Cruise Report

ROCS

cruise ROCS02-1/2

R.V. Pelagia cruises 64PE198/201

ROCS02-1: 15-20 July, 2002
ROCS02-2: 29 August-06 September, 2002

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(with contributions from participants)

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0. Contents

1. Summary of R.V. Pelagia ROCS cruises-1,2

Between mid-July and early September 2002 the R.V. Pelagia (NIOZ, The Netherlands) sailed twice to the Rockall Channel, mainly to deploy and recover moorings within 'ROckall Channel Studies (ROCS)'. ROCS is a NIOZ-funded project. It is a multidisciplinary oceanographic study (involving marine physicists and chemists) on the interaction between bottom topography and ocean (internal wave) currents. Specifically we study sudden transitions in bottom boundary layer currents and effects on resuspension of bottom material.

The working area of ROCS was the foot of the continental slope in the Rockall Channel near 54º 10' N, 14º 00' W (~2900 m depth). Four moorings were deployed at mutual distances of about 10 km. One mooring was on the 8% bottom slope, the others 5 or 10 km away from the abrupt change to the abyssal plain. All moorings sampled up to 50-100 m above the bottom during 45 days. One moorings held fast-sampling instruments: an acoustic Doppler current profiler (ADCP) sampling at once per 15 s and two NIOZ-built fast and accurate thermistor string sampling at once per 4 s and once per 30 s. The other three consisted of 4 current meters sampling once per 2 minutes, 1 optical backscatter sensor sampling once per 12 mins and 2 sediment traps sampling every 2-4 days. During the deployment cruise a single CTD-transect mapped the backgrouns hydrography perpendicular to the continental slope. For the interpretation of suspended sediment sampling, some benthic sedimentological sampling was performed.

In general, the cruise was successful. This was achieved because of the experienced crew and participants on board. Weather conditions were good. About 75% of the instruments worked flawlessly, with some problems occurring in acoustic (current) measurements attributable to the occasional clarity of the water due to a lack of appropriate scatterers.

Preliminary results show strong zonation of sediment across the foot of the continental slope. Resuspension was found to vary strongly in amplitude and in time across the short distances between the moorings. Like in previous studies in the Faeroe-Shetland Channel, sudden passages of near-bottom fronts were accompanied by vigorous resuspension, occurring on time scales of minutes.

Several tests were performed during the two cruises. Different types of current meters and acoustic releases were tested on the moorings. Shipborne LADCP was modified and tested. Current profiles of this instrument were compared with expendable current profiler (XCP) data, whilst results from the latter were also compared with microstructure data.

2. ROCS' general research objective.

The purpose of ROCS is to study the effects of internal waves and boundary currents on mixing in the bottom boundary layer at the foot (abrupt transition) of a smooth deep-ocean continental slope. The aim is to establish the physics of the sudden increases in near-bottom currents and their importance for sediment transport. Mainly fast sampling instrumentation is used, moored in the bottom boundary layer on different slopes, for the duration of 6 weeks. Additionally, some CTD- and bottom sampling is performed for hydrographic and calibration purposes.

We investigate strong variations in bottom boundary characteristics, such as height and mixing state. We also expect these variations to occur suddenly in time. Previous observations in the Faeroer-Shetland Channel showed sudden increases from 0 – 0.5 m s^{-1} occurring within a minute, and accompanied by dramatic changes in suspended material and in temperature when in sufficiently stratified waters (Fig. 1). The Rockall Channel location is deeper than the one in the Faeroer-Shetland Channel, and is characterized by a sudden change in bottom topography.

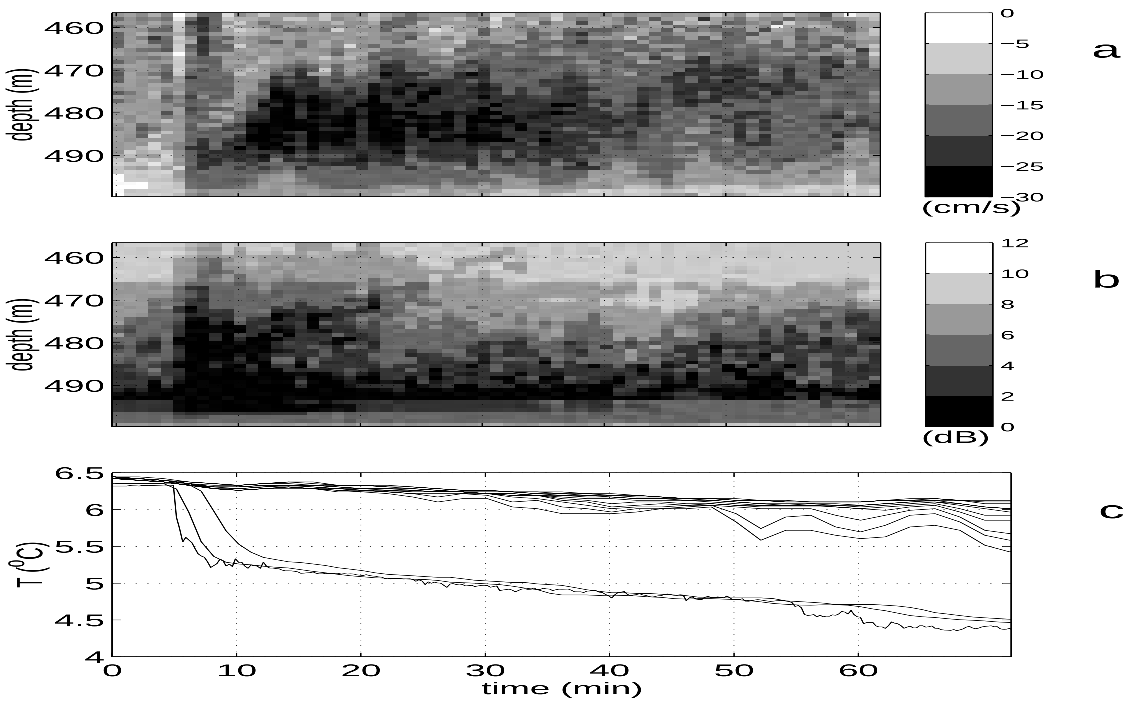


Fig. 1 Previous observations during PROCS, Faeroe-Shetland Channel, 1997. a. current amplitude, b. echo intensity, c. temperature.

a. ROCS' cruises and site.

All stations were in the lower left corner of heavy lined rectangular area in Fig. 2. The mooring positions were near 54º 10'N, 14º 01'W (~2900 m depth), near the foot of the bottom slope (Fig. 3).

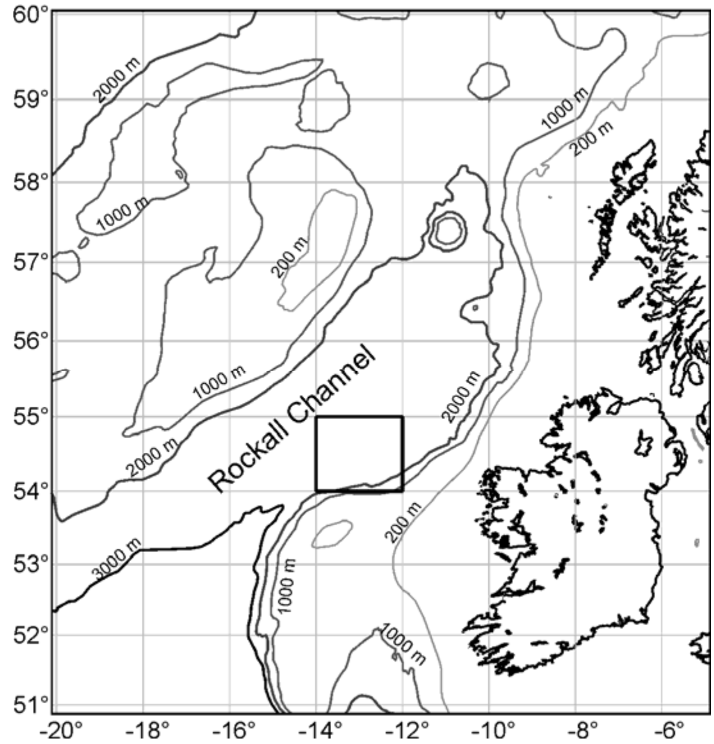


Fig. 2 Rockall Channel and ROCS area.

