RRS Challenger 140

PROVESS (Processes of Vertical Exchange in Shelf Seas)

Principal Scientist: John Howarth, POL

Contents

1. Personnel

Robin Plumley	Master
Richard Warner	Mate
Malcolm Graves	2nd Officer
Mick Hood	3rd Officer
Martin Holt	Chief Engineer
Anne James	2nd Engineer
Tony Healey	3rd Engineer
Doug Lutey	3rd Engineer (Elec.)
Mick Trevaskis	CPO (Deck)

Leg 1: Greenock - Peterhead

John Howarth	POL
Graham Ballard	POL
Gwen Moncoiffe	BODC
Ken Jones	DML
Ivan Ezzi	DML
Martyn Harvey	DML
Lionel Denis	COM, Marseille, France
Vivien Edwards	Napier University, Edinburgh
Colin Jago	School of Ocean Sciences, University of Wales, Menai Bridge
Rebecca Latter	School of Ocean Sciences, University of Wales, Menai Bridge
Jeff Benson	RVS
Andy Jones	RVS
Martin Bridger	RVS

Leg 2: Peterhead - Southampton

John Howarth*	POL
Graham Ballard*	POL
Tony Banaszek	POL
Mike Burke*	POL
John Humphery	POL
Emlyn Jones*	POL
Phil Knight*	POL
Andy Lane*	POL
Lorendz Boom	NIOZ, Texel, the Netherlands
Rebecca Latter*	School of Ocean Sciences, University of Wales, Menai Bridge
Jeff Benson	RVS
Andy Jones*	RVS
Martin Bridger	RVS

* Dropped off at Tyne on 9 November

2. Introduction

Challenger 140 contributes to the EU MAST III project PROVESS (Processes of Vertical Exchange in Shelf Seas) which is studying vertical exchanges of momentum, temperature, salinity, particles, nutrients and phytoplankton, particularly in relation to turbulence properties. A site in the northern North Sea has been chosen with weak tidal currents and 100 m water depth so that the surface and bed boundary layers in summer are well separated. Events during the autumnal breakdown of stratification are being measured. The moorings were deployed by RV Valdivia (Germany) on cruise 174, 5 - 17 September 1998. Other ships involved are RV Dana (Denmark, cruise 11/98) and RV Pelagia (the Netherlands).

3. Cruise objectives

1. To study benthic exchanges of nutrients and dissolved oxygen.
2. To study the in situ particle sizes of suspended particulate matter.
3. To deploy, turn round and recover moorings and bottom frames deployed by ‘Valdivia’ and ‘Pelagia’.
4. To study the water column properties by obtaining CTD profiles and water samples.

The cruise was split into two legs:
Greenock - Peterhead (21 October - 30 October)
Peterhead - Southampton (30 October - 11 November)

The objectives for leg 1:
1. To obtain cores for oxygen and nutrient flux studies using the DML and COM multi-corers at 59° 19.2′ N 1° 2.1′ E.
2. To obtain CTD and in situ particle size (with LISST) profiles and water samples in the vicinity of 59° 20′ N 1° E. Some of the profiles to be obtained over a tidal cycle at the same time as Pelagia was obtaining microstructure measurements. The water samples to be used for CTD sensor calibration (conductivity / salinity, transmissometer, fluorimeter, dissolved oxygen) and for nutrient (nitrate, ammonium, silicate, phosphate) determination.
3. Settling velocities using settling velocity tubes deployed near surface and near bed.
4. To obtain water samples with the near bed water sampler.
5. To deploy the fast sample 1.2 MHz ADCP (C) and near surface current (F) moorings, to turn round the three nutrient moorings (I, J1, J2) and to recover two moorings (the met.buoy, G, and an ADCP, V) on the way to Peterhead.

The specific objectives for leg 2:
1. To recover all the moorings deployed by Valdivia, Pelagia and Challenger (maximum of 19 - 10 moorings and 9 frames, planned 17).
2. To obtain CTD and in situ particle size (with LISST) profiles and water samples in the vicinity of 59° 20′ N 1° E. Some of the profiles to be obtained

over a tidal cycle. The water samples to be used for CTD sensor calibration (conductivity / salinity, transmissometer, fluorimeter, dissolved oxygen).

3. Sea-bed photographs with a bed-hopping camera.

4. Narrative

RRS Challenger left Greenock at 13.30 on **October 21**. The compass was swung and the ship's log checked in the Clyde Sea. The ship-mounted ADCP, meteorological package and surface logging system were switched on during the passage to the working area, which passed through the Sound of Islay, Sound of Mull and the Minches, giving some protection from the strong to gale force southwest to west winds, before steaming round the north of Scotland, to the north of the Orkneys.

