P.O.L.

RRS "CHALLENGER"

CRUISE 72A/90

20 SEPTEMBER - 2 OCTOBER 1990

NORTH SEA SURVEY AND MOORING DEPLOYMENTS

CRUISE REPORT NO. 10

1990

NATURAL ENVIRONMENT RESEARCH COUNCIL

PROUDMAN OCEANOGRAPHIC LABORATORY

PROUDMAN OCEANOGRAPHIC LABORATORY

CRUISE REPORT NO. 10

RRS CHALLENGER

Cruise 72A/90

20 September - 2 October 1990

North Sea Survey and mooring deployments

Principal Scientist

J.M. Huthnance

1990

DOCUMENT DATA SHEET

AUTHOR

HUTHNANCE, J.M.

PUBLICATION DATE 1990

TITLE

RRS "Challenger" Cruise 72a/90, 20 September - 2 October 1990
North Sea Survey and mooring deployments

REFERENCE

Proudman Oceanographic Laboratory, Cruise Report, No. 10, 26pp.

ABSTRACT

This report describes the first leg of 'RRS *Challenger*' cruise 72, from 20 September to 2 October, Great Yarmouth to Great Yarmouth. The cruise followed on from the North Sea Project survey cruises, with the objective of obtaining data in September/October for the third consecutive year. Additionally, 13 moorings were deployed; one in the Dover Strait (where two were recovered) maintaining a year-long record; two at 'survey' sites; ten at five locations in the Rhine outflow plume preparatory to the following Cruise leg. Time spent on these moorings, the loss of two days through bad weather, and a further day lost when the CTD fell to the sea floor (and was recovered), curtailed the survey track to 6½°E in the German Bight and a single return track off eastern England. Nevertheless, 93 well-distributed CTD stations and 5 core sites were sampled, almost all instrumentation worked well and valuable data on thermocline breakdown were obtained.

ISSUING ORGANISATION

Proudman Oceanographic Laboratory
Bidston Observatory
Birkenhead, Merseyside L43 7RA
UK

Director: Dr B S McCartney

TELEPHONE
051 653 8633

TELEX
628591 OCEAN B

TELEFAX
051 653 6269

KEYWORDS

NORTH SEA
SHELF CURRENTS
TEMPERATURE
SALINITY
SEDIMENTS
PLANKTON
AIR SAMPLING
"CHALLENGER"/RRS - CRUISE (1990) 72A

CONTRACT

PROJECT
NS-21,22,31,61

PRICE

Copies of this report are available from:
The Library, Proudman Oceanographic Laboratory.

CONTENTS

Scientific Personnel

J. Huthnance	POL	Principal Scientist
G. Ballard	POL	
K. Batten (Mrs)	RVS	
D. Flatt	POL	
G. Kennaway (Mrs)	UCNW	
I. Miller	UCNW	
D. Mills	UCNW	
T. Moffatt	PSW	
N. Nelson	Essex	
D. Phillips	RVS	
M. Preston	LUDO	
T. Shabbeer	Essex	
J. Watson	DML	
R. Wilton	UCNW	

Ship's Officers

G. Long	Master
R. Chamberlin	C/O
T. Morse	2/O
T. Boult	3/O
P. Jago	C/EO
N. Wilson-Deroze	2/EO
J. Clarke	3/EO
P. Edgell	E/E
M. Trevaskis	Bos'n

Acknowledgements

The scientific party extends warm thanks to the Master, G.M. Long, Officers and crew of RRS Challenger for their help and co-operation during the cruise, and to RVS, Barry, for its support, all willingly given and making the scientific work possible.

CRUISE OBJECTIVES

1) To make underway measurements of air-sea fluxes, surface-sampled variables (temperature, salinity, transmittance, fluorescence, irradiances) and Acoustic Doppler Current Profiles, around the set "survey" track covering the southern North Sea.

2) To make CTD stations (recording temperature, conductivity for salinity, transmittance, fluorescence, dissolved oxygen, up- and down-welling irradiance as functions of depth) at 120 sites along the track, also taking water samples for calibration measurements and nutrients.

3) To deploy a current meter mooring at site G and an ADCP and thermistor chain mooring at H.

4) To take multiple cores from sites 1 to 6 and carry out benthic flux and DMS analyses thereon.

5) To deploy current-meter/transmissometer/fluorometer moorings at positions A, B, C and D north of the Rhine outflow, and met. buoy, waverider and "eta" (near-surface current) moorings at position E between A-D.

6) To recover and redeploy ADCP and P/T/C/transmissometer moorings in the Dover Strait.

NARRATIVE

RRS Challenger departed Great Yarmouth at 1040 GMT on 20th September (dates hereafter refer to September until redefined). There was a moderate sea. After dropping the pilot, logging commenced (depth through the ship's transducer), the ADCP was set and the non-toxic supply was set running. The first CTD station AA (Project station no. 3532) was reached at 1300. Stations to AD were completed by 2020 when worsening weather caused RRS Challenger to heave to.

Operations recommenced on 22nd, with a CTD station at 0620 at station AE. This was also the site of mooring G, deployed from 0720-0750 without incident. Course was continued to stations AF, AG, and AH, which was completed by 1150, and then to mooring site C north of the Rhine outflow.

At C, a CTD cast was carried out, with transmissometers and Aanderaa T/C recorders for calibration prior to inclusion on Rhine outflow moorings. Then a U-shaped mooring, with an S4 and three RCM current meters on the line with the sub-surface float, and a transmissometer, T/S logger and fluorometer attached beneath the surface toroid, was deployed without incident. A bottom-mounted ADCP was also deployed quickly nearby, thus completing the mooring array at C. At site D north of the Rhine outflow, a CTD station and U-shaped mooring deployment were likewise carried out (no fluorometer on the mooring) but an ADCP deployment was postponed owing to a suspected instrument fault.