Between 2000-2800 m depth he ship's 3.5 kHz echo-sounder showed numerous side-reflections, evidence of rugged bottom topography (large boulders) or gullies and canyons. The bottom slope ended abruptly, and a weak slope (~0.5°) crossed the Channel to the Rockall Bank. This abrupt end was due to filling of the basin after landslides, the filling taking place in the past on geological timescales. In the along-slope direction, the steep slope was relatively smooth in comparison to locations to the north and south which showed more rugged canyon-like topography (de Stigter and de Haas, 2001).

ROCS consisted of two cruises. During the first one in mid-July we focused on the deployment of the moorings after site location using CTD and echo sounder information, and in situ thermistor string calibration. Additionally hydrographic and sedimentological data were sampled. During the second cruise in early September the moorings were recovered and some additional calibration data were collected. A acoustic release test mooring was deployed and recovered. Eight XCP probes were launched shortly after microstructure and LADCP profiling of the upper 1000 m of the water column.

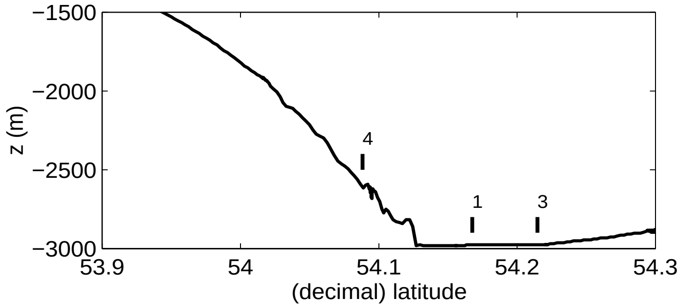


Fig3. Cross Section perpendicular to the continental slope, with some mooring positions.

3. Participants.

Institute	*Name*
NIOZ-FYS	Hans van Haren (PI)
NIOZ-FYS	Kees Veth
NIOZ-FYS	Theo Hillebrand
NIOZ-FYS/DMG	Margriet Hiehle
NIOZ-FYS	Phil Hosegood
NIOZ-MCG	Jérome Bonnin
NIOZ-DEL	Martin Laan
NIOZ-DZT	Lorendz Boom
NIOZ-DZT	Yvo Witte
NIOZ-DZT	Yvo Witte
Univ. Tokyo	Yoshihiro Niwa*
Univ. Tokyo	Maki Nagasawa*

* Cruise 2 only

NIOZ departments

FYS physical oceanography
MCG marine chemistry and geology
DEL electronics
DZT sea technology
DMG data management group

4. Instrumentation and sampling strategies.

a. Moorings (Appendix A for the diagrams)

All four moorings were short in length and the uppermost (buoyancy) elements were at about 100 m above the bottom. The moorings had a single BMTI ellipse-shaped buoyancy element at the top, which also held an ARGOS beacon (Fig. 4). This novel buoyancy design minimized mooring deflection, estimated <5° at 0.7 m s^{-1}. At the bottom, an instrumented frame contained a weight connected to two acoustic releases.

Three moorings **(ROCS-2-4)** contained 2 sediment traps, 1 optical backscatter sensor (OBS) with tilt meter and 4 current meters with temperature sensor. One mooring **(ROCS-4)** carried 2 extra current meters of different brands for testing purposes. The fourth mooring **(ROCS-1)** consisted of an upward looking fast-sampling 300kHz ADCP and two NIOZ-built thermistor strings (van Haren et al., 2001).

Mooring **ROCS-1** was the bottom lander containing the large memory 300 kHz ADCP and two fast and accurate thermistor strings. For reference, a mechanical current meter was moored just above the thermistor strings, at 85 m above the bottom. The equipment sampled at a fairly high temporal (4- 30 s) and spatial (0.5 m for thermistor strings and 1 m for the

ADCP) resolution the water temperature between 2-82 m above bottom (mab) as well as between 2.5-82.5 mab all three components of velocity and the echo amplitude (backscatter

Fig4. Recovery of mooring ROCS-1 showing ellipsoidal buoyancy element with ARGOS beacon in yellow sphere (photo: Margriet Hiehle).

strength). The latter estimated the relative variability of suspended matter in the water column. The purpose of the instrumental set-up was to estimate directly internal wave band eddy fluxes, besides the overall flow and temperature field. For this purpose memory capacity of the instrumentation was fairly large (450 MB for the ADCP and 512 MB for one thermistor string, 'NIOZ-2'). In order to associate the temperature variations to density variations a proper estimate of the temperature-density relationship was required from sufficient CTD sampling.

ROCS-2 and ROCS-3 were moorings holding one sediment trap with OBS/tiltmeters at the bottom (2 mab; in a bottom frame also holding the acoustic releases) and another without OBS/tiltmeters at a distance of 30 m above the bottom. The current meters were positioned at 8, 21, 35 and 48 m above the bottom. In each mooring, 2 current meters were of the mechanical type (Aanderaa RCM8) and 2 were acoustic Aanderaa RCM-11. The current meters sampled at once per 120 s and the OBS/tiltmeters at once per 720 s. The sediment traps rotated one cup per 2-4 days.

ROCS-4 was similar to ROCS-2,3 and included 2 extra current meters for test purposes. One of these current meters, a Nortek AquaDopp, sampled at 0.33 Hz. It was mounted at 50 mab with an RCM-8 and an RCM-11 just below it.

b. Shipborne equipment

During the first (mooring deployment) cruise a single CTD-section was sampled with 7 stations every 10 km along a transect perpendicular to the continental slope. At three of these stations sediment samples were taken using multicorer. During the second (mooring recovery) cruise turbulence measurements were made using two different sets of equipment: a microstructure profiler and XCP.

The Pelagia ***CTD/Rosette*** system contained a Seabird 911 CTD and with a Seapoint STM OBS. The CTD sampled at a 24 Hz rate. The CTD-frame held a Rosette with 22 12 l water bottles and a 'lowered ADCP' (***LADCP***) consisting of and upward and downward looking 1.2 MHz RDI-ADCP. In-situ water samples were taken for filling sediment trap cups.

A second Rosette frame was used without bottles. On this frame both NIOZ fast-thermistor strings were mounted briefly, for calibration. With the core of the Pelagia CTD inserted, this frame was lowered to the bottom near the planned mooring site for *in-situ* calibration of the thermistor strings.

A ***FLY-II*** microstructure profiler was used to measure the turbulence dissipation rate in the water column down to 1100 m. The FLY-II was still operating in a configuration so that its noise level was fairly high (2e-9 W/kg). Currently, the electronics are remodeled at NIOZ. Additionally, 7 Sippican expendable current profilers (***XCP***) (and XCTD) were launched for comparison, during a 15h station.

Sediment samples were collected using a NIOZ-built ***Multicorer*** to determine organic carbon content, and particle sizes. These samples will be analysed at NIOZ for the ^{210}Pb, ^{234}Th and biogenic silica activities to identify zones dominated by erosion and deposition, respectively.

Fig 5. Spare CTD-frame holding NIOZ-thermistor strings for calibration (photo: Margriet Hiehle).

5. Daily summaries of ROCS02.

a. Cruise-1

Monday 15 July

Reshifting and preparation of materials started at 8.00 local time in Galway harbour (Ireland). W3. Departure for the Rockall Channel at 20.00 GMT-DST.

Tuesday 16 July

WNW 3. 07.30 UTC test CTD on the continental shelf. CTD is working fine. 16 UTC arrival near the proposed central mooring site (54º 10'N, 14º 01'W (~2900 m depth). CTD and water samples taken for preparation of the sediment traps. Shifting of CTD-core into frame with thermistor strings. 20 UTC thermistor string calibration using the CTD. Old thermistor string works fine. New thermistor string shows problems for 20-25 sensors (of which 16 in one concentrator, #5) after being lowered deeper than 2500 m. During the night an echo sounder survey is made to determine the mooring locations.

Wednesday 17 July

SE2-4. 07 UTC preparation of the first mooring. Weather conditions are extremely good. Between 09-18 UTC all four moorings are deployed. No problems encountered, except some little difficulties in mounting cups in sediment traps.

Thursday 18 July

SSE4, 2 m swell. 07-22 UTC CTD transect passing the mooring positions and up the continental slope. Around mid-day CTD cable is taken out of heave-compensator because one of the bearings is not in good working order.

Friday 19 July

WNW3. 05-12 UTC Multicore. After a first mistrial, three times good samples are obtained. 12.30 UTC set course to Galway.

Saturday 20 July

SE2-4. 10 UTC arrival Galway harbour pilot station. 11 UTC participants arrive in Galway harbour, R.V. Pelagia leaves for Brest (France).

b. Cruise-2

Thursday 29 August

Loading on Texel. SW3. Departure for the Rockall Channel at 16.15 MEST, 14.15 UTC.

