SCOTTISH MARINE BIOLOGICAL ASSOCIATION

Dunstaffnage Marine Research Laboratory

CRUISE REPORT

R.R.S. CHALLENGER

Cruise 8/1980

10th - 23rd May

1980

1. Duration of Cruise

11.30 hrs 10th May (Ardrossan) until 08.30 hrs 23rd May (Ardrossan). All times are British Summer Time.

2. Localities

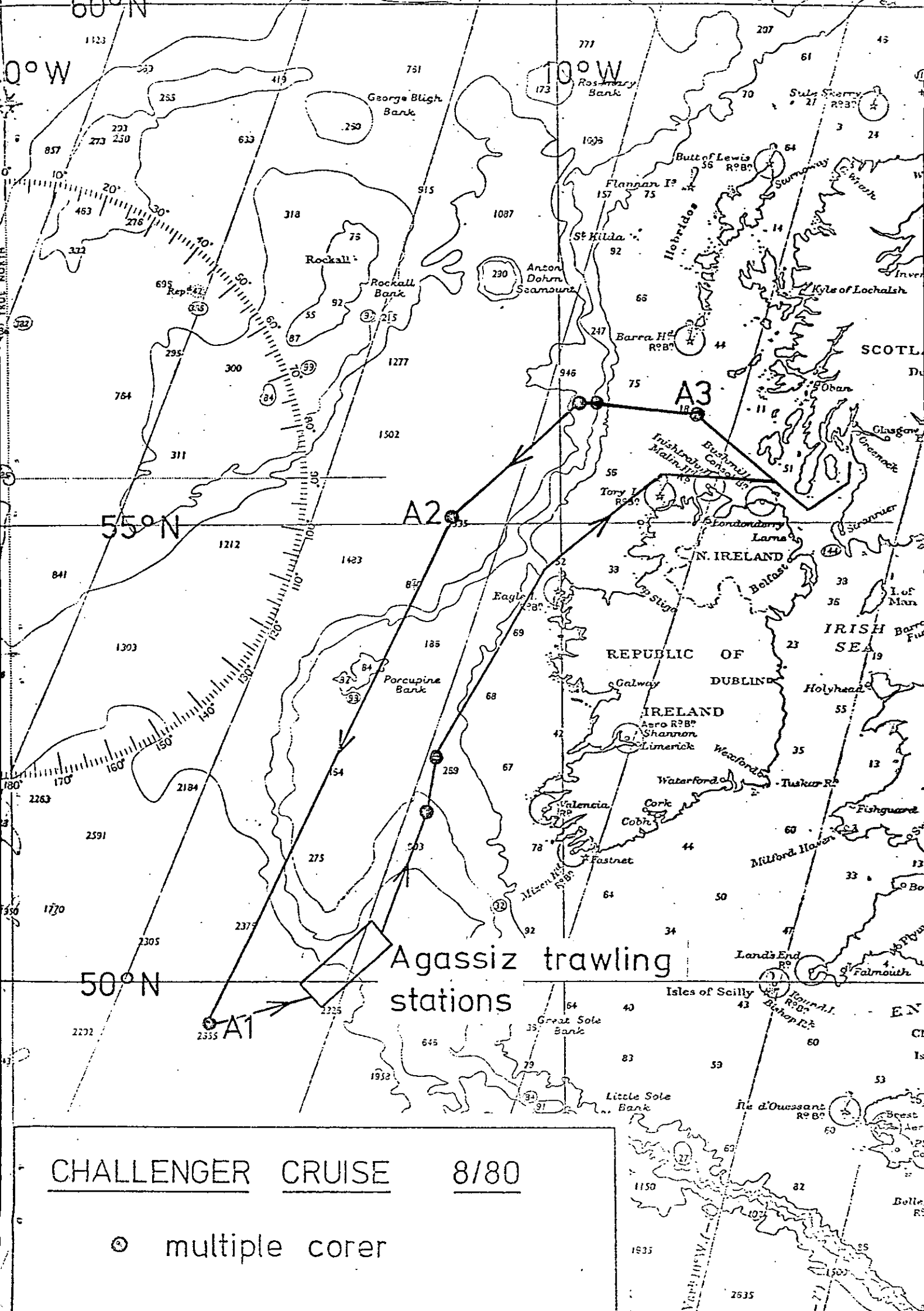
Continental shelf west of Scotland, Rockall Trough, Porcupine Abyssal Plain and Porcupine Seabight.

3. Scientific Staff

Dr. B.L.S. Hardy, S.M.B.A., Principal Scientist
Mr. J. Watson, S.M.B.A.
Mrs. J.A.R. Duncan, S.M.B.A.
Mr. F. Drake, S.M.B.A.
Dr. R. Herbert, University of Dundee
Mr. S. Fairnie, Heriot-Watt University, Edinburgh
Dr. D. Nedwell, University of Essex
Mr. I. Banat, University of Essex
Mr. N. Holmes, University College of Wales, Aberystwyth
Dr. J.W. Patching, University College, Galway, Eire
Dr. R. Raine, University College, Galway, Eire

4. Aims

(i) Study of bacteria in the deep-sea and shelf sediments and in the water overlying these sediments, using the SMBA multiple corer. Particular attention to be paid to the organisms concerned with organic degradation and nitrate and sulphate reduction in the deep sea and shelf sediments. Rates of oxygen uptake, the uptake of selected carbon substrates and ATP levels measured. Continuous flow enrichment cultures using bottom sediments to be set up at the beginning of the cruise and to continue for the duration of the cruise in a study of bacterial growth on inert surfaces at low nutrient concentrations.



