BODC

# Challenger 117/95B

[LOIS RACS(C)]

30 January to 13 February 1995

Cruise Report

P.G. Watson
Plymouth Marine Laboratory

# 1. OBJECTIVES

**1.1** To quantify hydrodynamical transports and the processes affecting transformations, interactions and fates of particles, biogeochemically important elements and representative contaminants from land sources to the coastal zone.

**1.2** To provide the first integrated environmental data base for a UK coastal region covering seasonal cycles and interannual variability and incorporating measurements of the fluxes of materials and rates of biological productivity.

**1.3** To generate new quantitative understanding of estuarine and coastal zone processes controlling the flux and reactivities of both natural and anthropogenic materials.

**1.4** To provide integratable models of these processes as building blocks for comprehensive coastal zone models which will realistically predict the effects of future environmental change.

# 2. SPECIFIC CRUISE OBJECTIVES

**2.1** To quantify the rates and processes of sediment-water exchange of nutrients, trace metals and oxygen in the sediments of the Humber/Wash and Tyne regions.

**2.2** To quantify pore water concentration gradients of nutrients and trace metals, the distributions of naturally occurring radionuclides, and the rates of denitrification/nitrification and sulphate reduction within the surficial zone of these sediments.

**2.3** To determine the population density of bioturbating macrofauna within these sediments.

**2.4** To map the distribution of dissolved nutrients, salinity, temperature, turbidity and fluorescence in the LOIS RACS(C) region.

**2.5** To deploy and recover one experimental mooring rig to measure currents, and recover six previously deployed instrument mooring rigs.

**2.6** To characterise orgainic micropollutant geochemistry in the waters, suspended particulates and sediments of the Humber/Wash region.

## 3. PERSONNEL

P.G. Watson (PML) Principal Scientist
R. Bellerby (PML)
G. Ballard (POL) # Moorings
J. Barnes (University of Newcastle upon Tyne) *
S. Barker (University of Newcastle upon Tyne) *
D. Braden (POL) # Moorings
R.J. Clifton (PML)
R. Cramer (BODC)
H. Cussen (IOSDL) *
A. Easton (PML) *
T. Fileman (PML)
D. Flatt (POL) # Moorings
T. Frickers (PML)
N. Hudson (University of Southampton) #
A. Jones (RVS) Electronics
A. Lord (RVS) Computing
A. Pool (RVS) * Box core technology
D. Smallman (DML) *
S. Widdicombe (PML)

* 30 January to 6 February 1995
\# 6 February to 13 February 1995

## 4. ITINERARY

This leg of cruise CH117/95 followed an earlier leg (CH117A/95) during which dissolved nutrient mapping and CTD deployment over the Humber/Tyne and Humber/wash grids were a main objective. This work was partially curtailed by adverse weather. The brief for the section reported on here was to make use of the time available after sediment coring and mooring recovery work, to fill in any gaps in the grids that remained.

**Monday 30th January 1995:** Scientific party joined the ship in Grimsby. Loaded and set up scientific equipment. Ship sailed into moderate swell at 1645 en route for the sediment sampling transect north of the Tyne.

**Tuesday 31st January:** Wind from the SE (expected to go to the SW) so most inshore station, T1, too vulnerable to on-shore wind. Proceeded to station T2. Commenced box-coring at 0830 using small corer. Following problems with loosened rubber sealing pad, changed to large box corer. After some success, coring suspended due to deteriorating weather with heavy swell. Proceeded to HT16,17,18,19,20 & 21 with continuous underway monitoring (nutrients: phosphate, silicate, nitrate & nitrite; salinity, temperature, suspended particulate, and chlorophyll fluorescence) and CTD deployment. Some problems with the Technicon nutrient analyser were resolved on route.

**Wednesday 1 February:** 0830 coring at station T2 and T3 until 1900. Hove to at station T3 overnight.

**Thursday 2 February:** 0813 Resumed coring at station T3, completed at 0939. Proceeded to station T1, coring failed due to nature of sediments. Proceeded to station T5, coring work until 1824. Proceeded to HT 32,33,34 and then to HW1,3,7,12 with underway monitoring and micropollutant water sampling, then to HW coring site 1.

**Friday 3 February:** Completed monitoring and water sampling at 1045. Arrived at coring station 1 at 1250 coring until 1737. Proceeded to HW14 and then to HW5 with underway nutrient monitoring, then followed transect to HW15 for micropollutant water sampling.

**Saturday 4 February:** Water sampling completed at 0549, then proceeded to HW coring station 8 arriving at 0930, coring until 1530. Then proceeded to HW17,16,15,8,11,10,9,13 for underway monitoring and micropollutant water sampling.

**Sunday 5 February:** Completed monitoring and water sampling at 0700. Then to HW coring station 9. At 0930 coring abandoned after limited success due to nature of sediment bed. Proceed to HW coring station 4 arriving at 1234 and coring until 1750. Then proceeded to HW10,11,8,6,4,2 for underway monitoring and micropollutant water sampling. Then proceeded to Spurn region.

**Monday 6 February:** 0843 Anchored at Bull Anchorage, HW coring station 6. 0908 Box coring, CTD and Day grab deployment, and continuous monitoring. 1640 transfer of 6 persons off and 4 persons on using Pilot Cutter. All sampling work complete at 2100. Left anchorage at 2115 and proceeded to HW 7,9,10,11 for underway monitoring and CTD.

**Tuesday 7 February:** Sampling completed at 0144, proceeded to Holderness region for rendezvous with Fishing vessel 'Janet M' at 0900. POL Mooring team transferred to 'Janet M' for recovery of S1 & N1 moorings. 1000 recovered S2 mooring, 1030 transferred S1 and N1 moorings and POL Mooring team to Challenger. 1140 recovered S3 mooring, 1410 recovered N3 mooring. 1415 proceeded to HW7 for continuous monitoring, and then to HW coring station S4 for detailed Day grab survey to define areal extent of sediment bed from 1840 to 2331. Then proceeded to Holderness region for mooring deployment.

**Wednesday 8 February:** 0830 current meter rig deployed. Proceeded to HW7 for Day grab survey at 1mile intervals to HW9, returning along same track to take sediment samples at selected sites, completed at 1650. Proceeded to HW3,4,2,1 for underway monitoring, comlpeted at 0125. Then proceeded to vicinity of N2 mooring.

**Thursday 9 February:** 0847 N2 mooring recovered, 0931 current meter mooring recovered. Proceeded to HW coring station 5 to attempt to recover small box corer lost during CH115/94, two grapple deployments unsuccessful, completed at 1741. Proceeded to HW15, 14 (CTD for mooring rig transmissometer calibration) HW16 and HW17 for underway monitoring.

**Friday 10 February:** 0206 sampling complete. Following advice from the ship's master regarding time required to get back to RVS Barry for the early morning tide on Monday 13 February, and making due allowance for expected adverse weather in the English Channel set return course at 0215. At 0712 collected MPMMG (475) water sample at Thames, Gabbard. At 1518 MPMMG (485) water sample at South Varne. Sediment incubations, nutrient analysis and data processing work carried out throughout the day. Strong W/SW winds and heavy seas impeded progress.

**Saturday 11 February:** 0033 MPMMG (495) water sample at Selsey Bill. At 1057 MPMMG (535) water sample at Centre Channel, and at 1823 MPMMG (585) water sample off Plymouth Sound. Sediment incubations, nutrient analysis and data processing work carried out throughout the day. Continuing strong W/SW winds and heavy seas.

**Sunday 12 February :** 0128 vessel off Wolf Rock Light. At 1328 MPMMG (615) water sample at Severn/Nash Point. Dismantling of equipment, packing *etc.* carried out. 1412 End of passage, off Breaksea Light Float. 1431 Pilot embarked. 1524 Vessel securely moored at RVS Barry.

**Monday 13 February:** Laboratories cleared of equipment and, together with moorings and deck mounted gear, unloaded from ship. All scientific party left by 1300.

# 5. INDIVIDUAL CRUISE REPORTS

## 5.1 NUTRIENT ANALYSIS

*Bekkqi Bellerby and Alison Easton*

Continuous on-line nutrient analysis was carried out using 3 different analysers over sections of the Coastal and Humber/Wash grids, not covered during leg A. A Technicon AA II system, developed at PML, and set up to measure nitrate, nitrite, silicate and phosphate was used. This was normally achieved during the night while steaming between sediment sampling sites. Water, supplied to the laboratory, from the ships non-toxic system was piped to the autoanalyser *via* an on-line filter mounted in a continuous filter block, using a 0.45µm Millipore filter.

Discrete analyses were carried out on sediment pore water and flux samples in support of on-board sediment core incubations. Nitrate, nitrite, silicate and phosphate were analysed using an Alpkem auto-analyser and ammonia samples analysed using a flow-injection gas diffusion analyser.

Nutrient calibration was effected by running standards made up in low nutrient sea water (Ocean Science International - OSI) or, towards the end of the cruise, sodium chloride solution. Standards were run for the on-line analysis at the beginning and end of each run.. Milli-Q water was used as a reagent blank and low nutrient sea water (or NaCl) as a standard zero. Working standards used were as follows: nitrate 5, 10, 15, 20µM /10, 20, 30, 40µM and 20, 40, 60, 80µM, nitrite 0.25, 0.5, 0.75, 1.0µM, silicate 5, 10, 15, 20µM and 10, 20, 30, 40µM, and phosphate 2, 4, 6, 8µM.

Standards for discrete analyses were run once or twice depending on the length of analyses, and were as follows: nitrate 5, 10, 15, 20µM , nitrite 0.25, 0.5, 0.75, 1.0µM, silicate 5, 10, 15, 20µM, phosphate 2, 4, 6, 8uM and ammonia 5, 10, 15, 20µM.

During the first few days of the cruise numerous difficulties were experienced with all 3 analysers. There were problems with the silicate channel of the Technicon, which remained unsolved from CH115 and additionally with precipitation in the ammonium molybdate reagent throughout the cruise. The Alpkem suffered from small bubbles in the silicate channel which were only cleared by copious and frequent washing of that channel with Milli-Q water and sodium hydroxide solution. This problem had also been experienced on CH115. The ammonia analyser suffered from intermittent electrical faults but thanks to Andy Jones, RVS, these problems were rectified.

### 5.1.1 Chlorophyll Samples

Water samples collected for chlorophyll analysis during legs A and B were processed on board using a fluorometric technique.

### 5.1.2 Scallop Growth Experiment ( University of Derby)

During CH115A/94, nets containing a number of scallops had been placed on 3 of the POL moorings: S2, N2 and N4.

During leg C, when the moorings were recovered, the scallop nets were retrieved. The nets were cleaned and the scallops maintained in aerated sea water from the non-toxic supply until they were reattached to the appropriate mooring when it was re-deployed.