It being now dark at 1800 after a full day's deployments, course was made for nearby CTD stations AW and AI which would otherwise have been diversions from the later cruise track, and opportunity was taken for a sustained aerosol sample heading into the wind.

Mooring site E was regained for a CTD station at 0440 during which transmissometers and T/C recorders were calibrated for later deployment. A meteorological buoy and waverider were each deployed on single-strand moorings by 0600 on 23rd without incident. An "eta" rig for two near-surface S4 current meters took longer to prepare and was deployed at 0745. Stations A and B off the Rhine were then occupied in turn, with a CTD station, U-shaped mooring (as at C, but with no fluorometer at B) and ADCP deployments at each. These sites were completed by 1045 (A) and 1340 (B) respectively. The sea state was moderate throughout, the main hindrance being the time taken for on-deck preparation of the complex U-shaped and "eta" rigs, necessarily in sequence.

Course was made to AJ on the standard survey track, CTD stations being performed here and subsequently at AK (with some damage to the sea-unit of the CTD, *q.v.*) to AP, completed at 0720 on 24th. From here RRS Challenger proceeded to the year-long site in the Dover Straits.

The position was reached at about 0950. Of the two Dover Straits moorings (*q.v.*) for recovery, the ADCP was retrieved with no difficulty; the subsurface mooring was located, switched into (acoustic) release mode but resisted firing for actual release until eventual recovery at 1530. The ADCP was redeployed at 1650, the next slack water.

There was no redeployment of the subsurface rig because the transmissometer had corroded during the previous month and there was no spare. Seas had been moderate throughout. The site was vacated at 1800.

Course was made for survey CTD stations AQ to AS which were completed in worsening conditions by 0520 on 25th. No core was attempted at this site 1 because of the sea state. However, RRS Challenger continued along the survey track; CTD stations AT and AU were omitted owing to rough seas (RRS Challenger hove to for an hour) but AV was carried out in improving conditions at 1430. No ADCP being ready, and deployment conditions being uncertain, it was decided not to revisit the Rhine outflow site D.

Course was made for AX (=AE repeated, AW having been profiled on 22nd; the passage was interrupted by a total power failure at about 1740). Stations to BB were completed by 0410 on 26th. Water samples were collected at BB, using the CTD GoFlo bottles, prior to successful use of the multi-corer at this core site 6.

An ADCP was deployed, this being also mooring site H. There being no remaining seasonal stratification evident in the CTD profiles, no thermistor chain was deployed as allowed for in cruise plans. Operations at site H were thus complete at 0530.

The standard survey track was resumed, station BC completed but at BD (0952) the CTD (*q.v.*) was lost.

A Dahn buoy was laid at the site (53°18.15'N, 04°00.12'E) as determined by Decca radar recorded on the bridge and the computer at the time, aided by the CTD pinger. RRS Challenger attended the location until 1015 on 27th when divers arrived from Den Helder. From RRS Challenger's launch maneouvred close to the Dahn buoy, the CTD was quickly located by a diver sweeping with a light line, which was then attached to the CTD cable. With a pellet and more secure line attached at the launch, the CTD was winched aboard at 1215, connections cleaned and dried, and reattachment made with the CTD winch cable. Meanwhile, the launch and Dahn buoy had been brought back on board.

The survey resumed with station BD at 1430 and continued to BF, ER where coring was successful at 2230, and through 28th to BT. Conditions were marginal for CTD operation later on 28th, but omission of BJ (by taking a short cut) and BR were through lack of any observed structure except closest to the coast, and through pressure of time.

From BT (2120 on 28th) lack of time necessitated omission of the inner German Bight; course was made for CI on the 55½°N transect, a new CTD station "GB" (0030 on 29th) being carried out to fill in the gap. Along 55½°N, stations CI to CX were occupied, and cores were taken at ES, CO and CS. Conditions improved, with only slight swell and almost no wind on 30th.

From CX (1440 on 30th), course was made direct to the near-coastal station CZ, whence the branch of survey track closest to the coast was followed to DD, DF (omitting DE) and thence in sequence to DQ, EL and so on, in good conditions throughout to AA. This (repeat) station was completed by 0250 on 2nd October, logging was stopped, and RRS Challenger put into Great Yarmouth at 0700, so finishing the cruise.

INDIVIDUAL PROJECT REPORTS

Moorings (G. Ballard, D. Flatt, R. Wilton, D. Mills)

Five sea-bed ADCPs were successfully deployed, see table. The one at the Dover Strait had first to be recovered (which was quickly done with the Benthos release system) and prepared for redeployment. A sixth planned deployment at station D had to be abandoned due to a fault in the instrument.

A "U"-shaped current meter mooring (site G), a surface-following current meter mooring ("eta"-rig), a meteorological buoy and a waverider (all at site E) were also successfully deployed, see table. The "eta"-rig has many components (shackles etc.) and therefore took a long time to prepare on deck.

A planned deployment of a thermistor string at H was not done because the water column was well mixed.

The transmissometer/current meter mooring in the Dover Strait was recovered, after considerable difficulty with the acoustics. The pinger was first heard at 1000 on 24th (shortly after arrival at the site. The ADCP's Benthos system had earlier been ranged at 4.5km). Release mode was attained but there was no response to repeated firings for actual release. Eventually, it was decided to home in and release the adjacent ADCP. Then the subsurface mooring was again brought into release mode; attempts to fire with the overside transducer failed and eventually became impractical as tidal currents caused the ship to drift quickly by; station was maintained (by steaming against the current) closely over the position of the rig as fixed by varying acoustic range and intensity, but again repeated firing with the hull transducer was to no avail. Eventually, a further attempt, drifting by with the overside transducer, proved successful. This was at 1515, ie. after about 4 hours of continual firing. Recovery was then relatively uneventful. It was clear from the shutting down procedure on board that the acoustic release was not properly responsive to transmitted signals.

