RV Pelagia Shipboard Report:

Cruise 64PE240, Project CLIVARNET Atlantic Monitoring Programme (CAMP)

C. Veth
Chief Scientist

CAMP 2005

BSIK
LOCO
CIS
VAMOC
CarbOcean

Royal NIOZ Texel, 2005

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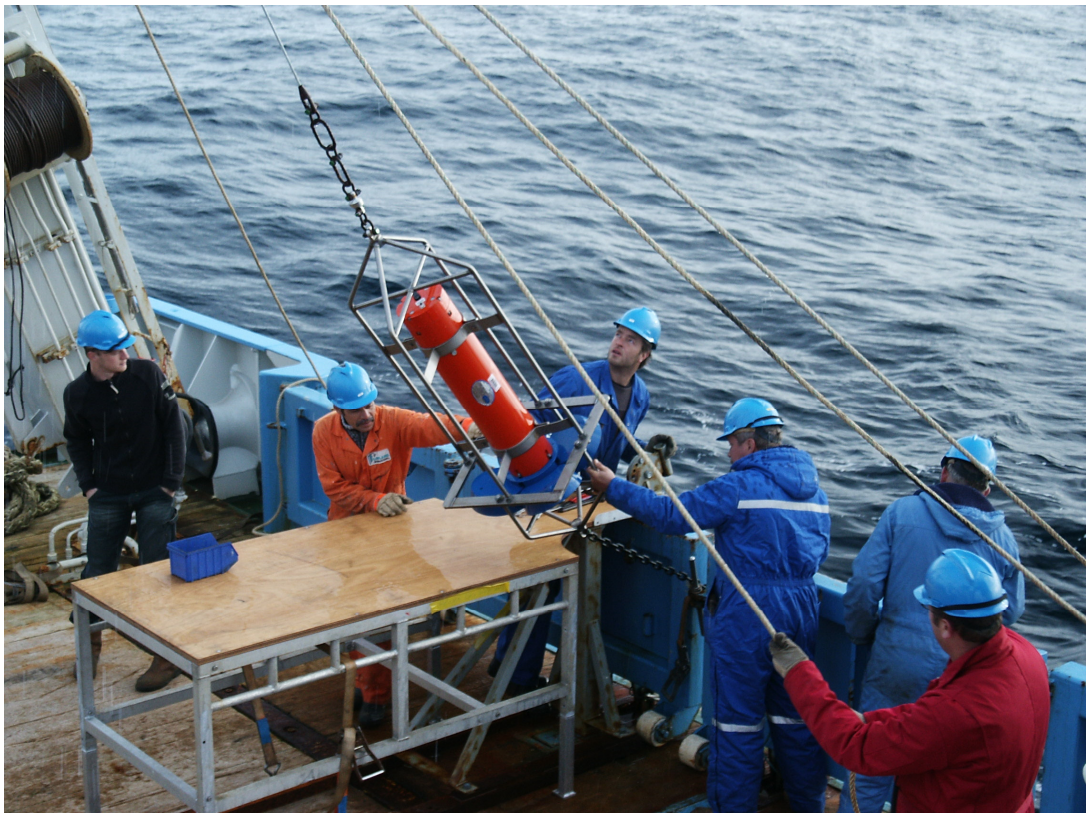
The research reported here is part of the Royal NIOZ contribution to the Dutch Clivar programme and also contributes to the Dutch LOCO programme, which received funding from the Netherlands Foundation for Scientific Research (NWO) and BSIK-KvR. Additional funding for the biogeochemical contribution came from the Foundation for Earth and Life Sciences (ALW), a subsidiary of NWO, within the VAMOC-project, as part of the joint UK, N and NL RAPID-programme.



1 Cruise Narrative

1.1 Highlights

a: Goals: The re-survey of WOCE Hydrographic Program Repeat Section A1/AR7E between Ireland and Greenland as part of the CAMP programme and the deployment of long term moorings in the Irminger Sea for the LOCO as well as VAMOC and CIS programmes.

b: Expedition Designation (EXPOCODE): 64PE240

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d: Ship: RV Pelagia, Call Sign: PGRQ, Captain: Mr. John Ellen
length 66 m.
beam 12.8 m
draft 4 m
maximum speed 11 knots

e: Ports of Call: Peterhead to Texel

f: Cruise dates: September 7, 2005 to October 5, 2005

1.2 Cruise Summary Information

September 8th . R.V. Pelagia left the harbour of Peterhead at 18:00 UTC and headed for the Pentland Firth.

September 9th. After the Pentland Firth in the direction of the southernmost point of Greenland.

September 10th. First CTD test station. Eight SeaCats mounted on the CTD-frame for calibration. Experiments to test flushing of the NOEX-bottles. Deteriorating weather (remains of hurricane Maria).

September 11th. Test CTD-cast. Investigation possible leakage of fresh water from closing system into the bottles.

September 12th. Much wind thanks to former hurricane Maria. Laboratory testing ARGO-floats.

September 13th. Deployment two KNMI ARGO-floats. Weather improved, but strong swell. Calibration cast near the position of the two KNMI ARGO-floats.

September 14th. Recovery of mooring LOCO03-2 in the morning. Deployment of LOCO03-3 in the afternoon followed by a calibration CTD-cast. The LOCO-moorings contain a McLane profiler, two RDI ADCP's and a SeaCat.

September 15th. Recovery of mooring IRM-2 with 2 sediment traps. The upper sediment trap did not function, but the bottom trap worked well. Recovery of mooring LOCO02-2. In the afternoon deployment of LOCO02-3 on the same position.

September 16th. Recovery of the ANIMATE/CIS-mooring. Start sailing in the direction of point P1 of the CTD-section along the former WOCE A1E-section..

September 17th. Shallow CTD-cast on the Greenland Shelf. Touristical visit near the coast and towards a stranded iceberg near Kap Hoppe. Extremely clear sight of more than 150 km. Photographs taken from Pelagia with iceberg from rubberboat. Many whales were observed. Iceberg samples were taken.

September 18th. Continued CTD-work. At station# 11 the ARGO-float was deployed for the Bedford Institute of Oceanography (Canada).

September 19th. Redeployment of the ANIMATE/CIS mooring. G.-J. Brummer got permission to use the British trap that originally had been part of the ANIMATE/CIS mooring. The owner of the trap passed during the day on board the RV Discovery. The IRM-3 mooring was deployed in the afternoon.

September 20th. Continuation of the CTD-section.

September 21st. Surprise: a red deep-sea shrimp turned up with the CTD. The two other KNMI ARGO-floats deployed. Continued CTD-work.

September 22nd. Continuation of the CTD-section.

September 23rd. Continuation of the CTD-section. First IFM-Hamburg ARGO-float deployed.

September 24th. Continuation of the CTD-section. Second and third IFM-Hamburg ARGO-floats deployed.

September 25th. Continuation of the CTD-section. Stop at CAMP-station P28 (=station # 37)

September 26th and September 27th. Storm. No data collection.

September 28th. Start CTD-section at CAMP-station P36 (=station # 38). No CTD-casts on the Rockall Plateau (after consulting H.M. van Aken).

September 29th. Continuation of the CTD-section until the Irish Continental Shelf. Heading north for the Poseidon moorings in the Faroe-Shetland Channel.

September 30th. Recovery ADCP-mooring. Strong wind and swell.

October 1st. Recovery STABLE bottom lander. Strong wind and swell. October 2nd - Heading for Texel.

Cruise Track

The cruise was carried out in the North Atlantic Ocean. The cruise track is shown in figure 1

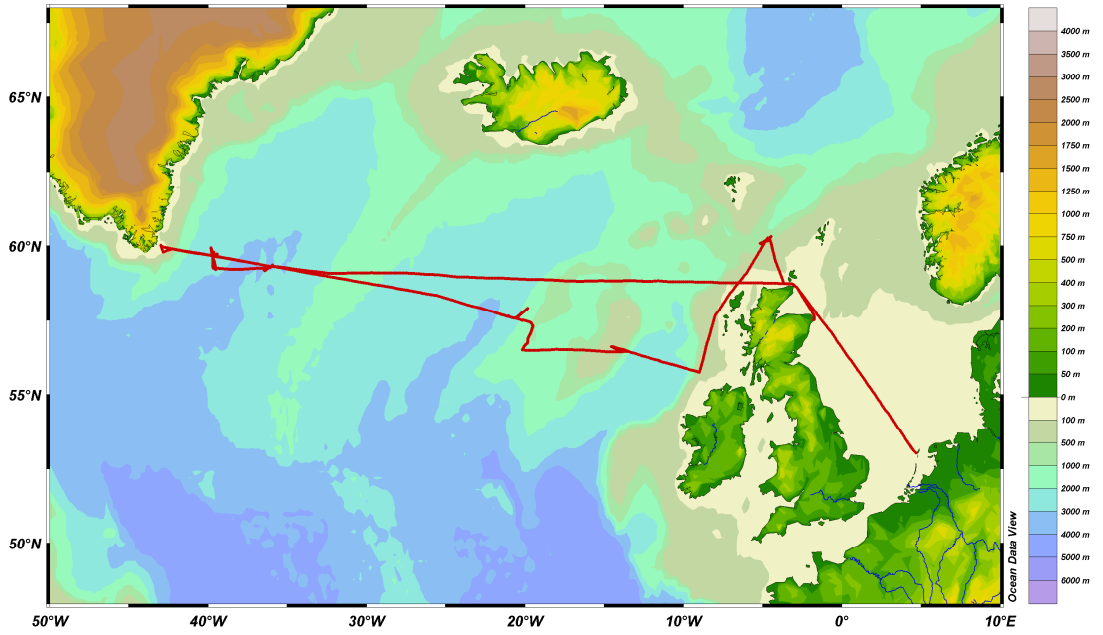


Figure 1. The cruise track of RV Pelagia during cruise 64PE240.

Mooring Deployments

At four positions a mooring was recovered and later re-deployed (see table 1 and figure 3). Moorings LOCO 02-2/3 and LOCO 03-2/3 were profiling moorings, fitted with a McLane/FSI CTD profiler, two RDI Long Ranger ADCPs and an SBE Seacat CTD. They were deployed at a depth of about 3000 m. Mooring IRM-2/3 was fitted with a Technicap-PPS5 sediment trap and a data logger in a bottom frame and another such sediment trap with data logger at ~250 m. This mooring was located at short distance from mooring LOCO 02-2/3.

MOORING	Action	DATE & TIME	LAT			LON			Echo depth
LOCO2-2	recovery	Sep 15 2005 10:18:46	59	12.32	N	39	29.947	W	3042
LOCO2-3	deployment	Sep 15 2005 16:44:10	59	16.21	N	39	29.798	W	3018
LOCO3-2	recovery	Sep 14 2005 08:32:16	59	14.64	N	36	23.655	W	3048
LOCO3-3	deployment	Sep 14 2005 14:39:41	59	11.59	N	36	26.742	W	2896
IRM-2	recovery	Sep 15 2005 08:16:31	59	14.87	N	39	39.796	W	3012
IRM-3	deployment	Sep 19 2005 19:07:11	59	15.05	N	39	38.461	W	3038
CIS	recovery	Sep 16 2005 10:57:19	59	40.91	N	39	42.622	W	2798
CIS	deployment	Sep 19 2005 08:49:28	59	43.33	N	39	25.208	W	2824

Table1. Positions of the moorings, serviced during Pelagia Cruise 64PE240. Further details of the mooring configuration are given in Appendix B.

