# RV Pelagia Shipboard Report:

# Cruise 64PE342, Project THOR

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**THOR 2011**

Royal Netherlands Institute for Sea Research

Texel, 2011

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## Acknowledgements

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# 1 Cruise Narrative

## 1.1 Highlights

a: Goals: The re-survey of former WOCE Hydrographic Program Repeat Section A1/AR7E between Ireland and the recovery and redeployment of a long term mooring in the Irminger Sea as part of the EU THOR programme.

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d: Ship: RV Pelagia, Call Sign: PGRQ, Captain: Ms. Corky Burkhard
length 66 m.
beam 12.8 m
draft 4 m
maximum speed 11 knots

e: Ports of Call: Reykjavik (iceland) to Texel (the Netherlands)

f: Cruise dates: July 24 2011 to August 8 2011

## 1.2 Cruise Summary Information

### Summary

In the evening of 24 July 2011, RV Pelagia left Reykjavik and set course to the position in the Irminger Sea to the position of the LOCO2 profiling mooring. After leaving port the underway recording system for navigational, meteorological, ADCP, and sea surface data was activated and a test cast with the CTD was carried out. A CTD cast was performed and the mooring (LOCO2-8) was recovered on July 27. After these mooring activities a CTD survey was carried out along the AR7E section between Greenland and Ireland. Two planned CTD stations in the continental shelf of Greenland were cancelled because of the presence of large quantities of pack ice. The CTD section was interrupted at July 29 for the redeployment of the mooring (LOCO2-9) and an extra CTD cast on that position. In the Irminger Sea 7 profiling ARGO floats were deployed in water deep then 2400 m. The last CTD cast was performed on August 5 on the continental shelf northwest if Ireland. In the evening August 8 RV Pelagia entered the NIOZ harbour at Texel.

### Cruise Track

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

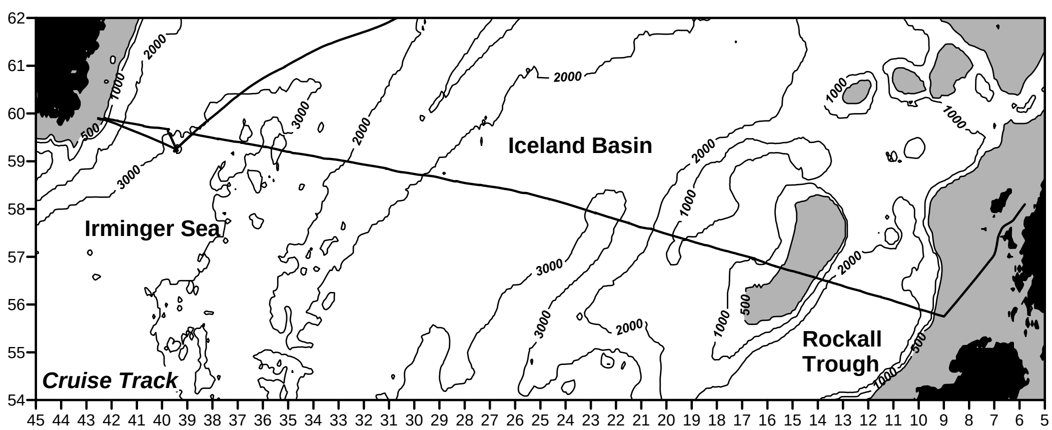


**Figure 1. Cruise track of Pelagia cruise 64PE342, between Reykjavik (Iceland) and Texel (the Netherlands).**

## Mooring Deployments

Mooring LOCO2-8 was recovered on July 27 while mooring LOCO2-9 was deployed on July 29 (MOR in appendix A). The mooring operations took place during daytime. The position of the deployment of LOCO2-9 is: 59°12.21'N, 39°30.32'W (cross in Figure 2), the deployment time was 12:22 UTC. During the last 10 minutes before deployment Pelagia has followed a course over ground in the direction of 260° relative to North. Both LOCO2-8 and 2-9 are profiling moorings, fitted with a McLane/FSI CTD profiler, two RDI Long Ranger ADCPs and an SBE Microcat CTD. They were positioned at a depth of about 3000 m at the foot of the East Greenland slope, approximately in the centre of the Irminger Gyre. See also Appendix B.

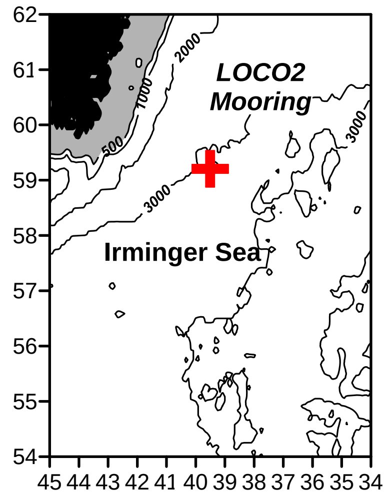


**Figure 2. The position of the profiling mooring LOCO2-9**

## Number of Hydrographic Stations

A total of 42 CTD casts were performed along the former WOCE AR7E section, one test station before that section was surveyed, and two CTD casts near the mooring site. The location of these casts is shown in figure 3. The mutual station distance is about 30 nautical miles, while over steep topography that distance was reduced to about 15 miles. Due to the good weather conditions no CTD stations had to be cancelled. Further information on the time and location of the stations can be found in the Cruise Summary File (CTD and ROS in Appendix A).

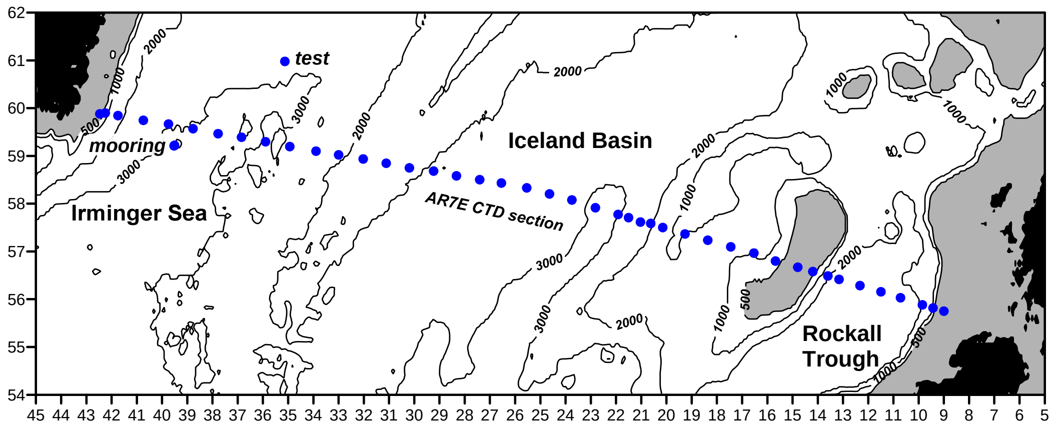


**Figure 3. The positions of the CTD casts, performed during cruise 64PE342.**

## Deployment of ARGO floats

Seven APEX ARGO floats were deployed in the Irminger Sea on behalf of Dr. A Sterl of the Dutch national meteorological service (KNMI), directly after a CTD cast (Figure 4, FLT in appendix A). All 7 buoys made contact the ground station by satellite (see: also http://www.knmi.nl/~sterl/Argo/).

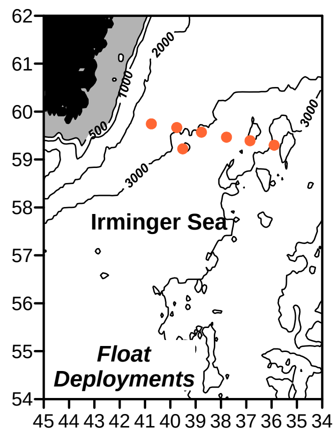


**Figure 5. The position in the Irminger Sea where the ARGO floats were deployed.**

## 1.3 List of principal Investigators

| *Name* | *Responsibility* | *Affiliation* |
|---|---|---|
| Dr. H.M. van Aken | Ocean hydrography | NIOZ/Texel |
| Dr. M.F. de Jong | moorings | NIOZ/Texel |
| Dr. A Sterl (no participant) | ARGO floast | KNMI/de Bilt |

## 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 Greenland and Ireland to allow the study of inter-annual hydrographic variability and water mass formation since 1990, and to service an instrumented mooring in the Irminger Sea, both as part of the EU THOR programme, and as an extension of the CAMP monitoring programme of NIOZ.

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.

The CTD 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 11 m from the bottom, until altimeter and/or the bottom switch indicated the proximity of the bottom. During the up-cast a few temperature samples where taken with the SBE35 reference thermometer at upto 12 prescribed depths, when the CTD winch was stopped, while water samples were collected with Niskin bottles for the determination of the salinity and the dissolved oxygen concentration. The CTD was also fitted with a lowered ADCP for the measurement of current profiles from the sea surface to the bottom, an oxygen sensor, a beam transmissometer for the determination of the turbidity (660 nm, path length 25 cm), and with a Fluorometer for the determination of the Chlorophyll-a concentration.

The mooring which was recovered (LOCO2-8) and re-deployed (LOCO2-9) was made available as part of the Dutch Long-term Ocean Climate Observations programme (LOCO). This programme aims at the establishment of a monitoring system which records climate relevant oceanographic parameters at several locations in the world ocean. The moorings contain a profiling CTD which records on a daily basis profiles of temperature and salinity between ~2400 and 160 m depth (McLane profiler). Additionally ADCPs record the velocity profiles in the upper and lower 600 m. Mooring LOCO2-9 is the 9-th of a series of moorings, each deployed for one year in the centre of the Irminger gyre.

