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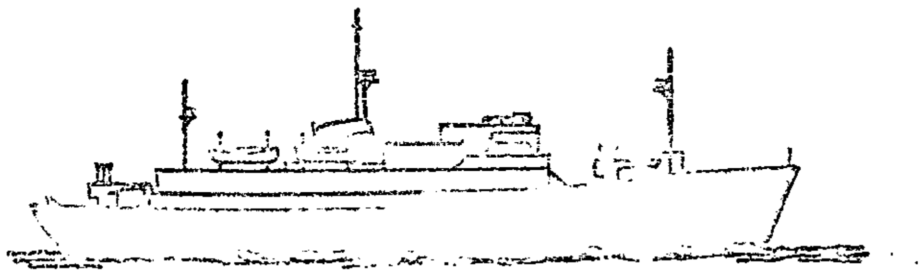

R.R.S. DISCOVERY

CRUISE 51

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N.E. ATLANTIC AND N.W. MEDITERRANEAN

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Objectives

Leg 1 Southampton to Gibraltar

1. Lay 3 current meter moorings on N. Biscay slope
2. Lay shallow tide gauge on Josephine Bank
3. Obtain a magnetometer profile from Biscay to Josephine Bank
4. Test new deep sea tide gauge acoustics
5. Test new pyro-releases
6. Develop new multiprogramming system on the computer
7. Make a combined TSD and camera profile in Gulf of Cadiz
8. Develop Mk III echo-sounder
9. Test explosive devices (Messrs. Albright and Wilson)

Leg 2 Gibraltar - Gulf of Lyons - Tyrrhenian Sea - Gibraltar

1. TSD survey and float tracking on the Rhone Fan (Medoc Area)
2. Coring, air gun profiles and dredging in the Tyrrhenian Sea (Southampton University, Department of Geology)
3. Magnetometer profiles on passage

Leg 3 Gibraltar to Barry

1. Repeat the TSD and camera station in the Gulf of Cadiz
2. Recover the tide gauge on Josephine Bank
3. Test new net monitors
4. Bathymetric and magnetic profiles on passage, along tracks chosen to fill gaps
5. Recover 3 current meter moorings near $47\frac{1}{2}°N$, $8\frac{1}{2}°W$
6. Towing trials on near-surface T-S fish. These were all done with some time to spare, and approximately 30 hours were spent in surveying part of Shamrock canyon, just to the north of the current meter mooring area.

Narrative

Leg 1

On leaving Southampton at 1630 hrs on 4th November the ship set course for the current meter mooring position (47°40'N, 08°20'W). The weather was good and seas slight, a state of affairs which persisted over the whole of the first leg. The E/S fish was streamed at 1000 hrs the following morning but watchkeeping did not start until 2220/5 approaching the edge of the shelf. On arrival at the first mooring position (130) at 0630/6 the wire was tightened before breakfast and the mooring laid without incident in the forenoon. In the afternoon the 2nd mooring about 9 miles down the slope was laid, again without incident. As the computer system was not up at the time and therefore no satellite fixes available when we laid mooring 130 we went back to check its position by satellite as it was now working. There was also some concern that our transmissions when laying mooring 131 might have fired the release of 130. Unable to turn on 130's command pinger we retreated to a safe distance and overnight took 3 pairs of 7½ litre water samples from shallow, mid and deep water for trace metal analysis. For the remainder of the night the new servo controlled electric winch was tested and calibrated. At 0630/7 after a short search the command pinger of mooring 130 was turned on. The mooring was fixed by satellite and found to be about 1'220° from the Decca position. With the command pinger turned off we moved to mooring position 132 again 9 miles down slope and had completed the mooring by 1640/7.

We now moved off into deep water for various tests overnight. Two new pyro release rigs for the M.O.D.E. neutrally buoyant floats were fired successfully at 4200 m depth.

Wire on the new winch was run out to 4200 m under auto velocity control with complete success. The lowering and raising times were precisely 50 minutes. In the daylight hours of the 8th the main warp was inspected, badly crippled wire dumped and spare wire from the wing drums spliced onto it in preparation for the coring and dredging programme on leg 2. Further trace metal samples were taken and acoustic checks made on the shallow (200 m) and deep (4000 m) tide gauges using the main warp. At 1742/8 passage was set to Josephine Bank taking a route out to 43°45'N, 16°W to provide a PES and magnetometer profile over ground not previously covered. Several hills were noted in an area which the bathymetric charts indicated as abyssal plain. A slight change in plain depth on either side of one of these suggested that it may be a fairly extensive feature.

Arriving in the neighbourhood of Josephine Bank at 1740/11 we took more deep samples for trace metal analysis before making a PES survey of the southern part of the bank overnight. This was satellite controlled and enabled us to proceed immediately it was light to lay the shallow tide gauge in a depth of 194 m. After checking the command pinger after breakfast, course was set for the Gulf of Cadiz. In the forenoon of 13th November the deep tide gauge was allowed to free fall to 3900 m and remain on the bottom for two hours before the acoustic release was fired. The gauge was recovered without incident after taking about one hour to surface. Passage continued towards Gibraltar until 1930 when we stopped for a TSD station requested by Dr Thorpe. The object was to lower a TSD through the Mediterranean water at a place where it was just lifting clear of the bottom. At the same time a camera below the TSD was observing possible suspended sediment. $7\frac{1}{2}$ litre bottles were also filtered for later examination of the sediment within and below the Mediterranean water. This completed our work on leg 1 and the ship docked in Gibraltar at 1330/14th November. The inboard work on the MK III PES and the computer system are discussed elsewhere in the report.

This is perhaps a suitable point to mention that we had all been agreeably surprised by the quality of the catering on board during the first leg. The exceptionally high standards maintained by the catering staff and stewards made a significant contribution to the cruise. These standards persisted for the whole cruise.

Leg 2

After numerous changes in the scientific party we sailed from Gibraltar at 1800/15, waited outside for a short while for a new Radio Officer and then set course south of the Balearics for the Gulf of Lyons. The magnetometer and PES were run on all passages on this leg. During passage to the Gulf of Lyons we stopped for three deep TSD stations in the Balearic basin to provide references against which to compare the deep water of the MEDOC area. On these earlier stations both a 9040 TSD and rosette multisampler cast followed by a conventional water bottle cast were made to help calibrate the TSD. Although the temperature sensor turned out to be very stable the salinity sensor was extremely unstable often slowing several jumps during one cast up to 0.03‰. It was only the fact that we had the multisampler, very good analysts and the very well defined situation existing in the Mediterranean bottom water that saved the situation.

We arrived in the Gulf of Lyons (42°N, 5°E) at 0600/19. Over the space of the next few days 6 floats were laid in the Intermediate and Deep water and tracked for up to 9 days. One further float failed on launching, the circumstances suggesting that a balancing weight had shorted the scroll terminals. A schematic of their direction of movement is shown in figure 2. The most distinctive feature of the flow is that it was generally along the contours although individual fixes (about 1 a day) showed some meandering across the contours. It is clear however that the floats on the SW slope of the Rhone fan were moving with a westerly component whilst those on the eastern slope were moving in a north easterly direction indicating a divergence at the southern end of the fan. One float was placed 2 m above the bottom in the narrow gully which cuts SSE down to the tip of the fan. This showed a slight tendency to move up the canyon into shallower water although the navigation has yet to be confirmed. 22 TSD stations were carried out in the area of the fan (fig. 3). A potential temperature minimum of depths greater than 1800 m was present on all stations supporting the findings of the Laboratoire d'Oceanographie Physique earlier in the year. The depth of the minimum was greatest for stations in the Balearic plain to the south. For a day and a half in the middle of our work there were storm force winds gusting to 60 kts from the north with air temperatures dropping to 8½°C. These brought outboard work to a standstill and significantly reduced the temperature of the surface layer though without any apparent effects on either the currents or deep structure. Near surface temperatures were observed routinely by hull and periscope mounted thermistors.

A feature of this leg was our increasing confidence in and use of the new servo controlled winch. It gave no trouble and was very much more convenient to use than the forw'd hydro winch. Problems remain with, for example, the communications between the winch in the forw'd hold and the deck. It is also extremely noisy and uncomfortable down below for the man on watch there. It is important not to drive the winch in auto velocity mode when equipment on the wire is close to or above the sea-surface as the direction that the wire will move in cannot be predicted. For the last three STD stations we transferred from the mid-ships to the electric winch the only problem arising, possibly coincidentally, from spiking noise on the temperature sensor.

