University of Southampton
Department of Oceanography
Cruise Report: 95/31

RRS Charles Darwin Cruise 94

OMEX
Ocean Margin EXchange Study
3 June -20 June 1995

Dr Peter J. Statham
Cruise Report 95/31, July 1995

Synopsis

This RRS Charles Darwin cruise forms part of an extensive sea time campaign on the Goban Spur and adjacent shelf break under the EU MAST funded project OMEX (Ocean Margin EXchange), and follows on from the RRS Charles Darwin Cruise 84 (Jan-Feb 1994, see cruise report by Statham 1994, for details). The shelf break area has been chosen for study because of its potential importance in the flux of materials between the land and the open ocean. The main focus on this cruise was on biogeochemical processes, with additional work being undertaken which is relevant to the OMEX project. Weather conditions were very much better than during CD84, and a large amount of sample and data collection was done.

The cruise started at Fairlie on the west coast of Scotland, and the ship initially visited the UK LOIS shelf edge study (SES) site on the Hebridean shelf. Water column and limited sediment sampling provided an opportunity to test new sampling bottles and to collect some data and samples for comparison with similar information form the OMEX region. After leaving the LOIS SES area, the cruise track went south following the 200 m isobath to the west of Ireland, until the main OMEX study site at the Goban Spur in the Celtic sea was reached. The primary sampling and data collection device was a CTD and rosette sampler of 10L lever action Niskin bottles. Samples were collected for analysis of dissolved and particulate trace metals (particulate metals collected by in situ pumping systems), oxygen, nutrients, dissolved and particulate organic carbon, pigments, carbohydrates, amino acids and micro-zooplankton. Hydrographic data on temperature, salinity, oxygen, fluorescence, and transmission were obtained from the CTD. The non-toxic pumped water supply on the ship was monitored to give data on surface temperature, salinity, transmission and fluorescence, as well as nutrient and dissolved aluminium data.

A series of Kasten and Box cores from varying depths on the Shelf were taken. Cores were sub-sampled to provide archive material and sediment samples for a variety of sedimentological analyses including organic carbon, particle size and X-ray photography.

Additional work relevant to the OMEX project included recovery of two current meter mooring arrays, interrogation of 3 other moorings (attempts were made to recover two of these, but without success), and deployment of a shallow mooring which had been previously destroyed by fishing activity in the area.

All data generated from the cruise will be banked with the OMEX database, which is being operated by the British Oceanographic Data Centre, Birkenhead Observatory, Birkenhead, Merseyside L43 7RA, United Kingdom.

Acknowledgements

The overall success of a research cruise of this nature relies on many factors, but paramount amongst them is how the personnel operate individually and as an effective team. To the Master, Richard Bourne, and the officers and crew of RRS Charles Darwin particular thanks are due for their continuing support and professional advice through - out the cruise. The RVS personnel supporting the shipboard activities operated in like mind, with every effort being made to ensure the trip was successful despite the range of usual and unusual problems which arose, including getting the new water sampling bottles operational. I am also grateful to individuals who helped with mobilisation and demobilisation, and Stephen Groom and Peter Miller at Plymouth who provided the satellite images to the ship. In particular I would like to acknowledge the help of Mr Chris Mair from the forwarding company, who went well beyond the norm in trying to help with replacement of chemicals and equipment which did not arrive at the ship, and Professor John Davenport at the Millport Marine Station on Cumbrae, who at the last minute was able to provide this missing support. My final thanks go to the scientists on board, who came from five European nations, and with good humour and flexibility, were prepared to work within the guidelines set by me. The effectiveness of the team on the ship operating together, with the aid of excellent weather, is amply demonstrated by the highly productive nature of the cruise in terms of the wide variety of data and samples collected. My thanks go to all those involved in making the cruise so successful.

I am grateful to Dennis Burton and David Hydes for their comments on an earlier version of this report.

CONTENTS

1. CRUISE PERSONNEL

Officers:	
Richard BOURNE	Master
Derek NODEN	Chief Officer
Phil OLDFIELD	Second Officer
Matt CROFTS	Third Officer
Jeff BAKER	Radio Officer
Andy ADAMS	Chief Engineer
Berni McDONALD	Second Engineer
Bob SMITH	Third Engineer
Phil PARKER	Electrical Engineer
Crew:	
Trev TREVASKIS	Bosun
Christos VRETTOS	Seaman
Kev LUCKHURST	Seaman
Paul DEAN	Seaman
Bob DICKINSON	Seaman
Andy MACLEAN	Seaman
Tony HEALY	Motorman
Ray BELL	Senior Catering Manager
Colin PERRY	Chef
Chris KENNY	M/Steward
Wal LINK	Steward
Sue SHIELDS	Steward
Scientists:	
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Pepe ALVAREZ-SALGADO	PML
Sarah BROWN	CAMES
Ilse BÜNS	ZMK
Marie-Helene COTTE	ENS
Ian HALL	CAMES
Christina HUNT	PU
David HYDES	IOS
Axel MILLER	PML
Nick MORLEY	SUDO
Jane SAN-JUAN	IFREMER
Petra SCHUMANN	ZMK
Tom TREACY	UCG
Research Vessel Services:	
Stirling JORDAN	Mechanical
Rob LLOYD	Computing
Jason SCOTT	Mechanical
Simon WATTS	Instruments
John WYNAR	Instruments

Abbreviations used, and addresses, are given in full on the next page.

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ZMK
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2. CRUISE OBJECTIVES

This Darwin cruise forms part of an extensive sea time campaign on this region of shelf break under the EU funded project OMEX (Ocean Margin EXchange). The shelf break area has been chosen for study because of its potential importance in the flux of materials between the land and the open ocean. The general arguments and background are well summarised in "Ocean margin processes in global change" eds Mantoura et al (1991) Wiley, and the detailed rationale and project description are given in the proposal to MAST. The OMEX Chief Scientist is Prof. R.Wollast, Université Libre de Bruxelles, Boulevard de Triomphe, 1050. Brussels, Belgium

This cruise focused mainly on the work of the Biogeochemical Processes Sub-Task of OMEX, and provided an opportunity to study concentrations and distributions of materials of interest during a summer period at the shelf break. Other cruises (CD84 winter 1994, and Discovery late summer 1995, plus cruises by other European colleagues) in combination with CD94 will provide a view of the seasonal variability of the distribution and concentrations of important chemical and micro-biological materials in this dynamic environment. The general scientific objectives of CD94 were:

1) To study the role of biogeochemical and hydrographic processes in controlling the distributions of dissolved trace metals in the shelf break region and adjacent waters, with due regard to temporal variability.
2) To estimate fluxes across trace metal fronts in the shelf break region and evaluate the use of trace metals as tracers of advective exchanges of waters at the shelf break.
3) Based on these and other OMEX data, to further the development of models for frontal exchange of dissolved trace metals and the linking of these models to a shelf seawater quality model.
4) In addition to the trace metal work, to collect other information and samples relevant to the aims of the OMEX project.

The general strategy was to go from Fairlie on the West Coast of Scotland to the Shelf Edge Study (SES) site on the Hebridean shelf. After a shakedown station and limited water column and sediment sampling the ship then moved to the Goban Spur area of the shelf along the 200m isobath to the west of Ireland. An array of sediment traps had been deployed as a component of the OMEX programme at the Goban Spur, and sampling stations were occupied along two parallel transects off shelf in the vicinity of these traps. The intention was then to collect data and sample along a zigzag track over the shelf break, to the previously occupied BELGICA station at La Chapelle Bank, carry out a detailed water column sampling, and then return to Barry.

3. CRUISE NARRATIVE

Loading of heavy equipment was completed by Friday 2 June at the NATO quay at Fairlie, which is situated on the west coast of Scotland. A dedicated clean container for trace metal work was not available, and the constant temperature laboratory on the ship was very effectively converted for trace metal handling operations by Dr N.H. Morley. The scientific complement worked throughout Friday to set up the ship. Mr Chris Mair of the shipping agency, was particularly helpful in trying to locate a supplier for chemicals and equipment required for the cruise, which had been ordered, but had not materialised at the ship. By the evening of the 2 June the remaining scientific complement had joined the ship. A consignment of lever action Niskin bottles, which were essential for the cruise, fortunately arrived by courier during the night, and the ship left the quay at 0815 on the 3 June 1995.

The principal scientific activities of the cruise are listed in chronological order in Appendix 1, and the overall cruise track is shown in Figure 1a. Details of the science activities are given in later sections, and Figure 1b shows the principal stations visited. The main study area for OMEX in the Celtic Sea was well to the south of the departure port, and so the first phase of the cruise was a passage leg with some limited operations en route. The ship initially visited the LOIS (Land-Ocean Interaction Study of the Natural Environment Research Council) Shelf Edge Study (SES; this project is linked to the OMEX study) site on the Hebridean shelf, to test new equipment, to collect samples in this area, and to recover a LOIS mooring. Initial problems with the new Niskin bottles were resolved during the work at the SES site, and samples taken. The ship headed south approximately along the 200 m contour to the west of Ireland. En route, the recovery of two OMEX moorings deployed by colleagues at University College Galway was attempted; a third mooring was remotely interrogated. Box cores and a Kasten core were taken in the Porcupine sea-bight.

In the OMEX study area on the Goban Spur, two parallel off-shelf transects of stations were occupied, which corresponded to stations identified for CD84 the previous year. There was also the opportunity to recover a mooring in c. 1500 m of water which had been deployed the previous year on CD84, and to replace a mooring, in 145 m of water, that had been destroyed by fishing activity. A problem became evident during the work on the Goban Spur. The French authorities had not given permission to work south of 48° N in their territorial waters. Whilst diplomatic channels were followed in the UK, an alternative sampling strategy was planned in which a third off-shelf section was to be sampled, which was parallel to the two previously worked. The ship was proceeding to the start of this alternative track, when verbal agreement was obtained for work at OM 13 and the Belgica station south of 48 N. The initial position occupied for the Belgica station was away from the previously occupied location, and the ship was repositioned for this work. A zigzag course across the shelf was then followed, which allowed surface mapping of key features in the water column and sample collection using the clean underway sampling fish. A satellite image of the area (one of 4 sent to the ship) was useful in helping to chose the route across the shelf. The ship was finally berthed at Barry at circa 1200 h on Tuesday the 20 June.