On board data processing of the CTD data was carried out. From the profiler data preliminary ASCII files with temperature and density as functions of the pressure were produced. Not enough time was available for complete data processing, which has been carried out back at NIOZ, including the LADCP processing.

In support of the CTD observations the sea surface temperature and salinity were recorded continuously as well as several meteorological parameters. Also the currents in the upper 600 m were recorded with the vessel mounted acoustic Doppler current profiler (VMADCP).

### 1.5 Lists of Cruise Participants

**Scientific crew**

| person | responsibility | Institute |
|---|---|---|
| H.M. van Aken | Chief Scientist | NIOZ/Texel |
| M.F,. de Jong | Moorings & hydrowatch | NIOZ/Texel |
| S. Ober | CTD & ADCP, hydrowatch | NIOZ/Texel |
| R. van der Heide | mooring instrumentation, & hydrowatch | NIOZ/Texel |
| K. Bakker | Oxygen Determination | NIOZ/Texel |
| L. Boom | Marine engineering | NIOZ/Texel |
| J.-W. Meijerink | Hydrowatch | IMAU/Utrecht |
| J. van Lent | Hydrowatch | IMAU/Utrecht |
| J. Menninga | Hydrowatch | IMAU/Utrecht |
| M. van der Mheen | Hydrowatch | IMAU/Utrecht |
| R. de Oude | Hydrowatch | IMAU/Utrecht |

*NIOZ:* *Royal Netherlands Institute for Sea Research, Texe*
*IMAU* *Institute for Marine and Atmospheric Research, Utrecht University.*

**Ships crew**

| | |
|---|---|
| C. Burkhard | Captain |
| J. van Haaren | First Mate |
| D. Verheyen | Second Mate |
| J. Seepma | Chief Engineer |
| M. Frankfort | Second Engineer |
| S. Maas | Able Seaman |
| C. Stevens | Able Seaman |
| J. Vitoria | Able Seaman |
| M. de Vries | Able Seaman |
| A. Lont | Cook |
| M. Zagars | Steward |

## 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 in the underway data logging system. An additional Seapath dual antenna GPS receiver also determined the ship’s heading. Data processing has been carried out back at NIOZ. The speed over ground and course over ground were determined from the

GPS positions for successive one minute periods. After removal of occasional spikes, the data were smoothed with a 5 min. running mean and sub-samples every 5 minutes.

### 2.2 Echo Sounding

The Kongsberg EA600 echo sounder was used on board to determine the water depth. The uncorrected depths from this echo sounder were recorded in the Casino underway data logging system. Erroneous data have been removed back at NIOZ. It appeared that in the deep part of the Rockall Channel the majority of the echo sounder data was erroneous.

### 2.3 Thermo-Salinograph Measurements

The Sea Surface Temperature and Salinity were measured continuously with the SBE Seacat thermo-salinograph system with the water intake at a depth of about 3 m. Back at NIOZ these sensors have been calibrated by comparison with the CTD-cast at 3 m. After removal of occasional spikes, the data were smoothed with 5 5 min running mean and sub-samples every 5 min.

### 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 true wind speed and direction were online calculated and also recorded. The connection with the solarimeter appeared to be defect. Therefore the solar radiation data are missing from the meteorological records. After removal of occasional spikes, the data were smoothed with a 5 min. running mean and sub-sampled every 5 min.

### 2.5 ADCP meaurements

The 75 kHz ADCP mounted under the Pelagia has been used to collect current data from the mooring recovery onwards. 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. The final processing of the data still has to take place at Texel.

# 3 Hydrographic measurements - Descriptions, Techniques, and Calibrations

## 3.1 CTD Data Collection and Processing

A recently (June 2011) calibrated SBE 9/11+ CTD, SN-0942, has been used to measure temperature, salinity, and turbidity profiles. The sensors mounted on the CTD were an SBE3 temperature sensor SN-034812, SBE4 conductivity sensor SN-043385, a Digiquatz pressure sensor SN-53978, SBE43 oxygen sensors SN-430350 (station 1 to 19) and SN- 431932 (station 20 to 42), a Wetlab CStar beam transmission meter SN-CST-1406DR with a path length of 25 cm, 660 nm wavelength, a Seapoint turbidity sensor SN-11541, and a Chelsea Aqua 3 fluorometer SN-088026, and a Tritech altimeter SN- 52077. The Seapoint turbidity sensor appeared to produce mainly faulty data.

The CTD was mounted in a special rack, which did contain 12 Niskin water samplers. The additional sensors of the CTD system were also recently calibrated by the manufacturers. To control the temperature measurements an SBE 35 Deep Ocean Standards thermometer was mounted next to the temperature sensor of the CTD. Reference temperature samples were taken with this when water samples were taken with the Niskin samplers. The water from these samplers was sub-sampled for the determination of dissolved oxygen, salinity, and $^{14}C$. THe latter samples will be analyzed at Groningen University in support of the GEOTRACES programme.

For the data collection the new Seasave software for Windows (version V 7.21d), 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, where a daily back-up copy was made.

Also mounted in the CTD rack was a Lowered ADCP (LADCP). Initially two ADCPs were used, a master and a slave. However, problems were encountered with the synchronisation cable or its connectors. Therefore most of the CTD casts were performed with only a single down looking master ADCP.

The CTD data were processed with the recently obtained calibration data, using the Seasoft software, also produced by SBE, and reduced to 1 dbar average ASCII files. The final calibration and data processing has been completed at Royal NIOZ, Texel.

### 3.2 Reference temperature measurements

Mounted on the CTD-rack was a high precision SBE35 reference temperature sensor, which recorded the temperature every time a Niskin sampler was closed by the CTD operator. These SBE35 temperature data have been used to control the calibration of the CTD temperature sensor. The mean difference $T_{SBE35}$-$T_{CTD}$ amounts to -0.0001°C (±0.0010°C stdev, N=323). No further corrections were applied to the CTD temperature.

### 3.3 Salinity water samples

At the deep stations up to 3 water samples were collected from relatively homogenous parts of the water column. The (practical) salinity of these samples was determined in a constant-temperature laboratory container with a Guldline 8400B salinometer. The standard water we used was from batch P146 (S = 34.992). The mean difference $S_{sample}$-$S_{CTD}$ amounts to 0.0014 (±0.0013 stdev, N=39). The CTD salinity was corrected for this offset.

### 3.4 Oxygen reference water samples (K. Bakker and J. Menninga)

Water samples were for the determination of the dissolved oxygen concentration were taken from the Niskin bottle at up to 12 depths per CTD cast. From the deepest bottle 3 subsamples were taken. The oxygen concentration was determined with a spectrophotometric analysis with Winkler chemistry.

*Equipment and methods:*

After reacting with the pickling reagents according to Winkler (1888), acid was added and the Iodine-colour formed was measured in an acclimatised lab container equipped with a, Technicon TRAACS 800 spectrophotometer, connected to a homemade sampler and peristaltic pump with a capacity of 30 Oxygen bottles. The sample rate was set at 30 samples per hour, measuring about 500 samples during the cruise

*Sample handling:*

The Oxygen samples were collected in approx 113ml glass BOD bottles, after being filled flushed over three times with sample without any air trapped, taken directly from the CTD-rosette bottles. On the deck, immediately after sampling, the pickling reagents MnCl and NaOH/KI were added with dispensers; the tip down into the shoulder level of the bottle, the glass stopper placed, and shakes to react to form higher oxidation state of the Manganese. After 15 minutes the samples were shake again, and then placed with a rubber bang around the stopper in a storage container filled with water to prevent direct air-contact. The samples were kept at lab temperature of 20°C, and analysed typically within 10 hours, and 16 hours as a maximum, but always after being settled for first two hours in the storage container under water.

*Calibration and Standards:*

$KIO_3$ as primary stock standard was prepared home at the lab, containing 71.48 mM of “Oxygen” equivalents, and used in addition to so called seawater blanks (seawater treated with inverse chemistry addition without any oxygen reaction) in calibrated Oxygen bottles. The calibration standards were prepared daily by diluting the separate stock standards, using an electronic pipette into four BOD-bottles when the stopper is removed, taking in account the extra volume of the pipette added.

In the lab the sample bottles with the settlement of the Manganese-oxides were gently lifted out of the storage container and with a dispenser 1 ml of 10 M of Sulphuric Acid was added to oxidise the available Iodide to form Iodine caused by liberation of the Manganese-oxides in acid medium. A teflonised magnetic stirring rod was put in the bottle and the bottle-opening immediately covered with parafilm to prevent any Iodine loss by evaporation, and covered to prevent light induced iodine forming.

Sample bottles including the calibration standards used were both sealed with "parafilm" under tension, a sharpened sample needle easily penetrated through leaving a small hole in the film. A peristaltic pump transporting the coloured solution to the flow cell in the spectrophotometer measuring the Absorbance at 460 nm light, produced with a LED and a bandpass filter.

To obtain high resolution values, an attempt was made to set the range for Oxygen to be measured in that way that the samples were always at a level of 40-80% of full scale values. To use the full A/D convertor of the spectrophotometer optimal and to reduce carryover, a baseline solution of around 160 µM $O_2$ in seawater was prepared being lower then the lowest Oxygen sample expected, and a maximum of 350 µM Oxygen calibrant was used to be the highest expected value.

