I.O.S.

R. R. S. DISCOVERY
CRUISE 79

28 October - 28 November 1976

Biological and Geochemical sampling off the North West African Coast

CRUISE REPORT No. 54

1977

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF OCEANOGRAPHIC SCIENCES

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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INSTITUTE OF OCEANOGRAPHIC SCIENCES

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Arrive Funchal 5 November 1976

Depart Funchal 7 November 1976

Arrive Santa Cruz de Tenerife 28 November 1976

SCIENTIFIC PERSONNEL

R.G. Aldred
D.S.M. Billett
S.E. Calvert (Funchal - Santa Cruz)
F. Culkin (" " ")
A.J. Gooday
J.W. Gould (Barry - Funchal)
Miss K. Hampton
M.J. Harris
C. Hazlehurst
D. Lewis
M.J. McCartney
C.I. Measures Southampton University
R.H. Moore " "
R.D. Peters
A.L. Rice (Principal Scientist)
D.M. Shale
J. Sherwood
M.H. Thurston
T.R.S. Wilson
R.A. Wild

SHIP'S OFFICERS

M.A. Harding Master, Barry-Funchal
P.H.P. Maw Master, Funchal - Santa Cruz
J.J. Moran Chief Officer
D.A. Pye 2nd Officer
R.I.P. Coutts 3rd Officer
D.B. Lyntern Chief Engineer

D. Warlow	2nd Engineer
J.R. Richardson	3rd Engineer
R. Fletcher	4th Engineer
J. Laudry	5th Engineer
R.G. Whitton	5th Engineer
J.G. Lewis	Snr Electrical Engineer
R.M. Cridland	Catering Officer

OBJECTIVES OF THE CRUISE

The principal objectives were:

1. To carry out an extensive biological sampling programme on the bottom and in the lower part of the water column in an abyssal area influenced by the north-west African coast upwelling system.

2. To obtain benthic samples at depths of about 2000m from several localities off the north-west African coast between Cap Blanc and the Canaries to fill gaps in previously obtained sample series.

3. To obtain a series of bottom pore-water and sediment samples, using a pore-water sampler and new box corer from a variety of environments off the north-west African margin, including the region of 6000+m depth reportedly extending westwards from about 24°N, 30°W.

4. To obtain a series of large volume water samples, at all depths, for investigations of the organic and inorganic composition of suspended particles and for studies of the concentration patterns of selected dissolved trace metals.

5. To obtain samples of the sea-surface organic films.

Subsidiary objectives were:

6. To obtain a mid-water sample in the upper 1000m from the repeat station at 44°N 13°W.

7. To obtain benthic and midwater samples from the Josephine Bank and to test a sensing system for fishing RMTs close to the sea-bed.

8. To lay a deep current meter mooring at about 46°N 17°W.

9. To obtain deep benthic animals for trace metal analyses.

10. To obtain deep benthic samplesdown to 6000+m if possible.

11. To test new polypropylene PDR fish cable fairing.

NARRATIVE

Discovery sailed from Barry at 0900/28 October 1976. After clearing the Bristol Channel a course was set for the deep mooring station at 46°N; 17°10'W.

At 0900/29 October the PDR fish was launched with a low density polypropylene cable fairing and observations of cable angle and vibration were made at several speeds up to 12.25 kts; the EM logs were cross calibrated at the same time. The normal course and speed were resumed at 1335 and at 1830 the magnetometer was streamed and normal echo sounder and magnetometer watches were started, with XBTs launched at two-hourly intervals from 1900. These regular XBT launches were continued until 0300/5 November and the magnetometer was run continuously, except for stations and the port call at Madeira, until 0500/16 November.

The general position of the deep mooring station was reached at 2230/30 October and an echo-sounding survey was carried out until 0800/26 when the ship was hove to. A 20-30kt wind from the north-east was producing too much swell for the deployment of the deep mooring and a wire test of the mooring releases, using the forward electric winch, was therefore undertaken in the hope that the sea state would moderate in the meantime. However, during the test, and a subsquent velocimeter cast to 2000m, the weather detiorated further and the deep mooring at this position was reluctantly abandoned in favour of an alternative site on the Iberian Abyssal Plain. At 1730 course was set for the repeat station.

The repeat station was reached at 1600/1 November and a 0-1000m oblique RMT 1+8 haul was completed by 1815.

The alternative deep mooring station at 41°56'N, 14° 00'W was reached at 0630/2 November and the mooring was successfully laid in position by 1200 noon at a depth of 5325m with current meters at 600, 1500, 3000, 4000 and 4800m depth.

Some 15 miles to the south of the deep mooring station a test cast with the pore-water sampler was successfully carried out and by 1700 the ship was underway towards Josephine Bank.

The Bank was reached at 2300/3 November and after a short echo-sounder survey a series of RMT 1+8 hauls were made, one within 20m of the bottom using a bottom indicator switch suspended beneath the weight bar, followed by two epibenthic sledge hauls.

We left Josephine Bank at 0600/4 November and recovered the PDR fish and magnetometer at 1500 the same day. Discovery docked at Funchal 0800/5 November.

We sailed from Funchal at 0845/7 November and a southwesterly course was made towards the 6000+m station. The PDR fish and magnetometer were launched at 1000 and normal watches resumed.

At 0900/8 November the PDR fish was taken inboard and a high density polypropylene cable fairing was fitted. The performance of the new fairing was checked at various speeds up to 10.7 kts and on completion of these tests at 1100 the normal course and speed were resumed.

An intended station in about 5000m was reached at 0200/10 November, but the bottom topography was found to be too uneven for benthic work, with depth changes of up to 600-700m over two miles. This situation continued until 0700/10 at which time this station was abandoned in favour of the 6000+m station. The expected position of this deep station was reached at 2000/10, but a rought bottom with depths no greater than 5800m was found here. An echo-sounding survey to the westwards located no depths greater than this until a longitude of 30° 25.5'W was reached when on a southerly course the depth increased fairly rapidly to about 6080m and then remained relatively flat. At 0350/11 the ship was hove to in 6083m for station 9128. This station was occupied until 1730/13 November by which time five hydrocasts, three gravity cores, two box cores, three pore-water sampler casts, two epibenthic sledge hauls and an XBT had been accomplished, though not all successfully.

On completion of station 9128 a course was set for a proposed station in 4000m at about 20°17'N, 21°45'W. During the passage to this position two further stations were worked, one (stn. 9129) at 5500-5600m depth and the other (9130) at 4900-5000m. At each of these stations two hydrocasts, one gravity core, one box core, one pore-water sample and one XBT were taken, and at the deeper station an epibenthic sledge haul was also obtained.