This Dover Strait transmissometer mooring could not be relaid due to corrosion of window fixing screws and loss of a window retainer on the transmissometer. The data were downloaded.

Current meter / temperature & salinity / transmissometer moorings, two with fluorometers, were laid at each of the Rhine outflow sites A, B, C, D. For calibration, the fluorometers had been substituted in turn on the CTD, vertically profiling the chlorophyll fluorescence. The extracted simultaneous chlorophyll samples will be used to calibrate the fluorometers for accurate determination of chlorophyll concentration. The transmissometers and T/S loggers had also been attached to the CTD frame, allowing transferred calibration from the CTD sensors, or (usually) direct from water samples.

Underway monitoring (D. Phillips)

Several surface parameters were continuously logged: salinity, temperature, fluorescence, transmission and irradiance. The temperature and salinity were measured using a Grundy 6620 Thermosalinograph; because of the age of the instrument the scale ranges have to be changed manually. This resulted in the instrument going off scale for a few long periods. The only problem with the Chelsea fluorometer and the Sea-Tech transmissometer was during rough weather when too many bubbles were getting into the non-toxic sea water supply and causing erratic readings. Irradiance was measured using a Kipp & Sonen solimeter and 2-Pi Par irradiance meter; both of these instruments have two sets of sensors mounted on the port and starboard sides of the Monkey Island.

The ship-borne ADCP performed satisfactorily throughout.

P.E.S. and winch monitoring (D. Phillips)

The precision echo sounder was only used during the mooring work for the location and recovery of rigs. The unit used was the one in the "plot" since the main laboratory unit had a fault, later cured. It was not used during the CTD casts because the water depth was so shallow. The fish was not deployed since the hull transducer was operating satisfactorily. The readouts for the CTD/hydro winch yet again caused some concern when they would reset themselves during the occasional cast, but generally worked very well.

CTD/rosette system (D. Phillips)

93 casts were performed, but with some mishaps. At one station a bottle was damaged during recovery; a sampling tap (subsequently replaced) was knocked off the no. 6 bottle, and the oxygen connection appeared to have been loosened, subsequent readings being erratic (eventually secured).

During some of the casts, the transmissometer was giving incorrect readings; unit 116-D was changed for 80-D.

At BD (0952 on 26th) the CTD, when raised and just outside the ship's rail, fell about 4 feet. On subsequent lowering, the cable stuck for a minute or more with 8m out below the surface (as recorded by the winch meter and the BBC micro in the general lab) and broke in the winch mechanism (the remaining cable on the winch was evidence; the broken end of the cable attached to the sea-unit was seen falling from above deck level). The CTD sea unit fell to the sea bed, the ship stayed on station until divers arrived and the unit was located and recovered. On inspection after recovery, the CTD looked undamaged except for an increase in corrosion on the rosette pylon. When it was connected to the wire again, it was found that the signal from the fluorometer was faulty, but this only proved to be moisture in one of the connectors. Therefore the wire was fully reterminated and the CTD was back in use. During the cruise, the Go-Flo bottles yet again needed a lot of attention, due to silt in the ball-valve assembly. At every CTD station, a salinity bottle was taken , and digital reversing thermometers were used to calibrate the collected data. The salinity bottles were analysed using a Guildline Autosal with a PC running the SIS Autosal programme.

The recovered CTD appeared to be intact after connections had been dried. The Go-Flo bottles had collected substantial quantities of sediment and had to be cleaned out before operating correctly.

Suspended sediments (T. Moffatt)

Continuous surface profiles of optical transmission/attenuance were made along the survey track using one deck-mounted transmissometer (PSW water jacket) linked into the ship's non-toxic water supply. Vertical profiles of optical transmission/attenuance were taken at each CTD station. Calibration water samples were taken at three depths (surface, middle and bottom) at 40 stations. A total of 58 water samples from 20 stations were analysed for particle size using a model 180XY Elzone Particle Analyser.

The bracket for the RVS transmissometer water jacket had been broken on an earlier cruise, so only the PSW transmissometer was operated for underway transmission measurements. During the early part of the cruise, the PSW transmissometer housing became "detached" from the deck as a consequence of a direct hit by a wave. Fortunately, the transmissometer continued to work, and the housing was lashed down and made secure. The housing will be re-mounted for the subsequent legs. Owing to the rough weather, the underway transmission measurements experienced some considerable "air bubble" interference.

The optical transmission/attenuance observations seem to show the now well-established distribution pattern of suspended sediments for this time of year. The highest turbidities and suspended sediment concentrations are associated with the coastal waters off East Anglia and in the Humber plume. There is evidence for the development of the plume emanating from the East Anglian high-turbidity zone, transporting sediment across the northern part of the Southern Bight. Off the continental European coast, high turbidities were encountered at the Rhine mooring sites. This suggests the presence of the Rhine plume which is transporting sediment northwards, along the coastline. Variations with water depth are consistent with previous surveys. For much of the survey area, the water column is well-mixed, giving fairly uniform concentration profiles with depth. However, some stations show higher concentrations near the bottom. These are resuspension events associated with the prevailing rough weather.

Nutrients (I. Miller)

The analytical system was provided by UEA. It is linked via an ADC to a PC, with software for peak height analysis and data logging. It has been used on previous North Sea Project cruises. After some modification at sea, adequate analytical systems were available for silicate, phosphate and nitrite. The nitrate and ammonium systems caused problems throughout the cruise.