*Reference standard:*

This Baker standard acts as a lab reference and its use is described under "quality control". It is diluted from a concentrated ampoule in the lab containing $KIO_3$, finally representing a concentration of 100 mM $O_2$ per litre. The average recovery found during this cruise is 100.2% of the certified value, n=17.

*Quality Control:*

The reference standard of Baker is measured in every run, its value showed no trend during the cruise, being stable over time. It is vitally important to get a good method to produce a 100% Oxygen standard in order to obtain real accuracy and so better comparison between labs and cruises. In Japan an attempt is made to prepare even an Oxygen reference standard, ready for use?!

After the cruise the $KIO_3$ standard has been measured against a new $KIO_3$ standard, together with the collected natural standards to check whether a correction will be necessary, because the $KIO_3$ stock standard onboard was made of $KIO_3$ crystals containing some lumpy stuff. This led to a final correction with 0.8% of the original concentration.

*Statistics:*

Precision of the Spectrophotometer set up was performed by analysing 5 samples from one mixed Iodine coloured seawater solution, showing a standard deviation of 0.06 µM $O_2$ on a level of 283 µM $O_2$ showing a instrumental c.v. of 0.02%, being close to the resolution of the spectrophotometer of 0.04 µM at the used range. However running a test CTD-station showed a s.d. of 0.41 µM $O_2$ on this level, for 23 duplicates with one outlier removed.

To obtain cross-run statistical values, analyses were carried out twice on the same sample from the bottle closed at the bottom layer in the first run, and one duplicate in the consecutive run. This gives the possibility to estimate the precision from station to station in a horizontal way. It's well known that the reproducibility in one calibrated run is much better than measurements made across several runs, with each run having its own calibration settings. Analysis of these duplicates in the runs show an RMS difference of 0.38 µM (n=32, within runs precision). Cross runs duplicate samples show absolute differences with an RMS of 0.93 µM (avg. level 250 µM, n=35)

One reference used is a diluted Baker Ampoule, monitored during all runs, and the other is 20 litre of seawater mixed and tapped under lab conditions. An attempt was made to “back correct” on its average value after the cruise and check if the RMS of the duplicates in-between the runs get smaller? Raw duplicate difference expressed in RMS get a smaller value from 0.93uM to 0.78uM overall, showing a slight improvement.

*Problems:*

During the first day there was quite some noise o the TRAACS of a level of +/-2%. Changing the current from the ships net from “fine” to “coarse”; improved this by reducing the noise to “0”.

Sometimes during a run, sticky Iodine colour was settled to the flow cell walls and be seen as gradual raise of the normal horizontal peak-plateau. By “babysitting” during the analysis, worse case could be avoided by pressing the pump-tubes after the flow cell for a few seconds so this could be removed by sudden under pressure in the flow line. Afterwards the problem was linked with the fact that first week the sampler setting was wrong, with sample to wash ratio of 105seconds over 15seconds?? During the second half of the cruise this was set back to its original setting of 90 s over 30 s what improved the peak shape a lot, showing less carryover and less Iodine sticking to the flow cell walls.

The difference between the oxygen concentration from the water samples (OXYGEN) and CTD oxygen concentration appeared to depend significantly (linear correlation) on the oxygen concentration (CTDOXY) itself, on pressure (CTDPRS), temperature (CTDTMP) and on the time, expressed as station number (STNNBR). A multi-parameter linear regression was used to determine the correction for the CTD oxygen concentration in the form:

$$OXYGEN = A \times CTDOXY + B \times CTDPRS + C \times CTDTMP + D \times STNNBR + E$$

The linear regression to determine the paramters A to E gave the following results (estimated value and standard deviation):

A = 1.032 (±0.003)

B = 0.0026 (±0.0002)

C = 0.16 (±0.04)

D = 0.096 (±0.008)

E = -8.0 (±0.9) .

The residual of the linear regression had a standard deviation of 0.7 µmol/kg (N = 203). This regression equation was used for the correction of the "raw" CTD oxygen concentration.

### 3.5 Data Management

All raw data were copied to a cruise directory on the network computer of RV Pelagia in different groups of sub-directories. Subsequent processed data, final products, documents and figures were copied to separate sub-directories within the same 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 portable hard-disk and on the disc of a notebook computer. By help of paper measurement forms and computerized data inventory files all data are tracked. A final inventory of the mooring activities, hydrographic stations, and the available raw data files was made in a cruise summary file (Appendix A).

## 4 Preliminary results

### 4.1 Potential Temperature

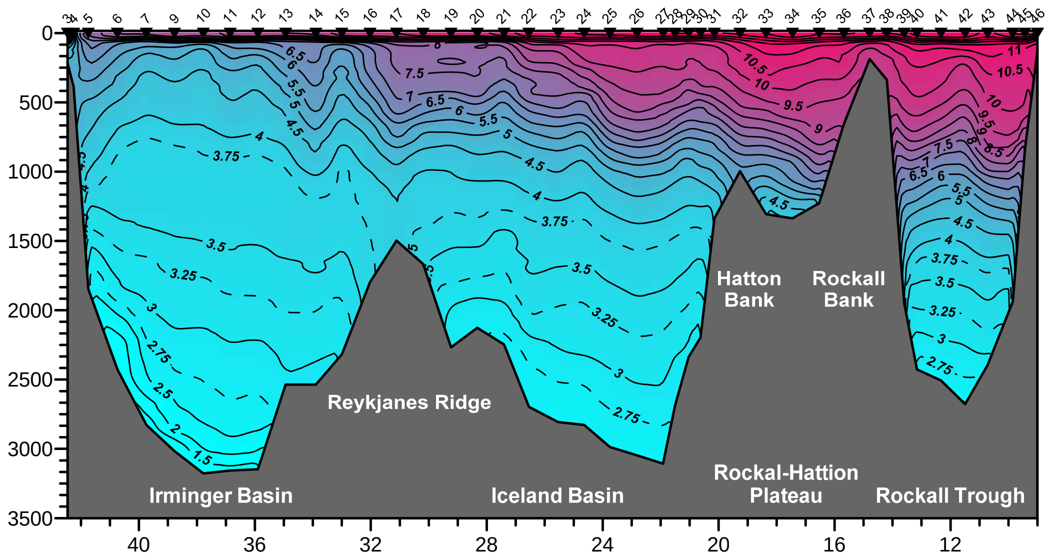


**Figure 6. The distribution of potential temperature (°C) along the AR7E section, derived from the CTD downcasts.**

The potential temperature distribution along the AR7E section (Figure 6) shows the usual structure. In the Irminger Sea the subarctic gyre in the Irminger Basin causes a doming of cold water in the centre of the basin, while along the edges of the basin a warmer boundary current (Irminger Current) surrounds the cold core. From the Reykjanes Ridge eastwards the permanent thermocline descends from about 500 dbar to over 1000 dbar, in agreement with the near geostrophic balance of the northward flowing warm near surface water of the North Atlantic current over slowly moving intermediate water. The relatively large isotherm distance between the seasonal thermocline at about 40 dbar (Figure 7) and the deeper permanent thermocline is indicative of the presence of Subarctic Mode Water, formed in the previous winter.

In the near bottom layers of the Irminger Basin the isotherms follow the topography of the East Greenland Slope closely, as can be expected from the fast, near geostrophic flowing Denmark Strait Overflow Water. In the western Iceland Basin the slightly warmer (2.5 to 3.0°C) Iceland-Scotland Overflow Water also causes the isotherms closely. Over the western slope of the Hatton Bank in the Iceland Basin the slope of both the topography and the isotherms is reversed due to the narrow northward flowing Deep Northern Boundary Current which transports the aged Lower Deep Water, admixed with traces of Antarctic Bottom Water. The slight topography following slope of the deepest isotherms in the Rockall Trough may be interpreted as a contour following flow in the deep layers of this narrow basin.

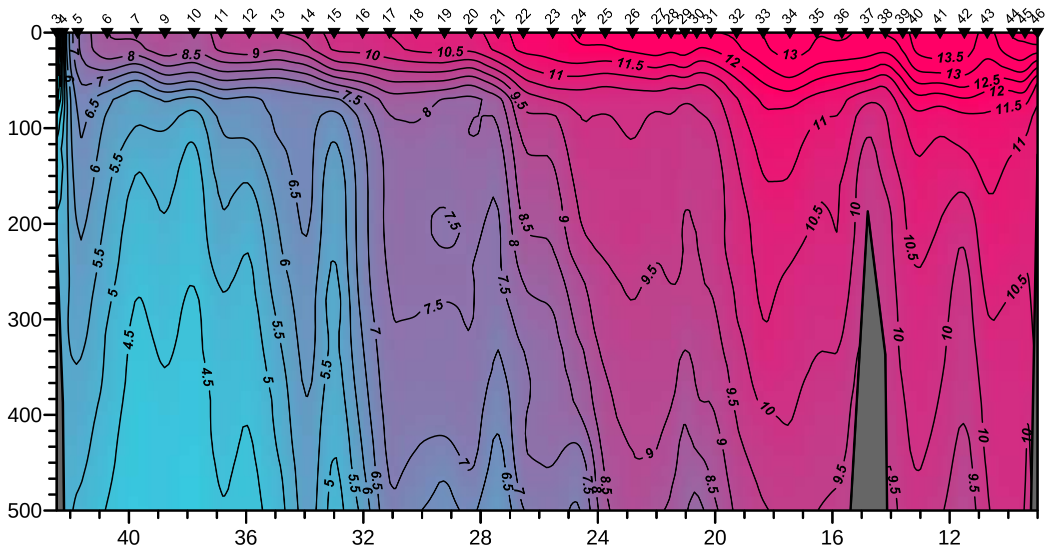


**Figure 7. The distribution of potential temperature (°C) in the upper 500 dbar, derived from CTD downcasts.**

In the upper 500 dbar the temperature distribution (Figure 7) shows a near constant depth of the seasonal thermocline at ~40 dbar, likely reflecting a near homogeneous wind climate. The large scale zonal trend of the temperature is interrupted by narrow cold bulges, which can be interpreted as transient cyclonic mid-ocean eddies, although the topography following doming of the isotherms around the Rockall Bank also can be connected with topography bound cyclonic circulation. Note here that in general the horizontal resolution of the survey (station distance) is not better than 30 n. miles (55 km) apart from the stations over steep topography which have a smaller mutual distance.