The 4000m station (9131) was reached at 1600/17 November and occupied until 1000/23. During this time four semi-balloon otter trawls, four epibenthic sledge hauls and a series of RMT 1+8 hauls in the lower 1000m of the water column were made, in addition to three hydrocasts, one gravity core, one box core, one pore-water sample and three XBTs.

Moving further in towards the African coast a 3000+m station (9132) was worked at about 21°N 19°W, very close to station 8512 on cruise 63. Here, two hydrocasts one gravity core, one box core, one pore-water sample, one otter trawl, one epibenthic sledge and one XBT were obtained.

At the same latitude a 2000m station (9133) was worked from 0630/25 to 0300/26 November, with two hydrocasts, one gravity core, one pore-water sample, one epibenthic sledge haul and one otter trawl being obtained.

During the epibenthic sledge haul at this station some time was lost due to problems with the main winch. At an earlier station (9131), with the ship rolling fairly heavily, considerable lateral movement of the main drum on the shaft had indicated wear to bearings producing an end float of some 2cm. At this later station the ship was not rolling significantly and there was no noticeable lateral movement of the drumn, but the port end-plate began to bind seriously on the guard plate beneath it. Though this could be partly explained by accumulated rust beneath the guard plate, it seemed also to signify collapse of the drum due to bearing wear. The guard plate was removed and some metal, as well as rust, was taken off so that it no longer fouled the drum end-plate when refitted. Since the winch seemed to be operating tolerably well after this treatment, the current haul and the two subsequent hauls planned were persevered with, but with considerable trepidation!

At the end of station 9133 we headed north and after fours hours steaming fished a final epibenthic sledge haul along the 2000m contour at station 9134, completing this at 1330/26 November, when a course was set for Tenerife. At 1300/27 November the ship was hove to to recover the PDR fish and to stow heavy gear. The passage to Tenerife was resumed at 1430 and the ship docked at Santa Cruz at 0800/28 November.

REPORT OF PROJECTS

BIOLOGY

Total Water Column Station

The main biological aim, to sample the benthos and lower part of the water column in an abyssal region influenced by the north-west African upwelling system, was carried out with considerable success in a depth of about 4000m some 250 miles west of Cap Blanc (station 9131).

In anticipation of difficulty in fishing the semi-balloon otter trawl at this depth, some 1400 metres of wire from the port wing drum was added to the main warp at the beginning of this station. In the event this proved to be unnecessary since the gear was fished successfully with less than 7000m of wire out. Four hauls with the otter trawl were made at this station on two parallel east-west lines about 10km apart, and four epibenthic sledge hauls were made over more or less the same tracks. During the epibenthic sledge hauls several hundred of photographs were obtained, revealing significant differences in the nature of the seabed which were reflected in the samples taken by the benthic gears.

The RMT 1+8 was fished through a series of horizons at this station from the bottom up to a depth of 3000m. For the two deepest of these horizons, that is within 10-20m and within 100m of the bottom repectively, a bottom contact indicator switch was used. This consisted of a mercury switch mounted in a finned body and suspended beneath the weight bar of the net on a 30m length of diver's conductor cable. When this switch was tipped from its vertical mid-water position by contact with the sea-bed an acoustic signal from the net monitor pinger was received at the Mufax. Unfortunately, the signal disappeared when the switch was completely horizontal on the bottom and the failure to recognise this event resulted in too much wire being paid out on the deepest haul and a good benthic sample being taken in the RMT 8, though without serious damage to the net! The bottom contact switch worked adequately for the horizons within 100m of the sea-bed, and the two shallower horizons, that is 4000-3500m and 3500-3000m were fished without major difficulty, though two abortive attempts were made at the latter of these because of failure of the RMT 8 to close properly in one case and the ship drifting over the warp in the second.

Deep Epibenthic Sledge Hauls

The epibenthic sledge was fished successfully three times at depths greater than any reached with this gear previously, 5590m at 9129#1, 5726m at 9128#6 and 6059m at 9128#10. The sediment at all of these stations was red clay with pumice, sharks teeth and a few small manganese nodules. The catches were understandably very small, with few large organisms represented, but are certainly of considerable interst.

Shallower Benthic Hauls

Due to the inevitable shortage of time, fewer relatively shallow samples were obtained than we had hoped. Nevertheless, the otter trawl and epibenthic sledge were both fished at 3000m and 2000m to the west of Cap Blanc (9132 and 9133) and the sledge alone was used at a second 2000m station (9134) some 40 miles to the the north. All of these samples, and particularly those from the more southerly stations, were very rich, with the dominant organisms in some of the hauls being represented by such large numbers that only a small part could be preserved. Material from these hauls was frozen for subsequent chemical analysis.

Josephine Bank Samples

The RMT samples from over the bank were surprisingly small with little evidence of meroplanktonic organisms. The two benthic samples, on the other hand, were rich despite the fact that the sledge fished for only a few minutes during each haul before the weak link parted. The photographs obtained during these hauls confirmed the presence of a firm, and in parts quite uneven, bottom with many gorgonians which dominated the catches.

R.G. Aldred, D.S.M. Billett, A. Gooday,
A.L. Rice, D.M. Shale, M.H. Thurston
R.A. Wild

Meiobenthos

To study meiobenthic animals and particularly the foraminfera, fine residues were obtained from bottom catches by sieving sediment collected at the bottom

of the sieving system on a 53μm mesh. Unsieved sediment samples were also taken from the catch before sieving. The residues were fixed in formalin for several days, stained with Rose Bengal and preserved in spirit. Cursory examination of the residues showed that many were rich in benthic foraminifera.

The successful box core was extensively subsampled with small rectangular perspex corers to investigate the absolute abundance of the meiofauna and its depth distribution within the sediment. The upper surface of the sediment core was undisturbed and in addition to numerous animal traces, such as tracks and mounds, there was a vertically embedded Bathysiphon apparently in life position. Several other large, agglutinated foraminifera were lying on the surface. Some small syringe samples were also taken and these will be analysed for chlorophyll.

A. Gooday

ORNITHOLOGY

Ornithological observations were carried out as and when other duties permitted. About 150 formal and over 50 casual observations were made.