Water samples were also taken at each of the mooring sites where scallops were deployed for later analysis.

The scallops were finally retrieved with the mooring on CH117B/95, and returned to the University of Derby for further study.

## 5.2 SEDIMENT DENITRIFICATION/NITRIFICATION STUDIES

*John Barnes*

Denitrification is a major sink for combined nitrogen in the marine environment. The objectives were to quantify this process and, in particular to determine the flux of the bio-gases nitrous oxide and nitrogen.

Measurements of denitrification rates will be calculated using a new $^{15}N$ isotope pairing technique in conjunction with the widely used, but more limited, acetylene block method. The isotopic pairing method allows estimates of both denitrification based on $NO^{3-}$ from the overlying water and of coupled nitrification/dentrification. More than 300 discrete gas samples have been collected from cores obtained at sations T2, T3, T5 (on the Tyne transect) and HW8 and HW4 in the Humber/Wash region. Analysis by isotope ratio mass spectrometry for nitrogen/nitrous oxide isotopic enrichment, and gas chromatography (electron capture detector) for nitrous oxide will be carried out at Newcastle-upon -Tyne University. Additionally, water samples were collected from vertical hydrocasts at stations T2, T3, T5 and HW8 for subsequent analysis for all inorganic nitrogen compounds using a novel hydroxylamine technique.

## 5.3 NATURAL ABUNDANCES OF STABLE ISOTOPES OF C & N IN MARINE FOOD WEBS

*Sam Barker*

The natural abundances of the stable isotopes of carbon and nitrogen can be used to establish trophic positions of organisms within a food web, due to isotopic fractionation that occurs at each trophic step. This is quite marked for $^{15}N$ but less so for $^{13}C$. At present this study is at a preliminary stage requiring the sampling of entire sites of both the benthic and pelagic layers.

Organisms were collected on an opportunistic basis from box cores, collected for other purposes, and plankton were sampled with vertical hauls using a 500 micron mesh net at sites T2, T3, T5, HW1, HW4, HW8 & HW9. Organisms were identified on board and then frozen to permit further analysis, on return to Newcastle, using a dual isotope continuous flow mass spectrometer.

## 5.4 SEDIMENT MIXING/ACCRETION AND SULPHATE REDUCTION RATES

*R.J.Clifton*

Objectives:

(a) To determine residence times, in the water column, of the suspended particulate material. To do this it is necessary to filter the suspended particulate material from large volumes of water (>200 litres) in order to obtain a measurable signal from the adsorbed $^{234}Th$ (daughter of $^{238}U$ which is dissolved in sea water).

(b) To determine mixing/accretion rates, mixing depths and 'focusing' ability of selected bed-sediment deposits. These parameters are determined from the sediment/depth profiles of a series of radio-nuclides(RI's). The samples are taken as 1cm 'scrapes' down to 6cm and as sectioned core samples (18cm diam.) down to 25-50cm.

(c) To determine sulphate reduction rates in bed-sediment deposits. 6cm. diam. sub-cores are taken from the large box-corer. These cores are, in turn, sub-sampled (4ml) at 5cm intervals to a depth of 20-30cm. The small sub-cores are 'spiked' with $Na_2{}^{35}SO_4$ and incubated for approx.24hrs. The incubated core is returned to the laboratory for analysis.

**Sampling and analyses completed.**

31/1/95. Tyne transect.- Station T2. Suspended load too high to filter enough water - only 10litres filtered. Sediment scrapes and 2 large cores taken for radioisotope distributions (RI). 2 (6cm) cores taken for $SO_4{}^{2-}$ reduction.

1-2/2/95. Tyne transect - Station T2. Only 35litres of water filtered. Scrapes and 2 cores taken for RI. 6cm. core for $SO_4{}^{2-}$ reduction.

2/2/95. Tyne transect - Station T1. No samples obtained.

2/2/95. Tyne transect - Station T5. Scrapes and cores for RI. 6cm. core for $SO_4{}^{2-}$ reduction. No water filtered.

3/2/95. PML Station 1. - No samples collected.

4/2/95. PML Station 8. Scrapes and cores for RI. 6cm core for $SO_4{}^{2-}$ reduction. 2 series of incubations for $SO_4{}^{2-}$ reduction completed (5hrs and 11hrs) in order to accommodate high reduction rates. Grab sample taken, homogenised and split into 2 for IOS(DL)/PML RI intercomparison.

5/2/95. PML Station 9 (Wash). No samples obtained.

5/2/95. PML Station 4 (Silver Pit). It was very difficult to obtain a sample at this site. The samples were shallow and we could not take scrapes from the surface. Shallow cores were obtained for RI and $SO_4^{2-}$ reduction.

6/2/95. PML Station 6 (Humber mouth). Scrapes and cores for RI. 6cm. core for $SO_4^{2-}$ reduction rates.

7/2/95 - 13/2/95. $SO_4^{2-}$ incubations and calculations.

## 5.5 DATA COLLATION

*Roy Cramer*

My prime objective was to ensure that a full record of the scientific activities was maintained, with accurate times and systematic sample identification. The 'rough' log was kept up to date and also recorded in separate spreadsheets for each of the sampling methods (CTD, Nutrient autoanalysis, non-toxic water sampling, water bottle sampling, sediment box coring, multicoring and Day grabs).
Additionally microcomputer assistance was made available to the scientists on the cruise, as well as general help with sampling.

## 5.6 SEDIMENTARY DISSOLVED OXYGEN, REDOX POTENTIAL AND $^{210}$PB DISTRIBUTIONS

*Helen Cussen*

As part of an investigation into the chemistry of the sediments and the extent of bioturbation within the sediments, samples from box cores T2, T3, T5, S8, HW4 and HW6 were taken for dissolved oxygen, redox potential (Eh), resistivity and radio-nuclide (210Pb) measurements.

Sub-cores from box cores T2, T3, T5, S8, HW4 and HW6 were profiled for dissolved oxygen using a robust dissolved oxygen electrode. The box cores were sub-cored into 10cm diameter clear plastic core tubes and 2-3cm depth of bottom water was retained over the sediment to reduce the effect of oxygen diffusion into the core. The sub-cores were immediately transferred to the constant temperature laboratory (8°C) where a computer controlled profiling device was used to push the oxygen electrode into the sub-core from above in steps of 1mm. The computer monitored the readings from the electrode at each step and when it considered the reading to be stable it logged the value for that depth increment. A plot of the data was displayed in real-time as the profile proceeded. The profiles indicate that oxygen penetrated to depths of between 2cm.and 8cm. with site HW4 having the smallest depth of oxygen penetration.

At the same sites a second sub-core was taken for redox potential (Eh), resistivity and radio-nuclide ($^{210}$Pb) measurements. This core was spilt and half was immediately sealed in plastic sleaving and stored at 8°C for radio-nuclide analysis on return to the Institute of Oceanographic Sciences (IOS). Eh and resistivity measurements were made on the other half of the core using a Kent-Taylor combined redox microelectrode and a prototype resistivity probe which was made at IOS. Readings were taken every centimetre for Eh and every two centimetres for resistivity. The tip of the Eh electrode was acid cleaned before use and a measurement was taken in a standard ferrocyanate solution to assess the electrode drift. Initially the readings within the sediments were very variable and drifted dramatically but the performance seemed to improve on later cores. The resistivity readings were more stable and general trends could be seen within the cores

## 5.7 ORGANIC MICROPOLLUTANTS

*Tim Fileman*

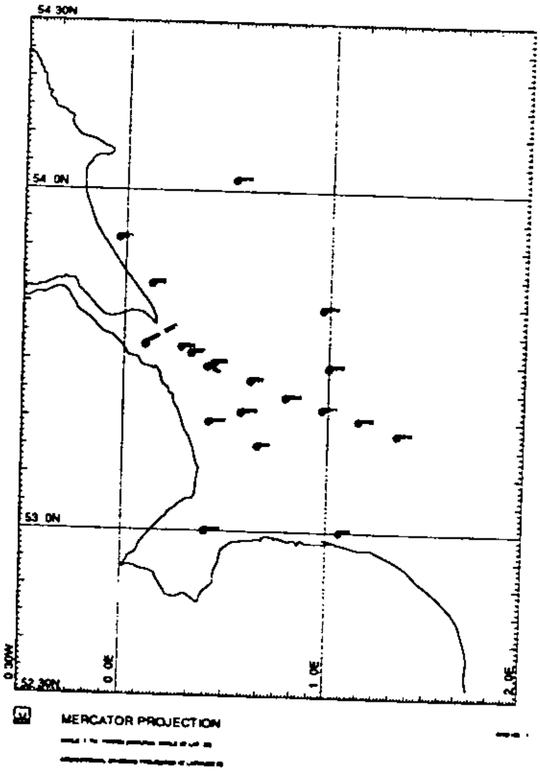
### Objectives

To sample selected sites on the Humber/Wash grid for water, suspended particulates and sediment in order to characterise micropollutant geochemistry. Sites were selected in order to provide the best coverage for modelling micropollutant fluxes from the Humber. Levels of a range of critically selected pollutants (PCBs, lindane, atrazine, PAHs, organophosphorous pesticides, pyrethroides and phthalate plasticisers) known to occur in the Humber will be measured together with other parameters, such as marine variables, POC, particulate mineralogy etc.

### Method

Water samples were taken using a hand held sampler (clean glass winchester held in a stainless steel frame with a sprung PTFE stopper) at a depth of about 1 metre. Samples were filtered and extracted on board Challenger. Extraction was performed using a solid phase extraction technique following addition of internal standards. Sub samples of water were also filtered for particulate organic carbon (POC) and suspended particulate gravimetry.

See chart and sample table below for sites sampled and samples taken.