When 59° 20′ N 1° E was reached, at 02.30 on **24 October**, conditions were marginal for CTD operations, which were therefore delayed until light. As part of the experiment, the Danish research vessel Dana and the Dutch research vessel Pelagia were already on site. The first CTD was recorded at 06.14, showing a sharp thermocline and halocline at 60 m. The surface buoys were checked and all were present except for the waverider. The fast sample surface current meter rig (Fb) was deployed between 09.10 and 09.53; winds were 25 knots from the south-west. The COM multicorer was deployed twice, the first time with its full complement of four 0.15 m diameter tubes and the second time with only two tubes. Both times, however, no cores were recovered, because either the sediment was too hard or the swell was too high. The fast sample 1.2 MHz ADCP (Cb) was deployed at 13.06, delayed until after 12.00 to check that it had switched on automatically. After the second CTD had been recorded at 13.45, operations were again suspended as the barometer plunged and the wind blew a steady 40 knots from 160°. On both casts, the fluorometer channel was very noisy. In the evening, RV Dana left for Hirtshals.

By 08.15 **25 October,** the wind had died down and the barometer had fallen to 960 mbars so the third CTD was recorded. However, the wind then increased rapidly to 40 knots from 330° as the barometer started to rise and operations were again suspended.

The weather had improved sufficiently on **26 October** (the wind had decreased to 15-20 knots) to deploy the SMBA multicorer six times, between 08.47 and 11.27, although again with a poor tally of recovered cores. The fluorometer on the CTD was changed and the fourth CTD profile recorded at 12.14, and a full rosette of water obtained for the core incubations. The first two (surface and bed) settling velocity tube samples were obtained 13.07 - 13.34. The next CTD profile (5) was recorded at 13.50 prior to the recovery of the surface nutrient mooring (I), 14.25 - 14.47. The release for the mid-depth nutrient mooring (J1) appeared to have been fired at 15.36 but despite searching until dark (17.00) the rig was not located on the surface - the acoustics show the mooring had not moved. The near bed water sampler was deployed twice over the stern but each time failed to trigger. Was the 30 s delay too long? The delay was set to let any disturbed sediment settle but its timing would be reset if the frame moved. Hourly CTDs (6-13) were recorded through the night from 19.23 until 02.52 (the timing was synchronised with FLY microstructure deployments on RV Pelagia), when weather again too rough, with winds up to 40 knots from south. Settling velocity tube samples 3 and 4 were obtained at 20.45 and 21.45.

RRS Challenger was hove to all **27** and most of **28 October**. RV Pelagia left for Texel on the morning of 28. As the weather improved in afternoon, CTDs 14 - 18, were recorded between 15.25 and 21.39 and settling velocity tube samples 5 and 6 were obtained at 16.00 and 17.48. However, in the evening the weather deteriorated and CTD operations were stopped at 22.30.

Since it was still too rough to work on at 09.00 **29 October**, a course set for Peterhead.

At 08.30 **30 October,** RRS Challenger tied up at Peterhead to unload some equipment and change personnel for leg 2.

14.00 **31 October** left Peterhead and resumed all surface logging.

RRS Challenger arrived back on site 05.00 **1 November**. All daylight was spent recovering moorings, from 08.06 to 15.57, recovering the near-bed nutrients rig (J2), thermistor chain rigs at R and S, STABLE (D), surface currents (E) and 1.2 MHz ADCP at B. Two rigs were not located - the thermistor chain at L and the surface current at F. One leg of STABLE was slightly damaged and the middle set of e-m heads were bent. During the night, CTD profiles 19 to 27 were recorded at hourly intervals at the main site before steaming eastward to X and recording CTD profiles 28 to 31 on the way.

The pressure recorder at X was recovered, 08.46 - 09.13 **2 November**, and the 150 kHz ADCP at U (10.25 - 11.18), both in marginal conditions with 25 - 30 knot winds. By the time RRS Challenger had arrived back at the main site conditions had deteriorated slightly so that recovery of the ADCP at A was delayed until 15.09-15.50 and then no further recoveries were attempted. Since ADCP at C had not been located, an acoustic search was carried out until 23.30, stopping to transmit and listen every mile. The search was interrupted at 18.35 for CTD 32 and at 19.07 to 19.23 for settling velocity tube samples 10 and 11. CTDs profiles 33 to 38 were then recorded from 23.30 - 05.40, northward on the way to Y.

The pressure recorder at Y was recovered from 08.00 to 08.59 on **3 November**. A fax was received from work showing why yesterday’s acoustic search for the ADCP at C had been unsuccessful - the ADCP had been recovered by a trawler and was now in Peterhead. The RVS 150 kHz ADCP at V was recovered at 10.30 - 11.08.