Friday 30 August

SW3-4. Transit, good weather conditions.

Saturday 31 August

NW4. Transit, good weather conditions.

Sunday 01 September

SW3-4. Transit, passing beautiful south-west coast of Ireland. Sightings of dolfins. good weather conditions.

Monday 02 September

S5-6, 3m swell. 13:50 UTC arrival at mooring site. First mooring recovery (ROCS-1) takes a little more time (1 hour) than usual due to swell conditions and too few pick-up possibilities. After the safe recovery of this mooring, ROCS-4 is recovered around 18-19 UTC. Actions suspended during nighttime.

Tuesday 03 September

N3-4. 7-10:45 UTC safe recovery of the moorings ROCS-2 and ROCS-3. 11 UTC deployment acoustic release test mooring. 15 UTC recovery test-mooring. 17:30 UTC start 15h (one inertial period) time series (of 17h of operations) of seven times the sequence of CTD, XCP, XCTD and FLY at a single station near the centre of the Rockall Channel (54°30’N, 14°30’W). The time series is for collection of mixing rate data resolving one inertial/tidal period, and also for the intercomparison of different measurement techniques and teaching new techniques to NIOZ technician and Pelagia crew for further deployments on the North-Atlantic Ocean after the ROCS-2 cruise. All went fine, except 1 XCP and 2 CTD (out of 29 operations).

Wednesday 04 September

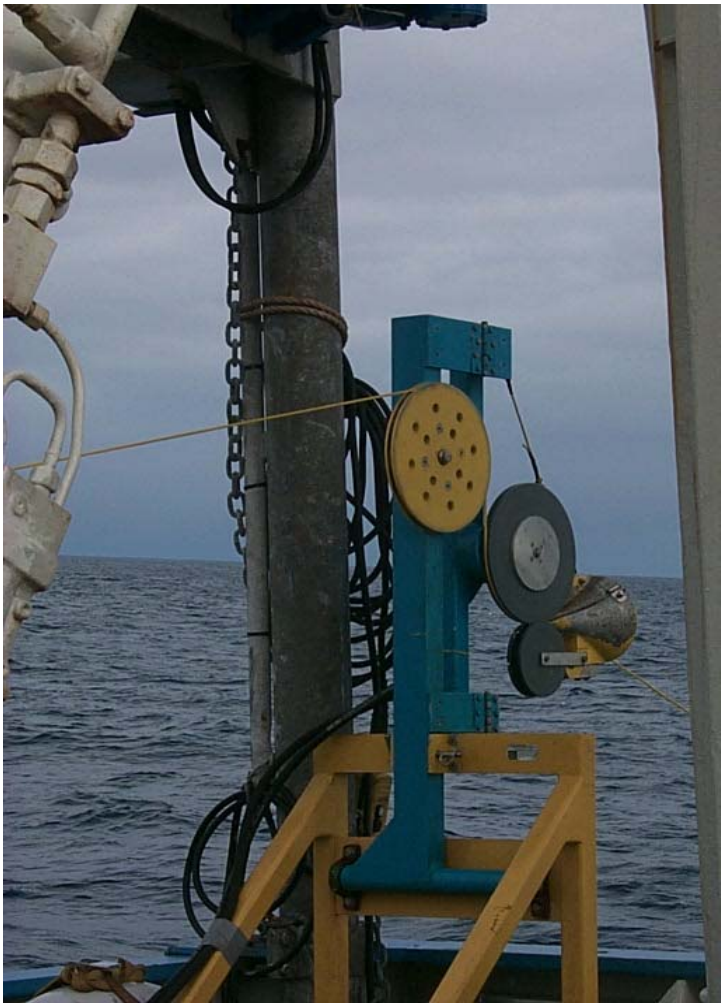
Var2-SW6. 10:30 UTC end 15h station. 11-14 UTC second calibration of the NIOZ thermistor strings against CTD data. NIOZ-2 does not respond to communications anymore. 14 UTC departure for Galway (Ireland).

Thursday 05 September

SW6. 15:30 UTC arrival at Galway pilot station.

Friday 06 September

Loading extra 11 XCP probes. Unloading all NIOZ instrumentation and Nortek-, Oceano-test-equipment for transport to Texel.



6. Scientific summary

a. Mooring deployments

The moorings were deployed from the stern, except for ROCS02-1 from the side. ROCS02-4 was on the rugged slope, whilst ROCS02-1, 2 in the plain just off the abrupt foot of the continental slope (Figs. 3, 6). Mooring ROCS02-3 was on the side of a little hump on the weak slope towards the Rockall Bank. The positions of the moorings are in Table 1, and schematically in Fig. 6. The sediment trap/current meter moorings occupied the corners of a triangle, to be able to get some information on internal wave direction. The ADCP/thermistor string mooring was in the centre of this triangle.

Table 1. Mooring positions

ROC02-1	2975 m	54°10.050’N -014°01.132’W
ROC02-2	2981 m	54°11.710’N -013°52.760’W
ROC02-3	2969 m	54°12.884’N -014°08.327’W
ROC02-4	2579 m	54°05.301’N -014°03.707’W

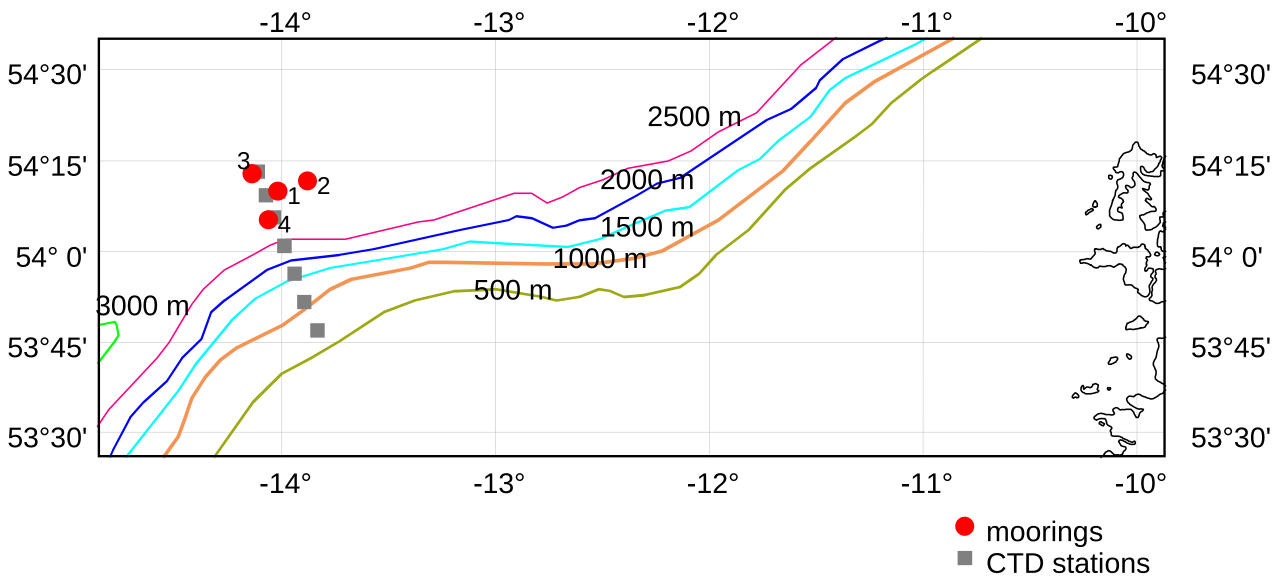


Fig. 6. Schematic of relative positions of ROCS-moorings in the Rockall Channel.

All moorings were recovered successfully after six weeks of deployment, and the results were good, as ~80% of the instruments delivered good data (see below). No instruments were lost or irrepairably damaged. The new ellipse shaped floats worked very well, as the moorings showed very little tilt < 1.5°. Slight disadvantage is that these floats laid ‘low’ on the surface. For future deployment it was recommended to put a flag on them and a ring or longer rope for easier catchment during retrieval.

1. Current and temperature measurements

The ADCP worked well and so did 11 out of 15 current meters (Table 2). The NIOZ-2 thermistor string provided excellent data, but, unfortunately, until the time of writing we are uncertain whether the new NIOZ-2 has collected data. The file summary did not show a file and awaits repair.

