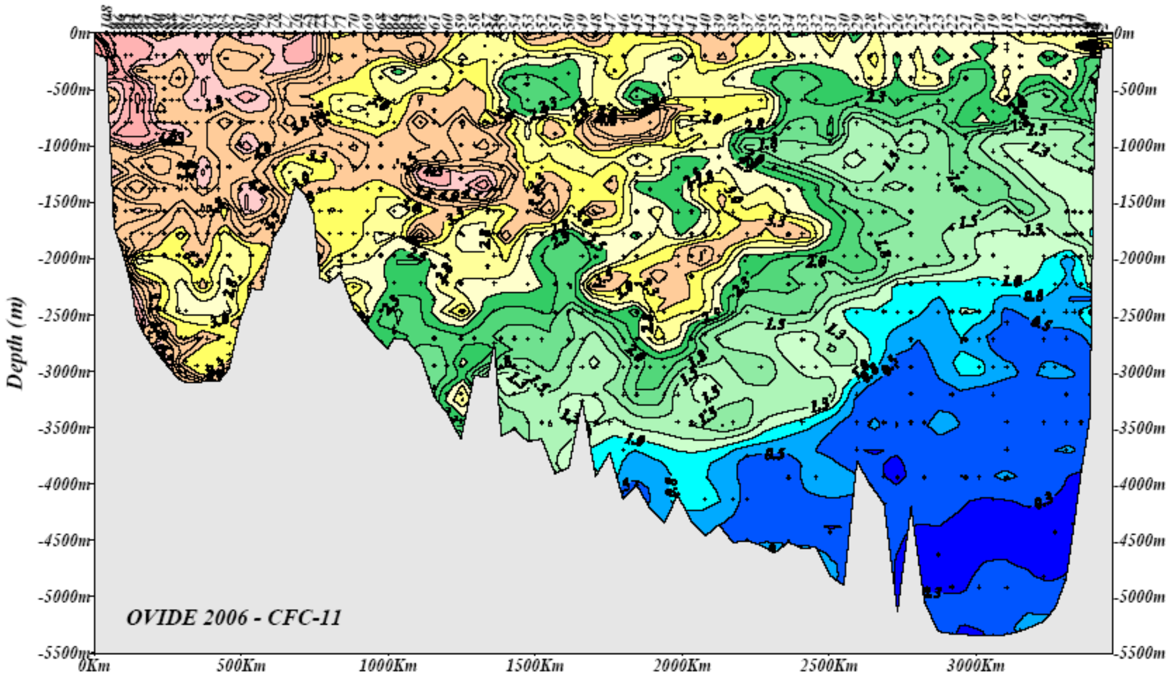


Figure 12 : ***Nitrate vertical section (μmol.l^{-1})***

1.4.3.2.CFC

Dissolved chlorofluorocarbons CFC-11, CFC-12, CFC-113 and CCl_4 were measured by by purge-and-trap gas chromatography following the protocol described in Connan et al. (1996). As CFC concentrations are much higher in the air than in most of the analysed water masses, this tracer is sampled first and suitable techniques (described in Morin et al., 2007) are used to avoid any contact between the sampled water and the air.



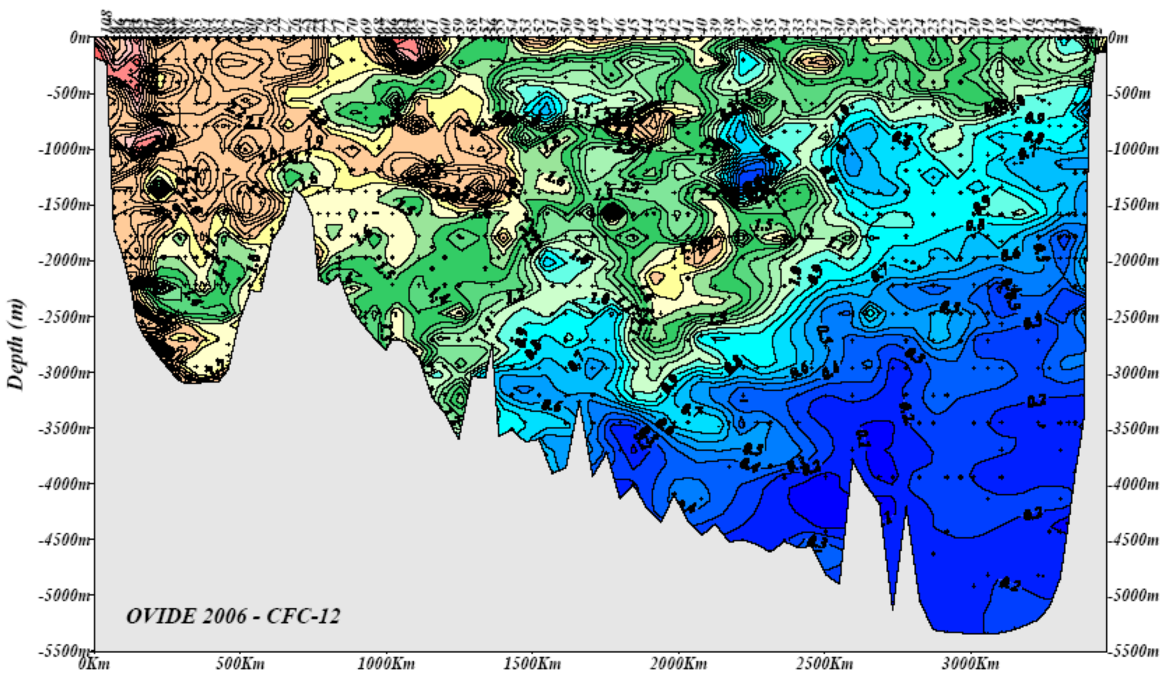


Figure 13 : ***CFC-11 and CFC-12 vertical sections (pmol.l^{-1}).***

During the cruise, repeatability obtained on several duplicates (2 samples from the same bottle) led to the following precisions:
CFC-12 : ± 4.45%, CFC-11 : ± 5.41%, CFC-113 : ± 6.25% and CCl_4 : ± 5.20%.

Freons are conservatives tracers that could be used to estimate the "age" of a watermass, i.e. the last time when it was in contact with the atmosphere. In Ovide, they are particularly valuable to trace the different vintages of LSW and their possible sites of ventilation.

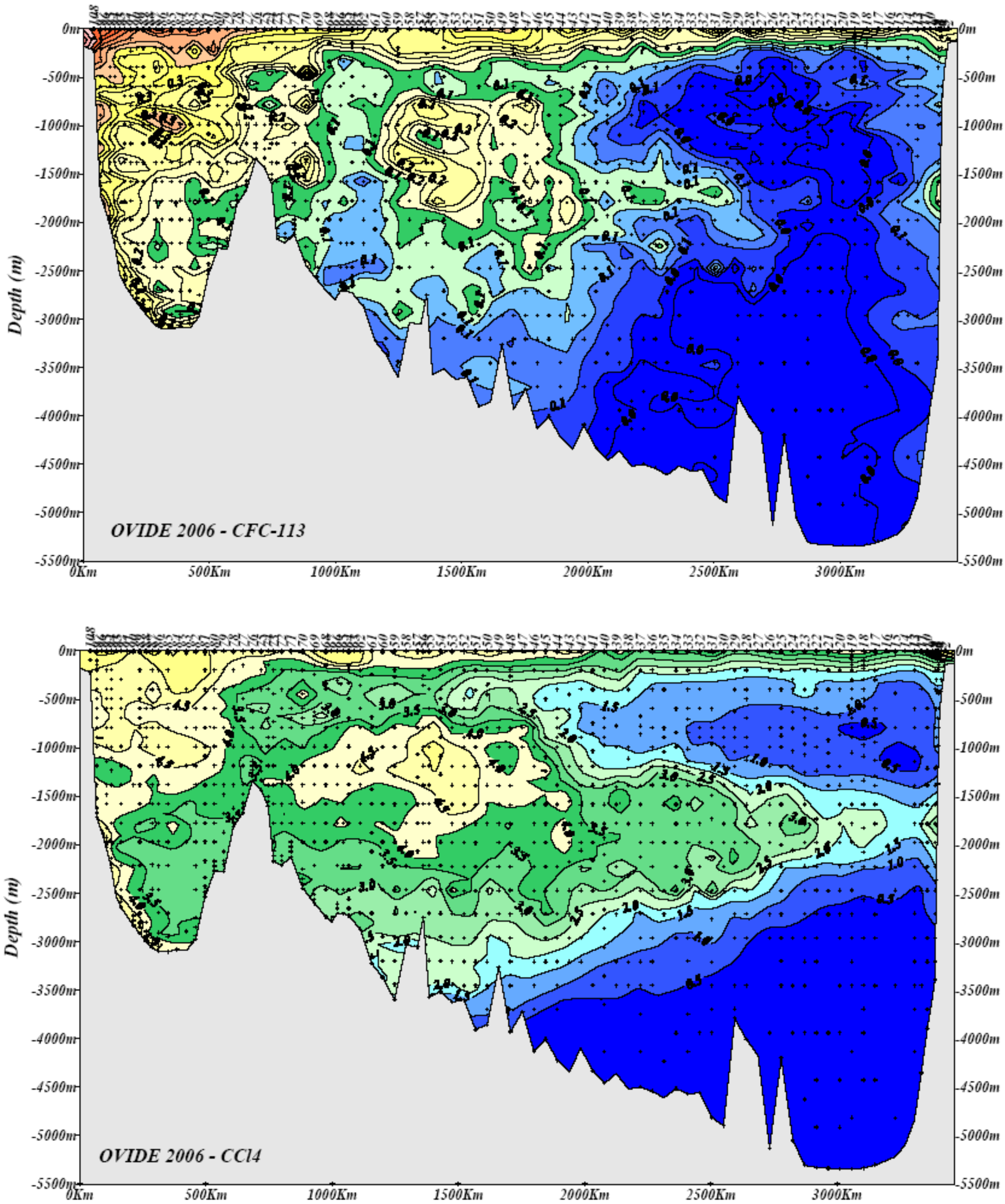


Figure 14 : ***CFC-113 and CCl4 vertical sections (pmol.l^{-1}).***

1.4.3.3.pH, alkalinity and anthropogenic carbon

The carbonic system measurement:

The total carbon (C_T or DIC) and the total alkalinity (A_T) are two independent variables of temperature and pressure.

$$\boldsymbol{C_T} = CO_2 + HCO_3^- + CO_3^{2-}$$

$$\boldsymbol{A_T} = HCO_3^- + 2 \cdot CO_3^{2-} + B(OH)_4^- + A_{Si(OH)4} + A_{H2PO4} + OH^- - H^+$$

fCO_2 = Solu(T,S).CO_2 and $\boldsymbol{pH_{T25}}$ ($H = 10^{-pH_{T25}}$) are dependent on temperature and pressure :
$\boldsymbol{C_T}$ is determined from $\boldsymbol{A_T}$ and $\boldsymbol{pH_{T25}}$

$$C_T = A_C \frac{(1 + H/k_1(S,T) + k_2(S,T)/H)}{(1 + 2 \cdot k_2(S,T)/H)} = f(S,T,pH,A_T)$$

The alkalinity was measured with a accuracy about 1 µmol·kg^{-1}
The pH was determined with a accuracy better than 0.002.
The C_T was calculated from A_T and pH with an error of 2 µmol·kg^{-1}

The alkalinity measurements:

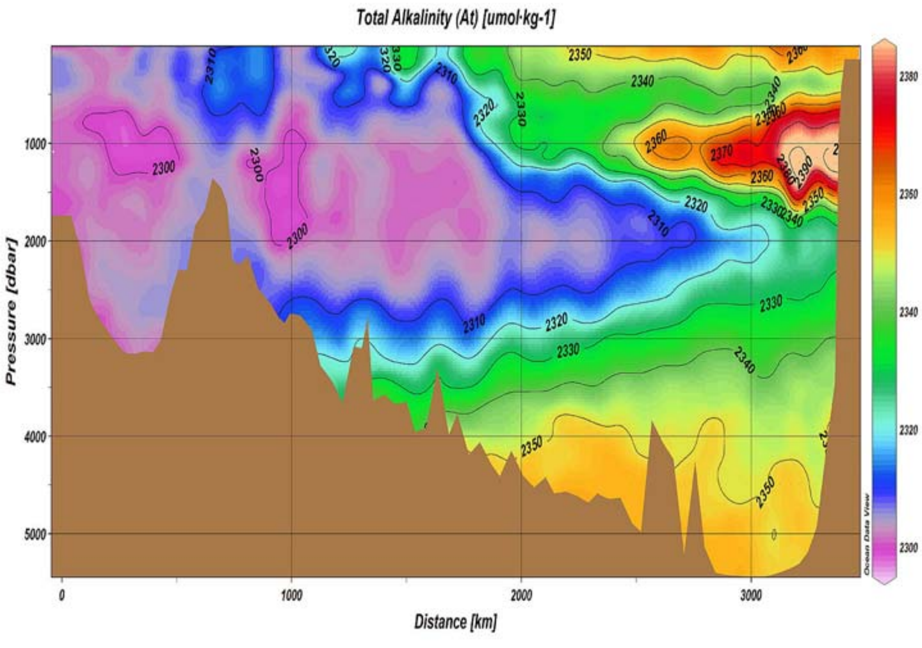


Figure 15 : *Total Alkalinity vertical section (µmol.kg^{-1})*

A_T was measured by single point potentiometric titration:
1123 samples were collected and measured over 58 stations. A_T profiles were usually sampled and analyzed every two stations. 24 samples were taken at each station. Seawater samples were collected after pH samples in 600 ml glass bottles.
Potentiometric titrations were performed with HCl (0.1 N) to an endpoint of pH=4.40 using an automatic titrator "Titrino Metrohm" and a pH-glass electrode. The electrode was standardised with a pH 4.41 buffer solution. The 0.1 N HCl was prepared with 0.5 mol of HCl (Riedel-deHaën® with mili-Q water into a graduated 5-L beaker at a known temperature).
Stations 1 through 20: samples were taken for accuracy estimation ± 1.1µmol.kg^{-1}
23 duplicates show an average reproducibility of 0.7 ± 1.0µmol.kg^{-1}

The pH measurements:

pH was measured spectrophotometrically (Clayton and Byrne;1993). On average, 2575 samples collected in 114 stations. Samples were collected after oxygen sampling, using cylindrical optical glass cells of 10 cm path-length. These were filled to overflowing to avoid bubbles and immediately closed after. Then, they were placed in a 25°C isotherm bath.

Once a baseline is determined, an m-cresol purple indicator dye solution is added to the seawater sample. After homogenisation, a *SHIMADZU UV-2401PC* spectrophotometer is used to measure the ratio (R) between the absorbencies at two different wavelengths at 25±0.2 ºC.

$pH_T=1245.69/T+3.8275+(2.11.10^{-3})(35-S)+\log((R-0.0069)/(2.222-R*0.133))$The replication, using 77 samples taken along the cruise, was 0.0015+0.0016 for pH. This is the equivalent to a replication in C_T of 0.6+0.7 µmol·kg^{-1}.

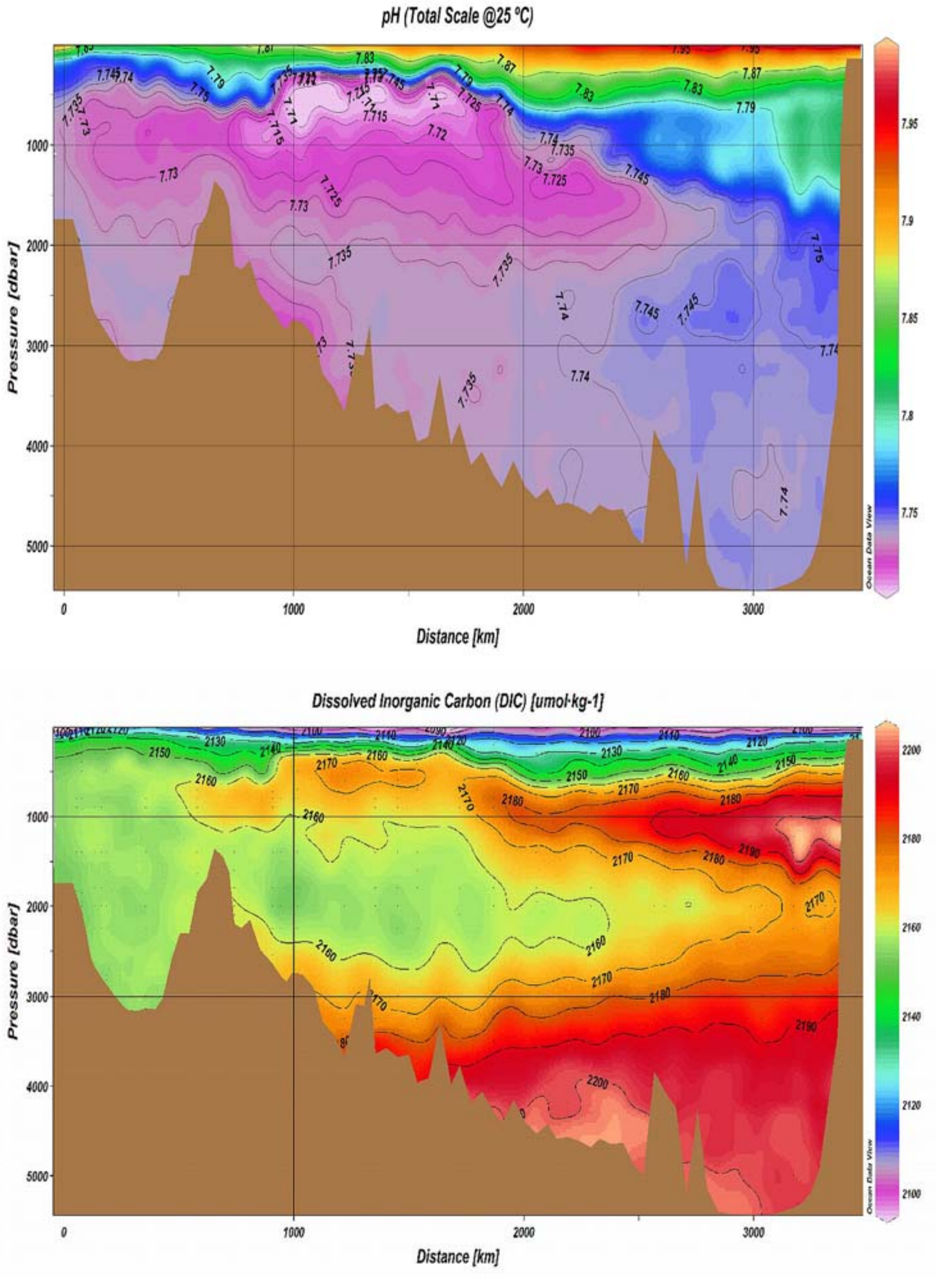


Figure 16 : ***pH and DIC (µmol.kg^{-1}) vertical sections***

The anthropogenic Carbon

The method to derive anthropogenic carbon is detailed in Vázquez-Rodríguez et al. (subm. DSR). The resulting C_{ant} evolution is shown on Figure 17. A remarkable variability is found, particularly in the Irminger Basin and the Iberian Abyssal Plain, where values are the lowest in 2002 and 2006. It is presently investigated.