Figure 1 Full cruise track for Charles Darwin Cruise 94

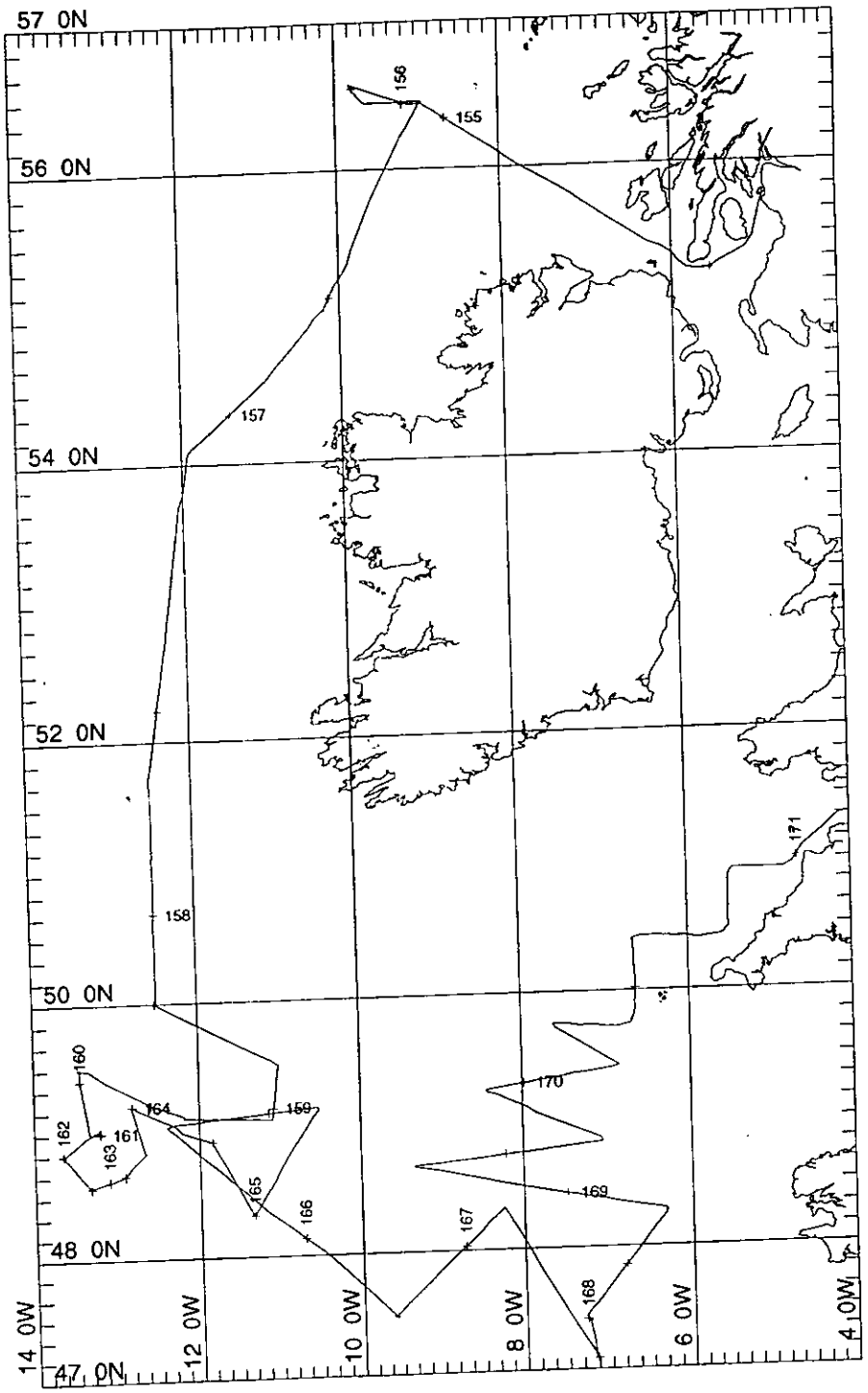
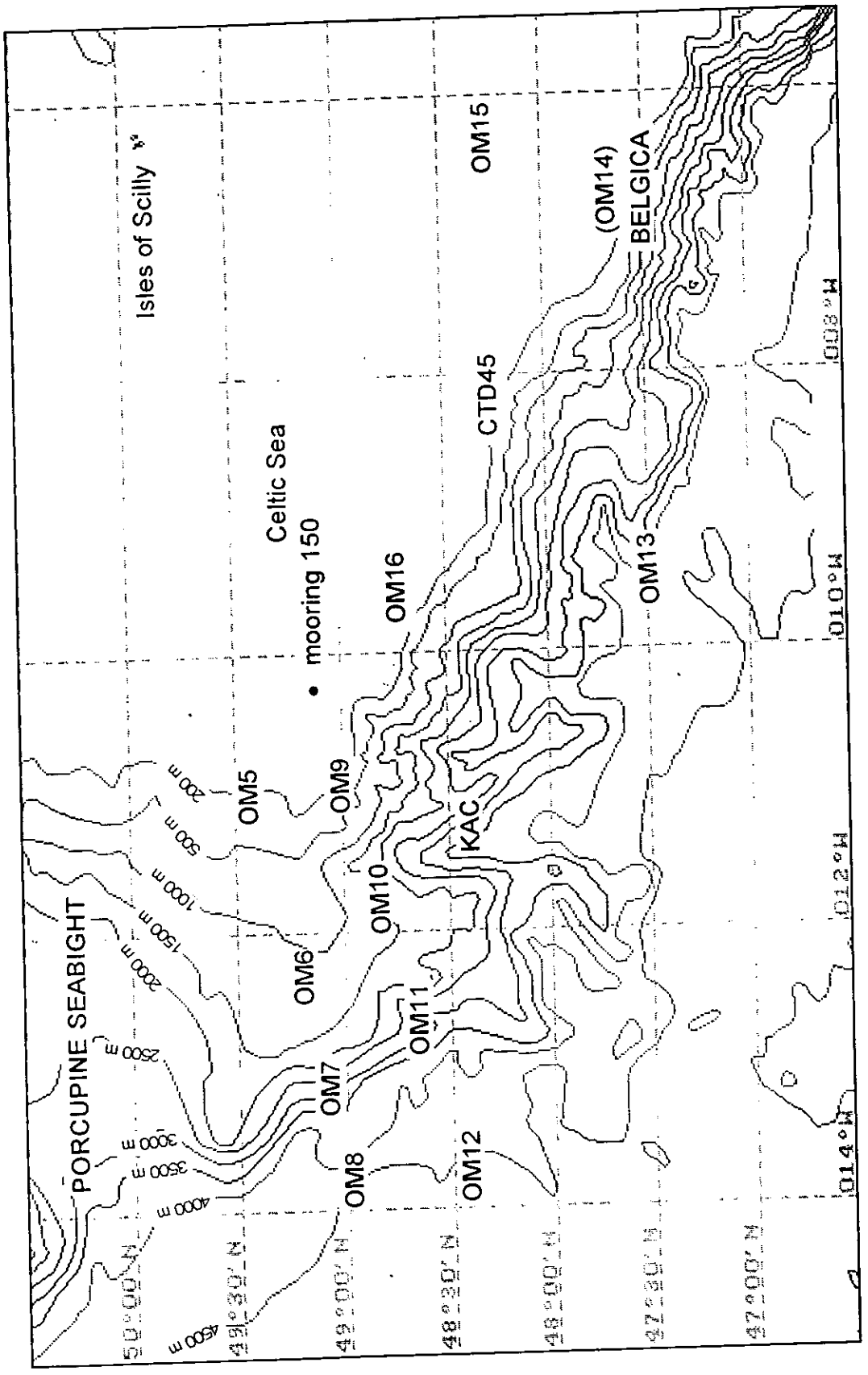


Figure 2 . Principal stations in the main OMEX research area visited during CD94



4. REPORT ON PERFORMANCE OF SHIP BOARD INSTRUMENTS AND EQUIPMENT

Equipment onboard generally worked well. As usual, the RVS personnel were extremely helpful, and their presence was vital to the successful collection of data and samples that took place. The Principal Scientist was particularly pleased to see that two problems identified during the earlier CD84 cruise has been addressed: the thermosalinograph had been replaced by a new FSI unit, and albeit at the last minute, the Go-Flo sampling bottles were replaced by new lever action Niskins. Specific points for comment are given below.

4.1 LEVER ACTION NISKIN BOTTLES AND THE ROSETTE SYSTEM

There was no opportunity to test the new bottles before departing from Fairlie. The conventional General Oceanic taps were replaced with Teflon taps taken from the old Go-Flos. Initial tests were disappointing, in that the firing module of the rosette was unable to rotate and allow the bottles to close. The motor in the pylon was replaced, but the problems of the bottle lanyards not being released still occurred. Fortunately the RVS technicians came up with the idea of reducing the tension on the springs by putting in a nylon monofilament loop, which effectively increased the length of the lanyards. This action, with some lubrication of the rotating release plate, solved the problem. The bottles subsequently worked almost faultlessly at depths of up to 4.5 km. One bottle appeared to be closing at the wrong depth based on aluminium results, although a test dip to 50 m did not reveal a problem with pre tripping. Further analysis of data on shore will help to determine if this bottle is mis-behaving. The data for dissolved aluminium obtained onboard looked good, supporting the idea that the bottles will be good for dissolved metal samples. It will be necessary to wait for a full set of analyses to be completed on shore before a decision about suitability of the bottles for collection of uncontaminated samples for all metals of interest, can be made.

It is desirable for these RVS sampling bottles to be stored at Southampton University Department of Oceanography, as has been the practice for the Go-Flo bottles, so that they can be maintained in a state suitable for their critical application in marine trace metal sampling. Bottles would of course be available to anyone in the NERC supported UK community who may have a requirement for this specialised facility.

4.2 GREASE CONTAMINATION OF THE CTD CABLE

The potential for contamination of samples by the grease around the port working area on the ship is a major concern. The new coring warp has a heavy coating of grease. Substantial amounts of this material become wiped off on sheaves through which it passes. The newly installed CTD winch (from the RRS Discovery) is fed through a sheave directly above the coring warp sheave. When the CTD cable is being deployed it rubs against the coring sheave and transfers grease to it.

There are two aspects to the contamination potential from the grease. The first is the CTD cable has to have some slack when on deck and this results in it contacting the bottles which are then contaminated with the grease; the cable must be handled and subsequent inadvertent contact with the bottles again leads to bottle contamination. The second concern is the more gross contamination of the CTD with accumulated grease falling from the CTD cable; at one point, the CTD cable had to be brought inboard before full deployment to remove several large balls of grease on the cable, which were threatening to fall directly onto the CTD only a few metres below!! Whilst the need to protect cables from corrosion is understood, the removal of excess from the warp and the regular cleaning of the sheaves would help considerably. Additionally, transferring the CTD wire to the unused sheave aft of the sheave currently used for the CTD wire would stop/reduce contact with the coring warp and its' associated contamination.

4.3 INADEQUATE SEATING IN LABORATORY SPACES

The seating in the main laboratory is totally inadequate. Of the 8 seats in the lab on leaving Fairlie, one had a broken back, another had top and bottom sections not properly connected, a third had such a corroded leg that this was gently pulled off before someone risked injury by trying to sit upon it and ending on the floor, and a fourth was tilted back such that it was very easy for it to tip over backwards. The remaining chairs looked as though they were rejects from a second hand office furnishers!

As a result, many of the operations carried out in the lab, where on busy occasions there could easily be 8-10 scientists and RVS personnel, were carried out by people perched on aluminium boxes or other impromptu and highly unsatisfactory seats. Additionally, in this age of computers it is not surprising that there were 10 computer VDUs in the lab which were in use at various stages during the cruise. The lab is therefore currently well behind current health and safety legislation for office workers using computers.

A series (say 12) of comfortable but basic chairs (obviously they need to be stable, and to have height adjustment) should be purchased. This should represent only a modest cost, but provide a significant improvement from the point of view of users of this area.

4.4 DEPLOYMENT OF THE KASTEN CORER

Whilst the situation may well have been worse if the full Kasten bucket were on deck, the presence of the bomb directly under the mid ships winch made deployment of box cores and the CTD difficult and potentially hazardous. Perhaps the introduction of an outboard bucket device, such as that used by the Dutch, should be investigated. It is highly probable that future cruises will wish to combine Kasten coring with other operations at the mid-ships winch.

4.5 PHOTOCOPIER AVAILABILITY

Only one photocopier was available on the ship during the cruise, and this was primarily for use by the Master on ship's business. Both during and especially towards the end of a cruise, there is a need for copies of papers for a variety of scientific purposes (work programmes for the day, copies of data, charts etc.). There is thus a strong argument for a scientific photocopier to be bought and installed on board, which in addition to fulfilling the need of the scientists, can provide a back up to the other unit on board. This photocopier could be located in the Principal Scientist's cabin, where a careful watch on the use of the machine can be made, i.e. ensuring only necessary copies are made, and that the machine is not abused.

4.6. WINCH FOR STAND ALONE PUMPS

Whilst the unit onboard functioned adequately in deploying and recovering SAPs, the speed with which this was done left much to be desired! An improvement in the performance of the winch, plus a new cable (as the plastic coating on he current wire is rapidly deteriorating) should be on the RVS procurement list if it is not already there. The meter wheel counter used to determine wire out depth was very unreliable and also needs refurbishment/replacement.

5. HYDROGRAPHIC PARAMETERS

Data on salinity, temperature, transmission and fluorescence were collected from both the CTD system, and the underway pumped system on the ship (other parameters from the CTD are considered below, as is the transmission data from the CTD in more detail). Both the CTD system and the shipboard thermosalinograph worked very well, and data for later shore based calibration of data by BODC were collected. In total there were 52 CTD casts. The main off shelf transects which were studied (OM5 to OM8, and OM9 to OM12) provided enough data to attempt three dimensional contouring of the data. The salinity maximum surface for the relatively warm Mediterranean Water is clearly seen in Figure 3; the decreasing depth of the surface on moving from north-east to south-west can be clearly seen. Contouring of surface collected data shows much higher chlorophyll *a* concentrations and lower temperatures on the shelf, relative to warmer, low chlorophyll waters towards the bay of Biscay (Figure 4).

6. SATELLITE IMAGES

Four satellite images covering parts of the Goban Spur, Bay of Biscay, and Amorican Shelf, were received on the ship. The images showed the same general trends noted in the surface transects with warm waters off-shelf, and a suggestion of advection of warmer water onto the shelf in filaments and larger masses of water). The data was useful during the cruise in refining in the zigzag pattern taken across shelf.

Figure 3. The isohaline surface for the core of the Mediterranean Outflow Water in the Goban Spur area, June 1995.