Analyses were carried out on surface, mid-water and bottom samples from all CTD stations bar two (when watch personnel were ill). Data were obtained for nitrite, silicate and phosphate (but not transferred to disc), but adequate nitrate and ammonium data were not obtained during the cruise. All samples were frozen for nitrate and ammonium analysis within about a week after return ashore - not ideal, especially with respect to ammonium.

The nitrate system suffered from an unstable and nitrate-contaminated base line. Tests on the system indicated the reagents rather than the water were the problem. However, over the ten days of the cruise, the contamination declined; it appears that the cadmium/copper column may have been the problem. Nothing could be done at sea to solve the reagent or column problems.

The ammonium system was hindered by lack of ammonium-free water for reagents and wash water. UEA were unable to provide clean water, and the ship's still water is unsuitable. In addition, during the 1½ hours that samples are exposed on the sample carousel, considerable amounts of ammonia are taken up from the laboratory atmosphere. Despite good linear calibration curves, sample reproducibility was poor, indicating variable contamination.

High nutrient levels were prevalent in the wash water. In the case of ammonium, this was principally owing to lack of analytically clean water. Sodium chloride (artificial sea water) is used as a wash/baseline, to avoid refraction problems in the photometer cells giving spurious optical densities. Despite using high-purity analytical-grade (ANALAR) sodium chloride, high levels of silicate and some phosphate and nitrite were found in the wash/baseline water. Ammonium and silicate levels were considerably higher in the wash/baseline water than in the sea water samples, producing negative peaks during analysis.

The software for peak-height analysis cannot treat negative peaks; all analytical records were analysed by hand - very time-consuming.

Linking the recorders to the ADC required novel wiring to achieve a positive digital output with a positive recorder output. On some systems, neutral to positive wiring was required - however, this was not consistent.

Chlorophyll (D. Mills)

At each survey site, water samples were collected from at least 3 depths for determination of chlorophyll-a and phaeopigment concentration. Samples were filtered and then extracted in acetone prior to measurement of pigment concentration on board.

The recording fluorometers deployed at moorings A and C will record hourly changes in chlorophyll fluorescence and hence phytoplankton biomass.

Phytoplankton (G. Kennaway)

The main objectives were (i) to preserve surface water samples for subsequent species identification and enumeration (ii) to examine and make a video record of the species composition of live samples.

Surface water samples were taken from alternate CTD casts and preserved in Lugols iodine and formalin for subsequent numerical and taxonomic analysis. Samples of live plankton were concentrated by filtraton through a 10μm nylon mesh and examined under the microscope at 1000× magnification using differential interference contrast.

Samples from the Dover Straits showed that diatoms (Rhizosolenia sp, Coscinodiscus sp.) were dominant. In the southern German Bight, diatoms (Eucampia sp, Chaetoceros sp, Biddulphia sp.), the coccolithophorid E. huxleyi and dino-flagellate cysts were common among the plankton. Further concentration of live samples by centrifugation (2 minutes at 2000 rpm) did not cause the disintegration of the coccolithophores. Epifluorescence (with blue excitation 450-490nm and a 520nm barrier filter) was used to distinguish between heterotrophic and autotrophic organisms. Micro-flagellate numbers were low and there was no evidence of autotrophic microflagellates in the live samples examined. Due to rough weather conditions only 25 minutes of film was taken.

The microscope and video unit will provide a useful tool for taxonomic identification of species that either disintegrate or distort beyond recognition on fixation. Some modifications are required to dampen engine vibrations.

Reduced sulphur gases: sediments, seawater, exchange (T. Shabbeer)

A Perkin Elmer F17 gas chromatograph equipped with a sulphur-sensitive Flame Photometric Detector (FPD) was used in line with a cryogenic purge and trap technique, to detect reduced sulphur gases such as H_2S, COS, CH_3SH, CS_2 and DMS (dimethyl-sulphide) in seawater, air and sediments. Samples were obtained from 5 stations (BB, ER, ES, CO and CS, see table).

Seawater was collected from different depths using CTD water bottles, while intact sediment cores were obtained using a SMBA multi-corer. Seawater samples were analysed immediately, and measurements made for the precursor of DMS, dimethylsulphoniopropionate (DMSP).

Intact sediment cores were placed in a water bath (at the same temperature as bottom water) and clean air bubbled through water enclosed above the sediment surface in each of three cores. These were left to equilibrate overnight in order to gain a constant flux across the sediment / water interface. Air samples exiting each core were then simultaneously cryogenically trapped, stored and analysed to determine a flux rate.

Sediment samples were also frozen from each site, so that in situ concentrations of sulphur gases could be determined at a later date.

Atmospheric constituents (N. Nelson)

Objectives were (i) to obtain samples of atmospheric chlorides, nitrates, sulphates and ammonium ions using filter packs (ii) to collect samples of atmospheric constituents to determine concentration levels of nitric acid, hydrogen chloride, and sulphur dioxide using the denuder tube method (iii) to measure continuously levels of nitrogen dioxide, ozone and peroxyacetylnitrate (PAN).

(i) Running the filter packs was quite straightforward with no real complications. By the end of the cruise, 21 samples had been collected. Occasionally, access to the filter pack probe was prohibited due to very rough sea conditions. As with all the sampling, information regarding the ship's position, wind speed and direction and ambient temperature were recorded throughout the sampling periods.

(ii) The denuder tube method had been very difficult on cruise 66 leg 1, and some design alterations had since been incorporated. Although the process of cleaning, drying and coating the tubes was very time-consuming, the actual extraction process (which caused most of the previous problems) seemed to run more smoothly. In all, 6 extraction and filter samples were obtained. Most of the practical problems had been eradicated; the minor problems associated with technique will hopefully diminish with more experience.