Table 2. Good data return from moored instruments; CM=current meter; TS=thermistor string; SD=sediment trap (space: bad data)

ROC02-1	ADCP; TS ,TS-1 (66-82 mab); CM mab	
ROC02-2	CM 08, 21, 35, 48 mab;	SD 02, mab; OBS
ROC02-3	CM 08, , 35, 48 mab;	SD , 30 mab; OBS
ROC02-4	CM 08, 21, , 47, 48, mab;	SD 02, 30 mab; OBS

The water column was generally very clear in terms of acoustic scatterers, comparable with Antarctic waters, albeit varying strongly with time. As a result, the range of good data varied between 40-80 mab and the thermistor strings were occasionally ‘heard’ at different

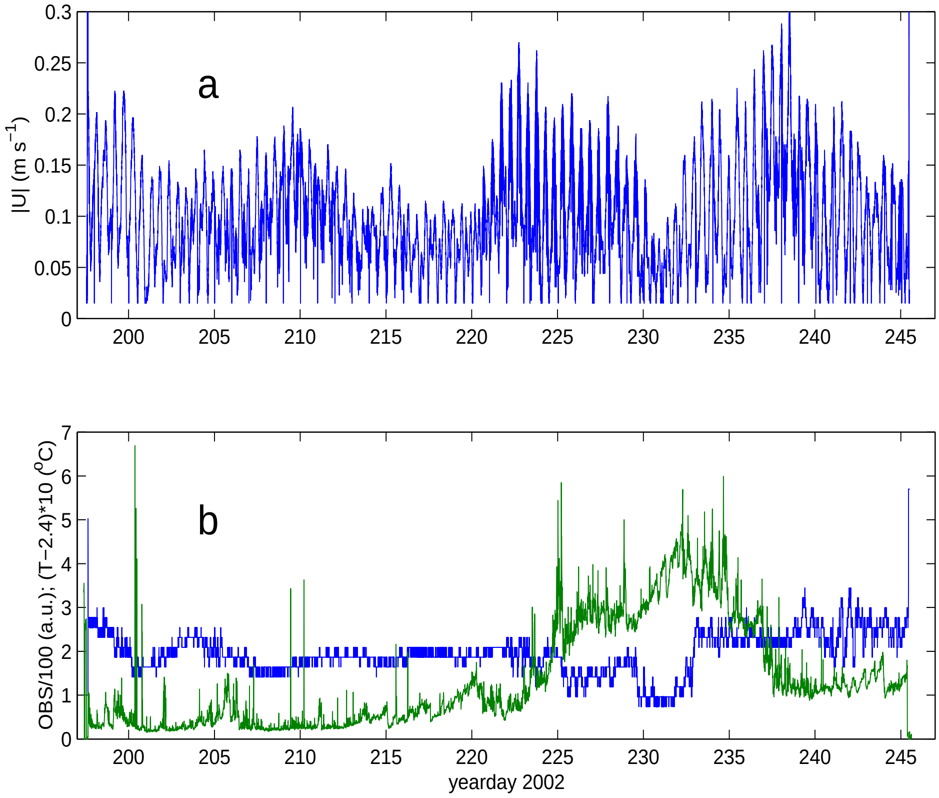


Fig. 7. Mooring ROC02-3 a. Current amplitude at 35 m above the bottom for the entire period of measurements.b. Temperature at 35 m above the bottom (blue) and OBS at 3 m above the bottom (green).

depth ranges. Currents varied at the dominant tidal time scale and at longer time scales (Fig. 7). Sediment resuspension was intense during short periods of time (Fig. 8), accompanied by strong bursts of acoustic reflection upon suspended particles so that the range of the ADCP was maximal (80 m). This resuspension had a strong tidal periodic character, albeit lasting for only ~3 days.

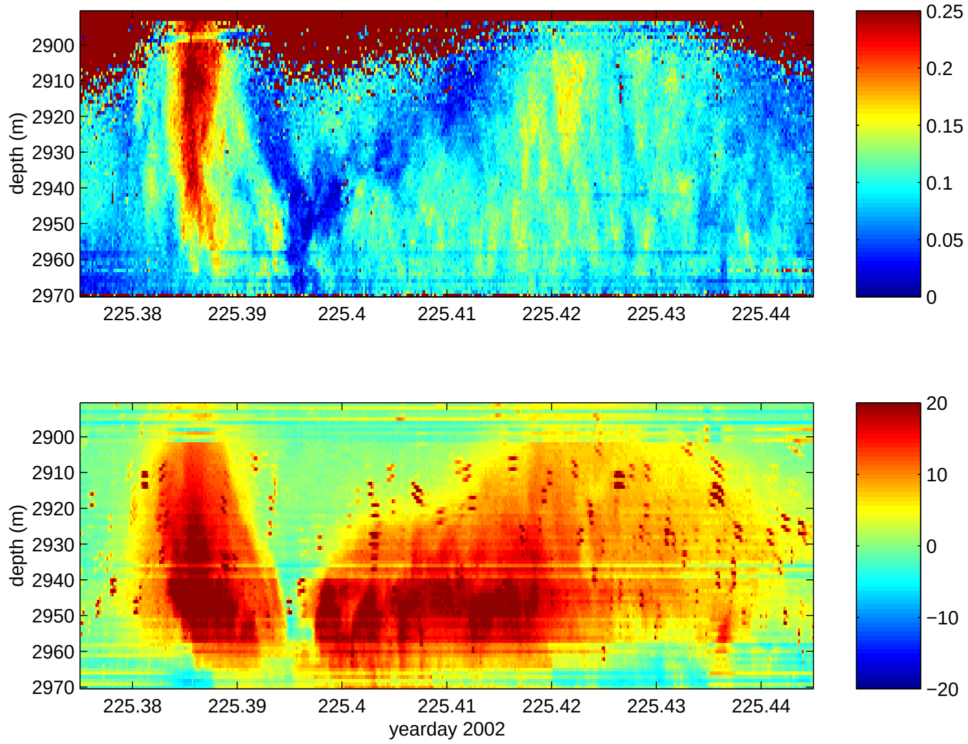


Fig. 8. Upper panel.100 mins of near-bottom current amplitude data (m s^{-1}) at mooring ROC02-1 (ADCP) Dark red near top indicates bad data. Lower panel. The corresponding back-scattered echo intensity (arbitrary units; mean subtracted).

2. Near-bottom turbidity

Timeseries of near-bottom turbidity were measured with Seapoint Optical Back-scattering Sensors (OBS) mounted on the bottom frame sediment traps (2 m above the bottom). We collected 3 good time series with data intervals of 12 minutes. Together with the OBS data, time series of the tilt angle (x, y) of the traps, temperature and pressure measured. The sensors worked fine with a sufficiently high signal-noise ratio. Even in the sometimes very clear water the OBS sensors produced reliable results (Fig. 7b). Results show considerable differences in near-bottom turbidity across the relatively small area covered with moorings. Highest turbidity was observed at mooring 3, farthest from the slope. Largest turbidity passed the sensors between days 225-235. High turbidity followed intense resuspension events on day 225 (Fig. 8). Resuspension was accompanied by a decrease in local temperature (Fig. 7b). The turbidity observations were directly reflected in sediment trap catches (see below).

3. Particle fluxes (by J. Bonnin)

Three moorings; ROCS 2, ROCS 3 and ROCS 4 equipped with 2 sediment traps each with their aperture situated at 2 and 30 meters above the bottom (mab) were deployed during the July cruise at water depth of 2981, 2969 and 2579 m respectively. Our aim was to collect resuspended material triggered by short-term variations in the currents. Traps were Technicap PPS 3/4 type, all equipped with 12 collecting bottles. All the traps were programmed to operate for a total 44 days, with 2 intervals of 48 hours each followed by 10 intervals of 96 hours each.

For the mooring ROCS 4, both traps functioned well and all the cups contained some material. The amount intercepted is quite small though and it is difficult to say anything on eventual flux variation before processing the samples on shore. The material caught, appears nevertheless very fluffy. The upper trap of mooring ROCS 3 worked well but the bottom one didn’t work probably due to an electronic failure of the motor. Nevertheless, cups of the upper trap show some variations with an apparent maximum flux for the cups 8 and 9. For the mooring ROCS 2, only the bottom trap functioned properly. The upper one worked for the first 2 cups only. As for the upper trap of mooring ROCS 3, the bottom trap here evidenced higher flux during cups 8 and 9 (~days 222-229) which point at higher energy near the bottom during this time interval, noted above.

b. CTD and water sampling

The CTD operations were ‘normal’, requiring cleaning prior to the first cast but no reparations.Water samples were only taken at the central mooring site, close to the bottom to prepare chemicals for the sediment traps. Once, a hydrographic section was sampled. This section was perpendicular to the continental slope (in the direction 160-340°). Seven stations at 8-10 km mutual distances covered the abyssal plain the western-most mooring and the continental slope upto about 600 m depth (Fig. 6**)**. The hydrographic surveys confirmed by-and-large previous CTD surveys (de Stigter and de Haas, 2001), showing enhanced turbidity in the lower 50-300 m above the bottom, and very smooth (constant) stratification almost all the way to the bottom, despite distinct different water masses as revealed by temperature and salinity profiles. The most distinct different water mass was found at the depth of the main pycnocline (600-900 m depth). In detail down- and upcast occasionally showed differences in steppiness of the profiles (with typical step sizes of about 10 m), evidence of high-frequency wave activity or short-scale layering.