### 4.2 Salinity

The salinity distribution along the AR7E section (Figure 8) shows in the upper 1000 dbar an eastward increase from the central Irminger Basin to the Irish slope. In the upper 40 dbar, above the thermocline, salinity is slightly reduced due to the precipitation excess since spring, when the seasonal stratification began. At station 3, over the Greenland continental shelf, surface water with a salinity below 32.0 was observed, well below the surface salinity of nearly 34.7 at the following station over the upper slope. This reflects the presence of the relatively fresh East Greenland Shelf Current and the more saline western part of the Irminger Current. In the Irminger Current encircling the Irminger Basin, near stations 5, 6 and 14, a high salinity subsurface core (S > 35.0) is encountered between 100 and 400 dbar. From this core relatively high salinities extend at 100 to 200 dbar towards the centre of the Irminger gyre.

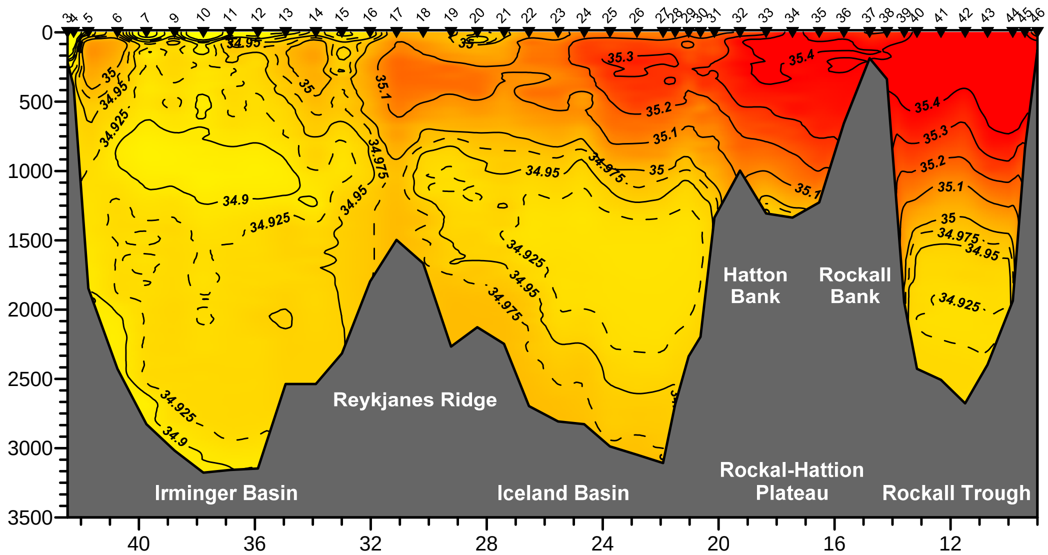


**Figure 8. The distribution of salinity (PSS-78) along the AR7E section, derived from the CTD downcasts.**

The low salinity core in the Irminger Basin between 600 and 1200 dbar reflect the Labrador Sea Water, as the name indicates formed in the Labrador Sea. Similar low salinity cores are also observed in the Iceland Basin and Rockall Trough (near ~ 22500 dbar), reflecting the eastward advection and descent of this intermediate water mass in the northern North Atlantic Ocean. The Denmark Strait Overflow Water near the bottom of the Irminger Basin has a salinity (S < 34.925) slightly below the salinity of the directly overlying water mass. The latter water mass is an advective extension towards the western Atlantic basins of the more saline (S > 34.975) Iceland Scotland Overflow that reached the Irminger Sea via the Charlie-Gibbs Fracture Zone at ~52°N. Over the top of the Reykjanes Ridge intermediate water with a salinity higher than the Labrador Sea Water is encountered, which most likely originates from mixing of thermocline water with Iceland Scotland Overflow Water southeast of Iceland (Icelandic Slope Water).

## 4.3 Dissolved Oxygen

The distribution of dissolved oxygen (Figure 9) shows oxygen maxima in the Irminger Sea at 300 to 500 dbar, overlying the salinity minimum of the Labrador Sea Water. This is likely to present the local Irminger Sea Mode Water, ventilated in the previous winter by convective mixing. Similar but lower oxygen maxima (~250 to 260 μmol/kg) are observed at the same depth range in the more saline Atlantic water above the main thermocline, the Sub-Arctic mode Water. The permanent thermocline is characterized by an oxygen minimum.

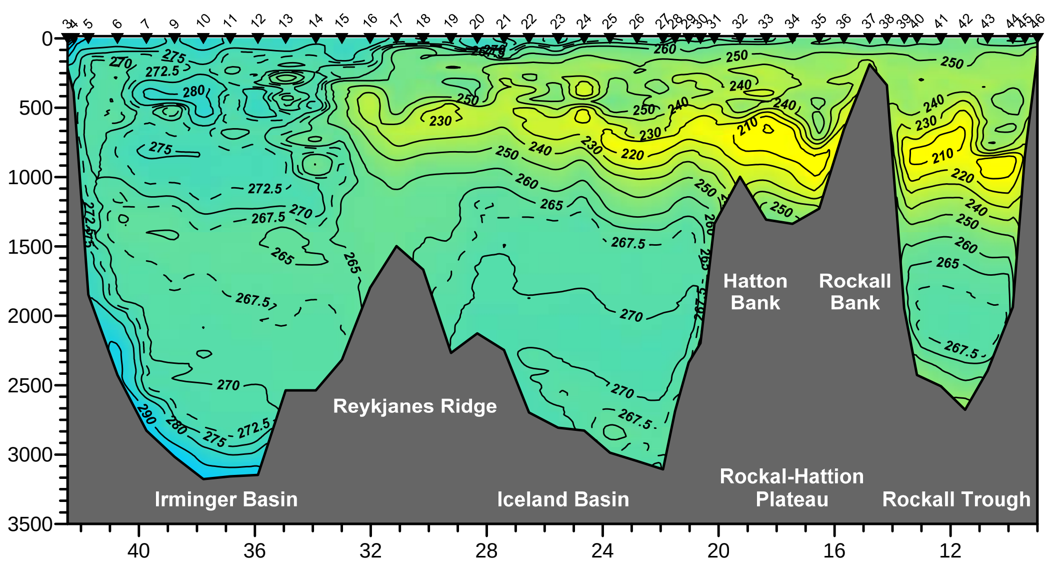


**Figure 9. The distribution dissolved oxygen (μmol/kg) along the AR7E section, derived from the CTD downcasts.**

The salinity minimum of the Labrador Sea Water is characterized by a secondary oxygen maximum, slightly lower than the maximum of the Irminger Sea Mode Water. The oxygen content of this water type in the Iceland Basin and Rockall Trough has lower values (~267.5 μmol/kg in the latter basin).

The overflow waters are characterized by relatively high oxygen concentrations, (~270 μmol/kg in the Iceland Basin, >290 μmol/kg in the Irminger Sea).

## 4.4 Potential vorticity

The planetary potential vorticity (PV, Figure 10) is a near conservative parameter, reflecting the static stability of the water column. The distribution of PV confirms the earlier findings, presented above. The Mode Waters in all three basins are characterized by a PV minimum, as is the underlying Labrador Sea Water below the permanent thermocline. The overflow waters are capped by a PV maximum, indicative for the enhanced stability due to the relatively large density difference between the overflow waters and the overlying older water mass.

A peculiar characteristic of the PV distribution is the minimum, directly overlying the top of the Reykjanes ridge. This is a recurrent feature, observed during all surveys of the AR7E section since 1990, and is likely caused by turbulent mixing, driven by breaking internal waves over the rough topography of the ridge.