Work was completed in the Gulf of Lyons at 1650/28 and passage set for the Tyrrhenian Sea via the Straits of Bonifacio. Although the French Naval authorities had been informed that we would be working in the area it turned out that there was a submarine exercise in progress for part of the time and that our pingers caused some confusion and concern to them. It was unfortunate that a signal informing us of this exercise was not received until after we'd left the area. Further comments and texts of relevant signals are contained in the Master's Cruise Report to RVB.

<u>Tyrrhenian Sea (Dr N. Hamilton, Dept. of Geology, University of Southampton)</u>

The geological-geophysical leg of the cruise had two principal objectives. Firstly, an investigation, by coring of the superficial sediments occurring in the north-eastern part of the Tyrrhenian abyssal plain and adjacent outer fan valley of the northern Naples canyon system. Secondly, to use the air-gun system of seismic profiling to determine the thickness and character of the unconsolidated sediments which blanket the older structural elements of the continental borderland region off Naples. At the same time to investigate the nature of several ridge-like blocks which also form an important physiographic component of the continental borderland in this region. Marine magnetic surveying and precision echo-sounding was planned for all tracks within the borderland region.

A subsidiary objective was to attempt to sample by means of a dredge haul the upper eastern slope of the central seamount, Mt Vavilov, on the abyssal plain.

At 0730 on the 30th November, <u>Discovery</u> was on station TS 53, north of Mt Vavilov and coring commenced using the short 1 m barrel of the 10 cm diameter gravity corer in a water depth of

3567 m. A full liner was obtained from this drop, this core was subsequently transferred to the constant temperature lab for culture experiment. A repeat drop was made but the core catcher broke and the core was lost. The 3 m barrel, with orientation camera attached to the weight stand was then lowered, but winch malfunction entailed retrieving the wire and after repair lowering recommencing at 1355, again the catcher failed to operate properly and most of the core was lost on surfacing. Discovery then steamed to the next station TS 54 allowing time to endeavour to improve the action of the catcher system. At 1752 the 3 m barrel was again lowered and a good length core (215 cm) obtained. At station TS 55 again catcher trouble occurred, the catcher sheared off probably on impact and was lost. Also the orientation camera trigger switch and trigger weight were lost. Discovery then steamed to station TS 56 in deteriorating sea conditions. Further attempts at coring were then abandoned on the Master's recommendation until the weather improved. Instead a short precision echo-sounding survey of the outer fan valley commenced at 0130 on the 1st December and ended at 0800 by which time a slight improvement in sea state was apparent.

Coring recommenced on station TS 57 but without the orientation camera attached; a successful core was brought on board at 0930. It was then decided to commence the air gun survey, anticipating that coring would be resumed when sea conditions improved. This break from coring would allow some time to repair the broken leaves on the catcher and time to devise another means of triggering the orientation camera. Discovery steamed NNW to come into position for the start of the planned profiling tracks. The air gun and hydrophone streamer were successfully launched and operational by 1130 hrs. The magnetometer was then streamed. At 2030 hours cabled clearance to enter Italian territorial waters was received and adjustment was made to the tracks to allow an originally planned track to be completed. Profiling continued until 1414 on 3rd December by which time sea conditions has improved greatly and all gear was satisfactorily retrieved.

Coring recommenced at station TS 59, at 1540 hours, with the repaired orientation camera attached. This station was located on a terrace immediately adjacent to the canyon axis. Penetration was limited to 8 cm due to a well indurated sandstone being encountered. Discovery then steamed parallel to the canyon westwards towards the abyssal plain, a further coring station TS 58 was attempted but had to be abandoned because of an unsuitable bottom and failure to obtain a good sea bottom return from the pinger. After another unsuccessful coring attempt at station TS 56 due to a faulty trigger of the catcher ring, Discovery steamed SE to core in an embayment to the east of Mt Flavio Gioia. A successful core was landed at 0740 on the 4th December. The magnetometer was then streamed and the ship got underway towards Mt Vavilov for the dredge haul station. A preliminary bathymetric survey was completed by 1103 and the dredge was put over at 1115, contact was made in a water depth of about 1000 fathoms at 1225 with the ship moving slowly forward at $\frac{3}{4}$ knot dredging continued until 1320. The dredge net was retrieved at 1415 but was empty.

The 1 and 2½ ton weak links had broken and the net had inverted. Smears of mud indicated contact had been made.

The magnetometer was streamed and Discovery got underway for the passage to Gibraltar. On 6th December whilst crossing the Balearic abyssal plain it was decided to attempt a further coring station. A successful core was obtained in a water depth of 2847 metres, this station was coded BB 1.

Leg 3

The ship sailed from Gibraltar at 1700/9. The echo-sounder and magnetometer were both streamed and watches commenced on both these and the hull mounted temperature sensor. The first station, occupied at 0630/10, was a repeat of station 8204 using TSD, multisampler and camera to investigate Mediterranean water in the Gulf of Cadiz. No large samples were filtered this time however.

Josephine Bank was reached at 1500/11 and the tide-gauge immediately located. It was inboard by 1600. The opportunity was taken to leak test the two net monitor cases at shallow depth (150 m) on the new winch.

From Josephine Bank the chosen track for magnetic and bathymetric profiles led almost due north to 43°30'N, 14°W, and thence to the area of the current meter moorings. Deep water (4000 m) was reached by 0230/12 and tests were made on one of the net monitors (station 8244). Good acoustic signals were obtained, and the net could be opened, but not closed. That test was completed by 0800/12. On resuming passage, the T-S fish was streamed; it appeared to tow quite well at all speeds up to the full speed available (10 knots). The second net monitor was tested successfully in the evening of the 12th (station 8245).

Passage continued northward and north eastward from 2030/13 in worsening weather until 0530/15 when mooring position 132 was reached. The command pinger was on at 0600 and all gear inboard by 0920. Mooring 131 was located at 0950 and inboard by 1135. The last mooring was located and inboard by 1350. After moving off into deep water the RMT1 + 8 net with net monitor was launched and hauled from a wire out of 3167 m. The monitor worked successfully. Because of the poor weather an echo-sounder and magnetometer survey was commenced of Shamrock Canyon on the northern side of the mooring area with the intention of breaking off for net calibrations when the weather moderated. This opportunity did not arise during the time we had available. The survey was completed at 0155/17 and course set for Barry. Before arrival a flow meter calibration was carried out at 2 knots. The ship docked at 1515/18.

List of Ship's Officers

G.L. Howe	Master
P.J. MacDermott	Chief Officer
D.A. Pye	2nd Officer
S.D. Mayl	3rd Officer
P. Singleton	Radio Officer (Leg 1)
P. Taylor	Radio Officer (Leg 2, 3)
A.E. Coombes	Chief Engineer
R. Young	2nd Engineer
H.K. Gabitas	3rd Engineer
M.J. Dicker	4th Engineer
H.G. Davies	5th Engineer
A.F. Patterson	5th Engineer
F.P. Sharpe	Chief Electrician
A. Lane	2nd Electrician

As usual, the Officers and crew of Discovery contributed materially and substantially to the success of the cruise and the scientists take this opportunity of thanking them for their co-operation.

List of Scientific Participants

Dr M.V. Angel	3	NIO
Mr J.R. Berry	1, 2, 3	NIO
Mr R. Blow	2	Southampton University
Mr R.N. Bonner	2	NIO
Dr R.M. Carson	3	NIO
Mr J. Cherriman	1	NIO
Dr C.H. Clayson	1	NIO
Mr I. Cole	2	Southampton University
Mr J. Crease	1, 2	NIO, Principal Scientist.
Dr F. Culkin	2	NIO
Mr E. Darlington	1, 2	NIO
Mr R. Dobson	1, 2, 3	NIO
Dr D. Frederick	2	Southampton University
Mr D. Grohmann	1	NIO
Dr D.T. Grossart	1, 2, 3	NIO
Mr T.J.P. Gwilliam	3	NIO
Dr N. Hamilton	2	Southampton University
Mr M.J. Harris	3	NIO
Mr C. Flewellen	2	NIO
Mr G.T. Mardell	2	NIO
Mr M.J. McCartney	1, 2	NIO
Mr M.J. Morgan	1	NIO
Mr N.J. Olliff	3	NIO
Mr N. Orr	3	NIO
Mr M. Palmer	1	Messrs Albright & Wilson
Mr H.S.J. Roe	3	NIO
Mr K. Sampson	2	NIO
Mr T. Sankey	2, 3	NIO
Mr J. Smallbone	1, 2	NIO
Mr M.L. Somers	1, 2	NIO
Mr R. Spencer	1	NIO
Mr W.K. Strudwick	1, 2, 3	NIO
Dr J. C. Swallow	3	NIO, Principal Scientist.
Dr A.J.R. Voss	1	NIO
Mr R.F. Wallace	1	NIO
Mr R.A. Wild	3	NIO

Leg 1. Southampton - Gibraltar

Leg 2. Gibraltar - Gibraltar

Leg 3. Gibraltar - Barry

Notes on Equipment and Observations

Coring, Dredging and Air Gun Profiles (Hamilton, Flewellen, Bonner)

Despite the set backs with the faulty operation of the core catcher and triggering device, three very useful cores were obtained in positions which should provide some valuable information about the character of the sediments adjacent to and in the outer fan valley.