CHALLENGER CRUISE 8/80

⊙ multiple corer

(ii) Sampling of the meiofauna of the deep sea and shelf sediments, using the SMBA multiple corer. Bottom photography at the sampling stations.

(iii) Studies of the distribution of planktonic foraminifera by means of vertical tow nets, pump sampling, and cores.

(iv) Agassiz trawling for fish and bottom invertebrates to supply additional material for SMBA deep-sea fish studies and IOS macrobenthos studies, to be undertaken if time permits.

5. Weather

Moderate to strong southerly winds at the beginning of the cruise did not seriously affect the scientific programme, although an increase in wind strength combined with a heavy swell was probably responsible for some slight damage to the multiple corer at station A2. Calm conditions prevailed in the middle of the cruise. In the latter part of the cruise, strong northerly winds, combined with a very heavy swell, prevented sampling at the 1000 m station in the Porcupine Seabight.

6. Narrative

Two of the scientific party joined the ship on 8 May and the remainder on 9 May. The Challenger sailed from Ardrossan at 11.30 hrs BST on 10 May.

The first sampling station, station A3, at 158 m on the continental shelf to the west of Scotland (Fig. 1, Table 1) was reached at 01.15 hrs on 11 May and the PDR fish launched for the remainder of the cruise. Four multiple corer hauls, each with 12 core tubes, were carried out at this station. The first haul provided 12 good cores of bottom material while the three subsequent hauls each provided 11 good cores. The bottom material from the first two hauls provided

material for microbiological and foraminifera studies, including the continuous flow enrichment cultures. These cultures were started by Mr. Drake and Mr. Fairnie at this stage in the cruise in order to provide a 10-day culturing period during the cruise. Bottom material from the latter two hauls at this station were sectioned and preserved for SMBA meiofauna (mainly harpacticoid copepod) studies.

After the coring was completed, a string of water bottle samples was taken by Dr. Patching and Dr. Raine, using N10 bottles, at 10, 20, 30, 40, 50 and 60 m above the bottom. One vertical plankton haul was taken to a depth of 110 m by Mr. Holmes, for a study of planktonic foraminifera.

Station A3 was completed at 0500 hrs on 11 May and the ship then steamed for the 500 m slope station where she arrived at 11.25 hrs on the same day. It was unclear from the charts if the slope at this location was sufficiently gentle for coring, nevertheless it was decided to try one haul with the multiple corer. On retrieval the corer was found to be slightly damaged and the core tubes empty, suggesting that the corer had fallen over on the slope. The Atlas echo-sounder showed that the bottom was shelving rapidly. It was therefore decided to abandon both the 500 m and the 1000 m slope stations with the hope that the two reserve stations at these same depths in the Porcupine Seabight could be worked later in the cruise.

The ship then proceeded to station A2. On route, plankton samples were collected by Mr. Holmes from the upper 5 m by passing the ship's non-toxic pumped seawater supply through plankton nets which were changed every half hour. Sampling was carried out between 1300 and 1900 hrs on 11 May.

The ship arrived at station A2, 2900 m in the Rockall Trough, at 0140 hrs on 12 May and coring commenced. A series of six multiple corer hauls were carried out at this station on 12 May. The first three of these hauls each provided 12 good cores, however the weather began to deteriorate after the third haul with strong S.E. winds approaching force 7 and a heavy swell. The fourth haul provided 12 cores but suspended material in the overlying water of some of the cores indicated some disturbance. The fifth and sixth hauls each provided ten cores. In the sixth haul the cores on one side of the corer were noticeably longer than those on the other, suggesting that the corer had landed at an angle. The disturbance in haul 4 cores and the loss of some material from hauls 5 and 6 was presumably caused by the adverse weather conditions. Cores from one haul provided samples for microbiological and foraminifera studies while the cores from the remaining hauls were preserved for SMBA meiofaunal studies.

The weather had improved by 1346 hrs, when the corer was lowered for the seventh time at station A2. This time, however, the corer was fitted with eight tubes instead of 12 so as to allow for better penetration by the core tubes and therefore longer cores. After the samples were collected the corer, instead of being hauled straight back to the ship, was left suspended at a depth of about 100 m above the bottom for 24 hours. This experiment was carried out in an attempt to measure the rate of benthic community respiration at a depth of 2,900 m and as a comparison with a similar experiment carried out last year (Challenger cruise 6/79).

At the end of this 24 hr experiment the corer was retrieved, being brought on board again at 1500 hrs on 13 May. The overlying water

from the cores was collected by Dr. Patching and Dr. Raine for oxygen analysis and the sediment was preserved for SMBA meiofaunal studies. The ship then steamed back onto the correct station A2 position, from which it had drifted during the 24 hr experiment. An eighth multiple corer haul was taken and on retrieval, six of the twelve cores were used by Drs. Patching and Raine as controls for the 24 hr experiment and the remaining cores were made available for other microbiological and meiofauna requirements.

After coring at station A2 was completed at 1730 hrs on 13 May, work with the hydrographic winch began. A string of water bottle samples was taken at depths of 20, 40, 60, 80, 100 and 120 m above the bottom for ammonia studies by Drs. Patching and Raine, and also to provide a low zinc standard seawater sample for heavy metal studies at Dunstaffnage. Although the bottles at 20 amd 80 m did not close properly, samples were collected successfully from the other depths. This was followed by a water bottle haul from 30 m below the surface, to provide a water sample for the study of the distribution of methane bacteria. An attempt was also made to collect a Niskin bottle sample from 30 m, however the bottle did not operate properly. Two vertical plankton hauls were taken to depths of 500 m and 50 m respectively by Mr. Holmes for a study of planktonic foraminifera. Mr. Holmes also collected plankton from the upper 5 m by passing the ship's pumped seawater supply through plankton nets which were changed every hour. The pump samples were taken between 0230 hrs on 12 May and 1700 hrs on 13 May to cover a 24 hr period while the ship was stationary for coring.