Hydrographic Stations

A total of 43 CTD casts were performed of which 36 were located along the former WOCE A1E section. The location of these casts is shown in figure 2. Further information on the time, location and samples taken during these casts can be found in the Cruise Summary File (Appendix A).

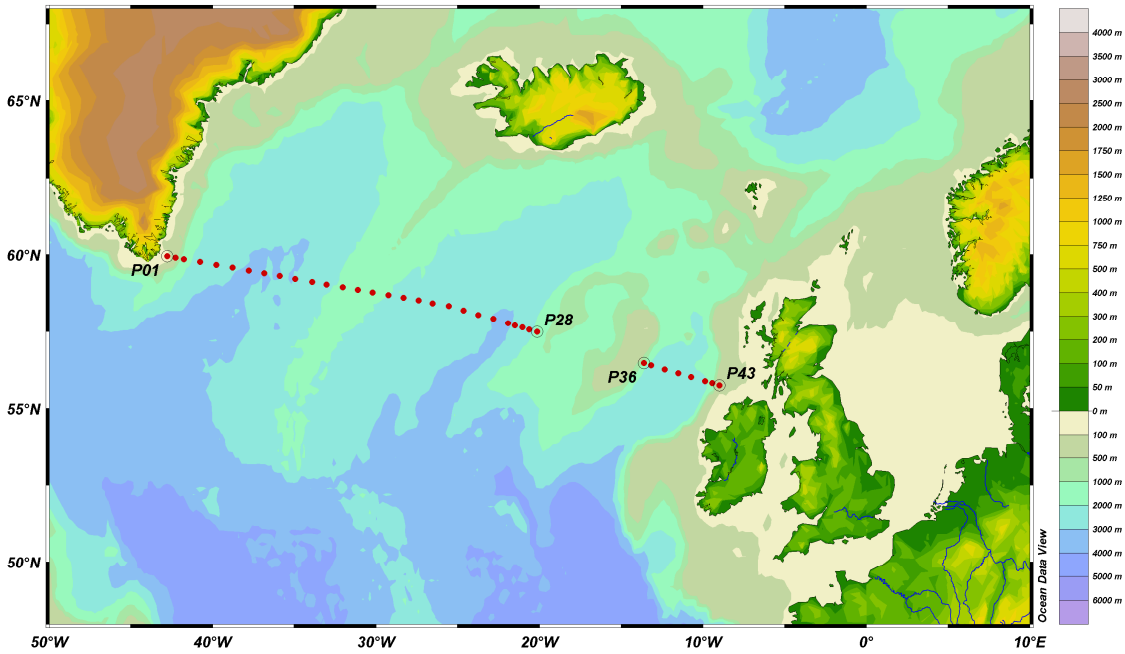


Figure 2. Position of the CTD casts along the former WOCE A1E section.

Special Stations

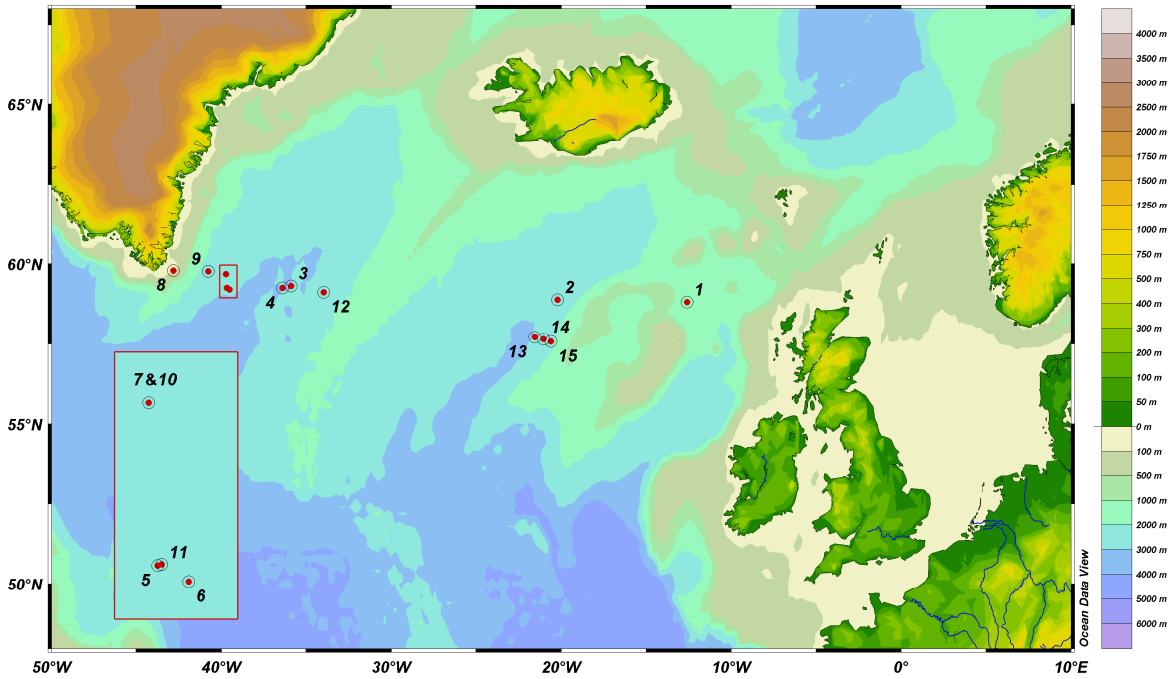


Figure 3. Special stations during the cruise(test CTD's, ARGO-floats, moorings, iceberg)

Legenda to the numbers of special stations presented in figure 3.

1. and 2. Test CTD-casts
3. 2 KNMI ARGO-floats
4. LOCO03-2 mooring recovery, LOCO3-3 deployment
5. IRM-2 mooring
6. LOCO02-2 mooring recovery, LOCO2-3 deployment
7. CIS-mooring recovery
8, Iceberg sample
9. Bedford Inst. Of Oceanography ARGO-float
10. CIS-mooring deployment
11. IRM-3 mooring deployment
12. 2 KNMI ARGO-floats
13. IFM-Hamburg ARGO-float
14. IFM-Hamburg ARGO-float
15. IFM-Hamburg ARGO-float

Not shown in the figure 3 are the positions of the recovered moorings in the Faroe-Shetland Channel.

Hydrographic Sampling

During the up-cast of the CTD/rosette water samples were taken. The water samples were analysed shipboard for the determination of salinity, dissolved nutrients (phosphate, nitrate, nitrite and silica) and oxygen, DIC and alkalinity. Samples were taken for DOC at all depths as well as for the oxygen isotope composition of the bottom water. Additionally calibration control measurements of pressure and temperature were made for each closed bottle. Furthermore surface water pCO_2 was measured continuously.

1.3 List of Principal Investigators

Name	Responsibility	Affiliation
Dr H.M. van Aken	Ocean hydrography	Royal NIOZ/Texel
Drs. M.F. de Jong	Ocean hydrography	Royal NIOZ/Texel
Dr. G.-J. A. Brummer	Biogeochemical fluxes	Royal NIOZ/Texel
M. Busack	CIS-mooring	IfM-GEOMAR/Kiel
Dr. H. Zemmelink	Carbonate chemistry	Royal NIOZ/Texel

1.4 Scientific Programme and Methods

The dual goal of the research carried out during the cruise was to establish the hydrography along a zonal section between Ireland and Greenland and to service four instrumented moorings in the Irminger Sea.
The zonal section is the former A1E/AR7E section of the WOCE Hydrographic Programme, which has been surveyed near-annually since 1990. The re-survey of this section is carried out in order to determine climate related inter-annual changes of the hydrographic structure in the North Atlantic Ocean. This survey has been planned in co-ordination with IfMH, Hamburg and BSH, Hamburg. These institutes are involved in the regular surveys of the A1E and A2 sections in the North Atlantic.

The CTD-rosette frame was fitted with weights in order to secure a fast enough falling rate. This package was lowered with a velocity of about 1 m/s, except in the lowest 100 m where the veering velocity was reduced. Measurements during the down-cast went on to within 3 m from the bottom, until the bottom switch indicated the proximity of the bottom. Over the Reykjanes Ridge the bottom switch wire was lengthened to 5 m. During the up-cast water samples where taken at prescribed depths, when the CTD winch was stopped. After each cast the CTD/rosette frame was placed on deck and the readings of the reversing electronic pressure sensors were recorded. Subsequently water samples were drawn for the determination of salinity, dissolved nutrients (phosphate, nitrate, nitrite and silica), TN, TP, oxygen, DOC, DIC and alkalinity as well as the oxygen isotope composition of the bottom water. In addition, chlorophyll samples were taken at the CIS and IRM mooring sites.
The moorings were deployed form part of the Dutch Long-term Ocean Climate Observations programme (LOCO). This programme aims at the establishment of a monitoring system that records climate relevant oceanographic parameters. Two of the moorings (LOCO2-2/3 and LOCO3-2/3) contain a profiling CTD which will record on a daily basis profiles of temperature and salinity between ~2200 and 100 m depth. Additionally ADCPs will record the velocity profiles in the upper and lower 600 m. It is intended to maintain these moorings for at least 5 years in the Irminger Sea.
In addition the LOCO program provides the unique opportunity to establish a concurrent 5-year time series of particulate matter fluxes by mooring sediment traps in parallel to the physical observation program in the Irminger Sea, a critical area with respect to deep convective mixing, global ocean circulation and climate change. A time series of particulate matter flux will add on to the current LOCO program by providing a parallel record of the seasonal and inter-annual change in particulate matter fluxes between the upper ocean and the ocean floor with a biweekly resolution. Secondly, it will allow for assessing particle settling through a well-defined volume transport field and better determine the advective components and the temporal dispersal of particles, given the associated *in situ* real-time measurements of ocean circulation recorded by the nearby LOCO-2 mooring. Thirdly, it allows for quantifying the magnitude and composition of the summer bloom with respect to the annual export flux of carbon and associated elements in response to upper ocean stratification. Fourthly, it will provide well-characterised material formed at the extreme end of the ocean temperature range needed for field verification of particle-based proxies for temperature that are used for paleoreconstruction. The sediment trap programme forms part of a PhD study, aiming to assess the effects of changes in the meridional overturning circulation on the sediment flux in the northern Atlantic Ocean in

both present and past. This PhD study is within the Variability of Atlantic Meriodional Overturning Circulation (VAMOC) project.

In support of the CTD observations the sea surface temperature and salinity were recorded continuously, and several meteorological parameters.