5. Reports

5.1 Sediment processes - Martyn Harvey (DML) and Lionel Denis (COM)

The COM multicorer was deployed twice on 24/10/98. Both deployments were unsuccessful, and on one of the deployments one of the core tubes was broken. Although no sediment was recovered, the failure was suggestive of a hard sediment surface. This was confirmed when the DML multicorer was deployed on 26/10/98 in a water depth of approximately 105 m. This corer met with very limited success. Six deployments were carried out, detailed below.

Deployment no.	Lat (N)	Long (E)	Cores retrieved
MC1	59° 19.41′	01° 02.23′	1/8
MC2	59° 19.38′	01° 02.10′	4/8
MC3	59° 19.44′	01° 02.22′	0/8
MC4	59° 19.44′	01° 02.20′	1/4
MC5	59° 18.96′	01° 03.25′	1/4
MC6	59° 19.38′	01° 02.16′	1/4

The retrieved sediment proved to be a coarse sand. The top 2 cm (approx.) was orange coloured, suggesting a very low organic matter content. Below this depth, the sediment was grey-brown, typical of sediments with slightly higher organic content and/or the admixture of some finer mineral material.

Four cores were incubated at in situ temperature in water obtained from within 5 m of the sea bed at the coring site, to determine the sediment oxygen uptake rate. Although the final results are not yet available, the raw data shows that there was little or no oxygen demand by the sediment.
Water samples removed from the incubated cores were also taken to be analyzed for their dissolved nutrient concentrations so that estimates of nutrient fluxes may be made.

An instrument designed to squeeze pore water from core slices failed to work. Whilst it had proved very efficient in the extraction of porewater from finer grained sediments, the incompressible nature and lower porosity of sand rendered it ineffectual.

Fluorescent beads of variable size (20-150 µm) were added to the overlying water within core tubes, and the cores incubated. Subsequent slicing of the cores and counting the beads in each slice will enable the degree of incorporation of particulate material into the sediment via bioturbation to be assessed.

Two cores were sectioned into centimetre slices down to 6 cm and preserved in buffered seawater formalin for future analysis of meiofauna. One core was also sliced and frozen for pigment analysis by HPLC at COM.

Two cores, which had been drilled with holes along their length at 1 cm intervals, were used to obtain samples for measurement of porosity and total organic matter content.

These were subcored using 3 ml plastic hypodermic syringes with their luer ends removed. The subcores were transferred to vials for transport back to DML and subsequent analysis.

Photographs taken with the bedhop camera system by John Humphery (POL) during the Valdivia cruise (on 15 September 1998, starting at 59° 18.99′ N 0° 59.55′ E) showed the sediment at this site to be a muddy sand with well-developed epifaunal and infaunal macrobenthic communities. The presence of infauna and the absence of ripple marks suggest a quiet environment with low bottom current speeds, where finer sediments are likely to accumulate. The nature of the sediment found during the present cruise is very different and it appears likely that during the past month there have been one or more storm events, which have scoured the seabed and removed all the fine material. The apparent lack of any oxygen demand by the sediment supports this. The bed photography planned for the second leg of this cruise should provide direct evidence to confirm a marked change in the bed sediment properties since September.

5.2 In situ nitrate analysers and fluorometers – K. Jones, I. Ezzi

(a) Surface Toroid

Mooring I was recovered on 26/10/98. This consisted of toroid-mounted fluorometer, nitrate analyser (DML) and transmissometer (POL) and a sub-surface fluorometer (NIOZ) mounted at 15 m. Both the fluorometers and the nitrate analyser were functioning on recovery. None of the instruments showed visible evidence of significant biofouling, and a check of the response of the surface fluorometer in 0.7 µm- filtered sea water before and after cleaning the fluorometer windows showed little change in performance. Complete continuous data records spanning ~560 h were recovered from both instruments. Data was not downloaded from the NIOZ fluorometer.

Considering the poor data return from the NAS nitrate analysers in the past, the record obtained was of reasonable quality and suggests that modifications incorporated in the version 2E of the instrument have solved some of the earlier problems of degradation of reduction column efficiency. The signal for the on-board standard (~10 µmoles l-1 NO3-N) rapidly stabilised after deployment and remained constant for the first half of the deployment period (Figure 1.). After about 230 hours, the standard signal became much more variable and column efficiency declined gradually over the remainder of the deployment period. Sample signals showed an overall decrease in voltage over the deployment period with more variability in the second half of the deployment with fluctuations closely following that of the on-board standard signal. Although some gradual deterioration in reduction column efficiency might be expected over a long deployment, the cause of the abrupt change around 230 h is less easy to explain. When the instrument was recovered it was noted that the cadmium wire reductor coil had been disturbed either by the flow or due to impact or vibration and had moved about 7 cm along its tube away from the instrument. This would have the effect of reducing the exposure of standards and samples to the cadmium surface and hence reducing the apparent column efficiency. Movement of the coil was possible because the reductor tube had been secured extended, rather than coiled, as had been previous practise.