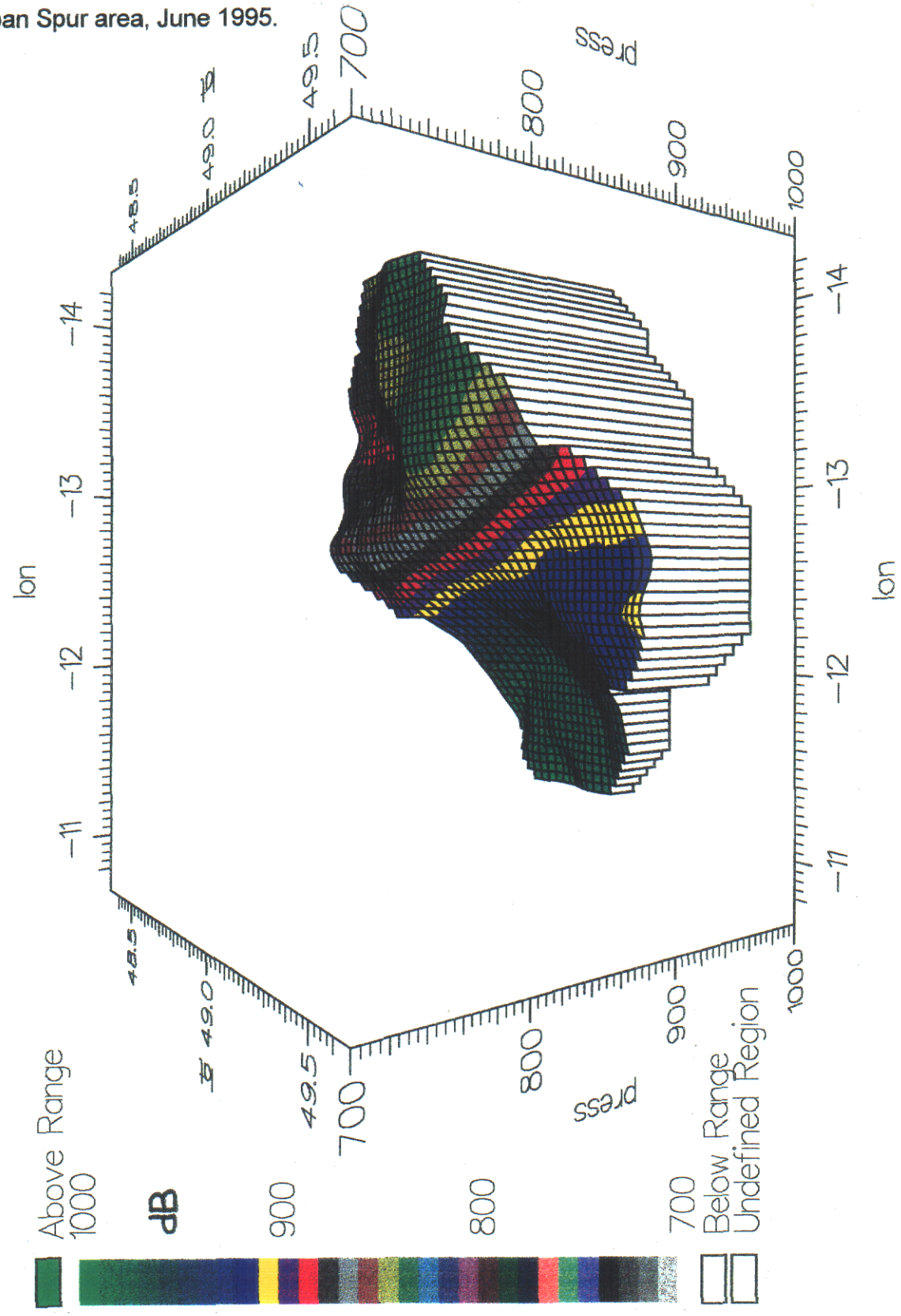
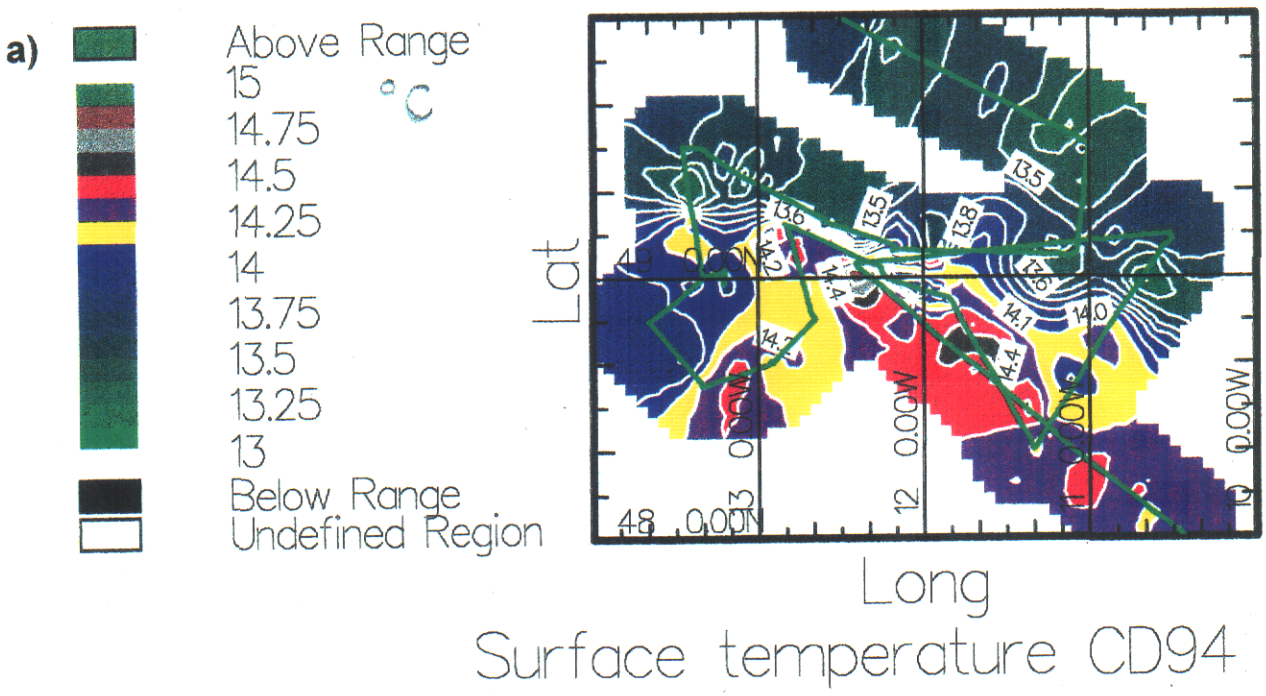
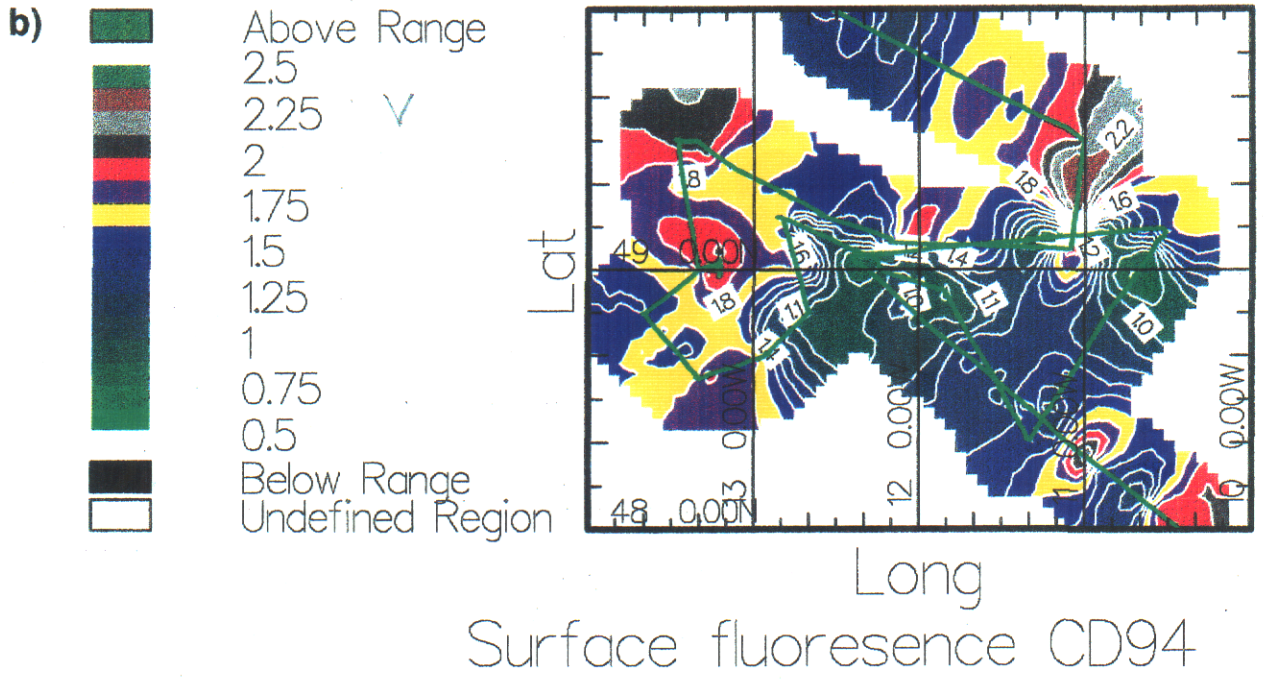


Figure 4. a) surface contours of temperature across the shelf break zone of the Celtic Sea, showing cooler shelf waters to the North and warmer water to the south towards the Bay of Biscay b) surface contours of fluorescence also showing an important change across the break area with highest values of fluorescence (assumed to be due primarily to chlorophyll *a* on shelf and lowest values in the warmer southern waters.





7. NUTRIENT STUDIES

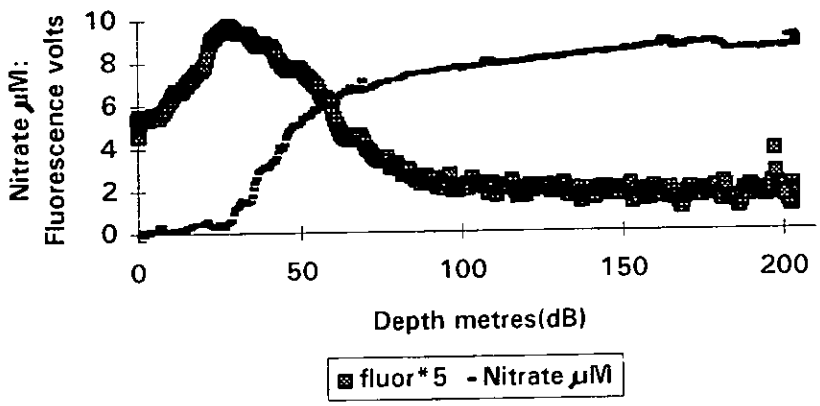
7.1. IOS NITRATE SENSOR

The IOS nitrate sensor is a newly developed instrument for the in-situ measurement of concentrations of dissolved nitrate in seawater. Measurement is based on the strong absorbance of dissolved nitrate in the UV region of the spectrum. Measurements are made at three wavelengths to compensate for the light losses due to dissolved organic material and scattering from particles entering the light beam. The instrument was developed by the Institute of Oceanographic Sciences from an optical design developed by the Department of Opto-electronics at the University of Southampton. This cruise was the first time the instrument had been used in the sea.

The instrument was deployed on nine of the stations occupied during the cruise. It was fitted to an FSI -CTD unit linked to a separate deck unit to that used for the main CTD operations for the cruise. Eight channels of data were collected. Operation was faultless at all stations. Water samples were collected in twelve 2.5l Niskin bottles on the up-cast of each deployment. These water samples were analysed for nitrate concentration on the UCG-Alpkem auto-analyser. Calibration of the sensor instrument was consistent from run to run, and within the precision of the auto-analyser measurements.

Figure 5 shows the distribution of nitrate and chlorophyll fluorescence measured on the down cast of a deployment to 200m depth at OMEX station OM13 (CD94-CTD-42). The distribution of the two parameters at this site suggests that upward movement of dissolved nitrate may be supporting a substantial faction of the production observed here as chlorophyll.

Figure 5. The vertical distribution of nitrate as determined by the nitrate sensor, and fluorescence (an indicator of chlorophyll *a*), at Station CTD 42 (OM13).



David Hydes

7.2. SHIPBOARD NUTRIENT AUTO-ANALYSER (UCG)

7.2.1. Objectives:

To measure Nutrients, $NO_2(N)$, $NO_3(N)$, $PO_4(P)$, and Si-Silicate aboard the ship, sampling from CTD casts and from the surface (hourly) along the ships course, in order to determine nutrient distributions in the OMEX Box area. It was planned to use $NO_3(N)$ data on a number of CTD casts to calibrate David Hyde's new nitrate analyser, based on a non-colorimetric spectrophotometric technique. Additionally it was planned to take a number of samples for an inter-calibration exercise with the University of Hamburg.