(iii) Continuous monitoring used sampling probes extending at least 1m from the starboard side of the ship. Ambient levels of ozone, PAN and nitrogen dioxide were analysed. The use of a Condensation Nuclei Counter was also incorporated to help identify periods of high contamination due to funnel smoke. These instruments were run continuously except for a short period when the ship encountered prevailing winds from the starboard side and thus picked up much funnel smoke contamination.

Trace organic compounds in the North Sea atmosphere (M. Preston)

The primary objective of this work was to test the suitability of two newly acquired air sampling units for marine conditions. These units consisted of Sierra Anderson cascade impactor and high volume/semi-volatiles collectors housed in a custom made wooden box. This box was sited on the deckhouse top in the position previously occupied by the Liverpool University atmospheric group "Green Box" pump housing.

The atmospheric components to be analysed include saturated hydrocarbons and PAH. If time and facilities permit this will be extended to chlorinated pesticides and PCBs. As such the work represents a logical extension of the North Sea Special Topic programme and will in fact provide some important information pertinent to attempts to translate atmospheric concentrations of trace organic compounds to the depositional fluxes required by the North Sea modelling exercise.

As will be clear from the main body of the report, this cruise was seriously affected by both the prevailing weather conditions and the loss of the CTD. Atmospheric sampling was limited to only a few hours for the first week of the cruise though it was gratifying to note that the specially constructed housing (The Beehive) stood up very well to the battering that it received and that the sampling units inside remained well protected.

After the loss of the CTD the ship remained on station close to the site which provided an excellent opportunity for sampling under near ideal conditions. This went some way to make up the shortfall in the previous sampling periods,

Altogether 5 high volume, 4 semi-volatile and 1 (x 7) cascade impactor samples were collected representing in total some 160 hours of pumping time. Under the difficulties that prevailed during the cruise this was considered to be a very satisfactory result. Data generated during the cruise will eventually be placed in the BODC North Sea data base.

<u>Computing</u> (K. Batten)

The computer system aboard Challenger for this cruise consisted of the RVS 'ABC' system. Data were logged from various instruments: em log, gyro, Decca navigator, MX1107 satellite navigator, light meters, solar integrator, thermosalinograph, fluorometer and transmissometer, Simrad depth recorder, Acoustic Doppler Current Profiler (ADCP) and the CTD.

Multiple plots were produced of each CTD dip, of various transects of CTD dips and ADCP data. Plots of the surface samples, light sensor readings and depth records, and cruise track were produced daily.

At the end of the cruise various items were produced: surface contours of temperature, salinity, fluorescence and transmittance; cruise track charts; charts of station positions and lists of station information.

The computer system worked well throughout the cruise.

CTD Station List

Stn No.	Code	Year	Day	Time	Start Latitude N	Longitude	Depth	End Day	Time	End Latitude N	Longitude	Depth	Comment
3532	AAA	1990	263	1314	52 43.47	01 55.55E	29	263	1324	52 43.82	01 55.21E	32	Dwirr cap on
3533	ABA	1990	263	1545	52 41.22	02 24.80E	50	263	1558	52 41.65	02 24.88E	52	
3534	ACA	1990	263	1758	52 39.99	02 50.16E	46	263	1811	52 40.12	02 50.41E	46	
3535	ADA	1990	263	2008	52 37.80	03 15.25E	34	263	2017	52 37.54	03 15.38E	34	
3536	AEA	1990	265	0615	52 37.04	03 46.30E	32	265	0625	52 37.04	03 46.40E	29	only 1,2 up fired
3537	AFA	1990	265	0853	52 36.88	03 59.93E	26	265	0905	52 36.69	03 59.88E	26	only 1,3 up fired
3538	AGA	1990	265	1034	52 36.92	04 19.77E	22	265	1041	52 36.65	04 19.50E	22	
3539	AHA	1990	265	1137	52 34.23	04 08.87E	26	265	1146	52 33.95	04 08.78E	26	
3540	MCA	1990	265	1404	52 15.82	04 13.41E	19	265	1433	52 15.76	04 13.81E	21	20min at 5m depth
3541	MDA	1990	265	1725	52 10.04	04 14.93E	18	265	1734	52 10.11	04 15.10E	18	
3542	AWA	1990	265	2016	52 20.97	03 59.81E	24	265	2023	52 20.90	03 59.81E	24	
3543	AIA	1990	265	2205	52 27.96	03 41.93E	31	265	2209	52 27.65	03 41.85E	32	
3544	MEA	1990	266	0448	52 12.40	04 09.93E	22	266	0517	52 12.65	04 10.94E	20	20min at 5m depth
3545	MAA	1990	266	0822	52 08.98	04 06.00E	22	266	0829	52 08.96	04 06.00E	21	
3546	MBA	1990	266	1138	52 15.03	04 03.89E	21	266	1152	52 14.85	04 03.84E	23	
3547	AJA	1990	266	1722	52 21.61	03 16.02E	37	266	1729	52 21.61	03 16.30E	34	
3548	AKA	1990	266	1933	52 15.10	02 49.87E	40	266	1942	52 15.17	02 49.77E	42	O_2 loosen? no6tap
3549	ALA	1990	266	2144	52 09.94	02 20.06E	53	266	2155	52 09.63	02 19.86E	45	
3550	AMA	1990	266	2354	52 04.77	01 49.65E	27	267	0005	52 04.15	01 49.21E	28	
3551	ANA	1990	267	0151	51 46.99	01 46.83E	30	267	0203	51 46.88	01 46.78E	29	
3552	AOA	1990	267	0406	51 29.98	01 44.96E	38	267	0415	51 30.10	01 45.30E	39	
3553	APA	1990	267	0706	51 11.03	01 34.19E	52	267	0716	51 10.88	01 34.09E	52	
3554	MDS	1990	267	1617	50 55.56	01 15.62E	36	267	1622	50 55.58	01 15.67E	34	bottom sample only
3555	AQA	1990	267	2149	51 02.47	01 48.30E	30	267	2157	51 02.20	01 47.99E	30	
3556	ARA	1990	268	0255	51 28.09	02 40.16E	34	268	0304	51 28.03	02 40.45E	34	
3557	ASA	1990	268	0509	51 44.96	03 00.06E	34	268	0518	51 44.99	03 00.19E	32	samples at 5depths
3558	AVA	1990	268	1427	52 12.96	03 51.90E	23	268	1434	52 12.86	03 51.88E	25	
3559	AXA	1990	268	1828	52 37.50	03 45.86E	32	268	1835	52 37.60	03 46.00E	27	
3560	AYA	1990	268	2016	52 47.08	03 37.04E	32	268	2024	52 47.25	03 37.01E	30	
3561	AZA	1990	268	2211	53 00.05	03 26.01E	28	268	2219	52 59.89	03 25.98E	29	