Perhaps the most outstanding feature of the coring was the penetration of the indurated sandstone on the canyon terrace at station TS 59. This specimen though small is laminated at its base, and has abundant foraminifera and is moderately well cemented. Its abrupt contact with some 3 cm of brown mud that overlies it is interesting in that the interface is very well defined. It is probable that the sandstone forms part of a much older sequence of sediments than those currently accumulating in the abyssal plain region. Dating should be possible on the basis of the foraminifera.

The air gun profiling was very successful and good records were obtained for the whole of some 50 hours profiling, during which over 300 miles of track were steamed. Quieter sea conditions allowed in the latter part a broader band width filter (40 - 400 Hz) to be used, thus achieving both good resolution and penetration. Maximum penetration achieved was of the order of 1½ secs. two-way travel time. Penetration of the full reflector sequence of the 1000 metre plain peri-Tyrrhenian basin off Capri is a substantial achievement and will add much to our understanding of the structure of the continental borderland region. Throughout the survey the Barringer magnetometer using the RVU1 fish performed very well and provision of the regional magnetic field values by the computer at 10 min. intervals will make interpretation somewhat easier. As expected the major anomalies were encountered off the volcanic block of Ischia and Ventotene, as well as over the central seamount, but subsidiary anomalies occur in other parts of the region.

The core obtained from the Balearic abyssal plain will be useful for comparison with the Tyrrhenian superficial sediment sequences. The precision echo-sounding data and total field magnetics completed during passage from Gibraltar to the Medoc area, from the Medoc area across to the Tyrrhenian Sea, and from the Tyrrhenian Sea to the Alboran Sea, can be incorporated into the existing bathymetric and total field charts. There passage tracks were completed to a large extent along previously unsurveyed lines.

There is a need to modify the core catcher system, though the repaired catcher with thicker sail makers cloth (terylene) does appear to be more promising. The orientation camera, too, needs some rethinking, the Marsh - Marine plug is vulnerable to damage by the main warp shackle.

Current Meter Moorings

Aim To set three current meter moorings whose details are given in table 2.

On passage out, when we came to wind the mooring wire on the main winch it was found that the traverse guides were jammed solid. These took several hours to free. Mooring 130 and 131 were laid on 6th November 1972. With the exception of some trouble with the trawl winch, the moorings were laid according to plan.

The trawl winch lost its ability to run at a constant slow speed. With the control switch set at the 1st position, it would start paying out slowly, and then gradually increase its speed. The moorings were laid by paying out until the winch reached an unacceptable speed, and then the winch was stopped, and the process repeated.

Mooring 132 was laid on 7th November 1972. On laying up the wire on the trawl winch, the end of the 500 m x 8 mm length of Kilindo wire caught in its wooden storage drum. This badly "kinked" the wire, and was consequently replaced by a 500 m length of 8 mm ordinary wire which was hand spliced. Apart from this the mooring was laid successfully.

With the moorings completed time could be spent stripping down the control box of the trawl winch. It was repaired successfully in a few hours by the Electrical Officer.

Net Monitor trials (Angel, Harris, Wild)

The two new net monitor systems were successfully tested out to depths of 2000 m and ranges of 3000 m. Net angle measurements and flow meter calibration could not be carried out since insufficient time was available when weather conditions would have permitted the work to be done.

Freeze drying (Angel, Roe)

Weather conditions on the third leg did not permit the collection of as much material as was hoped to examine the feasilibity and usefulness of freeze drying in the study of oceanic ecology. However, a large range of material was freeze dried in an EF2 dryer. The material retained colour well and shape reasonably. It tended to take up water after drying and so may show long term deterioration. The main problems are 1) the removal of excess salt 2) the rapidity of freezing 3) possible volatisation of high vapour pressure oils. These problems are most acute for jelly organisms such as siphonophores. Even so the technique may prove very useful in dry weight studies and in biochemical analyses, especially as there are techniques which allow rehydration of the material for taxonomic studies.

Navigation Equipment

Satellite Receiver

(a) 702CA - The receiver generally performed well throughout the cruise but at one time it was down for several hours through an intermittent bad wiring connection on one of the units. There also appeared to be occasional overheating (or variable heating) problems as has been observed before.

(b) 702A3 - The new receiver was not run routinely but towards the end of the second leg we were able to sample its data into file satisfactorily. The data transfer and coding information available promises to make programming and checking much easier. There is a problem however with the hardware at present in that it does not appear possible to suppress the 2 minute interrupt between passes as we could on the old system.

Loran C

The receiver was not used operationally though at one time in the Gulf of Lyons we thought we might need to. It was impossible for us to keep the receiver indexed properly without a lot of manual intervention. The Master station in Italy was noisy and weak whilst the Spanish station was very strong.

Omega

We were expecting to have a new Redifon receiver on this cruise but in the event the company failed to deliver it at two successive port calls at Gibraltar.

Decca

This was only used during the run to the Bay of Biscay and for the early morning work. It worked satisfactorily. Comparison with satellite fixes showed it to be between 1' and 2', 040° displaced.

Tide Gauges (Spencer, Grohman)

Shallow Tide Gauge

An off shore tide gauge was layed on Josephine Bank off the southern west coast of Portugal, position 36°41'N, 14°15'W at a depth of 194 metres. The position is part of a general investigation into the ocean tides of the north Atlantic for Dr D.E. Cartwright. The gauge was recovered successfully after a month, however an electronic fault had prevented the collection of any data.

Deep Sea Tide Gauge

Tests were also carried out on a device designed to measure tides at depths up to 4000 metres. A mechanical assembly with acoustics only was free-falled to a depth of 4000 metres. After an hour of sitting on the bottom the ballast frame was released using the acoustic monitoring system and the gauge ascended to the surface, and was recovered.

Digitiser Trials with PES Mk III (M.L. Somers).

Introduction

The purpose of the trials was to evaluate the performance of a commercial depth digitiser interfaced with the NIO Mk III PES. The subject of the trials was the EDO Western Model 261C Digitrak belonging to and kindly lent by RVB, which the NIO survey of the suppliers had singled out as probably the best buy. The trials included the purely electronic problems of interfacing with the PES without interfering with the operation of the latter, and more importantly the accuracy and tracking capability of the Digitrak under the signal to noise conditions prevailing in the Mk III PES. As a further experiment a coded signal generator and matched filter system was taken to sea, the idea being that if the signal to noise conditions in the Mk III were unfavourable then the processing gain of the correlator might enable the Digitrak to work.

Leg 1

On this leg the Digitrak was very easily connected to the PES and the performance checked out. The RVB Digitrak has not got the multi-ping option which enables correct depths to be read on higher phases of the PES, so it was indicating only the residual portion of the display scale i.e. up to 800 FMs. Certain minor modifications had to be carried out to the Digitrak and even so the gate control circuitry was faulty, but this did not prevent proper operation of the Digitiser merely making results slightly worse than they need have been. The results were very encouraging and the operating principles behind the Digitrak design fit the NIO depth presentation very well, which is to say that no special timing sequences were required so the record can look much as it always has done. As yet the time cannot be foreseen when depth digitising will be an unattended operation, for instance it will not be possible for the Digitrak to go unaided through phase transitions since it has no facilities for generating automatic pulse gating sequences. Also there are times when the nature of the bottom renders it inherently impossible to maintain continuous track. Another difficulty lies in bottom echo fluctuations which don't bother the human observer who can, even on weaker echoes, read the leading edge, while the Digitrak being a threshold device registers a jitter in these circumstances. These difficulties imply that the Digitrak should be considered not as an automatic system but rather as an aid to the watchkeeper to log into the computer more frequent and error free depth values.

