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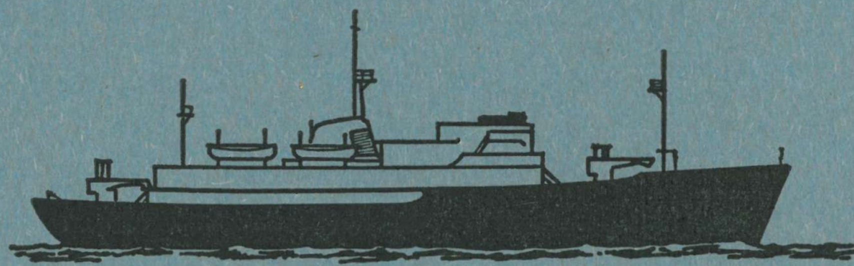

R.R.S. DISCOVERY

CRUISE 46

27 April to 30 May 1972

DEVELOPMENT OF EQUIPMENT

N.I.O. CRUISE REPORT No. 55
(Issued January 1973)

N. I. O. CRUISE REPORTS

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CONTENTS

General Notes

The cruise was originally planned in 4 legs. Legs 2 and 3 were eventually run together, but the original nomenclature has been retained to avoid confusion.

Legs 1 and 4 were similar and legs 2 and 3 were similar. This report is therefore in two parts, corresponding to these pairs.

Part 1: Legs 1 and 4

Part II: Legs 2 and 3

CONTENTS (continued)

CRUISE 46: Legs 1 and 4

Introduction

The main object of these legs of the cruise was an assessment of the Telesounder. This is a side-scan sonar with many lobes produced by an interferometer arrangement, and is intended as a tool to allow the bathymetric survey of a swathe of sea bed 400 to 500m wide (if a double-sided system were used) in shallow water. The device used on this cruise was an experimental 'lash-up' to allow an investigation of the potentialities and problems.

The opportunity was also taken to use the 36kHz side-scan sonar on some interesting areas of the sea bed.

On both legs a team was aboard setting up the new software system for the shipborne computer.

On leg 4, work was also done on improvements to the suite of routine meteorological sensors on board, and some preliminary work on cloud cover photography and balloon following in connection with the forthcoming JASIN expedition.

Narrative

The first leg of the cruise commenced from Barry at 0900 on the 27th April. It was known that the telesounder being mounted on the side-scan sonar imposed additional strain on the latter and a speed restriction of 6 knots was observed. However damage to the operating gear did occur on 29th April probably during a box survey of the Horshoe Rocks when the vessel rolled heavily in gale force winds. Withdrawal of the Asdic/Telesounder assembly promised to be a delicate operation if damage to the telesounder was to be avoided and it was therefore decided to return to Barry to withdraw the assembly in still water. The damage to the operating gear was such that the whole assembly was returned to NIO and the balance of the first leg of the cruise cancelled apart from work on the computer software which continued while the vessel was alongside at Barry.

For the 4th leg of the cruise the vessel sailed from Millbay Dock, Plymouth at 1530 on the 25th May and anchored in the Sound to mount the Asdic plate. Owing to the prevailing weather, sailing was delayed until the following morning and shortly after daylight the vessel proceeded to sea en route to Start Bay. Weather conditions again were unfavourable and it was decided to move to Tor Bay where tests of the telesounder equipment were carried out. At 0051 on the 27th the vessel left Tor Bay for Mevagissey Bay, progress was slow off Start Point against head winds with the engines racing from 100-190 revs. at half speed. The after peak was ballasted and the third engine brought into the loop to minimize the danger of the engines cutting out. This proved effective, racing was reduced and the vessel reached Eddystone at about 1100 hours for a check on the Hi-fix and hove to in Mevagissey Bay at 1330. After further checks on the equipment a telesounder survey was made off Dodman Point.

This survey was designed to check the accuracy of the bathymetric measurements under good conditions. A flat sea bed was therefore chosen and several lines run in each of two directions at right angles. This enabled the side-scan measurements to be checked against the vertical echo-sounding mode along a number of lines.

During the night of 27th May a 36kHz side-scan sonar survey was carried out between Dodman Point and the Eddystone.

The 28th was devoted mainly to surveying the area near the Manacles previously used in the DTI experiments on sonar location of aircraft wreckage, some of which was expected to be still in position. The 36kHz side-scan sonar was used to get a general picture of the area, and then the Telesounder was used with one transducer only as a high resolution side-scan sonar. The E.G. and G. dual side-scan sonar loaned by the Unit of Coastal Sedimentation was also used. Good pictures were obtained of the wrecked ships in the area, but no contact which could be identified as aircraft wreckage with any certainty. The Hi-fix navigation was good enough to allow repeated investigation of certain bottom features of interest.

During the night, a 36kHz side-scan sonar survey was made in the area between the Scillies and Lands End, giving interesting results. This was the only period during this leg when the winds dropped below force 7.

On the 29th May the vessel proceeded into the Bristol Channel and used the Telesounder on an area of sandwaves east of Lundy Island. She then proceeded to the English and Welsh Grounds light vessel to set up the Hi-fix. It had been intended to survey the adjacent Bridge area, but in view of the strong tides and gale force winds, the Captain decided that the survey would not be safe in these very restricted waters. The vessel therefore proceeded to the area approximately 1 mile west of the Breaksea light vessel and carried out a small survey in this area. The transducer plate was then lifted and the ship docked at Barry at 2050 hours.

Notes on equipment and observations

(1) The Telesounder

First leg 27th April - 29th April. For the first trial the telesounder system consisted of 2 Edo-Western 250kHz transducers (each in 2 sections) with a reflector plate (giving a Lloyds Mirror Interferometer), all bolted to the back of the DISCOVERY narrow beam sonar transducer. The telesounder electronics unit contained a 250kHz pulse generator, a 200 watt pulse power amplifier, a receiver pre-amplifier and a heterodyne circuit to bring the frequency of the received signal down to 36.3kHz.

This signal was then fed into the side-scan sonar (SSS) receiver, which included TVG circuits and whose bandwidth was temporarily modified to handle the shorter (0.4mS) telesounder pulses. An external wide-band marking amplifier was then used to display signals on the 11" Mufax recorder, which is normally used for the SSS, and which provided a trigger pulse in the normal way.