1.5 Lists of Cruise Participants

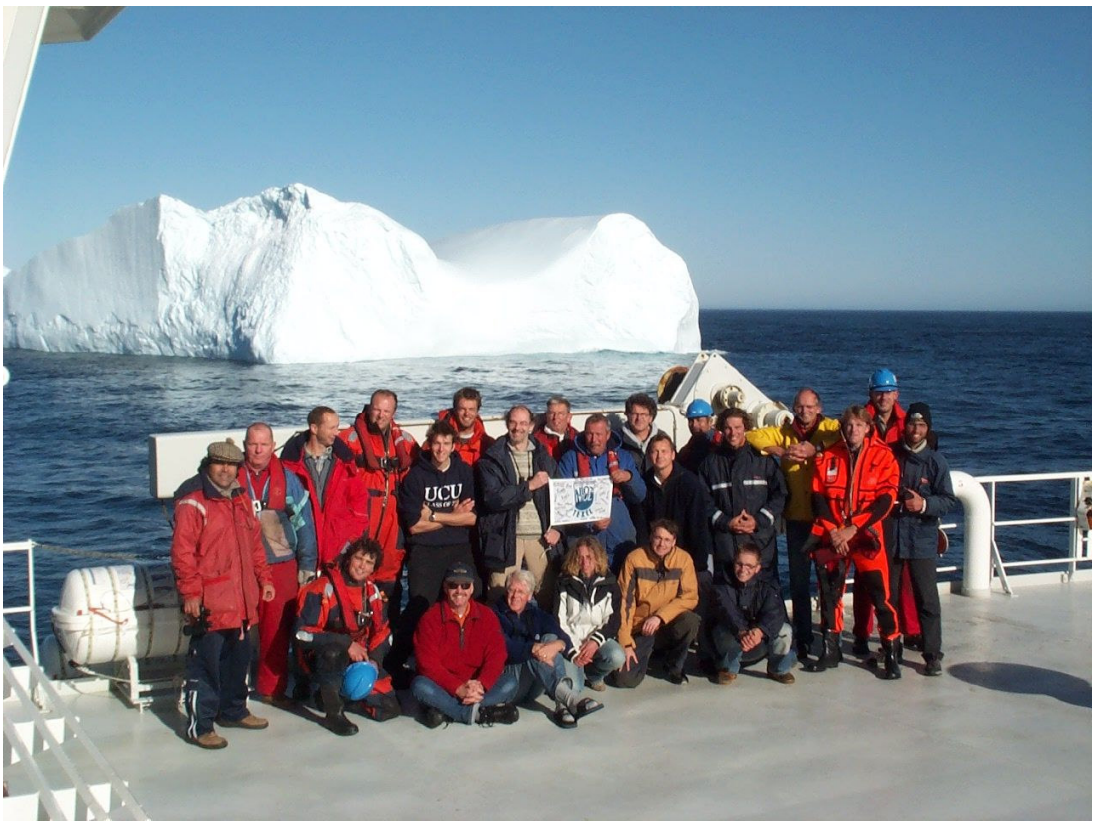
Scientific crew

person	**responsibility**	**Institute**
C. Veth	Chief Scientist	NIOZ
G.-J. A Brummer	sediment traps, chlorophyll	NIOZ
M.F. de Jong	CTD, data management, hydrowatch	NIOZ
R.L. Groenewegen	Electronic engineering, hydrowatch, moorings	NIOZ
L.N. Boom	Mooring construction & engineering	NIOZ
K.M.J. Bakker	Chemical analysis	NIOZ
S.R. Gonzales	Chemical analysis	NIOZ
L.P. Jonkers	sediment traps, chlorophyll	NIOZ
H.J. Zemmelink	Carbon analysis	UEA
S. van Heuven	stud. Marine biol. Carbon analysis	RUG
M. Busack	Mooring technology	IFM-Geomar
M. Kohlhaus	Mooring technology	IFM-Geomar
P. Smorenburg	student oceanography, hydrowatch	IMAU
J. Floor	student oceanography, hydrowatch	IMAU
M. Pau	student oceanography, hydrowatch	IMAU

NIOZ:	*Royal Netherlands Institute for Sea Research, Texel*
IMAU	*Institute for Marine and Atmospheric Research, Utrecht University.*
IFM-Geomar	*Leibnitz-Institut fuer Meereswissenschaften IFM-GEOMAR, Kiel*
UEA	*University of East Anglia, School of Environmental Sciences, Norwich*
RUG	*State University of Groningen*

Ships crew

J.C. Ellen	Captain
M.D. van Duijn	First Mate
R.J. Spaan	Second Mate
K.C. Kikkert	Chief Engineer
H. List	Second Engineer
S. Maas	Ships Technician
J.A. Israel Vitoria	Ships Technician
G. Vermeulen	Ships Technician
R. v/d Heide	Ships Technician
J. Dresken	Cook



2 Underway Measurements

2.1 Navigation

A differential GPS receiver was used for the determination of the position. The data from the GPS receiver and the gyro compass were recorded every ten seconds in the underway data logging system. After removal of a few spikes and application of a 5 min. running mean these data were sub-sampled every five minutes. An additional Thales Aquarius^2 dual antenna GPS receiver also determined the ship's heading. During the cruise the Thales Aquarius^2 dual antenna GPS receiver stopped working.

2.2 Echo Sounding

The 3.5 kHz echo sounder was used on board to determine the water depth. The uncorrected depths from this echo sounder were recorded in the underway data logging system.

2.3 Thermo-Salinograph Measurements

The Sea Surface Temperature, Salinity, Fluorescence and Optical Back-Scatter were measured continuously with the thermo-salinograph system with the water intake at a depth of about 3 m. For the calibration of the salinity sensor, water samples were taken. The sensors for Fluorescence and Optical Back-Scatter didn't measure properly and the container for determining the Fluorescence was leaking. These two sensors have been switched off.

2.4 Meteorological data

Air temperature and humidity, relative wind velocity and direction as well as air pressure and solar radiation were measured and recorded by the underway logging system. The wind direction sensor was found to be unreliable.

3 Measurements - Descriptions, Techniques, and Calibrations

3.1 Rosette Sampler and Sampler Bottles (R. Groenewegen)

A 22 position rosette sampler was used, fitted with 10 litre NOEX sampler bottles. A multi-valve system, developed at NIOZ, allowed closing the sampler bottles by computer command from the CTD operator. A new piston pressure system was applied to close the bottles. This new system operated very well as long as one does not forget to fill up the pressure tank.

3.2 Temperature measurements (R. Groenewegen)

Mounted on the CTD-rack was a high precision SBE35 reference temperature sensor, which recorded the temperature every time a sampler was closed. Halfway the cruise the integration time of the SBE35 has been reset from 32 to 20 seconds.

3.3 Pressure measurements (CTD party)

On sampler bottles 1, 6, and 11 thermometer racks were mounted, fitted with 2 SIS reversing electronic pressure sensors. On deck, prior to the CTD cast, these pressure sensors corrected internally for zero pressure. The readings of these sensors are used to monitor, and if necessary to correct the calibration of the CTD pressure sensor.

3.4 Salinity sampling (CTD party)

Water samples for the salinity determination were collected in homogeneous layers at a depth of 2000 m and deeper. After 3 times rinsing water was drawn from the samplers into a 0.25 litre glass sample bottle a stopper as well as a screw lid for subsequent salinity determination at NIOZ. The salinity data will be used to check the calibration of the CTD conductivity sensor (SN 043035).

3.5 Oxygen measurements (S. Gonzalez)

For the determination of dissolved oxygen concentration, water samples were drawn into pre-calibrated 120 ml pyrex glass bottles. Before drawing the sample, each bottle was flushed with at least 3 times its volume. The determination of the volumetric dissolved oxygen concentration of water samples was carried out by measuring the formed Iodine colour at 460nm on a Traacs 800 continuous flow spectro-photometer, combined with a stand-alone NIOZ-made sampler, based on Winkler technique (see Su-Chen Pai et al., Marine Chemistry 41 (1993), 343-351). Immediately after acidification, all bottles were covered with

parafilm against evaporation and shielded with PVC caps to prevent light-induced Iodine formation. A stock solution of KIO_3 was used in the analysis spiked to seawater blanks (reversed order addition of the Winkler chemicals) to obtain a calibration line, with an R^2=1.0000 for 4 calibrants in each run, for calibrating the spectrophotometer. The stock solution was stored in an airtight water-saturated box (100% humidity) to prevent evaporation.

At each cast duplicate samples were taken from the shallowest Rosette-bottle, in order to determine the inter variability between the daily runs. Gain-drift of the spectrophotometer was corrected by the used software. To obtain accuracy in between the runs a reference sample was measured, drawn from a large volume of saturated ocean water (50l container) bottled according to Winkler. The reference yielded a narrow band signal of +/- 1 µMol on a level of 236 µMol O_2 between the runs and better than 0.20 µMol within a run. From the volumetric oxygen concentration in µMol/dm^3 the densimetric oxygen concentration in µMol/kg was determined by dividing the sample density at sample temperature and salinity.

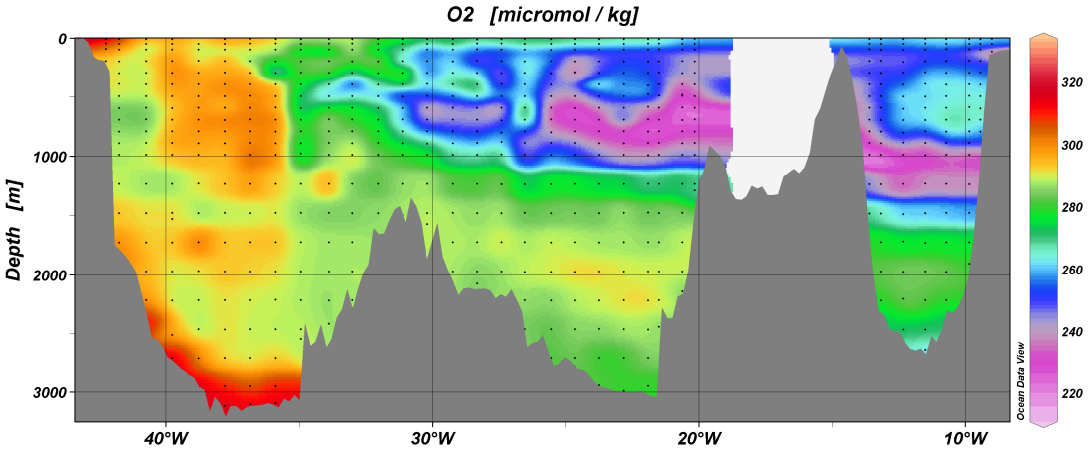


Figure 4. Dissolved oxygen concentration

3.6 Nutrient measurements (K. Bakker)

From all Rosette bottles samples were drawn for the shipboard determination of the nutrients silica, nitrite, nitrate and phosphate. The samples were collected in polyethylene sample bottles after three times rinsing. The samples were stored dark and cool at 4°C. All samples were analysed within 12 hours with an autoanalyzer based on colorimetry using a Technicon TRAACS 800 autoanalyzer. The samples, taken from the refrigerator, were directly poured in open polyethylene vials (6ml) and put in the auto sampler-trays. A maximum of 60 samples in each run was analysed. The different nutrients were measured colorimetrically as described by Grashoff (1983).

- Silicate reacts with ammoniummolybdate to a yellow complex, which, after reduction with ascorbic acid forms a blue silica-molybdenum complex that was measured at 800nm (oxalic acid was used to prevent formation of the blue phosphate-molybdenum).
- Phosphate reacts with ammoniummolybdate at pH 1.0, and potassiumantimonyltartrate was used as an inhibitor. The yellow phosphate-molybdenum complex was reduced by ascorbic acid to a blue complex and measured at 880nm.

- Nitrite was diazotated with sulphanilamide and naftylethylenediamine to a pink coloured complex and measured at 550nm.
- Nitrate was mixed with the buffer imidazole at pH 7.5 and reduced to nitrite by a copper-coated cadmium coil (efficiency > 98%), and measured as nitrite (see above) to yield the nitrate content after subtraction of the nitrite content. The reduction efficiency of the cadmium column was measured in each run.