7.2.2. Methods:

An Alpkem Perstorp Auto Analyser was used to carry out the nutrient analyses. It was decided not to test for $NO_2(N)$, the reason being that nitrite nitrogen levels were assumed to be negligible, and certainly not to have a significant impact on $NO_3(N)$ results, which were based on the reduction of $NO_3(N)$ to $NO_2(N)$ and then measuring total $NO_2(N)$colorimetrically @ 540 nm.

Some methods were altered to improve existing accuracies and precisions. The sample time for the $NO_3(N)$ was changed to 40 secs, wash time to 20 secs. The $PO_4(P)$ and Si-Silicate methods were not altered, however, both systems were thoroughly washed before use.

7.2.3. Samples analysed:

Under-way samples were collected and analysed for $NO_3(N)$,$PO_4(P)$ and Si-Silicate. Most CTD casts were sampled at various depths for these nutrients. Samples were taken and analysed using the Alpkem analyser to calibrate the IOSDL nitrate probe. Samples from at least 180 under-way locations and 43 CTD casts had been analysed by the end of the cruise. Some under-way samples taken late in the cruise were poisoned with Mercuric Chloride and will be tested back in Galway.

7.2.4. Precision and accuracy of results:

The following precisions were obtained during the cruise.

$NO_3(N)$: %RSD = 0.52%
Si-Silicate: %RSD = 2.02%
$PO_4(P)$: % RSD = 1.95%

Correlation coefficients obtained for calibration graphs were 0.980 and greater.
A large seawater sample was taken early on the cruise and used as a QC check throughout the testing. This was done to monitor quality of analysis.

Accuracy was demonstrated by analysing reference standards supplied by IOS, Wormley. These standards were preserved using a mercuric chloride solution. Graphs were plotted to show the variation of both the quality check sample and the reference standards. A statistical analysis of this data yielded the following % RSDs:

Quality check sample.

NO_3(N) %RSD = 22.03%
PO_4(P) % RSD =21.48%
Silicon % RSD = 7.155%

IOS Ref. Standards.

NO_3(N) % RSD = 7.07%
PO_4(P) % RSD = 10.79%
Silicon % RSD = 7.268%

These results are shown in Figure6, and indicate that a significant variation in the data was observed during the cruise. A more detailed assessment of the quality of results will be carried out at UCG.

7.2.5. Conclusion:

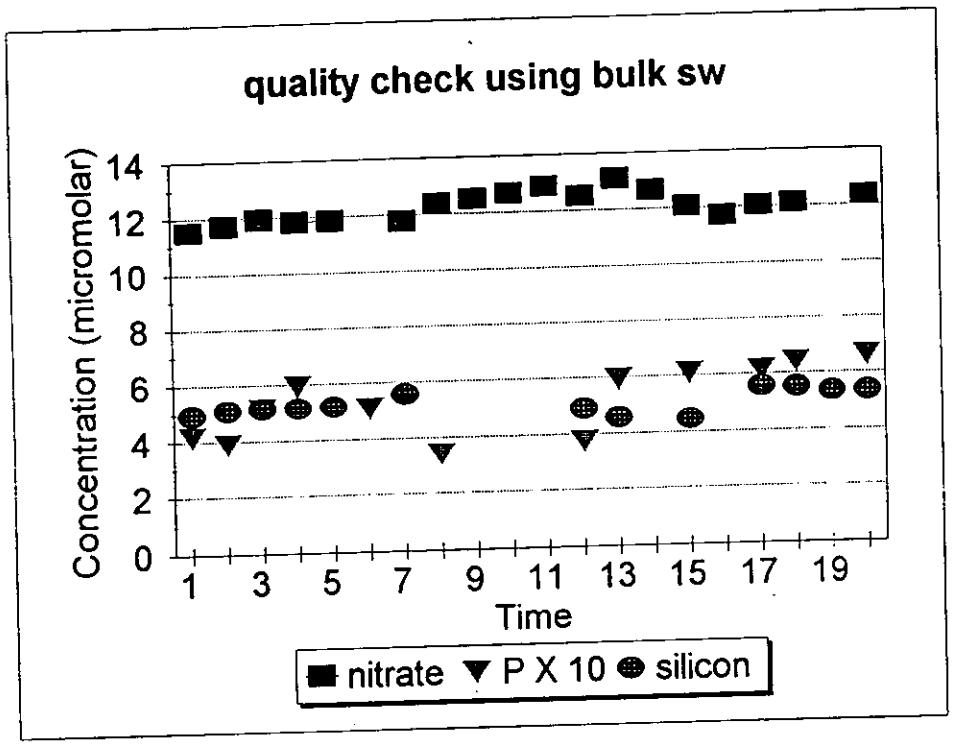
The aims of the exercise were achieved. Nutrients were analysed on board within hours of being sampled. All samples were stored at 4°C in the dark until they were tested. This form of storage and testing is probably the best way of achieving quality results. Results obtained showed expected trends i.e. values being relatively low in the surface and increasing with depth. An example of a typical profile can be seen for Station OM 12 in Figure 7. Both NO_3(N) and Si-Silicate showed a significant increase with depth, PO_4(P) showed a less significant increase with depth. An interesting feature of the profile is the impact of Mediterranean Outflow Water between approximately 900 m and 1200 m. Both NO_3(N) and Si-Silicate show a levelling off in concentrations in this depth interval. Warmer Mediterranean waters contain less nutrients than waters in the Celtic Sea.

Samples were collected for nutrient inter-calibration. These samples were poisoned with mercuric chloride for storage and will be analysed back in Galway. The results of this inter-calibration will be a good test on the nutrient analyser's accuracy which should increase confidence in all the data collected on this cruise.

Tom Treacy

Figure 6 Quality control data for the nutrient analysis work. a) repeated analysis of a bulk seawater over the period of the cruise b) repeated analysis of an IOS reference standard over the period of the cruise.

a)



b)

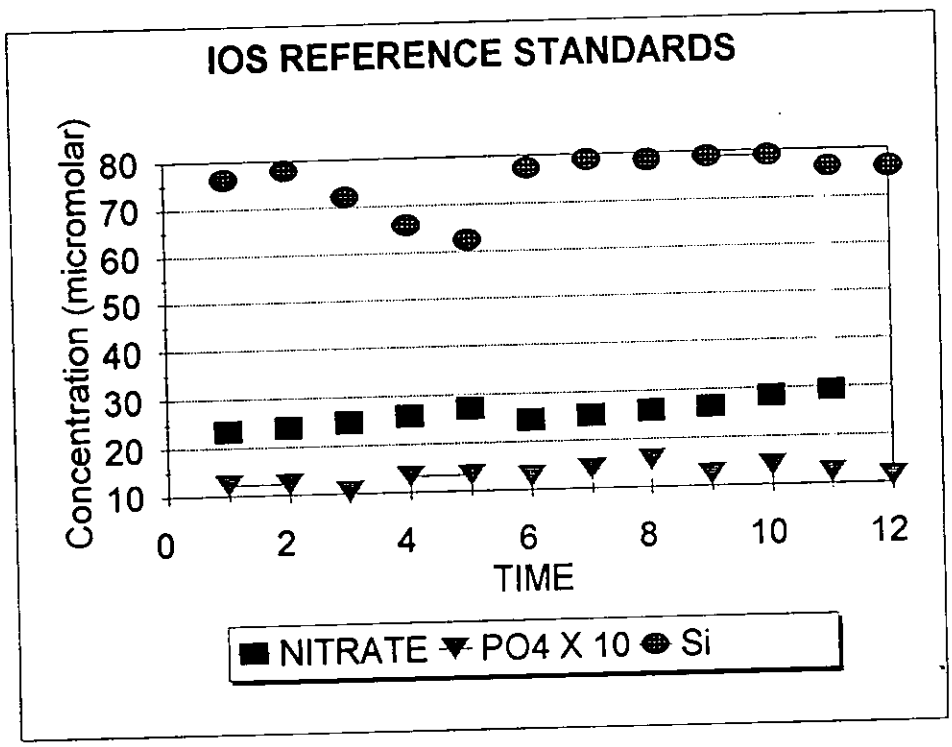
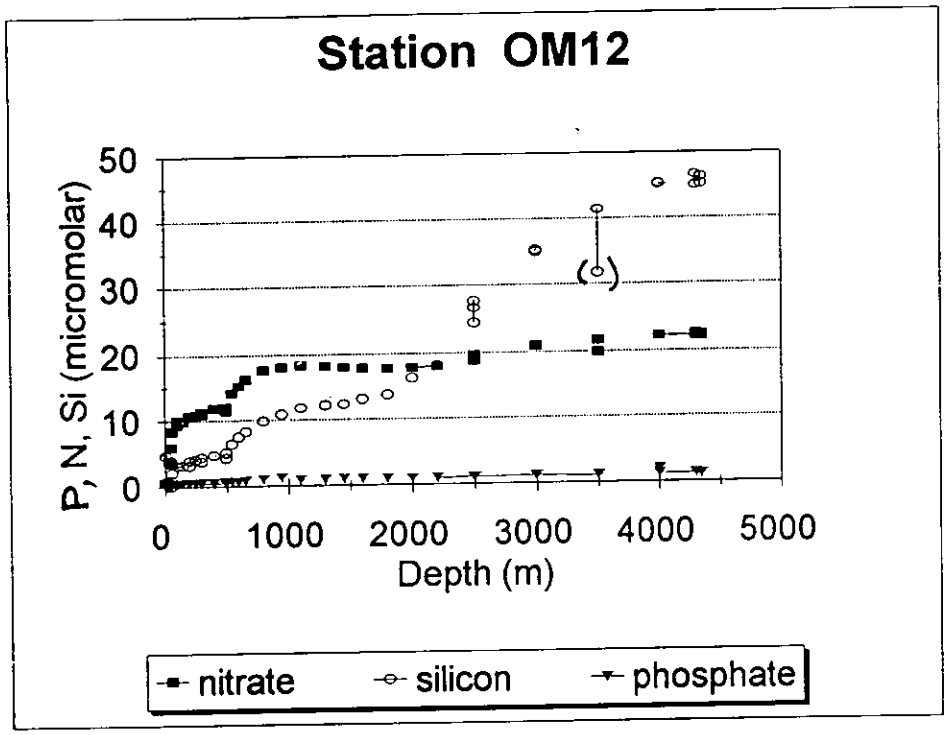


Figure 7 . Vertical profiles of dissolved nitrate plus nitrite, phosphate, and silicon at Station OM12



8. DISSOLVED ORGANIC CARBON & DISSOLVED ORGANIC NITROGEN ANALYSIS USING HIGH TEMPERATURE CATALYTIC OXIDATION

8.1. INTRODUCTION

Rapid and precise techniques are now available for the determination of dissolved organic carbon (DOC) and dissolved organic nitrogen (DON). Increasingly used for this purpose is high temperature catalytic oxidation (HTCO), results from which have profound implications for mass-balancing carbon and nitrogen budgets and material fluxes across estuarine and shelf interfaces and within oceanic systems. Ocean margins are key areas for investigating impacts of DOC on the carbon cycle, since both the export of terrestrial DOC and the import of oceanic DOC occur at this boundary. Preliminary studies in ocean margins indicate non-conservative removal of riverine and shelf produced DOC/DON, with minimal export to the ocean. However, such results cannot be generalised since neither the seasonal variability nor the effect of contrasting transitional zones have been systematically investigated. OMEX and LOIS (SES) studies in the Celtic Sea and Hebridean Shelf respectively will provide data covering contrasting seasons and geographical regions.

8.2. METHODOLOGY

HTCO techniques involve the direct injection of acidified and decarbonated sea water onto a platinised alumina catalyst, at high temperatures (680 - 900°C), under an atmosphere of oxygen or high purity air. Quantitative production of CO_2 gas allows DOC concentrations to be determined using a CO_2-specific infrared gas analyser (IRGA). Plymouth Marine Laboratory perform these measurements with a *Shimadzu TOC 5000* analyser. Incorporation of a *Licor 6252*, solid-state IRGA, and a PC-based integration system (ATi Unicam, *4880*) allows high precision measurements to be made against the noisy background of an ocean-going research platform.

Recent purchase of a nitrogen-specific chemiluminescence detector provides an opportunity for measurements of Total Dissolved Nitrogen (TDN) to be collected in the field. Combustion of nitrogenous compounds under an oxygen atmosphere at 680°C (in the *TOC 5000* furnace) leads to quantitative production of the nitric oxide radical. Subsequent reaction with ozone produces excited nitrogen dioxide species, which emit quantifiable light energy upon decay to their ground state. When finalised N-based nutrient data are available, the TDN concentrations can be corrected, giving a measure of DON, complementary to HTCO-DOC measurements.

8.3. OBJECTIVES

Determination of HTCO-DOC from transects across the Goban Spur and Hebridean Shelf.

Continued field testing of the Antek 705D Nitrogen-Specific Chemiluminescence Analyser; in order to quantify HTCO-DON concentrations in various aquatic environments.