RRS Challenger 117b - Bottle Sample Sites

## Sample Table: Organic Micropollutants

| Sample | Date | Time (Z) | LOIS HW Grid # | Lat | Lon | Depth (m) | Temp (°C) | Salinity (PSU) | Sed # | Water Vol (ml) |
|---|---|---|---|---|---|---|---|---|---|---|
| BS1 | 03/02/95 | 05:55 | 1 | 53 51.44N | 0 1.90W | 18.5 | 5.51 | 34.06 | NO SAMPLE | 20 |
| BS2 | 03/02/95 | 06:57 | 3 | 53 43.44N | 0 7.78E | 21.1 | 6.10 | 34.23 | NO SAMPLE | 20 |
| BS3 | 03/02/95 | 08:47 | 7 | 53 29.04N | 0 23.90E | 17 | 5.39 | 32.25 | NO SAMPLE | 18 |
| BS4 | 03/02/95 | 10:43 | 12 | 53 15.21N | 0 38.97E | 24.7 | 5.06 | 32.99 | NO SAMPLE | 20 |
| BS5 | 03/02/95 | 18:15 | 14 | 52 59.99N | 1 4.02E | 21 | 5.25 | 33.31 | NO SAMPLE | 20 |
| BS6 | 03/02/95 | 23:09 | EAST OF 5 | 53 32.35N | 0 16.39E | 14.3 | 5.33 | 29.75 | ESEA249 | 20 |
| BS7 | 03/02/95 | 23:34 | 5(A) | 53 31.37N | 0 19.30E | 13.9 | 5.53 | 32.12 | ESEA250 | 20 |
| BS8 | 04/02/95 | 00:16 | 5(B) | 53 29.72N | 0 25.93E | 14.8 | 5.43 | 32.23 | NO SAMPLE | 20 |
| BS9 | 04/02/95 | 01:12 | 5(C) | 53 26.71N | 0 36.53E | 18.4 | 4.97 | 32.17 | ESEA251 | 20 |
| BS10 | 04/02/95 | 02:11 | 10 | 53 23.78N | 0 46.99E | 15.9 | 5.58 | 33.39 | ESEA252 | 20 |
| BS11 | 04/02/95 | 03:13 | 10(A) | 53 21.75N | 0 58.15E | 21.3 | 5.69 | 33.63 | NO SAMPLE | 20 |
| BS12 | 04/02/95 | 04:33 | 10(B) | 53 19.87N | 1 9.26E | 29.5 | 5.89 | 34.10 | ESEA253 | 20 |
| BS13 | 04/02/95 | 05:48 | 15 | 53 17.45N | 1 20.83E | 23.6 | 6.00 | 34.36 | ESEA254 | 20 |
| BS14 | 05/02/95 | 00:37 | 8 | 53 39.23N | 0 57.86E | 25.8 | 6.33 | 34.37 | ESEA255 | 20 |
| BS15 | 05/02/95 | 02:01 | 11 | 53 29.06N | 0 59.98E | 20.6 | 6.16 | 34.19 | ESEA256 | 20 |
| BS16 | 05/02/95 | 04:00 | 9(A) | 53 21.20N | 0 33.92E | 14.5 | 4.85 | 32.30 | ESEA257 | 20 |
| BS17 | 05/02/95 | 04:49 | 9 | 53 19.41N | 0 24.71E | 16.1 | 4.86 | 31.28 | ESEA1 | 20 |
| BS18 | 05/02/95 | 07:02 | 13 | 53 0.02N | 0 24.02E | 31.7 | 5.03 | 30.31 | ESEA2 | 20 |
| BS19 | 06/02/95 | 01:06 | 2 | 54 1.93N | 0 31.08E | 50.5 | 6.54 | 34.46 | ESEA3 | 20 |
| BS20 | 06/02/95 | 13:17 | 5 | 53 32.73N | 0 6.14E | 14.5 | 5.47 | 24.19 | STN20 | 20 |
| BS21/1 | 06/02/95 | 15:38 | 5 | 53 32.73N | 0 6.15E | 13.2 | 5.45 | 20.50 | NO SAMPLE | 20 |
| BS21/2 | 06/02/95 | 15:38 | 5 | | | | | | NO SAMPLE | 20 |
| BS21/3 | 06/02/95 | 15:38 | 5 | | | | | | NO SAMPLE | 20 |
| BLANK | 06/02/95 | Milli-q water processed + IS | | | | | | | | 20 |

## 5.8 SEDIMENT-WATER EXCHANGE.

*Trish Frickers & Peter Watson*

**Objectives**

1 To quantify the effect macro-benthic animals have on sediment-water exchange of nutrients (nitrate, nitrite, phosphate, silicate and ammonia) and trace metals (iron, manganese, nickel, zinc, copper, cadmium and lead) in the Humber plume and Wash region at sites established during previous cruises. (DOE contract no PECD/7/7423).

2 To investigate sediment-water exchange at sites along the Tyne transect established during cruise CH115/94B.

3 To investigate sediment-water exchange at gravel / pebble sites between the Humber and Wash.

**Achievements**

1 Box cores were taken at 5 sites in the Humber /Wash region ( sites HW1, HW4, HW6, HW8 and HW9) and at 3 sites across the Tyne transect (T2, T3 and T4).

2 Bulked Day-grabs were taken from areas between the Humber and Wash at gravelly sites that were impossible to box core.

3 The box cores were sub-cored for duplicate large (20cm dia) microcosm cores for incubation, duplicate small cores (6cm dia) for sediment redox potential and for porosity & C/N determinations and particle size distribution.

4 Ship board analysis was carried out on flux samples and porewaters for alkalinity, redox and nutrients.

5 Samples for trace metal determinations were acidified and stored for return to PML for further analysis

6 On completion of the chemistry all the box core derived microcosm cores were then sieved for macro-faunal extraction.

## 5.9 SEDIMENT-WATER EXCHANGE OF NUTRIENTS

*David Smallman*

Marine sediments in the Humber/Wash region (HW4 & HW8) and off the Tyne Estuary (T2, T3 & T5) were examoned to determine sediment-water exchange processes. Sediments were collected utilizing two different sampling procedures.

(i) Undisturbed cores, in which the sediment/water interface remained intact, were obtained using a Bowers and Connelly mini-corer. The corer is configured so that two 65mm id and two 100mm id cores can be collected with each deployment. The larger diameter cores were used to measure oxygen and nutrient fluxes by an incubation procedure. The two smaller cores were used to determine pore water nutrient concentrations and for chemical analysis (carbon and nitrogen) of the solid phase constituents.

(ii) 65mm and 100mm id cores were also sub-sampled from box-cores and used to determine the same parameters as above.

Incubation studies were carried out after immersing the cores in water which overlay the sediment. The temperature of the water was maintained at 8°C in a constant temperature room. Water to immerse the cores in was collected by means of the RVS CTD Rosette sampler.
The sampling pattern was:-

| Station | Minicore samples | Box core samples | CTD No |
|---|---|---|---|
| T2 | 1L + 2S | BC6: 2L | 4 |
| T3 | 2L + 1S | BC10,11: 2L | 5 |
| T5 | 1L | BC18,19:2L | 6 |
| HW8 | 2L | BC32:2L | 8 |
| HW4 | 2L | BC45:2L | 8 |

**Note** L = Large core, S = Small core

The overall aim of the study, together with denitrification rate (Newcastle-upon-Tyne University), sulphate reduction measurements (PML) and diffusive predictions obtained from dissolved oxygen profiles (IOSDL) is to derive qualitative and quantitative profiles of coastal early diagenetic processes along the UK North-East coastline. The eventual aim being to create a model of these processes with respect to organic inputs into the sediments.

## 5.10 BENTHIC FAUNA

*Steve Widdicombe*

**Aims:** 1) To revisit sites established on the cruise CH99/92 within the Humber Plume Zone as the faunal part of the sediment heterogeneity study (DOE PECD 7/7/423).

2) To revist sites established on the cruise CH115B/94 north of the Tyne.

**Sites:** HW1,HW4,HW6,HW8 & HW9 (Humber Plume Zone).
T2,T3 & T5 (Tyne).

**Activity:** 1) At each site 4 box cores ($0.1m^2$) were deployed. Each was sieved for macrofauna using a 0.5mm square meshed sieve and the residue was preserved in 10% formaldehyde solution.

2) The cores used by Frickers and Watson were sieved and preserved (as described above) after all samples for nutrients and metals had been taken.

**Notes:** 1) Site HW9 was only sampled by Frickers and Watson. Collection of cores for complete faunistic analysis was not possible.

## 5.11 MOORINGS - HOLDERNESS COAST

*Dave Flatt*

**Objectives:**

a) To recover 6 x PMP moorings at sites S1 - S3 and N1 - N3.

b) To deploy and recover a "current meter tripod" mooring.

**Activities:**

1) Monday 6th February. The POL mooring team (G.Ballard, D.Braden and D.Flatt) joined Challenger at 1700h from the Bull anchorage by pilot boat.

2) Tuesday 7th February. Boat transfer to Janet-M. Recover N1 at 0926h, S1 at 1007h. Challenger recovered S2 at 0955h. Rejoin Challenger and recover S3 at 1151h and N3 at 1421h.

3) Wednesday 8th February. Assemble CM tripod mooring and deploy at 0831h, next to N2, position 53 47.73N 00 03.19E

4) Thursday 9th February. Recover N2 0847h and CM tripod at 0927h

5) 9th - 12th February. Download data from instruments.

**Recovery**

| STN | adcp | tilt | pwr | s4 | trans | abs | emp 2000 | WATER IN | WATER OUT |
|---|---|---|---|---|---|---|---|---|---|
| N3 | POLDOP2 | ? | 8(7) | 1265 RVS | 1762(10) WSO | --- | ---- | 1637 20.1.95 | 1421 7.2.95 |
| N2 | POLDOP10 | ? | 1(27) | 1832 POL | 1761(10) WSO | --- | 1066 | 0935 19.1.95 | 0847 9.2.95 |
| N2 | S4 current | meter | rig | | | | | 0831 8.2.95 | 0927 9.2.95 |
| N1 | POLDOP4 | 7 | 2(27) | 2006 POL | 1686(10) WSO | LA | ---- | 1348 16.1.95 | 0926 7.2.95 |
| S3 | POLDOP7 | ? | 6(7) | 1196 POL | 3(25) UNCW | --- | ---- | 0920 21.1.95 | 1151 7.2.95 |
| S2 | POLDOP1 | ? | 4(27) | 1119 RVS | 1760(10) WSO | --- | 1065 | 0834 19.1.95 | 0955 7.2.95 |
| S1 | POLDOP9 | 4 | 3(27) | 2005 POL | 1683(10) WSO | LB | ---- | 1230 16.1.95 | 1007 7.2.95 |

Position of S4 current meters on CM tripod mooring.

---

Top 2006
1119
1196
1265
2005

S4 setups

---

2005,2006 PC
1119,1265 P0,0020/0,0100
1196 P0,0030/0,0100

## 5.12 RVS SCIENTIFIC COMPUTING

*Andy Lord*

The main activities were logging the fitted instruments and the PML nutrient autoanalyser. The instruments logged were:-

| | |
|---|---|
| WINCH | Ships Seametric winch cable metering system. |
| RD200A | Ships Bridge fitted echosounder |
| GPS_TRIM | The Trimble GPS satellite position finder |
| RVS_CTDF | The RVS CTD instrument on the starboard A frame |
| EA500D2 | The Simrad scientific echosounder |
| LUMEN | The port and starboard 2piPar light meters |
| FLUTE | The non toxic Fluorimeter and Transmissometer |
| TSG103 | The non toxic Thermosalingraph |
| LOG_CHF | Chernikeef electromagnetic log |
| MX1107 | Transit satellite navigator |
| BIN_GYRO | Ships gyro |
| SOLI | Solar integrator port and starboard light meters |
| NUTRI2 | PML Nutrient autoanalyser |
| ADCP | Acoustic Doppler Current Profiler |

The logging was mainly trouble free apart from one occasion when the clean AC began fluctuating and eventually went off. This resulted in a six hour period when the data was either absent or highly suspect.