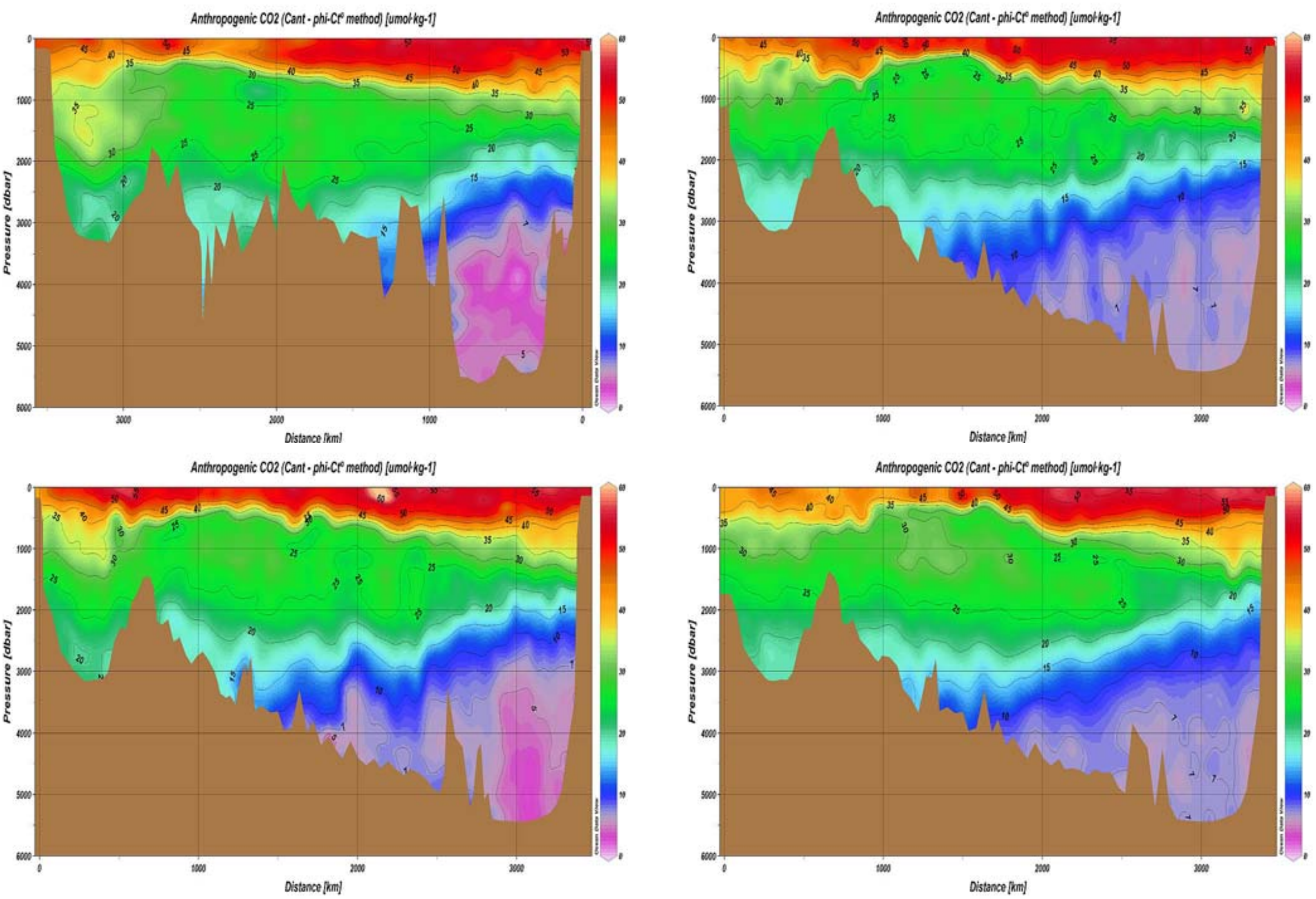


Figure 17 : the evolution of Anthropogenic Carbon contents on the A25/Ovide line (µmol.kg^{-1}).

1.4.4. Mooring operations

The 4 moorings could be recovered at the following positions. Moorings A, B and D had been in the water for 2 years. Cb was maintained in Sept. 2005 on the Discovery cruise D298 (Bacon 2006). Mooring A gave us some difficulties since it appeared that it was released during our first visit in the surroundings, i.e. several hours before the actual recovery. That is why it took nearly an hour to find it. Did the EM120 send the release signal to the mooring? Although it seems unlikely, this is the only hypothesis we have now.

	LATITUDE	*LONGITUDE*	*DEPTH*	*LENGTH*	*HEAD*	*ON DECK (UTC)*
A	N59°39.223'	W41°47.596'	1894m	1718m	-176m	2006/06/17 22:23
B	N59°45.215'	W42°07.454'	1732m	1517m	-215m	2006/06/22 02:23
Cb	N59°47.620'	W42°15.922'	1112m	810m	-301m	2006/06/22 07:21
D	N59°48.949'	W42°19.122'	490m	332m	-158m	2006/06/22 04:59

Recovered instruments:

Mooring A
Seacat #2345, RCM8 #9940, #10229, #10230, #10231 and #10234, Argos Beacon #11261, acoustic release #445.

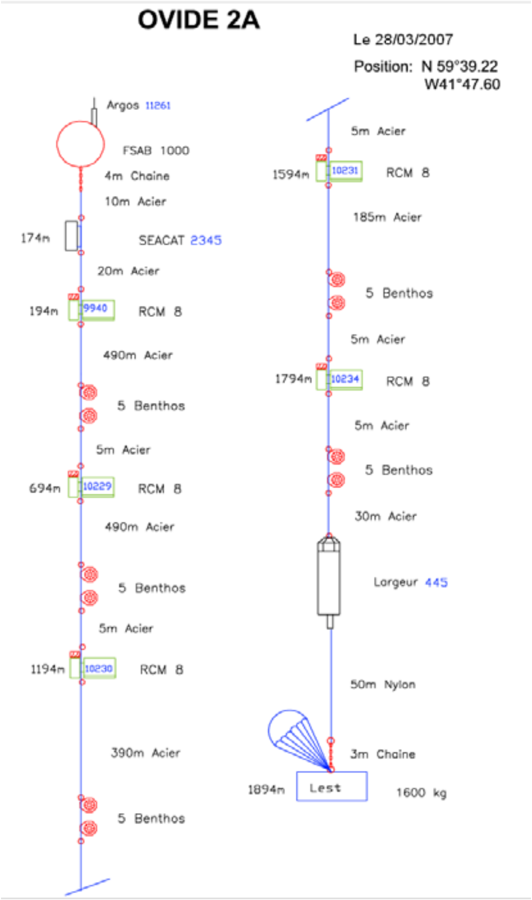
Mooring B
RCM8 #10238, #10240, #10243, #10244 and #10245, Argos #11262, acoustic release #446.

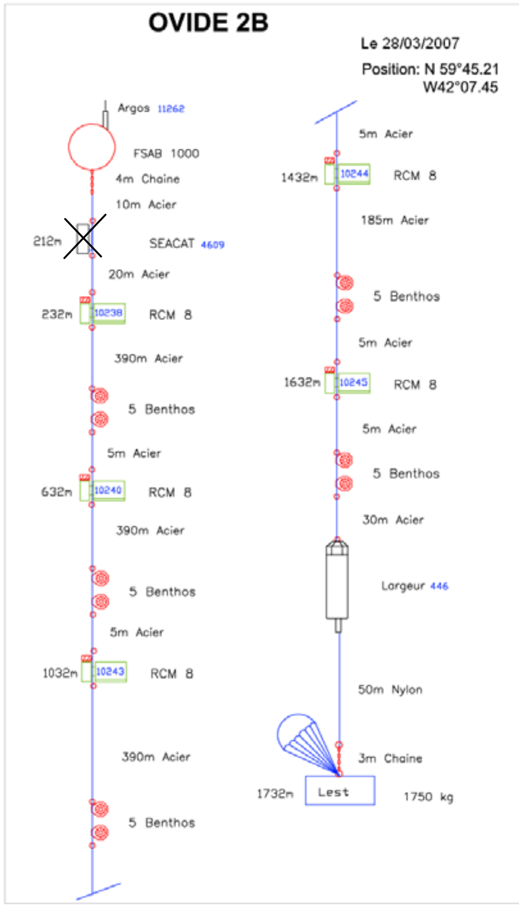
Mooring Cb
Microcat #4008, ADCP 75kHz #881, RCM8 #10743, #10233and #10232, RCM11 #454, Aquadopp #1337, Argos #11263, acoustic releases #294 and #447.