Preservation of water samples, along the OMEX sediment trap transect (OM 5 - OM 8), for DON inter-comparison exercise using: Kjeldahl (Vigo), persulphate (Hamburg) and HTCO (PML) methods.

Preservation of water samples, from the Belgica reference station, for HTCO-DOC inter-comparison exercise with OMEX colleagues (Thomas Raabe, Hamburg).

Collection of data for comparison of HTCO-DOC with trace metal concentrations and their speciation (Jane San-Juan, IFREMER & Marie-Hélène Cotté, ENS).

8.4. SAMPLES COLLECTED

The following samples were collected

Station	CTD	Depth Range , m	Date
SES 700	6	2 - 737	04/06
SES 140	7	3 - 141	05/06
OM 5	9 , 10	10 - 182	07/06
OM 911	10 - 216	08/06	
OM 6	12 , 13	2 - 1160	08/06
OM 7	14 , 16 , 17	2 - 3631	09/06
OM 8	18 , 19 , 22 , 23	2 - 4493	10/06
OM 12	24 , 25 , 27 , 28	2 - 4347	11/06
OM 11	29 , 30 , 32	2 - 3585	12/06
OM 10	34 , 36	2 - 1489	13/06
OM 13	40 , 41 , 43 , 44	5 - 4295	15/06
BELGICA	47 , 48 , 50	2 - 1917	17/06

In addition to the CTD stations, samples were collected at 2-hourly intervals from the *Belgica* station, across the shelf, and through a partial axial transect of the Severn Estuary to Barry.

8.5. SUMMARY OF ACHIEVEMENTS

Problems with new CTD bottles limited collection of samples across the Hebridean shelf. However, sampling in the Celtic Sea region was wholly successful, providing two cross-shelf transects through the water column; and additional stations in the region of the OMEX reference station *Belgica*.

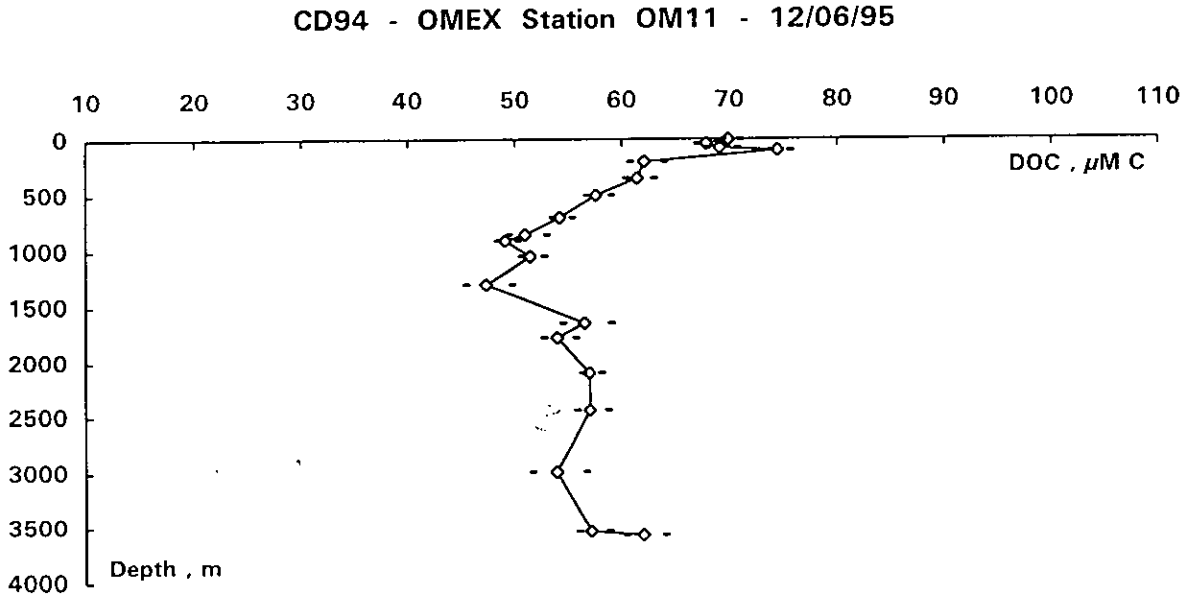
HTCO-DOC measurements were made on samples from the majority of casts. Preliminary DOC concentrations in surface waters consistently ranged from 70-80 μM C; generally falling to around 50 μM C in the deeper waters. Well defined vertical gradients through the upper 200m were observed at all off shelf stations. An example of a full water column profile is given in Figure 8.

Start-up and initial operation of the Antek 705D chemiluminescence detector went well. However, development of severe baseline spiking, and subsequent sample peak interference, prevented measurement of TDN for most profiles. Shipboard measurements were made for stations OM13 and *Belgica*. Aliquots of all other samples were archived for analysis back in the laboratory.

Water samples for preservation for a DON inter-comparison (PML & Vigo) were successfully collected along the OMEX sediment trap transect (OM 5 - OM 8).

Twelve samples, covering the whole water column at *Belgica* station were analysed onboard. Replicate aliquots were archived for re-analyses and inter-comparison with HTCO-DOC measurements to be made in Hamburg.

Figure 8. Dissolved organic carbon profile at Station OM11. Mean error, as covariance: 2.2%; range 1.1 - 4.2 %. Baseline noise to signal ratio, expressed relative to signal: <2.0%.



9. STUDIES ON SELECTED ORGANIC COMPOUNDS

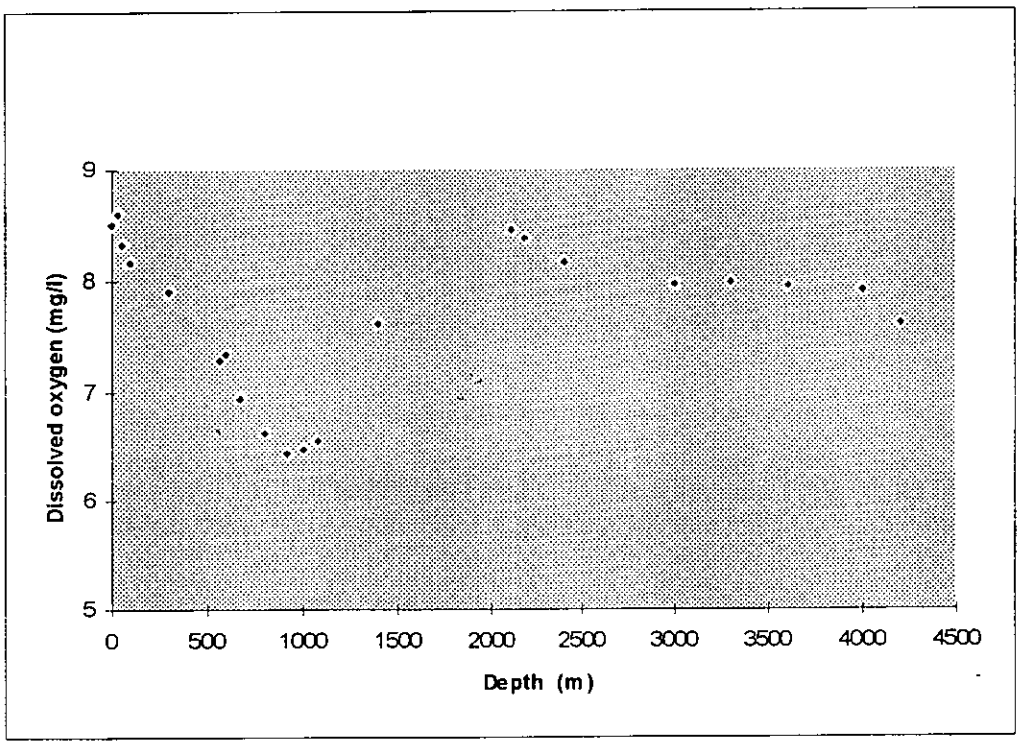
Samples were taken on the following stations: OMEX 5 - 13 and Belgica-station.
Altogether 148 samples were taken for measurement by different methods, for example the nutrients (nitrate, nitrite, ammonia, silicate and phosphate) by an auto-analyser Technicon, DON/DOP, CHN, particulate P, particulate carbohydrates, amino-acids and dissolved carbohydrates. The samples will be analysed as soon as possible in our lab in Hamburg.
Inter-calibrations were done with Tom Treacy (nutrients) at stations Omex 5,6,9 and Belgica. An additional inter-calibration was executed with Axel Miller for DOC (Thomas Raabe) at Belgica.

Ilse Buns and Petra Schumann

10. DISSOLVED OXYGEN

Samples were taken at all stations form conventional Niskin bottles for onboard oxygen analysis by the Winkler technique with electrochemical end-point detection. Samples were fixed immediately and analysed typically within a couple of hours. All data has been tabulated, and the oxygen concentrations were used to calibrate the oxygen sensor on the CTD. There were problems with direct comparison of Winkler and CTD data as the signals taken close to bottle firing times were corrupted. An example of an oxygen profile from towards the end of the cruise is shown below.

Figure 9. Profile of dissolved oxygen at Station OM13.



Oxygen concentrations typically fall in the range 4.49-6.41 ml/L (200-286 μmol/L). The oxygen minimum falls consistently at approximately 900 m at all sites that were profiled, which is approximately coincident with the presence of Mediterranean Outflow Water.

Ilse Buns and Petra Schumann

11. PLANT PIGMENTS AND MICRO ZOOPLANKTON

11.1. PLANT PIGMENTS

Samples collected in the upper 200m of the water column (Christina Hunt, University of Plymouth) were filtered and stored in liquid nitrogen. Additional samples were collected from the non-toxic supply, for calibration of shipboard fluorometers. Pigment analysis will be performed by high-performance liquid chromatography (HPLC) at the Plymouth Marine Laboratory (Ray Barlow and Denise Cummings).

11.2. MICROZOOPLANKTON

Samples collected in the upper 200m of the water column (Christina Hunt, University of Plymouth) were preserved with Lugols iodine. Microzooplankton analysis will be performed at the Plymouth Marine Laboratory (Elaine Edwards).

Number of samples taken from upper 200m, by station:

	Pigments	Micro-zoo.
OM 5	6	6
OM 6	5	5
OM 7	5	5
OM 8	4	4
OM 9	5	-
OM 10	5	-
OM 11	5	-
OM 12	5	-
KAC	4	-
OM 13	4	-
Belgica	6	6
OM 15	4	-
OM 16	5	-

A total of 17 pigment samples were collected for the calibration of the continuous flow fluorometer.

Axel Miller
Pepe Alvarez-Salgado

12. DISSOLVED TRACE METALS

12.1. TRACE METAL SAMPLING

Two improved sampling systems were available for use on CD94:

1) The new lever action Niskin (LAN) bottles, delivered immediately prior to departure from Fairlie, proved to have a considerably higher success rate than was the case for Go-Flo bottles (better than 90% as opposed to <50%). They were also considerably easier to deploy than their Go-Flo predecessors. Therfore sampling for most trace metals in the water column was done using these 10 litre lever action Niskin (LAN) bottles, which had been modified for trace metal work on the ship. The sampling rosette and CTD was also carefully cleaned, zinc sacrificial electrodes removed, and key exposed corrodible metal parts coated in parafilm, prior to the sampling. The choice of sampling depths was greatly facilitated by the use of an improved CTD data visualisation package developed by Simon Watts. This allowed high resolution monitoring of water column features in real time enabling effective sampling of fine structure features. All profiles were extended as close to the bottom as conditions permitted, normally within 10 meters.

All handling of sea water samples for metal work was done inside the clean laboratory set up in the constant temperature laboratory by Nick Morley. Samples were pressure filtered (circa 0.8 bar high purity nitrogen) through acid washed 0.4 μm Nuclepore membranes.

2) Surface seawater samples were also collected from a modified 3.5KHz fish which was towed from the starboard side of the ship. A tube made of low density polyethylene of 12 mm internal diameter, led from the fish to a pneumatically operated all PTFE bellows pump on deck. Fully wrapping the cable/tube assembly with PVC tape prior to deployment allowed continuous deployment at full passage speed without excessive noise. When the fish was recovered and redeployed, as part of mooring operations, inspection and minor repairs to the cable assembly were carried out. Water from the pump was filtered directly through an in-line 142mm Nuclepore filter held in a poly propylene housing, at a typical rate of about 1L per minute.