Plots were produced showing the locations and water depths of all deployments of the core samplers, CTD, bottle samples for micropollutants and deployment of the nutrient analyser.

Plots were also made of each CTD cast of the main parameters of temperature salinity and transmittance.

In total about 78 M bytes of data were collected.

## 6. REPORT

*Summary and assessment of achievements*

6.1 Figure 1 shows the complete cruise track.
6.2 All the major objectives were met
6.3 Eight sediment sites (5 in the Humber/Wash region and 3 in the Tyne region) were examined in detail, in all 46 box cores and 5 multi cores were collected (see Tables 1 and 2; Figures 2 and 3).
6.4 Further investigations of sediment type and distribution were made by Day grab sampling (see Table 3; Figure 4) including a detailed survey of the Silver Pit site (HW4) where it has proved difficult to locate suitable material for coring on previous cruises. Additionally a survey of the coastal region from south of the Humber mouth towards the Wash, which was thought to be predominantly coarse gravels, revealed regions of silty-sands. This will enable sediment-water exchange studies to be extended into an important and previously unsampled region within the Humber plume.
6.5 Sediment cores were analysed on board ship or prepared for subsequent laboratory analysis to provide a comprehensive investigation of physical, chemical and biological sedimentary processes. These included: vertical pore water gradients and sediment-water exchange of nutrients and trace metals, rates of nitrification/denitrification and sulphate reduction, dissolved oxygen profiles and sediment oxygen uptake, sediment mixing/accretion rates and mixing depth, redox, particle size distribution and porosity. An illustration of the varying chemical status of the sediments under investigation is shown by the strikingly different dissolved oxygen profiles determined at sites HW4 (Silver Pit) and at HW8 off the NE Norfolk coast (see Figures 5(a) and 5(b) *from measurements made by Helen Cussen*).
6.6 To supplement water column data which was restricted on CH117A/95 due to mechanical and weather problems, CTD casts were made at 19 stations (Table 5; Figure 6) supported by sampling from the non-toxic supply ( Table 6) for calibration purposes and, at eight sites, for nutrients and salinity for the MPMMG survey.
6.7 To supplement water column nutrient analyses sections of the LOIS sampling grid not covered on CH117A/95 were sampled (Figure 7) and analyses carried out for nitrate, nitrite, phosphate, silicate and when possible also for ammonia.
6.8 A complimentary suite of supporting water column variables (fluorescence, temperature, salinity and transmission) were measured.
6.9 Six instrumented benthic mooring arrays were recovered (Figure 8) and an experimental CM tripod mooring was successfully deployed and recovered.
6.10 Samples were collected and processed from 20 sites for micropollutant geoechemical studies.
6.11 Plankton samples for stable isotope analysis were collected opportunistically from vertical hauls of a 500 micron mesh net.

6.12 An attempt was made to recover a small box corer lost during CH115/94; two grapple deployments were unsuccessful.
6.13 Problems were experienced with both nutrient autoanalysers and the ammonia analyser. These were temporarily resolved to enable the essential work to proceed, but will require more detailed attention on return to PML.
6.14 The weather was generally good in this coastal region sheltered from W & SW winds; there was only a moderate swell which limited coring work on one day only.

*Ship operations and facilities*

6.15 As usual RVS Challenger was efficiently and professionally run, and the support from the ships officers, crew and from RVS personnel was excellent.
6.16 The laboratory facilities were satisfactory. There was a loss of AC power for a short while necessitating resetting of instrumentation and computers. The seal on the starboard side door of the container let in water in moderate sea conditions and there was no telephone connected.
6.17 The large SMBA box corer gave adequate service enabling major objectives of the cruise to be met. On-going servicing by an RVS technician (Mr David Poole) enabled some problems to be resolved, particularly when a box was distorted due to deployment in mixed sediment materials. It would have been helpful if some spare front panels were available to refurbish the boxes. It would also be desirable to investigate the provision of boxes, or front panels constructed from heavier guage stainless steel. Some lack of control of the main winch was observed, and this may have contributed to failiure of the corer to seal properly if it was pulled from the sediment bed before the spade had fully closed. A recommendation was made that the winch control mechanism be serviced.
6.18 Despite the physical nature of much of the sediment coring and processing work, the provision of an exercise facility was greatly appreciated by many people, particularly those who would otherwise have been unable to pursue their fitness routines. Informal record challenges generated some friendly competetiveness which provided a welcome relief from the arduous daily work (see Table 7).

## TABLES



## FIGURES

| Grab no | Latitude | Longtitude | Depth |
|---|---|---|---|
| DG61 | 53 24.90N | 0 25.45E | 11.700000 |
| DG62 | 53 24.92N | 0 25.43E | 11.500000 |
| DG63 | 53 24.75N | 0 25.61E | 12.700000 |
| DG64 | 53 24.79N | 0 25.58E | 12.200000 |
| DG65 | 53 24.82N | 0 25.51E | 13.100000 |
| DG66 | 53 24.86N | 0 25.50E | 12.800000 |
| DG67 | 53 7.90N | 0 33.32E | 33.700000 |
| DG68 | 53 28.96N | 0 23.95E | 17.400000 |
| DG69 | 53 32.70N | 0 6.10E | 13.300000 |

Table 4 Day grab stations and descriptions

| Day Grabs | | | | |
|---|---|---|---|---|
| Cruise | Sample | Date/time | Fixed Station | Comments |
| CH117B | DG1 | 3/2/95 23.08 | | Stones : Gravel : Shell |
| CH117B | DG2 | 3/2/95 23.35 | | HW5a : Stones : Gravel |
| CH117B | DG3 | 4/2/95 00.15 | | HW5b : Stones : No sample taken |
| CH117B | DG4 | 4/2/95 01.11 | | HW5c : Gravel |
| CH117B | DG5 | 4/2/95 02.08 | HW10 | Sand - Fine |
| CH117B | DG6 | 4/2/95 03.10 | | HW10a : Stones : Shells - No sample taken |
| CH117B | DG7 | 4/2/95 04.30 | | HW10b : Shells : Sand |
| CH117B | DG8 | 4/2/95 05.45 | HW15 | Sand : Shells |
| CH117B | DG9 | 4/2/95 12.43 | Station 8 | Mud |
| CH117B | DG10 | 5/2/95 00.37 | HW8 | Rocks and sand |
| CH117B | DG11 | 5/2/95 02.02 | HW11 | Shells and sand |
| CH117B | DG12 | 5/2/95 03.57 | | HW9a : Sand |
| CH117B | DG13 | 5/2/95 04.48 | HW9 | Coarse Sand - Gravel |
| CH117B | DG14 | 5/2/95 06.59 | HW13 | Mud and stones |
| CH117B | DG15 | 5/2/95 12.38 | Station 4 | Mud |
| CH117B | DG16 | 6/2/95 01.21 | HW2 | Sand |
| CH117B | DG17 | 5/2/95 17.07 | Station 4 | Cobbles |
| CH117B | DG18 | 7/2/95 18.48 | SP20 | Muddy sand |
| CH117B | DG19 | 7/2/95 19.01 | SP21 | Coarse muddy sand : Shells |
| CH117B | DG20 | 7/2/95 19.17 | SP22 | Stones |
| CH117B | DG21 | 7/2/95 19.25 | SP22 | Soft mud with stones |
| CH117B | DG22 | 7/2/95 19.35 | SP23 | Muddy sand with shells |
| CH117B | DG23 | 7/2/95 19.55 | SP24 | Sandy mud with shells |
| CH117B | DG24 | 7/2/95 20.08 | SP25 | Sandy mud with shells |
| CH117B | DG25 | 7/2/95 20.22 | SP26 | Clay |
| CH117B | DG26 | 7/2/95 20.28 | SP26 | Clay |
| CH117B | DG27 | 7/2/95 20.43 | SP27 | Clay |
| CH117B | DG28 | 7/2/95 20.51 | SP27 | Sand and shells |
| CH117B | DG29 | 7/2/95 21.06 | SP28 | Muddy sand and shells |
| CH117B | DG30 | 7/2/95 21.23 | SP29 | Muddy sand and shells |
| CH117B | DG31 | 7/2/95 21.39 | SP30 | Fine sandy mud |
| CH117B | DG32 | 7/2/95 22.10 | SP31 | Stones |
| CH117B | DG33 | 7/2/95 22.24 | SP32 | Stones |
| CH117B | DG34 | 7/2/95 22.31 | SP32 | Sandy mud |
| CH117B | DG35 | 7/2/95 22.45 | SP33 | Mud |
| CH117B | DG36 | 7/2/95 23.02 | SP34 | Sandy mud with shells |
| CH117B | DG37 | 7/2/95 23.15 | SP35 | Sand with some mud |
| CH117B | DG38 | 7/2/95 23.27 | SP36 | Sandy mud |
| CH117B | DG68 | 8/2/95 10.39 | HW7 | Stones and gravel |
| CH117B | DG39 | 8/2/95 10.55 | | Cobbles |

| Day Grabs | | | | |
|---|---|---|---|---|
| Cruise | Sample | Date/time | Fixed Station | Comments |
| CH117B | DG40 | 8/2/95 11.12 | | Small cobbles |
| CH117B | DG41 | 8/2/95 11.35 | | Small cobles |
| CH117B | DG42 | 8/2/95 11.57 | | Pebbles |
| CH117B | DG43 | 8/2/95 12.17 | | Coarse sand |
| CH117B | DG44 | 8/2/95 12.36 | | Sand |
| CH117B | DG45 | 8/2/95 12.53 | | Cobbles and sand |
| CH117B | DG46 | 8/2/95 13.09 | | Very coarse sand |
| CH117B | DG47 | 8/2/95 13.26 | | Sand and pebbles |
| CH117B | DG48 | 8/2/95 13.38 | | Sandy mud and pebbles with clay |
| CH117B | DG49 | 8/2/95 14.20 | DG44 | A stone |
| CH117B | DG50 | 8/2/95 14.24 | DG44 | Sand and a stone |
| CH117B | DG51 | 8/2/95 14.28 | DG44 | Sand and small cobbles |
| CH117B | DG52 | 8/2/95 14.37 | DG44 | Sand |
| CH117B | DG53 | 8/2/95 14.42 | DG44 | Sand |
| CH117B | DG54 | 8/2/95 14.47 | DG44 | Sand and stone |
| CH117B | DG55 | 8/2/95 15.13 | DG42 | Pebbles |
| CH117B | DG56 | 8/2/95 15.16 | DG42 | Pebbles |
| CH117B | DG57 | 8/2/95 15.19 | DG42 | Cobbles and pebbles |
| CH117B | DG58 | 8/2/95 15.23 | DG42 | Cobbles |
| CH117B | DG59 | 8/2/95 15.51 | DG42 | Cobbles |
| CH117B | DG60 | 8/2/95 15.55 | DG42 | Pebbles |
| CH117B | DG61 | 8/2/95 15.58 | DG42 | Cobbles |
| CH117B | DG62 | 8/2/95 16.00 | DG42 | Cobbles |
| CH117B | DG63 | 8/2/95 16.12 | DG42 | Two stones |
| CH117B | DG64 | 8/2/95 16.15 | DG42 | Pebbles |
| CH117B | DG65 | 8/2/95 16.18 | DG42 | Pebbles |
| CH117B | DG66 | 8/2/95 16.21 | DG42 | Pebbles |
| CH117B | DG67 | 5/2/95 08.21 | Station 9 | Coarse sand and gravel |
| CH117B | DG69 | 6/2/95 15.50 | Station 6 | Fine sand and mud |