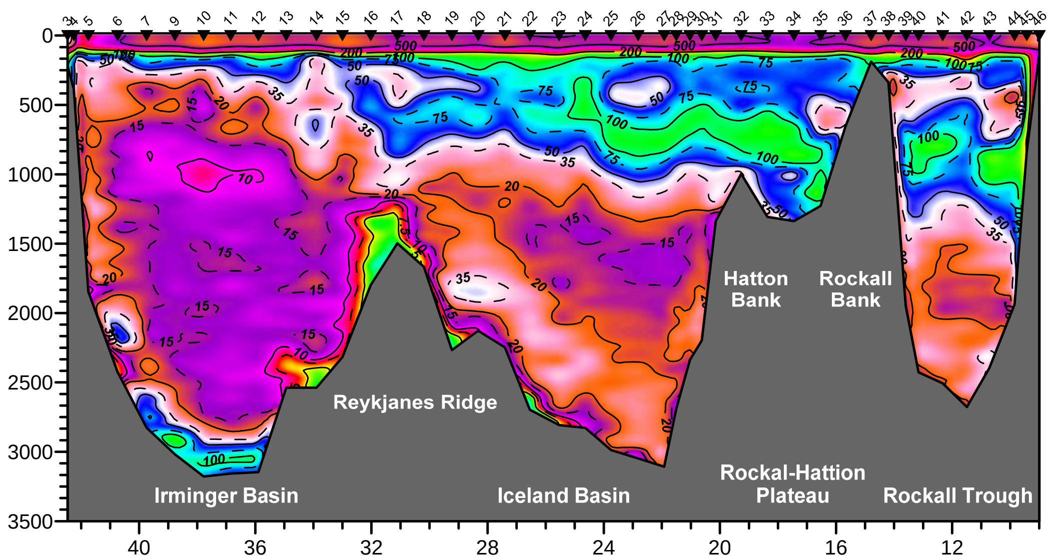


**Figure 10. The distribution of the potential planetary vorticity ($10^{-12}s^{-1}$) along the AR7E section derived from the CTD downcasts.**

## 4.5 Velocity

Overall the LADCP observations reveal mainly a near columnar (=barotropic) flow, modified by some typical baroclinic features. The typical horizontal scales of the uni-directional velocity columns amounts to about 150 to 200 km. The meridional velocity (Figure 11) shows a mainly cyclonic circulation in the Irminger Sea at nearly all depths. In the near bottom layer, where Denmark Strait Overflow Water is found, two southward high velocity cores (V < -20 cm/s) are observed. In the centre of that basin that water type in the near-bottom layer recirculates to the north again. In the near bottom layer in the Iceland Basin, the Iceland-Scotland Overflow water is transported southwards in two separate high velocity cores, while along the western slope of the Hatton Bank the deep flow transports Lower Deep water to the north.

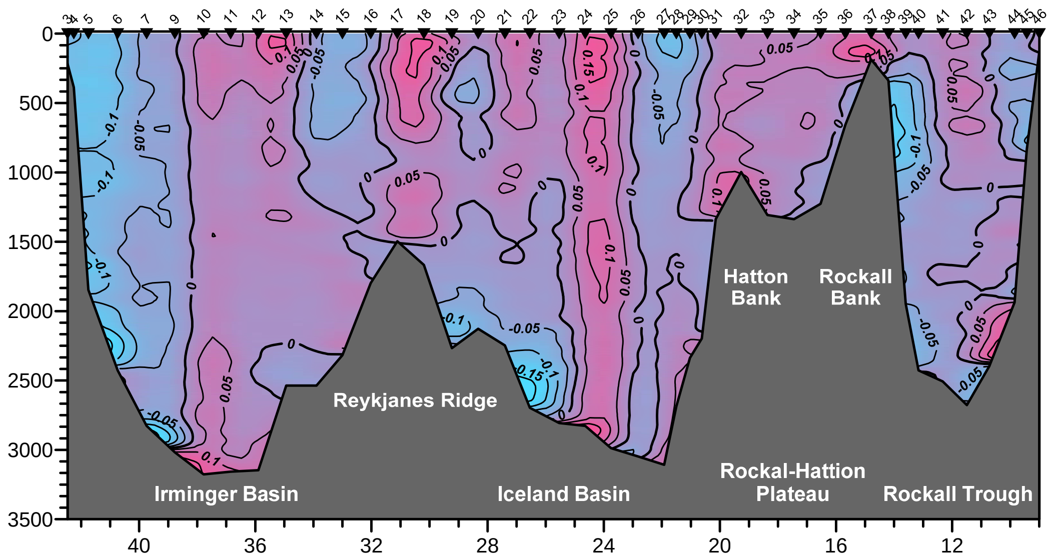


**Figure 11. The distribution of the North component of the water velocity (m/s) along the AR7E section, measured with the LADCP during the CTD casts.**

# Appendix A. Cruise Summary Pelagia Cruise 64PE342

**CAST TYPE**

| | | | |
|---|---|---|---|
| CTD | CTD cast | MOR | Mooring |
| FLT | ARGO Float | | |

**EVENT CODE**

| | | | |
|---|---|---|---|
| BE | Begin | BO | Bottom |
| EN | End | | |
| RE | Recovered | DE | Deployed |