Hydrographic wire work was completed by 2004 hrs on 13 May after which one Agassiz trawl was carried out at station A2. The trawl was successful and provided a supplementary fish sample for deep-sea fish studies by Dr. J. Gordon at Dunstaffnage (Agassiz haul 1). Trawling and sampling at station A2 was completed at 01.39 hrs on 14 May and the ship then steamed south for 360 miles to station A1.

On route to station A1, surface (upper 5 m) plankton samples for planktonic foraminifera studies were again collected by Mr. Holmes from the pumped seawater supply. The pump samples were collected between 12.30 and 15.30 hrs and between 20.00 and 21.00 hrs on 14 May, between 23.00 and 02.00 hrs on 14-15 May and between 08.00 and 11.00 hrs on 15 May. During each sampling period the net was changed at the end of each hour's sampling and the ship's position recorded.

Calm weather conditions prevailed during passage and the ship made good time, arriving at station A1, 5000 m depth in the Porcupine Abyssal Plain, at 17.53 hrs on 15 May. Coring commenced immediately on arrival at station A1 and by 09.23 hrs on 16 May six successful hauls had been carried out using the SMBA multiple corer. Each haul provided 12 good cores, 25-30 cm in length. The cores from one haul provided samples for microbiological and foraminifera studies. The cores from the remaining hauls were preserved for SMBA meiofaunal studies while some of the overlying water was collected by Drs. Patching and Raine for oxygen determinations.

At 09.23 hrs on 16 May the corer was lowered for a seventh time at station A1. After the samples had been collected the corer., instead of being hauled straight back to the surface, was left suspended at a depth of about 100 m above the bottom for 36 hrs. This experiment

was carried out in an attempt to measure the rate of benthic community respiration at a depth of 4,900 m and as a comparison with the 24-hour experiment carried out at station A2. The corer was retrieved at 23.08 hrs 17 May on completion of the 36 hour experiment and contained 11 good cores. The overlying water in the core tubes was removed for oxygen determinations and the cores were made available for SMBA meiofaunal studies.

After the 36-hour experiment four more hauls were made with the multiple corer, each provided 12 good cores. Three cores from one haul provided material for microbiological studies while the remaining cores were sliced and preserved for SMBA meiofaunal studies. Some overlying water from the cores was collected by Drs. Patching and Raine for oxygen determinations. While the ship was stationary for coring at station A1, surface plankton samples were again collected by Mr. Holmes from the pumped seawater supply. These pump samples were collected between 09.00 and 12.00 hrs on 17 May and the net was changed at the end of each hour.

After the completion of coring at station A1 (at 08.30 hrs on 18 May) work began with the hydrographic winch. Two vertical plankton hauls were taken to a depth of 500 m by Mr. Holmes. This was followed by a Niskin bottle haul to 30 m, which was again unsuccessful due to the failure of the bottle to open properly. An N10 water bottle sample collected from the same depth, for studies of methane bacteria, completed the work at this station at 10.00 hrs.

The ship now steamed eastward towards the Porcupine Seabight. On route to the Seabight, surface plankton samples were again collected by Mr. Holmes from the pumped seawater supply, the pumped samples being

collected between 18.00 and 20.00 hrs on 18 May. Soon afterwards, the ship arrived at station PA1, the first of a series of Agassiz trawling stations in the Porcupine Seabight. Before trawling, however, a series of three vertical plankton hauls were collected to a depth of 500 m by Mr. Holmes, using the hydrographic winch. This was followed by a Niskin bottle haul which was only partially successful. Agassiz trawling began at 22.16 hrs on 18 May and 10,025 m of wire were paid out to fish at a depth of 4080 m. On recovery at 04.08 hrs on 19 May it was found that the cod-end had opened, presumably due to chafing on the bottom. Most of the catch had been lost but a large number of echinoderms were still adhering to the net and these were sufficient to provide a sample for IOS macrobenthic studies (Agassiz haul 2).

On completion of station PA1, the ship steamed towards station PA3. As time was insufficient to sample all the Agassiz trawling stations in the Porcupine Seabight, stations were selected in the most suitable trawling sites and to give the best range of depths.

The ship arrived at station PA3 in the Porcupine Seabight at 06.10 hrs on 19 May. Agassiz trawling began and 10,000 m of main wire were paid out in order to trawl at a depth of 4,000 m. The net was towed along the bottom for 30 minutes before hauling began. During hauling, the dynamometer fairlead sheave of the main wire started to run hot due to a sleeve slipping between the bearings and the axle. The metering gear had to be detached with 4000 m of wire still to come in. The remaining wire, therefore, had to be hauled in without knowledge of metres out, which necessitates a much slower haul rate

than normal. Despite these difficulties, the trawl contained a good catch of fish and invertebrates (Agassiz haul 3) which were sorted and preserved separately by Mrs. J. Duncan, the fish for Dr. J. Gordon at Dunstaffnage and the invertebrates for macrobenthos studies by Mr. D. Billett of IOS Wormley.

Once the trawl was on board again, the first officer (G. Long), chief engineer (C. Storrier) and engineering staff put a considerable effort into tracing and rectifying the fault. The main wire fairlead sheave was found to be unserviceable and was replaced by the starboard trawl fairlead sheave so that Agassiz trawling could continue.