Despite the changes in reduction efficiency, it should be possible to calibrate the sample signal for the whole deployment. Roughly calibrated data (Figure 2) shows relatively constant nitrate concentrations (1.5 µmoles/litre) at the surface until 280 h. This was followed by followed by a period of small increase in nitrate accompanied by increased variability. Finally, during late October, concentrations rose further to 5-6 µmoles/litre.

The uncalibrated fluorometer record suggests the occurrence of two small autumnal peaks in September and early October followed by a gradual decline through the remainder of the deployment period.

(b) Other Environmental Moorings

Recovery of Mooring J1 was unsuccessful. Although communication was established with the release, the mooring failed to surface. Extremely poor weather prevented further attempts at recovering this and the remaining environmental moorings during Leg A of the cruise.

5.3 Dissolved Oxygen – K. Jones

Dissolved oxygen profiles were measured on 3 (CTD casts 2, 5 & 14) occasions during the cruise using precise micro-Winkler titration using a Radiometer auto-burette and photometric endpoint detector. Additionally an experiment was carried out with water from CTD cast14 to determine a vertical profile of microplankton respiration. Replicate water samples were incubated in the dark for 24h at temperatures representative of surface and bottom mixed layers. Respiration will be determined from differences in oxygen concentrations before and after incubation.

5.4 Other water column measurements - K. Jones, I. Ezzi, V. Edwards, M. Harvey, L. Denis, G. Moncoiffe

(a) Nutrients

Nutrient samples were taken from most CTD casts, filtered through a GF/F filter and frozen. A problem with alignment of the autoanalyser autosampler prevented on board analysis of these samples. The samples were therefore returned to Dunstaffnage frozen, for later analysis.

(b) Chlorophyll

Full vertical profiles of phytopigment distribution were determined from ?? CTD casts and samples from surface and bottom mixed layers and thermocline only at the remaining CTD stations. Occasional samples were taken from the non-toxic water supply for calibration of the underway fluorometer. Water (200 ml) was filtered through 2.5 cm GF/F filters and the filters stored frozen for later analysis by HPLC at

Dunstaffnage. At one CTD station, water samples were size-fractionated by passage through a filter stack consisting of polycarbonate filters of 18, 2 and 0.2 μm pore size. Filters were stored as described above.

(c) Particulate carbon and nitrogen

Samples were collected for determination of vertical profiles of particulate carbon and nitrogen from ?? CTD casts. Water (500ml) was filtered through pre-combusted 2.5 cm GF/F filters and stored frozen for later analysis.

(d) Phytoplankton species

Water samples from 1 CTD cast were taken and preserved using Lugol's iodine for later microscopic examination.

5.5 Interfacial Sampler – K. Jones, I. Ezzi

The opportunity to deploy the interfacial sampler was severely restricted by bad weather and the one occasion when deployment was attempted was in marginal conditions. Three drops of the sampler failed to retrieve any samples. The likely reason for failure was the difficulty of keeping the frame stationary on the bed for a long enough period for the timing mechanism to fire. The system incorporates a tilt-switch that prevents the sampler from firing if it detects significant deviation from vertical orientation within a 30 second period. The timing mechanism was subsequently adjusted to reduce this period to 15 seconds but continuous high seas prevented further deployments of the sampler during Leg A.

5.6 Suspended particulate matter (SPM) in the water column

Three sets of measurements were made to quantify and characterise the suspended particulate matter (SPM) in the water column:

1. The particle size spectrum of SPM was measured using a LISST laser sizer attached to the CTD frame. Data at 2Hz were collected between surface and bottom on each CTD cast except one (number 2) - a total of 59 profiles.

2. The settling velocity spectrum of SPM was measured using quasi in situ settling velocity tubes (SVTs) deployed 1m above the seabed and 5m from the sea surface. Each SVT deployment required a 7 hour settling time on recovery. A total of 14 SVT deployments were successfully achieved.

3. Surface and bottom waters were recovered from the rosette sampler at each CTD cast for filtering and subsequent gravimetric determination of SPM concentration. These data will be used for calibration of the CTD- and mooring-deployed transmissometers.

Preliminary analysis of the data shows increasing SPM concentration from the surface to the bottom with a marked transition at the thermocline; and increasing concentration below the thermocline during the period of the cruise. Both trends are a consequence of storm, and not tidal, resuspension of seabed material. SPM size spectra show two pronounced modes at c. 15 µm and >250 µm. The larger mode comprises aggregates, the smaller mode the basic floc structures that make up the aggregates.