| SHIP/CRS. EXPOCODE | WOCE SECT. | STN NBR | CAST NO | CAST TYPE | DATE | TIME UTC | EVENT CODE | LATITUDE Deg | LATITUDE Min. | H | LONGITUDE Deg | LONGITUDE Min. | H | NAV | UNC. DEPTH | MAX PRESS | COMMENTS | CTD DATA file |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 64PE342 | | 01 | 1 | ROS | 26-Jul-2011 | 13:12 | BE | 60 | 58.75 | N | 35 | 07.95 | W | GPS | 3001 | | oxygen sensor S/N 430350 | |
| 64PE342 | | 01 | 1 | ROS | 26-Jul-2011 | 13:18 | BO | 60 | 58.74 | N | 35 | 07.86 | W | GPS | 3001 | 205 | test | PE342011 |
| 64PE342 | | 01 | 1 | ROS | 26-Jul-2011 | 13:27 | EN | 60 | 58.75 | N | 35 | 07.73 | W | GPS | 3001 | | test | |
| 64PE342 | | 02 | 1 | ROS | 27-Jul-2011 | 10:21 | BE | 59 | 12.66 | N | 39 | 31.39 | W | GPS | 3043 | | | |
| 64PE342 | | 02 | 1 | ROS | 27-Jul-2011 | 11:12 | BO | 59 | 12.65 | N | 39 | 31.37 | W | GPS | 3043 | 3057 | | PE342021 |
| 64PE342 | | 02 | 1 | ROS | 27-Jul-2011 | 11:48 | EN | 59 | 12.65 | N | 39 | 31.37 | W | GPS | 3043 | | | |
| 64PE342 | | 02 | 2 | MOR | 27-Jul-2011 | 13:40 | RE | 59 | 12.44 | N | 39 | 30.34 | W | GPS | 3034 | | LOCO2-8 | |
| 64PE342 | AR7E | 03 | 1 | ROS | 28-Jul-2011 | 06:10 | BE | 59 | 52.82 | N | 42 | 27.99 | W | GPS | 222 | | | |
| 64PE342 | AR7E | 03 | 1 | ROS | 28-Jul-2011 | 06:15 | BO | 59 | 52.84 | N | 42 | 27.97 | W | GPS | 222 | 206 | | PE342031 |
| 64PE342 | AR7E | 03 | 1 | ROS | 28-Jul-2011 | 06:24 | EN | 59 | 52.83 | N | 42 | 27.85 | W | GPS | 221 | | | |
| 64PE342 | AR7E | 04 | 1 | ROS | 28-Jul-2011 | 08:08 | BE | 59 | 53.90 | N | 42 | 15.09 | W | GPS | 395 | | | |
| 64PE342 | AR7E | 04 | 1 | ROS | 28-Jul-2011 | 08:15 | BO | 59 | 53.89 | N | 42 | 15.12 | W | GPS | 394 | 379 | | PE342041 |
| 64PE342 | AR7E | 04 | 1 | ROS | 28-Jul-2011 | 08:29 | EN | 59 | 53.90 | N | 42 | 15.10 | W | GPS | 394 | | | |
| 64PE342 | AR7E | 05 | 1 | ROS | 28-Jul-2011 | 10:24 | BE | 59 | 50.68 | N | 41 | 44.83 | W | GPS | 1850 | | | |
| 64PE342 | AR7E | 05 | 1 | ROS | 28-Jul-2011 | 10:59 | BO | 59 | 50.68 | N | 41 | 44.85 | W | GPS | 1849 | 1838 | | PE342051 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 64PE342 | AR7E | 05 | 1 | ROS | 28-Jul-2011 | 11:52 | EN | 59 | 50.67 | N | 41 | 44.86 | W | GPS | 1850 | | | |
| 64PE342 | AR7E | 06 | 1 | ROS | 28-Jul-2011 | 15:30 | BE | 59 | 44.72 | N | 40 | 44.64 | W | GPS | 2418 | | | |
| 64PE342 | AR7E | 06 | 1 | ROS | 28-Jul-2011 | 16:13 | BO | 59 | 44.74 | N | 40 | 44.55 | W | GPS | 2418 | 2414 | | PE342061 |
| 64PE342 | AR7E | 06 | 1 | ROS | 28-Jul-2011 | 17:20 | EN | 59 | 44.68 | N | 40 | 44.63 | W | GPS | 2416 | | | |
| 64PE342 | AR7E | 06 | 2 | FLT | 28-Jul-2011 | 17:32 | DE | 59 | 44.63 | N | 40 | 44.85 | W | GPS | 2413 | | APEX float S/N 5792, ID A9872 | |
| 64PE342 | AR7E | 07 | 1 | ROS | 28-Jul-2011 | 21:00 | BE | 59 | 40.04 | N | 39 | 44.61 | W | GPS | 2413 | | | |
| 64PE342 | AR7E | 07 | 1 | ROS | 28-Jul-2011 | 21:49 | BO | 59 | 40.03 | N | 39 | 44.68 | W | GPS | 2812 | 2819 | | PE342071 |
| 64PE342 | AR7E | 07 | 1 | ROS | 28-Jul-2011 | 22:58 | EN | 59 | 40.03 | N | 39 | 44.67 | W | GPS | 2811 | | | |
| 64PE342 | AR7E | 07 | 2 | FLT | 28-Jul-2011 | 23:10 | DE | 59 | 40.01 | N | 39 | 44.65 | W | GPS | 2812 | | APEX float S/N 5788, ID A9906 | |
| 64PE342 | | 08 | 1 | MOR | 29-Jul-2011 | 12:22 | DE | 59 | 12.21 | N | 39 | 30.32 | W | GPS | 3043 | | LOCO2-9 | |
| 64PE342 | | 08 | 2 | CTD | 29-Jul-2011 | 13:02 | BE | 59 | 13.38 | N | 39 | 30.22 | W | GPS | 3034 | | | |
| 64PE342 | | 08 | 2 | CTD | 29-Jul-2011 | 13:56 | BO | 59 | 13.37 | N | 39 | 30.37 | W | GPS | 3034 | 3049 | | PE342082 |
| 64PE342 | | 08 | 2 | CTD | 29-Jul-2011 | 14:50 | EN | 59 | 13.34 | N | 39 | 30.42 | W | GPS | 3034 | | | |
| 64PE342 | | 08 | 3 | FLT | 29-Jul-2011 | 14:58 | DE | 59 | 13.36 | N | 39 | 30.44 | W | GPS | 3034 | | APEX float S/N 5789, ID A9902 | |
| 64PE342 | AR7E | 09 | 1 | ROS | 29-Jul-2011 | 18:26 | BE | 59 | 34.20 | N | 38 | 46.41 | W | GPS | 2991 | | | |
| 64PE342 | AR7E | 09 | 1 | ROS | 29-Jul-2011 | 19:19 | BO | 59 | 34.21 | N | 38 | 46.31 | W | GPS | 2991 | 3006 | | PE342091 |
| 64PE342 | AR7E | 09 | 1 | ROS | 29-Jul-2011 | 20:35 | EN | 59 | 34.20 | N | 38 | 46.29 | W | GPS | 2991 | | | |
| 64PE342 | AR7E | 09 | 2 | FLT | 29-Jul-2011 | 20:43 | DE | 59 | 34.19 | N | 38 | 46.20 | W | GPS | 2991 | | APEX float S/N 5790, ID A9900 | |
| 64PE342 | AR7E | 10 | 1 | ROS | 30-Jul-2011 | 00:10 | BE | 59 | 27.93 | N | 37 | 46.72 | W | GPS | 3144 | | | |
| 64PE342 | AR7E | 10 | 1 | ROS | 30-Jul-2011 | 01:05 | BO | 59 | 27.92 | N | 37 | 46.76 | W | GPS | 3145 | 3162 | | PE342101 |
| 64PE342 | AR7E | 10 | 1 | ROS | 30-Jul-2011 | 02:30 | EN | 59 | 27.85 | N | 37 | 46.62 | W | GPS | 3144 | | | |
| 64PE342 | AR7E | 10 | 2 | FLT | 30-Jul-2011 | 02:43 | DE | 59 | 27.94 | N | 37 | 46.79 | W | GPS | 3144 | | APEX float S/N 5791, ID A9907 | |
| 64PE342 | AR7E | 11 | 1 | ROS | 30-Jul-2011 | 05:56 | BE | 59 | 23.50 | N | 36 | 50.98 | W | GPS | 3127 | | | |
| 64PE342 | AR7E | 11 | 1 | ROS | 30-Jul-2011 | 06:52 | BO | 59 | 23.49 | N | 36 | 51.00 | W | GPS | 3127 | 3146 | | PE342111 |
| 64PE342 | AR7E | 11 | 1 | ROS | 30-Jul-2011 | 08:10 | EN | 59 | 23.49 | N | 36 | 51.00 | W | GPS | 3127 | | | |
| 64PE342 | AR7E | 11 | 2 | FLT | 30-Jul-2011 | 08:18 | DE | 59 | 23.53 | N | 36 | 51.00 | W | GPS | 3126 | | APEX float S/N 5787, ID A9913 | |
| 64PE342 | AR7E | 12 | 1 | ROS | 30-Jul-2011 | 11:34 | BE | 59 | 17.79 | N | 35 | 53.77 | W | GPS | 3119 | | | |
| 64PE342 | AR7E | 12 | 1 | ROS | 30-Jul-2011 | 12:32 | BO | 59 | 17.83 | N | 35 | 53.76 | W | GPS | 3119 | 3137 | | PE342121 |
| 64PE342 | AR7E | 12 | 1 | ROS | 30-Jul-2011 | 13:52 | EN | 59 | 17.81 | N | 35 | 53.76 | W | GPS | 3119 | | | |
| 64PE342 | AR7E | 12 | 2 | FLT | 30-Jul-2011 | 14:00 | DE | 59 | 17.89 | N | 35 | 53.88 | W | GPS | 3119 | | APEX float S/N 5786, ID A9951 | |
| 64PE342 | AR7E | 13 | 1 | ROS | 30-Jul-2011 | 17:17 | BE | 59 | 11.78 | N | 34 | 56.19 | W | GPS | 2520 | | | |
| 64PE342 | AR7E | 13 | 1 | ROS | 30-Jul-2011 | 18:01 | BO | 59 | 11.76 | N | 34 | 56.20 | W | GPS | 2520 | 2527 | | PE342131 |
| 64PE342 | AR7E | 13 | 1 | ROS | 30-Jul-2011 | 19:06 | EN | 59 | 11.79 | N | 34 | 56.19 | W | GPS | 2521 | | | |
| 64PE342 | AR7E | 14 | 1 | ROS | 30-Jul-2011 | 22:56 | BE | 59 | 06.00 | N | 33 | 53.72 | W | GPS | 2516 | | | |
| 64PE342 | AR7E | 14 | 1 | ROS | 30-Jul-2011 | 23:46 | BO | 59 | 06.01 | N | 33 | 53.71 | W | GPS | 2514 | 2527 | | PE342141 |
| 64PE342 | AR7E | 14 | 1 | ROS | 31-Jul-2011 | 00:52 | EN | 59 | 05.91 | N | 33 | 53.72 | W | GPS | 2524 | | | |
| 64PE342 | AR7E | 15 | 1 | ROS | 31-Jul-2011 | 04:15 | BE | 59 | 01.35 | N | 33 | 00.04 | W | GPS | 2302 | | | |
| 64PE342 | AR7E | 15 | 1 | ROS | 31-Jul-2011 | 04:57 | BO | 59 | 01.33 | N | 32 | 59.99 | W | GPS | 2303 | 2301 | | PE342151 |
| 64PE342 | AR7E | 15 | 1 | ROS | 31-Jul-2011 | 05:58 | EN | 59 | 01.33 | N | 33 | 00.03 | W | GPS | 2303 | | | |
| 64PE342 | AR7E | 16 | 1 | ROS | 31-Jul-2011 | 09:22 | BE | 58 | 56.14 | N | 32 | 01.51 | W | GPS | 1794 | | | |
| 64PE342 | AR7E | 16 | 1 | ROS | 31-Jul-2011 | 09:56 | BO | 58 | 56.15 | N | 32 | 01.50 | W | GPS | 1793 | 1787 | | PE342161 |
| 64PE342 | AR7E | 16 | 1 | ROS | 31-Jul-2011 | 10:46 | EN | 58 | 56.15 | N | 32 | 01.50 | W | GPS | 1793 | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 64PE342 | AR7E | 17 | 1 | ROS | 31-Jul-2011 | 13:45 | BE | 58 | 50.81 | N | 31 | 06.56 | W | GPS | 1495 | | | |
| 64PE342 | AR7E | 17 | 1 | ROS | 31-Jul-2011 | 14:11 | BO | 58 | 50.81 | N | 31 | 06.76 | W | GPS | 1488 | 1481 | | PE342171 |
| 64PE342 | AR7E | 17 | 1 | ROS | 31-Jul-2011 | 14:51 | EN | 58 | 50.80 | N | 31 | 06.98 | W | GPS | 1487 | | | |
| 64PE342 | AR7E | 18 | 1 | ROS | 31-Jul-2011 | 18:04 | BE | 58 | 44.98 | N | 30 | 11.62 | W | GPS | 1646 | | | |
| 64PE342 | AR7E | 18 | 1 | ROS | 31-Jul-2011 | 18:36 | BO | 58 | 44.98 | N | 30 | 11.62 | W | GPS | 1645 | 1652 | no LADCP | PE342181 |
| 64PE342 | AR7E | 18 | 1 | ROS | 31-Jul-2011 | 19:23 | EN | 58 | 44.96 | N | 30 | 11.61 | W | GPS | 1672 | | | |
| 64PE342 | AR7E | 19 | 1 | ROS | 31-Jul-2011 | 23:04 | BE | 58 | 40.99 | N | 29 | 13.94 | W | GPS | 2234 | | | |
| 64PE342 | AR7E | 19 | 1 | ROS | 31-Jul-2011 | 23:47 | BO | 58 | 40.99 | N | 29 | 13.94 | W | GPS | 2234 | 2251 | bad CTD oxygen values from | PE342191 |
| 64PE342 | AR7E | 19 | 1 | ROS | 01-Aug-2011 | 00:46 | EN | 58 | 40.98 | N | 29 | 13.90 | W | GPS | 2238 | | sample 4 upwards | |
| 64PE342 | AR7E | 20 | 1 | ROS | 01-Aug-2011 | 04:20 | BE | 58 | 34.97 | N | 28 | 19.61 | W | GPS | 2112 | | new oxygen sensor (S/N 431932) | |
| 64PE342 | AR7E | 20 | 1 | ROS | 01-Aug-2011 | 04:56 | BO | 58 | 34.97 | N | 28 | 19.59 | W | GPS | 2113 | 2112 | installed | PE342201 |
| 64PE342 | AR7E | 20 | 1 | ROS | 01-Aug-2011 | 05:53 | EN | 58 | 34.99 | N | 28 | 19.59 | W | GPS | 2113 | | | |
| 64PE342 | AR7E | 21 | 1 | ROS | 01-Aug-2011 | 09:32 | BE | 58 | 30.16 | N | 27 | 24.29 | W | GPS | 2232 | | | |
| 64PE342 | AR7E | 21 | 1 | ROS | 01-Aug-2011 | 10:15 | BO | 58 | 30.16 | N | 27 | 24.29 | W | GPS | 2232 | 2233 | | PE342211 |