Table 5 CTD casts

| CTD Casts | | | | | |
|---|---|---|---|---|---|
| Cruise | Cast id | Start Date/Time | End Date/Time | Fixed Station | Comments |
| CH117B | CTD1 | 31/1/95 15.41 | 31/1/95 15.55 | C17 | |
| CH117B | CTD2 | 31/1/95 18.55 | 31/1/95 19.07 | C19 | |
| CH117B | CTD3 | 31/1/95 22.26 | 31/1/95 22.36 | C21 | |
| CH117B | CTD4 | 1/2/95 08.09 | 1/2/95 08.32 | T2 | Tyne Tees Transect |
| CH117B | CTD5 | 1/2/95 20.10 | 1/2/95 20.27 | T3 | |
| CH117B | CTD6 | 2/2/95 17.27 | 2/2/95 17.42 | T5 | |
| CH117B | CTD7 | 3/2/95 16.55 | 3/2/95 17.01 | Station 1 | |
| CH117B | CTD8 | 4/2/95 13.04 | 4/2/95 13.15 | Station 8 | |
| CH117B | CTD9 | 4/2/95 17.27 | 4/2/95 17.35 | HW17 | |
| CH117B | CTD10 | 4/2/95 18.57 | 4/2/95 19.03 | HW16 | |
| CH117B | CTD11 | 4/2/95 21.37 | 4/2/95 21.42 | HW15 | |
| CH117B | CTD12 | 5/2/95 17.35 | 5/2/95 17.45 | Station 4 | |
| CH117B | CTD13 | 5/2/95 20.10 | 5/2/95 20.16 | HW11 | |
| CH117B | CTD14 | 5/2/95 22.50 | 5/2/95 23.05 | HW4 | |
| CH117B | CTD15 | 6/2/95 01.05 | 6/2/95 01.20 | HW2 | |
| CH117B | CTD16 | 6/2/95 15.37 | 6/2/95 15.44 | Station 6 | |
| CH117B | CTD17 | 6/2/95 22.21 | 6/2/95 22.26 | HW7 | |
| CH117B | CTD18 | 6/2/95 23.30 | 6/2/95 23.36 | HW9 | |
| CH117B | CTD19 | 9/2/95 22.29 | 9/2/95 22.52 | HW14 | 6 Mooring Trans. cal. |

Table 6 Water samples taken from non-toxic supply

| General Non-toxic Supply Batch 2 | | | | | |
|---|---|---|---|---|---|
| Cruise | Sample id | Date/Time | Fixed Station | Determinants | Comments |
| CH117B | PG301 | 31/1/95 17.07 | C18 | PML Gravi +Chloro | |
| CH117B | PG302 | 31/1/95 20.50 | C20 | ditto | |
| CH117B | PG303 | 2/2/95 18.52 | C17 | ditto | |
| CH117B | PG304 | 2/2/95 20.26 | C32 | ditto | |
| CH117B | PG305 | 2/2/95 22.27 | C33 | ditto | |
| CH117B | PG306 | 3/2/95 00.50 | C34 | ditto | |
| CH117B | PG307 | 3/2/95 05.56 | HW1 | ditto | |
| CH117B | PG308 | 3/2/95 06.57 | HW3 | ditto | |
| CH117B | PG309 | 3/2/95 08.47 | HW7 | ditto | |
| CH117B | PG310 | 3/2/95 10.43 | HW12 | ditto | |
| CH117B | PG311 | 3/2/95 18.15 | HW14 | ditto | |
| CH117B | PG312 | 3/2/95 23.14 | HW5 | ditto | |
| CH117B | PG313 | 4/2/95 02.10 | HW10 | ditto | |
| CH117B | PG314 | 4/2/95 05.47 | HW15 | ditto | |
| CH117B | PG315 | 5/2/95 07.37 | MPMMG 385 | Nutrient and Salinity | |
| CH117B | PG316 | 5/2/95 18.51 | HW10 | PML Gravi+Chloro | |
| CH117B | PG317 | 6/2/95 09.02 | MPMMG335 | Nutrient and Salinity | |
| CH117B | PG318 | 10/2/95 07.10 | MPMMG475 | ditto | |
| CH117B | PG319 | 10/2/95 15.21 | MPMMG485 | ditto | |
| CH117B | PG320 | 11/2/95 00.33 | MPMMG495 | ditto | |
| CH117B | PG321 | 11/2/95 10.58 | MPMMG535 | ditto | |
| CH117B | PG322 | 11/2/95 18.23 | MPMMG585 | ditto | |
| CH117B | PG323 | 12/2/95 13.28 | MPMMG615 | ditto | |

| General Non-toxic Supply Batch 1 | | | | | |
|---|---|---|---|---|---|
| Cruise | Sample id | Date/Time | Fixed Station | Determinants | Comments |
| CH117B | PG101 | 31/1/95 08.15-08.25 | T2 | 234Th | Too high SPM only 10L |
| CH117B | PG102 | 2/2/95 08.05-08.20 | T2 | 234Th | Too high SPM only 35L |

## Table 7 Concept II rowing ergometer: records

**Concept II Rowing Ergometer : Record sheet**

CH117B/95

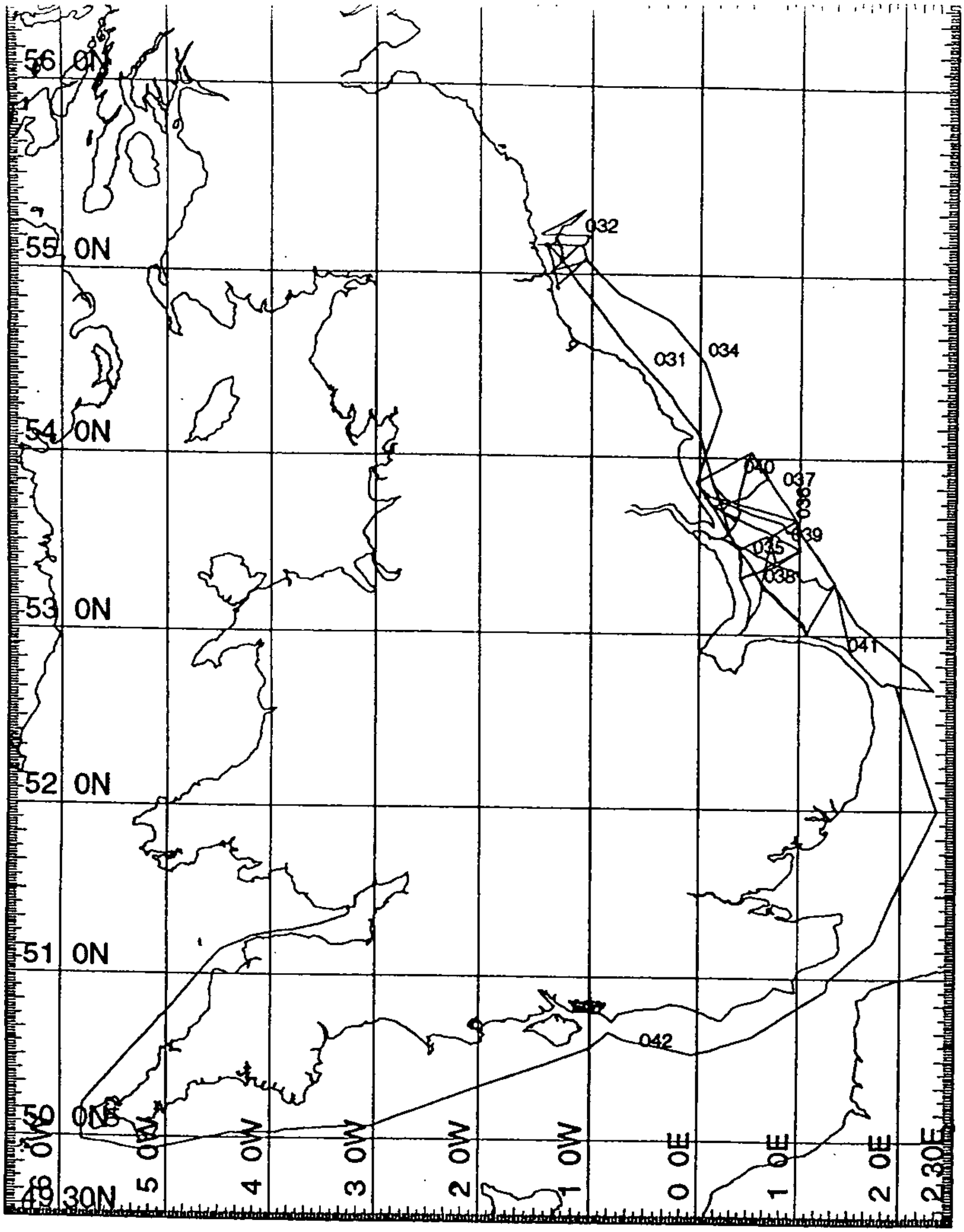
| 1K | 2.5K | 5K | 10K |
|---|---|---|---|
| 3.17 Ray Cramer (BODC) | 9.28 Neil Hudson (PML) | 19.24 Steve Widdicombe (PML) | Not attempted |
| 3.21 Steve Widdicombe (PML) | | | |
| 3.45 Neil Hudson (PML) | | | |
| 4.05 Bob Clifton (PML) | | | |
| 4.10 Tim Fileman (PML) | | | |

| 20 Min | 30 Min | 60 Min |
|---|---|---|
| 3965 Bob Clifton (PML) | 7390 Steve Widdicombe (PML) | 13894 Steve Widdicombe (PML) |
| | 6750 Ray Cramer (BODC) | |

RULES:

1. No rolling starts.
2. No stopping during record attempt.
3. Each category is a separate discipline. Split times do not count as records.

GOOD LUCK & HAPPY ROWING.