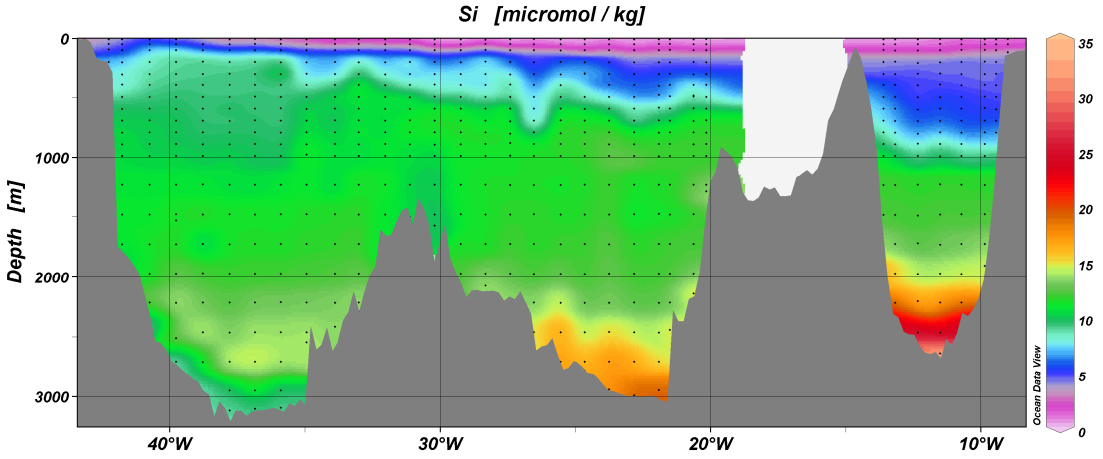


Figure 5. Dissolved silicate

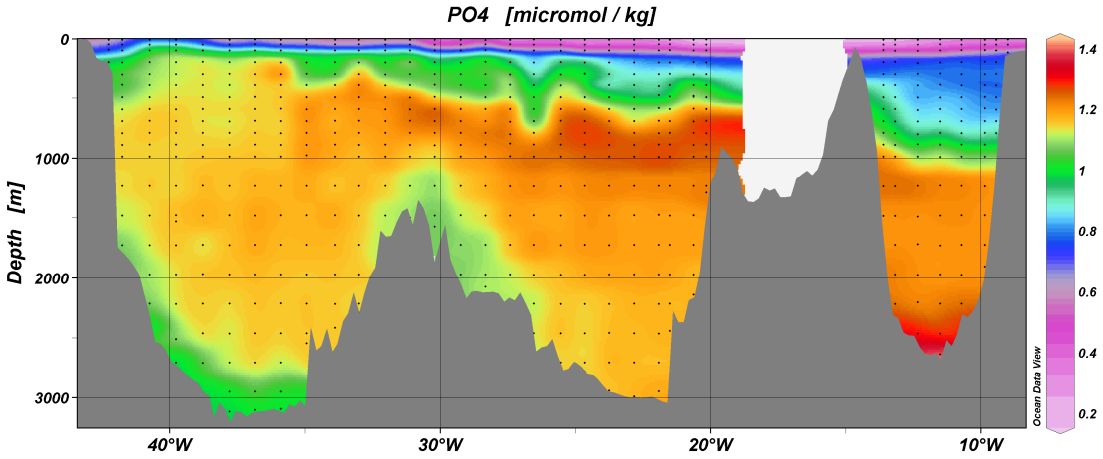


Figure 6. Dissoved phosphate

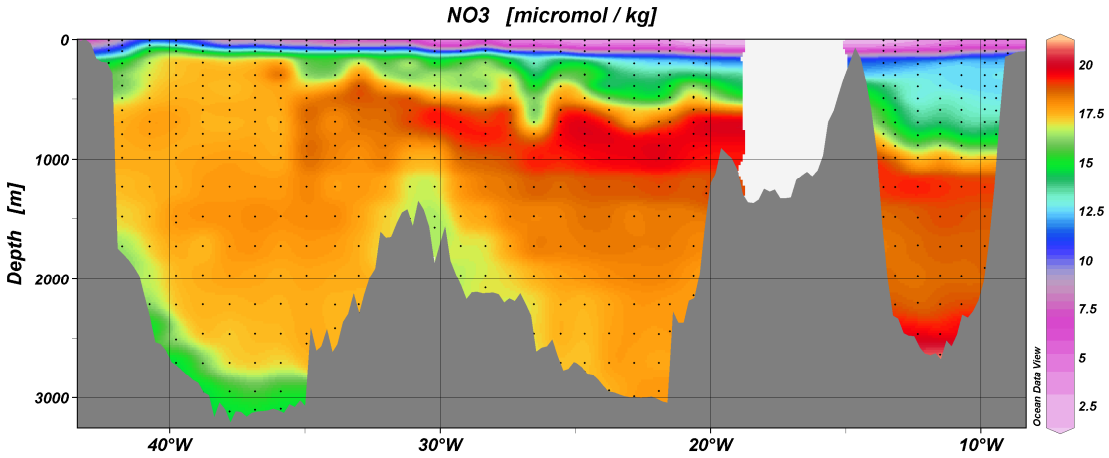


Figure 7. Dissolved nitrate

Calibration standards were prepared by diluting stock solutions of each nutrient in the same nutrient depleted surface ocean water as used for the baseline water. The standards were kept dark and cool in the same refrigerator as the samples. Standards were prepared fresh every two days. Each run of the system had a correlation coefficient for the standards of at least 0.999. The samples were measured from the surface to the bottom to obtain the smallest possible carry-over-effects. In every run a mixed control nutrient standard containing silicate, phosphate and nitrate in a constant and well known ratio, the so-called nutrient-cocktail, was measured, as well as control standards sterilised in an autoclave or gamma radiation. These standards were used to check the performance of the analysis and the gain factor of the autoanalyzer channels. As a result for silica there will be a recalculation of about 1.5 % later in the lab, after checking the standard.

The autoanalyzer determined the volumetric concentration (µMol/dm^3) at a temperature of 24°C. In order to obtain the densimetric concentration in µMol/kg, the volumetric concentrations were divided by the density of sea water at 24°C, at sample salinity and zero sea level pressure.

In addition, samples were taken for determination of the concentrations of total nitrogen (TN) and total phosphorous (TP), which, after subtraction of the inorganic nutrient phases (see above), will yield the concentrations of total organic nitrogen (TON) and total organic phosphorous (TOP). Samples were drawn from all Rosette bottles, then frozen and stored at -20°C for subsequent analysis at Royal NIOZ.

3.7 DOC (S. Gonzalez)

Twenty milliliter samples were collected in amber colored glass vials for the analysis of dissolved organic carbon (DOC). Subsequently five drops of H_3PO_4 were added in order to convert inorganic carbon to CO_2 and the acidified samples were stored at 4˚C for later analysis. At NIOZ, the inorganic carbon will be stripped from 8 ml subsamples by vigorous bubbling with nitrogen. DOC will be measured by combustion of the subsample at 680˚C into an infrared gas analyzer (IRGA, LiCor-6262) using oxygen as carrier gas. Prior to the analysis the carrier gas is dried over a cold trap (-180˚C) and brought back to room temperature.

3.8 DIC and Alkalinity (S. van Heuven and H. Zemmelink)

Seawater samples were collected at different depths by a rosette unit equipped with NOEX bottles. Subsamples of 0.5 L were collected from the NOEX bottles and analyzed within 12 hours for total dissolved inorganic carbon and alkalinity using a VINDTA-3C system (designed by Dr. L. Mintrop, Marine Analytics and Data, Germany).

Dissolved inorganic carbon (TCO_2) in a 100 ml sample was determined by coulometry. An automated extraction line takes a volumetrical subsample which is acidified with 8.5% phosphoric acid (H_3PO_4) to decrease the pH and all DIC to $CO_{2,aq}$. The sample is stripped using nitrogen gas and the carrier gas is led into the titration cell. This cell contains a solution of dimethylsulfoxide, ethanolamine and the colourimetric indicator thymolphtalein. The irreversible reaction of the CO_2 gas with the ethanolamine generates hydroxyethylcarbamic acid which in turn gives a color change of the dark blue indicator. The fading of the

color is detected photometrically. During the electrochemical titration the hydroxyethylcarbamic acid is neutralized by OH^- ions. From start to end of the titration the current is integrated over time the concentration of DIC computed.

Alkalinity was determined by potentiometric titration of 20 ml samples with 0.1 M HCl. From the titration curve the total carbonate alkalinity (TA) was calculated by subtracting the contribution from other ions present in seawater as determined from the salinity and initial pH of the sample.

The precision of both TA and TCO_2 was determined from duplicate analysis on a number of samples. The accuracy was set by running certified standards made available by Dr. A. Dickson of the Scripps Institution of Oceanography (USA) for each set of 10 samples.

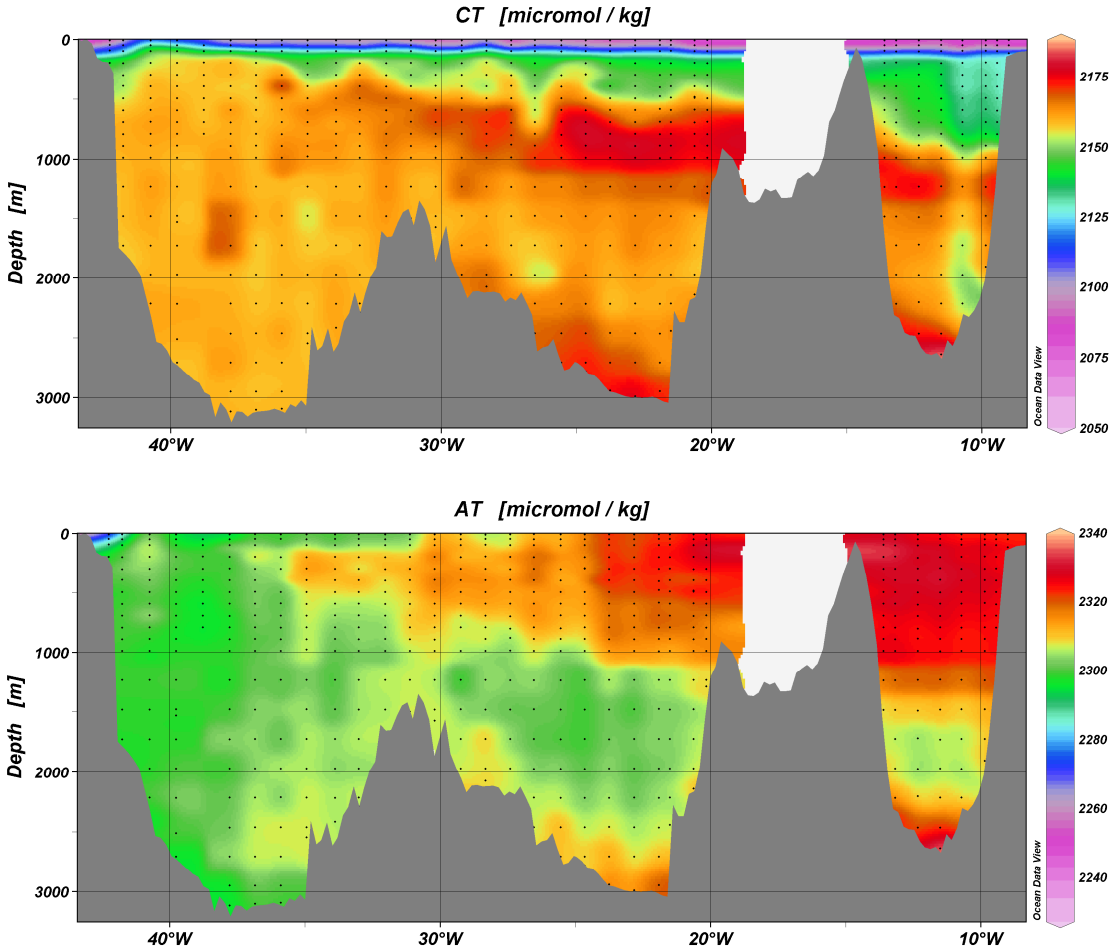


*Figure 8-. Distribution of (**a**) dissolved inorganic carbon (CT) and (**b**) total or titration alkalinity (AT) along the former WOCE AE1 section.*

The concentrations of dissolved inorganic carbon (CT, Fig.8a) vary slightly with depth in the water column. Lowest values, around 2070 µmol kg^{-1}, are found in the surface waters. The Irminger Sea, characterized by Labrador Seawater reveals a homogeneous distribution of around 2160 µmol kg^{-1} with similar values in Denmark Strait Overflow Water at the bottom. CT values increase towards the Rockall Plateau and in the Rockall Through, with highest values in North East Atlantic Deep Water at the bottom and in the North Atlantic Current Water around 1000 m depth.