Numbers of species and individuals recorded were, in general, rather low and conformed to the patterns of distribution established for the N.E. Atlantic. On the leg from Barry to Madeira only kittiwakes (Rissa tridactyla) were seen with any degree of regularity once west of 10°W. The most notable sighting was of a flock of 200 Greater shearwaters (Puffinus gravis) at 49°N 11°W. After leaving Madeira, Cory's (Calonectis diomedea) and Greater shearwaters, and Leach's and Madeiran storm petrels (Oceanodroma leucorhoa and O. castro) were seen, usually in small numbers. During this part of the cruise a feature was the southerly migration of the two shearwater species, virtually every individual making good a course of 160-200°T. On 21 November at 20°N 21°W this migration amounted to at least 50 birds per hour per minute of longitude across more than 15 nautical miles. During the last part of the cruise from 20°N 20°W to Tenerife further evidence of migration of Greater shearwaters was obtained, Leach's storm petrels were seen in greater numbers than at any other time and Wilson's storm petrels (Oceanites oceanicus) were encountered for the first time. This latter observation accords with the known out-of-breeding concentrations off the continental shelf of West Africa.

The ship's track lay for the most part far from land so the number of non-seabirds recorded was very low. Of note was a very pale and lightly marked kestrel (Falco tinnunculus), possibly belonging to the Eastern Canary Island race, seen at 20°N 21°W.

Nineteen Leach's storm petrels and two Madeiran storm petrels were found on board at various times. These birds were weighed, measured, checked for moult stage and ringed before release.

M.H. Thurston

HYDROGRAPHIC WORK

Hydrographic casts were made at the stations listed in Table 1, using various combinations of 1-, 8- and 30-litre sampling bottles. The 1-litre bottles were used to obtain thermometric depths for the large-volume bottles and to provide samples for the determination of salinity, dissolved oxygen, reactive silicate and phosphate using standard procedures. The samples from the large-volume bottles were used for the collection of suspended particles, by pressure-filtration through 0.4μm pore size Nuclepore membrane filters, and for trace metal and organic carbon analyses.

Water samples were analysed on board for selenium using a novel gas chromatographic method. 100ml samples were reacted with 4-nitro-o-phenylene-diamine to form 5-nitro-piaselenol, the complex was extracted into toluene and quantified by electron capture gas chromatography.

In a parallel project, filtered water samples were used to determine dissolved organic carbon, using an autoanalyser and infra-red detection, and for the preconcentration of certain dissolved trace metals. Various forms of copper were recovered using chelating ion-exchange resins, photo-oxidation followed by the same concentration procedure and solvent extraction using dithizone. Samples from the last technique will also be used to measure dissolved Cd, Zn, Ni and Co. All concentrates from these procedures, together with duplicate frozen samples, will be returned to Southampton University Oceanography Department for completion of the analyses.

S.E. Calvert, F. Culkin, K. Hampton, M.J. McCartney, C.I. Measures, R. Moore

SEDIMENT SAMPLING

a) Gravity Coring

A stainless-steel gravity corer, with 10-cm diameter barrels 1 and 2m in length was used to collect sediment cores. Details of sample recovery are given in Table 1.

b) Box Coring

A new box corer, designed to recover undisturbed surface sediments, was used for the first time in deep water. The cores consist of a stainless-steel box, 30cm square and 2m in length, on which can be mounted up to 200kg weight. The box is provided with vertical perspex windows and sampling ports along opposite sides and can be closed top and bottom by two sets of shovels on pivoted arms. The whole box, weight and shovel assembly is mounted in a tubular aluminium frame and is attached to a piston, mounted on top of the frame, which allows slow penetration of the box. A 16-mm camera is also mounted on the frame and is activated by bottom contact.

The corer is lowered on a commercial life-boat no-load release which is activated when the frame is placed on the sea floor. The corer then operates and finally releases a pair of restraining wires attached to the shovels keeping them away from the box itself. Full penetration of the box is monitored by a pinger housed on the main frame. After the coring is completed the shovels are closed by hauling on the main warp and then the corer is lifted out of the sediment.

The corer was used twice on station 9128. On the first occasion the box failed to penetrate fully and the restraining wires were not released. On the second occasion, the corer was pulled out of the sediment at an angle, because of ship-drift during lowering, and the base of the piston was damaged.

The corer was then modified for use without the piston and main frame. On stations 9129 and 9130, the corer penetrated satisafcatorily but problems with rigging prevented recovery of any samples. However, on stations 9131 and 9132 good core samples were recovered, although worsening sea state made recovery of the core progressively more difficult. The cores collected had well preserved

surfaces and were extensively sub-sampled on deck. Samples were preserved in the deep-freezer.

S.E. Calvert, R. Peters

SEA SURFACE FILM SAMPLING

Samples of the sea-surface microlayer were collected on station 9131#13 in order to investigate the occurrence and nature of natural high-molecular weight organic material at the sea-surface. This is an extension of similar work carried out on Discovery cruise 55, 63 and 73.

The samples were collected from a small rubber inflatable boat upwind from the ship by slowly draining the contents of a large polypropylene funnel, after it had been submerged and had broken an undisturbed surface, thereby coating the inner surface of the funnel with the monomolecular organic film. The film was then eluted with $ChCl_3$ into a glass container. A subsurface water sample was also collected at the same time.

Weather conditions prevented similar collections on the other stations.

S.E. Calvert, F. Culkin, M.J. McCarney, R. Peters

PORE WATER SAMPLING AND ANALYSIS

A total of 9 pore water sample drops were made, at seven stations. On all occasions useful samples were obtained from all eight sample ports. All samples were analysed on board for alkalinity, silicate, and total carbon dioxide. Analyses for oxygen, nitrogen and ammonia were also made on selected samples.

A minor problem was encoutered in correct setting of the sampling-in-progress pinger. This arose because of the use of an improved pump for pressurising the system, with different characteristics to the pump used on previous cruises.

The sampling-in-progress pinger failed to cancel at the end of sampling on the first two drops, 17 and 18 on stations 9127 and 9128. A bleed control valve was made up, and this permitted the setting of the pinger switch to be made with

greater accuracy. The sampling pinger cancelled correctly at all stations after 9128.

The only major system malfunction occurred on drop 19, the second deep station 9128. No sampling-in-progress signal was obtained; when the unit was recovered it was found that most of the master cylinder high pressure had been lost. Sample recovery was low. It is thought that leakage of the main control valve occurred prior to the drop, perhaps because of particulate contamination of the valve seat. However, the fault could not be duplicated on tests. A check for leakage immediately prior to the drop was made at all subsequent stations, and the problem did not recur.