As soon as the transducer plate was fitted and the trunk emptied, it was found that the extreme static and dynamic 'out-of-balance' load due to the reflector plate would prove to be more than the servo unit could handle, so the latter was not fitted. The first records from the telesounder were obtained whilst at anchor near the Breaksea light vessel by about 1900 hours on 27th and these demonstrated that the expected interference beams were being formed, and therefore the pressure-release material on the reflector plate was indeed acting as a good reflector. However considerable hum interference was being picked up in the unbalanced cable between the asdic compartment and the electronics laboratory. At 2000 hours the telesounder was switched off and the system reconnected as a side-scan sonar for the overnight survey. An isolating transformer to overcome the hum was built overnight and at 1000 on 28th when the telesounder system was reconnected instead of the SSS, the transformer did eliminate most of the hum. Records were obtained underway during 28th with only minor problems with the recorder and marking amplifier. Records with both the available transducer-to-reflector spacings were giving the expected number of interference fringes and, with both transducers switched in simultaneously, the different pattern allowed identification of the individual beams. A third transducer section outside the line of the reflector could be used in an alternative conventional but high resolution, short range side-scan mode.

Good records limited only by the unstabilised roll and fixed tilt angle were obtained in the Bristol Channel in depths down to about 50m, echoes being obtained out to almost 250m. At 2100 on the 28th the system was again changed to SSS for an overnight survey, which was eventually abandoned at 0400 on the 29th after rougher weather caused heavier loading on the transducer stub axle, which twisted through about 20°. The ship then returned to Barry Dock, where the transducer plate was lifted and the transducer gearbox dissembled and examined. It was clear that the damage was extensive and no further work could be undertaken on this leg, which was then abandoned.

<u>4th leg - 25th May to 30th May</u>

Instead of using a transducer and reflector to produce multiple fringe beams it was decided to use the two transducers without a reflector, so that no severe unbalanced loads were presented to the repaired gear train and stub axle and the roll servo unit was fitted. However this meant that the system of altering the fringe spacing for identification could not be used since both transducers were in use and no more were available. However records during the first leg had shown that one fringe was particularly strong and could be used as a 'marker'. It is believed that this is due to sound being reflected from objects near the transducers: possibly each transducer is receiving sound reflected by the other. It was a fortuitous but useful feature.

During this leg the weather was rather poor so that records were affected by aeration of the water and by the pitch and heave of the ship. Also an intermittent fault on the 36kHz asdic transducer introduced interference until the leads were shorted, and the wide-band marking amplifier was not available, so that the records were generally not as good as during the first leg. However it was possible to demonstrate that the double transducer array produced similar beams to the transducer/ reflector arrangement. A Hi-fix receiver was fitted for precise navigation and used with manual readings for a survey involving crossing lines in a very flat sandy area near Dodman Point during the evening of 27th May. From this survey it was possible to check the beam identifications and to calculate some of the errors of the side-scan sounding beams. Records were processed (off line) by first tracing the centre line of the fringes from the record, identifying the beams, and then digitising,using the D-MAC, the coordinates of each beam trace in turn for about 5 minutes length of record. The D-MAC output was a paper tape, which after editing was input to the shipboard computer, from which the final output was a record of depths in decimetres plotted to a true scale of 1 : 1000 (i.e. 1 cm of plot equivalent to 10m on the ground). Rough weather prevented further use of the D-MAC after the first half of the Dodman Point survey had been digitised on board.

During the morning of the 28th the SSS (36kHz) was used to look for wreckage by MATSU personnel and during the afternoon for the same purpose the telesounder was reconnected, but with one transducer only as a high resolution side-scan sonar. Later in the evening the effect on the multiple beams of tilt of the telesounder transducer axis was examined, before converting the system back to SSS for the overnight westward run from the Lizard to the Scillies and then round to Lundy by the evening of the 29th. The telesounder was reconnected and despite severe quenching aeration and pitching conditions, records were obtained in deepish water over sandbanks with small sand waves (wavelength $\sim$ 3m) on one side and in some cases coinciding with bands of noise generated by the sea bed. Interesting records were obtained overnight during the run up the Bristol Channel for a survey of the 'Bridge' area where Hi-fix was available on the morning of the 30th. However strong winds, tides and shipping presented difficult navigational conditions and the survey was cancelled. The ship then returned to the area of the Breaksea light vessel where Hi-fix signals were still being received from the Cardiff Chain though the chart for this area was not onboard and a survey was made, logging the Hi-fix data on a Dynamco data logger. The pattern for this survey was a pair of parallel lines crossed with another pair and each line run in both directions to provide double-sided coverage and many intersections in an area of gentle topography.

The transducer plate was lifted from the sonar trunk during the afternoon of the 30th prior to docking in Barry at the end of the cruise.

B.S. McC.

(2) 36kHz Side-scan Survey

Lines were run to fill gaps in the existing coverage particularly in Plymouth Bay, between Lands End and the Scilly Isles and in the outer Bristol Channel. In addition a search was made for possible sites for repeated side-scan surveys, in order to determine any future changes in the pattern of sediment bed forms.

N.K.

(3) Meteorological Instruments

The main part of the work on meteorological instruments was to test the feasibility of using an f.m. system for measuring air and sea temperatures on board RRS DISCOVERY, and to compare different exposures.

Five f.m. thermometers (using platinum resistence elements) were installed at various points on the ship:

(a) The foremast platform
(b) Wheelhouse top (port side)
(c) Wheelhouse top (starboard side)
(d) Bridge deck (port side)
(e) Bridge deck (starboard side)

The intention was to record these on a five channel counter-logger (adapated from the spar buoy system).

The accumulated one second count was sampled at one minute intervals, and the time of each observation was also logged.

In the event, due to counter faults, only four thermometer channels could be recorded at any one time. However, at least partial series of observations were obtained for all five locations.

Recording was started at 1935 GMT on the 27th May and continued until 1221 GMT on the 30th May.

Spot checks of the output frequencies were made at intervals throughout the recording time.

The thermometers and their radiation shields were found to be contaminated to some extent with salt and soot after their three days exposure; but, as might be expected, the installation on the foremast was by far the least affected. All the electronics housings had remained clean and dry.

Since the cruise the magnetic tapes have been translated and written to disk, the thermometers have been recalibrated, and most of the checking and analysis programs written. When time allows this analysis will be continued.

Some work was also done on the routine meteorological instruments, in particular the thermometer bridge unit was made serviceable.

E.G.P.