Leg 2

The second part of the programme, consisting of the correlation processer tests was not strictly necessary for the digitiser trials, but since an improvement in signal to noise ratio of about 10 dB would make the Digitrak operation much more reliable an attempt was made to carry out the trials. It had been anticipated that the processer might not be needed so it was given low priority in the cruise preparations and came to sea untested. The system consisted on the transmission side of an enlarged pulse power amplifier fed by a 13 bit phase reversal Barker code pulse of 20 milliseconds duration, while the processer consisted of a tapped shift register wired as a discrete transversal filter for the 13 bit Barker code. Two shift registers were fed at base-band by the outputs of in-phase and quadrature detectors and the register outputs were re-modulated to carrier frequency with in-phase and quadrature references and then summed, this operation being equivalent to vector addition of the two matched filter outputs. Two types of shift registers were used. In the first, the detector outputs were hard-clipped and polarity samples were fed into a digital shift register, while the second consisted of so called MOST 'bucket-brigade' stages in which analogue samples are stored and shifted by a process of charge deficit transfer.

The results of these trials, unfortunately all negative, were as follows: (a) Phase reversal coding is not suitable for echo-sounding, at least with digital processing. This is a pity because the system is very flexible, requiring a simple change of oscillator frequency to change pulse length and resolution. Transducer Doppler shift places an upper limit to the pulse length of pseudo-noise codes, of which the Barker codes are examples, but in the trials on this cruise the transducer motion was small enough to place the limit well above 20 mS. (b) The reason for the poor performance of the digital processer most probably lies in the reverberative nature of the bottom, interacting with the non linear processing. The result was a very high side lobe level with a badly fluctuating correlation peak for the bottom echo. The results were taken on an oscilloscope and were not even worth displaying on the Mufax let alone on the Digitrak. (c) 'Bucket brigade' technology is not yet seaworthy. As already pointed out the system came to sea untested and it turned out that so many of the bucket-brigade devices were faulty, for reasons not yet known, that it was impossible to construct two registers, and attempts to cannibalise one register to get the other working met with no more success.

These results, negative as they are, are useful in pointing the way to a successful pulse compression system. This must be linear, simple, robust and doppler tolerant, the price for these advantages being flexibility. Thus the obvious system is a linear FM sweep with a lumped constant dispersive delay time.

Other work carried out on the PES during the cruise consisted of a systematic drawing of all the PES ship wiring and a detailed sheet of instructions for connecting any combination of recorder and transducer. Finally a decoder was constructed to decode the Digital clock output to produce PES time marks on a 6 min/2 min basis instead of the present 5 minutes. The necessary hardware such as plugs and sockets were not on board to complete the installation but the decoder itself was successfully tested.

Magnetometer (M. Harris)

The magnetometer failed to operate when first streamed on the last leg of the cruise. The fault proved to be a damaged inboard cable connector. As this connector was too badly corroded to repair the cable ends were soldered and taped together. After this the magnetometer worked properly for the remainder of the cruise.

Trace elements in sea water (Culkin, McCartney)

40 large samples (51) were collected at 15 stations in the Bay of Biscay, Straits of Gibraltar, Mediterranean, and Tyrrhenian Seas for trace element analyses. The trace elements were concentrated on board by means of a chelating ion exchange resin and stored in nitric acid solution for subsequent atomic absorption analysis at NIO.

Salinometer (Culkin, McCartney, Mardell)

The following points require attention or consideration:-

1) Some difficulty was experienced when the laboratory temperature was high (25°C). Filling the cells with water at this temperature caused the bath temperature to increase by several tenths of a degree. This difficulty of working at high ambient temperatures can be overcome to some extent by reducing the setting of heater 2 during the filling process but this is not completely satisfactory. More guidance on operating procedure seems to be required.

2) On one occasion the air-bleed tap was left open or worked itself loose, resulting in loss of oil. Consideration might be given to fitting a spring-loaded tap.

3) Brilliance on cathode-ray tube unsatisfactory.

4) Cells need re-platinizing.

5) A longer polythene jet should be fitted to the filling device so that the sample bottle can be held vertically during the filling process.

6) Drain aspirator and pump should be repositioned so that the electronics can be made waterproof.

7) Stand for sub-standard should be secured more firmly.

8) Drip-tray should be leak-proof.

Electric Hydrographic Winch (Bonner, Clayson, Dobson, Wallace)

Further operational tests were successfully carried out. Main modifications carried out prior to the cruise included: improved statimeter load cell mountings, revised drive to the mechanical counter, installation of digital readout displays and wire velocity meters in deck and portable controllers, digital readout and warning light on the bridge. The modified and renovated main drive gearbox had been tested on the previous cruise.

The winch was used successfully for water sampling and T.S.D. stations. Practical experience in controlling the winch was gained by several of the scientific crew and no difficulty was experienced. The only important addition now outstanding is the provision of an effective voice communications system between deck and hold and reduction of the noise in the hold.

The considerable effort put in by other members of the workshop and Applied Physics Group is gratefully acknowledged.

T.S.D. (Mardell, Crease)

While in Southampton the screen of the cable on the mid-ships had been connected through the slip-ring rather than through a sea-earth in an attempt to eliminate some noise problems.

Due to the imminence of MODE only the 9040 TSD was used. On all stations the rosette sampler was also in use. This turned out to be essential as the salinity sensor showed extremely erratic behaviour (±.03) even on a single cast. The temperature sensor remained stable with a bias of 0.03°C. The rosette in general functioned well although the thermometer frame of bottle no. 7 consistently tended to hang up on the one next to it. Spares will be required for the rosette as none are available at present.

Computing (Voss, Berry, Strudwick, Smallbone)

For the DPG, cruise 51 was intended to act as a shake-down cruise for the new MPX-SHIP software. In this it has been reasonably successful. The data collected will be very useful for the development of the new DISTRESS data retrieval package during January-March 1973. The system was also of assistance to the other activities on the cruise, but the continuity of the service provided was not up to the standard which has come to be expected. However the experience gained should assist considerably in future cruises.

Systems and Programming (Voss, Smallbone, Strudwick)

Leg 1

A number of bugs introduced since cruise 50 were corrected. In addition, some rather unexpected difficulties were encountered which may have been due to the faults in the hardware which were imminent. The major problems were due to hardware failures as follows:

During the first 3 days, the CPU was down with various faults, to be detailed later in this report.

The digital gyro had to be taken off-line during investigations. There was no analogue back up. The software to cope with both gyros off-line had not been tested and several bugs were present. These caused erroneous data to enter the files, including incredible wind and ship speeds. The software is now functioning, but it must be pointed out that with both gyros off-line no D.R. information is available and satellite fixes are not possible. The provision of a back-up is important.

By the end of leg 1 the system was functioning reasonably well, but was rather sensitive to the remaining errors. Storage protection of Inskel Common had had to be abandoned, possibly due to a hardware fault as mentioned above. The main short coming of the system at this stage was the lack of documentation. This was an unfortunate situation, but one that could not be avoided, in view of the time scale. Handing over the system without the documentation was a calculated risk.

Leg 2

With one exception the system functioned fairly successfully for leg 2, and there was usually enough time to deal with remaining bugs as we met them.

Throughout the leg there were occasional system hangups probably due to a re-entrancy problem in the sampling routines but it was decided not to risk upsetting the sampling by attempting a fix. In all but one case the system was recovered by the restart facilities written into the system.

On the morning of 30th November the system failed to restart and in order to resume normal service it was necessary to initialise a new leg on the back-up copy of the system. Down time was about 6/7 hours including the time taken for investigating action such as core dumps and file examination.

At this stage the lack of documentation caused further delay in implementation of the navigation suite which otherwise worked beautifully once it was running.

For the majority of the leg, navigation was initiated automatically at the end of each satellite fix, providing a D.R. to Bridge, based on the last fix.

The T.S.D. sampling system was fully implemented and collected useful data despite teething problems. The new satellite receiver was also sampled, collecting raw data for analysis.

The conversational entry to SAMON proved self-explanatory and enabled

(i) re-calibration of the ship hull-thermometer to be performed easily and successfully. It is unfortunate that the voltage supply to the instrument was later altered which rendered the calibration useless. Some degree of co-ordination seems to be required here.

(ii) addition of a temporary datapath for regional magnetic field - requested by Southampton University.

(iii) status of data to be lowered or restored as and when desirable.