5.7 Moorings

NIOZ - recovered, instruments switched off

STABLE recovered - some damage

3 deployments of camera - 2.5 films shot

6. PROVESS Challenger CH140 Data

6.1 Stations

1. Station "A" 150kHz ADCP S/N1149
Data OK 1 ensemble missing.
BPR 1357 Full data set.
Minilog 1362 Data OK

2. Station "B" UWB 1.2MHz ADCP
Full data set
Minilog 1371 Data OK

3. Station "C" POL 1.2MHz ADCP
1st deployment from Valdivia yielded a full data set.
Minilog 1371 data OK
2nd deployment CH140 deployment. Instrument trawled awaiting return from Peterhead.
Minilog 1371 deployed.

4. Station "D" STABLE data not yet available.
RCM7-11814+Sea Tech 637 30 days of data before batteries ran out. Calibrated on CTD Cast 52.

5. Station "E" S4s 05451264 and 05111119 10 min/hour both gave good data.

6. Station "F" S4s 08582005 and 08582006 Fast sampling.
1st deployment on Valdivia gave good data. Challenger deployment. Rig trawled and awaiting return from Norway.

7. Station "G" MET Buoy.
Recovered successfully. Awaiting download of data.

8. Station "I" Environmental Surface Buoy.
Transmissometer TRB2-1761 gave a full data set. Calibration data available from CTD52 cal.
Fluorometers 112/2530/011 and 112/2478/007 + NAS 1714 returned to DML. Awaiting data.

9. Station "J1" Mid water Environmental mooring.
RCM7-11814+Sea Tech 631 30 days of good data before the batteries ran out. Calibrated CTD Cast 52.
Fluorometer 12/2530/014+NAS 1754 returned to DML Data not yet available.

10. Station "J2" Nearbed Environmental mooring
RCM7-11817+Sea Tech 557 30 days of good data before the batteries ran out. Calibrated CTD Cast 52.

Fluorometer 12/2530/012+NAS1751 returned to DML. Data not yet available.

11. Station "L" LOST

12. Station "R" Pop Up Thermistor Rig
TR7-1456+Chain 2334 Instrument believed to have stopped half way through the deployment. Needs checking.
Minilogs 2413,2414,2415,2417 all gave good data. Minilog 2416 did not work for some reason i.e.: stopped after 11 readings (approx 1 hour)

13. Station "S" Pop Up Thermistor Rig
TR7-1451+Chain 2331 gave good data.
Minilogs 2419,2420,2421,2422,2423,2425,2427 all gave good data.

14. Station "U" 150kHz Broadband ADCP
Good data.
Minilog 2406 gave good data

15. Station "V" 150 kHz Narrow band ADCP
Returned to RVS for data download.
Minilog 2407 gave good data

16. Station "X" Teleost Pressure Recorder
BPR 444 10min sampling Good Data. Note that temperature data recorded is Tx temperature and not sea water temperature.

17. Station "Y" Teleost Pressure Recorder
BPR 445 10 min sampling. Good data. See note above concerning temp data.

6.2 CTD – Jeff Benson and Andy Jones

1. A total of 60 CTD casts were completed during this cruise. The sensor configuration was as follows:

Aux 1	20cm path transmissometer
Aux 2	Fluorimeter
Aux 3	Down-welling irradiance
Aux 4	Up-welling irradiance
Aux 5	Altimeter
Aux 6	Oxygen pump

2. Fluorimeter SA-226 removed from frame at cast 005 and replaced with SA3-254 due to noise/spikes in data.

3. Altimeter working properly from cast 005.

4. Transmissometer T-1022D spiking intermittently, suspect moisture in slip ring

assembly. Replaced with transmissometer T-1019D for one cast but noise persisted. Swapping out of cables, connectors and the breakout box did not solve the problem.

5. All other instruments/sensors functioning properly.

6.3 ADCP – Jeff Benson and Andy Jones

1. No problems experienced.
2. Software used was TRANSECT.

6.4 Surfmet – Jeff Benson and Andy Jones

The surfmet system consisted of the following sensor suite:

(a) starboard and port 2-pi par light meters
(b) air temperature
(c) relative humidity
(d) barometric air pressure
(e) wind speed and direction
(f) 25cm path transmissometer/fluorometer
(g) housing/remote surface sea water temperature
(h) conductivity/salinity for surface sea water

1. Wind direction not functioning for most of first leg; one failure of the sensor on the second leg.
2. Corrected surface CTD readings correlate well with the corrected TSG fluorometer surface readings.