(4) Tests on meteorological equipment for the JASIN Expedition

(a) The measurement of winds in the boundary layer over the ocean by optical tracking of balloons.

The aim was to assess the accuracy and feasibility of optical tracking of radio-sonde balloons from on board ship and to determine whether this method can provide a useful supplement to winds obtained from standard radar tracking, as the latter are inaccurate and the lowest wind obtained is usually above the boundary layer.

The balloons were tracked independently in elevation using a sextent and in azimuth using a sighting compass. In this experiment as a balloon shelter was not available, pilot balloons were tracked instead of radio-sondes. However as most of the problems encountered would be considerably less important when using radio-sondes this test can be considered a useful and severe test of the technique.

The balloons could be tracked to within $.1^{o}$ in elevation and 0.5^{o} in azimuth, but only to a range of 1.5km with the naked eye. However, as the radio-sonde balloons are approximately three times the diameter of pilot balloons, these could be followed to about 4.5km range.

It is concluded that the radio-sonde could be tracked optically to 0.1^{o} in elevation and 0.5^{o} in azimuth up to a height of about 1km or to cloud base.

(b) All-sky photographs for the study of cloud formations.

During the 1972 JASIN experiment, Imperial College wish to study the organisation of convection on the scales of 1-10km (cloud bands or 'streets') and 10-100km (cloud ensembles). It is important to know the location of these cloud systems relative to the network of observations, and it is therefore desirable to supplement visual reports with photographic evidence of their existence and orientation and location.

A movie camera taking pictures approximately every 5 minutes was mounted above a convex mirror to obtain the photographs. The object was to test the reliability and sea worthiness of the equipment and to test the resolution of the photographs. With a few modifications it is expected that the equipment can stand up to a month at sea.

D.M.

CRUISE 46: Legs 2 and 3

4th - 24th May 1972

Introduction

The main purpose of this part of the cruise was to test newly built components of the 'Minimode' acoustic float tracking system, to get the whole system working and to operate it on a large enough scale to show whether the proposed 1973 experiment is feasible. Although we do not yet have a satisfactory winch, and got little practice with combined use of the acoustic interrogator and TSD, the acoustic system worked successfully and up to 5 sound sources were tracked simultaneously. Extending that to the proposed total of 18 does not seem unreasonable.

Despite considerable efforts put into improving the safety of operation of the new hydrographic winch, a proper evaluation has not been possible because of the appearance of still more defects. These are described in detail below.

PROTAS (a free-fall probe recording ocean temperature and shear) was released and recovered sixteen times in deep water, but in a final test lowering the empty tube collapsed at 1900m.

Calibration runs for the electromagnetic logs were made, relative to a surface drogue.

The current meter spar intended for use in September during JASIN 1972 was given a mechanical test and appeared to have a suitably small response to surface waves.

The multisampler was brought into more routine use, and procedures for TSD calibration are being steadily improved.

Mooring 108 was recovered, after nearly 5 months exposure, and two new current meter moorings, 117 and 118, were laid in over 4000m depth intended for recovery in September.

TSD sections were worked across the Rockall trough (through the new mooring positions), and on the continental shelf and slope in the Western Approaches. Echo soundings were taken on passage in deep water.

Narrative

Leaving Barry at 1015 May 4th, course was set towards mooring 108 ($47^{o}32'.3$ N, $8^{o}23'.4$ W). TSD dips were made at 30 ml spacing on the way out. The mooring area was reached late on May 5th and work continued within a 25 ml radius of the mooring position for the next 10 days. Two transponders were tested overnight and, after recovering mooring 108, a short term mooring was laid p.m. May 6th incorporating one of the 'MODE' transponders and two current meters. This was left in place until leaving the area p.m. May 15th.

Work alternated between acoustic tests, TSD and multisampler dips, PROTAS, and running the new hydrographic winch. The e.m. logs were calibrated during daylight on May 7th. In the final acoustic experiment in this area, three transponder floats were laid, loaded for 1800m, and were tracked for 3 days whilst another float was laid, recovered and re-laid at 850m. All four floats and the mooring were recovered on May 15th. The call at Falmouth that had been planned for May 16th was cancelled - it had been put in to give an opportunity to collect the e.m. current meter spar, but that was not ready. Instead, a direct passage was made towards 52°15'N, 17°45'W, in an area exceeding 4000m. depth where moorings would be conveniently placed for recovery in September during JASIN 1972. On the way, the current meter spar was assembled and put out twice for observation of its response to surface waves.

After a brief bathymetric survey to find an area of suitable depth, mooring 117 was laid a.m. 18th May. Proceeding then to the neighbourhood of O.W.S. "J", a TSD section working back eastwards at 30ml spacing was started late that evening. On the westward run, a sudden change of surface temperature had been noted, and two extra TSD dips to 500m were made, on either side of the discontinuity. A second deep current meter mooring No. 118, was laid on 19th May, and the section continued eastwards overnight. During daylight on the 20th, one of the transponders was put out, suspended at 800m below a buoy, and interrogated at various ranges to determine the directivity pattern of its transducer in a vertical plane. Later the same day, the collapsing depth of the PROTAS tube was determined. One more TSD station was worked in the section across the Rockall trough, but the last station planned, on the western slope of Porcupine Bank, was not attempted because of bad weather.

Course was then set for 47½°N, 8½°W, with one TSD station on the way, in the deep embayment SE of Porcupine Bank. On that station, the E/S fish was changed. It had been vibrating intermittently for a few days, and several fairing clips (the new plastic ones) were found to be loose or missing.

Another TSD section was started on arriving at 47½°N, 8½°W, in the evening of the 22nd, and was continued up the slope and across the shelf in towards Plymouth. Two extra stations out towards the middle of the channel were occupied overnight 23rd - 24th May, and 'DISCOVERY' arrived in Millbay Docks, Plymouth, at 1500/24th.

J.C.S.

Notes on equipment and observations

(5) Acoustic Trials of the MODE Float Tracking System

All aspects of the float tracking system were tested except that a maximum of five floats only were used compared with 18 expected to be deployed at any one time during MODE.

For the first experiments two floats were lowered, one at a time, on a wire to 2000m. A high false trigger rate was attributed partly to ship noises at shallower depths and partly to noisy couplings on the wire. Poor transponding rates were attributed to the weak vertical directivity of both the transponder transducer on the float and the transducers in the towed fish assembly. Though the 10kHz command signal successfully switched the "dead-time" period, the first pyro-release did not work and the second was damaged even though not connected. In the second case a 'puffer' inside the tube fired correctly. The pyrorelease failure was subsequently believed to be caused by a fracture of the fuse igniter by the high acoustic field of the transducer nearby.