| 64PE342 | AR7E | 21 | 1 | ROS | 01-Aug-2011 | 11:13 | EN | 58 | 30.16 | N | 27 | 24.31 | W | GPS | 2232 | | | |
| 64PE342 | AR7E | 22 | 1 | ROS | 01-Aug-2011 | 14:26 | BE | 58 | 26.01 | N | 26 | 32.63 | W | GPS | 2265 | | | |
| 64PE342 | AR7E | 22 | 1 | ROS | 01-Aug-2011 | 15:15 | BO | 58 | 25.97 | N | 26 | 32.75 | W | GPS | 2666 | 2682 | | PE342221 |
| 64PE342 | AR7E | 22 | 1 | ROS | 01-Aug-2011 | 16:27 | EN | 58 | 25.94 | N | 26 | 32.74 | W | GPS | 2668 | | | |
| 64PE342 | AR7E | 23 | 1 | ROS | 01-Aug-2011 | 20:06 | BE | 58 | 19.89 | N | 25 | 32.41 | W | GPS | 2783 | | | |
| 64PE342 | AR7E | 23 | 1 | ROS | 01-Aug-2011 | 20:59 | BO | 58 | 19.88 | N | 25 | 32.38 | W | GPS | 2782 | 2799 | | PE342231 |
| 64PE342 | AR7E | 23 | 1 | ROS | 01-Aug-2011 | 22:09 | EN | 58 | 19.89 | N | 25 | 32.38 | W | GPS | 2782 | | | |
| 64PE342 | AR7E | 24 | 1 | ROS | 02-Aug-2011 | 01:34 | BE | 58 | 12.34 | N | 24 | 38.32 | W | GPS | 2797 | | | |
| 64PE342 | AR7E | 24 | 1 | ROS | 02-Aug-2011 | 02:26 | BO | 58 | 12.26 | N | 24 | 38.23 | W | GPS | 2800 | 2817 | | PE342241 |
| 64PE342 | AR7E | 24 | 1 | ROS | 02-Aug-2011 | 03:31 | EN | 58 | 12.29 | N | 24 | 38.30 | W | GPS | 2798 | | | |
| 64PE342 | AR7E | 25 | 1 | CTD | 02-Aug-2011 | 06:51 | BE | 58 | 04.68 | N | 23 | 45.02 | W | GPS | 2954 | | | |
| 64PE342 | AR7E | 25 | 1 | CTD | 02-Aug-2011 | 07:45 | BO | 58 | 04.66 | N | 23 | 45.03 | W | GPS | 2954 | 2973 | sampling failed | PE342251 |
| 64PE342 | AR7E | 25 | 1 | CTD | 02-Aug-2011 | 07:57 | EN | 58 | 04.66 | N | 23 | 44.99 | W | GPS | 2954 | | upcast aborted | |
| 64PE342 | AR7E | 26 | 1 | ROS | 02-Aug-2011 | 12:23 | BE | 57 | 54.87 | N | 22 | 48.94 | W | GPS | 3007 | | | |
| 64PE342 | AR7E | 26 | 1 | ROS | 02-Aug-2011 | 13:19 | BO | 57 | 54.92 | N | 22 | 49.04 | W | GPS | 3006 | 3034 | | PE342261 |
| 64PE342 | AR7E | 26 | 1 | ROS | 02-Aug-2011 | 14:33 | EN | 57 | 54.90 | N | 22 | 49.00 | W | GPS | 3007 | | | |
| 64PE342 | AR7E | 27 | 1 | ROS | 02-Aug-2011 | 17:44 | BE | 57 | 46.42 | N | 21 | 55.07 | W | GPS | 3061 | | | |
| 64PE342 | AR7E | 27 | 1 | ROS | 02-Aug-2011 | 18:40 | BO | 57 | 46.44 | N | 21 | 55.09 | W | GPS | 3062 | 3091 | | PE342271 |
| 64PE342 | AR7E | 27 | 1 | ROS | 02-Aug-2011 | 19:57 | EN | 57 | 46.44 | N | 21 | 55.09 | W | GPS | 3063 | | | |
| 64PE342 | AR7E | 28 | 1 | CTD | 02-Aug-2011 | 21:44 | BE | 57 | 42.47 | N | 21 | 30.17 | W | GPS | 2654 | | | |
| 64PE342 | AR7E | 28 | 1 | CTD | 02-Aug-2011 | 22:24 | BO | 57 | 42.48 | N | 21 | 30.19 | W | GPS | 2656 | 2676 | no LADCP | PE342281 |
| 64PE342 | AR7E | 28 | 1 | CTD | 02-Aug-2011 | 23:24 | EN | 57 | 42.49 | N | 21 | 30.20 | W | GPS | 2658 | | | |
| 64PE342 | AR7E | 29 | 1 | ROS | 03-Aug-2011 | 01:23 | BE | 57 | 36.92 | N | 21 | 01.97 | W | GPS | 2316 | | | |
| 64PE342 | AR7E | 29 | 1 | ROS | 03-Aug-2011 | 02:05 | BO | 57 | 36.94 | N | 21 | 01.91 | W | GPS | 2316 | 2323 | | PE342291 |
| 64PE342 | AR7E | 29 | 1 | ROS | 03-Aug-2011 | 03:08 | EN | 57 | 36.94 | N | 21 | 01.85 | W | GPS | 2317 | | | |
| 64PE342 | AR7E | 30 | 1 | CTD | 03-Aug-2011 | 04:39 | BE | 57 | 35.20 | N | 20 | 37.41 | W | GPS | 2175 | | | |
| 64PE342 | AR7E | 30 | 1 | CTD | 03-Aug-2011 | 05:17 | BO | 57 | 35.19 | N | 20 | 37.42 | W | GPS | 2176 | 2180 | | PE342301 |
| 64PE342 | AR7E | 30 | 1 | CTD | 03-Aug-2011 | 05:55 | EN | 57 | 35.21 | N | 20 | 37.40 | W | GPS | 2176 | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 64PE342 | AR7E | 31 | 1 | ROS | 03-Aug-2011 | 07:43 | BE | 57 | 30.06 | N | 20 | 08.89 | W | GPS | 1325 | | | |
| 64PE342 | AR7E | 31 | 1 | ROS | 03-Aug-2011 | 08:09 | BO | 57 | 30.05 | N | 20 | 08.88 | W | GPS | 1325 | 1322 | | PE342311 |
| 64PE342 | AR7E | 31 | 1 | ROS | 03-Aug-2011 | 08:47 | EN | 57 | 30.05 | N | 20 | 08.86 | W | GPS | 1325 | | | |
| 64PE342 | AR7E | 32 | 1 | ROS | 03-Aug-2011 | 12:23 | BE | 57 | 22.00 | N | 19 | 15.98 | W | GPS | 993 | | | |
| 64PE342 | AR7E | 32 | 1 | ROS | 03-Aug-2011 | 12:47 | BO | 57 | 21.94 | N | 19 | 15.96 | W | GPS | 994 | 989 | | PE342321 |
| 64PE342 | AR7E | 32 | 1 | ROS | 03-Aug-2011 | 13:10 | EN | 57 | 21.95 | N | 19 | 15.96 | W | GPS | 994 | | | |
| 64PE342 | AR7E | 33 | 1 | ROS | 03-Aug-2011 | 16:14 | BE | 57 | 14.15 | N | 18 | 21.72 | W | GPS | 1302 | | | |
| 64PE342 | AR7E | 33 | 1 | ROS | 03-Aug-2011 | 16:37 | BO | 57 | 14.15 | N | 18 | 21.73 | W | GPS | 1301 | 1298 | | PE342331 |
| 64PE342 | AR7E | 33 | 1 | ROS | 03-Aug-2011 | 17:14 | EN | 57 | 14.16 | N | 18 | 21.72 | W | GPS | 1302 | | | |
| 64PE342 | AR7E | 34 | 1 | ROS | 03-Aug-2011 | 20:30 | BE | 57 | 05.79 | N | 17 | 27.02 | W | GPS | 1328 | | | |
| 64PE342 | AR7E | 34 | 1 | ROS | 03-Aug-2011 | 20:55 | BO | 57 | 05.79 | N | 17 | 27.03 | W | GPS | 1328 | 1324 | | PE342341 |
| 64PE342 | AR7E | 34 | 1 | ROS | 03-Aug-2011 | 21:32 | EN | 57 | 05.79 | N | 17 | 27.03 | W | GPS | 1328 | | | |
| 64PE342 | AR7E | 35 | 1 | ROS | 04-Aug-2011 | 00:47 | BE | 56 | 57.98 | N | 16 | 32.01 | W | GPS | 1217 | | | |
| 64PE342 | AR7E | 35 | 1 | ROS | 04-Aug-2011 | 01:12 | BO | 56 | 57.95 | N | 16 | 31.99 | W | GPS | 1216 | 1214 | | PE342351 |
| 64PE342 | AR7E | 35 | 1 | ROS | 04-Aug-2011 | 01:46 | EN | 56 | 57.95 | N | 16 | 32.07 | W | GPS | 1216 | | | |
| 64PE342 | AR7E | 36 | 1 | ROS | 04-Aug-2011 | 04:59 | BE | 56 | 47.96 | N | 15 | 40.69 | W | GPS | 649 | | | |
| 64PE342 | AR7E | 36 | 1 | ROS | 04-Aug-2011 | 05:11 | BO | 56 | 47.95 | N | 15 | 40.70 | W | GPS | 649 | 641 | | PE342361 |
| 64PE342 | AR7E | 36 | 1 | ROS | 04-Aug-2011 | 05:31 | EN | 56 | 47.96 | N | 15 | 40.70 | W | GPS | 650 | | | |
| 64PE342 | AR7E | 37 | 1 | ROS | 04-Aug-2011 | 08:49 | BE | 56 | 40.19 | N | 14 | 47.59 | W | GPS | 187 | | | |
| 64PE342 | AR7E | 37 | 1 | ROS | 04-Aug-2011 | 08:55 | BO | 56 | 40.18 | N | 14 | 47.59 | W | GPS | 187 | 174 | | PE342371 |
| 64PE342 | AR7E | 37 | 1 | ROS | 04-Aug-2011 | 09:03 | EN | 56 | 40.19 | N | 14 | 47.59 | W | GPS | 187 | | | |
| 64PE342 | AR7E | 38 | 1 | ROS | 04-Aug-2011 | 11:15 | BE | 56 | 34.74 | N | 14 | 11.78 | W | GPS | 332 | | | |
| 64PE342 | AR7E | 38 | 1 | ROS | 04-Aug-2011 | 11:21 | BO | 56 | 34.73 | N | 14 | 11.78 | W | GPS | 331 | 320 | | PE342381 |
| 64PE342 | AR7E | 38 | 1 | ROS | 04-Aug-2011 | 11:32 | EN | 56 | 34.72 | N | 14 | 11.79 | W | GPS | 334 | | | |
| 64PE342 | AR7E | 39 | 1 | ROS | 04-Aug-2011 | 13:45 | BE | 56 | 29.25 | N | 13 | 36.01 | W | GPS | 1926 | | | |
| 64PE342 | AR7E | 39 | 1 | ROS | 04-Aug-2011 | 14:23 | BO | 56 | 29.23 | N | 13 | 35.96 | W | GPS | 1926 | 1938 | | PE342391 |
| 64PE342 | AR7E | 39 | 1 | ROS | 04-Aug-2011 | 15:20 | EN | 56 | 29.21 | N | 13 | 35.96 | W | GPS | 1927 | | | |
| 64PE342 | AR7E | 40 | 1 | ROS | 04-Aug-2011 | 17:03 | BE | 56 | 24.92 | N | 13 | 09.48 | W | GPS | 2399 | | | |
| 64PE342 | AR7E | 40 | 1 | ROS | 04-Aug-2011 | 17:46 | BO | 56 | 24.92 | N | 13 | 09.49 | W | GPS | 2401 | 2415 | | PE342401 |
| 64PE342 | AR7E | 40 | 1 | ROS | 04-Aug-2011 | 18:46 | EN | 56 | 24.93 | N | 13 | 09.50 | W | GPS | 2401 | | | |
| 64PE342 | AR7E | 41 | 1 | ROS | 04-Aug-2011 | 21:46 | BE | 56 | 17.13 | N | 12 | 19.65 | W | GPS | | | | |
| 64PE342 | AR7E | 41 | 1 | ROS | 04-Aug-2011 | 22:31 | BO | 56 | 17.13 | N | 12 | 19.67 | W | GPS | | 2495 | | PE342411 |
| 64PE342 | AR7E | 41 | 1 | ROS | 04-Aug-2011 | 23:38 | EN | 56 | 17.11 | N | 12 | 19.58 | W | GPS | | | | |
| 64PE342 | AR7E | 42 | 1 | ROS | 05-Aug-2011 | 02:38 | BE | 56 | 09.44 | N | 11 | 29.84 | W | GPS | 2244 | | | |
| 64PE342 | AR7E | 42 | 1 | ROS | 05-Aug-2011 | 03:29 | BO | 56 | 09.35 | N | 11 | 29.80 | W | GPS | 2221 | 2668 | not all bottles did close | PE342421 |
| 64PE342 | AR7E | 42 | 1 | ROS | 05-Aug-2011 | 04:46 | EN | 56 | 09.34 | N | 11 | 29.78 | W | GPS | 2335 | | | |
| 64PE342 | AR7E | 43 | 1 | ROS | 05-Aug-2011 | 07:30 | BE | 56 | 01.81 | N | 10 | 43.21 | W | GPS | 2370 | | | |
| 64PE342 | AR7E | 43 | 1 | ROS | 05-Aug-2011 | 08:13 | BO | 56 | 01.82 | N | 10 | 43.25 | W | GPS | 2371 | 2387 | | PE342431 |
| 64PE342 | AR7E | 43 | 1 | ROS | 05-Aug-2011 | 09:13 | EN | 56 | 01.82 | N | 10 | 43.25 | W | GPS | 2372 | | | |
| 64PE342 | AR7E | 44 | 1 | ROS | 05-Aug-2011 | 12:13 | BE | 55 | 52.94 | N | 9 | 51.22 | W | GPS | 1918 | | | |
| 64PE342 | AR7E | 44 | 1 | ROS | 05-Aug-2011 | 12:49 | BO | 55 | 52.90 | N | 9 | 51.17 | W | GPS | 1917 | 1924 | | PE342441 |
| 64PE342 | AR7E | 44 | 1 | ROS | 05-Aug-2011 | 13:43 | EN | 55 | 52.88 | N | 9 | 51.23 | W | GPS | 1917 | | | |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 64PE342 | AR7E | 45 | 1 | ROS | 05-Aug-2011 | 15:23 | BE | 55 | 48.97 | N | 9 | 26.00 | W | GPS | 824 | | | |
| 64PE342 | AR7E | 45 | 1 | ROS | 05-Aug-2011 | 15:38 | BO | 55 | 48.97 | N | 9 | 25.97 | W | GPS | 823 | 821 | | PE342451 |
| 64PE342 | AR7E | 45 | 1 | ROS | 05-Aug-2011 | 16:04 | EN | 55 | 49.00 | N | 9 | 25.95 | W | GPS | 821 | | | |
| 64PE342 | AR7E | 46 | 1 | CTD | 05-Aug-2011 | 17:49 | BE | 55 | 45.01 | N | 8 | 59.99 | W | GPS | 124 | | | |
| 64PE342 | AR7E | 46 | 1 | CTD | 05-Aug-2011 | 17:51 | BO | 55 | 45.02 | N | 8 | 59.99 | W | GPS | 124 | 112 | bottles malfunctioned | PE342461 |
| 64PE342 | AR7E | 46 | 1 | CTD | 05-Aug-2011 | 17:59 | EN | 55 | 45.02 | N | 8 | 59.98 | W | GPS | 124 | | | |