The main permanent pycnocline was located where the bottom slope was rather smooth and moderately steep, between 500-1200 m depth. Buoyancy frequency N ~ 10^{-3} s^{-1}. Between 1800-2600 m depth, where the bottomslope was steeper ~0.1 (Fig. 3), stratification varied between N ~ 0.8-1.2 10^{-3} s^{-1}, so that the bottom slope was near-critical for internal tides. At these depths the CTD profiles showed occasional overturning or neutral stable layers (see detailed plots of Fig. 9). In the lowest 100 m above the bottom N ~ 0 - 0.5 10^{-3} s^{-1}, partially due to bottom boundary mixing.

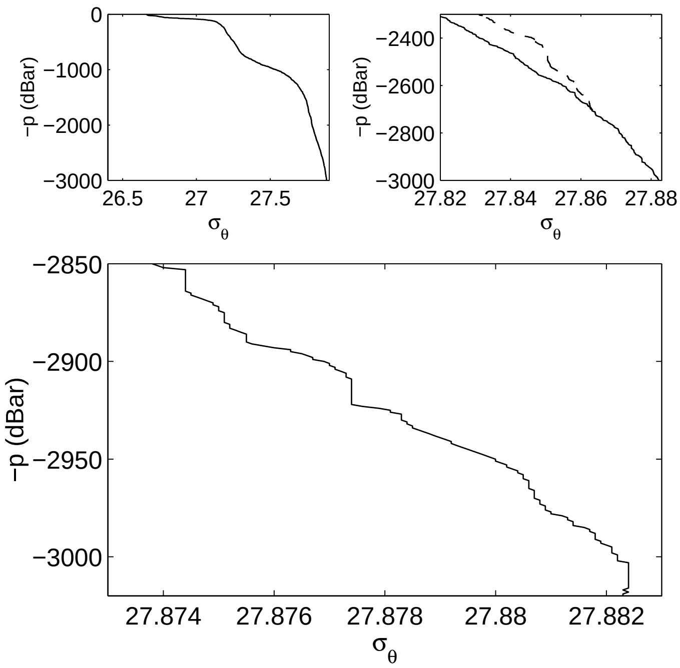


Fig. 9. CTD station 5 (ROCS03) in 2980 m waterdepth (pressure not corrected for speed of sound) near mooring 1 (solid line) and mooring 4 (dashed line in upper right panel).

c. Sedimentological sampling (by J. Bonnin)

Surface sediment samples were collected using a multicorer that collected virtually undisturbed sediment with a thickness up to 30-40 cm and clear overlying water. The multicorer was deployed at 3 stations: 15, 16 and 17 at 2981, 2695 and 1988 m water depth respectively during the July cruise. At the deepest station (15), a light brown layer of sand of approximately 6 cm was overlying greyish silty sediments. The surface of the cores was covered with some sponges and shells and a thin layer of fluffy material. At station 16, the multicorer couldn’t work properly due to the presence of glacial gravel up to a few centimetres in size enbedded in light brown sandy sediments (~2 cm) and overlying clayish material. Thus only 5 cm of sediment were recovered. Sediment at station 17 was mainly composed of light brown silty sand through the whole core with a thin fluff layer on top. The cores have been sliced in thin layers of 0.25 cm for the first cm, 0.5 for the next 2 cm, 1 cm for the following 4 cm and 2 cm for the last 8 cm. The material will be further analysed on shore for organic carbon and nitrogen, ^{210}Pb, ^{234}Th and biogenic silica.

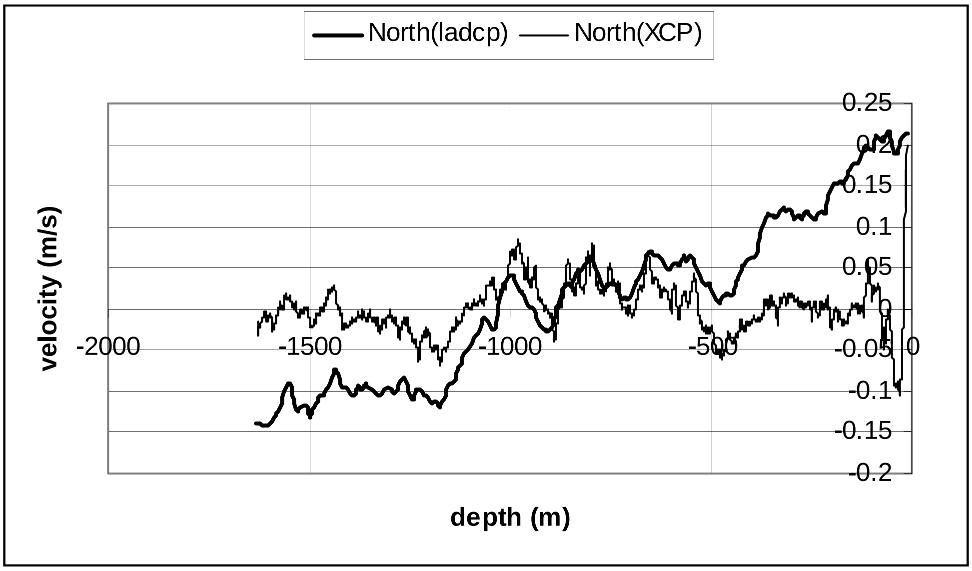
d. LADCP test (by C. Veth)

During the 17-hours timestation 5 profiles of current velocity and direction from the upper 1500 m of the water column were measured with the L(owered) ADCP system. Because of the failure of the CTD-casts at series 3 and 4, the corresponding LADCP's are missing. Only a shallow measurement at series 3 was performed. The LADCP consists of two synchronized self-contained 300 kHz ADCP's (RD Instruments - Workhorses) mounted on the CTD frame in the so-called Janus configuration: one of the two is looking downward (the master) and the other one looking upward (the slave). Data collection takes place during the down- and up-cast of the CTD/Rosette. The data are subsequently stored in the solid state memory inside the ADCP.

The LADCP data collection was started a few minutes before the deployment of the CTD and was stopped immediately after the CTD was back on deck. Then the data were transferred from the internal solid state memory to the dedicated service computers, and subsequently copied in the appropriate directory on the ships computer network.

A series of MATLAB script files developed by Martin Visbeck, LDEO, (version 7.0, Sept. 2002), has been used for data processing, data reduction and calculations of the currrent velocity and direction profiles. Essential in the calculations is the correct synchronization of the clocks in the ADCP's with the GPS times as recorded by the CTD computer in order to know the exact GPS positions (also recorded by the CTD computer) at all times during the cast. In the calculation the lowering speed of the CTD and the horizontal motions of the ship have been taken into account. The MATLAB programme exports the results in a data file and plots the results of the measurements and calculations as well as several quality parameters. The velocity profile has been calculated for depth intervals of 8 and 20 m. The estimated accuracy of the velocity measurement is of the order of 0.05 m s^{-1}.

As an example of LADCP profiles the north and east components are shown in Figure 10 below. For comparison the XCP-profiles have been added to the figures.