Total alkalinity (AT, Fig.8b) shows low values (~ 2270µmol kg^{-1}) in the relative fresh water close to Greenland. Alkalinity concentrations in the Irminger sea are homogeneously distributed, while towards the East concentrations increase, with highest values in North Atlantic Current Water between 1000 m and the surface.

3.9 CTD Data Collection and Processing (M.F. de Jong)

For the data collection the new Seasave software for Windows (V 5.28c), produced by SBE, was used. The CTD data were recorded with a frequency of 24 data cycles per second. After each CTD cast the data were copied to a hard disk of the ship's computer network, and a daily back-up copy was made.

On board the up-cast data files were sub-sampled to produce files with CTD data corresponding to each water sample, taken with the rosette sampler. The CTD data were processed with the preliminary calibration data, and reduced to 1 dbar average ASCII files. These were used for the preliminary analysis of the data. Full data processing with the final calibration values will be completed at Royal NIOZ, Texel.

3.10 VMADCP Data Collection and Processing (C. Veth)

The VMADCP data were collected with a dedicated service computer, together with the appropriate navigational data. Daily these data were transferred to the appropriate directory of the ships computer network. For the determination of the alignment of the VMADCP relative to the newly installed dual GPS antennas bottom tracking data were collected over the continental shelves if Ireland and Greenland. Final data processing will take place at NIOZ after the cruise. The Thales Aquarius dual GPS system showed more and more failures during the cruise and stopped providing the ships heading. From that moment the gyro-compass heading was used.

3.11 Sediment trap moorings and sample processing (G.J.A. Brummer and L. Jonkers)

During cruise 64PE240 sediment trap mooring IRM-2 at 59°14.88'N 39°39.21'W (Figure 3) was successfully recovered on September 15, 2005. The mooring was deployed next to CTD-profiler/ADCP-mooring LOCO 02-2 during cruise CD164 on October 2, 2004. It consisted of two Technicap PPS-5/2 sediment traps (24 cups), one mounted in a bottom frame at 2993 m depth, the other at 238 m above the bottom, both with a collecting area of 1.0 m^2 and provided with a 1.5 cm honeycomb baffle. In addition, each sediment trap was provided with a sensor package for recording trap tilt, ambient pressure, temperature, and optical back scattering (OBS), a measure of turbidity, logging the data every 6 minutes. The bottom trap completed its pre-programmed sampling programme, which started on October 6, 2004 at 01:00 UCT with 8 19 days intervals followed by 16 9.5 days intervals, thus ending on August 7, 2005. Due to a motor failure, the trap at 238 m above the bottom collected all sediment in the first bottle. Both sensor packages performed flawlessly. Immediately after recovery and 1, 3 and 13 days later, subsamples were taken of the supernate solution from the collecting cups and filtered for shipboard analysis of dissolved silica and phosphate in order to determine chemical dissolution and physical diffusion fluxes.

Following servicing of the traps and sensors, the mooring was redeployed as IRM-3 at 59°14.86'N 39°39.47'W, waterdepth 3038 m alongside the LOCO 02-3 mooring on September 19 2005. Configuration of the mooring (Figure 9) was the same as for IRM-2, except that the trap at 238 m above the bottom was replaced by a McLane Mark 78G-21 trap recovered from the CIS-mooring nearby. This trap was kindly from the British marine instrumentation pool through mediation by Dr. Lampitt from NOC, Southampton, UK. The McLane Mark 78G-21 sediment trap (21 cups) has a collecting area of 0.5 m^2 and a 2.5 cm honeycomb

baffle. Rotation schemes of both traps are given in table 2. Sample cups of the bottom trap were filled with seawater collected near the deployment depth of the traps and near the actual deployment site, to which a biocide ($HgCl_2$; end-concentration 1.9 g l^{-1}) and a pH-buffer ($Na_2B_4O_7 \cdot 10H_2O$; end concentration 1.9 g l^{-1}) were added, supplemented by milliQ-water. Sample cups 4 through 24 from the recovered shallow IRM-2 trap were reused. These too were filled with ambient seawater, to which a biocide ($HgCl_2$; end-concentration 1.8 g l^{-1}) and a pH-buffer ($Na_2B_4O_7 \cdot 10H_2O$; end concentration 3.6 g l^{-1}) were added, supplemented by milliQ-water to a density of 0.002 g cm $^{-3}$ in excess of the ambient seawater. A blank sample was taken for later comparison with the actual collecting cups to determine chemical dissolution fluxes. As for IRM-2, each sediment trap was provided with a sensor package for recording trap tilt, ambient pressure, temperature and turbidity by optical back scattering (OBS), logging the data every 6 minutes.

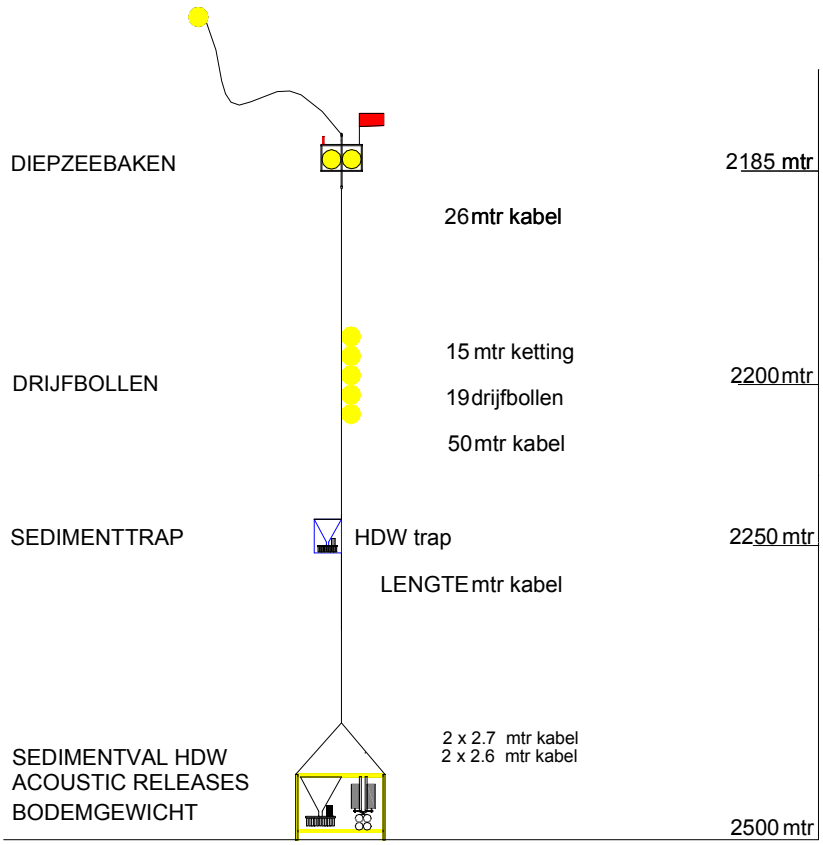


Figure 9. IRM-2 and IRM-3 mooring configuration

Bottom trap			Shallow trap		
Bottle #	Start dd/mm/yr hr:min	Collecting interval (days)	Bottle #	Start dd/mm/yr hr:min	Collecting interval (days)
IRM-3 B1	21/09/05 01:00	16.0	IRM-3 A1	21/09/05 01:00	16.0
IRM-3 B2	07/10/05 01:00	16.0	IRM-3 A2	07/10/05 01:00	16.0
IRM-3 B3	23/10/05 01:00	16.0	IRM-3 A3	23/10/05 01:00	16.0
IRM-3 B4	08/11/05 01:00	16.0	IRM-3 A4	08/11/05 01:00	16.0
IRM-3 B5	24/11/05 01:00	16.0	IRM-3 A5	24/11/05 01:00	16.0
IRM-3 B6	10/12/05 01:00	16.0	IRM-3 A6	10/12/05 01:00	16.0
IRM-3 B7	26/12/05 01:00	16.0	IRM-3 A7	26/12/05 01:00	16.0
IRM-3 B8	11/01/06 01:00	16.0	IRM-3 A8	11/01/06 01:00	16.0
IRM-3 B9	27/01/06 01:00	16.0	IRM-3 A9	27/01/06 01:00	16.0
IRM-3 B10	12/02/06 01:00	16.0	IRM-3 A10	12/02/06 01:00	16.0
IRM-3 B11	28/02/06 01:00	16.0	IRM-3 A11	28/02/06 01:00	16.0
IRM-3 B12	16/03/06 01:00	16.0	IRM-3 A12	16/03/06 01:00	16.0
IRM-3 B13	01/04/06 01:00	8.0	IRM-3 A13	01/04/06 01:00	16.0
IRM-3 B14	09/04/06 01:00	8.0			
IRM-3 B15	17/04/06 01:00	8.0	IRM-3 A14	17/04/06 01:00	16.0
IRM-3 B16	25/04/06 01:00	8.0			
IRM-3 B17	03/05/06 01:00	8.0	IRM-3 A15	03/05/06 01:00	16.0
IRM-3 B18	11/05/06 01:00	8.0			
IRM-3 B19	19/05/06 01:00	16.0	IRM-3 A16	19/05/06 01:00	16.0
IRM-3 B20	04/06/06 01:00	16.0	IRM-3 A17	04/06/06 01:00	16.0
IRM-3 B21	20/06/06 01:00	16.0	IRM-3 A18	20/06/06 01:00	16.0
IRM-3 B22	06/07/06 01:00	16.0	IRM-3 A19	06/07/06 01:00	16.0
IRM-3 B23	22/07/06 01:00	16.0	IRM-3 A20	22/07/06 01:00	16.0
IRM-3 B24	07/08/06 01:00	16.0	IRM-3 A21	07/08/06 01:00	16.0
end	23/08/06 01:00		end	23/08/06 01:00	

Table 2 Deployment scheme sediment trap IRM-3

3.12 Organic contaminants sampling

Knowledge of organic contaminant transport in the environment primarily stems from measurements in terrestrial and coastal systems, particularly in the vicinity of densely populated areas. The evidence available for open ocean systems shows that distinct north-south gradients exist in atmosphere, water, and organisms. The general picture is that the more volatile compounds show an increase in concentration between the equator and the poles, and that the less volatile compounds show a decrease in concentration, probably because the less volatile compounds need more time to establish a steady-state distribution. The existing models on global transport of organic contaminants identify the poles as the final sink where most of these compounds will condense. Very little is known, however, to what extent the oceanic circulation plays a role in redistributing organic contaminants. It is assumed that the ocean is vertically well-mixed with respect to organics, but no data is available to check whether this assumption makes sense at all. The situation is further complicated by the fact that the aqueous concentration (which is the quantity of interest, because it is closely related to the thermodynamic potential) of most organic contaminants is in the low pg/L range, necessitating large water volumes and low blank values. With the recent developments in the field of passive sampling of organic contaminants new methods have become available to address these issues. The samplers are typically small (which allows for low blank values) and the effective water volume that can be extracted with these

devices can be quite high (m^3 range, depending on the compound). The effecting sampling rates are often the limiting factor, however (~ 10 L/d). The long-term mooring deployments within LOCO (> 1 year) create new opportunities to deploy passive samplers for prolonged time periods in remote areas in the deep oceans.
During cruise 64PE240, two pairs of passive samplers were successfully mounted on the LOCO profiler moorings, one pair on LOCO02-3 (#7 and #9) and the other pair on LOCO-03-3 (#11 and #28), of which one sampler was mounted above each CTD-profiler section and the other below the profiler section, i.e. shallow and deep, respectively. Each sampler cage contained three different plastic membranes with a high affinity for organic contaminants, which are rapidly taken up as a function of temperature and flow, i.e. silicone, double layered LDPE and trioleine coated SPMD. Prior to deployment, all sampler cages were kept in metal cans and stored at -20°C as the membranes are very efficient air samplers as well. For the same reason each sampler to be deployed was accompanied by a blank one which was exposed to the same conditions as reasonably possible. Immediately prior to mounting, the appropriate metal cans were transferred to the aft deck, where they were opened and the aluminium foil cover removed. Immediately after the sampler cage was mounted, the blank sampler was returned to its metal can and transferred back to the -20°C freezer for subsequent analysis at the Royal NIOZ.