# Appendix B. Mooring summary file of LOCO2-9

| **Mooring LOCO 2-9** | S/N | **relasred** | | | bumpers | recording rate/release code | remarks |
|---|---|---|---|---|---|---|---|
| instuments & cables | | length | height above bottom | Depth in water (m) | | | |
| bottom weight | | 1 | | **3018** | | | corrected depth |
| | | | 1 | 3017 | | | |
| 5 m chain | | 5 | | | | | |
| | | | 6 | 3012 | | | |
| releases | | 2 | | | | | |
| OCEANO RT | #1227 | | | 3010 | | 08D2 | |
| OCEANO AR | #0450 | | 8 | 3010 | | 1478 | |
| Microcat | 2675 | 573 | | 3003 | | | |
| cable | | 572 | | | | | |
| | | | 580 | 2438 | | | |
| chain | | 1 | | | | | |
| | | | 581 | 2437 | | | |
| Longranger ADCP | 3699 | 2 | | | | | down-looking |
| | | | 583 | 2435 | | | |
| chain | | 1 | | | | | |
| bumper | | | | 2433 | | | |
| | | | 584 | 2434 | | | |
| cable | | 2284 | | | | | |
| McLane profiler | 11564-01 | | | 150-2400 | | | |
| | | | 2868 | 150 | | | |
| bumper | | | | 151 | | | |
| chain | | 1 | | | | | |
| | | | 2869 | 149 | | | |
| sub-surface buoy | | 1 | | | | | |
| | | | 2870 | 148 | | | |
| chain | | 2 | | | | | |
| | | | 2872 | 146 | | | |
| cable | | 27 | | | | | |
| | | | 2899 | 119 | | | |
| chain | | 1 | | | | | |
| | | | 2900 | 118 | | | |
| Longranger ADCP | | 1 | | | | | down-looking |
| | | | 2901 | 117 | | | |
| floating line | | 10 | | | | | |
| top buoy | | | 2911 | 107 | | | |
| ARGOS baken | 60667 | | | | | | **ID=22580** |