The ship now proceeded to station PA5 in the Porcupine Seabight, a surface (upper 5 m) plankton sample being collected on route from the pumped seawater supply. Station PA5 was reached at 19.20 hrs and Agassiz trawling began immediately with 7,000 m of main wire being paid out to trawl at a depth of 2975 m. While paying out, a short circuit developed in the power supply to the metering gear, causing the unit to overheat. On this occasion two of the scientific staff, Mr. J. Watson and Mr. F. Drake, assisted the first officer and chief engineer in tracing the fault and replacing the power supply unit. Fault finding and rectification had to be carried out while the trawl was on the bottom with the result that hauling could not begin until repairs were complete. As a result of this the trawl was towed along the bottom for nearly twice the recommended time of 30 minutes and, when the trawl was eventually hauled on board, the net was found to be missing. Presumably an excessive amount of material had been collected

during the extra long tow and the weight of material had been too much for the net which was torn completely from its frame.

The ship now hove to while work began with the hydrographic winch. Vertical plankton work began at 00.42 hrs on 20 May and three successful hauls to 500 m were carried out. Meanwhile a spare Agassiz net was repaired by Mr. F. Dunning, the fishing skipper, and attached to the Agassiz frame.

Time did not permit a repeat trawl at station PA5 so when the plankton hauls were completed at 02.22 hrs the ship proceeded to station PA7, arriving on station at 03.20 hrs. The Agassiz trawl was shot immediately on arriving at station PA7, 6,000 m being paid out to trawl at a depth of 2750 m. The trawl was successful, a small but representative catch of fish and invertebrates (Agassiz haul 5) being obtained, the fish and invertebrates (including webbed starfish) were sorted and preserved separately by Mrs. J. Duncan for Dr. Gordon of SMBA and Mr. Billett of IOS.

On completion of trawling at station PA7 at 07.37 hrs, the ship steamed to station PA8 where she arrived at 09.17 hrs. The Agassiz trawl was shot immediately on arriving at station PA8, 6,000 m being paid out to trawl at a depth of 2,600 m. When brought on board again the net was found to be badly torn and the catch lost, presumably due to a rough bottom. Time did not permit a repeat trawl and the ship left the station at 13.40 hrs to steam to the 1000 m reserve coring station in the Porcupine Seabight (= Station P7 in Challenger Cruise 12/77). On route to the 1,000 m coring station surface plankton samples were again collected by Mr. Holmes from the pumped seawater supply.

Pump samples were collected between 16.15 and 19.15 hrs on 20 May and the net was changed at the end of each hour.

The ship arrived at the 1,000 m coring station at 01.30 hrs on 21 May but the weather conditions had deteriorated so badly with a strong northerly wind and heavy swell that it was considered too dangerous to carry out coring operations at this station. The 1,000 m coring station was abandoned and the ship now proceeded towards the 500 m coring station (= Station P8 in Challenger Cruise 12/77) where she arrived at 05.30 hrs. The weather conditions at the 500 m station were still poor for coring but not as dangerous as at the 1,000 m station and it was decided to attempt a haul with the multiple corer. The multiple corer was lowered at 06.22 hrs, carrying eight core tubes instead of 12 to allow for better penetration in the fine muddy-sand sediment of this station. Eight good cores were obtained, each about 25 cm long, which provided material for microbiological studies. During coring operations the ship lay well 'head to wind' and, although a heavy swell was still running, the handling of the multiple corer frame at the stern did not prove to be too difficult.

Coring at the 500 m station was completed at 06.45 hrs on 21 May and the ship then steamed north for Ardrossan. The ship docked in Ardrossan at 08.30 hrs on 23 May and the scientific party left the ship later that day.

7. Results

The SMBA multiple corer worked very well throughout the cruise, complete sets of cores being obtained from most hauls. Several hauls were taken at each of the main sampling stations A1, A2 and A3. On

only one occasion did the corer return empty, when a haul was attempted on the 500 m slope station on 11 May. Failure on this occasion was almost certainly due to the corer falling over on the very steep slope. As a result, both the 500 m and 1000 m slope stations were abandoned in favour of two reserve stations at 500 m and 1000 m in the Porcupine Seabight. The 1000 m Porcupine station also had to be abandoned, due to bad weather on 21 May, but the 500 m station was completed successfully.

The microbiological work carried out successfully on this cruise was a continuation and extension of the microbiological work carried out by or under the supervision of Professor C.M. Brown, Heriot-Watt University, on Challenger cruises 5/75, 6/79 and 15/79. Vertical plankton hauls and pump sampling for planktonic foraminifera were also carried out successfully.

The success of the coring programme permitted some time to be spent on Agassiz trawling. Some samples of additional material were obtained for SMBA deep-sea fish studies and for IOS deep-sea macrofauna studies. However, the Agassiz trawl nets issued did not appear to be very strong and Mr. F. Dunning, the fishing skipper, had to carry out a number of major repairs to make them serviceable. Trouble with the metering gear resulted in the trawl being towed for far too long on one occasion and was probably responsible for the loss of the net. On another occasion the net was badly torn, presumably as a result of being towed over rough ground.

Bottom photography at the main coring stations was not undertaken because of lack of time.

a. Coring for all projects (Dr. B. Hardy, Mr. J. Watson and Mrs. J. Duncan)

The SMBA multiple corer worked very well throughout the cruise and provided samples of bottom material for microbiological, foraminifera, meiofauna and chemical studies from most of the coring stations. The multiple corer was used with a 12-core assembly throughout most of the cruise. An 8-core assembly was used on only two hauls, haul 7 at station A2 and the single haul at station P8, when longer cores than normal were required.