6.5 Fixed Equipment – Jeff Benson and Andy Jones

1. Chernikeef log recalibrated at beginning of cruise.
2. Simrad EA-500 echosounder had no working problems; however the speaker selection for the 10kHz beacon was not working for the bed-hop camera deployments.

6.6 Portasal – Jeff Benson and Andy Jones

1. The portasal was installed in the darkroom lab for the cruise.
2. A total of 74 CTD/TSG salinity samples were taken on this cruise.

6.7 CTD winch slipring – Jeff Benson and Andy Jones

1. Problems with water in slipring assembly prior to sailing; slipring was disassembled, cleaned, dried and wire number 3 reterminated before reassembly.
2. Further investigation of the assembly periodically throughout the cruise revealed small amounts of moisture ingress, which contributed to intermittent noise/spikes in the data.

6.8 Moored instrumentation – Jeff Benson and Andy Jones

1. Inerocean S4 current meters
2. RDI SCADCP
3. Oceano Releases

Two S4 current meters and one RDI SCADCP were deployed previously on the R.V Valdivia and recovered on this cruise, they all appear to have worked successfully and have full data sets. There were six Oceano releases used on moorings, five of which were recovered successfully and one other, which was not recovered due to its mooring having been trawled and seemingly losing some of its buoyancy. All six of the releases fired and released successfully although there was initially a slight difficulty in firing two of the releases, which had been trawled and dragged from their original positions. During the search for the trawled moorings using the overside transducer it was found that a range of 2500 m was achievable.

6.9 Miscellaneous – Jeff Benson and Andy Jones

Milli-Q system needed replacement of Super-C carbon cartridge at less than one week of use, as not enough water pressure was available for the RO unit. Less than 24 hours later again there was not enough water pressure for the RO unit to function properly; the RO pack was replaced, along with the Super-C carbon cartridge, which provided only a temporary solution. Feed water pressure is suspected to be too low to allow the RO to operate continuously; the newly concrete-cleaned and chlorinated fresh water tanks onboard the ship may be clogging the pre-filters; the RO membrane may need replacing or cleaning; any combination of the above may be responsible for the problems. The system was able to run long enough to keep the tank supply to the Milli-Q itself full throughout the cruise.

Computing no problems - no surface fluorimeter for first 2 days (steaming)

Table 1.
Equipment on moorings

A	150 kHz RDI broadband ADCP, pressure recorder, minilogger, Argos, Benthos releases.
B	1.2 MHz RDI workhorse ADCP (UWB), minilogger, Argos, Benthos releases,
C	1.2 MHz RDI workhorse ADCP (POL), minilogger, Argos. Benthos releases. Fast sample. Deploy on Challenger leg 1.
D	STABLE - 3 twin e-m, 3 fast sample thermistors + conductivity, digiquartz, slow response sensors, transmissometer (SeaTech?), ABS, Benthos releases.
E	Surface currents. S4s (RVS) at 4, 10 m below surface, Argos beacon. 'J' rig.
F	Surface currents. S4s (POL) at 4, 10 m below surface. 'ETA' rig, Argos beacon. Fast sample. Deploy on Challenger leg 1.
G	Met. Buoy, NIOZ instrument, Argos beacon.
H	Waverider, data transmitted by Argos.
I	Surface nitrate (DML), transmissometer (POL, TRB2), fluorometer (DML); fluorometer (NIOZ) at 14 m depth, Argos beacon. Turn round on Challenger 140 leg 1.
J1	Sub-surface nitrate (DML), fluorometer (DML), Aanderaa / transmissometer (POL, SeaTech) at 50 m above the bed, Oceano release. Turn round on Challenger 140 leg 1.
J2	Near-bed nitrate and silicate (DML), fluorometer (DML), Aanderaa / transmissometer (POL, SeaTech) at 9 m above the bed, Oceano release. Turn round on Challenger 140 leg 1.
L	Sub-surface 50 m thermistor chain, 5 miniloggers, INFLUX, Oceano release.
M	NIOZ frame, 300 & 1.2 MHz ADCPs, thermistor chain, Benthos releases.
R	Sub-surface 50 m thermistor chain, 5 miniloggers, Oceano release.
S	Sub-surface 40 m thermistor chain, 7 miniloggers, Oceano release.
U	150 kHz RDI broadband ADCP, pressure recorder, minilogger, Argos, Benthos releases.
V	150 kHz RDI narrowband ADCP (RVS), minilogger, Argos, Oceano release.
X	Teleost pressure recorder, minilogger, Benthos release.
Y	Teleost pressure recorder, minilogger, Benthos release.