Owing to documentation problems CHARP was not available but track plots were provided, courtesy of TRPLA, and, with the new CDAT listing program, we were able to supply Southampton University with data to be used in conjunction with their off-line magnetometer data before the end of the leg.

At the end of the leg SAMON was rebuilt to include the ENDLEG phase and although this phase was completed satisfactorily, time prevented the eradication of all known bugs.

Leg 3

The bugs in the sampling monitor left over from the previous leg prohibited the collection of data for the first two days but apart from this, and a difficulty in starting the navigation suite, the system worked fairly well without any intervention.

Some errors similar to these which plagued the first two legs were encountered but these were overcome without difficulty and the computer was available most of the time.

The automatic initiation of the navigation suite was not used on this leg on the request of the Principal Scientist and all satellite fixes were checked manually.

An error still remaining in the sampling monitor prohibited a "tidy" shut down of the sampling system at the end of the leg.

Engineering (Berry)

After a hectic start the system hardware worked fairly well except for an occasional hardware parity error which I believe is located in the core block itself.

C.P.U.

Timer C failed ½ hour before sailing, timer failed to generate a cycle steal while in a /3000 wait, the diagnostics do not cater for this error but the fault was traced to board B-A1K2/3 and this board interchanged with an identical board in timer A's circuity and a new board ordered and fitted at Gibraltar.

Core block B-B3 (8 to 16K) started producing READ/WRITE parity errors traceable to 'Y' decode wire 1Ø1-Ø11Ø, interchanging logic cards and resistance measurements failed to produce any result but while I was still working on the Y line fault a hard X parity error occurred on high decode function ØØØ. I diagnosed that there must be an O/C or high resistance on this line, I would have liked to have had the use of a current probe at this stage. The next stage reached was to remove the K5 Storage Jumper but no removal tool was available so a keybutton puller was modified to produce a make-shift tool. When the storage jumper was eventually removed it was obvious that the D13 pin was covered with varnish and was the cause of the trouble, removal of the varnish cleared the 'X' line fault. It was several weeks before the 'Y' line fault reappeared, when the fault occurs, the 'B' reg contains all zeros so the fault is very unlikely to be a sense/ inhibit line fault or to be in the 'B' register as this would normally be only one or two bits and secondly the fault occurs on READ/WRITE with the high and low 'Y' pattern, I therefore deduced that the fault must be on the particular 'Y' line through core and as the fault was very intermittent I decided not to try and force it as there was always a possibility that the fault would become hard leaving the system unuseable. I have suggested to B.J. Hinde and it has been agreed with B. Ellis that the erroneous Core Board be changed with one from the lab so that IBM correct the fault there.

1816/1053's

The computer room 1816 went solidly off-line due to a faulty connector pin on the CPU plug.

The plot 1Ø53 suffered from a seized motor due to lack of lubrication but when allowed to cool off and then lubricated the motor was found to be OK.

The bridge 1Ø53 had an intermittent '9's' print error due to the rotate arm being out of adjustment the C/R interlock contacts were found to be loose causing the contacts to intermittently short against part of the mechanism and thus print on C/R.

Facit Equipment

Punch 2: I have rectified the fault which caused this unit to occasionally fail to give a ready signal. This was due to a leaky heat sensitive OC83 on the ready line drive. In the process of rectifying this fault I found that the ready line documentation was incomplete and what was included was wrong and was therefore rectified. I feel that it would be a good idea if a drawing of all the special connections be kept at the lab.

Reader: This M/C needs investigation by FACIT, as it has trouble in reading WHITE tapes and tapes with unipunched holes. Some tapes read correctly when first punched but after about a day reading problems were encountered. This problem is mainly confined to tapes punched on the Facit punch although a very few creed punched tapes have caused trouble. Strangely enough the holes punched on the creed are more ragged than those punched on the FACIT. The problem may be due to moisture as all electrical checks showed the reader to be OK.

Gyro Encoder/Interface

I have rectified the fault reported by B. Page on cruise 5Ø. This was caused by HF noise on gray bit 8 due to Board '9's' edge connector having one of the edge connector backing contacts turned over on itself causing the connector to make imperfect contact. This probably happened because someone forced board '9' in too quickly and too hard. I must stress that all edge connectors should be inserted gently with correct alignment. It is often difficult to change these edge connectors so please be careful in future. While changing this edge connector I took the opportunity to change the I/P connectors of 29, 13, 22 and 6 to 3Ø, 14, 23 and 7 respectively. This puts the gyro I/P directly into the NAND gate I/P's instead of via the expander I/P thereby increasing the system noise immunity. The old (BLACK) encoder was then found to give erroneous readings between 10° - 20° and was therefore changed. GYCHK has had a ESQRT instruction added to allow at least 5 sec read time.

Satellite Navigators

702CA - This instrument has given some trouble during the second leg. An intermittent fault was found on the 15 MHz Synth, I resoldered a suspect joint on this unit but have not had an opportunity to do a test. I also had trouble with a cable from the 400 MHz analog board to the Meter where a joint in the cable loom had been remade. The routing of the cable loom allowed the cable to be trapped behind the tray hinge. I therefore put in a new length of cable and resited the loom. The unit still suffers from temperature problems. When closed up there is trouble with the high channel lock and when right out there is trouble with the low channel lock and the oscillator stable light is inoperative. I therefore made 2 blocks of wood $2\frac{1}{4}$" long to hold the M/C open and requested that the workshop manufacture some metal bars to do a permanent job. I am also investigating the possibility of purchasing a miniature fan to circulate air within the case.

7Ø2A-3(NEW) - I have built an interrupt inhibit circuit into the computer interface board and made all the cable connections to the computer. Two connections to the edge connector on the interface board were found to be wrong. J. Crease wrote a program to retrieve the data fed to the computer and we are reasonably satisfied that the interface is working correctly. When we build the spare board I feel it would be a good idea to have a P-C board made up as the wiring on the existing board is fairly complex and many connections existing on the board have to be cut. We seem to be a long way from a working 23 sec doppler satellite software system. I feel that this important point must be pursued if we are ever likely to have a working system for MODE and I feel that far too little progress was made during this cruise. One unexpected point has occurred. The Navigator gives continuous 2 minute interrupts which are updated at every fix. These are impossible to inhibit unless an internal mode is made. Magnavox have not responded to this and if it proves impossible to provide, then we must incorporate them into our software system. It may be beneficial to do this as the interrupts are very accurate.

Loran

This instrument is often very difficult to set up; there is often noise covering part of the trace; it constantly fades and drifts. It still jumps lanes especially when there is a ship radio transmission. The instrument inspires no confidence from the Master and his Officers who generally treat it as a White Elephant.

Multiplexer

This has an intermittent fault which can be cured by moving the cards in their sockets. There are no supply test points easily accessible from the front of the unit and the indicator lamps are difficult to change.

Clock Interface

The interface has been modified to allow a CPU ECO closure to enable the interrupt line.

Magnetometer

Use of a Baringer Magnetometer on this cruise has meant that the computer was not able to log magnetic data. The H-P strip chart recorder on this instrument failed on leg 3 and was replaced by one from the TSD system and the hour marker fed from the clock relay closure circuitry but this circuit is obviously noisy and should be overhauled.

Meteorological Observations (D.T. Grossart)

Continuous analogue records were taken on the Leeds and Northrup Speedomax recorder of air temperatures (port and starboard, dry and dry minus wet bulb temperatures) given by the resistance thermometers in screens on Monkey Island, and of solar radiation from the solarimeter. Two minute mean values of these variables were also stored by the computer and printed out at 10 minute intervals on the plotting office printer, together with wind speed and direction from the NIO anemometer.

To monitor the measurements, daily check readings were taken using other sensors. For air temperatures, readings were made with an Assmann psychrometer, mercury-in-glass thermometers in the screens on the bridge deck and from the resistance thermometers in the bridge screens connected to R.A.S.T.U.S. Wind speed and direction readings were taken from the Met. Office anemometer. The checks on air temperatures showed good agreement with the recorded values except that the wet bulb readings of the Assmann were slightly lower throughout, as can be expected. There was a short period during leg 1 when the recorded wet bulb readings were incorrect due to trouble with the wicks and at the beginning of leg 3 the starboard air temperatures shown on the printer were -147°C to -148°C - this was due to circuit modification at the computer changing the polarity of the voltage and when this was corrected the readings became sensible again. The NIO anemometer was apparently reading satisfactorily although the values of wind speed printed out need to be corrected to take account of an erroneous calibration factor. Readings from the solarimeter also seemed satisfactory.