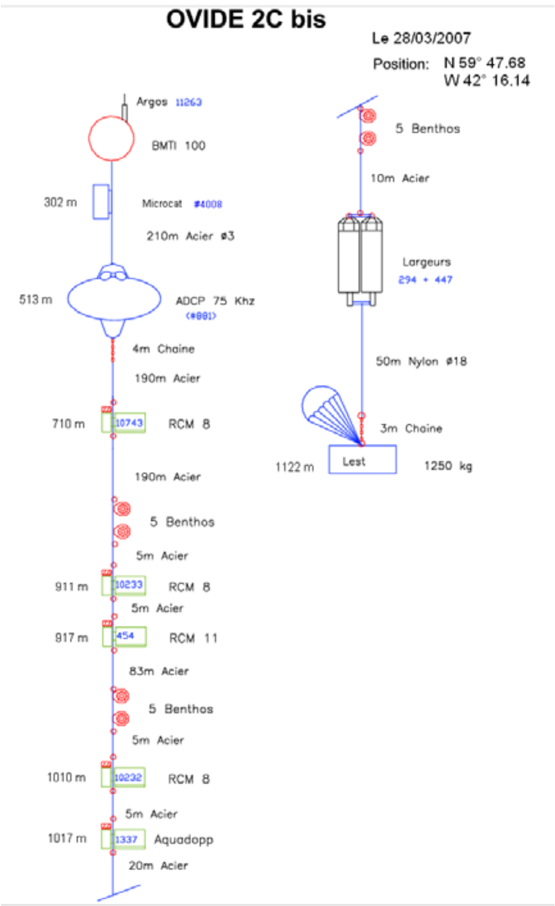
Mooring D
Seacat #4611, RCM8 #12678 and #12679, Argos #11264, acoustic release #375.

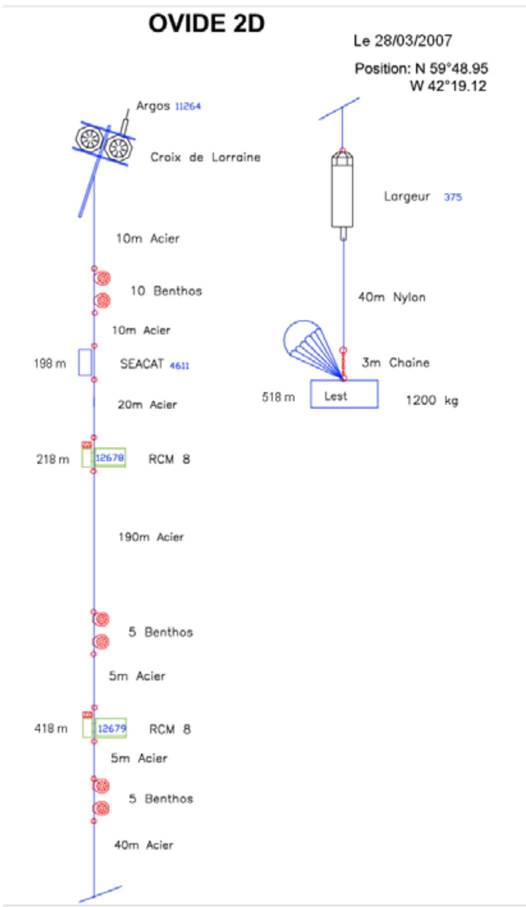
Lost instruments: Seacat #4609 on mooring B

Apart from the Aquadopp that did not start (configuration issue), all the instruments show the correct amount of data in their memory. A first look at ADCP and Seacat data is satisfying.


OVIDE 2A
Le 28/03/2007
Position: N 59°39.22
W41°47.60
Argos 11261
FSAB 1000
4m Chaine
10m Acier
174m
SEACAT 2345
20m Acier
194m
9940
RCM 8
490m Acier
5 Benthos
5m Acier
694m
10229
RCM 8
490m Acier
5 Benthos
5m Acier
1194m
10230
RCM 8
390m Acier
5 Benthos
5m Acier
1594m
10231
RCM 8
185m Acier
5 Benthos
5m Acier
1794m
10234
RCM 8
5m Acier
5 Benthos
30m Acier
Largeur 445
50m Nylon
3m Chaine
1894m
Lest
1600 kg


OVIDE 2B
Le 28/03/2007
Position: N 59°45.21
W42°07.45
Argos 11262
FSAB 1000
4m Chaine
10m Acier
212m
SEACAT 4609
20m Acier
232m
10238
RCM 8
390m Acier
5 Benthos
5m Acier
632m
10240
RCM 8
390m Acier
5 Benthos
5m Acier
1032m
10243
RCM 8
390m Acier
5 Benthos
5m Acier
1432m
10244
RCM 8
185m Acier
5 Benthos
5m Acier
1632m
10245
RCM 8
5m Acier
5 Benthos
30m Acier
Largeur 446
50m Nylon
3m Chaine
1732m
Lest
1750 kg


OVIDE 2C bis
Le 28/03/2007
Position: N 59° 47.68
W 42° 16.14
Argos 11263
BMTI 100
302 m
Microcat #4008
210m Acier ø3
513 m
ADCP 75 Khz
(#881)
4m Chaine
190m Acier
710 m
10743
RCM 8
190m Acier
5 Benthos
5m Acier
911 m
10233
RCM 8
5m Acier
917 m
454
RCM 11
83m Acier
5 Benthos
5m Acier
1010 m
10232
RCM 8
5m Acier
1017 m
1337
Aquadopp
20m Acier
5 Benthos
10m Acier
Largeurs
294 + 447
50m Nylon ø18
3m Chaine
1122 m
Lest
1250 kg


OVIDE 2D
Le 28/03/2007
Position: N 59°48.95
W 42°19.12
Argos 11264
Croix de Lorraine
10m Acier
10 Benthos
10m Acier
198 m
SEACAT 4611
20m Acier
218 m
12678
RCM 8
190m Acier
5 Benthos
5m Acier
418 m
12679
RCM 8
5m Acier
5 Benthos
40m Acier
Largeur 375
40m Nylon
3m Chaine
518 m
Lest
1200 kg

A precise bathymetric chart could be drawn with the multibeam sounder EM120 of the Merian (Figure 18).

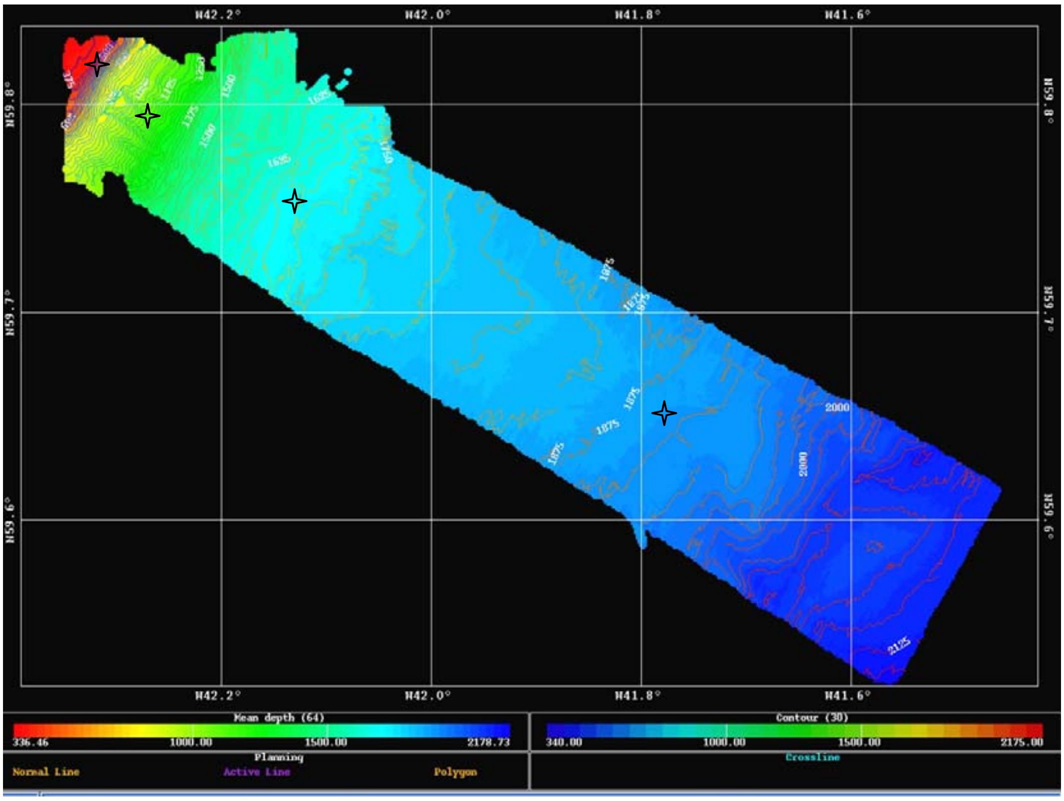


Figure 18 : the bathymetry of the mooring area. Moorings A, B, C and D are represented with black stars.

1.4.5. Float Deployments

16 profiling floats were deployed on the way at positions shown by green dots on Figure 1 (Provor CTS3). The serial number of each float and the position and date of deployment are indicated in section 1.6. They were programmed as indicated on the table below:

	Choice		Choice
Nomber of cycles	255	Aquisition period during drift	24h
Depth of drift	1000 dbar	Measurem.: upcast +1st downcast	yes
Cycle periodicity	10 days	Depth of the surface layer	500 dbar
Max depth of the upcast	2000 dbar	Sampling in the surface layer	50 dbar
Stalling mode	Stays at the bottom	Sampling below	60 dbar

The deployment is a participation to the ARGO program via the Coriolis project at Ifremer. In addition, floats are expected to sample the formation and advection of the SPMW, although a mistake in the parameters (50 dbars instead of 20 in the surface layer) may complicate this study.
All floats were deployed nominally and their first profiles were checked.