3.13 Stable oxygen isotopes (G.-J.A. Brummer)

A total of 33 samples for analysis of the stable oxygen isotope composition ($\delta^{18}O_w$) of bottom waters were drawn from the appropriate NOEX bottle at each CTD station along the former WOCE A1E section sinto a 35 ml glass bottle after 3 times rinsing and closed airtight by a rubber septum. In addition several samples were taken from drifting land-derived ice near the Greenland coast. These will complement the surface water samples taken along the same transect during the CAMP2003 cruise and be analysed at the Free University Amsterdam within the collaborative VAMOC project in order to determine the (dis)equilibrium calcification of modern benthic foraminifera for paleoreconstruction of bottom water flow and provenance from down-core sediment records.

3.14 Chlorophyll sampling (G.J.A. Brummer)

In order to calibrate the fluorometer mounted in the CIS-mooring, between 2 and 5 liters of water drawn from 12 CTD bottle depths were filtered onto 25 mm GF/F glass fibre filters. In addition 6 depths were sampled at the nearby IRM-2/3 mooring site. These will be analysed for chlorophyll-a at the NOC, Southampton.

3.15 Data Management (M.F. de Jong)

All raw data were copied to a cruise directory on the network computer in different groups of sub-directories. Subsequent processed data, final products, documents and figures were copied to separate sub-directories within the cruise directory. Back ups of the network disks were made on a daily basis. At the end of the cruise copies of the whole cruise directory have been made on a laptop PC. A final overview of the mooring

activities, hydrographic stations, water samples, and the available raw data and samples was made in the cruise summary file (Appendix A).

3.16 Servicing of CIS Mooring (M. Busack, M. Kohlhaus)

The interdisciplinary CIS (Central Irminger Sea) mooring is funded by the European project MERSEA.

The recovery of the 2745m long mooring took place on 16 September 2005.
It included :
- 14 SBE37 (MicroCats), salinity and temperature recorders, 6 of them with pressure sensors, at several depths down to 1500m
- 2 ADCPs at 151m (Workhorse 300kHz up-looking, LongRanger 75kHz down-looking)
- a sensor frame at 40m with a NAS nutrient sensor, fluorescense, pCO2 and also a MicroCat for T,S and P
- two RCM-8 current meters
- and a small telemetry bouy at the surface for realtime data transmissions (this failed shortly after deployment by the Charles Darwin cruise CD161 in September 2004).

All recovered instruments worked well and recorded data.
For the new deployment two days later it was necessary to check, service and calibrate 6 of the 14 MicroCats, 8 new ones came from Kiel. The two ADCPs got new Batteries and were also re-deloyed in the new mooring. For the sensor frame at 40m new nutrient, flurenscense and pCO2 sensors had been provided by the project partners. Two new RCM-8 arrived also from Kiel.
The new mooring was deployed on the 19 September again with a telemetry buoy, which now includes an additional temperature sensor at the surface. Otherwise the mooring is identical to the recovered one. First data received indicated functioning of the telemetry system but only to 40m depth.

3.17 ARGO-float deployments (C. Veth, R. Groenewegen)

Three institues have asked to deploy ARGO floats during the cruise at certain positions along the CTD-section.

KNMI De Bilt (Netherlands):	4 ARGO-floats (Metocean – MARTEC)
IFM-Hamburg (Germany):	3 ARGO-floats (Webb)
Bedford Institute of Oceanography (Canada):	1 ARGO-float (Webb).

KNMI
KNMI-Float 1
nr.: 6300383 SN.:05 MT-S2-01 ARGOS ID (HEX): 52A7AF2
date: sept 13th 2005 time magnet: 18:33:30 UTC time water: 18:38:00 UTC
position: 59 18.47 N 35 53:53 W

KNMI-Float 2

nr.: 6300384 SN.:05 MT-S2-02 ARGOS ID (HEX): 543C100

date: sept 13th 2005 time magnet: 18:43:00 UTC time water: 19:02:00 UTC

position: 59 20.40 N 35 55:14 W

CTD-cast position near floats 1&2: station # 3

59 20.32 N 35 54.89 W

KNMI-Float 3

nr.: 6900385 SN.:05 MT-S2-03 ARGOS ID (HEX): 543C113

time magnet: 23:42:45 UTC date: sept 20th 2005

time water: 00:06:00 UTC date: sept 21th 2005

position: 59 07.04 N 33 57:98 W

KNMI-Float 4

nr.: 6900386 SN.:05 MT-S2-04 ARGOS ID (HEX): 543C126

time magnet: 00:07:15 UTC date: sept 21th 2005

time water: 00:30:00 UTC date: sept 21th 2005

position: 59 06.68 N 33 53:33 W

CTD-cast position near floats 3&4: station # 20

59 06.70 N 33 53.20 W

IFM-Hamburg floats

float 2242 ARGOS ID number 29BD44C

magnet reset: 23 sept 2005, 21:10:00 UTC deployed: 23 sept 2005, 23:35:40 UTC

Position North: 57 42.08 Position West: 21 33.47

CTD station 34 (ID CAMP-25) at same position

float 2243 ARGOS ID number 29BD45F

magnet reset: 24 sept 2005, 05:33:30 UTC deployed: 24 sept 2005, 07:34:00 UTC

Position North: 57 38.71 Position West: 21 02.67

CTD station 35 (ID CAMP-26) at same position

float 2247 ARGOS ID number 29BD4D4

magnet reset: 24 sept 2005, 13:23:00 UTC deployed: 24 sept 2005, 13:37:50 UTC

Position North: 57 34.35 Position West: 21 36.55

CTD station 36 (ID CAMP-27) at same position (CTD on the next day because of storm)

Bedford Institute of Oceanography

Serial No. 1400 Argos No. 48869 WMO Code 4900502

Float was started with magnet: 17th sept 2005, 19:14:25 GMT

Float was deployed: 17th sept 2005, 22:18:30 GMT

Event no. station # 11 cast 1
Latitude 59 45.70 N Longitude 40 44.77 W
Water depth 2416 m
Nearest CTD:
Event no. Station #11 cast 2 17th sept. 2005, 22:31:00 GMT
Latitude: 59 45.84 N Longitude: 40 44.68 W
Max. depth: 2416

4. Preliminary results

Hydrography

At the end of the cruise the data were available in raw form and in partially processed form, but without final calibrations applied. From these data preliminary sections of potential temperature and salinity were plotted (Figures 10 and 11). The potential temperature and salinity at a pressure of 500 dbar can be compared with the results for the CAMP survey in the summer of 2000 (Figure 12).

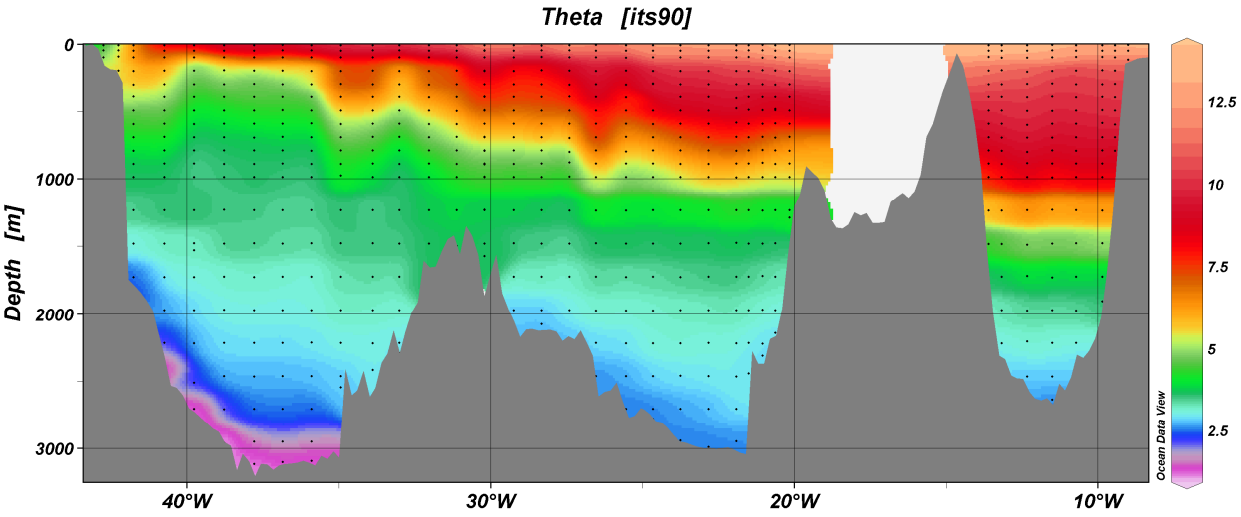


Figure 10. The vertical distribution of the potential temperature along the former WOCE A1E section observed during the CAMP survey in 2005.