The modifications which had been made to unit number one for this cruise were successful. The use of stainless steel storage capillary allowed dissolved gas analyses to be made for the first time. Preliminary results appear most interesting and experience has been gained in the technique of on-board gas analyses. It is hoped that a reduction in sample size from the 0.5ml currently used will be possible on future cruises.

A short pilot corer was fitted for the first time on this cruise. After some modification this, too, operated successfully, and cores were obtained at five stations. In addition, box core sub-samples were obtained at the two stations at which the box corer was successful. Sections of these cores were squeezed on board at bottom temperatures for later comparison with the results obtained from the in situ device.

T.R.S. Wilson

ACOUSTIC TELEMETRY SYSTEMS AND ASSOCIATED EQUIPMENT

Net Monitor (Blue)

The monitor was used on 11 hauls to a maximum depth of 4025m, with a maximum range of 8481m wire out. The release system was 100% reliable in its operation. The data telemetry systems operation was 100% reliable. The pressure calibration appeared to have an offset of 20m on range 1 and 40m on range 3. Range 2 was not checked. The evidence suggests that the response of the pressure transducer has shifted. It will not be possible to confirm this until the monitor is

returned to IOS Wormley. The bottom proximity indicator used in conjunction with the net monitor worked quite well. It lost its fin when being used on Josephine Bank. The replacement fin was made shorter and was more firmly secured. This fin survived the remaining bottom hauls that were made with the RMT 1+8. The ambiguity of the mercury switch in the bottom indicator made it difficult to tell if the device was completely horizontal or withon 20° of the vertical. It may be possible to persuade the manufacturers of the mercury switch to modify the device to remove this ambiguity.

Acoustic Beacons

None of the beacons failed in operation at any time. There were occasions when the signal to noise ratio of the received pulses was uncomfortably low. As the poor quality of the signal did not always conincide with the maximum acoustic range it suggests that the beacons were operating outside the main beams of the acoustic transducers.

The following table gives information concerning the usage of the beacons:

Beacon application	No of hauls	Maximum depth of operation in m	Maximum range wire out in m	Total hours of operation
BN1.5	11	6059	8250	53
OTSB	6	4009	6950	41
Hydro cast	7	6081		21
Main warp for gravity, box and harpoon corers	18	6083		56
Sample indicator in harpoon corer	8	6081		23

M.J. Harris

COMPUTING

The computer system was used in its normal role for the collection, analysis and display of data. The routine sampling included meteorological instruments,

magnetometer, fluorometer, and manual depth entry. The depths were listed, checked and plotted along the ship's track. A daily check of all recorded data was made and detectable spikes were removed.

The live track plot facility was used for station work and during trawls. Towards the end of the cruise, large scale track charts of the station areas were made on the drum plotter.

A data file was kept containing the details of each biological station, and this was moved onto a final data disk, and a listing made.

A number of programs for the geochemists on board were available on a special users' disk. One of these programs, for making temperature corrections on reversing, protected and unprotected thermometers was modified to store calibration data on disk.

Other programs were used to calculate titration end-points. All of these programs used the line-printer as the output device and some delays were incurred when this machine overheated, corrupting and missing out characters.

An E M log calibration run was made in which calibration constants were derived for the new starboard log by comparison with the port log. Two iterations of program MISAL were made, and the raw data have been saved to magnetic tape at IOS Barry.

Routine XBT drops were made and it was hoped to log the data on the computer. However, due to an irreparably broken re-transmitting potentiometer, this was not possible.

The crystal clock repeaters failed early in the cruise. The 2's bit was being dropped on the less significant seconds digit, and this was traced to a loose connection in the computer room junction box, probably disturbed after the refit.

Several other hardware errors occurred. The new Magnavox Satellite Navigation System was inoperative throughout the cruise, and the satellite data were handled in the normal way by the IBM 1800 computer. The CAMAC interface system suffered from a number of intermittent problems which were investigated with some success. Disk failure halted the system a couple of times but no

serious loss of data was incurred.

C. Hazlehurst

STN.	DATE 1976	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9058 # 0	29/10	48 53.5N	10 56.3W	XBT	0-520	1900- NIGHT	
9059 # 0	29/10	48 39.6N	11 20.9W	XBT	0-553	2100- NIGHT	
9060 # 0	29/10	48 24.1N	11 47.3W	XBT	0-523	2310- NIGHT	
9061 # 0	30/10	48 10.7N	12 9.6W	XBT	0-541	0100- NIGHT	
9062 # 0	30/10	47 56.2N	12 34.2W	XBT	0-550	0300- NIGHT	
9063 # 0	30/10	47 44.5N	13 1.2W	XBT	0-543	0500- NIGHT	
9064 # 0	30/10	47 33.2N	13 28.2W	XBT	0-534	0700- NIGHT	
9065 # 0	30/10	47 22.2N	13 53.4W	XBT	0-894	0900- DAY	
9066 # 0	30/10	47 11.1N	14 20.9W	XBT	0-540	1106- DAY	
9067 # 0	30/10	47 1.9N	14 46.5W	XBT	0-842	1300- DAY	
9068 # 0	30/10	46 51.0N	15 16.2W	XBT	0-545	1506- DAY	
9069 # 0	30/10	46 41.6N	15 42.9W	XBT	0-844	1700- DAY	
9070 # 0	30/10	46 32.3N	16 11.3W	XBT	0-541	1900- NIGHT	

STN.	DATE 1976	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9071 # 0	30/10	46 22.2N	16 41.3W	XBT	0-851	2110- NIGHT	
9072 # 0	31/10	45 55.7N	17 10.8W	XBT	0-450	1314- DAY	
9073 # 0	31/10	45 57.9N	17 16.3W	VELOCIMETER	0-2000	1600-1730 DAY	100M INTERVALS DURING LOWERING 50M INTERVALS DURING RECOVERY
9074 # 0	31/10	45 47.6N	16 59.0W	XBT	0-513	1910- NIGHT	
9075 # 0	31/10	45 37.2N	16 36.3W	XBT	0-247	2100- NIGHT	CONDUCTOR BROKE AT 247 M.
9076 # 0	31/10	45 31.5N	16 24.8W	XBT	0-916	2200- NIGHT	
9077 # 0	31/10	45 26.3N	16 15.1W	XBT	0-523	2300- NIGHT	
9078 # 0	1/11	45 14.3N	15 53.4W	XBT	0-899	0100- NIGHT	
9079 # 0	1/11	45 2.8N	15 29.0W	XBT	0-539	0306- NIGHT	
9080 # 0	1/11	44 52.6N	15 7.9W	XBT	0-853	0502- NIGHT	
9081 # 0	1/11	44 42.7N	14 45.8W	XBT	0-522	0702- NIGHT	
9082 # 0	1/11	44 32.6N	14 20.5W	XBT	0-297	0906- DAY	CONDUCTOR BROKE AT 297 M.
9083 # 0	1/11	44 26.5N	13 57.5W	XBT	0-542	1100- DAY	