At station A3 (158 m) the corer provided 45 cores out of a possible 48 in four hauls. At station A2 (2,880 m) it provided 88 cores out of a possible 92 in eight hauls while at station A1 (4,900 m), 131 cores were collected out of a possible 132 in 11 hauls. Only one haul was attempted at station P8 (535 m), providing 8 cores out of a possible 8, whereas no cores were obtained from the Rockall Trough 500 m slope station, presumably because the corer had fallen over on the steep slope. Coring was not attempted at station P7 because of rough seas.

b. Bacteriological Studies 1. (Mr. S. Fairnie and Mr. F. Drake)
(Account by Professor C.M. Brown, Heriot-Watt University, Edinburgh)

Samples of sediment and overlying water were obtained from four stations in the N.E. Atlantic (A3, A2, A1 and P8) by means of the S.M.B.A. multiple corer. These samples were used to conduct four experiments:

(i) Bacterial enrichments

Four sterile 1 litre chemostat vessels were inoculated with 10mls each of sediment from station A3. The vessels were then filled to overflowing with overlying water obtained from the same cores. The chemostats were run for 10 days using media containing single and mixed organic substrates. The contents

of each chemostat were sampled every 24 hours. These samples were serially diluted and plated out. The plates were incubated in the ship's cold room for counting ashore. The object was to enrich for populations able to utilise the substrates provided and to enumerate them.

A sterile glass slide was suspended in the medium of each chemostat so as to provide a surface for bacterial adhesion. Colonisation of these surfaces would permit slow growing bacteria to remain within the system. The slides were heat fixed for examination ashore.

(ii) Sulphate reduction experiments

Samples of sediment from each station were used to inoculate enrichment cultures to test for the presence of sulphate reducing bacteria. The rate of any possible sulphate reduction was to be established by the use of $^{35}SO_4$ tracer. At each station six flasks were inoculated with 5mls of sediment taken from the top 5cms of a single core. Three of the flasks contained sterile sea water and three contained sea water enriched with lactate. A known amount of $^{35}SO_4$ tracer was added to each flask. The flasks were incubated in the ship's cold room for 24 hours and then injected with 5mls cadmium acetate to fix any sulphide. They were then placed in the freezer to prevent any further bacterial activity and subsequently transported on ice to Heriot-Watt University for analysis.

(iii) Nitrate reduction

In order to establish the possible numbers of NO_3 reducing bacteria a serial dilution was made of sediment taken from the

top 5cms of cores from each station. A sample from each dilution was plated out onto agar plates containing added nitrate. The plates were incubated in anaerobic jars in the ship's cold room. The counting and subsequent analysis was carried out ashore. In an attempt to establish the rate and products of nitrate reduction, sediment samples contained in universal bottles were supplemented with various substrates. One such experiment was supplemented with glutamate in order to study the mineralisation of organic nitrogen in deep sea sediments.

(iv) Distribution of Methanogens

Samples of sediment, overlying water and surface water from stations A2 and A1 were added to methanogenic media in 1 litre airtight bottles. The bottles were then gassed out with nitrogen and left to ferment. The headspace gasses will be tested periodically for the presence of methane. It is hoped that this experiment will shed some light on the distribution of methane bacteria in the oceans.

c. Bacteriological Studies 2. (Account by Dr. R. Herbert)

Undisturbed sediment samples were obtained from sampling stations A1, A2, A3 and one station on the continental slope (station P8) using the S.M.B.A. multiple corer. The top 5 cm of the undisturbed cores was used to isolate various bacterial groups on selective media as follows:-

(i) Total viable counts of heterotrophic bacteria were determined using Zobell's marine agar and the plates incubated under aerobic and anaerobic conditions at $4^{\circ}C$ and room temperature. Visible bacterial growth on all the plates inoculated with A3 sediment

was apparent by the end of the cruise. Further characterisation and physiological studies will be carried out on shore.

(ii) Nitrate respiring bacteria were determined on nutrient agar + 1% $^{w}/_{v}$ KNO_3 + 3% $^{w}/_{v}$ NaCl media and incubated under anaerobic conditions. The isolates which develop under these growth conditions will be further characterised and studied on shore.

(iii) Nitrate reduction rates from all the stations were determined by inoculating 10 g sediment slurries with different concentrations of KNO_3 and incubating at $4^{o}C$ and laboratory temperatures for 7 days before freezing the samples to stop the reaction. Chemical analyses for NH_4^+ - N, NO_3^- - N and NO_2^- - N will be carried out on shore.

(iv) Enrichment culture for sulphate reducing bacteria and viable counts of sulphate reducing bacteria were carried out at each sampling station using Postgate's medium amended with different carbon sources. For the enrichment cultures 11 carbon sources were used:- lactate, acetate, pyruvate, succinate, formate, fumarate, propanol, ethanol, butanol, propionic acid, butyric acid and no carbon addition. Positive sulphate reduction was observed with A3 sediments at room temperature at the termination of the cruise. Total viable counts of sulphate reducing bacteria at each station were performed using the most probable number techniques with five carbon sources:- acetate, pyruvate, lactate, ethanol and propionate.

d. Microbiological experiments (Dr. D. Nedwell and Mr. I. Banat)

(Account by Dr. D. Nedwell)

The purpose of our work was

(i) to measure rates of sulphate reduction by bacteria in bottom sediments, using $^{35}SO_4$ as a radiotracer.

(ii) to measure in situ sedimentary concentrations of volatile fatty acids, principally acetate, propionate and butyrate.