One of the float tubes was assembled and attached to a mooring at 841 metres in 2052 metres water depth, with sub-surface buoyancy at 12 metres and a surface dan buoy with 200m scope. Ranging and fixing experiments were then carried out around a triangular course relative to the buoy from 1 to 4.3 miles range using the towed interrogator at speeds up to 8 knots, and using the lowered array interrogator when hove-to. Radar ranges were between 0 and 0.1 N mile lower than the acoustic ranges, part of the differences being the buoy scope. The array interrogator gave better results than the towed fish in general beyond 4 miles out to 20 miles, providing the array was 150metres or more deep, though the towed fish did by chance interrogate successfully at approximately 26 miles on one occasion. The success or failure to interrogate by either system could be accounted for qualitatively by the ray path structure (computed using a velocity profile provided by the TSD data) rather than by the signal power level. The moored transponder was near the depth of the sound velocity maximum, which is a particularly unfavourable condition.

A float was ballasted to 1000 metres relying on a soluble link to release the weight, which occurred after approximately 14 hours. The main purposes of this experiment were to check the false target rate under more realistic conditions than on a mooring, to practise the homing phase with the float at the surface and to observe whether a pyrorelease was damaged by the acoustic field when placed further (90cm) from the transducer. No difficulty was experienced in directing the ship to the float and the pyrorelease seemed to remain intact as judged by its resistance measurement.

Three floats were ballasted to settle gently on the sea floor in 2100 metres of water, relying on soluble links to release the weights, but two being wired with internal puffers to check the command circuits and one wired with a pyrorelease at 90cms from the transducer and in series with the link. Together with the moored transponder this enabled practice to be gained at ranging on four floats at a time and allowed an estimate of the fixing errors to be made. The command switches were operated before the links released and the pyrorelease fired. All floats were recovered without difficulty.

The same three floats were then ballasted to be neutrally buoyant at 1800 metres depth and all fitted with a pyrorelease at 90cm spacing. With the moored transponder as the northern corner, the three floats were released to form a square pattern of side 10 miles. A fifth float with soluble link, as there were no more serviceable pyro-releases, was later added, allowing tracking on five channels.

Ship navigation could occasionally be compared with the acoustic range from the moored transponder, which by this time had exceeded its expected life time, on the basis of number of interrogations and its own false trigger rate. This particular unit had a frequency at the lower end of the reply band 5.51 to 6.75kHz and it was realised that the filter rejection of its own frequency compared with the interrogation frequency of 5.10kHz was not adequate, and that many of the false triggers could be attributed to responses off its own surface or bottom echoes. Another float at this end of the band exhibited the same behaviour and it was recovered, the circuit modified to give more rejection and redeployed with another soluble link; the modifications were effective and, apart from the initial fall when close to the ship, false triggers were greatly reduced. It is clear that even on the higher frequency floats great care must be taken over setting the transponder recognition threshold. In the laboratory this problem had been masked because the predominant noise to which the A.G.C. loop controlled the gain was a steady hum interference, whose amplitude distribution had different characteristics from the gaussian distribution of the narrow band ambient sea noise. Consequently there had been a tendency to set the threshold too low, causing an uneconomical false trigger rate in the sea. Measured rates agreed approximately with the theoretical rates calculated using the measured values of the threshold to mean A.G.C. level ratio, so that in future the correct threshold can be set. A slight increase in threshold reduces the false trigger rate for a negligible reduction in transponding performance. It was found that confusion can be caused by transponders locking in to bottom or surface reflected interrogation paths in preference to direct paths, where the latter are weak due to refraction or where the "dead-time" and travel times fit better.

All three floats with pyroreleases were fired satisfactorily and all floats were recovered. When a float came to the surface the ship steamed until the transponder range as indicated on the Mufax was a minimum, the float then being abeam; turning the ship through a right angle until the float was abeam again usually placed it within approximately 200 metres and in visual range of the Bridge.

The mooring with transponder attached was also recovered, the transponder still working though more weakly, as expected after 9 days life with more transmission per day than the MODE operational requirement. Battery volts were down to 1.17 volts per cell, end of nominal life having been arbitrarily calculated on the basis of 1.0 volts per cell.

The bottom half fibreglass cover and the two ITC 2003 transducers of the towed fish were lost after a few days possibly due to acoustic or cable vibration or even just slack bolts. Transducers were replaced, another cover borrowed from the spare echo-sounder fish and the towed interrogator was operational again. The listening range of this interrogator was probably less than its interrogation range due to ship noise, which was found to be speed dependent and some other noise which was dependent upon course relative to the sea; its interrogation range seemed to be limited by propagation conditions rather than its power level of 100 watts. This power could be reduced until interrogation failed, but it was not possible to be consistent about this, because of the directivity of the fish transducers and of the float transducer. The directivity of the latter was measured by interrogating from the towed fish a transponder slung 806 metres below a surface buoy and listening for the reply on an omnidirectional hydrophone towed 150m astern as the ship steamed by. The transponder source level is practically constant from 10^o elevation to 50^o elevation, but there is a clear 25dB reduction in source level between 65^o and 70^o, then increasing again to a side lobe between 70^o and 80^o. Angles between 80^o and 90^o could not be obtained without passing too close to the surface buoy. Absolute levels appear to be of the right order, but await more precise hydrophone calibration, and even then are subject to error due to the surface reflected paths. The float directivity at 10kHz, the command frequency, will be different again and may show more than one minimum.

After some difficulty in setting up the deep interrogator array electronics to transmit and receive properly when connected to the armoured cable on the starboard winch, it interrogated floats down to 2000m with greater than 600W pulsed (electrical input) power to ranges limited by the allowed propagation paths. The switching circuit allowing the TSD unit and interrogator array to be used on the same armoured cable worked without interference between units. The multisampler was tried on deck with the TSD and array satisfactorily, but not outboard as the steam winch could not handle the total load. The bottom polypropylene nose cone of the interrogator array could usefully be replaced by a metal one, so that there would then be no need to sling a weight beneath. The receiver section of the sea unit had rather more gain than necessary and this too can be reduced to ease the cable matching problem. It was possible to receive interrogated replies during lowering provided the array was deeper than about 150-200 metres, beyond the worst of the ship noises.