STN	DATE 1976	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9084 # 0	1/11	44 17.1N	13 33.5W	XBT	0-534	1300- DAY	
9085 # 0	1/11	44 8.8N	13 13.6W	XBT	0-558	1500- DAY	
9086 # 0	1/11	43 59.7N 43 57.7N	13 0.7W 13 1.3W	RMT 1 RMT 8	0-1000	1632-1742 DAY	OBLIQUE TOW FLOW DIST. 3.32KM.
9087 # 0	1/11	43 51.2N	13 5.1W	*XBT	0-450	1904- NIGHT	NO DATA ON DEPTH OBTAINED
9088 # 0	1/11	43 30.2N	13 14.3W	XBT	0-493	2110- NIGHT	
9089 # 0	1/11	43 11.4N	13 23.1W	XBT	0-548	2306- NIGHT	
9090 # 0	2/11	42 49.1N	13 33.0W	XBT	0-533	0116- NIGHT	
9091 # 0	2/11	42 29.9N	13 41.7W	XBT	0-531	0306- NIGHT	
9092 # 0	2/11	42 8.8N	13 54.8W	XBT	0-558	0510- NIGHT	
9093 # 0	2/11	41 54.6N	14 6.2W	CURRENT MOORING	600-4000	1109- DAY	METERS AT 600, 1500, 3000, 4000 & 4800M. DEPTH 5325M.
9094 # 0	2/11	41 50.3N	14 3.5W	XBT	0-560	1220- DAY	
9095 # 0	2/11	41 36.1N	13 59.4W	PWS		1514-1530 DAY	62% RECOVERY
9096 # 0	2/11	41 34.1N	13 59.5W	XBT	0-480	1706- DAY	

STN	DATE 1976	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9097 # 0	2/11	41 12.9N	13 57.7W	XBT	0-553	1906- NIGHT	
9098 # 0	2/11	40 50.6N	13 56.5W	XBT	0-562	2112- NIGHT	
9099 # 0	2/11	40 31.2N	13 55.3W	XBT	0-533	2306- NIGHT	
9100 # 0	3/11	40 10.9N	13 54.6W	XBT	0-544	0100- NIGHT	
9101 # 0	3/11	39 48.8N	13 56.0W	XBT	0-558	0300- NIGHT	
9102 # 0	3/11	39 23.4N	13 54.7W	XBT	0-561	0516- NIGHT	
9103 # 0	3/11	39 4.1N	13 55.1W	XBT	0-542	0700- NIGHT	
9104 # 0	3/11	38 39.9N	13 55.7W	XBT	0-537	0912- DAY	
9105 # 0	3/11	38 18.3N	13 56.2W	XBT	0-558	1116- DAY	
9106 # 0	3/11	38 2.8N	13 57.4W	XBT	0-547	1306- DAY	
9107 # 0	3/11	37 41.9N	13 58.8W	*XBT	0-450	1502- DAY	NO DATA ON DEPTH ATTAINED
9108 # 0	3/11	37 12.6N	14 0.7W	XBT	0-549	1750- DAY	

STN	DATE 1976	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9109 # 0	3/11	36 58.6N	14 1.0W	XBT	0-535	1906- NIGHT	
9110 # 0	3/11	36 48.8N	14 7.8W	XBT	0-543	2006- NIGHT	
9111 # 0	3/11	36 46.2N	14 9.5W	XBT	0-544	2022- NIGHT	
9112 # 0	3/11	36 43.6N	14 11.2W	XBT	0-541	2038- NIGHT	
9113 # 0	3/11	36 41.5N	14 12.6W	XBT	0-531	2051- NIGHT	
9114 # 0	3/11	36 39.3N	14 15.4W	XBT	0-220	2127- NIGHT	
9115 # 1	3/11	36 38.5N 36 39.2N	14 13.2W 14 14.0W	*RMT 1 RMT 8	150-195	2332-0002 NIGHT	BOTTOM INDICATOR SWITCH USED FLOW DIST. 1.68KM.
9115 # 2	4/11	36 40.0N 36 40.9N	14 14.7W 14 15.2W	*RMT 1 RMT 8	100-170	0032-0102 NIGHT	BOTTOM INDICATOR SWITCH USED FLOW DIST. 1.68KM
9115 # 3	4/11	36 41.9N 36 42.9N	14 15.7W 14 16.1W	*RMT 1 RMT 8	55-125	0133-0202 NIGHT	BOTTOM INDICATOR SWITCH USED FLOW DIST. 1.91KM
9115 # 4	4/11	36 37.7N 36 37.9N	14 14.6W 14 14.8W	*BN1.5/5C BCAM	200-207	0403-0412 NIGHT	WEAK LINK BROKEN, NET TURNED OVER
9115 # 5	4/11	36 39.9N 36 40.1N	14 15.8W 14 15.8W	*BN1.5/5C BCAM	200-200	0535-0542 NIGHT	TOWING BRIDLE BROKEN BACK BAR BENT
9116 # 0	4/11	36 38.7N	14 16.7W	XBT	0-533	0619- NIGHT	

STN	DATE 1976	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9117 # 0	4/11	36 35.3N	14 18.8W	XBT	0-560	0640- NIGHT	
9118 # 0	4/11	36 32.6N	14 20.5W	XBT	0-550	0655- NIGHT	
9119 # 0	4/11	36 11.8N	14 32.6W	XBT	0-550	0900- DAY	
9120 # 0	4/11	35 51.4N	14 44.2W	XBT	0-557	1100- DAY	
9121 # 0	4/11	35 11.7N	15 7.0W	XBT	0-538	1500- DAY	
9122 # 0	4/11	34 52.7N	15 17.0W	XBT	0-533	1700- DAY	
9123 # 0	4/11	34 31.4N	15 27.0W	XBT	0-551	1900- NIGHT	
9124 # 0	4/11	34 9.5N	15 37.5W	XBT	0-531	2110- NIGHT	
9125 # 0	4/11	33 50.0N	15 46.8W	XBT	0-559	2305- NIGHT	
9126 # 0	5/11	33 32.2N	15 56.6W	XBT	0-558	0100- NIGHT	
9127 # 0	5/11	33 13.1N	16 6.6W	XBT	0-557	0300- NIGHT	
9128 # 1	11/11	24 16.5N	30 27.2W	H	1-1500	0441- NIGHT	
9128 # 2	11/11	24 16.6N	30 28.0W	GC	6083	0655- NIGHT	SURFACE DISTURBED. RED CLAY.