(iii) to measure turnover rates of acetate in bottom sediments, using uniformly labelled ^{14}C-acetate as a radiotracer.

(iv) to attempt to measure the importance of acetate as a substrate for sulphate-reducing bacteria in the sediment.

At all stations small cores of sediment in hypodermic syringes have been taken from the large cores obtained with the SMBA multiple corer. Small cores have been taken from both the 0-5 cm depth horizon, and from the bottom 5 cm of the core (usually 10-15 cm depth). Duplicate small cores from each depth have been injected with radiotracers and incubated at 4°C in the ship's low temperature room. Incubation has been for 48 hours for $^{35}SO_4$, and 1-2 hours for ^{14}C-acetate turnover. At the end of incubation the injected cores are deep-frozen for analysis on return to shore.

Fatty acid concentrations have been analysed on board with a gas liquid chromatograph. Detectable levels of acids were present at stationA3, but in the deeper water stations there is too little to detect without concentration by rotary evaporation. Frozen samples are therefore being returned to shore for analysis.

Sediment slurries will be made from sediment from station A2, and held under nitrogen or hydrogen in conical flasks. Sulphate reduction

rates will be measured using $^{35}SO_4$. The importance of acetate as a substrate for sulphate reducing bacteria will be examined using β-fluoroacetate, an inhibiting analogue of acetate, to show the proportional inhibition of sulphate reduction in the presence of the analogue. These last experiments will be carried out at room temperature in order to get a relatively rapid rate of sulphate reduction.

e. Respiration and metabolic activity of deep-sea sediments

(Account by Dr. J. Patching and Dr. R. Raine)

The objective was to obtain additional information on oxygen uptake by the sediment and flux of ammonia across the sediment-water boundary layer at sites A1, A2 and A3.

(i) Sediment oxygen uptake

Both onboard and in situ systems were used to monitor oxygen uptake.

The onboard technique, involving the recirculation of water over cores maintained at in situ temperatures, was used at each location. Significant drops in oxygen concentration of overlying water were observed in all cases.

The in situ technique, where the cores were taken and suspended ca. 100 m above bottom for a period of time, was used at A1 and A2. Incubation times were 36 hr and 24 hr respectively. In both cases, measurable oxygen consumption was recorded.

(ii) Measurements of ammonia concentration

The ammonia concentration in interstitial water of sediment at sites A1 and A2 were measured, and gradients of concentration with depth were recorded. Measurements of ammonia concentration in

overlying water at A2 and A3 did not show vertical gradients, however this could not be tested at A1. In conjunction with these interstitial water measurements, samples were also taken and stored for organic carbon and nitrogen analysis at University College, Galway.

Surface water samples were also taken for the study of small- and large-scale horizontal variations in heterotrophic activity (dark bottle oxygen uptake), chlorophyll and total bacterial counts at stations A1, A2 and A3.

f. Planktonic foraminifera studies (account by Mr. N. Holmes)

The aim of this work was to obtain live and dead planktonic foraminifera from the water column and sediment to establish and compare species distribution.

Using cores from the multiple corer, recent foraminifera were obtained from the top 1 cm of sediment. The cores were also sectioned at 1-2, 2-4 and then at 4 cm intervals for future study. Cores were obtained at stations A3 (core 8), A2 (core 7) and A1 (cores 2 and 12).

Living planktonic foraminifera were collected in nets with a mesh size of 148μ by two methods:

(1) From vertical hauls, from 500 m to the surface, using a conventional plankton net with an 18-inch diameter ring. The following hauls were made:

No. of hauls	Time (B.S.T.)	Date	Position
1*	0408-0424	11/5	St. A3
2**	2014-2104	13/5	St. A2
2	0832-0935	18/5	St. A1
3	2026-2148	18/5	$49^{\circ}45.3'$N $14^{\circ}08'$W
3	0042-0222	20/5	St. PA5

* Due to the depth, this haul was made from 110 m to the surface

** The second haul was made from a depth of 50 m.

(2) Using a constant-flow non-toxic pump, sea water was filtered using two interchangeable bag-shaped nets. Each sample was taken after 1 hour of filtering. Water was pumped from a depth of 5 m. Two variations of sampling were used here:

(i) Whilst the ship was moving samples were taken to provide a transect from one area to another where the composition of the foraminiferal assemblage may be different. At each haul the ship's position was recorded.

The following samples were taken:

No. of Samples	Samples	Time (BST)	Date	Position
7	A-G*	1300-1900	11/5	56°08.6'N 9°20.8'W to 55°40.6'N 10°38.3'W
3	A-C	1230-1530	14/5	53°31'N 13°17.9'W to 53°03.9'N 13°43.0'W
1	D	2000-2100	14/5	52°31.7'N 14°07.0'W to 52°21.7'N 14°13.3'W
3	E, F, A	2300-0200	14, 15/5	52°04.5'N 14°26.3'W to 51°37.7'N 14°48.9'W
3	B-D	0800-1100	15/5	50°48.5'N 15°27.9'W to 50°20.7'N 15°50.5'W
2	A-B	1800-2000	18/5	49°42.7'N 14°39.9'W to 49°45.6'N 14°09'W
1	A	1500-1600	19/5	50°08.5'N 13°45.3'W to 50°11.6'N 13°32.4'W
3	A-C	1615-1915	20/5	50°42.6'N 13°14.2'W to 51°08.9'N 13°01.9'W

* Samples A + B were of ½ hour's duration.