The receiver unit in the laboratory selected, amplified and displayed each channel on the Mufax, channel selection being manually controlled. Close range float replies were observed to break through on adjacent channels, but this was usually obvious by the double edged character of the leading and trailing edge transients of the pulse. Phasing the Mufax, that is determining how many integral sweep durations to add to the observed arrival time during the sweep, was done by observing the pulse shift when the Mufax synchronisation frequency was changed by plus or minus 5%. A more convenient switching system for this and for stopping the transmitter pulse is required. At short ranges the time of arrival can be determined to better than 10 metres equivalent slant range, whilst if detectable at long ranges the corresponding figure increases to about 35 metres. In all the tracking a nominal sound speed of 1,500 metres/second was used, which could produce a maximum range error of no more than 0.3% of the range, which is generally within the ship's navigational fix accuracy. To be realistic in practice at tracking the floats, interrogation was restricted to 4 minutes duration per fix for each float, i.e. about 30 interrogation pulses, and, if the float was going to lock-in at all, this time seemed to be adequate, including a phasing check. Some tape recordings on continuous tape were taken and also on a 4 minute tape loop. Difficulty in synchronising the Mufax on replay was traced to an intermittent fault in the hysteresis motor which was then replaced. Synchronisation of the replay was then possible, but further work is required on the timing arrangements to make the replayed trigger pulse time appear at the L.H.S. of the Mufax record, as it does during the recording mode. Tape replay speed-up factors of 16 can be achieved, but more reliable operation can probably be obtained at a 4 times speed-up. Thus 20 float channels would take 4 minutes to record simultaneously and 20 minutes to replay serially on to the Mufax. On an 8 second sweep the Mufax paper dries out at the edges, but no effort has been made to seal the paper compartments yet.

The experience which this six channel system has given suggests that extension to 20 channels with 18 floats out at a time is a workable proposition; the problems of the float electronics are understood and solvable; perhaps a third interrogator, in the form of an array identical to the deep one, capable of being lowered to 200 metres from a part of the ship distant from the forward hydro winch would be a valuable addition, enabling time to be saved during deep cast stations; floats could be released satisfactorily from the poop deck, but modifications to the aft, rough laboratory are really required if 20 floats are to be stored and assembled there.

B.S.McC.

(6) TSD Multisampler

(a) Instrumentation

This cruise was concerned with testing instruments to be used in the MODE 1 experiment therefore only the 9006 sea unit which has a 6000m depth capability was used (it may be necessary to work to 4-5 thousand metres during MODE 1). There are two salinity sensors for this instrument both of which were used during the cruise. The new salinity sensor had more backlash, between down and up casts, than the old sensor. In the past the old salinity sensor has refused to restart if it was turned off in the water, this effect has now been cured and both complete sets of sensors (salinity, temperature and depth, old and new) are compatible with the General Oceanics' multisampler.

In the past the multisampler has proved difficult to handle in conjunction with either TSD sea unit, but particularly difficult when used in conjunction with the larger 9006 instrument. In order to alleviate this handling problem a frame has been designed and built at the NIO which combines the 9006 sea unit and multisampler in "parallel" rather than in "series". This frame made handling straightforward. The bottles were loaded and unloaded from the multisampler at the hydrographic platform. This new configuration makes the multisampler usable in nearly any sea conditions that one might contemplate using a TSD profiler. Some trouble was experienced with multisampler bottles not closing, this was remedied by lengthening the lanyards on all the bottles.

During MODE 1 it will be necessary to interrogate transponding Swallow floats. Greater ranges and reception reliability may be obtained if the interrogating equipment is operated at specific deep-water depths. To facilitate this, without invoking time consuming separate interrogation casts, it was proposed that the interrogation and listening array should be hung beneath the TSD sea unit so that the interrogation could be carried out by interrupting a TSD cast for a few minutes. As the TSD profiler cable has only a single conductor a tone operated switch was constructed, using cards from the NIO acoustic telemetry system. This switch selects either the TSD and multisampler or the interrogating system at the end of the wire; it was used on many casts to 2000 metres and it worked satisfactorily in conjuction with the TSD profiler, multisampler and interrogator.

Several TSD dips were recorded, in composite signal form, on a new Revox A77 entertainment tape recorder and one such dip was replayed through the standard NIO - TSD - computer interface. Although special software capable of handling "drop out" data was required the final computer plot overlayed the original perfectly. On the expanded scale records, the noise level of the replayed cast was about 0.005 on both salinity and temperature and the order of 2 metres in depths.

The Cox thermostat salinometer has recently been modified to make its thermostatic tank into a continuous flow device with carefully controlled heaters backing off a commercial chiller unit. This causes the temperature of the thermostatic bath to cycle slowly by a few hundredths of a degree centigrade about the selected temperature. Operating the instrument in this way was found to be less time-consuming than the old stop-go method. Some 150 samples and their duplicates were measured during the cruise by an operator working on a part-time basis. The quality of the measurements appeared to be unaltered by the increase in speed of operation.

G.K.M.

(b) Calibration and processing

TSD Computing System

The system was used throughout the cruise. In general it worked well although some faults still caused difficulty and small amounts of data (never as much as an entire station) were lost. Work is continuing to modify the system so that faults due to hardware or operator error are either dealt with automatically or can be easily remedied without data loss.

New programs successfully used included:

VCALC which enables derived variables other than potential temperature and potential density to be calculated and stored.

The revised plotting package (Programs HYPLO, HYPLP, NSIZE, NPPLO, INSCL, DSCL)

This package is very flexible and allows the plotting not only of S, θ and σ_θ against P but also, for example θ - S plots and Brunt-Vaisala frequency and sound velocity profiles. There is a wide possible choice of scales and overall size.

CPARE a program to compare TSD and bottle salinities from the multisampler.

DATIO - DATIN the standard program outputs an average of 5 points selected at each 20m nominal depth interval. DATIO outputs an average value for every 5 points of raw data. Any group of five which contains any out of range depth values is rejected. The program is limited to handling 15 sectors of raw data (equivalent to 12 minutes at a sample interval of 0.8s). Further data are ignored. The program was successfully used for the stations on the continental shelf and to look in detail at portions of two deeper dips.

Development work was done on DATIP, a version of DATIN which includes a dump of the raw data in integer form to file RSTD.