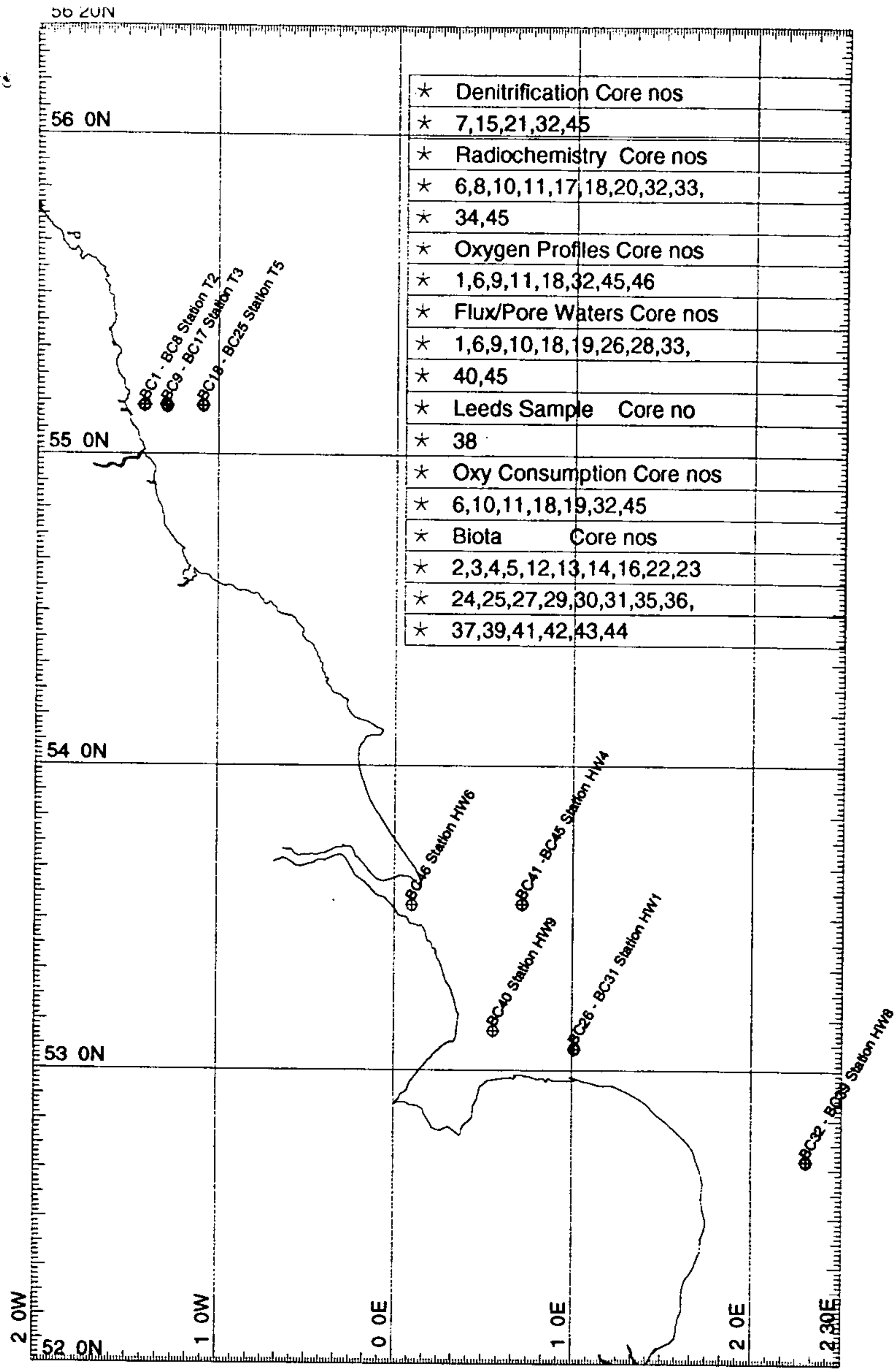

MERCATOR PROJECTION

SCALE 1 TO 5000000 (NATURAL SCALE AT LAT. 52)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 54

RRS Challenger-Cruise 117-B Cruise Track Feb 95

Figure 1 Cruise track




MERCATOR PROJECTION

GRID NO. 1

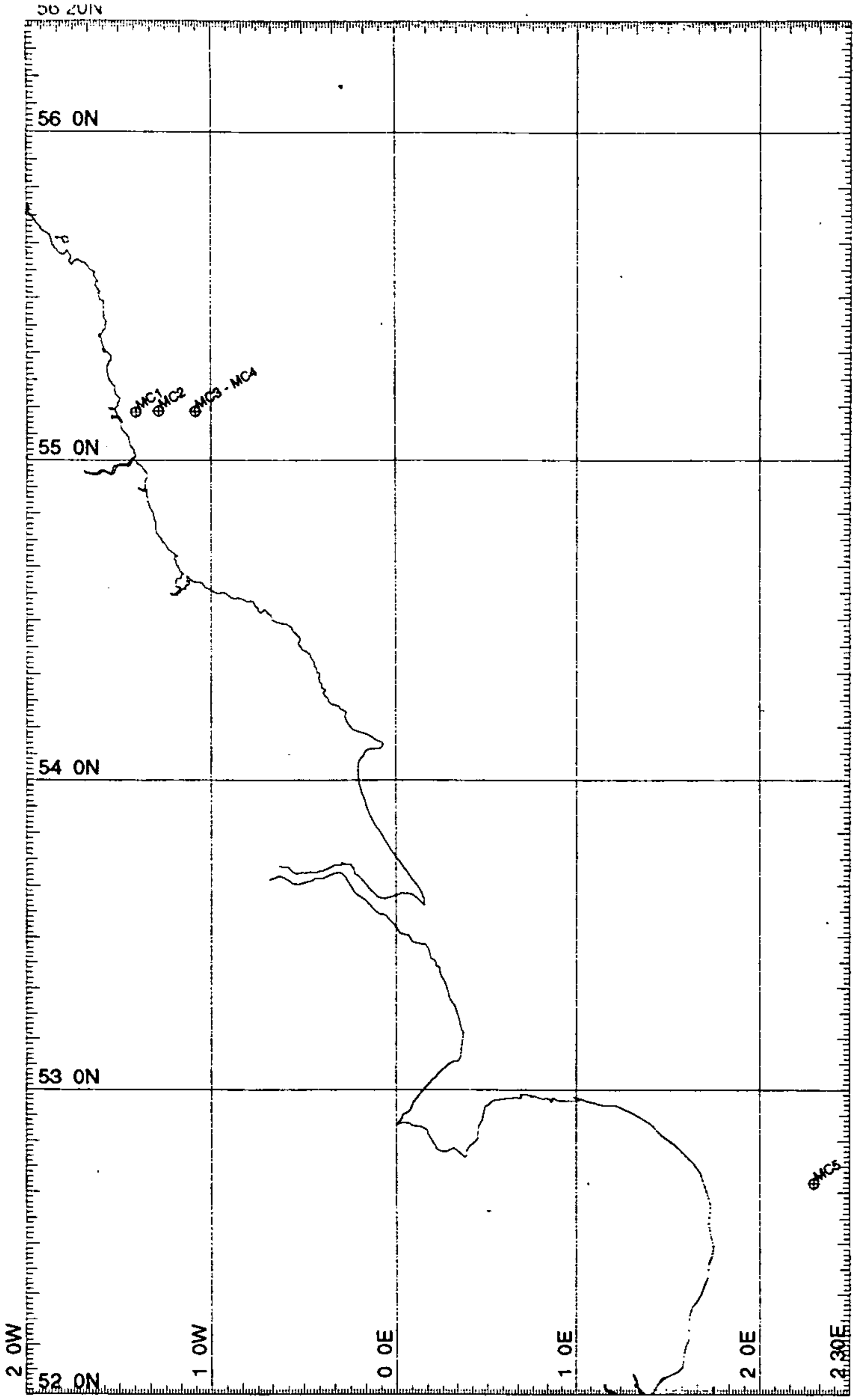
SCALE 1 TO 2000000 (NATURAL SCALE AT LAT. 52)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 52

Challenger 117B Coring Stations Feb 95

Figure 2 Box core sites & components measured

Scaled to fit




MERCATOR PROJECTION

GRID NO. 1

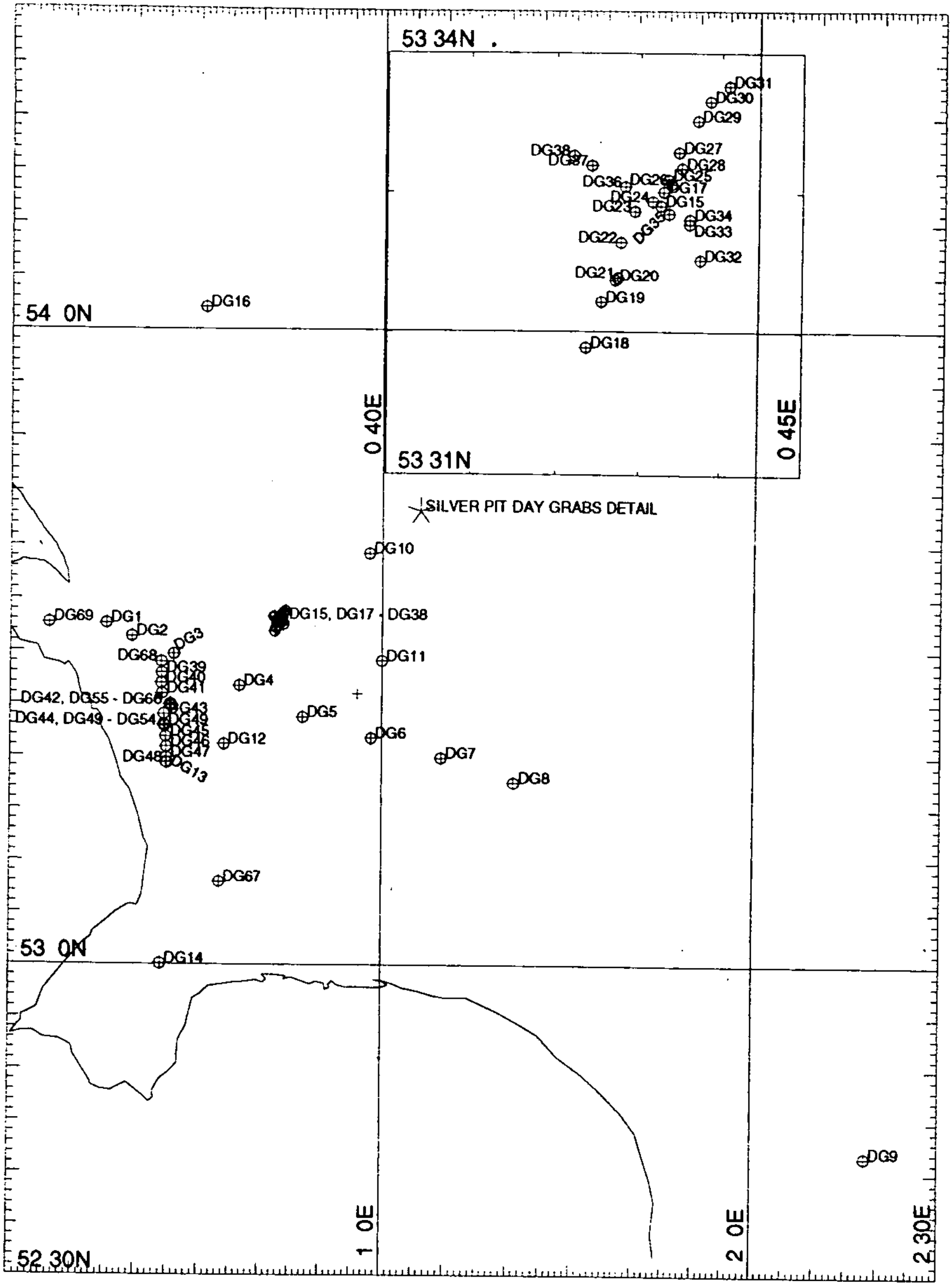
SCALE 1 TO 2000000 (NATURAL SCALE AT LAT. 52)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 52