STN	DATE 1976	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9128 # 3	11/11	24 16.4N	30 28.8W	PWS	6099	0956-1020 DAY	35% RECOVERY
9128 # 4	11/11	24 16.5N	30 29.4W	GC	6083	1359- DAY	NO SAMPLE. TOP VALVE JAMMED.
9128 # 5	11/11	24 16.6N	30 30.7W	H	1990-4010	1705- DAY	PRETRIPPED TWICE. ALL CLOSED ABOVE 2000M. SAMPLE REJECTED.
9128 # 6	11/11	24 10.5N 24 10.6N	30 27.1W 30 26.8W	*BN1.5/5C 5726-5726 BCAM		2214-2224 NIGHT	EARLY LOSS OF TRACE, WEAK LINK BROKEN.
9128 # 7	12/11	24 16.9N	30 31.7W	H	4490-6000	0534- NIGHT	LOWER PART PRETRIPPED, DEEPEST BOTTLE 5239M.
9128 # 8	12/11	24 17.8N	30 32.0W	PWS	5970	0924-1000 DAY	43% RECOVERY
9128 # 9	12/11	24 17.9N 24 17.9N	30 33.2W 30 33.3W	*BC 5970-5970 BCAM		1413-1429 DAY	NO CORE. SPADE WIRES PARTED.
9128 #10	12/11	24 18.0N 24 18.2N	30 28.2W 30 27.2W	BN1.5/5C 6059-6059 BCAM		2106-2156 NIGHT	WEAK LINK BROKE NEAR SURFACE.
9128 #11	13/11	24 19.2N	30 27.2W	H	1990-4010	0400- NIGHT	
9128 #12	13/11	24 17.9N	30 27.3W	GC	6018	0712- DAY	GOOD CORE, SURFACE INTACT. RED CLAY.
9128 #13	13/11	24 17.3N 24 17.3N	30 28.0W 30 28.0W	*BC 6081-6081 BCAM		1132-1140 DAY	NO CORE. SPADE JAMMED AGAINST FRAME.
9128 #14	13/11	24 17.6N	30 28.9W	PWS	6071	1453-1535 DAY	33% RECOVERY
9128 #15	13/11	24 18.1N	30 29.4W	H	25-175	1726- DAY	

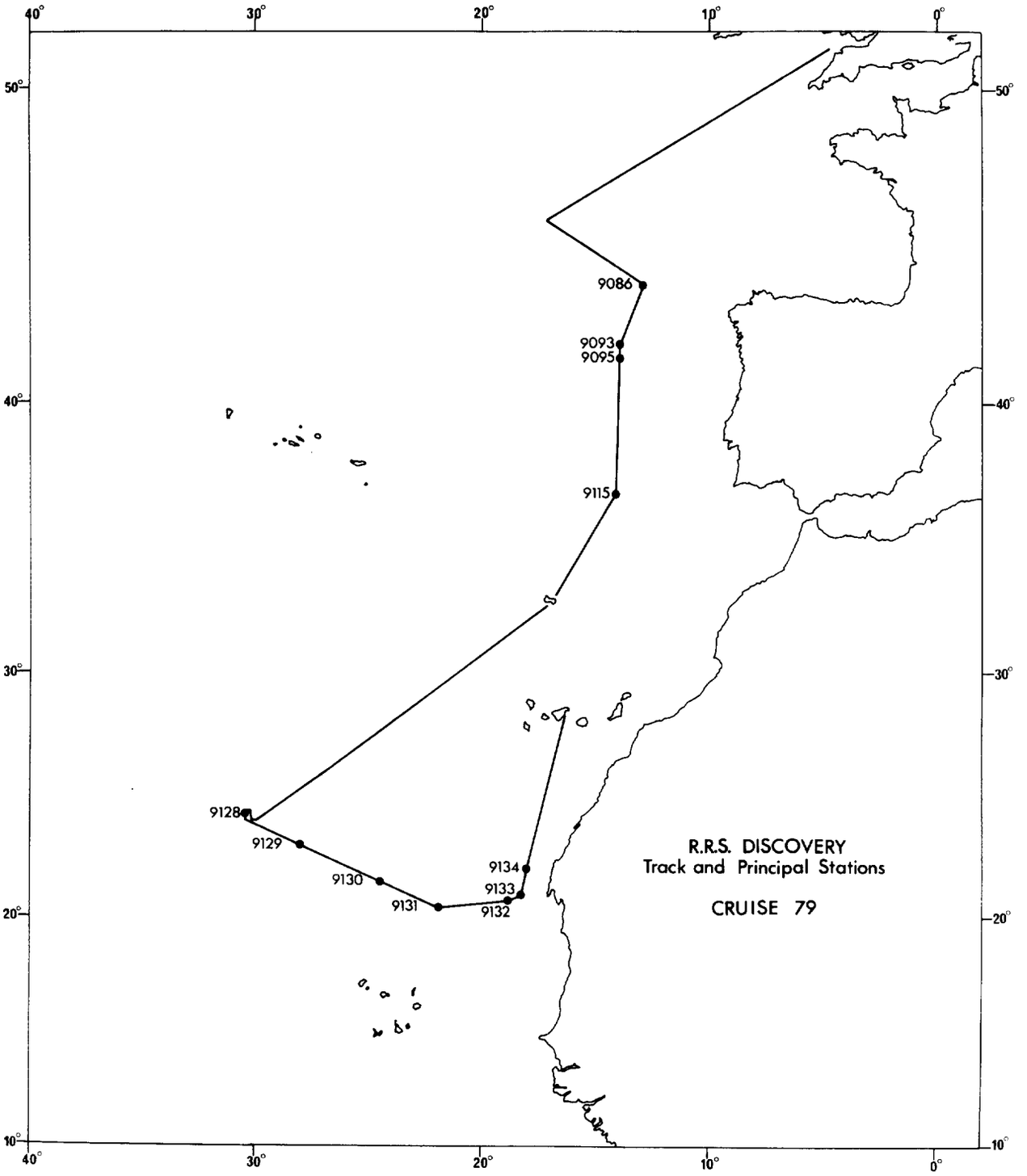
STN	DATE 1976	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9128 #16	13/11	24 18.1N	30 29.5W	XBT	0-550	1736- DAY	LAUNCHED WITH SHIP HOVE-TO.
9129 # 1	14/11	23 5.7N 23 6.3N	27 58.7W 27 57.6W	BN1.5/5C BCAM	5590-5590	1324-1406 DAY	DEPTH RATIO 1.3-1.38.
9129 # 2	14/11	23 5.9N 23 5.9N	27 53.4W 27 53.4W	BC BCAM	5569-5569	1926-1929 NIGHT	USED WITHOUT FRAME. SMALL CORE.
9129 # 3	14/11	23 6.1N	27 52.6N	PWS	5564	2214-2235 NIGHT	49% RECOVERY.
9129 # 4	15/11	23 5.9N	27 52.2W	H	1-1000	0044- NIGHT	ALL CORRECT.
9129 # 5	15/11	23 5.7N	27 51.4W	GC	5569	0245- NIGHT	
9129 # 6	15/11	23 6.0N	27 50.1W	H	1-5500	0632- NIGHT	ALL CORRECT EXCEPT BOTTOM BOTTLE.
9129 # 7	15/11	23 5.0N	27 47.0W	XBT	0-450	0913- DAY	NO DATA ON DEPTH ATTAINED.
9130 # 1	16/11	21 30.5N	24 30.0W	XBT	0-450	0518- NIGHT	NO DATA ON DEPTH ATTAINED.
9130 # 2	16/11	21 29.5N	24 28.5W	H	25-1500	0630- NIGHT	ALL CORRECT.
9130 # 3	16/11	21 29.5N	24 28.5W	GC	4956	0821- DAY	GOOD CORE. SURFACE INTACT. PINK CALCAREOUS CLAY.
9130 # 4	16/11	21 29.1N	24 28.6W	PWS	4956	1150-1201 DAY	81% RECOVERY
9130 # 5	16/11	21 28.2N	24 28.5W	H	750-4500	1610- DAY	ALL CORRECT.