1.4.6. XBT section

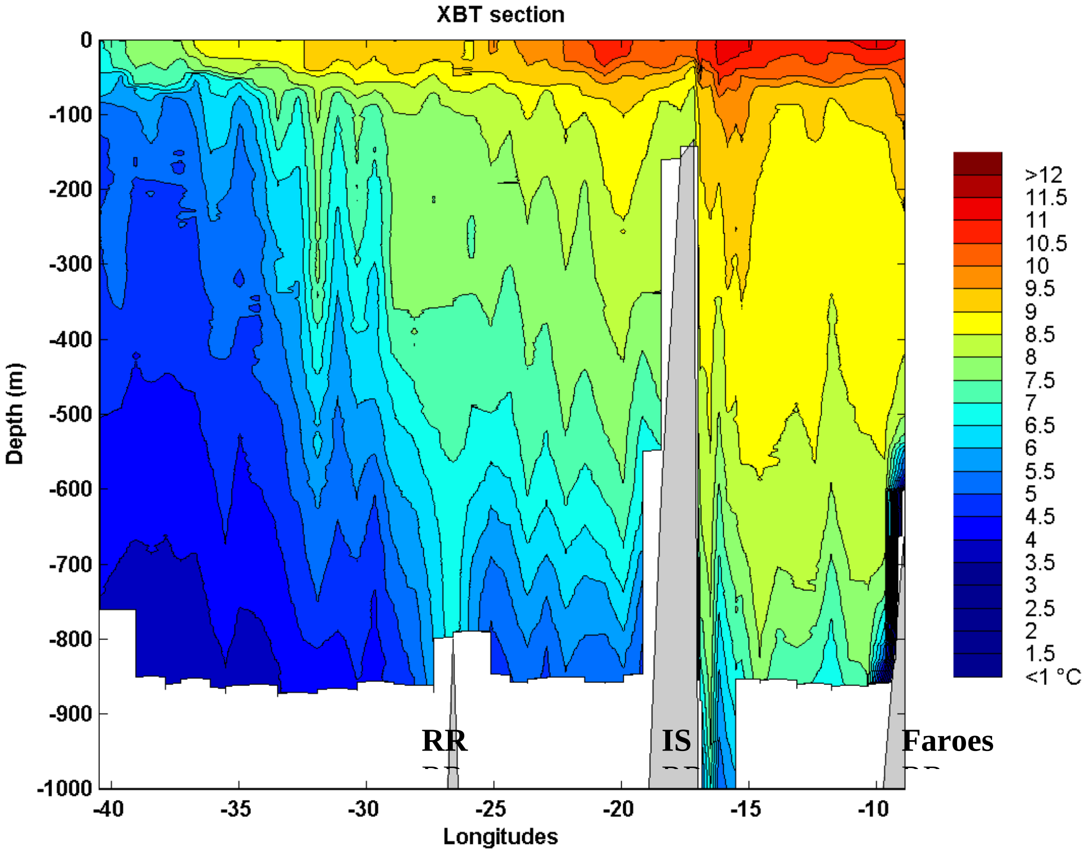


Figure 19 : ***Temperature section from Greenland to Faeroe Islands.*** *RR: Reykjanes Ridge. IS: Iceland Shelf.*

During the transit back to Thorshavn, Expandable BathyThermographs (XBT) were launched every 2 hours, i.e. about 20nm (Figure 1). CTD stations 116 to 120 were used off the Icelandic shelf to sample the ISOW, which is more clearly seen cascading off the Faeroes on the shallow section of Figure 19.

1.5.The web site

During the whole mission, a French web site was maintained on shore and updated every 3 days:
http://www.ifremer.fr/lpo/ovide/ovide06/index.htm
Further results on the Ovide project can be found on
http://www.ifremer.fr/lpo/ovide/

All the data collected by the PROVOR floats, the glider, the XBT and a vertically subsampled CTD dataset have been sent to the Coriolis Regional Data Center [http://www.coriolis.eu.org/] in real time.

1.6.Station List MSM02/1

MSM station name	Task	Latitude deg N	min	Longitude deg W	min	Dec. Latitude	Dec. Longitude	Depth (m)	Duration (h)	Dist from n-1 (nm)	time to be reached (h)	Task	Day of arrival	mo.	Time of arrival	Time of departure	Time reference
	Lisbon	38	42.75	9	7.34	38.713	-9.122			0.0		Port	23	5	22:00		UTC-1
MSM2/359-1	sta 0	38	26.00	10	42.00	38.433	-10.700	4500	5:30	76.0	7:18	Test Seabird	24	5	6:00		
MSM2/360-1	sta 1	38	26.00	10	42.00	38.433	-10.700	4500	6:30	0.0	0:00	Test NeilBrown	24	5	12:30	19:00	
MSM2/361-1	sta 2	40	20.00	9	27.56	40.333	-9.459	150	1:58	127.3	11:58	Station CTD	25	5	6:58	8:56	
MSM2/362-1	sta 3	40	20.00	9	38.57	40.333	-9.643	427	1:07	8.4	1:09	Station CTD	25	5	11:15	12:22	
MSM2/363-1	sta 4	40	20.06	9	45.85	40.334	-9.764	805	1:19	5.6	0:54	Station CTD	25	5	13:16	14:36	
MSM2/364-1	vmp 4-1	40	18.30	9	45.29	40.305	-9.755	798	1:14	1.8	0:09	Station VMP	25	5	14:46	16:00	
MSM2/365-1	sta 5	40	20.00	9	47.00	40.333	-9.784	975	1:43	2.1	0:35	Station CTD	25	5	16:36	18:19	
MSM2/366-1	sta 6	40	20.00	9	48.09	40.333	-9.802	1368	1:56	1.7	0:33	Station CTD	25	5	18:53	20:49	
MSM2/367-1	sta 7	40	20.00	9	52.56	40.333	-9.876	2352	2:29	3.4	0:42	Station CTD	25	5	21:32	0:01	
MSM2/368-1	sta 8	40	20.00	9	56.56	40.333	-9.943	3399	4:46	3.0	0:40	Station CTD	26	5	0:42	5:28	
MSM2/369-1	sta 9	40	20.00	10	1.94	40.333	-10.032	3549	3:09	4.1	0:46	Station CTD	26	5	6:14	9:24	
MSM2/370-1	sta 10	40	20.00	10	17.97	40.333	-10.300	3898	3:02	12.2	1:30	Station CTD	26	5	10:54	13:57	
MSM2/371-1	sta 11	40	20.00	10	34.54	40.333	-10.576	4361	3:18	12.6	1:32	Station CTD	26	5	15:30	18:49	
MSM2/372-1	sta 12	40	20.00	10	54.25	40.333	-10.904	4850	3:34	15.0	1:45	Station CTD	26	5	20:35	0:09	
	Figuera da Foz	40	8.50	8	53.10	40.142	-8.885	60	3:00	93.3	8:10	take spare part	27	6	8:20	11:20	
MSM2/373-1	sta 13	40	20.00	10	54.25	40.333	-10.904	4853	3:34	93.1	8:09	Station CTD	27	6	19:29	23:04	
MSM2/374-1	sta 14	40	20.00	11	20.45	40.333	-11.341	5104	3:43	20.0	2:12	Station CTD	28	5	1:17	5:00	
MSM2/375-1	sta 15	40	20.00	11	46.72	40.333	-11.779	5116	3:43	20.0	2:13	Station CTD	28	5	7:13	10:57	
MSM2/375-2	PV530	40	20.09	11	46.71	40.335	-11.779	5112	0:10	0.0	0:00	Provor deployt	28	5	10:57	11:07	
MSM2/376-1	sta 16	40	20.00	12	13.22	40.333	-12.220	5263	3:48	20.2	2:14	Station CTD	28	5	13:11	16:59	
MSM2/377-1	sta 17	40	33.06	12	38.76	40.551	-12.646	5310	3:50	23.4	2:31	Station CTD	28	5	19:31	23:21	
MSM2/378-1	sta 18	40	47.16	13	5.88	40.786	-13.098	5340	3:51	24.9	2:39	Station CTD	29	5	2:01	5:52	