3562	BAA	1990	269	0010	53 12.02	03 16.02E	27	269	0018	53 11.76	03 15.88E	27	
3563	BBD	1990	269	0354	53 30.15	02 59.92E	31	269	0403	53 30.15	02 59.50E	31	
3564	BCA	1990	269	0729	53 24.75	03 26.98E	29	269	0738	53 24.87	03 27.04E	29	
3565	BDA	1990	269	0951	53 18.05	04 00.09E	28	269	0952	53 18.15	04 00.12E	28	CTD fell from 8m
													new calibration should be used hereafter
3566	BDA	1990	270	1421	53 17.94	03 59.96E	28	270	1432	53 17.70	03 59.80E	27	only 1 bottle shut
3567	BDA	1990	270	1453	53 17.38	03 59.83E	28	270	1500	53 17.20	03 50.78E	28	
3568	BEA	1990	270	1639	53 13.20	04 20.10E	30	270	1646	53 13.00	04 19.90E	30	
3569	BFA	1990	270	1805	53 09.88	04 37.14E	21	270	1811	53 09.70	04 37.00E	22	
3570	ERD	1990	270	2209	53 37.02	04 35.80E	30	270	2220	53 37.09	04 35.74E	30	
3571	BGA	1990	270	2330	53 38.96	04 50.11E	31	270	2340	53 38.86	04 50.10E	31	
3572	BHA	1990	271	0128	53 54.90	04 50.12E	41	271	0137	53 54.82	04 50.34E	41	no stratification
3573	BIA	1990	271	0352	54 14.99	04 49.72E	46	271	0402	54 14.90	04 49.50E	47	no stratification
3574	BKA	1990	271	0543	54 19.07	05 14.96E	43	271	0552	54 18.90	05 14.80E	44	
3575	BLA	1990	271	0810	54 03.00	05 40.03E	37	271	0819	54 03.00	05 39.90E	36	
3576	BMA	1990	271	0921	53 56.45	05 49.97E	33	271	0929	53 56.41	05 49.94E	32	
3577	BNA	1990	271	1030	53 50.00	06 00.00E	28	271	1037	53 49.92	06 00.04E	29	
3578	BOA	1990	271	1227	53 39.00	06 09.98E	27	271	1234	53 38.94	06 10.26E	25	
3579	BPA	1990	271	1400	53 42.99	06 30.05E	22	271	1405	53 43.06	06 30.31E	23	
3580	BQA	1990	271	1551	53 54.98	06 24.86E	26	271	1557	53 55.01	06 25.15E	26	
3581	BSA	1990	271	1911	54 20.04	06 24.86E	38	271	1921	54 20.06	06 24.63E	38	
3582	BTA	1990	271	2113	54 35.01	06 25.05E	38	271	2123	54 35.01	06 24.51E	39	
3583	GBA	1990	272	0027	55 01.86	06 27.33E	46	272	0036	55 01.61	06 27.74E	46	
3584	CIA	1990	272	0352	55 30.07	06 29.92E	42	272	0401	55 29.90	06 30.30E	44	
3585	ESD	1990	272	0613	55 29.84	06 05.85E	50	272	0625	55 29.57	06 06.09E	50	
3586	CJA	1990	272	0712	55 30.01	05 59.94E	51	272	0723	55 29.98	05 59.80E	50	
3587	CKA	1990	272	0954	55 29.99	05 29.99E	52	272	1006	55 30.03	05 29.91E	52	
3588	CLA	1990	272	1228	55 30.03	04 59.08E	44	272	1235	55 30.04	04 59.16E	44	
3589	CMA	1990	272	1441	55 30.01	04 31.25E	32	272	1449	55 29.93	04 31.38E	33	
3590	CNA	1990	272	1750	55 30.00	03 44.99E	44	272	1758	55 29.90	03 45.10E	34	
3591	COD	1990	272	2006	55 29.98	03 10.02E	36	272	2017	55 29.92	03 09.38E	36	
3592	CPA	1990	272	2231	55 29.90	02 34.88E	48	272	2244	55 29.90	02 34.80E	48	
3593	CQA	1990	273	0041	55 29.86	02 02.19E	67	273	0056	55 29.79	02 02.13E	67	
3594	CRA	1990	273	0315	55 30.03	01 25.14E	76	273	0327	55 30.20	01 25.10E	75	
3595	CSD	1990	273	0524	55 29.98	00 54.13E	85	273	0539	55 30.17	00 53.70E	82	