The distribution of the potential temperature along the A1E section (Figure 10) shows the customary picture with the main mass of warm water in the eastern half of the Atlantic ocean. At ~35ºW a front is encountered in the upper 1000 dbar, which separates the water of the Irminger Current from the colder waters in the centre of the Irminger Basin. An eddy like structure seems to be visible between 35ºW and 32ºW. At approximately 27ºW the Sub-Arctic front is encountered which forms the western boundary of the North Atlantic Current in the Iceland Basin. In the deep layers the cold overflow water from Denmark Strait is

found over the continental slope off Greenland (θ < 1.5ºC). In the Iceland Basin the overflow water originating from the sills between Iceland and Scotland can be observed over the eastern slope of the Reykjanes Ridge (θ < 2.5ºC)

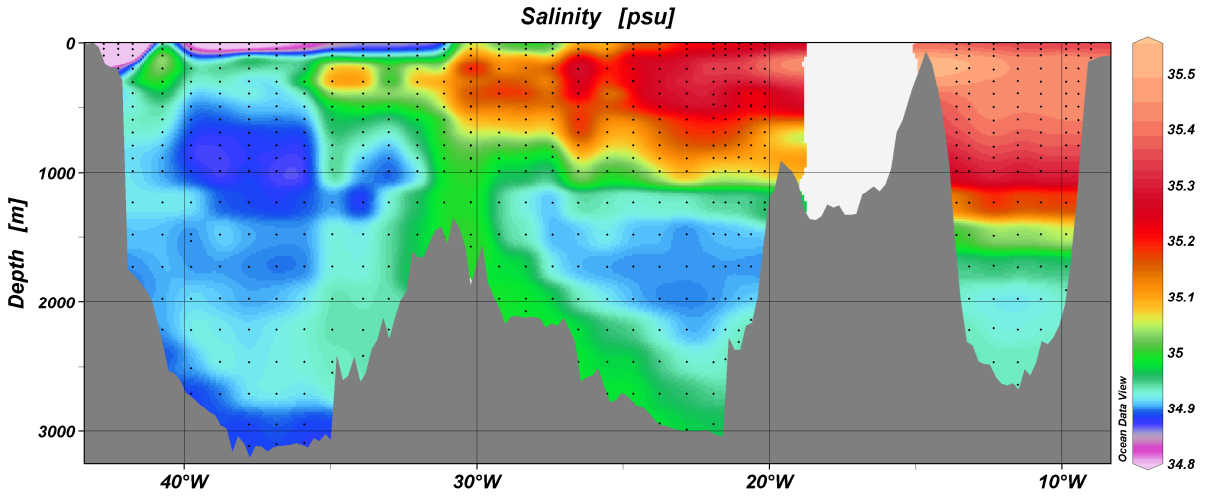


Figure 11. The vertical distribution of the salinity along the former WOCE A1E section as observed during the CAMP survey in 2005

The distribution of the salinity along the A1E section (Figure 11) shows that in the upper 1000 dbar the temperature fronts, mentioned above, coincide with salinity fronts. In the Irminger Basin at intermediate levels the two low salinity cores of "Labrador Sea Water" near 800 and 1600 dbar, also encountered in 2000 are still present. Their salinity seems to have not significantly increased since then, but in contrast to 2003. There is a weak indication of an isolated body of saline water (S > 34.90) probably originating from a meso-scale eddy, is found in the centre of the Basin, like in 2003. The Labrador Sea water in the Iceland Basin and the Rockall Channel still show a single low salinity core near respectively 1800 and 2000 dbar.

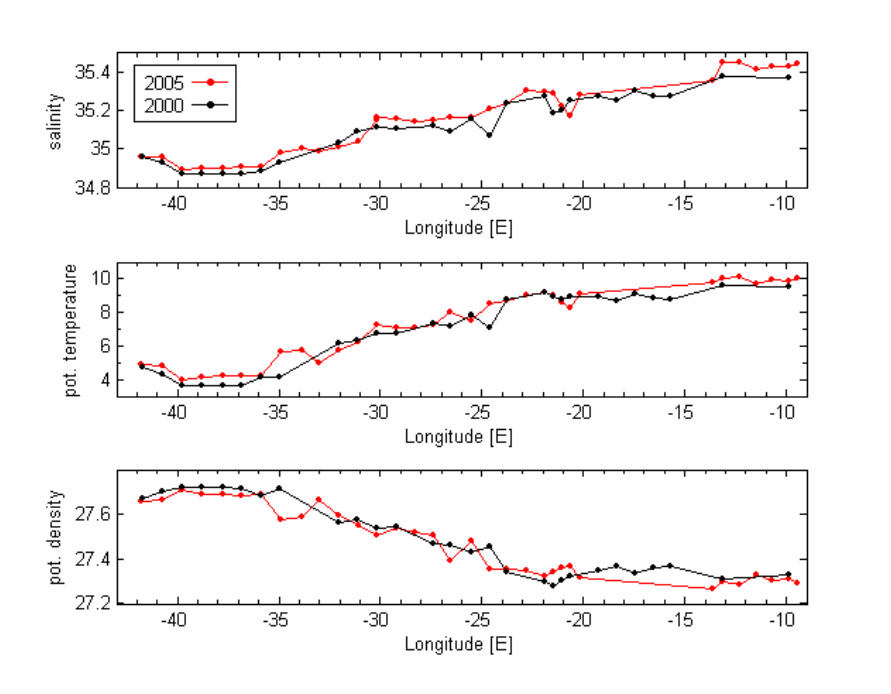


Figure 12. The potential temperature and salinity from the bottles at a pressure of 500 dbar along the A1E section from the CAMP survey of 2000 (black symbols) and of 2005 (red symbols).

For comparison 2000 and 2003 from the Cruise report of CAMP 2003

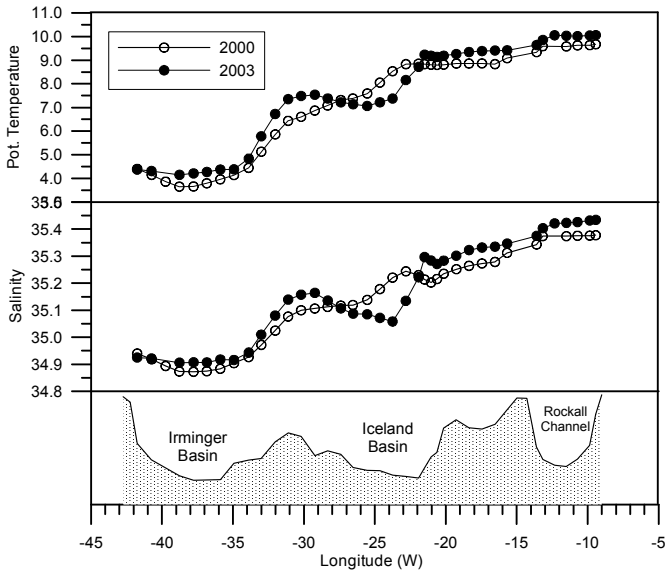


Figure 13. The zonally smoothed potential temperature and salinity at a pressure of 500 dbar along the A1E section from the CAMP survey of 2000 (open symbols) and of 2003 (black symbols).

Sediment trap mooring IRM-2

Since the sediment trap at 239 m above the bottom did not function properly, this section applies to the trap at 2 m above the bottom only. Throughout the year, the bottom trap intercepted extraordinary large amounts of fluffy sediment. Approximate accumulation rates, calculated assuming constant density, are variable and range from 8.4-16.4 mm m^{-2} day^{-1} (Fig.14) The overall high accumulation rates are probably due to resuspended particles and/or advective depositional focussing, with highest values are reached between March and April 2005. No macroscopic swimmers were detected and since no ammonia data of the sample solution are available yet, it is difficult to ascertain whether biological decay of organic matter is taking place in the samples due to insufficient biocide concentrations with respect to the large quantities of particulate residue. Presence of swimmers, hidden in the sediment, is however expected.