STN	DATE 1976	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9130 # 6	16/11	21 27.5N 21 27.5N	24 28.7W 24 28.7W	BC	4952-4952	2029-2030 NIGHT	NO CORE SPADES DROPPED PREMATURELY.
9131 # 1	17/11	20 17.2N 20 16.6N	21 42.3W 21 40.3W	OTSB14	4002-4007	1941-2043 NIGHT	
9131 # 2	18/11	20 14.8N 20 14.7N	21 24.9W 21 23.4W	*OTSB14	3926-3927	0348-0442 NIGHT	ROLLER INDICATED DISTANCE RUN 897M.
9131 # 3	18/11	20 10.6N 20 10.3N	21 40.2W 21 37.5W	*OTSB14	3931-3935	1422-1539 DAY	ROLLER 1907M. RATIO 1.57-1.74.
9131 # 4	18/11	20 8.5N 20 7.5N	21 27.2W 21 23.6W	*OTSB14	3868-3879	2146-2341 NIGHT	ROLLER 2666M. RATIO 1.43-1.75.
9131 # 5	19/11	20 5.9N	21 17.8W	*XBT	0-450	0314- NIGHT	NO DATA ON DEPTH ATTAINED.
9131 # 6	19/11	20 18.1N	21 49.2W	*XBT	0-450	0613- NIGHT	NO DATA ON DEPTH ATTAINED.
9131 # 7	19/11	20 18.8N	21 49.3W	H	1-1000	0740 DAY	
9131 # 8	19/11	20 19.2N	21 48.9W	GC	4017	0927 DAY	GOOD CORE, PINK CALCAREOUS OOZE.
9131 # 9	19/11	20 18.3N 20 17.9N	21 43.4W 21 42.3W	*BN1.5/5C BCAM	4006-4015	1305-1344 DAY	NO ROLLER, RATIO 1.54-1.66.
9131 #10	19/11	20 15.1N 20 14.5N	21 35.5W 21 34.6W	*BN1.5/5C BCAM	3950-3952	1847-1930 DAY	ROLLER 851M. RATIO 1.27-1.4.
9131 #11	20/11	20 9.0N 20 8.7N	21 40.0W 21 39.3W	*BN1.5/5C BCAM	3921-3921	0137-0214 NIGHT	ROLLER 762M. RATIO 1.19-1.24.
9131 #12	20/11	20 7.0N 20 6.6N	21 26.0W 21 25.1W	*BN1.5/5C BCAM	3856-3861	0822-0901 DAY	ROLLER 738M. RATIO 1.19-1.25.

STN	DATE 1976	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9131 #13	20/11	20 17.4N	21 48.2W	SF	0	1415- DAY	
9131 #14	20/11	20 17.3N	21 48.1W	PWS	4009	1454-1510 DAY	100% RECOVERY.
9131 #15	20/11	20 17.2N	21 47.5W	H	1-4000	1737- DAY	TWO BOTTLES PRETRIPPED.
9131 #16	20/11	20 16.3N 20 16.3N	21 47.0W 21 47.0W	BC	4005-4005	2102-2105 NIGHT	
9131 #17	21/11	20 11.6N 20 8.6N	21 37.0W 21 30.3W	RMT 1 RMT 8	3910-3995	0236-0548 NIGHT	DEPTH IS CORRECTED (40M ERROR), FLOW DIST. 11.08KM.
9131 #18	21/11	20 7.7N 20 9.1N	21 32.9W 21 40.4W	RMT 1 RMT 8	3760-3920	1123-1523 DAY	DEPTH IS CORRECTED. BOTTOM SWITCH. FLOW DIST. 12.32KM.
9131 #19	21/11	20 14.4N 20 23.8N	21 47.0W 21 49.4W	RMT 1 RMT 8	3500-3760	2016-0116 NIGHT	DEPTH IS CORRECTED. FLOW DIST. 13.66KM.
9131 #20	22/11	20 26.8N 20 23.0N	21 48.1W 21 44.0W	RMT 1 RMT 8	200-305	0407-0607 NIGHT	DEPTH IS CORRECTED. FLOW DIST. 7.99KM.
9131 #21	22/11	20 16.4N 20 6.1N	21 38.1W 21 30.9W	*RMT 1 RMT 8	3000-3500	0940-1440 DAY	INCOMPLETE CLOSURE OF RMT 8, RMT 1 OK. FLOW DIST. 20.14KM.
9131 #22	22/11	20 3.5N 20 4.1N	21 30.7W 21 33.3W	*RMT 1 RMT 8	3260-3500	1834-1941 DUSK	HAUL ABORTED. WIRE PULLED UNDER STERN. FLOW DIST.2.09KM.
9131 #23	23/11	20 4.4N 20 10.3N	21 43.8W 21 49.0W	RMT 1 RMT 8	3000-3500	0053-0453 NIGHT	DEPTH IS CORRECTED. FLOW DIST. 13.44KM.
9131 #24	23/11	20 12.6N	21 52.2W	H	1-1000	0815- DAY	ALL CORRECT.
9131 #25	23/11	20 13.1N	21 48.7W	XBT	0-450	1012- DAY	NO DATA ON DEPTH ATTAINED.