3596	CTA	1990	273	0741	55 30.03	00 23.97E	74	273	0752	55 30.08	00 23.89E	74
3597	CUA	1990	273	0932	55 30.00	00 04.00W	74	273	0943	55 29.97	00 04.03W	74
3598	CVA	1990	273	1124	55 29.98	00 32.15W	64	273	1138	55 29.81	00 32.41W	63
3599	CWA	1990	273	1258	55 30.02	00 52.05W	92	273	1314	55 29.92	00 52.16W	96
3600	CXA	1990	273	1431	55 30.00	01 12.05W	88	273	1445	55 29.82	01 12.15W	90
3601	CZA	1990	273	1612	55 19.97	01 29.79W	41	273	1623	55 19.97	01 29.90W	41
3602	DAA	1990	273	1733	55 10.01	01 26.99W	37	273	1741	55 10.10	01 26.99W	37
3603	DBA	1990	273	1859	55 00.02	01 17.97W	41	273	1908	55 00.10	01 18.20W	40
3604	DCA	1990	273	2031	55 00.00	00 56.86W	83	273	2047	55 00.14	00 57.09W	83
3605	DDA	1990	273	2207	55 00.03	00 35.94W	72	273	2222	55 00.01	00 35.80W	71
3606	DFA	1990	273	2318	54 51.94	00 33.09W	65	273	2333	54 51.72	00 33.16W	65
3607	DGA	1990	274	0101	54 44.04	00 50.95W	57	274	0112	54 43.90	00 50.60W	56
3608	DHA	1990	274	0212	54 39.00	01 03.00W	28	274	0219	54 38.85	01 02.95W	27
3609	DIA	1990	274	0301	54 38.79	00 53.17W	45	274	0310	54 38.60	00 53.30W	46
3610	DJA	1990	274	0418	54 34.94	00 36.99W	51	274	0428	54 34.70	00 37.60W	50
3611	DKA	1990	274	0540	54 30.93	00 21.13W	58	274	0551	54 31.00	00 21.50W	58
3612	DLA	1990	274	0727	54 26.00	00 00.04W	59	274	0738	54 26.20	00 00.40W	58
3613	DMA	1990	274	0922	54 19.98	00 24.01E	59	274	0931	54 19.99	00 23.67E	61
3614	DNA	1990	274	1041	54 09.96	00 23.96E	56	274	1050	54 09.88	00 23.86E	56
3615	DOA	1990	274	1220	53 55.04	00 23.87E	49	274	1229	53 54.76	00 23.97E	48
3616	DPA	1990	274	1352	53 39.82	00 24.13E	23	274	1359	53 39.40	00 24.23E	22
3617	DQA	1990	274	1454	53 30.00	00 24.05E	17	274	1500	53 29.82	00 24.12E	18
3618	ELA	1990	274	1602	53 19.81	00 30.06E	18	274	1608	53 19.60	00 30.06E	18
3619	EMA	1990	274	1714	53 09.97	00 31.02E	23	274	1721	53 09.97	00 31.20E	23
3620	ENA	1990	274	1802	53 05.01	00 30.06E	34	274	1809	53 05.01	00 30.20E	33
3621	EOA	1990	274	1950	53 13.10	00 47.04E	22	274	1955	53 13.24	00 47.15E	21
3622	EPA	1990	274	2138	53 00.99	01 03.84E	16	274	2142	53 00.94	01 03.64E	16
3623	EQA	1990	274	2324	53 00.90	01 26.30E	28	274	2331	53 00.65	01 25.57E	26
3624	AAA	1990	275	0233	52 43.13	01 55.88E	27	275	0241	52 43.32	01 55.94E	27

Station codes refer to the site (first two letters) and to the observations there (last letter: A - CTD and water bottles; D - CTD, water bottles and cores). Unless otherwise stated, samples were obtained near-surface, at mid-depth and near-bottom for nutrients, chlorophyll and suspended sediment, and near-bottom also for salinity. The near-bottom temperature was also recorded by reversing thermometers. For stations 3532 to 3536, fluorometer SA109 was fitted and bottles fired at six depths; likewise 3537 to 3541 with fluorometer SA113; this was to calibrate these fluorometers for their subsequent use on moorings C, A. Subsequently, fluorometer SA246 was fitted and 2 bottles fired at each of near-bottom, mid- and near-surface levels.