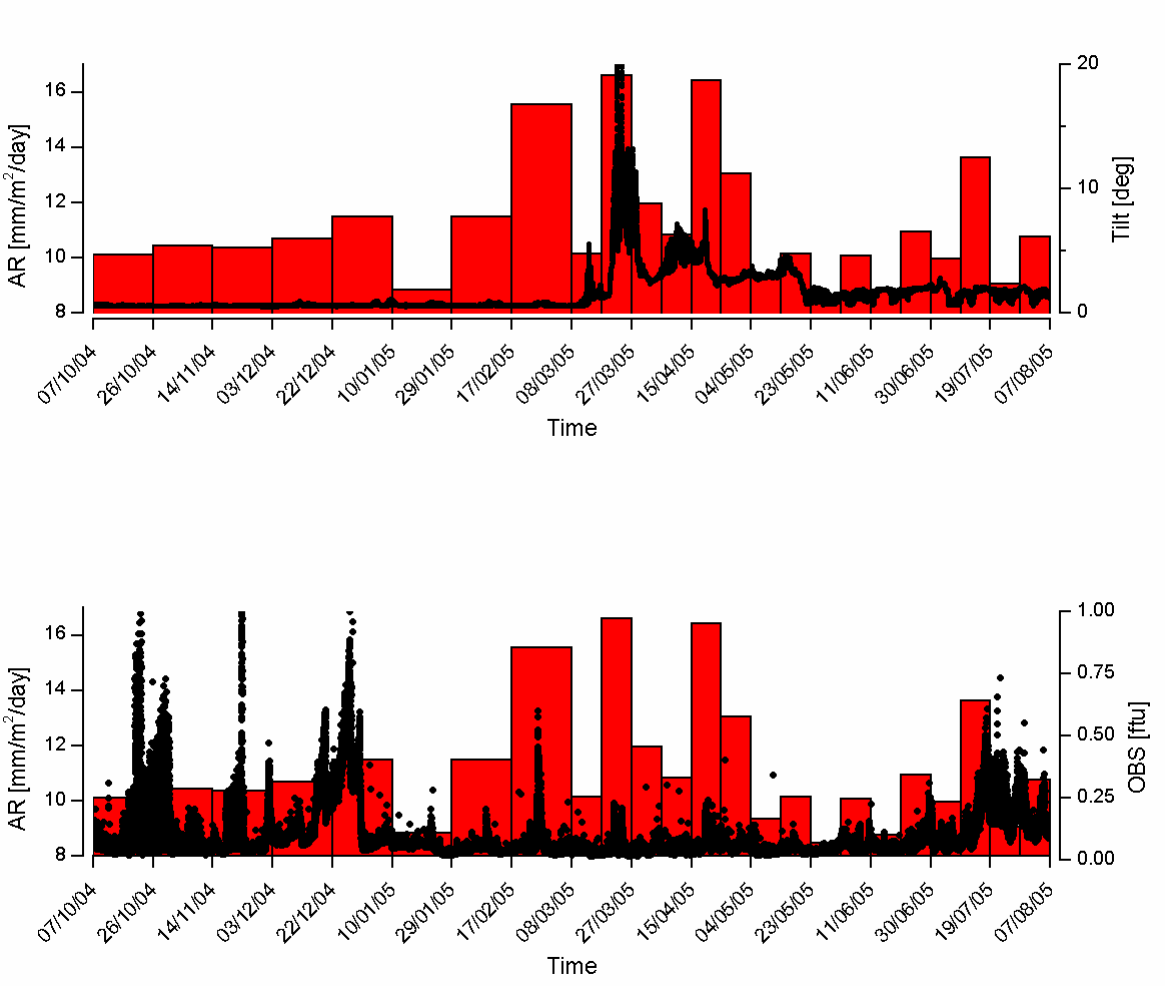


Figure 14. Accumulation rates in the trap bottles

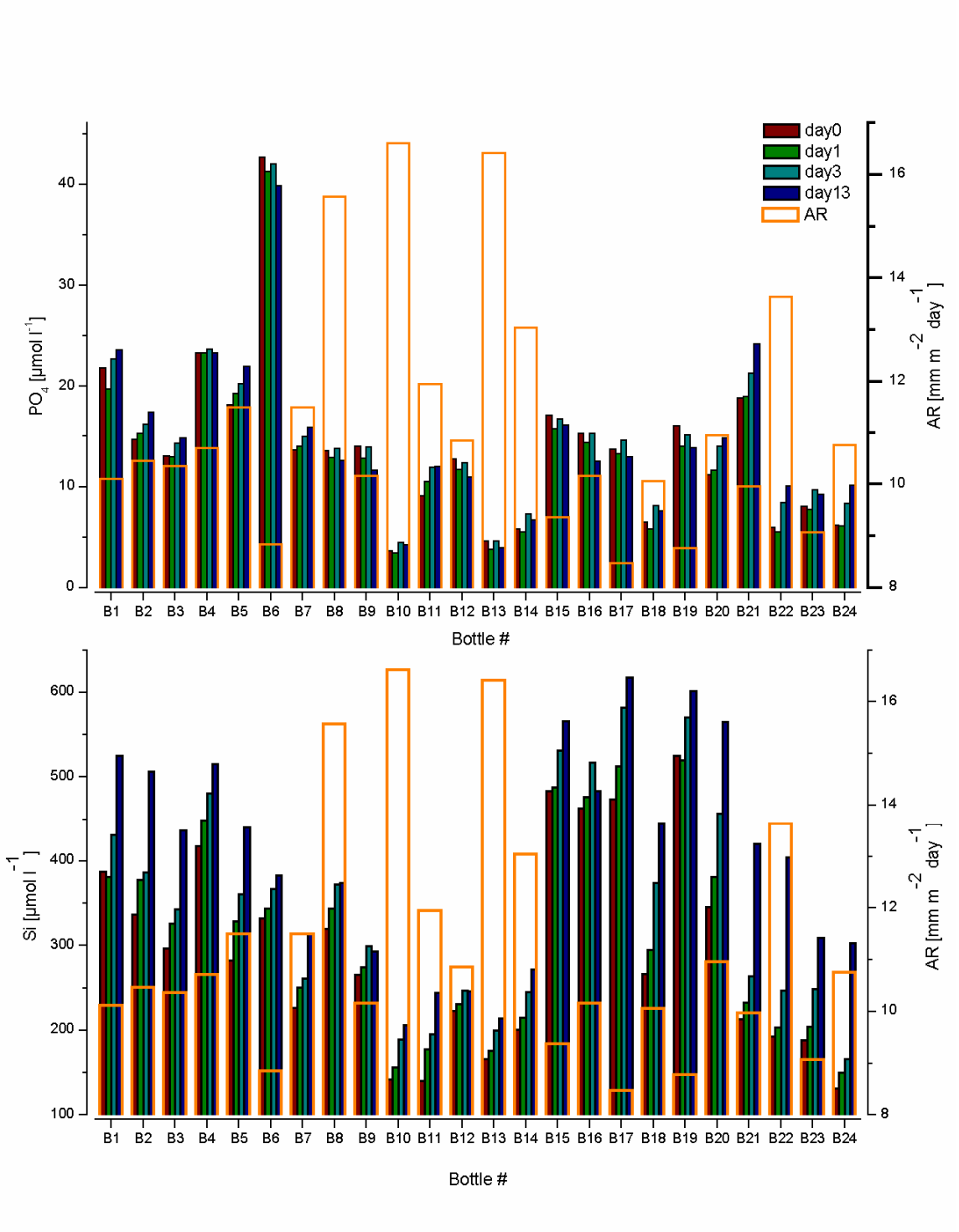


Figure 15. Dissolved phosphate and silica in the sample solution.

Dissolved phosphate and silica concentrations in the sample solution are given in Figure 15. The silica concentrations peak in May-June 2004, probably related to the spring bloom. Phosphate concentrations remain quite constant, except for the peak concentration in bottle 6, which occurs concurrently with a sharp decrease in the particle accumulation rate. Subsequent measurements show that the phosphate concentrations remain constant within the analytical error, whereas silica concentrations clearly increase. The increase in silica concentrations is related to the continuing chemical dissolution of particulate opal, e.g. from diatom frustules, and, possibly as a result of the sudden decrease in pressure the samples after their recovery. Proper

shore-based processing, gravimetric and chemical analyses are, however, needed to provide firm data on the actual mass flux and its composition through time.

Preliminary, that is uncorrected data, from the sensor packages mounted on the traps are available for both trapdepths (see Figure 16). Optical back scattering (OBS) on the shallow trap shows an extreme high spike during the last days of 2004 and the first days of 2005. The sudden increase in turbidity on December 26, 2004 is striking but its cause yet remains unknown. Minor peaks in the turbidity record might be associated with intermediate layer activity or a temporal shoaling of the benthic nepheloid layer. Changes in turbidity do not seem to occur simultaneously with changes in tilt, pressure or temperature. OBS values for the bottom trap show generally higher values than those of the shallow trap. Peaks, occurring mainly during the initial and the final deployment period, last longer than those 238 m above the bottom and are probably related to enhanced resuspension. Again OBS values do not seem to be influenced by tilt, pressure or temperature. Tilt of the trap has, however, influenced the accumulation rate (Figure 14). It should be noted that due to fouling of the OBS sensor, it becomes less sensitive to enhanced turbidity with time, thus increasingly obscuring maxima as observed during the initial deployment period.

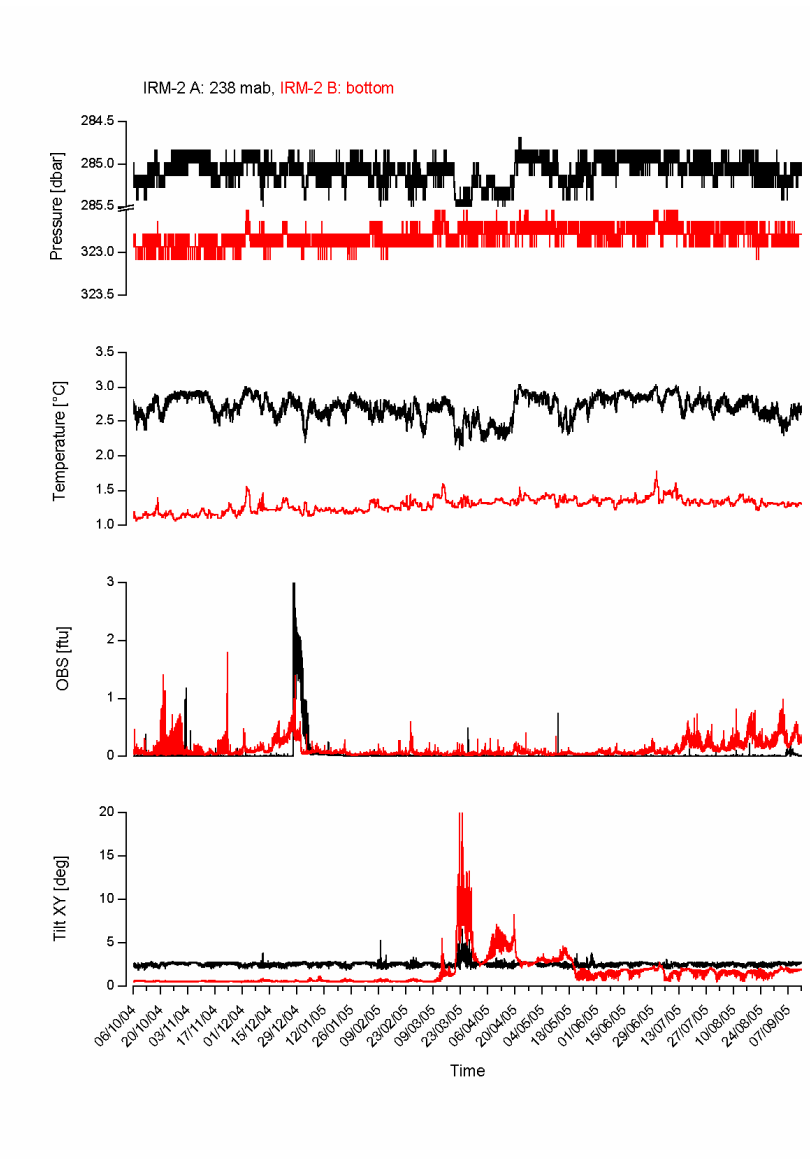


Figure 16. The data from the sensor packages on the IRM-2 mooring

Samples will be analysed for dry bulk mass, organic matter (Corg, N), carbonate ($CaCO_3$), biogenic silica and lithogenic matter at Royal NIOZ, as well as for dissolved phases sampled shipboard. These will be followed by more specific analyses of bulk molecular, element and isotope composition, grain size distribution as well as analysis of specific particle groups and sizes, such as foraminiferal species and their element and isotope composition. Together, they will inform on the provenance and magnitude of the intercepted fluxes, and be interpreted using the physical forcing conditions as measured by the instrumentation on the nearby LOCO 02-2 mooring alongside (current direction and strength, stratification and mixing, temperature, etc.).

5. Bird Observations (L. Jonkers)

A total of 29 bird species (see table 3 next page) was seen during the cruise. Observations were made irregularly and most time was spent on the open ocean, therefore the abundance given below serves as an indication only.

The Northern Fulmar was by far the commonest bird; a few were virtually always present, even during very bad weather. The dark phase of the species was observed regularly near Greenland. Surprising were the two groups of Oystercatchers that were encountered on the open ocean. These were probably birds from Iceland that were on migration and possibly blown off track.

Abundance of each species is given for 3 different regions:

- O: Atlantic Ocean, roughly extending from 30 nautical miles (n.m.) offshore
- G: Irminger Sea close (±<15 n.m.) to Greenland
- E: Areas close to British Isles, including the North Sea, extending north to the Faroe region.

Table 3. Bird Observations

Species				**Abundance**[1]		
				O	G	E
1	Black-throated Diver	Parelduiker	**Gavia immer**	-	-	2
2	Northern Fulmar	Noordse Stormvogel	*Fulmaris glacialis*	6	5	6
3	Great Shearwater	Grote Pijlstormvogel	*Puffinis gravis*	5	1	4
4	Sooty Shearwater	Grauwe Pijlstormvogel	*Puffinus griseus*	4	1	3
5	Manx Shearwater	Noordse Pijlstormvogel	*Puffinus puffinus*	1	-	-
6	European Storm-petrel	Stormvogeltje	*Hydrobates pelagicus*	-	-	2
7	Northern Gannet	Jan-van-gent	*Morus bassanus*	2	-	6
8	European Shag	Kuifaalscholver	*Stictocarbo aristotelis*	-	-	2
9	Grey Heron	Blauwe Reiger	*Ardea cinerea*	-	-	1
10	Greylag Goose	Grauwe Gans	**Anser anser**	-	-	3
11	Oystercatcher	Scholekster	*Heamatopus ostralegus*	3	-	-
12	Turnstone	Steenloper	*Arenaria interpres*	-	-	2
13	Great Skua	Grote Jager	*Stercorarius skua*	3	-	4
14	Pomarine Skua	Middelste Jager	*Stercorarius pomarinus*	2	-	-
15	Arctic Skua	Kleine Jager	*Stercorarius parasiticus*	-	1	-
16	Black-headed Gull	Kokmeeuw	*Larus ridibundus*	-	-	3
17	Herring Gull	Zilvermeeuw	*Larus argentatus*	-	-	3
18	Lesser Black-backed Gull	Kleine Mantelmeeuw	*Larus Graellsii*	3	-	3
19	Great Black-backed Gull	Grote Mantelmeeuw	*Larus marinus*	-	-	2
20	Glacous Gull	Grote Burgemeester	*Larus hyperboreus*	-	2	-
21	Iceland Gull	Kleine Burgemeester	*Larus glaucoides*	-	3	1
22	Kittiwake	Drieteenmeeuw	*Rissa tridactyla*	5	5	5
23	Sandwich Tern	Grote Stern	*Sterna sandvicensis*	-	-	3
24	Arctic Tern	Noordse Stern	*Sterna paradisea*	-	-	2
25	Common Guillemot	Zeekoet	*Uria aalge*	-	-	3
26	Razorbill	Alk	*Alca torda*	-	-	3
27	Meadow Pipit	Graspieper	*Anthus pratensis*	3	-	3
28	Pied Wagtail	Rouwkwikstaart	*Motacilla yarelli*	-	-	2
29	Northern Wheatear	Tapuit	*Oenanthe oenanthe*	2	1	2

*
1: 1
2: 2-10
3: 10-40
4: 40-100
5: 100-1000
6: >1000

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Chief Scientist

Appendix A Cruise Summary File

Appendix B Mooring Summary File