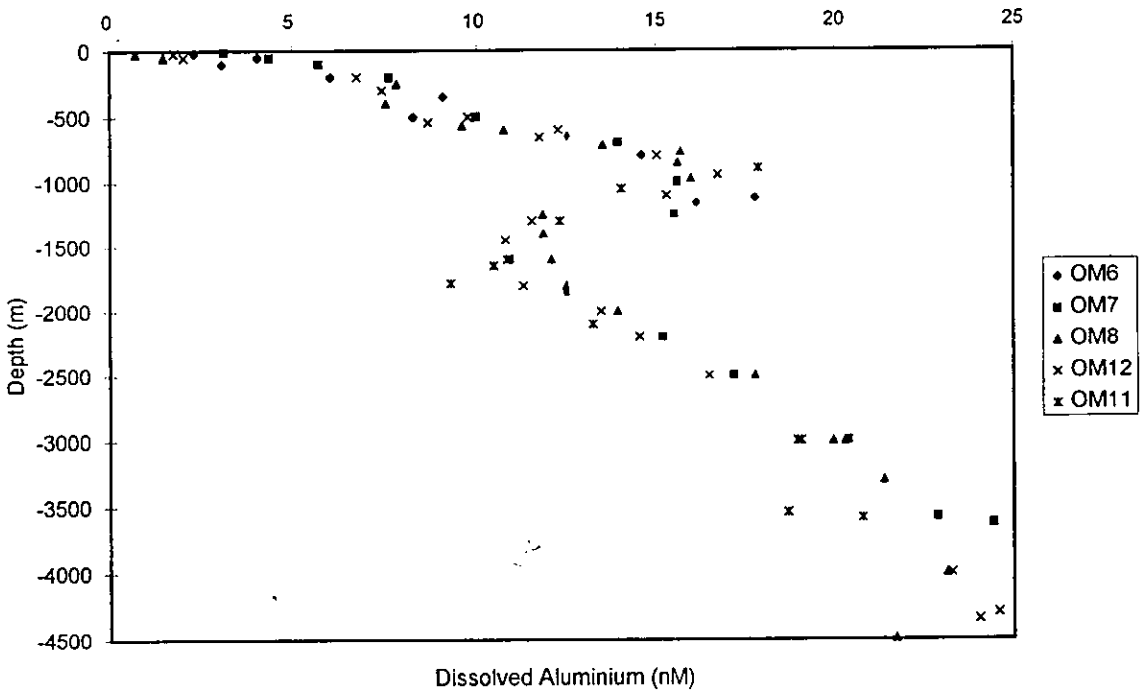
Details of the work of individual groups represented on the ship are given below.

12.2. DISSOLVED ALUMINIUM

Dissolved aluminium, and dissolved plus reactive particulate aluminium in unfiltered samples, were determined by the lumogallion technique onboard. Samples of seawater were collected by the underway clean pumped system (see below) and by lever action Niskin bottles. In general concentrations were in the same range as has been noted previously in this region. A strong aluminium signal was evident in the Mediterranean

outflow water, which was a clear feature in all CTD casts to greater than 1km (see Figure10). Some of the surface concentrations of dissolved aluminium observed are the lowest measured thus far in the North Atlantic.

Figure 10. Profiles of dissolved aluminium at the main OMEX stations; the aluminium rich Mediterranean Outflow Water is a clear feature at all stations.



David Hydes

12.3 DISSOLVED METAL SAMPLES FOR THE INSTITUT BIOGEOCHIMIE MARINE, AND IFREMER

12.3.1. Main Objectives

The main objectives of the CD 94 cruise, were to study the dissolved concentrations of trace metals (Cd, Cu, Ni, Fe, Pb and Zn) including mercury during a spring period, i.e. when usually high primary production s observed associated with the shelf break zone. This results will be compared with the previous work in the same area (CD 84) carried out in the winter period when productivity is low.

12.3.2. Sampling

The samples from vertical profiles have been taken with 10 litre Lever Action Niskin samplers, and surface samples (at a depth of approximately 5 m) were collected using a pneumatically operated teflon pump.

Table 1 Samples collected in the main study area (Goban Spur)

OM5	one profile surface	6 samples 1 sample
OM9	one profile	6 samples
OM6	one profile surface	12 samples 1 sample
OM7	one profile surface	18 samples 1 sample
OM8	one profile surface	23 samples 1 sample
OM12	one profile	24 samples
La Chapelle Bank		
BELGICA	one profile	18 samples
OM15 (Hg)	one profile	3 samples
The Hebridean Shelf zone (mercury only)		
CTD 7	one profile	12 samples

Some underway samples were taken between the Belgica station and Barry.

The samples were filtered on board through Nuclepore filters (0.4 μm pore size, 47mm diameter) directly from Niskins under nitrogen pressure, using an in line filter holder. Samples were then acidified.

Samples for later mercury analysis were filtered through glass fibre filters (GF/F, 0.7μm, 47mm diameter) using nitrogen purified with a golden trap.

12.3.3. Analysis

After an extraction of complexed metals into freon, and back extraction of the metals into dilute nitric acid, the trace elements will be analysed by graphite furnace atomic absorption spectrophotometry (GFAAS) at IBM Montrouge.

The analysis of mercury will be done on an auto analyser equipped with an atomic fluorescence detector (IFREMER Nantes).

Jane Sanjuan, LCCM, IFREMER, Nantes (France)
Marie-Hélène Cotté, IBM/ENS, Montrouge (France)

12.4. DISSOLVED METAL SAMPLES FOR SOUTHAMPTON UNIVERSITY

The Southampton work, in parallel with dissolved studies at IBM and particulate trace metal studies at ULB, has the objective of measuring distributions of trace metals across the shelf break, and to assess this data for i) use of metals as tracers of cross shelf water movement ii) in improving our understanding of the biogeochemical cycling and fate of trace metals in the shelf break zone. Samples collected are listed in Table 2.

Southampton samples have been acidified (1 ml of concentrated nitric acid per litre of seawater) to ensure no changes in concentration during transport and storage. The metals Cd, Co, Cu, Mn, Ni, Pb and Zn will be determined in the shore laboratory by graphite furnace atomic absorption spectrometry (GFAAS) after pre-concentration and separation from the salt matrix by chelation and solvent extraction procedures, using the specialised facilities, including a dedicated clean laboratory, at Southampton.

Nick Morley
Peter Statham

Table 2. Samples taken for later analysis of dissolved trace metals at Southampton:

LOIS Site
Teething problems with the LANs limited water column trace metal sampling to one full profile (CTD 7), with 11 samples successfully filtered.

OMEX Site

SITE	CASTS	DEPTH	SAMPLES	COMMENTS
OM 5	2	186	6	2 LANs misfired on first cast
OM 9	1	221	5	Sample lost on filtration
OM 6	2	1181	12	
OM 7	3	3640	18	SAPs deployed
OM 8	4	4500	23	Sample lost
OM 12	4	4355	24	
OM 11	3	3595	18	
CTD 33	1	1415	4	SAPs depths only
OM 10	2	1500	12	
KAC	2	3320	12	Limited coverage
OM 13	4	4300	24	
CTD 45	1	180	4	
OM 14	3	1925	18	BELGICA site, SAPs
OM 15	1	140	3	SAPs
OM 16	1	166	5	

13. STUDIES ON PARTICULATE TRACE METALS

There exist very few data on the trace metal composition of particulate material in the oceanic water column. The objective of this study is to investigate the vertical and horizontal distribution of the trace metal content of suspended matter in the OMEX study area.

13.1. WATER COLUMN PUMPED SAMPLES

Particulate matter was collected by in-situ filtration of large volumes of seawater at various depths using the Stand Alone Pumps (SAPs) where a polypropylene filter holder is housed directly on top of the pump. Nuclepore filters of 293 mm diameter and 0.4 μm porosity were used. Filter volumes varied from between ~50 and 300 litres of seawater. No more than four SAPs where deployed during a single cast. To allow the calculation of metal distribution coefficients sample depths were chosen to coincide with dissolved trace metal sampling. At the sediment trap station OMEX II samples were taken at trap depths allowing a comparison of the suspended particles with those recovered from the traps. Wire time for the deeper traps (>1000m) was considerable due to the slowness of the SAPs winch (<~20 m/min).

Details of SAP stations are given in Table 3.

Table 3. SAP sampling station data.

OPERATION NO.	DATE	SAMPLING STATION	SAMPLING DEPTH (M)
SAP1	9/6/95	OM7	40 75 100
SAP2	9/6/95	OM7	850 1250 1600
SAP3	10/6/95	OM7	200 350 560
SAP4	13/6/95	SED TRAP II	300 595 800 1052
SAP5		BELGICA	1600
SAP4	15/6/95	BELGICA	1300 1000 800
SAP5	17/6/95	BELGICA	400 150 100 20
SAP6	17/6/95	BELGICA- OM14	65 20

Filters were rinsed thoroughly to remove sea salt and will be kept frozen until analysis. Suspended material will be detached from the filter ultrasonically. Solid materials will be dried. Particulate Mn, Zn, Fe, Cd, Co, Ni and Pb will be analysed by direct injection of solid samples suspended in an acidic medium using graphite furnace electrothermal atomic absorption spectrometry with Zeeman correction. Particulate aluminium will be determined as an indicator of terrestrial particles and used for normalisation.

Ian Hall
Sarah Brown

13.2. SAMPLES OF PARTICLES COLLECTED BY SURFACE PUMPING

Samples for both dissolved and particulate trace metals were taken from the clean pumped system throughout the cruise. Volumes filtered varied from < 5 to 45 litres (dependent on filter clogging). This system was also used to provide near surface samples at sites listed above. A series of small volume unfiltered samples on the track across the shelf back to Barry were also taken for dissolved Mn analysis.

14. RADIO-NUCLIDE SAMPLING

As part of a larger programme which is studying the dispersion of man-made radio-nuclides in shelf and nearshore waters, the opportunity provided by CD94 was taken to collect samples from the western edge of the North West European Shelf. The programme is co-ordinated through Dr Pierre Guegueniat at the Laboratoire Radioecologie in Cherbourg.

Samples for the later radiometric determination of Cs-137 and Sb-125 were collected at the locations given in the following table:

Table 4. Stations at which samples for radiochemical analysis were collected.

SAMPLE NUMBER	LATITUDE N	LONGITUDE W
PG1	56 33.67	09 48.03
PG2	51 44.66	12 30.45
PG3	49 47.53	11 53.76
PG4	48 49.92	13 40.27
PG5	47 28.55	09 34.32
PG6	50 11.03	06 38.06

Because of difficulties in getting the necessary chemicals delivered to the vessel, samples were collected in their 100L plastic tubs, and the co-precipitation was done at

Barry where chemicals had been delivered at the end of the cruise. The precipitates with co-precipitated radio-nuclides will be sent to Cherbourg for the determination of the Cs and Sb nuclides.

15. ATMOSPHERIC SAMPLING

The western English Channel has been defined as an area receiving an unknown atmospheric flux of trace metals (Al, Fe, Zn, Mn, Cu, Ni, Pb, Cd and Co). A site on the south Devon coast was established for the collection of atmospheric particulate and rain water samples, in an attempt to redress this balance. A land based site was chosen as it was easily accessible and manned throughout the year. It was also situated in a position, where the prevailing south westerly wind passed over only a small section of land prior to sampling. Current atmospheric particulate data suggest that the site is ideal for marine atmospheric trace metal sampling (Table 5).

Table 5. Atmospheric particulate data obtained from samples collected in October/November 1994 at Slapton, south Devon.

Element	Al	Fe	Zn	Mn	Cu	Ni	Pb	Cd	Co
Geometric mean ng m^{-3}	239	189	35.0	8.30	2.70	1.86	1.48	0.79	0.20
Enrichment factor (average)	1	1.60	257	4.57	24.2	17.9	111	3610	3.40

However, the general consensus of opinion is that marine aerosols should be sampled at sea. Therefore, the aims of this study were to:

- assess the trace metal flux to the shelf boundary region of the Celtic Sea
- assess the trace metal content of pristine marine end-member aerosols
- compare land and sea based sampling, and
- assess the possible contamination caused by the passage of the wind over land prior to sampling.

Atmospheric particulate samples were collected using an in-house built filter holder, connected via a length of flexi-hosing to a Secomak high volume pump. The filter heads were loaded with acid washed Whatman 41 filter papers, and suspended at the bow during periods of dry weather, for an accumulated 15-20 hours (approx.). Samples were collected over a number of consecutive days, provided the wind direction was from the

same direction (Table 6). Further sample resolution was not considered to be beneficial due to the expected low concentrations of trace metals in the sample. The sampling equipment was covered during wet periods, and also whilst stationary, to limit possible contamination from the stack. A 'potentially polluted' sample was collected during a period of stationary activity to assess this.

Table 6. data referring to samples collected during June 1995, OMEX, Celtic Sea (CD 94).