STN	DATE 1976	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9132 # 1	24/11	20 43.1N	18 52.8W	H	1-1000	0427- NIGHT	
9132 # 2	24/11	20 43.6N	18 53.3W	GC	3032	0612 DAY	
9132 # 3	24/11	20 43.8N	18 54.1W	PWS	3054	0754-0809 DAY	89% RECOVERY.
9132 # 4	24/11	20 43.9N 20 43.9N	18 54.6W 18 54.6W	*BC	3062-3062	1017-1020 DAY	LARGE CORE OBTAINED.
9132 # 5	24/11	20 50.1N 20 52.7N	18 55.5W 18 56.2W	*OTSB14	3089-3109	1408-1530 DAY	ONLY 56 MINUTES FISHING ON BOTTOM.
9132 # 6	24/11	20 56.8W	18 57.5W	H	1-3000	1908- NIGHT	
9132 # 7	24/11	20 58.8N 20 59.8N	18 59.1W 18 59.8W	*BN1.5/5C BCAM	3083-3094	2208-2308 NIGHT	NO ROLLER. RATIO 1.20-1.33-1.26.
9132 # 8	25/11	21 1.4N	18 58.4W	*XBT	0-450	0056- NIGHT	NO DATA ON DEPTH ATTAINED.
9133 # 1	25/11	20 47.4N	18 14.2W	H	1-1950	0753 DAY	
9133 # 2	25/11	20 47.1N	18 14.8W	PWS	1798	0918-0926 DAY	52% RECOVERY
9133 # 3	25/11	20 46.7N	18 15.2W	GC	1776	1025- DAY	
9133 # 4	25/11	20 56.0N	18 14.0W	*XBT	0-450	1158- DAY	NO DATA ON DEPTH ATTAINED.
9133 # 5	25/11	20 57.5N 20 58.9N	18 13.7W 18 13.6W	*BN1.5/5C BCAM	2112-2160	1642-1729 DAY	ROLLER 1215M. RATIO 1.85-1.84.

STN	DATE 1976	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
9133 # 6	25/11	21 2.4N	18 13.1W	H	1-1030	2055- NIGHT	
9133 # 7	26/11	21 9.0N 21 10.4N	18 8.8W 18 7.9W	*OTSB14	2130-2191	0000-0040 NIGHT	ROLLER 557M. RATIO 2.35-2.57
9134 # 0	26/11	21 54.6N 21 54.9N	18 2.8W 18 2.2W	*BN1.5/5C BCAM	1942-1949	1147-1223 DAY	ROLLER 251M. RATIO 1.33-1.40.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R.R.S. DISCOVERY
Track and Principal Stations
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CRUISE REPORTS

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D.E. "VICKERS VOYAGER" AND "PISCES 111"	
June - July 1973	IOS CR [1]
RRS ~~B~~R. "DISCOVERY"	
1 (International 2 (Indian Ocean) 3 (Expedition)	Published and distributed by the Royal Society
	NIO CR [1]
4 February - March 1965	4
37 November - December 1970	37
38 January - April 1971	41
39 April - June 1971	40
40 June - July 1971	48
41 August - September 1971	45
42 September 1971	49
43 October - November 1971	47
44 December 1971	46
45 February - April 1972	50
46 April - May 1972	55
47 June - July 1972	52
48 July - August 1972	53
49 August - October 1972	57
50 October 1972	56
51 November - December 1972	54
52 February - March 1973	59
53 April - June 1973	58
	IOS CR [2]
54 June - August 1973	2
55 September - October 1973	5
56 October - November 1973	4
57 November - December 1973	6
58 December 1973	4
59 February 1974	14
60 February - March 1974	8
61 March - May 1974	10
62 May - June 1974	11
63 June - July 1974	12
64 July - August 1974	13
65 August 1974	17
66 August - September 1974	20
68 November - December 1974	16
73 July - August 1975	34
74 Leg 2)	33
74 Leg 1 & 3)	35
75 October - November 1975	43
77 July - August 1976	46

[1] NIO CR National Institute of Oceanography, Cruise Report
[2] IOS CR Institute of Oceanographic Sciences, Cruise Report

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R.R.S. "CHALLENGER"	
August - September 1974	IOS CR 22
March - April 1976	IOS CR 47
R.V. "EDWARD FORBES"	
October 1974	IOS CR 15 *
January - February 1975	IOS CR 19
April 1975	IOS CR 23
May 1975	IOS CR 32
May - June 1975	IOS CR 28
July 1975	IOS CR 31
July - August 1975	IOS CR 36
August - September 1975	IOS CR 41
August - September 1976	IOS CR 44
February - April 1976	IOS CR 48
R.R.S. "JOHN MURRAY"	
April - May 1972	NIO CR 51
September 1973	IOS CR 7
March - April 1974	IOS CR 9
October - November & December 1974	IOS CR 21
April - May 1975	IOS CR 25
April 1975	IOS CR 39
October - November 1975	IOS CR 40
August - October 1975	IOS CR 42
N.C. "MARCEL BAYARD"	
February - April 1971	NIO CR 44
M.V. "RESEARCHER"	
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May - June 1975	IOS CR 30
August - September 1975	IOS CR 38
March - April 1976	IOS CR 44
R.S.S. "SHACKLETON"	
August - September 1973	IOS CR 3
January - February 1975	IOS CR 18
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February - March 1975	IOS CR 29
July - August 1975	IOS CR 37
June - July 1976	IOS CR 45
October - November 1976	IOS CR 49
M.V. "SURVEYOR"	
February - April 1971	NIO CR 38
June 1971	NIO CR 39*
August 1971	NIO CR 42*

* not distributed