Challenger 117B Multicore Sites Feb 95

Figure 3 Multicore sites

Scaled to fit




MERCATOR PROJECTION

GRID NO. 1

SCALE 1 TO 1000000 (NATURAL SCALE AT LAT. 52)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 52

Challenger 117B Day Grab sites Feb 95

Figure 4 Day grab sites including detail at Silver Pit site (HW4)

Scaled to fit

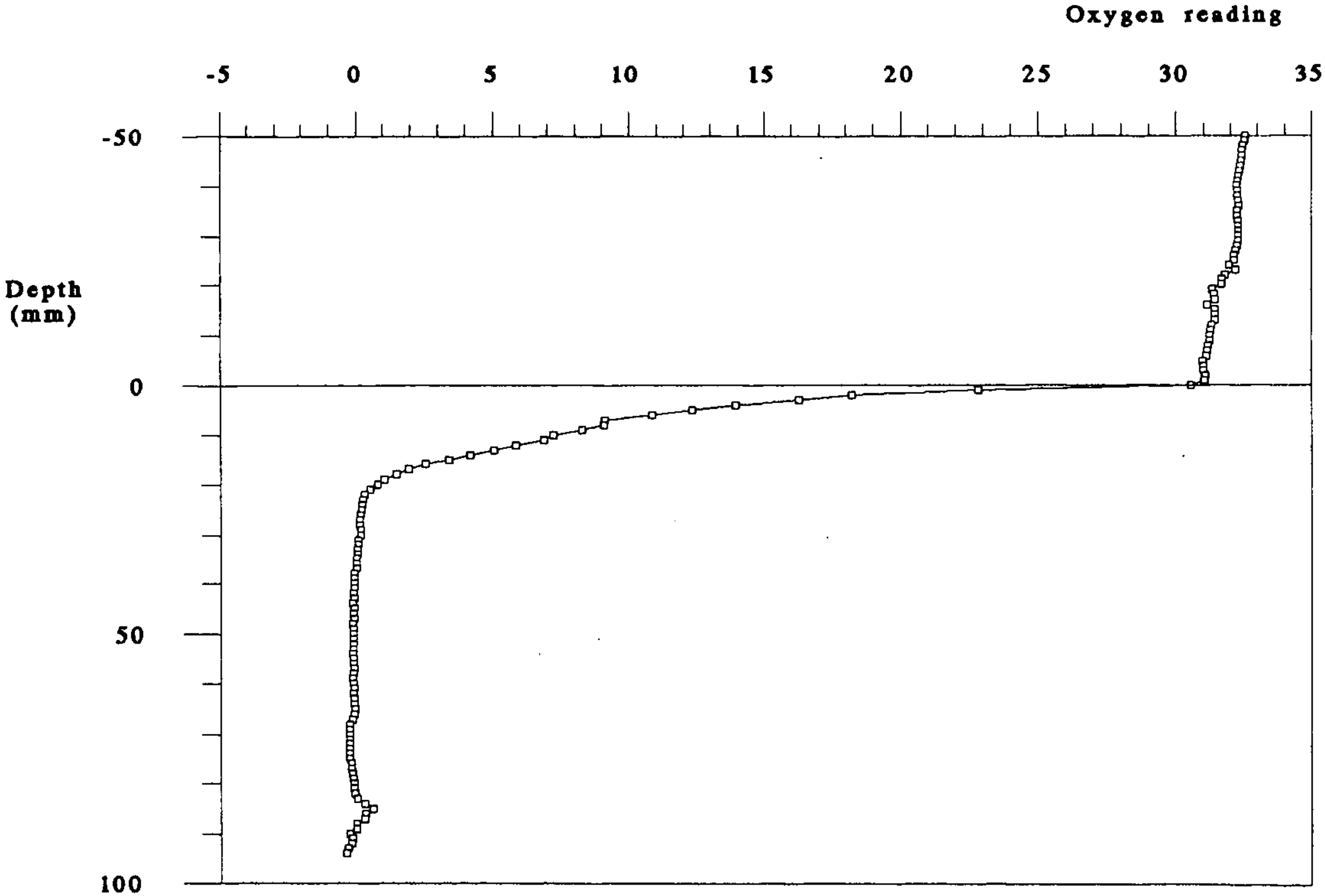



Figure 5(a) Sediment dissolved oxygen profile at site HW4

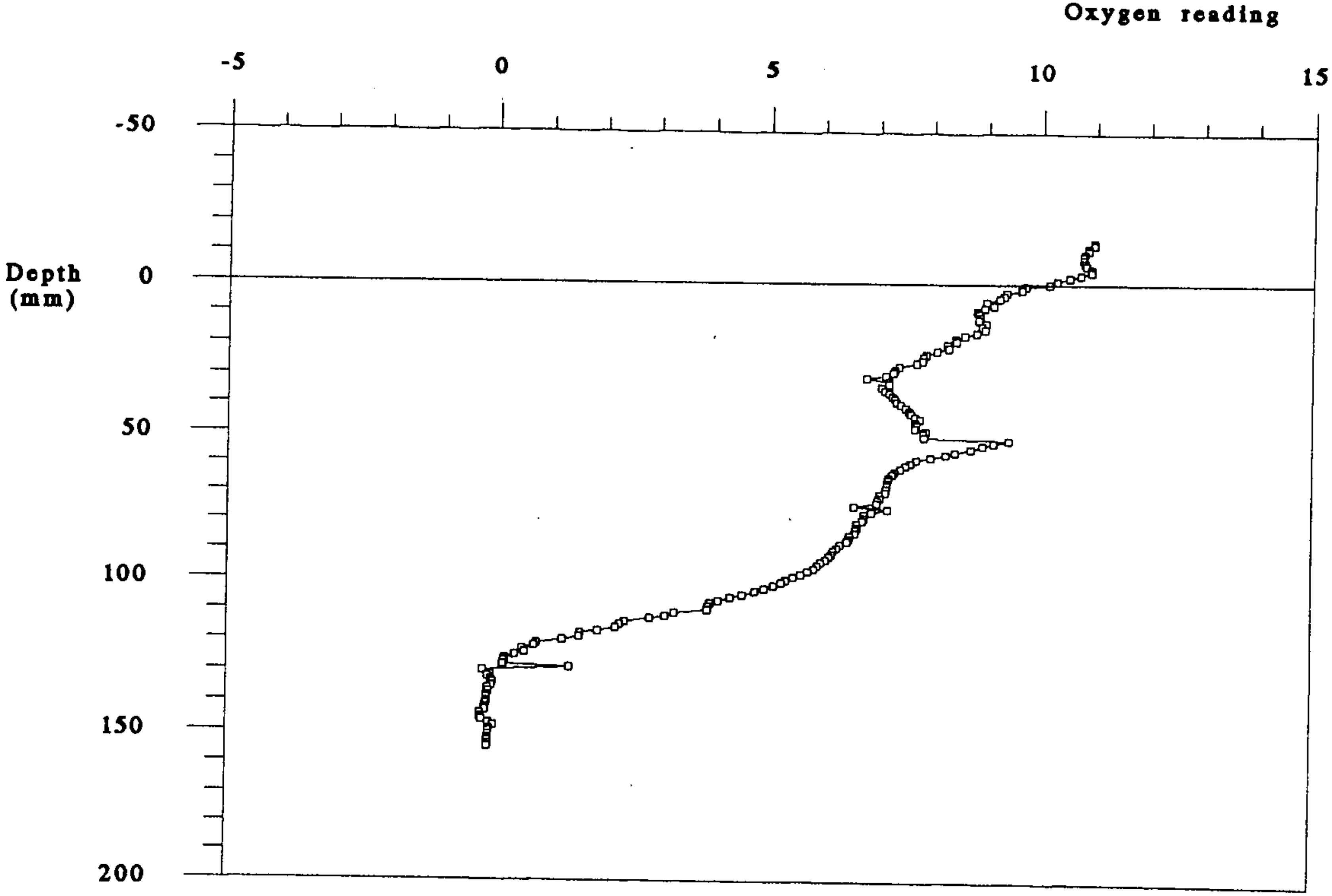
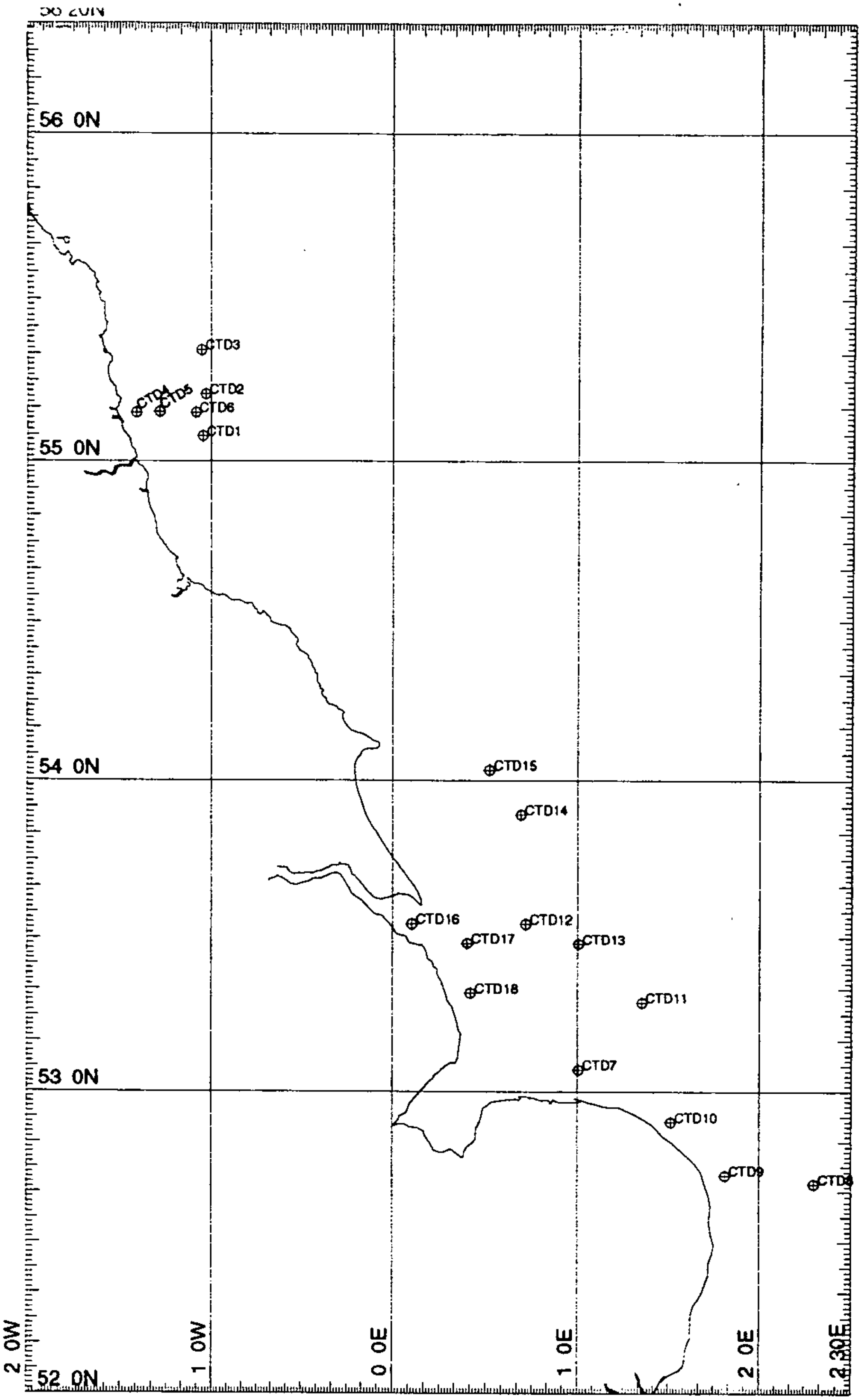