TSD Calibrations

The type 9006 was used throughout and NIO waterbottles were used for calibration on a total of 43 dips. In most cases two bottles were used, one attached just above the TSD and reversed at depth, the other on a separate wire at 10m. The General Oceanics multisampler was used on 12 dips.

Temperature calibration

The same temperature sensor was used throughout and a total of 14 protected thermometers were used for comparison with it. The thermometer pairings were rotated at regular intervals so that the whole group could be intercompared. Within the limits of observational error the differences found were consistent. It was found that one batch, for which maker's calibrations were used, were systematically low and somewhat scattered relative to batches calibrated at Lowestoft by Mrs. Edwards. The extreme thermometers differed by about 0.04^{o}C. A single NPL calibrated thermometer was on average 0.005^{o}C lower than the Lowestoft batch but on the strength of the comparisons made this is marginally significant.

Pressure calibration

The same pressure gauge was used throughout. However its calibration appeared to change by 7 or 8 metres at the surface when the old salinity sensor was used in place of the new one. A transponder was used on three dips, its depth being observed on the echo-sounder and corrected by the local sound velocity profile. It was found that the metre wheel was reading 0.8% low, roughly the error to be expected from using 7mm wire on a wheel designed for 4mm wire. The three means available for TSD pressure calibration were the use of corrected metre wheel values in calm weather, a bottom pinger on casts close to the sea floor and unprotected thermometers. It was found that after correction the thermometers were reading high relative to the other methods by about 15 or 20 metres at 1000 metres and there was considerable scatter. For reliable results unprotected thermometers need to be used with several on each cast which was not the case on this cruise.

Salinity calibration

The availability of the multisampler enabled more calibration data to be obtained. It was observed that the scatter of the difference between duplicate samples was slightly larger for multisampler bottles as opposed to NIO water bottles. The significance level was not very high so it is possible that some external factor such as the sample bottles used may have caused this effect. For most of the cruise the new TSD salinity sensor was used. This showed an irregular hysteresis between the down and up traces of about 0.020‰ when used at depth. The effect could be due to either temperature or pressure. This made the calibration of this probe difficult. The old salinity sensor was used on 10 dips and by contrast behaved very consistently although it had a large constant offset of about 0.300‰ and a differential error between 0 and 2000m of about 0.050‰.

T.S.

(c) Observations

TSD stations 7858-7868 comprised a section from Hartland Point to mooring 108, the working area just off the slopes in the Bay of Biscay. The water on the shelf was generally homogeneous though the incipient stages of stratification were evident at a few shallow stations. The temperature ranged from 10°C - 10.5°C and the salinity ranged from 35.0 - 35.5‰ the water becoming progressively warmer and saltier as the continental slopes were approached.

Station 7870 was the first deep station in the working area near mooring 108. An interesting feature of the water column here was that water with the properties found on the shelf (<200m) were found between 400 and 500m. It appeared that water was sinking off the shelf and down the slopes to these deep levels. The surface density in the Biscay area was ~ 27.05 σ_t, a value 0.1 σ_t less than that found on the shelf. A short return run towards the shelf (station 7871, 7872) failed to find a surface density discontinuity. The shallowest station, station 7871, in 360m was presumably not inshore enough, the water properties there having values in common with the surface water further offshore.

TSD stations 7874-7887 inclusive were all close to the mooring area. The results showed two points of interest concerning the deeper water. A pinger used with the TSD allowed profiles to be continued down to within a few metres off the bottom. In some stations it was evident that mixing was more vigorour close to the bottom. The Väisälä frequency dropped from values characteristically of order 1 cycle/hour to zero in the last few metres.

At about 1900-2000m a change in the θ, S relationship was sometimes evident. This region also contained small scale temperature and salinity structures. The use of the multisampler allowed as many as 12 samples to be taken across a feature, thus fixing the highly resolved salinity values absolutely. Vertical profiles of chemical properties of small-scale features are an interesting possibility with this technique. One salinity feature thought to be instrumental was 'caught' in the multisampler. Subsequent analysis showed it to be real.

Stations 7890-7900 consisted of a section from OWS 'J' eastwards across the Rockall Trough. Geostrophic considerations suggested that these stations may have cut through a warm cone anticyclonic eddy or a meander of similar sense in the North Atlantic Drift. This description was consistent with the pattern of surface currents obtained from combination of satellite fixes and the DR from the EM log. With a level of no motion at about 1500m a current of 20cm/sec between stations to depths of 700m was obtained. A surface discontinuity in density was also observed, between stations 7891 and 7892. During the passage between these two stations, the surface temperature increased by 0.6°C in a distance of less than 3km.

Stations 7802 - 7813 were obtained on the return run from the Biscay working area to Plymouth. The water on the shelf was now stratified consisting of two well mixed layers, one due to air-sea interaction, the other due to bottom friction. The water temperature has risen by about $\frac{1}{2}^{o}C$ and was now only dense enough to mix to depths of under 300m on the slopes.

R.D.P.

(7) Electric hydrographic winch trials

(a) Electrical

A number of minor electrical modifications had been made since the previous trials in September 1971. The modifications were mainly concerned with providing the operator on deck with improved indication of fault conditions and with an improved display of wire out and wire velocity.

The existing 'traverse stopped' audible alarm was supplemented by a 'slack wire' alarm with both audible and visible indicators fitted in the deck pedestal controller. Each slack sensor consists of a roller, mounted on spring loaded swinging arms, bearing on the wire. When slack develops, downwards motion of the roller actuates a cam-operated microswitch and a geared-up potentiometer. The microswitch operates warning lamps in the hold and in the deck pedestal controller. It also sets a latching relay which actuates the audible alarm in the deck controller. This relay can be reset by a push-button on the controller: it is also automatically reset and the alarm is muted when the motor brake is applied. The potentiometer serves to apply additional feedback from the winch motor tachogenerator when slack develops, thus reducing the effective wire velocity demand signal.

These alarms worked satisfactorily and the potentiometer allowed smooth take up of slack when lifting a load off the deck. However, when the wire was paid out too fast in rough conditions (force 7 - 8), the potentiometer did not result in sufficient deceleration; it is thought that a logarithmic law will improve matters. It was found possible to apply manual 'heave compensation' and pay-out rate of 1 - $1\frac{1}{2}$ m/s were then possible in force 7 - 8 with three Lucas weights on the 4mm wire rope. Such manual compensation was much more easily effected than would have been possible with any of the steam winches, but required practice.