Table 2

Times and positions of deployments and recoveries

Rig	Time	Date	Time	Date	Lat (N)	Long (E)	Depth
	(m)				° ′	° ′	
A	08.56	08/09/98	15.09	02/11/98	59 19.70	1 00.22	105
B	11.35	08/09/98	15.30	01/11/98	59 19.54	0 59.99	105
Ca	12.17	08/09/98	08.17	15/09/98	59 19.42	1 00.08	107
Cb	13.04	24/10/98			59 18.79	1 00.74	
D	06.56	08/09/98	11.38	01/11/98	59 19.89	1 00.06	140?
E	09.33	09/09/98	14.13	01/11/98	59 19.21	1 00.02	-
Fa	12.26	09/09/98	08.50	15/09/98	59 19.10	0 59.99	107
Fb	09.53	24/10/98			59 18.72	0 59.80	118
G	08.00	08/09/98	16.05	03/11/98	59 20.61	0 59.73	104
H	10.47	08/09/98			59 20.45	1 00.87	104
I	07.35	09/09/98	14.34	26/10/98	59 19.38	1 00.62	104
J1	09.35	10/09/98	08.29	05/11/98	59 19.59	1 00.65	103
J2	17.59	09/09/98	08.06	01/11/98	59 19.74	1 00.58	103
L	06.58	10/09/98			59 19.95	1 00.62	-
M	14.00	21/10/98	13.26	03/11/98	59 19.05	1 00.52	110
R	12.14	10/09/98	09.01	01/11/98	59 20.00	1 05.00	105
S	14.14	10/09/98	10.21	01/11/98	59 22.45	1 00.00	107
U	11.36	07/09/98	10.40	02/11/98	59 19.97	1 25.07	100
V	16.22	09/09/98	10.32	03/11/98	59 32.64	0 59.62	109
X	10.25	07/09/98	08.47	02/11/98	59 19.93	1 40.43	113
Y	15.05	08/09/98	08.38	03/11/98	59 45.00	1 00.08	114

Table 3
Times and positions of CTD profiles

CTD	Date	Time (GMT)	Latitude (N)	Longitude (E)	Water depth (m)	
1	24/10/98	06.14	59° 19.5′	0° 57.2′	119	
2	24/10/98	13.45	59° 18.8′	1° 01.2′	108	No lisst
3	25/10/98	08.15	59° 18.5′	0° 53.5′	118	
4	26/10/98	12.14	59° 19.5′	1° 02.5′	103	
5	26/10/98	13.50	59° 19.1′	1° 00.7′	110	
6	26/10/98	19.23	59° 19.9′	1° 01.7′	105	
7	26/10/98	20.22	59° 19.4′	1° 02.2′	105	
8	26/10/98	21.24	59° 19.3′	1° 02.2′	105	
9	26/10/98	22.22	59° 19.3′	1° 02.2′	106	
10	26/10/98	23.27	59° 19.3′	1° 02.3′	105	
11	27/10/98	00.24	59° 19.1′	1° 02.2′	107	
12	27/10/98	01.38	59° 19.3′	1° 02.4′	103	
13	27/10/98	02.52	59° 19.3′	1° 02.2′	106	
14	28/10/98	15.25	59° 19.4′	1° 02.1′	106	
15	28/10/98	17.22	59° 18.3′	1° 02.0′	108	
16	28/10/98	18.45	59° 18.5′	1° 01.6′	108	
17	28/10/98	20.00	59° 19.5′	1° 01.8′	106	
18	28/10/98	21.39	59° 19.2′	1° 02.4′	103	
19	01/11/98	17.27	59° 19.2′	1° 03.7′	100	
20	01/11/98	19.04	59° 19.2′	1° 02.8′	104	
21	01/11/98	20.04	59° 19.3′	1° 02.5′	104	
22	01/11/98	21.05	59° 19.3′	1° 02.2′	105	
23	01/11/98	22.07	59° 19.3′	1° 02.2′	105	
24	01/11/98	23.05	59° 19.4′	1° 02.2′	103	
25	02/11/98	01.11	59° 19.4′	1° 02.4′	105	lisst pres. cal.
26	02/11/98	02.08	59° 19.6′	1° 02.4′	102	lisst pres. cal.
27	02/11/98	03.09	59° 19.4′	1° 02.3′	103	
28	02/11/98	04.20	59° 20.1′	1° 10.0′	110	
29	02/11/98	06.17	59° 20.0′	1° 22.7′	109	U
30	02/11/98	07.12	59° 20.1′	1° 30.4′	108	
31	02/11/98	08.17	59° 20.1′	1° 39.7′	116	X
32	02/11/98	18.30	59° 18.5′	1° 00.2′	111	
33	02/11/98	23.34	59° 20.0′	0° 59.8′	110	
34	03/11/98	00.53	59° 24.9′	1° 00.0′	115	
35	03/11/98	02.16	59° 31.0′	1° 00.1′	112	V
36	03/11/98	03.16	59° 35.1′	1° 00.1′	114	
37	03/11/98	04.39	59° 40.0′	1° 00.0′	120	
38	03/11/98	05.33	59° 45.2′	1° 01.2′	119	Y
39	03/11/98	22.48	59° 18.4′	1° 00.1′	111	
40	04/11/98	00.58	59° 18.5′	0° 35.7′	131	
41	04/11/98	02.30	59° 18.6′	0° 19.9′	139	
42	04/11/98	03.42	59° 18.5′	0° 09.8′	139	