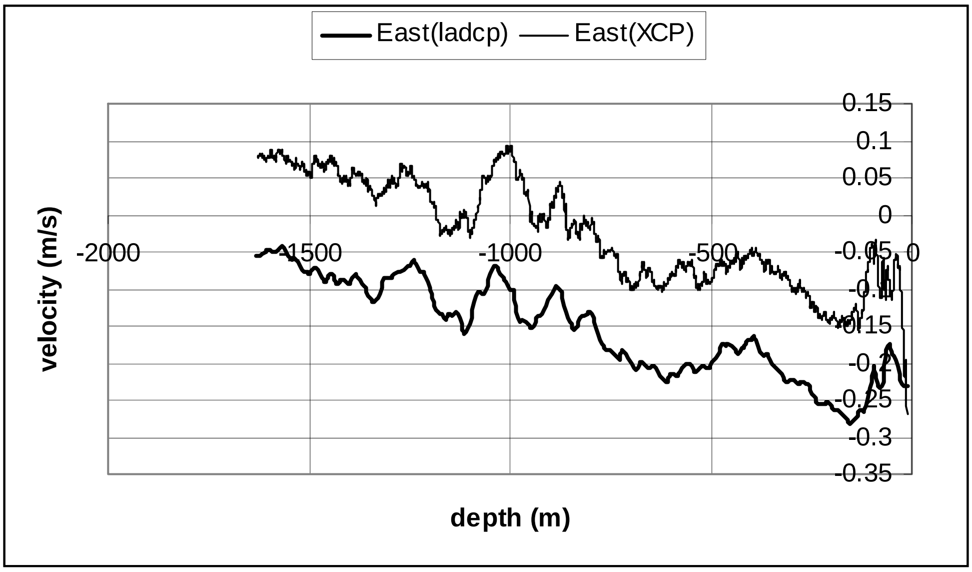


Fig. 10. Comparison of LADCP and XCP profiles.

e. FLY microstructure profling (by C. Veth)

At all seven 2.5 hours cycles of the measurement series during the 17-hours timestation a micro-structure probe deployment was done with the FLY II. The micro-structure probe FLY II has been deployed in order to determine the rate of dissipation of turbulent kinetic energy ε down to a depth of 1000m. The FLY II deployment requires a special winch and linepuller, in such a way that the instrument can make an almost free-falling motion through the water. During the free fall horizontal shear is measured with airfoil lift shear probes.

The threshold level of the instrument is about 2×10^{-9} Wkg^{-1} for ε. This relatively high threshold level is caused by the internal electronics, because the instrument was originally designed for rather shallow tidal waters (depth range: 0 – 300 m).

f. XCP (by Y. Niwa, M. Nagasawa)

In order to estimate diapycnal diffusivities in the deep ocean, fine-scale measurements of horizontal velocity and density stratification from the surface down to a depth of about 1500 m were carried out at 54.5˚N, 14.5˚W every 2.5 hours during September 3–September 4 using 7 sets of expendable current profiler (XCP) and expendable conductivity-temperature-depth profiler (XCTD).

Applying Gregg's (1989) empirical formula to the observed vertical shear of horizontal velocity yields a diapycnal diffusivity ranging from 0.1 to 0.4 cm^2s^{-1} (Fig. 11), consistent with previous microstructure measurements in the deep ocean. This value is much lower than required to satisfy the large-scale advective-diffusive balance of the large-scale thermohaline circulation.

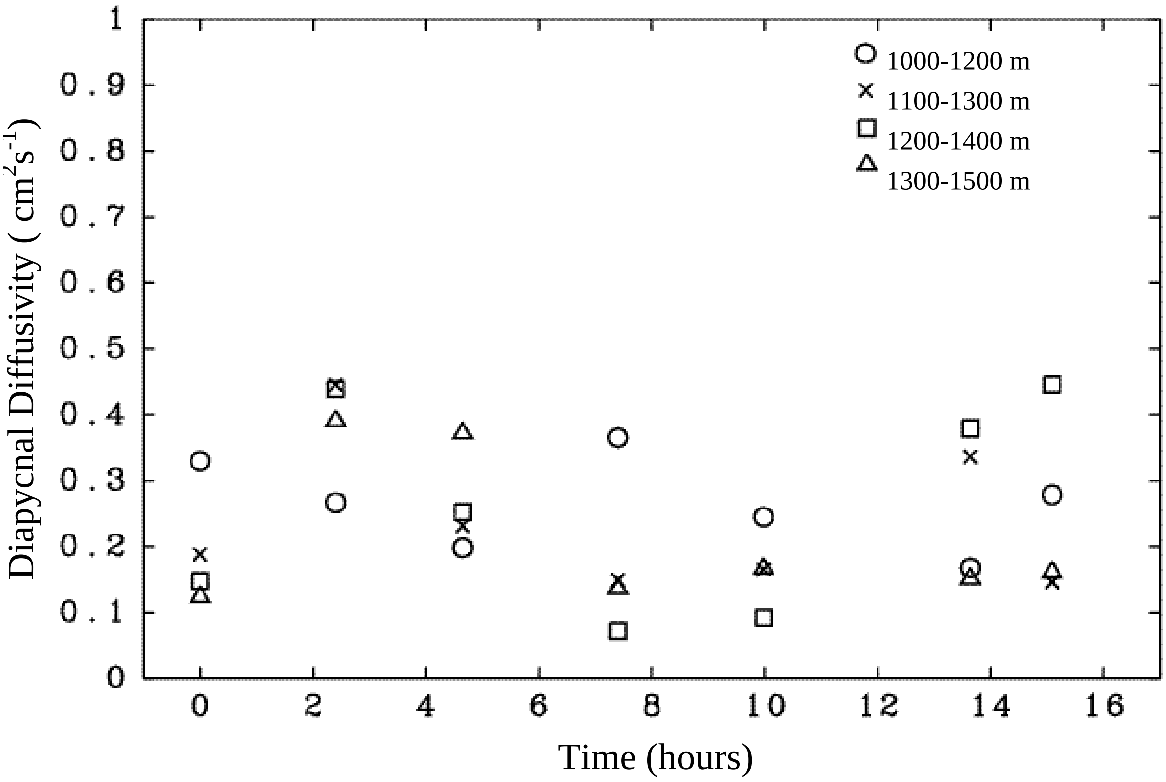


Fig. 11 Diapycnal diffusivitiy estimated at each depth bin from XCP data.

g. Calibration NIOZ thermistor strings

The accurate NIOZ thermistor strings are difficult to calibrate. Lab calibrations are extremely time consuming and are 'only' accurate to within 3 mK (van Haren et al., 2001), whilst the thermistor strings are stable to within the electronic noise of ~1 mK and ~30 μK for the new and old strings, respectively. A better calibration seemed an in situ calibration by lowering the strings mounted on a CTD-frame (Fig. 5) to the same depths as the mooring later. At least 5 layers were sought having different temperatures that were stable to within ~1 mK for the duration of 2-3 minutes. This requirement was more or less achieved within a period of about 3 hours. Post processing took about 2 days to extract the calibration data and match the different files. One of the problems encountered was a mismatch in timing of the CTD-computer and the standard on-board time by about 2 mins.

h. Current meter test

On the top of mooring 4 three current meters were moored at distances of 1 m for comparison: a Nortek AquaDopp, an Aanderaa RCM-8 and and Aanderaa RCM-11. Results showed rather noisy acoustic instrumentation, probably due to the clear water. In such circumstances an old-fashioned RCM-8 is better (for example for high-frequency internal wave observations). However, the mechanical RCM-8 shows (well-known) problems at low current speeds, and overspeeding with increasing current speeds, with respect to the acoustic instruments. The (much) faster sampling AquaDopp showed compass problems that were reported to the manufacturer. Also between the two Aanderaa instruments a compass difference was detected.

i. Acoustic release test (with M. Laan and R. Groenewegen)

A new type of acoustic release (Oceano) was tested against a Benthos acoustic release. Both releases were mounted between an anchor and a buoyancy element and deployed at 3000 m depth for the duration of several hours. At several distances up to ~14 km acoustic response was tested. It turned out that, acoustically, the Oceano release was even better than the (already good) Benthos release.

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7. Concluding remark

This cruise was successful. The relatively high successrate of the moorings, the completion of a short hydrographic survey, the sediment sampling and the intercomparison of several types of instrumentation, such as XCP with microstructure profiler, all contributed to the results. First analyses show that we captured fast and vigorous eventlike bursting of near-bottom processes. The results will be compared with those from previous studies, as above the continental slope in the Faroe-Shetland Channel.

On behalf of the participants I thank captain Hans Groot (cruise 1) and John Ellen (cruise 2) and the crews of R.V. Pelagia for the very pleasant cooperation.

Appendix A Mooring diagrams (by. Dept. of Sea Tech.)