Sample	Position		Wind direction	Exposure		Volume of rain water
	Latitude (N)	Longitude (W)		Particulate	Rain	
1	55 17.00 to 56 31.88	05 30.00 to 9 33.34	NW to SW	4.5 hours	Carried over	Carried over
2	56 27.17 to 51 10.23	8 57.19 to 12 30.02	W to NW	15 hours	17 hours	60ml (approx.)
3	49 57.35 to 49 30.36	12 23.78 to 13 28.55	N	10.5 hours	-	-
4*	48 34.87 to 48 54.05	13 20.09 to 11 49.66	N	54 hours	-	-
5	48 54.05 to 47 28.77	11 49.66 to 9 36.55	NE	29 hours	-	-
6	47 30.17 to 47 4.94	9 33.99 to 7 10.10	N to NW	16.5 hours	-	-
7	47 24.92 to 48 39.63	7 16.00 to 9 16.97	W to SW	-	14 hours	60ml (approx.)
8	48 49.92 to 49 15.13	7 0.96 to 8 30.25	W	6 hours	-	-
9	49 16.54 to 49 47.87	8 15.96 to 6 39.48	W	-	12 hours	25ml

* 'potentially polluted' sample.

Rain water samples were collected using a system comprising an acid washed funnel - filtration unit - bottle (containing 1ml 1:1 Aristar (BDH) HCl:Milli-Q water), whereby particulates were collected on acid washed cellulose acetate membrane filters by gravity filtration. The system, which was situated on the starboard railings of the bridge, was exposed during periods of wet weather, mostly drizzle, and covered with a large plastic bag during dry weather, again to minimise possible contamination from material from the stack.

All samples were stored frozen to await treatment. At Plymouth, atmospheric and rain water particulate samples will undergo a hot HNO_3/HF digest, with subsequent analysis by either FAAS/GFAAS or ICP-MS depending on the trace metal concentration. Rain

water samples will be analysed by either adsorptive cathodic stripping voltammetry (ACSV) or ICP-MS, again depending on the trace metal concentration. Geometric means, enrichment factors and tentative fluxes will then be calculated. Weather information, obtained from the ship during the cruise, will be used to plot back trajectories for the air masses sampled.

Christina Hunt

16. PLANKTON SAMPLING

16.1. HAMBURG UNIVERSITY

At several stations, a hand towed small plankton net was deployed. The samples were examined on board ship and sub-samples were preserved for later examination in Hamburg, in order to give a qualitative assessment of major species present in the upper water column.

16.2. CAMBRIDGE UNIVERSITY

Plankton was collected by two methods. The first was by tows with a 200m plankton net at a depth of approximately 50m. Tows lasted for 10 minutes after the net had been let out to the full extent of the 90m Kevlar line. Four tows were done and water samples (250ml) from a depth of 50m were collected and acidified from the nearest CTD cast. The temperature and salinity profiles of the top 100m of these casts were noted. Plankton was also collected over several hours from the ship's non-toxic supply. This was generally done whilst on station. At the same time the temperature and salinity of the water was noted and a water sample (250ml) was collected and acidified for future analysis. All plankton samples were frozen in plastic pots.

Plankton was collected to investigate the dependence of the Sr/Ca and Mg/Ca ratios of the calcite tests of planktonic foraminifera on temperature and salinity. For this the Sr/Ca and Mg/Ca ratios of the habitat water must also be known because the ratios in the calcite are also dependent on the ratios in the water from which it precipitates.

A comparison will also be made between the Sr/Ca and Mg/Ca ratios in the planktonic foraminifera collected from the surface and those from the box core tops, to identify any changes in chemical composition after death and deposition.

Plankton collection data are given in Tables 7 and 8.

Table 7. Data on collection of plankton using the non-toxic water supply

NON-TOXIC SAMPLE	DATE	START TIME	START POSITION	END TIME	END POSITION
NTP1	4/6/95	0200	56 27.76'N 8 57.05'W	1035	56 31.23'n 9 46.56'W
NTP2	7/6/95	0420	49 59.99'N 12 30.98'W	1000	49 59.93'N 12 31.19'W
NTP3	9/6/95	0720	49 00.26'N 13 12.08'W	2210	49 02.18'N 13 12.34'W
NTP4	11/6/95	1013	48 34.98'N 13 19.84'W	1630	48 35.29'N 13 20.12'W
NTP5	15/6/95	1158	47 29.03'N 9 34.95'W	1846	47 28.97'N 9 35.46'W
NTP6	16/6/95	1059	47 04.13'N 709.07'W	1545	47 24.79'N 7 16.01'W
NTP7	16/6/95	1550	47 24.74'N 7 16.11'W	0634	47 24.62'N 7 16.40'W

Table 8. Data on collection of plankton using the towed net.

Tow Sample	Date	Start Time	Start Position	End Time	End Position
PT1	4/6/95	2314	56 27.42'N 9 12.09'W	2340	56 27.14'N 9 12.99'W
PT2	7/6/95	0940	49 59.82'N 12 31.31'W	1001	50 00.33'N 12 31.56'W
PT3	11/6/95	1605	48 35.00'N 13 20.20'W	1628	48 35.28'N 13 20.20'W
PT4	15/6/95	1424	47 29.12'N 9 34.78'W	1446	47 29.62'N 9 34.74'W

17. CORING OPERATIONS

17.1. 3.5khz BOTTOM RECORD

The 3.5 kHz profiler was run continuously from the Northern SES station to la Chapelle bank at 47 N. Penetration was mainly from 20 to 40m but occasionally >50 m.

At a number of the deeper stations the record showed the presence of a developed reflector in the region of 10 and 30 m below the seabed.

As noted during cruise CD88, the 3.5 kHz record was degraded substantially by noise when the ship was running at speeds above about 8 knots, however, the attachment of the clean trace metal sampling system to the 3.5 kHz fish had little if any effect.

3.5 kHz records are held at the Department of Earth Sciences, Cambridge.

17.2. KASTEN CORING

It was intended that 7m long kasten cores would be collected from both the Goban Spur and Porcupine Seabight, however the lack of a core bucket being supplied by RVS (an essential piece of equipment for the safe handling of the core bomb) made this an impossible task. We therefore decided to use only the single 4m barrel. An early attempt to collect a core on the Hebridean Slope was thwarted after we ran over 8 PM (by half an hour), the deadline for crew on deck. However our fortunes changed and we managed to collect two cores; first from the Porcupine Seabight and second from the Goban Spur.

Results from the present OMEX study reveal that the outer margin of the Goban Spur shows apparently little difference in the accumulation rates and proportions of sediment components (carbonate and organic carbon) with the open ocean (20W) situation at the same latitude, not influenced by shelf edge and slope processes. Given the dominance of the poleward flow of deep water in the region, we need to establish whether the Porcupine SeaBight (PSB) is the depositional sink for the across and along slope transport of fine grained sediment and organic carbon in suspension over the Celtic Sea shelf edge and slope. This work will be carried out by investigation of OM-4K. The core OM-5K was taken to fill in a depth gap in our kasten core transect taken during CD-84.

Sub sampling of the kasten cores was as follows:

1. Outer few mm cleaned off, styrene trays (330 x 15 x 25 mm) pressed into core barrel long length
2. Core extruded sideways, mud slabs removed in trays by cheese wire. Trays cleaned, labelled as the archive set and heat sealed in polythene.

3. A second set of cores taken in the same manner. To ensure good results from x-radiography these set were carefully levelled off to equal thickness across the slab.
4. Core surface levelled off and core description made.
5. Samples taken for water content determination at 4 cm intervals, using cut-off syringes.
6. Third set of slabs taken as before to act as initial "working set".

Kasten core sampling data is given in Table 9.

Table 9. Data on Kasten core sampling.

CORE	LAT (N)	LONG (W)	DEPTH (M)	WIRE OUT	TIME/ DATE	LENGTH (M)
OMEX 4K	49 59.82'	12 31.06'	2280	2292 5	11.44 7/6/95	371+ 0.19CC
OMEX 5K	48 50.07'	12 39.95'	2333	2240	18.36 12/6/95	+ 0.19CC

OMEX 4K recovered a sloppy foram ooze, similar to that seen in the box core taken at the same site, suggesting very little if any loss of the surface. The upper 52 cm of the core is foram and nano ooze underlain by olive grey muds. Glacial dropstones appear at around 100 cm. No obvious turbidites are present.

OMEX 5K. Comparison of the box core and surface of the kasten suggests that the surface layer remained largely intact. The upper material is sloppy foram ooze which is replaced below 46 cm by grey mud with dropstones below 141 cm. No obvious turbidites are present.

Figure 11 shows bulk magnetic susceptibility with depth for the two cores.

Analyses will be made of water content, magnetic susceptibility, carbonate, organic carbon, terrigenous material content, grain size, delta ^{18}O and delta ^{13}C on pelagic and (if sufficient) benthic foraminifera.

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17.3. BOX CORING

We collected a total of 11 box cores with a 0.25 m^2 Sandia Mark II box corer. Entry speed was varied between 20 and 30 m/min depending on the 3.5 kHz record for the

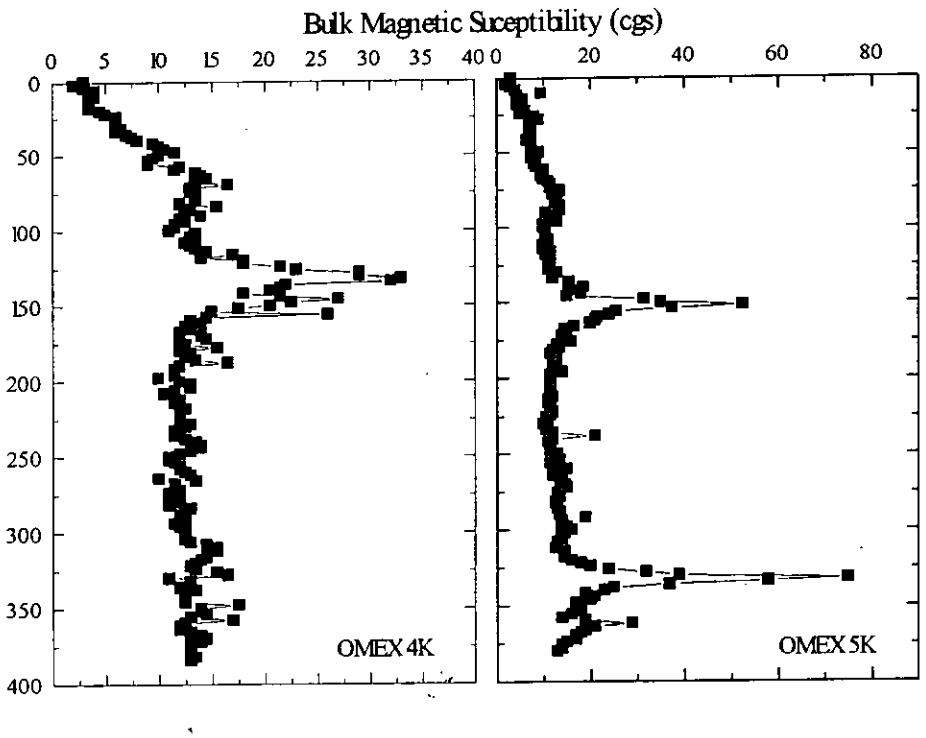
area. No problems were experienced with the box corer operation and our 100% success rate was largely due to the weather and competence of the RVS technicians and crew. The standard sub-sampling was: two 10 cm diameter drainpipes, two surface (~0.5 cm) scrapes for recently living planktonic and benthic foraminifera and the remainder of the surface 0-5 cm removed and stored in two large plastic bags. The drainpipes were sealed and stored at 2°C. Analyses will be made of total, organic, and carbonate carbon content. The use of short lived radioisotopes (^{210}Pb and ^{137}Cs) will also be used to determine biological mixing depths and rates over the OMEX region. Some animals found in various cores were preserved and a third sub-core was taken from OMB12 for organic geochemical analysis.

Table 10. Data on box core sampling.

CORE	LAT N	LONG W	DEPTH (m)	WIRE OUT (m)	TIME-DATE	LENGTH OF CORE (m)
OMEX 6B	56 34.311'	09 49.191'	1683	1693	13.46 4/6/95	0.32m
OMEX 7B	51 44.83'	12 30.27'	1223	1235	14.301 6/6/95	0.38m
OMEX 8B	51 10.15'	12 30.09'	1823	1832	20.15 6/6/95	0.36m
OMEX 9B	49 59.59'	12 31.14'	2284	2296	05.25 7/6/95	0.45 m
OMEX 10B	49 29.99'	11 0.07'	200	210	20.20 7/6/95	0.22m
OMEX 11B	49 30.25'	13 26.29'	2045m	2058	21.55 8/6/95	0.45 m
OMEX 12B	48 59.91'	13 12.72'	3649	3655	02.04 10/6/95	0.30-0.35 m
OMEX 13B	48 49.81'	13 39.47'	4485	4492	23.45 10/6/95	0.45 m
OMEX 14B	48 35.28'	13 20.37'	4335	4342	18.37 11/6/95	0.30-0.35 m
OMEX 15B	48 40.54'	12 54.84'	3580	3580	06.41 12/6/95	0.45 m
OMEX 16B	48 50.05'	12 39.90'	2338	2346	16.15 12/6/95	0.30 m
OMEX 17B	48 54.99'	11 50.08'	1484	1496	15.38 13/6/95	0.38 m

The bulk magnetic susceptibility characteristics of Kasten cores OMEX 4K and 5K are shown in Figure 11 below.