MSM station name	Task	Latitude deg N	min	Longitude deg W	min	Dec. Latitude	Dec. Longitude	Depth (m)	Duration (h)	Dist from n-1 (nm)	time to be reached (h)	Task	Day of arrival	mo.	Time of arrival	Time of departure	Time reference
MSM2/379-1	sta 19	41	5.04	13	29.46	41.084	-13.491	5344	3:51	25.2	6:23	Station CTD	29	5	12:15	16:07	
MSM2/380-1	vmp 19-2	41	5.04	13	29.46	41.084	-13.491	5360	5:27	0.0	0:00	Station VMP	29	5	16:07	21:34	
MSM2/380-2	free-ctd-1	41	5.06	13	29.51	41.084	-13.492	5361	0:35	0.0	0:00	free-fall ctd	29	5	16:22	16:57	
MSM2/380-3	free-ctd-2	41	4.89	13	29.73	41.082	-13.496	5361	0:35	0.0	0:00	free-fall ctd	29	6	18:42	20:17	
MSM2/381-1	sta 20	41	23.01	13	53.31	41.384	-13.889	5355	3:51	25.4	2:42	Station CTD	30	5	0:16	4:08	
MSM2/382-1	sta 21	41	40.98	14	16.62	41.683	-14.277	5347	3:51	25.0	2:40	Station CTD	30	5	6:48	10:39	
MSM2/382-2	PV533	41	41.15	14	16.50	41.686	-14.275	5347	0:10	0.0	0:00	Provor deployt	30	5	10:39	10:49	
MSM2/383-1	sta 22	41	58.90	14	40.32	41.982	-14.672	5337	3:50	25.1	2:41	Station CTD	30	5	13:20	17:11	
MSM2/384-1	sta 23	42	16.86	15	3.90	42.281	-15.065	5311	3:50	25.0	2:40	Station CTD	30	5	19:52	23:42	
MSM2/385-1	sta 24	42	34.86	15	27.48	42.581	-15.458	5056	4:11	25.0	2:40	Station CTD	31	5	2:22	6:34	
MSM2/386-1	sta 25	42	52.86	15	51.00	42.881	-15.850	4201	3:13	24.9	5:27	Station CTD	31	5	12:02	15:15	
MSM2/387-1	sta 26	43	10.80	16	14.76	43.180	-16.246	5132	3:44	24.9	2:40	Station CTD	31	5	17:55	21:39	
MSM2/388-1	sta 27	43	28.74	16	38.34	43.479	-16.639	4173	2:57	24.8	2:27	Station CTD	1	6	0:07	3:04	
MSM2/388-2	PV535	43	28.74	16	38.34	43.479	-16.639	4173	0:15	0.0	0:00	Provor deployt	1	6	3:04	3:19	
MSM2/389-1	sta 28	43	46.68	17	1.92	43.778	-17.032	4010	3:06	24.7	2:33	Station CTD	1	6	5:52	8:59	
MSM2/390-1	sta 29	44	4.62	17	25.56	44.077	-17.426	3764	2:58	24.7	2:32	Station CTD	1	6	11:32	14:30	
MSM2/391-1	sta 30	44	22.62	17	49.02	44.377	-17.817	4899	3:36	24.6	2:32	Station CTD	1	6	17:02	20:39	
MSM2/392-1	sta 31	44	40.50	18	12.72	44.675	-18.212	4836	3:24	24.6	2:32	Station CTD	1	6	23:11	2:35	
MSM2/393-1	sta 32	45	2.94	18	30.24	45.049	-18.504	4613	3:16	25.6	2:37	Station CTD	2	6	5:13	8:30	
MSM2/394-1	sta 33	45	25.32	18	47.82	45.422	-18.797	4565	3:15	25.6	2:37	Station CTD	2	6	11:07	14:22	
MSM2/395-1	sta 34	45	47.70	19	5.46	45.795	-19.091	4511	3:13	25.5	2:37	Station CTD	2	6	16:59	20:13	
MSM2/395-2	PV531	45	47.70	19	5.46	45.795	-19.091	4511	0:15	0.0	0:00	Provor deployt	2	6	20:13	20:28	
MSM2/396-1	sta 35	46	10.20	19	23.10	46.170	-19.385	4602	3:26	25.6	2:37	Station CTD	2	6	23:05	2:32	
MSM2/397-1	sta 36	46	32.52	19	40.44	46.542	-19.674	4537	3:24	25.3	2:36	Station CTD	3	6	5:08	8:32	
MSM2/398-1	sta 37	46	54.96	19	58.14	46.916	-19.969	4491	3:22	25.5	2:36	Station CTD	3	6	11:09	14:32	

MSM station name	**Task**	**Latitude deg N**	**min**	**Longitude deg W**	**min**	**Dec. Latitude**	**Dec. Longitude**	**Depth (m)**	**Duration (h)**	**Dist from n-1 (nm)**	**time to be reached (h)**	**Task**	**Day of arrival**	**mo.**	**Time of arrival**	**Time of departure**	**Time reference**
MSM2/399-1	sta 38	47	17.52	20	15.78	47.292	-20.263	4507	5:13	25.5	2:37	Station CTD	3	6	17:09	22:22	
MSM2/400-1	sta 39	47	39.90	20	33.36	47.665	-20.556	4341	3:17	25.3	2:36	Station CTD	4	6	0:58	4:16	
MSM2/401-1	sta 40	48	2.28	20	51.06	48.038	-20.851	4447	3:21	25.3	2:36	Station CTD	4	6	6:52	10:13	
MSM2/402-1	sta 41	48	24.72	21	8.52	48.412	-21.142	4327	3:17	25.3	2:35	Station CTD	4	6	12:49	16:06	
MSM2/402-2	PV534	48	24.72	21	8.52	48.412	-21.142	4327	0:05	0.0	0:00	Provor deployt	4	6	16:06	16:11	
MSM2/403-1	sta 42	48	47.16	21	25.98	48.786	-21.433	4080	2:54	25.2	2:23	Station CTD	4	6	18:35	21:29	
MSM2/404-1	sta 43	49	9.48	21	43.62	49.158	-21.727	4336	3:12	25.1	2:41	Station CTD	5	6	0:10	3:22	
MSM2/405-1	sta 44	49	31.92	22	1.20	49.532	-22.020	4223	3:08	25.2	2:43	Station CTD	5	6	5:05	8:14	time change: UTC
MSM2/406-1	sta 45	49	54.36	22	18.84	49.906	-22.314	3993	3:01	25.2	2:59	Station CTD	5	6	11:14	14:15	
MSM2/407-1	sta 46	50	16.74	22	36.36	50.279	-22.606	4129	3:05	25.0	2:58	Station CTD	5	6	17:14	20:19	
MSM2/408-1	sta 47	50	38.52	22	54.06	50.642	-22.901	3713	2:51	24.5	2:55	Station CTD	5	6	23:15	2:06	
MSM2/409-1	sta 48	51	1.62	23	11.64	51.027	-23.194	3924	2:58	25.6	3:02	Station CTD	6	6	5:09	8:08	
MSM2/409-2	vmp 48-3	51	1.62	23	11.64	51.027	-23.194	3924	5:20	0.0	0:00	Station VMP	6	6	8:08	13:28	
MSM2/409-3	PV528	51	1.62	23	11.64	51.027	-23.194	3924	0:15	0.0	0:00	Provor deployt	6	6	8:13	8:28	
MSM2/410-1	sta 49	51	24.06	23	29.10	51.401	-23.485	3252	2:26	24.9	2:58	Station CTD	6	6	16:26	18:53	
MSM2/411-1	sta 50	51	46.38	23	46.62	51.773	-23.777	3851	2:56	24.8	2:48	Station CTD	6	6	21:41	0:38	
MSM2/411-2	PV537	51	46.38	23	46.62	51.773	-23.777	3851	0:10	0.0	0:00	Provor deployt	7	6	0:38	0:48	
MSM2/412-1	sta 51	52	8.82	24	4.26	52.147	-24.071	3897	2:57	24.9	2:58	Station CTD	7	6	3:46	6:44	
MSM2/413-1	sta 52	52	31.26	24	21.78	52.521	-24.363	3594	2:47	24.8	2:57	Station CTD	7	6	9:41	12:29	
MSM2/413-2	PV529	52	31.26	24	21.78	52.521	-24.363	3594	0:10	0.0	0:00	Provor deployt	7	6	12:29	12:39	
MSM2/414-1	sta 53	52	53.58	24	39.36	52.893	-24.656	3617	2:48	24.7	4:44	Station CTD+ glider calib	7	6	17:24	20:12	
MSM2/415-1	sta 54	53	16.14	24	57.00	53.269	-24.950	3519	2:45	24.9	3:14	Station CTD	7	6	23:27	2:12	
MSM2/416-1	sta 55	53	38.40	25	14.40	53.640	-25.240	3516	2:45	24.5	2:55	Station CTD	8	6	5:08	7:53	
MSM2/417-1	sta 56	53	49.70	25	23.25	53.828	-25.388	3250	2:36	12.4	1:35	Station CTD	8	6	9:28	12:04	