ROCS02-1

ROCS02-2

ROCS02-3

ROCS02-4

Appendix B Cruise summary of stations (activities) of ROCS02-1

STATION NR.	CAST NR.	CAST TYPE	EVENT CODE	CAST DATE	LATITUDE dec. degr.	LONGITUDE Dec. degr.	Uncorr. DEPTH	COMMENTS	raw CTD file name	L-ADCP data file name
1	1	CTD; no samples	Begin	jul 16 2002 08:13:02	53.73843	-12.19303	331	test	p198test	
1	1	CTD; no samples	Bottom	jul 16 2002 08:20:46	53.73840	-12.19293	331			
1	1	CTD; no samples	End	jul 16 2002 08:32:00	53.73738	-12.19247	330			
2	1	CTD + samples	Begin	jul 16 2002 15:59:09	54.16530	-14.01130	2975		p19801	ROC1
2	1	CTD + samples	End	jul 16 2002 16:52:30	54.16530	-14.01130	2975			
2	2	CTD +Thermistor string	Begin	jul 16 2002 19:31:41	54.16612	-14.01685	2975	CTD time = GPS time - 129 sec. Calibration thermistorstring with markfile	p19802 (downcast); p19802b (upcast), 2 files + mark file (p19802b.mrk & p19802b.txt)	
2	2	CTD +Thermistor string	Bottom	jul 16 2002 20:16:02	54.16630	-14.01693	2975			
2	2	CTD +Thermistor string	End	jul 16 2002 21:40:08	54.16670	-14.01720	2975			
none	none	None		jul 17 2002 08:40:09				cleaning aquaflow		
3	1	Mooring deployment	Begin	jul 17 2002 09:15:16	54.16677	-14.01652	2975			
3	1	Mooring deployment	End	jul 17 2002 09:24:51	54.16747	-14.01885	2975	Rocs 1		
4	1	Mooring deployment	Begin	jul 17 2002 11:37:10	54.19785	-13.87183	2981			
4	1	Mooring deployment	End	jul 17 2002 11:52:03	54.19522	-13.87930	2981	Rocs 2		
5	1	Mooring deployment	Begin	jul 17 2002 13:45:04	54.21473	-14.13880	2975	Rocs 3		
5	1	Mooring deployment	End	jul 17 2002 14:26:52	54.21473	-14.13880	2969	Rocs 3		
6	1	Mooring deployment	Begin	jul 17 2002 16:38:42	54.09532	-14.07067	2731			
6	1	Mooring deployment	End	jul 17 2002 17:32:45	54.08837	-14.06188	2603	Rocs 4		
7	1	CTD; no samples	Begin	jul 18 2002 07:05:36	54.30020	-14.16260	2884		p19803	ROC2
7	1	CTD; no samples	Bottom	jul 18 2002 07:55:51	54.30018	-14.16253	2884			
7	1	CTD; no samples	End	jul 18 2002 08:38:54	54.29965	-14.16168	2884			
8	1	CTD; no samples	Begin	jul 18 2002 09:20:28	54.22060	-14.11210	2975		p19804	ROC3
8	1	CTD; no samples	Bottom	jul 18 2002 10:11:23	54.22110	-14.11307	2975			
8	1	CTD; no samples	End	jul 18 2002 11:04:23	54.22048	-14.11275	2975			
9	1	CTD; no samples	Begin	jul 18 2002 13:01:44	54.15590	-14.07428	2981		p18905	ROC4
9	1	CTD; no samples	Bottom	jul 18 2002 13:50:42	54.15575	-14.07365	2981			
9	1	CTD; no samples	End	jul 18 2002 14:38:09	54.15563	-14.07443	2981			
10	1	CTD; no samples	Begin	jul 18 2002 15:15:57	54.09532	-14.03670	2634		p19806	ROC5
10	1	CTD; no samples	Bottom	jul 18 2002 16:01:15	54.09432	-14.03493	2640			
10	1	CTD; no samples	End	jul 18 2002 16:43:46	54.09373	-14.03635	2621			

11	1	CTD; no samples	Begin	jul 18 2002 17:38:29	54.01653	-13.98740	1920		p19807	ROC6
11	1	CTD; no samples	Bottom	jul 18 2002 18:00:16	54.01633	-13.98713	1914			
11	1	CTD; no samples	End	jul 18 2002 18:33:04	54.01632	-13.98840	1920			
12	1	CTD; no samples	Begin	Jul 18 2002 19:11:45	53.94000	-13.93947	1475		P19808	ROC7
12	1	CTD; no samples	Bottom	Jul 18 2002 19:35:07	53.93978	-13.94232	1475			
12	1	CTD; no samples	End	Jul 18 2002 19:56:33	53.94062	-13.94208	1481			
13	1	CTD; no samples	Begin	Jul 18 2002 20:37:07	53.86197	-13.89438	1060		P19809	ROC8
13	1	CTD; no samples	Bottom	Jul 18 2002 20:55:45	53.86215	-13.89358	1060			
13	1	CTD; no samples	End	Jul 18 2002 21:13:45	53.85000	-13.88333	1060			
14	1	CTD; no samples	Begin	Jul 18 2002 21:52:59	53.78333	-13.83333	658		P19810	ROC9
14	1	CTD; no samples	Bottom	Jul 18 2002 22:05:30	53.78333	-13.83333	670			
14	1	CTD; no samples	End	Jul 18 2002 22:17:32	53.78425	-13.84503	658			
15	1	Multicore	Begin	Jul 19 2002 05:09:59	54.15460	-14.07583	2975			
15	1	Multicore	Bottom	Jul 19 2002 05:59:22	54.15388	-14.07368	2975			
15	1	Multicore	End	Jul 19 2002 06:48:19	54.15243	-14.07462	2981	Failed		
15	2	Multicore	Begin	Jul 19 2002 06:50:52	54.15210	-14.07463	2981			
15	2	Multicore	Bottom	Jul 19 2002 07:42:22	54.15457	-14.07460	2975			
15	2	Multicore	End	Jul 19 2002 08:27:31	54.15142	-14.07753	2981			
16	1	Multicore	Begin	Jul 19 2002 09:17:03	54.09377	-14.03747	2682			
16	1	Multicore	Bottom	Jul 19 2002 09:49:07	54.09288	-14.03863	2689			
16	1	Multicore	End	Jul 19 2002 10:31:53	54.08333	-14.03863	2695			
17	1	Multicore	Begin	Jul 19 2002 11:12:29	54.02528	-13.99328	1993			
17	1	Multicore	Bottom	Jul 19 2002 11:44:19	54.02560	-13.99313	2000			
17	1	Multicore	End	Jul 19 2002 12:20:03	54.02598	-13.99313	2000			

Appendix C Cruise summary of stations (activities) of ROCS02-2

STATION NR.	CAST NR.	CAST TYPE	EVENT CODE	CAST DATE	LATITUDE degr:min	LONGITUDE degr:min	Uncorr. DEPTH	COMMENTS
None	None	None	begin	Sep 01 2002 14:53:44				Clearing Aquaflow
none	None	None	end	Sep 01 2002 15:21:44				Clearing Aquaflow
1	1	CTD without samples	Begin	Sep 02 2002 13:55:19	54:10.0	-14:01.04	2975	test ctd
1	1	CTD without samples	Bottom	Sep 02 2002 14:04:06	54:10.1	-14:01.04	2975	
1	1	CTD without samples	End	Sep 02 2002 14:12:33	54:10.1	-14:01.09	2975	
1	2	Mooring recovery	Begin	Sep 02 2002 15:01:08	54:10.4	-14:00.46	2975	rocs1 partl1
1	2	Mooring recovery	End	Sep 02 2002 15:01:09	54:10.4	-14:00.46	2975	
2	1	Mooring recovery	Begin	Sep 02 2002 15:19:07	54:10.4	-14:00.61	2975	rocs1 part 2
2	1	Mooring recovery	End	Sep 02 2002 15:19:08	54:10.4	-14:00.61	2975	
3	1	CTD without samples	Begin	Sep 02 2002 16:49:54	54:05.3	-14:03.75	2591	
3	1	CTD without samples	Bottom	Sep 02 2002 16:58:09	54:05.3	-14:03.75	2603	
3	1	CTD without samples	End	Sep 02 2002 17:07:33	54:05.3	-14:03.70	2591	
3	2	Mooring recovery	Begin	Sep 02 2002 18:09:50	54:05.3	-14:03.72	2603	ROCS4
3	2	Mooring recovery	End	Sep 02 2002 18:21:30	54:05.4	-14:03.79	1115	
4	1	Mooring recovery	Begin	sep 03 2002 07:05:53	54:05.5	-14:03.74	2981	ROCS 2
4	1	Mooring recovery	End	sep 03 2002 07:05:56	54:11.7	-13:52.57	2981	
5	1	Mooring recovery	Begin	sep 03 2002 10:00:18	54:12.9	-14:08.26	2969	rocks 03
5	1	Mooring recovery	End	sep 03 2002 10:14:17	54:13.1	-14:08.03	2969	
6	1	Mooring overboord	Begin	sep 03 2002 10:44:07	54:12.7	-14:08.25	2975	test mooring
6	1	Mooring overboord	End	sep 03 2002 13:17:58	54:20.2	-14:08.25	2865	mooring released
6	2	Mooring recovery	Begin	sep 03 2002 14:52:02	54:13.2		2975	test mooring on deck
6	2	Mooring recovery	End	sep 03 2002 14:52:09	54:13.2		2975	
7	1	CTD without samples	Begin	sep 03 2002 17:32:17	54:30.0	-14:30.00	2743	
7	1	CTD without samples	Bottom	sep 03 2002 17:55:04	54:30.0	-14:30.00	2737	1500 m
7	1	CTD without samples	End	sep 03 2002 18:17:11	54:30.0	-14:30.00	2737	
7	2	XCP	Begin	sep 03 2002 18:24:35	54:30.1	-14:29.98	2737	
7	2	XCP	End	sep 03 2002 18:33:29	54:30.4	-14:30.13	2737	
7	3	XCTD	Begin	sep 03 2002 18:35:22	54:30.4	-14:30.16	2737	
7	3	XCTD	End	sep 03 2002 18:41:54	54:30.5	-14:30.00	2737	