Figure 11. Bulk Magnetic Susceptibility for cores OMEX 4K and 5K.



18. SUSPENDED SEDIMENTS

Water samples were collected to determine the concentration of suspended particulate material gravimetrically, and to examine the composition of suspended particles using scanning electron microscopy. Sampling was carried out in layers of high optical turbidity and intervening clear waters at a total of 22 depths from 9 CTD stations.

Samples were collected using 10 L conventional Niskin bottles mounted on the CTD rosette. The suspended particles in samples were collected by filtration, under clean conditions, through individual pre-weighed (to 10^{-6}g) 0.4 μm, polycarbonate (Cyclopore) membranes. The membranes were rinsed with 5x25 ml sub-boiling distilled water to remove sea salt, air dried and stored in sealed polystyrene petri dishes awaiting laboratory analysis. All critical handling steps were performed within a Class-100 laminar flow hood.

Table 11. Samples collected for suspended particulate matter studies.

CTD CAST	STATION	FILTER NUMBER	DEPTH (m)	VOLUME FILTERED (l)
12	OM18	45	1161	10.6
12	OM18	46	651	10.5
14	OM7	47	1847	10.48
16	OM7	48	500	10.45
18	OM8	49	4491	9.95
19	OM8	50	2500	10.6
24	OM12	51	4347	9.95
25	OM12	52	2500	10.46
27	OM12	53	500	10.45
~~28~~ 29?	OM12	54	3585	10.65
30	OM11	55	1650	10.6
34	OM10	56	1489	10.5
34	OM10	57	1250	10.5
36	OM10	58	500	10.6
37	KA Canyon	59	3313	10.55
37	KA Canyon	60	800	10.55
40	OM13	61	4295	10.45
41	OM13	62	500	10.65
44	OM13	64	2600	10.4
48	Belgica	65	1916	10.6
50	Belgica	66	951	10.55
Surface		67	5	1

These loaded membranes will be weighed and examined by scanning electron microscopy for particle types at Cambridge. The analytical blank will be estimated from a total of 15 membranes subjected to an identical handling protocol but with no sample filtration. Sampling data for Niskin CTD casts for suspended particulate material are given in Table 11.

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19. MOORING OPERATIONS

Additional work relevant to the OMEX project included a variety of mooring operations. The S700 toroid mooring in the LOIS Shelf Edge Study (which is complementary to the OMEX study) area on the Hebridean Shelf was recovered, the instruments removed, and the un-instrumented mooring redeployed. The instruments with their associated data were returned via RVS to the DML laboratory.

The passage leg along the shelf break allowed the opportunity to interrogate and try and recover a series of three moorings deployed off Ireland by OMEX colleagues from UCG. All three were contacted and attempts were made to release the first two. Unfortunately, in both cases no equipment reached the surface, and it seemed that the most likely scenario was that buoyancy had been lost due to fishing or related activity, and the remaining instrumentation was not positively buoyant. In the case of the third mooring, interrogation indicated that the sea floor release unit was present but no attempt was made to recover the unit as it was passed by at night. Information on the status of the investigated moorings was passed on to colleagues in Galway.

OMEX current meter mooring 154 which was originally deployed on cruise CD84 was successfully recovered in circa 1500m of water. The data was down loaded and passed to Dr Robin Pingree at the PML after the cruise. OMEX current meter mooring 150 in circa 148 m of water, which had been previously destroyed by fishing activity in the area, was replaced later in the cruise.

20. STANDARD SEAWATER COLLECTION

A collection of circa 2000 litres of seawater was made for the Standard Seawater Service, using the shipboard fire-fighting pump system. The collection took place at circa 48° 34.98 N 13° 19.84 W. Approximate salinity and temperature values were 35.583 and 14.2° C respectively.

21. THE OMEX DATABASE

All key data from the OMEX project, including data from this cruise, will be archived with the British Oceanographic Data Centre (BODC, Birkenhead Observatory, Birkenhead, Merseyside, L43 7RA United Kingdom), after careful calibration and data checking. Data from underway and CTD measurements will be banked very rapidly, whilst data which is generated after work in the shore laboratory, or extensive calibration, will be added at a later stage. Access to data may be restricted for a specified period of time. Queries about the data base and access to it should be directed to Dr Roy Lowry at the BODC.

APPENDIX 1 Station locations and operations carried out. (All times in GMT). Both conventional (C) and lever action (LAN) Niskin bottles were used for CTD sampling.

Date/time	Lat. N Long. W (degrees and minutes)	Activities
3 June 1995 0726		depart Fairlie, Western Scotland
4 June 0737	56 27.60 09 39.11	CTD 1 Deployed to 54 m. at Station S1500. New ;ever Niskin bottles did not close
0825	56 27.63 09 39.02	CTD 2; Deployed to 25 m. at Station S1500. Only limited success with new lever action Niskin bottles; bottles and rosette motor modified / changed by RVS technicians
1059	56 33.23 09 47.89	CTD 3: IOSDL CTD system deployed to 500 m with optical nitrate sensor and 2.5L conventional Niskins
1325	56 33.92 09 48.48	Box Corer OM6B; water depth 1683 m.
1525	56 35.20 09 50.11	CTD 4: 25m test of LANs; bottles fired correctly
1835	56 26.72 09 10.77	LOIS Shelf Edge Study (SES) toroidal mooring S700 recovered; instruments removed
2002	56 27.20 09 09.43	LOIS Shelf Edge Study toroidal mooring S700 redeployed
2100	56 27.15 09 09.97	CTD 5: 25m test of LANs: all bottles except on fired OK
2135	56 27.29 09 10.14	CTD 6: to 737m at SES site S700; only one bottle closed. Further modifications to bottles.
2314	56 27.42 09 12.09	Plankton net at S700

Date/time	Lat. N Long. W (degrees and minutes)	Activities
June 5 0218	56 27.07 08 57.20	CTD 7: to 141m at SES station S140
1234	55 02.50 10 12.10	University College Galway mooring B
1851	54 33.40 10 57 32	University College Galway mooring A
June 6 0217	54 04.90 11 55.40	University College Galway mooring C
1445	51 44.93 12 30.07	Box core OM7B
1924	51 10.14 12 29.95	Box core OM8B
June 7 0423	49 59.95 12 30.98	Box core OM9B
1920	49 30.00 11 00.00	CTD 8: IOSDL CTD deployed to 500 m; OM5
2005	49 29.98 11 00.07	Box core OM10B
2127	49 29.97 11 00.10	CTD 10: to 21m ; no samples taken
June 8 0035	49 05.02 11 05.14	CTD 11: to 217 m at Station OM9
0827	49 06.60 12 10.60	OMEX 154 current meter array recovered
1154	49 13.02 12 35.53	CTD 12: to 1161 m at Station OM6

Date/time	Lat. N Long. W (degrees and minutes)	Activities
1442	49 12.93 12 35.91	CTD 13: to 500 m at Station OM6
2041	49 30.13 13 25.25	Box core OM11B
June 9 0314	48 59.94 13 12.12	CTD 14: to 3631 m at Station OM7
0651	48 59.96 13 11.89	CTD 15: to 500 m at Station OM7
0854	49 00.10 13 12.01	Stand Alone Pump System (SAPs) to 100 m at OM7
1135	49 01.08 13 12.06	small surface plankton net tow
1220	49 00 13 12	CTD 16: to 1600 m at Station OM7
1454	48 58.30 13 12.53	SAPs to 1543 m at Station OM7
2238	49 00.02 13 11.95	CTD 17: to 600 m at Station OM7
June 10 0022	48 59.87 13 12.17	Box core OM12B
0518	48 59.90 13 12.23	SAPs deployed to 562 m
1101	48 50 01 13 39.93	CTD 18: to 4497 m at Station OM8
1523	48 49.90 13 40.06	CTD 19: to 3000 m at Station OM8
1813	48 50.09 13 40.01	CTD 20: IOSDL CTD to 500 m at Station OM8
1904	48 50.07 13 39.93	CTD 21: to 500 m at Station OM8

Date/time	Lat. N Long. W (degrees and minutes)	Activities
2015	48 50.06 13 40.00	CTD 22: to 600 m at Station OM8
2145	48 50.00 13 39.99	Box core OM13B in 2145 m bottom depth
June 11 0224	48 49.95 13 39.99	CTD 23: to 1249 m at Station OM8
0545	48 34.94 13 20.21	CTD 24: to 4347 m at Station OM12
1006	48 35.02 13 19.89	CTD 25: to 2500 m at Station OM12
1010	48 34.98 13 19.84	Collection of Standard Seawater (2 x 1000 L)
1335	48 34.96 13 20.20	CTD 26: IOSDL CTD to 500 m at Station OM12
1510	48 34.95 13 19.97	CTD 27: to 500 m at Station OM12
1605	48 35.00 13 20.20	Plankton net deployed
1648	48 35.05 13 19.85	Box core OM14B in 4335 m water depth
2120	48 34.99 13 19.92	CTD 28: to 1100 m at Station OM12
June 12 0106	48 40.00 12 55.15	CTD 29: to 3585 m at Station OM11
0500	48 40.09 12 54.78	Box core OM15B in 3580 m
0852	48 40.10 12 54.85	CTD 30: to 2000 m at Station OM11
1054	48 40.02 12 54.97	CTD 31: IOSDL CTD to 500 m at Station OM11

Date/time	Lat. N Long. W (degrees and minutes)	Activities
1120	48 40.06 12 54.81	small plankton net
1158	48 40.07 12 55.00	CTD 32: to 500 m at Station OM11
1444	48 50.04 12 39.91	Box core OM16B in 2338 m water depth
1732	48 50.10 12 39.82	Kasten core OM5K in 2333 m water depth
2300	49 12.20 12 49.19	CTD 33: CTD to 1415 m
June 13 0104	49 12.31 12 52.12	SAPs deployed to 1050 m at OMEX sediment trap site 2
1214	48 55.03 11 50.11	CTD 34: to 1489 m at Station OM10
1454	48 54.97 11 50.15	Box core OM17B in 1484 m water depth
1653	48 55.02 11 49.89	CTD 35: IOSDL CTD to 200 m at Station OM10
1805	48 55.06 11 50.10	CTD 36: to 650 m at Station OM10
2253	48 19.97 11 20.10	CTD 37: to 3313 m at Station King Arthur's Canyon (KAC)
June 14 0228	48 20.06 11 20.11	CTD 38: to 800 m at Station KAC
0852	49 09.04 10 30.81	Deployment of current meter mooring 150 in circa 146 m of water
June 15 0112	48 00.96 10 27.06	CTD 39: to 2500 m . Physical data only collected from CTD system

Date/time	Lat. N Long. W (degrees and minutes)	Activities
0725	47 28.99 09 35.11	CTD 40: to 4295 m at Station OM13
1205	47 28.94 09 34.98	CTD 41: to 500 m at Station OM13
1329	47 29.03 09 34.93	CTD 42: IOSDL CTD to 200 m at Station OM13
1424	47 29.12 09 34.78	Plankton net deployed
1515	47 28.95 09 34.96	CTD 43: to 3200 m at Station OM13
1812	47 29.02 09 35.20	CTD 44: to 1200 m at Station OM13
June 16 0235	48 20.03 08 15.09	CTD 45: to 172 m
1112	47 05.00 07 10.01	CTD 46: to 10 m
1516	47 24.87 07 15.97	CTD 47: to 500 m at BELGICA (OM14)
1655	47 23.86 07 13.63	SAPs to 1598 m
June 17 0036	47 24.90 07 15.95	CTD 48: to 1916 m at BELGICA (OM14)
0245	47 24.95 07 15.92	CTD 49: IOSDL CTD to 200 m at BELGICA (OM14)
0408	47 24.74 07 16.09	CTD 50: to 1000 m at BELGICA (OM14)
0535	47 24.91 07 15.98	SAPs deployment to 400 m at BELGICA
1607	48 14.85 06 19.92	SAPs deployed to 100 m at Station OM15, CTD51

Date/time	Lat. N Long. W (degrees and minutes)	Activities
June 18 0736	48 40.21 09 19.72	CTD 52: to 131 m at Station OM16 End-member shelf station; Zig-zag underway sampling across shelf
June 19		Zig-zag underway sampling across shelf
June 20 1130	Arrive Barry Lock Gate	End cruise CD94