The performance under 'automatic velocity' and 'automatic position' control was very satisfactory in these conditions: very little variation in wire tension resulted. A phase adjusting network had been incorporated in the heave velocity channel and this was adjusted for minimum tension variation. A pressure housing incorporating a pendulous accelerometer was attached to the wire to monitor residual wire motion under 'automatic position' control, but the high frequency vibrations of the wire masked the motions of interest. In the future, it is hoped to try this again with an integrator on the output of the wire-mounted accelerometer, so as to obtain a more informative error signal.

After the winch had been running for about $4\frac{1}{2}$ hours in 'automatic' control modes a failure occurred. The sequence of events is thought to have been as follows.

A surge of output voltage from the GLORIA alternator occurred - this was accompanied by an abrupt change in the pitch of the alternator which was heard by R. Wallace on watch in the hold. The accompanying surge in the -20V supply to the accelerometer control panel in the hydrographic laboratory resulted in failure of a series regulator and of the operational amplifier integrator. This caused the heave demand signal to rise instantly to ±13V, which is equivalent to a payout demand of about 7m/s, resulting in slack wire in the hold. A disaster was only averted by the prompt action of R. Wallace, who pressed the emergency stop switch. Even with the alarms, the operator on deck might not act fast enough in such a situation.

After this disturbing mishap, additional protection against surges was incorporated in the hydrographic laboratory regulators. In addition, a manual speed control adjustment was incorporated in the GLORIA generator-set motor, bypassing the tach-feedback system which had always displayed doubtful stability. This improved the motor speed stability by a factor of about 3, under regenerative loading conditions. Soon after these modifications, the winch gearbox faults were discovered and operations were limited to running in all modes with a continuous loop of wire in the hold. No further electrical troubles resulted.

Other modifications included the installation of disc brakes for emergency use, operated by a push button switch in the deck pedestal controller; these are intended for use if the drive coupling between the motor and spool should break.

An 'hours-run' timer was fitted so as to run when the motor brake is lifted. This is necessary to indicate when servicing is required.

The hydrographic laboratory wire velocity meter was recalibrated on a linear scale and digital wire out indicators were fitted in the deck pedestal. A wire velocity meter will also be fitted in the deck pedestal in the near future.

Completely resdesigned alarm logic and accelerometer control unit electronics were fitted. These are of a more serviceable nature than the previous temporary units.

Installation work in Barry had been carried out by Messrs. Bonner, Clements, Peters and Waddington, together with Messrs. Clayson and Dobson. Work at sea was carried out by Messrs. Clayson, Dobson and Wallace. Design work at the NIO was carried out by N. Timmins.

C.H.C.

(b) Mechanical

The winch was run intermittently for approximately 70 hours spread over a period of several days, during this time an increase in gearbox temperature and gear noise was noticed. The gearbox was opened up for inspection and there was seen to be a considerable amount of metal in suspension in the oil.

The oil was drained off with difficulty owing to the close proximity of the drain hole to the 15" wide drum flange, also the oil had to be pumped out of the wormwheel compartment owing to there being no connection between the two sections below the bearing level.

There was considerable marking of the helical spur gears which drive the worms for the 15" and 24" wide drums, and some chipping was noticed, there was also wear on the wormwheel, the worm was inaccessible for examination and small pieces of steel were found in the bottom of the gear box.

Two unbrako screws that had sheared at the thread undercut were found in the gearbox, these were two of the four that connect the clutch to the spur gear input drive to the 15" drum. Checking the 24" drum clutch with a micrometer gave .090" eccentricity relative to the gear on which it was mounted. The remaining screws were removed from the clutches and from the surface finish appeared to have been machined with a file. The screws were checked with a micrometer and were found to taper from 0.215" diameter down to 0.205" diameter. These screws should have been a close fit in holes which measured .256" diameter.

The bearing bush in one of the helical gears instead of being a press fit in the gear fell out when the gear was removed from its shaft, the bore of the bush was a rough finish and appeared to have been treated with a rotary file. Vernier measurement gave 1.512" shaft diameter and maximum internal diameter of bush 1.540", also there were no oilways in the bush. The outside of the bush had originally been centre punched to raise the surface and make it a tight fit in the gear but running had flattened the centre punch marks.

The main drive coupling was withdrawn and the key was found to be less than half the length of the keyway and the key had been hammered into shape to make it fit.

To re-assemble the winch with the Clarke Chapman components would have made it unsafe to operate, effective repairs could not be carried out on board because of lack of material and also worn state of engine room lathe which makes it impossible to do precision turning.

R.D.

(8) PROTAS (Probe Recording Ocean Temperature and Shear)

A series of trials were made of a revised Protas system designed to extend measurements of velocity and temperature gradients down to a depth of 1500m. The new pressure case consists of a thin walled tube of HE 48 alloy with stiffening rings attached at intervals along its length. Prior to the cruise it was pressure tested to 1650m in the GPO tank at Dollis Hill. Other modifications of the shallow water system included, new GC 32 thermistors mounted in hypodermic needles with a time constant of 100ms, and a radio beacon recovery system, replacing the acoustic pinger used previously.

The trials were designed to investigate the drag characteristics of the new tube, as well as its compressibility which, if mismatched to the water, may have caused unacceptable changes in fall speed with depth. Results indicate that the effect of the stiffening rings, together with a buffer ring which have been added for protection, is to increase the drag coefficient by a factor of ~2.5 so that ballasting is now much less critical. The variation in fall speed is not serious, amounting to about 15% between the surface and 1500m for an initial value of 40cm/s.

A technique for expressing Protas down through the surface layers using extra pressure release was tried and found to work satisfactorily. This approach allows slower fall speeds at depth and therefore higher resolution of microstructure in the deep water.

Difficulty was experienced with the connections to the thermistor needles which leaked through sea water intruding along the araldite/PVC interface. This problem was eventually overcome by the use of a soft seal (silastic) around the back of the hypodermic units.

The radio beacon proved satisfactory except for the failure due to mechanical stress of the inhibit unit which keeps the transmitter off while Protas is submerged. An aerial mounted forward on the port side was calibrated for d.f. purposes.

In all sixteen releases of Protas were made, eleven to a depth of 1500m. As far as can be assessed at this stage most of the data both from Biscay and the area west of Ireland are of good quality and should provide a useful baseline for studies of deep microstructure in the Mediterranean outflow region.