43	04/11/98	05.13	59° 18.5′	0° 29.7′	133	
44	04/11/98	06.41	59° 18.5′	0° 49.7′	128	
45	04/11/98	19.20	59° 20.1′	1° 02.3′	103	
46	04/11/98	21.14	59° 10.0′	1° 02.1′	118	
47	04/11/98	22.51	59° 01.3′	1° 01.8′	126	
48	05/11/98	00.52	58° 49.9′	1° 01.7′	115	
49	05/11/98	02.22	58° 55.0′	1° 01.8′	112	
50	05/11/98	04.42	59° 05.0′	1° 02.0′	124	
51	05/11/98	06.44	59° 15.0′	1° 02.1′	113	
52	05/11/98	21.07	59° 18.8′	0° 59.7′	113	rec. trans. cals
53	06/11/98	18.13	59° 19.2′	1° 02.3′	104	
54	07/11/98	15.17	59° 17.2′	0° 58.7′	113	
55	07/11/98	16.20	59° 14.1′	0° 50.5′	143	
56	07/11/98	17.07	59° 11.9′	0° 45.9′	148	
57	07/11/98	18.14	59° 08.0′	0° 39.7′	123	
58	07/11/98	19.16	59° 03.4′	0° 33.4′	153	
59	07/11/98	20.20	59° 00.2′	0° 26.9′	146	
60	07/11/98	21.26	58° 56.4′	0° 20.2′	148	

Table 4
Times and positions of settling velocity (SVT) tube deployments

SVT	Date	Time (GMT)	Latitude (N)	Longitude (E)	Sample depth (m)	CTD
1	26/10/98	13.07	59° 19.3′	1° 02.3′	near bed	4, 5
2	26/10/98	13.24	59° 19.3′	1° 02.2′	5 m depth	4, 5
3	26/10/98	20.45	59° 19.5′	1° 02.1′	near bed	7
4	26/10/98	21.45	59° 19.3′	1° 02.3′	5 m depth	8
5	28/10/98	16.00	59° 19.4′	1° 02.4′	near bed	14
6	28/10/98	17.48	59° 18.3′	1° 02.1′	5 m depth	15
7	01/11/98	17.52	59° 19.2′	1° 03.5′	no sample	
8	01/11/98	18.09	59° 19.1′	1° 04.2′	5 m depth	19
9	01/11/98	19.29	59° 18.9′	1° 02.9′	near bed	20
10	02/11/98	19.07	59° 17.0′	1° 00.2′	near bed	32
11	02/11/98	19.23	59° 16.9′	1° 00.3′	5 m depth	32
12	04/11/98	18.21	59° 19.7′	1° 02.6′	near bed	45
13	04/11/98	18.55	59° 20.0′	1° 02.5′	5 m depth	45
14	06/11/98	18.48	59° 19.5′	1° 01.4′	near bed	53
15	06/11/98	19.12	59° 19.7′	1° 00.6′	5 m depth	53

Table 5
Recovery positions

Rig	Time	Date	Lat (N)	Long (E)	Depth (m)
A	15.09	02/11/98	59 19.84	1 00.39	-
B	15.30	01/11/98	59 19.50	1 00.15	111
D	11.38	01/11/98	59 19.86	1 00.07	110
E	14.13	01/11/98	59 19.28	1 00.17	-
G	16.05	03/11/98	59 20.66	0 59.88	-
I	14.34	26/10/98	59 19.38	1 00.77	110
J1	08.29	05/11/98	59 15.56	1 09.98	-
J2	08.06	01/11/98	59 19.60	1 00.60	-
M	13.26	03/11/98	59 19.08	1 00.53	109
R	09.01	01/11/98	59 19.90	1 05.19	-
S	10.21	01/11/98	59 22.40	1 00.15	114
U	10.40	02/11/98	59 19.99	1 24.99	105
V	10.32	03/11/98	59 32.55	0 59.79	114
X	08.46	02/11/98	59 19.94	1 40.28	114
Y	08.38	03/11/98	59 45.07	1 00.14	-