7	4	FLY 1000 m	Begin	sep 03 2002 18:46:39	54:30.5	-14:30.09	2737	
7	4	FLY 1000 m	End	sep 03 2002 19:02:13	54:30.9	-14:30.39	2743	
7	5	CTD without samples	Begin	sep 03 2002 20:02:22	54:30.0	-14:29.99	2737	
7	5	CTD without samples	Bottom	sep 03 2002 20:22:50	54:30.0	-14:30.01	2737	1500 mtr
7	5	CTD without samples	End	sep 03 2002 20:44:45	54:30.0	-14:30.01	2737	
7	6	XCP	Begin	sep 03 2002 20:48:19	54:30.0	-14:30.04	2737	
7	6	XCP	End	sep 03 2002 20:55:35	54:30.2	-14:30.00	2737	
7	7	XCTD	Begin	sep 03 2002 21:07:12	54:29.6	-14:29.88	2737	
7	7	XCTD	End	sep 03 2002 21:12:55	54:29.6	-14:30.00	2743	
7	8	FLY 1000 m	Begin	sep 03 2002 21:19:45	54:30.0	-14:29.93	2737	
7	8	FLY 1000 m	End	sep 03 2002 21:52:35	54:30.7	-14:30.05	2743	
7	9	CTD without samples	Begin	sep 03 2002 22:33:50	54:30.0	-14:29.98	2737	Afgebroken cast
7	9	CTD without samples	Bottom	sep 03 2002 22:55:32	54:30.0	-14:29.99	2737	
7	9	CTD without samples	End	sep 03 2002 22:59:24	54:30.0	-14:30.03	2737	
7	10	XCP	Begin	sep 03 2002 23:02:50	54:30.0	-14:30.08	2737	
7	10	XCP	End	sep 03 2002 23:10:29	54:30.2	-14:29.81	2743	
7	11	XCTD	Begin	sep 03 2002 23:19:51	54:30.1	-14:29.18	2737	
7	11	XCTD	End	sep 03 2002 23:25:38	54:30.0	-14:29.08	2731	
7	12	FLY 1000 m	Begin	sep 03 2002 23:35:57	54:30.0	-14:30.03	2737	
7	12	FLY 1000 m	End	sep 04 2002 00:03:22	54:30.3	-14:30.23	2737	
7	13	CTD without samples	Begin	sep 04 2002 00:23:03	54:30.0	-14:29.92	2743	test ctd
7	13	CTD without samples	Bottom	sep 04 2002 00:33:05	54:30.0	-14:29.95	2743	test ctd
7	13	CTD without samples	End	sep 04 2002 00:33:08	54:30.0	-14:29.95	2743	test ctd
7	14	XCP	Begin	sep 04 2002 01:48:40	54:30.1	-14:30.02	2737	
7	14	XCP	End	sep 04 2002 01:59:51	54:30.5	-14:29.94	2737	
7	15	XCTD	Begin	sep 04 2002 02:07:44	54:30.3	-14:29.47	2743	
7	15	XCTD	End	sep 04 2002 02:13:34	54:30.2	-14:29.83	2743	
7	16	FLY 1000 m	Begin	sep 04 2002 02:20:57	54:30.0	-14:29.99	2743	
7	16	FLY 1000 m	End	sep 04 2002 02:52:57	54:29.7		2737	
7	17	CTD without samples	Begin	sep 04 2002 03:32:16	54:30.0	-14:30.00	2743	
7	17	CTD without samples	Bottom	sep 04 2002 03:54:54	54:30.0	-14:30.01	2737	
7	17	CTD without samples	End	sep 04 2002 04:16:28	54:30.0	-14:30.01	2737	

7	18	XCP	Begin	sep 04 2002 04:23:17	54:30.1	-14:30.06	2737	
7	18	XCP	End	sep 04 2002 04:30:39	54:30.3	-14:30.18	2737	
7	19	XCTD	Begin	sep 04 2002 04:45:36	54:29.5	-14:29.69	2731	
7	19	XCTD	End	sep 04 2002 04:51:22	54:29.8	-14:29.62	2737	
7	20	FLY 1000 m	Begin	sep 04 2002 04:58:47	54:30.0	-14:30.01	2737	
7	20	FLY 1000 m	End	sep 04 2002 05:28:31	54:30.4	-14:30.33	2737	
7	21	CTD without samples	Begin	sep 04 2002 06:01:17	54:30.0	-14:30.00	2737	
7	21	CTD without samples	Bottom	sep 04 2002 06:26:05	54:30.0	-14:30.00	2737	
7	21	CTD without samples	End	sep 04 2002 06:50:03	54:30.0	-14:30.00	2737	
7	22	XCP	Begin	sep 04 2002 06:54:22	54:30.0	-14:30.00	2737	XCP failed
7	22	XCP	End	sep 04 2002 06:58:58	54:29.9	-14:30.08	2737	
7	23	XCTD	Begin	sep 04 2002 07:11:50	54:30.6	-14:30.07	2737	
7	23	XCTD	End	sep 04 2002 07:17:38	54:30.3	-14:30.51	2737	
7	24	FLY 1000 m	Begin	sep 04 2002 07:25:30	54:30.1	-14:30.23	2731	
7	24	FLY 1000 m	End	sep 04 2002 08:00:24	54:29.6	-14:29.91	2737	
7	25	XCP	Begin	sep 04 2002 08:02:56	54:29.6	-14:29.82	2737	
7	25	XCP	End	sep 04 2002 08:10:46	54:29.5	-14:29.38	2731	
7	26	CTD without samples	Begin	sep 04 2002 08:33:47	54:30.0	-14:29.98	2737	
7	26	CTD without samples	Bottom	sep 04 2002 08:58:17	54:30.0	-14:29.99	2737	1500
7	26	CTD without samples	End	sep 04 2002 09:23:56	54:30.0	-14:29.98	2737	
7	27	XCP	Begin	sep 04 2002 09:29:38	54:30.0	-14:30.00	2737	
7	27	XCP	End	sep 04 2002 09:36:53	54:29.7	-14:30.11	2743	
7	28	XCTD	Begin	sep 04 2002 09:49:35	54:30.5	-14:30.06	2737	
7	28	XCTD	End	sep 04 2002 09:55:19	54:30.7	-14:30.08	2743	
7	29	FLY 1000 m	Begin	sep 04 2002 10:03:36	54:30.1	-14:30.10	2737	
7	29	FLY 1000 m	End	sep 04 2002 10:10:32	54:30.0	-14:30.11	2737	Failed
7	29	FLY 1000 m	Begin	sep 04 2002 10:11:04	54:29.9	-14:30.11	2737	
7	29	FLY 1000 m	End	sep 04 2002 10:44:27	54:29.6	-14:30.21	2743	
7	30	CTD metThermistor	Begin	sep 04 2002 11:16:22	54:30.0	-14:29.96	2737	
7	30	CTD metThermistor	Bottom	sep 04 2002 12:02:19	54:30.0	-14:30.00	2737	Thermistor string test
7	30	CTD metThermistor	End	sep 04 2002 13:59:39	54:30.0	-14:30.00	2743	