Figure 5(b) Sediment dissolved oxygen profile at site HW8




MERCATOR PROJECTION

GRID NO. 1

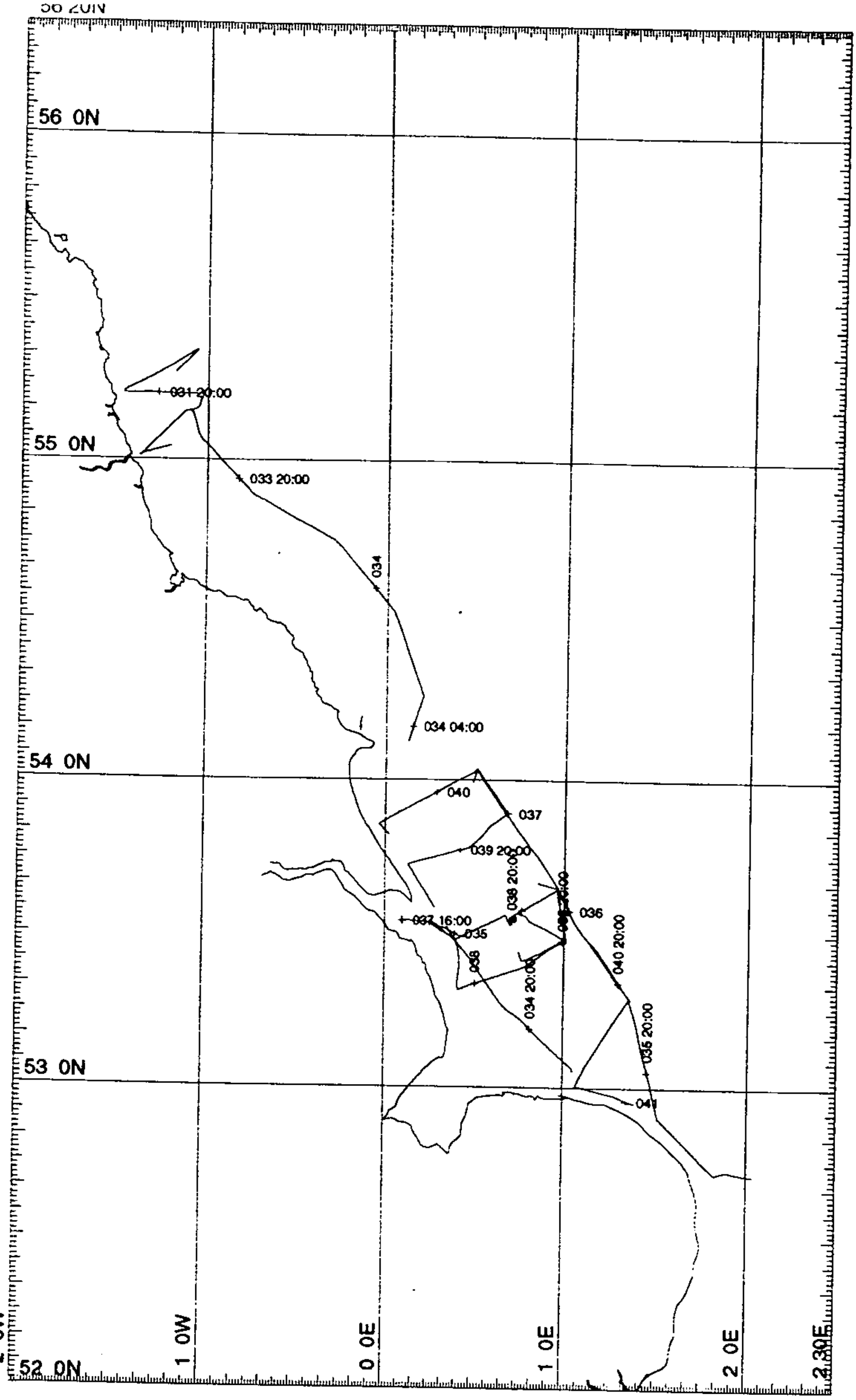
SCALE 1 TO 2000000 (NATURAL SCALE AT LAT. 52)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 52

Challenger 117B CTD Stations Feb 95

Figure 6 CTD stations

Scaled to fit




MERCATOR PROJECTION

SCALE 1 TO 2000000 (NATURAL SCALE AT LAT. 52)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 52

GRID NO. 1

Challenger 117B Nutrient Analyser Deployment Feb 95

Figure 7 Continuous nutrient analysis track

Scaled to fit

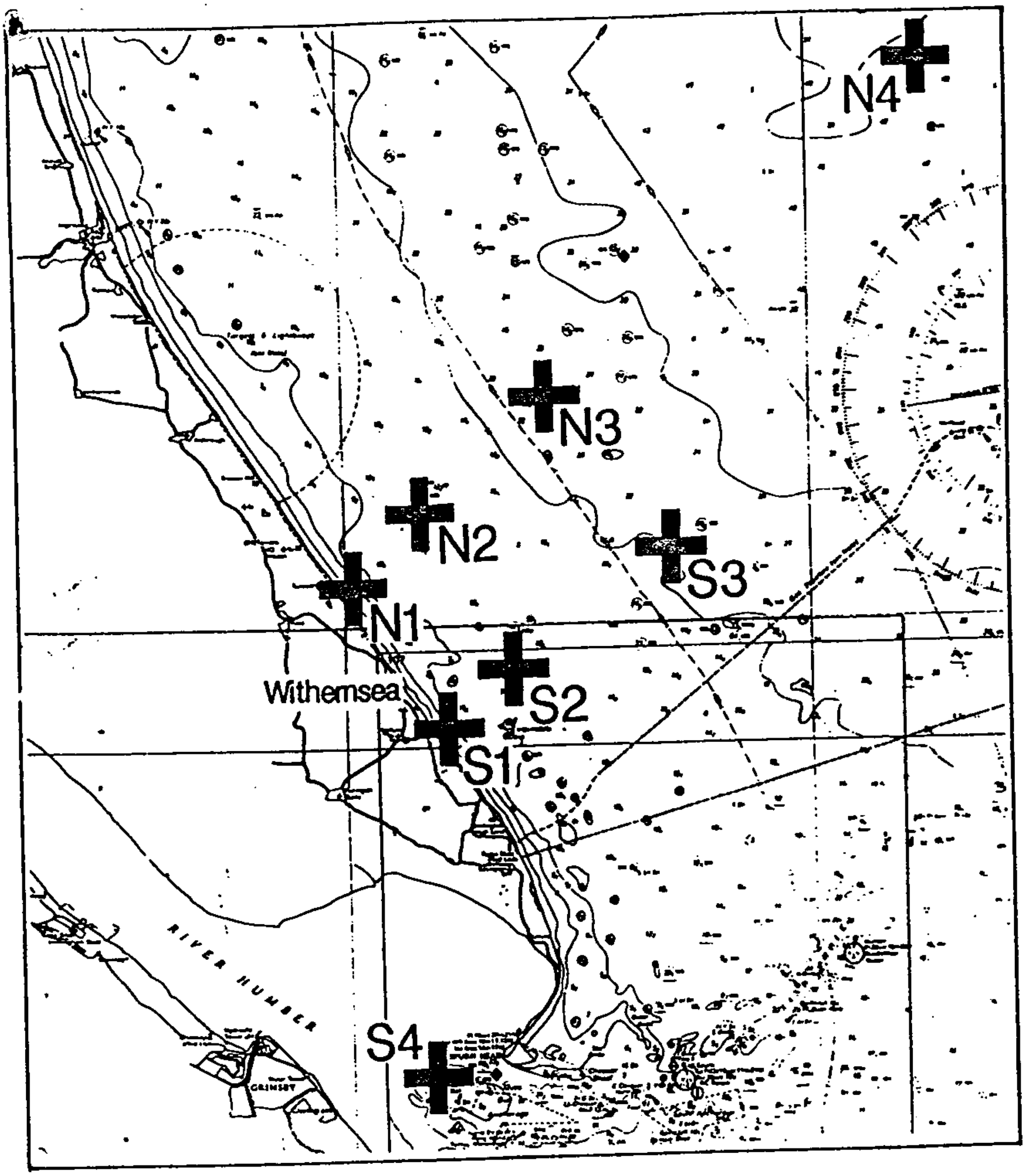



Figure 8 Mooring sites