Routine observations of sea surface temperature were taken daily from the Met. Office hull limpet connected to R.A.S.T.U.S. and by Crawford bucket. The latter were generally 0.1°C to 0.2°C higher. Series of these measurements at 4 hourly intervals were also done for comparison with those from Morrison's Wien Bridge Oscillator unit connected to four sensors, one on the hull and three in the periscope. The Wien Bridge Oscillator unit gave a consistent linear calibration against the other sea temperature readings with the periscope sensors but during leg 2 an apparent step change in calibration occurred with the hull sensor.

Station List Table 1

Stn. No.	Date	Time GMT	Depth m.	Lat.	Long.	Method	Equipment
8196	6/11	0905-1018		47°38.2'N	08°23.2'W	S	C/M(130)
8197	6/11	1506-1739		47°35.1'N	08°27.0'W	S	C/M(131)
8198	6/11	2332-0057	1460	47°40.8'N	08°20.9'W	S	B/B
8199	7/11	1515-1640		47°31.2'N	08°33.0'W	S	C/M(132)
8200	8/11	0950-1200	4454	47°20'N	09°14'W	DR	B/B
8201	10/11	1656-1702		41°54.0'N	15°38.7'W	DR	Surf
8202	11/11	1749-2146	2478	37°39.3'N	14°32.6'W	S	B/B
8203	12/11	0730-0935	194	36°40.56'N	14°14.67'W	S	TG
8204	13/11	1934-2205	1447	36°13.2'N	08°00.1'W	S	TSD,R,B/B,Cam.
8205	16/11	2027-0106	2676	37°03.3'N	00°29.3'W	S	TSD,R,B/B,W/B
8206	17/11	1826-2316	2643	38°35.9'N	02°55.0'E	S	TSD,R,B/B,W/B
8207	18/11	1721-2219	2670	40°58.3'N	04°51.5'E	S	TSD,R,B/B,W/B
8208	20/11	1912-2130	1858	42°20.0'N	04°59.0'E	DR	TSD,R
8209	20/11	2312-0015	2152	42°08.8'N	04°51.8'E	S	TSD,R
8210	21/11	0224-0432	2368	41°59.5'N	04°43.0'E	S	TSD,R
8211	21/11	0554-0759	2484	41°48.2'N	04°36.0'E	S	TSD,R
8212	21/11	2318-0231	2067	42°51.3'N	05°36.1'E	S	TSD,R

Stn. No.	Date	Time GMT	Depth m.	Lat.	Long.	Method	Equipment
8213	22/11	0351-0602	2250	42°39.5'N	05°36.2'E	S	TSD,R
8214	22/11	0800-0957	2352	42°29.2'N	05°35.0'E	S	TSD,R
8215	22/11	1114-1312	2399	42°19.6'N	05°36.2'E	S	TSD,R
8216	22/11	1757-2006	2397	42°08.7'N	05°35.0'E	S	TSD,R,B/B(Surf)
8217	22/11	2113-2327	2424	41°59.7'N	05°35.6'E	S	TSD,R
8218	23/11	1240-1439	1975	42°13.4'N	04°57.6'E	S	B/B
8219	23/11	2030-2225	2198	42°15.2'N	05°09.2'E	DR	TSD,R
8220	24/11	0144-0356	2302	42°10.0'N	05°18.0'E	DR	TSD,R
8221	24/11	0456-0711	2344	42°03.0'N	05°27.1'E	S	TSD,R
8222	26/11	0840-1134	2121	42°09.5'N	04°49.2'E	S	TSD,R
8223	26/11	1340-1512	1921	42°19.6'N	04°43.5'E	S	TSD,R
8224	26/11	1706-1807	1494	42°34.1'N	04°51.8'E	S	TSD,R
8225	26/11	2049-2201	1829	42°46.0'N	05°20.0'E	DR	TSD,R
8226	27/11	1000-1114	2002	42°12.2'N	04°52.1'E	S	TSD,R
8227	27/11	1542-1826	2337	41°59.5'N	04°28'E	S	TSD,R,B/B
8228	27/11	1953-2147	1868	42°10.7'N	04°18.4'E	S	TSD,R

Stn. No.	Date	Time GMT	Depth m.	Lat.	Long.	Method	Equipment
8229	27/11	2310-0149	2008	42°20.4'N	04°27.4'E	S	TSD,R
8230	28/11	1235-1452	2159	42°39.0'N	05°29.35'E	S	W/B
8231	30/11	0840-1030 1500-1654	3567	40°06.2'N 40°08.0'N	12°37.1'E 12°42.3'E	S S	C(TS53A) C(TS53)
8232	30/11	1850-2052	3573	40°04.4'N	12°48.1'E	S	C(TS54)
8233	30/11	2150-0020	3583	40°11.0'N	12°46.2'E	R	C(TS55)
8234	1/12	0740-1006	3146	40°17.5'N	13°00.7'E	S	C(TS57)
8235	3/12	1536-1724	2208	40°26.25'N	13°25.8'E	R	C(TS59)
8236	3/12	2030-2247	2903	40°19.74'N	13°11.23'E	S	C(TS58)
8237	4/12	0030-0235	3585	40°11.0'N	12°56.0'E	DR	C(TS56)
8238	4/12	0442-0648	3216	39°56.03'N	13°10.30'E	S	C(TS60)
8239	4/12	1014-1408		39°53.1'N	12°39.2'E	S	Dr
8240	5/12	1400-1409		38°35.5'N	07°53.5'E	DR	Surf
8241	6/12	1351-1702	2784	37°38.8'N	02°51.4'E	S	C(BB1),B/B
8242	7/12	1135-1140		37°00.0'N	00°49'W	DR	Surf
8243	10/12	0710-0854	1545	36°12.5'N	08°01.8'W	S	TSD,R,Cam.
8244	12/12	0248-0758		37°50.6'N 38°02.8'N	14°11.7'W 14°18.3'W	S S	RMT 1 + 8, net monitor NN

Stn. No.	Date	Time GMT	Depth m.	Lat.	Long.	Method	Equipment
8245	12/12	1916-2205		39°49.0'N 39°53.4'N	14°08.2'W 14°12.4'W	S S	RMT 1 + 8, net monitor NN
8246	15/12	1443-1800		47°35.8'N 47°39.1'N	08°26.1'W 08°38.8'W	S	RMT 1 + 8, net monitor

Symbols

1. Method

S	Satellite
R	Radar
DR	Dead Reckoning

2. Equipment

C/M	Current meter mooring
B/B	7½ litre water sample
Surf	Surface bucket samples
TSD	TSD
R	Rosette sampler
Cam	Camera
W/B	Water bottles
C(TS-)	Core with Southampton University No.
Dr	Dredge
RMT	Rectangular Marine Trawl
NN	Neuston Net

Table 2 - Mooring List

No.	Time/Date	Lat.	Long.	Water Depth (m)	CM No.	Depth (m)	Record No.
130	1017/6.11 -1217/15.12	47°38.2'N	08°23.2'W	1589	469*	321	13001
					466*	1348	13002
131	1738/6.11 -1002/15.12	47°35.1'N	08°27.0'W	1901	280*	323	13101
					305	1651	13102
132	1640/7.11 -0635/15.12	47°31.4'N	08°33.4'W	2091	301+	325	13201
					467	839	13202
					156	1850	13203
Tide Gauge	0847/12.11 -1528/11.12	36°40.6'N	14°14.7'W	194	Short record due to power supply failure		

* Rotor loose but still turning spindle freely

+ Rotor fins and end plates had disappeared

Table 3 - Float List

NIO Consec. Float No.	Cruise Float No.	Lay			Last Fix			Corrected Depth of water (m)	Depth of Float (m)
		Time	Position		Time	Position			
			N	E		N	E		
236	1	0639Z/19/XI	42°04.7'	04°56.6'	0400/28	42°12.0'	04°42.5'	2147	1900±10
237	3	1108Z/19/XI	42°05.2'	04°57.3'	0512/28	42°12.7'	04°49.4'	2040	1550*±100
238	4	1835Z/19/XI	42°20.2'	05°13.5'	0958/28	42°25.2'	05°09.7'	2140	500**
239	5	1916Z/19/XI	42°20.6'	05°14.0'	1131/28	42°30.1'	05°22.1'	2230	1535±10
240	6	1952Z/21/XI	42°36.8'	05°35.8'	1612/28	42°38.0'	05°35.5'	2244	500**
241	7	1546Z/23/XI	42°11.3'	04°59.4'	0714/28	42°11.8'	04°59.0'	1966	4 m above sea floor