(ii) Whilst the ship was stationary, to detect any change in the composition of the foraminiferal assemblage over a composite period of 24 hours. The following samples were taken:

No. of Samples	Samples	Time (BST)	Date	Position
8	A-F	0230-1030	12/5	St. A2
7	G-M	1700-2400	12/5	St. A2
6	N-S	1100-1700	13/5	St. A2
3	A-C	0900-1200	17/5	St. A1

g. Meiofauna studies (Dr. B. Hardy, Mr. J. Watson and Mrs. J. Duncan)

Multiple corer samples were collected from the routine sampling stations A1, A2 and A3, sectioned, and preserved for examination at the Dunstaffnage Laboratory. The samples provided material for S.M.B.A. meiofauna studies being carried out with special reference to the systematics, distribution and seasonal changes of benthic harpacticoid copepods in the deep sea.

h. Agassiz trawling (Dr. B. Hardy, Mr. J. Watson and Mrs. J. Duncan)

Agassiz trawling was carried out when time permitted, once at Station A2 in the Rockall Trough and on five occasions, each at a different depth, in the Porcupine Seabight. One net was lost while trawling at 2975 m in the Seabight, when a fault developed in the metering system and prevented the net from being hauled at the correct time. It is thought that too much material was collected on this occasion and that the weight of material caused the net to tear away from its frame. On another occasion, at 2600 m in the Porcupine Seabight, the net was badly torn, presumably as a result of being towed over rough ground. The other hauls provided samples of fish and

invertebrates which were sorted and preserved separately by Mrs. J. Duncan as supplementary material for S.M.B.A. deep-sea fish studies (Dr. J. Gordon) and for macrofauna studies at IOS Wormley (Mr. D. Billett).

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We are extremely grateful to the master, Captain Selby-Smith and his officers for their helpful cooperation and advice, to the first officer Mr. G. Long, and chief engineer, Mr. C. Storrier, for ensuring the continued operation of the gear and to the fishing skipper, Mr. F. Dunning for his help with the trawling.

Finally, we wish to thank Mr. C. Adams and Mr. I. Innes for their willing help in planning and preparing for this cruise.

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9th June, 1980.

Table 1 Challenger Cruise 8/80

Summary of Sampling Stations

Station and Date	Gear and Haul No.	Position		Depth (m)	Bottom water		Remarks
		N	W		Temperature °C	Salinity ‰	
A3	Multiple Corer 1	56°01.4′	07°39.1′	158	8.92		12 cores for Bacteria and Foraminifera studies.
11 May	2	56°02.4′	07°39.0′	158			11 cores (12 possible) for Bacteria studies.
	3	56°01.4′	07°39.0′	158			11 cores (12 possible) for meiofauna studies
	4	56°01.6′	07°38.8′	158		35.324	11 cores (12 possible) for meiofauna studies
	Water bottles	56°01.7′	07°38.7′	98			10, 20, 30, 40, 50 and 60 m above bottom for ammonia analyses.
				108			
				118			
				128			
				138			
				148			
	Plankton net (Vertical haul)	56°01.9′	07°38.7′	110 to surface			1 haul for planktonic foraminifera

Table 1 (Cont.)

Station and Date	Gear and Haul No.	Position		Depth (m)	Bottom water		Remarks
		N	W		Temperature °C	Salinity ‰	
500 m slope station	Multiple corer	56°09.35′	09°12.06′	500			No cores, bottom slope probably too steep.
On route 500 m slope station to A2	Pumped seawater supply through plankton net	56°08.6′ to 55°40.6′	9°20.8′ to 10°38.3	5			Net changed every ½ hour for planktonic foraminifera studies. (1300 to 1900 hrs on 11 May)
A2 12-14 May	Multiple corer 1	55°03.6′	12°03.5′	2,880		34.972	12 cores
	2	55°03.4′	12°03.4′			34.941	12 cores — for meiofauna studies
	3	55°03.5′	12°03.02′				12 cores
	4	55°03.4′	12°03.3′				12 cores — 7 for bacteria and foraminifera; 5 for meiofauna studies
	5	55°03.18′	12°02.73′				10 cores (12 possible)
	6	55°03.3′	12°03.4′				10 cores (12 possible) — for meiofauna studie
	7	55°03.0′	12°03.8′				8 cores (8 possible) suspended 100 m above bottom for 24 hrs to estimate O_2 consumptio in situ.
	8	55°03.5′	12°03.5′		2.73		12 cores — 6 as control for haul 7; 1 for bacteria studies; 5 for meiofauna studies

Table 1 (Cont.)

Station and Date	Gear and Haul No.	Position		Depth (m)	Bottom water		Remarks
		N	W		Temperature °C	Salinity ‰	
A2 (Ctd.)	Water bottles	55°03.5′	12°03.3′	2,760 2,780 2,800 2,820 2,840 2,860			20*, 40, 60, 80*, 100 and 120 m above bottom for ammonia analyses. (* No water sample obtained) and to provide a sample of low zinc standard seawater.
	Niskin bottle	55°03.5′	12°01.2′	30			Sample for bacteria studies, but did not operate.
	Water bottle	55°03.5′	12°01.2′	30			Sample for study of distribution of methane bacteria.
	Plankton net 1 (Vertical haul)	55°03.56′	12°01.02′	500 to surface			2 hauls for planktonic foraminifera studies.
	2	55°02.72′	12°02.65′	50 to surface			
	Pumped seawater supply through plankton net.	55°03.5′	12°03.5′	5			Planktonic foraminifera studies. Net changed every hour between 0230-1030 hrs and 1700-2400 hrs on 12 May and 1100-1700 hrs on 13 May.
	Agassiz Trawl 1	55°02.29′	12°02.37′	2,865			Good catch, sample for SMBA deep-sea fish studies.