MSM station name	Task	Latitude deg N	min	Longitude deg W	min	Dec. Latitude	Dec. Longitude	Depth (m)	Duration (h)	Dist from n-1 (nm)	time to be reached (h)	Task	Day of arrival	mo.	Time of arrival	Time of departure	Time reference
MSM2/417-2	PV527	53	49.70	25	23.25	53.828	-25.388	3251	0:10	0.0	0:00	Provor deployt	8	6	12:04	12:14	
MSM2/418-1	sta 57	54	0.96	25	32.10	54.016	-25.535	3068	2:30	12.4	1:34	Station CTD	8	6	13:49	16:19	
MSM2/419-1	sta 58	54	23.22	25	49.68	54.387	-25.828	3047	2:29	24.5	2:55	Station CTD	8	6	19:14	21:44	
MSM2/420-1	sta 59	54	45.72	26	7.38	54.762	-26.123	3610	2:48	24.7	4:08	Station CTD	9	6	1:53	4:41	
MSM2/421-1	sta 60	55	8.94	26	24.66	55.149	-26.411	3375	2:40	25.2	3:00	Station CTD	9	6	7:41	10:22	
MSM2/421-2	PV532	55	8.94	26	24.66	55.149	-26.411	3375	0:10	0.0	0:00	Provor deployt	9	6	10:22	10:32	
MSM2/422-2	vmp 61-4	55	31.06	26	40.47	55.518	-26.675	3234	5:11	23.9	3:27	Station VMP	9	6	13:59	18:10	
MSM2/422-1	sta 61	55	30.36	26	42.36	55.506	-26.706	3234	2:35	1.3	0:24	Station CTD	9	6	14:24	16:59	
MSM2/423-1	sta 62	55	52.98	26	59.88	55.883	-26.998	2879	2:23	24.7	2:56	Station CTD	9	6	22:07	0:31	
MSM2/424-1	sta 63	56	4.14	27	8.64	56.069	-27.144	2812	1:53	12.2	1:33	Station CTD	10	6	2:04	3:58	
MSM2/425-1	sta 64	56	15.24	27	17.40	56.254	-27.290	2733	2:09	12.1	1:38	Station CTD	10	6	5:37	7:46	
MSM2/426-1	sta 65	56	26.46	27	26.10	56.441	-27.435	2726	2:18	12.2	1:33	Station CTD	10	6	9:19	11:38	
MSM2/427-1	sta 66	56	37.74	27	34.80	56.629	-27.580	2721	2:18	12.3	1:33	Station CTD	10	6	13:12	15:30	
MSM2/428-1	sta 67	56	49.02	27	43.77	56.817	-27.730	2813	2:21	12.3	1:34	Station CTD	10	6	17:04	19:26	
MSM2/429-1	sta 68	57	0.30	27	52.74	57.005	-27.879	2747	2:19	12.3	1:33	Station CTD	10	6	21:00	23:20	
MSM2/429-2	PV536	57	0.30	27	52.74	57.005	-27.879	2747	0:10	0.0	0:00	Provor deployt	10	6	23:20	23:30	
MSM2/430-1	sta 69	57	22.62	28	10.32	57.377	-28.172	2594	1:56	24.2	3:13	Station CTD	11	6	2:44	4:40	
MSM2/431-1	sta 70	57	40.44	28	43.56	57.674	-28.726	2460	1:52	25.2	3:33	Station CTD	11	6	8:13	10:05	
MSM2/432-1	sta 71	57	58.26	29	16.62	57.971	-29.277	2126	1:40	25.0	4:49	Station CTD	11	6	14:55	16:36	
MSM2/432-2	PV538	57	58.26	29	16.62	57.971	-29.277	2126	0:10	0.0	0:00	Provor deployt	11	6	16:36	16:46	
MSM2/433-1	sta 72	58	12.48	29	43.44	58.208	-29.724	2224	1:44	20.0	3:17	Station CTD	11	6	20:03	21:47	
MSM2/434-1	sta 73	58	24.60	30	6.12	58.410	-30.102	2176	2:05	17.0	2:37	Station CTD	12	6	0:25	2:30	
MSM2/435-1	sta 74	58	33.00	30	21.90	58.550	-30.365	1702	1:49	11.8	1:40	Station CTD	12	6	4:10	6:00	
MSM2/436-1	sta 75	58	43.62	30	41.76	58.727	-30.696	1453	1:41	14.8	2:03	Station CTD	12	6	8:03	9:45	
MSM2/437-1	sta 76	58	50.64	31	16.08	58.844	-31.268	1484	1:27	19.1	2:35	Station CTD	12	6	12:20	13:47	

MSM station name	Task	Latitude deg N	min	Longitude deg W	min	Dec. Latitude	Dec. Longitude	Depth (m)	Duration (h)	Dist from n-1 (nm)	time to be reached (h)	Task	Day of arrival	mo.	Time of arrival	Time of departure	Time reference
MSM2/438-1	sta 77	58	54.60	31	54.66	58.910	-31.911	1689	1:26	20.3	2:35	Station CTD	12	6	16:23	17:49	
MSM2/439-1	sta 78	58	58.32	32	33.18	58.972	-32.553	1873	1:32	20.2	2:26	Station CTD	12	6	20:16	21:48	
MSM2/440-1	sta 79	59	2.34	33	11.58	59.039	-33.193	2279	1:45	20.2	2:26	Station CTD	13	6	0:14	2:00	
MSM2/441-1	sta 80	59	6.18	33	49.86	59.103	-33.831	2273	1:45	20.0	2:33	Station CTD	13	6	4:34	6:20	
MSM2/441-2	PV526	59	6.18	33	49.86	59.103	-33.831	2273	0:10	0.0	0:00	Provor deployt	13	6	6:20	6:30	
MSM2/442-1	sta 81	59	9.90	34	28.56	59.165	-34.476	2538	2:17	20.2	2:43	Station CTD	13	6	9:13	11:30	
MSM2/443-1	sta 82	59	13.92	35	6.90	59.232	-35.115	2985	2:17	20.0	2:42	Station CTD	13	6	14:13	16:30	
MSM2/444-1	sta 83	59	17.94	35	45.72	59.299	-35.762	3093	2:51	20.2	2:34	Station CTD	13	6	19:05	21:56	
MSM2/445-1	sta 84	59	21.84	36	23.76	59.364	-36.396	3089	2:20	19.8	2:31	Station CTD	14	6	0:28	2:49	
MSM2/446-1	sta 85	59	25.68	37	2.22	59.428	-37.037	3120	2:22	19.9	2:47	Station CTD	14	6	5:36	7:58	
MSM2/447-1	sta 86	59	29.52	37	40.80	59.492	-37.680	3107	2:21	20.0	2:49	Station CTD	14	6	10:47	13:09	
MSM2/448-1	sta 87	59	32.16	38	6.38	59.536	-38.106	3090	2:21	13.2	2:36	Station CTD	14	6	15:45	18:06	
MSM2/449-1	sta 88	59	34.80	38	31.96	59.580	-38.533	3000	2:18	13.2	15:34	Station CTD	15	6	9:41	11:59	
MSM2/450-1	sta 89	59	37.44	38	57.54	59.624	-38.959	2889	2:14	13.2	2:24	Station CTD	15	6	14:23	16:37	
MSM2/451-1	sta 90	59	39.44	39	23.40	59.657	-39.390	2830	2:12	13.2	2:24	Station CTD	15	6	19:01	21:13	
MSM2/452-1	sta 91	59	41.44	39	49.26	59.691	-39.821	2730	2:09	13.2	2:24	Station CTD	15	6	23:37	1:46	
MSM2/453-1	sta 92	59	43.44	40	15.12	59.724	-40.252	2649	2:06	13.2	1:39	Station CTD	16	6	3:26	5:33	
MSM2/454-1	sta 93	59	44.39	40	36.09	59.740	-40.602	2510	2:01	10.6	1:22	Station CTD	16	6	6:55	8:57	
MSM2/455-1	sta 94	59	45.33	40	57.06	59.756	-40.951	2225	1:52	10.6	1:22	Station CTD	16	6	10:20	12:12	
MSM2/456-1	sta 95	59	46.27	41	18.03	59.771	-41.301	2065	1:46	10.6	1:22	Station CTD	16	6	13:35	15:21	
MSM2/457-1	sta 96	59	47.22	41	39.00	59.787	-41.650	1890	1:41	10.6	1:22	Station CTD	16	6	16:44	18:25	
MSM2/458-1	sta 97	59	51.95	41	56.61	59.866	-41.944	1735	1:35	10.0	1:52	Station CTD	16	6	20:17	21:53	
MSM2/459-1	sta 98	59	47.22	41	38.71	59.787	-41.645	1880	1:40	10.2	8:23	Station CTD	17	6	6:17	7:58	
MSM2/460-1	sta 99	59	46.26	41	17.97	59.771	-41.300	2044	1:56	10.5	1:21	Station CTD	17	6	9:19	11:16	
MSM2/460-2	glider 004	59	46.26	41	17.97	59.771	-41.300	2044	03:00	0.0	0:00	Glider deployt	17	6	11:16	14:16	