Core Station List

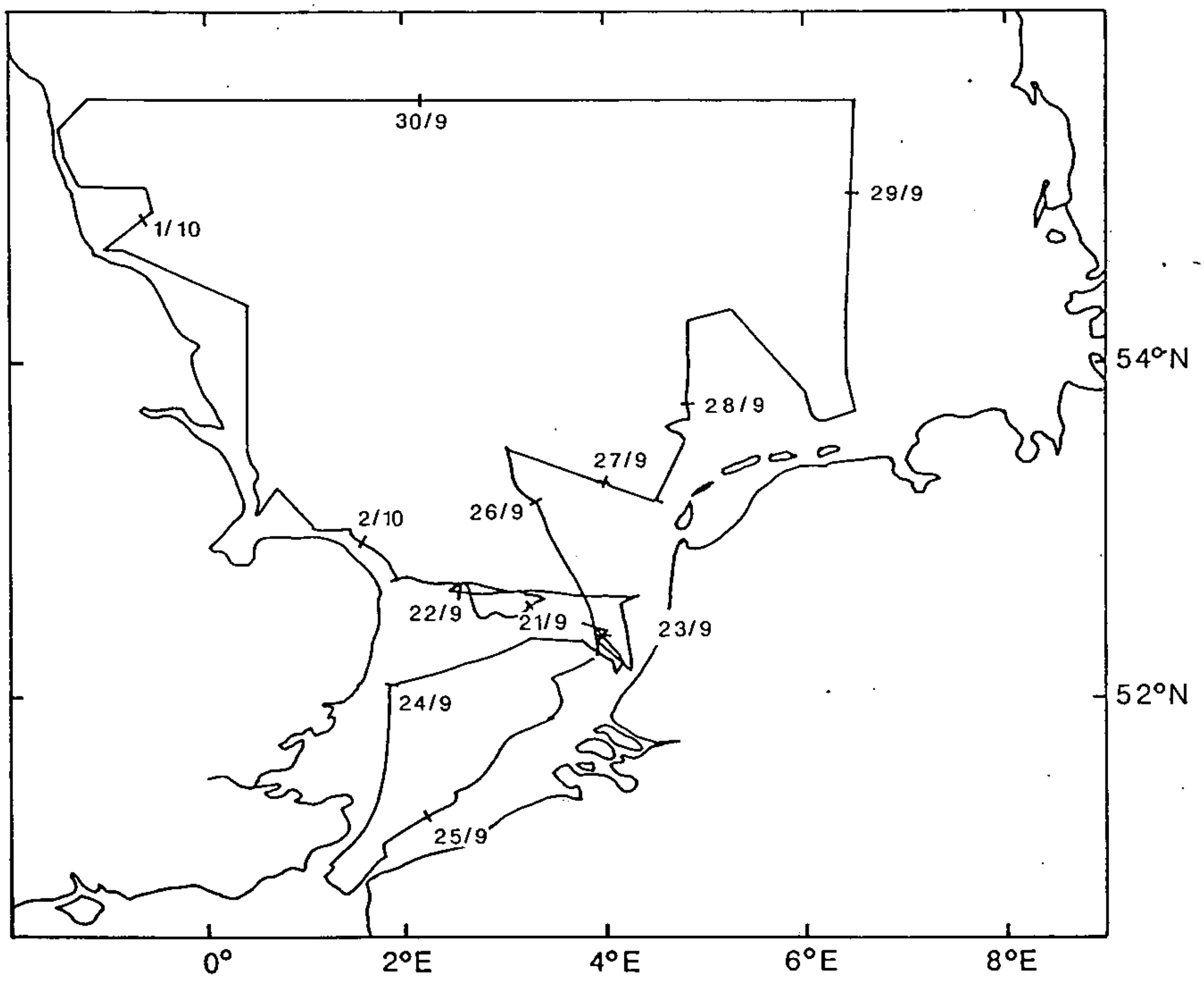
Core Site No.	Date	Time	Latitude N	Longitude E	Water Depth m	Tubes Deployed	Cores Obtained	Comments
2	27/09/90	2229	53 37.01	04 36.02	30	6	6	6 good cores 3 layers, anoxic
3	29/09/90	0631	55 29.60	06 05.97	50	6	6	2 not capped below anoxic mud
CO	29/09/90	2023	55 29.92	03 09.60	37	6	4	4 good cores shell fragments
4	30/09/90	0550	55 29.93	00 54.57	84	6	6	6 good cores no apparent structure
6	26/09/90	0501	53 31.02	02 59.04	31	6	6	6 good cores, anoxic one with sea urchin

Table

Moorings and Bottom Mounted Instruments

Mooring Code	Latitude N	Longitude E	Water Depth m	Time/date recovered	laid	Instrument	Height m
A	52 08.92	04 05.86	21		1000, 23/09/90	Tr #3,T/S#8240	on
						Fl SA113	toroid
						S4#05451262	surface-1
						RCM#3257	12
						RCM#3261	8
						RCM#9652	4
A	52 08.89	04 05.50	21		1042, 23/09/90	POLDOP#6A	0.5
						WLR#444	
						Acoustics#44021/7A	
B	52 14.89	04 03.91	21		1252, 23/09/90	Tr #4,T/S#5228	on toroid
						S4#05451264	surface-1
						RCM#9680	11
						RCM#9634	7
						RCM#3308	3
B	52 14.88	04 03.72	21		1338, 23/09/90	POLDOP#2A	0.5
						WLR#500	
						acoustics#40258/1B	
C	52 16.21	04 13.36	21		1519, 22/09/90	Tr #1, T/S#6275,	on
						Fl #109	toroid
						S4#05111117	surface-1
						RCM#6749	11
						RCM#5913	7
						RCM#9643	3
C	52 16.63	04 13.58	21		1528, 22/09/90	POLDOP#4A	0.5
						WLR#915	
						acoustics#44056/5A	

D	52 10.12	04 15.19	18		1800, 22/09/90	Tr #2,T/S#6941	on toroid
						S4#05451263	surface-1
						RCM#9650	9
						RCM#9632	6
						RCM#7063	3
E	52 12.49	04 08.97	22		0543, 23/09/90	POL Met buoy	surface
E	52 12.32	04 08.97	22		0557, 23/09/90	Waverider#67749-7	surface
E	52 12.47	04 09.57	21		0746, 23/09/90	S4#05451306	surface-5
						S4#05451308	surface-11
G	52 37.01	03 45.97	32		0740, 22/09/90	RCM#9631	7
						S4 #1196	12
H	53 29.95	03 00.15	31		0528, 26/09/90	POLDOP#7	0.5
						RCM#9959	
						acoustics#44018/6A	
Dover Strait	50 56.7	01 15.6	32	1130, 24/09/90		POLDOP#10A	0.5
						WLR#1038	
	50 56.51	01 15.85	36		1650, 24/09/90	acoustics#44059/8A	
Dover Strait	50 56.7	01 15.5	34	1520, 24/09/90		Tr #6	5.5
						RCM#5229	4
						acoustics#236	



Cruise track