Table 1 (Cont.)

Station and Date	Gear and Haul No.	Position N	Position W	Depth (m)	Bottom water Temperature °C	Bottom water Salinity ‰	Remarks	
On route A2 to A1 14-15 May	Pumped seawater supply through plankton net 1	53°31.0′ to 53°03.9′	13°17.9′ to 13°43.0′	5			1230 to 1530 hrs on 14 May	Planktonic foraminifera studies. Net changed every hour.
	2	52°31.7′ to 52°21.7′	14°07.0′ to 14°13.3′				2000 to 2100 hrs on 14 May	
	3	52°04.5′ to 51°37.7′	14°26.3′ to 14°48.9′				2300 hrs on 14 May to 0200 hrs on 15 May	
	4	50°48.5′ to 50°20.7′	15°27.9′ to 15°50.5′				0800 to 1100 hrs on 15 May	

Table 1 (Cont.)

Station and Date	Gear and Haul No.	Position N	Position W	Depth (m)	Bottom water Temperature °C	Bottom water Salinity ‰	Remarks
A1 15-18 May	Multiple corer 1	49°30.2′	16°29.2′	4900			12 cores for bacteria and foraminifera studies.
	2	49°30.16′	16°29.7′				12 cores
	3	49°29.3′	16°28.0′				12 cores
	4	49°30.0′	16°30.1′			34.906	12 cores — for meiofauna studies and water chemistry.
	5	49°29.9′	16°29.9′			34.949	12 cores
	6	49°30.1′	16°29.7′				12 cores
	7	49°29.9′	16°29.9′				11 cores (12 possible) suspended 100 m above bottom for 36 hrs to estimate O_2 consumption in situ.
	8	49°30.04′	16°30.1		2.59		12 cores - 3 for bacteria/chemistry, 9 for meiofauna.
	9	49°30.0′	16°29.9′				12 cores
	10	49°30.1′	16°30.14′				12 cores — for meiofauna studies
	11	49°30.3′	16°29.8′				12 cores
	Pumped seawater supply through plankton net.	49°30′	16°30′	5			Planktonic foraminifera studies. Net changed every hour between 0900 - 1200 hrs on 17 May

Table 1 (Cont.)

Station and Date	Gear and Haul No.	Position N	Position W	Depth (m)	Bottom water Temperature °C	Bottom water Salinity ‰	Remarks
A1 (Ctd)	Plankton net (Vertical haul) 1	49°30.49′	16°30.03′	500 to surface			2 hauls for planktonic foraminifera studies.
	2	49°30.6′	16°29.18′	500 to surface			
	Niskin bottle	49°30.78′	16°29.18′	30			Sample for bacteria studies, but failed to operate.
	Water bottle	49°30.8′	16°29.12′	30			Sample for study of distribution of methane bacteria.
A1 to Porcupine Seabight 18 May	Pumped seawater supply through plankton net.	49°42.7′ to 49°45.6′	14°39.9′ to 14°09′	5			Plankton foraminifera studies. Net changed every hour between 1800 - 2000 hrs on 18 May.
PA1 18 May	Plankton net (Vertical haul) 1	49°45.4′	14°08.5′	500 to surface			3 hauls for planktonic foraminifera studies.
	2	49°45.22′	14°08.57′	500 to surface			
	3	49°45.03′	14°08.53′	500 to surface			

Table 1 (Cont.)

Station and Date	Gear and Haul No.	Position		Depth (m)	Bottom water		Remarks
		N	W		Temperature °C	Salinity ‰	
PA1 (Ctd)	Niskin bottle	49°45.20′	14°08.8′	30			Sample for bacteria studies, but did not operate properly.
	Agassiz Trawl 2	49°45.9′	14°08.85′	4080			Net opened, no fish but numerous invertebrates adhering to net.
PA3 19 May	Agassiz Trawl 3	49°47.4′	14°02.1′	4000			Good catch, fish and invertebrates for SMBA deep-sea fish studies and IOS macrobenthos studies.
On route PA3 to PA5 19 May	Pumped seawater supply through plankton net	50°08.5′ to 50°11.6′	13°45.3′ 13°32.4′	5			Planktonic foraminifera studies 1500 - 1600 hrs.
PA5 19-20 May	Agassiz Trawl 4	50°07.6′	13°29.3′	2,975			Lost net - towed too long because of metering failure.
	Plankton net (Vertical haul) 1	50°17.56′	13°32.92′	500 to surface			3 hauls for planktonic foraminifera studies.
	2	50°17.53′	13°34.82′				
	3	50°17.29′	13°34.22′				

Table 1 (Cont.)

Station and Date	Gear and Haul No.	Position		Depth (m)	Bottom water		Remarks
		N	W		Temperature °C	Salinity ‰	
PA7 20 May	Agassiz Trawl 5	50°18.9′	13°25.0′	2,750			Good catch, fish and invertebrates for SMBA deep-sea fish studies and IOS macrobenthos studies.
PA8 20 May	Agassiz Trawl 6	50°19.29′	13°12.39′	2,600			Net torn - no catch.
On route PA8 to P7 20 May	Pumped seawater supply through plankton net	50°42.6′ to 51°08.9′	13°14.2′ 13°01.9′	5			Planktonic foraminifera studies. Net changed every hour between 1615 - 1915 hrs on 20 May
P7 21 May	Multiple corer	51°55′	12°46′	1,000			Station abandoned - sea too rough for coring.
P8 21 May	Multiple corer	52°28,9′	12°25.7′	535			8 cores (8 possible) for bacteria and chemical studies.