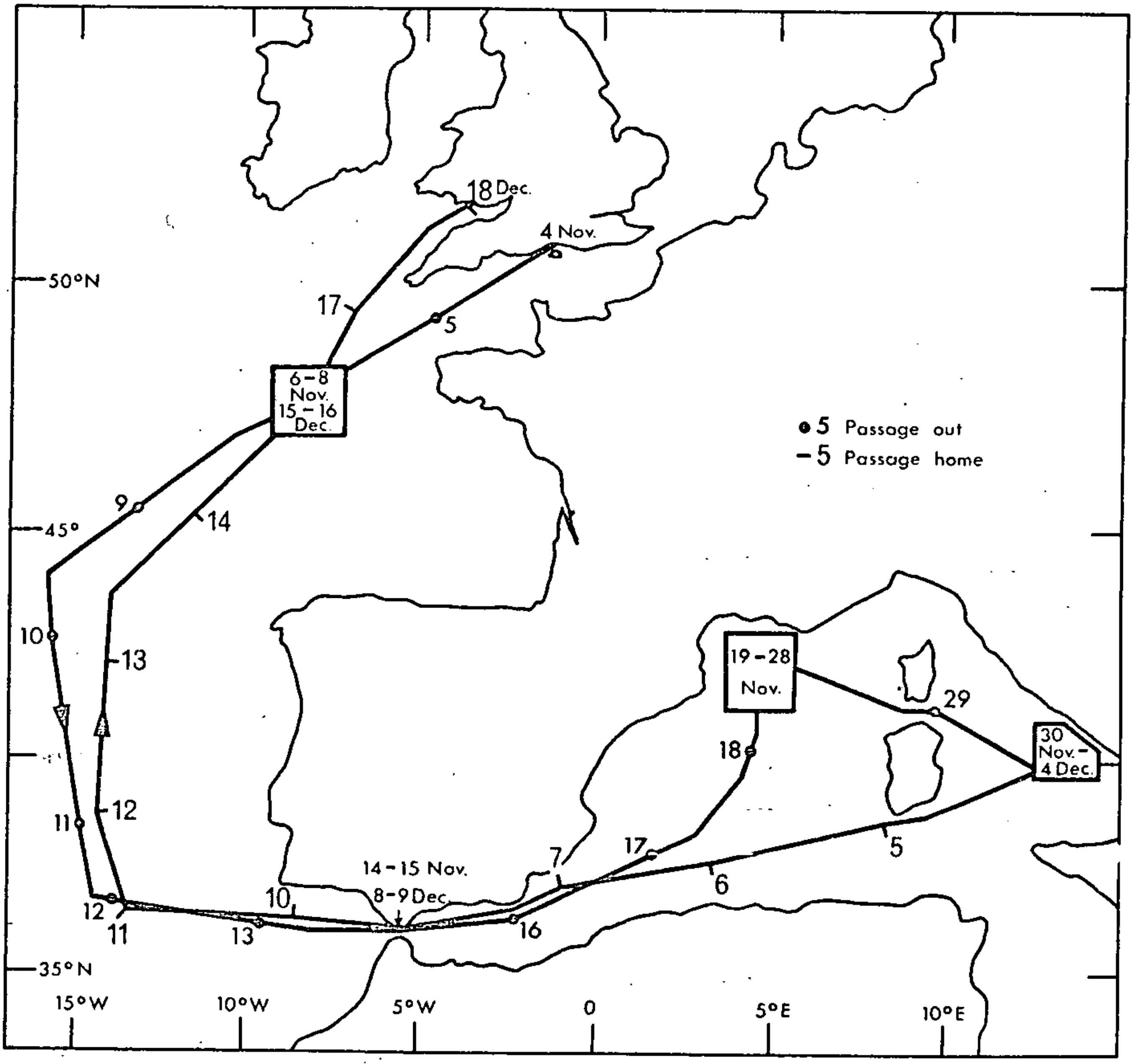
* No good bottom echoes

** Nominal depths not yet finally checked

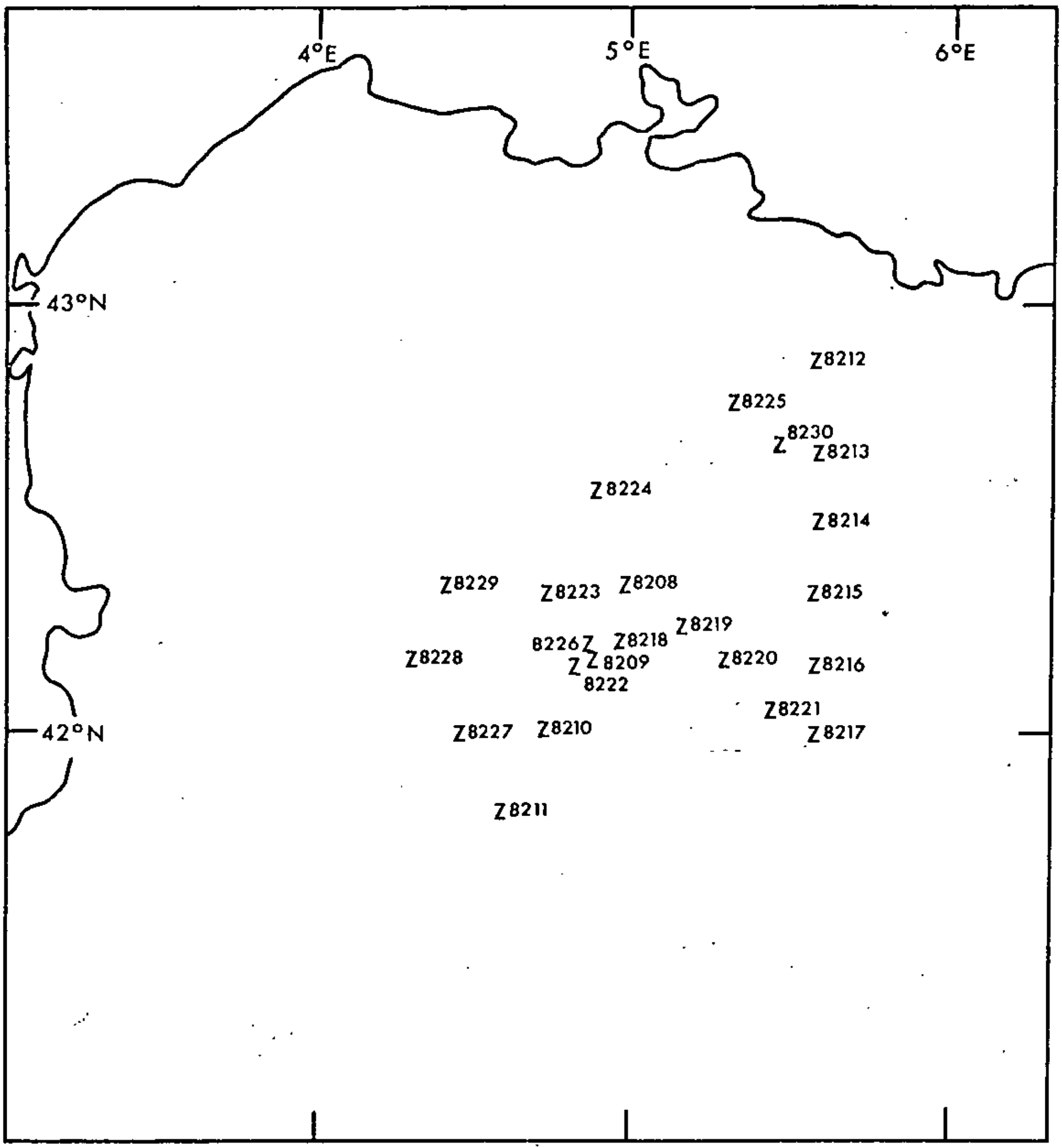
Table 4. AIR GUN PROFILING & MARINE MAGNETICS