MSM station name	Task	Latitude deg N	min	Longitude deg W	min	Dec. Latitude	Dec. Longitude	Depth (m)	Duration (h)	Dist from n-1 (nm)	time to be reached (h)	Task	Day of arrival	mo.	Time of arrival	Time of departure	Time reference
MSM2/461-1	mooring A	59	39.22	41	47.60	59.654	-41.793	1894	04:30	16.5	3:42	Mooring recovery	17	6	17:58	22:28	
MSM2/461-2	sta 100	59	39.25	41	47.81	59.654	-41.797	1881	1:40	0.1	0:25	Station CTD	17	6	22:53	0:34	
MSM2/462-1	sta 101	59	1.50	39	49.00	59.025	-39.817	3033	2:34	71.9	7:31	Station CTD	19	6	8:06	10:40	
MSM2/463-1	sta 102	59	9.80	40	14.00	59.163	-40.233	2985	2:17	15.3	1:53	Station CTD	19	6	12:34	14:51	
MSM2/464-1	sta 103	59	17.50	40	39.50	59.292	-40.658	2727	2:08	15.1	1:52	Station CTD	19	6	16:44	18:53	
MSM2/465-1	sta 104	59	23.00	40	56.50	59.383	-40.942	2631	2:05	10.3	1:58	Station CTD	19	6	20:51	22:57	
MSM2/466-1	sta 105	59	28.00	41	14.00	59.467	-41.233	2367	1:56	10.2	1:51	Station CTD	20	6	0:48	2:45	
		61	0.00	35	17.00	61.000	-35.283		0:15	196.0	19:13	Rescue op.	20	6	21:59	22:14	
MSM2/467-1	sta 106	59	44.74	42	3.41	59.746	-42.057	1755	1:36	218.2	21:10	Station CTD	21	6	19:25	21:01	
MSM2/467-2	mooring B	59	45.22	42	7.70	59.754	-42.128	1733	02:40	2.2	0:38	Mooring recovery	21	6	21:40	0:20	
MSM2/468-1	sta 107	59	49.31	42	20.11	59.822	-42.335	375	0:32	7.5	1:08	Station CTD	22	6	1:29	2:01	
MSM2/469-1	sta 108	59	54.31	42	23.85	59.905	-42.398	229	0:32	5.3	0:44	Station CTD	22	6	2:45	3:18	
MSM2/470-1	mooring D	59	48.95	42	19.12	59.816	-42.319	491	01:00	5.9	0:47	Mooring recovery	22	6	4:05	5:05	
MSM2/471-1	mooring Cb	59	47.62	42	15.92	59.794	-42.265	1113	02:40	2.1	0:24	Mooring recovery	22	6	5:30	8:10	
MSM2/472-1	sta 109	59	48.56	42	18.11	59.809	-42.302	820	1:20	1.4	1:03	Station CTD	22	6	9:13	10:34	
MSM2/474-1	sta 110	59	49.03	42	19.07	59.817	-42.318	500	0:44	0.7	0:44	Station CTD	22	6	11:18	12:02	
MSM2/476-1	sta 111	59	47.64	42	15.95	59.794	-42.266	1115	1:05	2.1	1:38	Station CTD	22	6	13:41	14:47	
MSM2/477-1	sta 112	59	46.20	42	11.50	59.770	-42.192	1590	1:31	2.7	0:50	Station CTD	22	6	15:37	17:08	
MSM2/478-1	sta 113	59	43.00	42	0.00	59.717	-42.000	1730	1:35	6.6	1:30	Station CTD	22	6	18:38	20:14	
MSM2/478-2	sta 114	59	39.20	41	47.60	59.653	-41.793	1880	1:32	7.3	1:12	Station CTD	22	6	21:27	23:00	
MSM2/479-1	sta 115	59	33.60	41	29.10	59.560	-41.485	2128	1:25	10.9	1:36	Station CTD	23	6	0:36	2:02	
MSM2/480-1	PV540	62	0.00	35	0.00	62.000	-35.000	2870	0:10	234.1	22:41	Provor deployt	24	6	0:44	0:54	
		62	0.00	26	35.00	62.000	-26.583	775	0:00	237.1	22:33	change route	24	6	23:27	23:27	
		63	20.00	17	10.00	63.333	-17.167	967	0:00	265.9	1.04	change route	26	6	0:22	0:22	
MSM2/481-1	sta 116	63	0.00	16	50.00	63.000	-16.833	1450	1:12	22.0	2:25	Station CTD	26	6	2:47	4:00	

MSM station name	Task	Latitude deg N	min	Longitude deg W	min	Dec. Latitude	Dec. Longitude	Depth (m)	Duration (h)	Dist from n-1 (nm)	time to be reached (h)	Task	Day of arrival	mo.	Time of arrival	Time of departure	Time reference
MSM2/482-1	sta 117	62	40.00	16	30.00	62.667	-16.500	1910	1:27	22.0	2:26	Station CTD	26	6	6:26	7:54	
MSM2/482-2	free-ctd-3	62	40.00	16	30.00	62.667	-16.500	1910	1:42	0.0	0:00	free-fall ctd	26	6	7:54	9:36	
MSM2/483-1	sta 118	62	20.00	16	10.00	62.333	-16.167	2100	1:34	22.1	2:36	Station CTD	26	6	12:12	13:46	
MSM2/483-2	PV541	62	20.00	16	10.00	62.333	-16.167	2100	0:10	0.0	0:00	Provor deployt	26	6	13:46	13:56	
MSM2/484-1	sta 119	62	0.00	15	50.00	62.000	-15.833	2240	1:38	22.1	2:43	Station CTD	26	6	16:40	18:18	
MSM2/485-1	sta 120	61	40.00	15	30.00	61.667	-15.500	2340	1:56	22.1	2:36	Station CTD	26	6	20:55	22:51	
MSM2/485-2	sta 121	61	40.00	15	30.00	61.667	-15.500	100	0:28	0.0	0:24	Test Seabird	26	6	23:15	23:44	
MSM2/485-3	sta 122	61	40.00	15	30.00	61.667	-15.500	2340	1:28	0.0	0:00	Test Seabird	26	6	23:44	1:12	
MSM2/485-4	PV	61	40.00	15	30.00	61.667	-15.500	2340	0:10	0.0	0:00	Provor deployt	27	6	1:12	1:22	
Thorshavn		62	0.00	6	47.00	62.000	-6.783	0		246.3	1.03	Arrival	28	6	3:00		time change: UTC-1

1.7.Concluding remarks

Several technical issues mainly due to the ship youth delayed the work by 6 days. An accident was deplored. However, tenacity and competence of the crew led by Captain von Staa was determinant in the achievement of this cruise. The only unperformed work was the mooring deployment planned on the shelf at 63°N for our German colleagues. Reasons were both difficult sea-ice conditions and a broken pod. The thermosalinograph data may also be difficult to use, due to intermittent pump problems. Despite this, the Spanish GASPAR system, used to measure surface pCO_2 along the route, could provide relatively good data.

We gathered an impressive harvest of good quality data, including CTD, tracers and direct current measurements. In terms of transports, first estimates show a MOC that is 40% weaker than 1997 estimate. This quite striking result goes with a weakening of all the main currents of the North Atlantic that are crossed by Ovide section (NAC, EGC, DWBC). This result needs to be explained by a more detailed analysis of the Subpolar Gyre dynamics. Particularly, the disagreement with some recent data synthesis assessing a relatively stability of the MOC needs to be thoroughly discussed in terms of the time scale of the anomalies for example.

The situation near Greenland was quite unusual. After a decade of sea-ice retreat at this latitude, a large pack of multiyear ice drifted through Fram Strait at the beginning of the year (seen by satellite images) and was found a few month later along the south-east coast of Greenland. Recovering the four moorings turned out to be a patience game, followed by an intensive day of work, when easterlies finally pushed the ice against the coast for a few hours. All four moorings were recovered, with a 90% data return. First estimates of the current near Greenland indicate an unusually weak East Greenland Current while we were on site, and the EGCC could not be sampled at all unfortunately.

During the cruise, several instruments were tested: an autonomous CTD performed 2 profiles, a brand new Vertical Micro Profiler performed 3 profiles, including one at more than 5-km depth. The VMP was lost at the fourth profile east of Reykjanes Ridge, and different elements let us think that it stayed stuck at the bottom, despite several safeties to release the lest. A specific report was written.

Along the Ovide section and on our way to the Faeroe Islands, 16 profiling floats (PROVOR) were deployed in the frame of the ARGO program. They are programmed to drift at 1000m depth and collect temperature and salinity profiles from 2000m and surface every 10 days. They should be active for about 4 years. The passage near the Central Irminger Sea mooring was also the occasion to deploy a Spray glider from the European MERSEA project in order to complement the mooring measurements. The glider was recovered by the Discovery 2 months later. Finally, on our way back, 48 Expendable BathyThermographs (XBT) were launched. All the data collected by the PROVOR, the glider, the XBT and a vertically subsampled CTD dataset have been sent to the Coriolis Regional Data Center [http://www.coriolis.eu.org/] in real time.

1.8.References

Aminot, A. & Chaussepied, M., 1983. Manuel des analyses chimiques en milieu marin. Publications du CNEXO, 395p.

Bacon, S., 2006. Cruise Report No. 11 : RRS Discovery Cruise 298 23 Aug. – 25 Sep. 2005, CFER-1. NOC Southampton. http://eprints.soton.ac.uk/42442 .

Connan, O., Le Corre, P. & Morin, P., 1996. Analyse des composés halocarbonés volatils dans l'eau de mer : extraction par un système de purge and trap, dosage par chromatographie en phase gazeuse. Analusis, 24, 55-59.

Gourcuff, C., P. Lherminier, C. Kermabon, H. Mercier, Sept. 2006. OVIDE 2006 : Traitement des données de l’ADCP de Coque RDI « Ocean Surveyor » 75kHz du Maria S. MERIAN. Rapport OPS/LPO 06-07.

Lherminier, P., H. Mercier, C. Gourcuff, M. Alvarez, S. Bacon, C. Kermabon, 2007. Transports across the 2002 Greenland-Portugal OVIDE section and comparison with 1997. J. Geophys. Res., 112(C7), C07003, doi:10.1029/2006JC003716.

Morin, P., E. Louarn, G. Thoumelin, T. Cariou, B. Cocquempot, and E. Macé, Aug. 2007. Recueil des données Ovide 2006 : Traceurs géochimiques (Éléments nutritifs et fréons).

Saunders, P.M., 1986. The accuracy of measurement of salinity, oxygen and temperature in the deep ocean. J. Phys. Oceanogr., 16, 189-195.

Vázquez-Rodríguez, M., X. A. Padin, A. F. Ríos, R. G. J. Bellerby, F. F. Pérez, 2007. Anthropogenic carbon determination from subsurface boundary conditions. Submitted to Deep Sea Research I.

Visbeck, M, 2002. Deep Velocity Profiling Using Lowered Acoustic Doppler Current Profilers : Bottom Track and Inverse Solution. Journal of Atmospheric and Oceanic Technology, 2002, 794-807.

WOCE Operations Manual, 1991. Volume 3 : The Observational Program Section 3.1 WOCE Hydrographic Program Part 3.1.3 : WHP Operations and Methods. WOCE Report n°68/91, July 1991.