	Length (km)	STARTS	ENDS
LINE 1	139	40°22.5'N, 12°58.0'E	39°35.0'N, 14°12.0'E
LINE 2	77	39°35.0'N, 14°12.0'E	40°12.3'N, 14°32.0'E
LINE 3	121	40°12.3'N, 14°32.0'E	40°53.0'N, 13°23.5'E
LINE 4	30	40°53.0'N, 13°23.5'E	40°40.5'N, 13°14.0'E
LINE 5	125	40°40.5'N, 13°14.0'E	39°59.5'N, 14°21.5'E
LINE 6	49.5	39°59.5'N, 14°21.5'E	40°02.0'N, 13°47.0'E
LINE 7	59	40°02.0'N, 13°47.0'E	40°28.0'N, 13°23.6'E

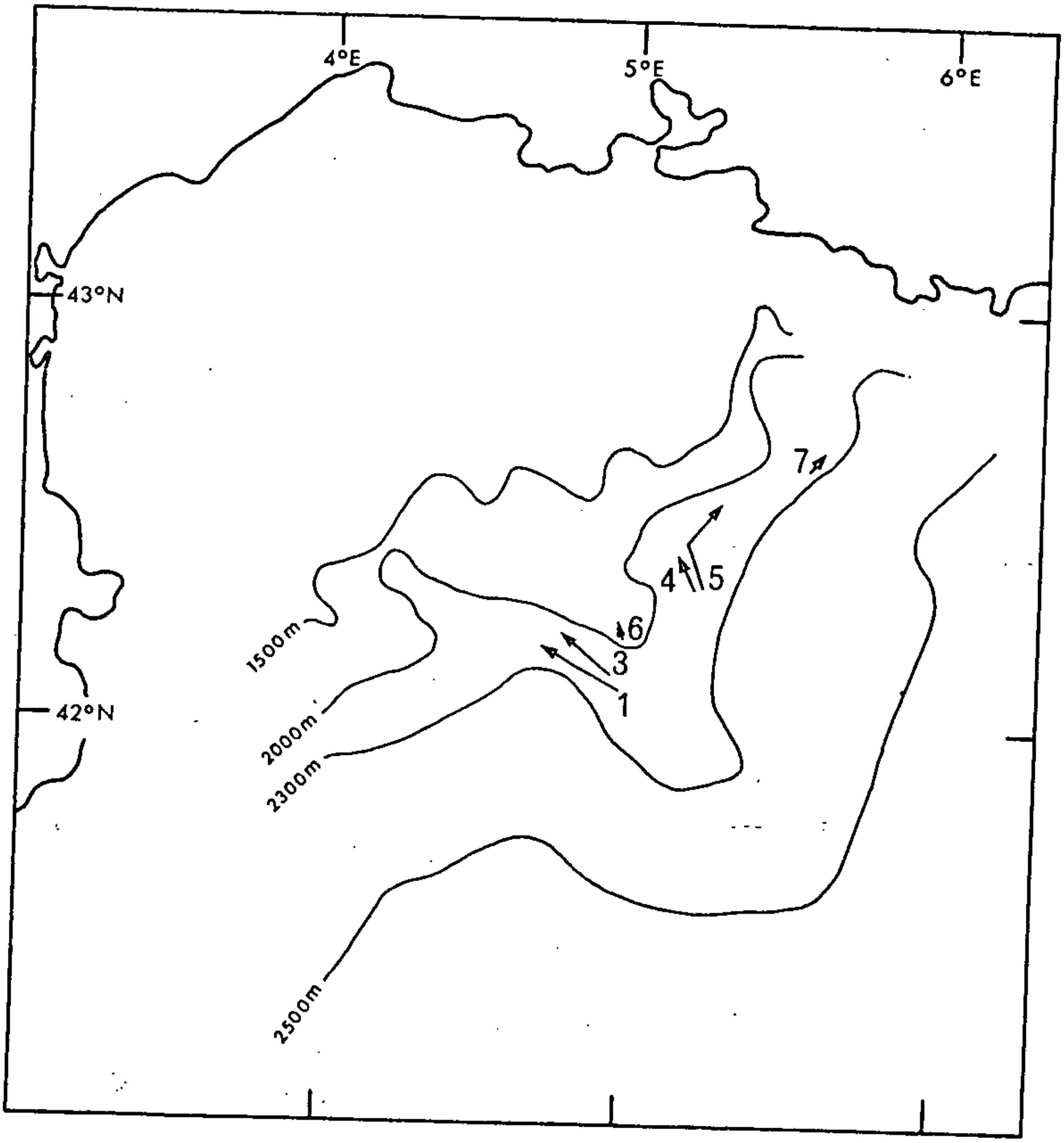
CRUISE 51 Noon Positions



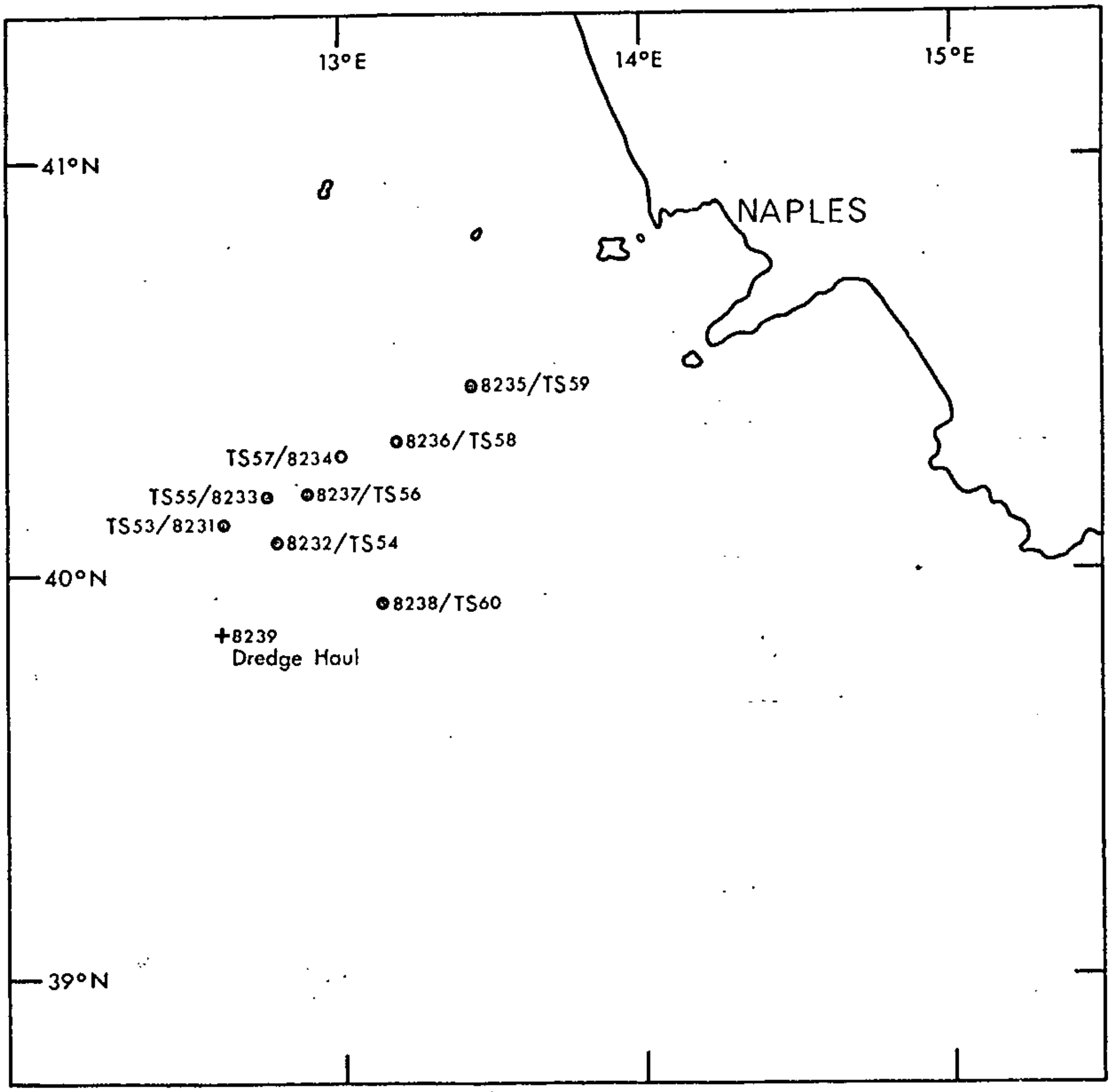
CRUISE 51 Stations 20 - 28 November



CRUISE 51 Neutrally Buoyant Float Tracks



CRUISE 51 Stations 30 Nov. - 4 Dec.



CRUISE 51 Airgun Seismic Profiling Tracks