In a wire test for the maximum design depth (2300m) the empty tube imploded at 1900m apparently due to dailure of the stiffening rings. The poor quality of the welds may also have been a contributory factor.

J.H.S.

(9) Ship Computer System

The main projects on the ship computer system were the improvement of the DECCA and LORAN sampling software to detect, and allow for, lane jumps and the installation and testing of a new digital clock interface.

The computer was also used to calibrate the two-component EM log against fixes determined by radar bearings on a drifting buoy. A multiple regression technique was used to calculate the calibration constants, which it is hoped will give a more accurate value for the athwartships calibration constant.

M.J.R.F.

(10) Current Meter Spar Trials

Owing to manufacturing delays, only two of the three buoyancy tubes were available. However, by not attaching a VACM dummy weight in the upper cage and by suitably adjusting the ballast weight, the thin surface-piercing spar could still be made to float at the desired level.

The aims of the trial were: (a) to see whether the spar would fracture whilst being handled, (b) to practice launching and recovery techniques, and (c) to see how well the spar's motion would be decoupled from the surface waves.

The spar was successfully launched on the 16th and 17th, each time the shipborne wave recorder indicating the dominant waves to have a 7 second period and a 2 ft. height. The pitching during the first trial was visually estimated to be $\pm 5^{\circ}$, with the spar's level irregularly varying by a foot or so over a period of minutes as indicated by a pressure recorder mounted on the spar. For the second trial a cylindrical canvas jacket was fitted between the two cages to greatly increase the dynamic mass of the spar. The resulting pitching and heaving were both much less than during the first trial.

T.R.B.

(11) Current Measurements

Mooring 108, a near-bottom mooring containing a single current meter laid during 'DISCOVERY' Cruise 44 on 10th December 1971, was recovered on 6th May after 148 days in the water. There was slight corrosion on the buoyancy sphere and on the housings of the current meter and the acoustic release, and the stainless steel lock nuts on the tie rod of the release had almost disintegrated (they were not the proper grade of stainless steel and were in fact slightly magnetic). Unfortunately the clock in the current meter must have stopped at the time of launching, and no record of current was obtained.

Two current meters were incorporated in mooring 116, the short term mooring laid primarily to test a 5.1kHz transponder. These were fitted with crystal clocks (the first time we had used them in current meters) set to sample at $2\frac{1}{2}$ minute intervals, and gave apparently satisfactory records over the 9 day period of the mooring, 6th to 15th May. The records have not yet been processed.

Two long-term moorings, No.117 containing 4 current meters, and No.118 with 3 meters, were laid in more than 4000m depth. These are the first long-term moorings (i.e. intended to stay out for 2 months or more) that we have laid in more than 2000m depth. They are intended to be recovered in September 1972. Their records should help to determine whether there is any persistent northward flow above the main thermocline in that region, as has been inferred from the near-surface temperature distribution. They will also be relevant to the observations planned near O.W.S. "J" in September (JASIN 1972). Details of the current meter moorings for this cruise are summarized in Table 2 below.

In the course of the acoustic tests, floats were launched and recovered 10 times. On three of these occasions the floats were deliberately sent to the bottom, held by soluble links to an excess weight, and on three other occasions floats were loaded for mid depths for short runs of less than a day, again using soluble links to release a weight. One float was included in mooring 116. The remaining 3 occasions yielded the current measurements detailed in Table 3. Fixing was by acoustic ranging on the transponders. Depths were determined from minimum ranges when passing closely over the float positions. Navigation was based on satellite fixes, with interpolation from the 2-component e.m. log. The satellite receiver was not working well and relatively few usable fixes were available. Nevertheless, the uncertainty in the mean currents over the 3 day period is believed to be no more than ±1 cm/sec. Trajectory No.234 (see Table 3) was almost opposite in direction to Nos.233 and 235 though separated initially by only 20km from them and at the same nominal depth. These observations were made on the slope, and No.234 was in water depths of about 4000m whereas the other two were in approximately 2300m depth.

J.C.S.

TABLE 1

Cruise 46 legs 2 and 3 station list

Station Number	Date	Time (BST) Start	Finish	Latitude N	Longitude W	Gear used
7858	4	1658	1724	50°56'.2	4°48'.4	TSD (50m)
7859		1959	2026	50°38'.4	5°16'.4	TSD (50m)
7860		2305	2332	50°20'.4	5°44'.4	TSD (50m)
7861	5	0248	0310	49°50'.0	6°05'.0	TSD (75m)
7862		0535	0604	49°29'.0	6°25'.5	TSD (100m)
7863		0836	0856	49°08'.4	6°47'.2	TSD (115m)
7864		1131	1156	48°47'.5	7°07'.8	TSD (138m)
7865		1417	1507	48°26'.2	7°29'.0	TSD (155m)
7866		1715	1748	48°05'.8	7°50'.0	TSD (183m)
7867		2030	2152	47°43'.3	8°12'.6	TSD (1200m)
7868	6	1232	1412	47°31'.6	8°23'.6	PROTAS (test lowering to 500m), TSD (500m)
7869		1415	1630	47°29'.9	8°24'.6	Mooring 116 (transponder + CM)
7870	7	0052	0321	47°28'.6	8°22'.9	TSD (2070m)
7871		0620	0700	47°54'.9	8°00'.6	TSD (360m)
7872		0726	0840	47°51'.9	8°04'.3	TSD (830m)
7873	9	1054	1312	47°27'.2	8°24'.9	PROTAS
7874		1640	1829	47°28'.3	8°25'.5	TSD, MS (2100m)
7875	10	1102	1201	47°28'.0	8°22'.5	PROTAS
7876		1308	1533	47°28'.0	8°22'.0	TSD, MS (1200m) PROTAS
7877		1706	1941	47°29'.7	8°22'.3	TSD, MS (2098m) PROTAS
7878	11	0100	0350	47°12'.5	8°37'.0	TSD (3000m)
7879		1416	1630	47°09'.5	8°22'.5	PROTAS
7880	12	2130		47°19'.7	8°19'.6	TSD + 10kHz transponder depth gauge cal.) 1000m (twice) 1600m.
	13		0357	47°16'.4	8°19'.5	
7881		1002	1205	47°25'.0	8°36'.6	PROTAS
7882		1550	1750	47°24'.5	8°19'.1	PROTAS
7883	14	0140	0310	47°11'.2	8°47'.0	TSD + 5.1kHz interrogator (500m)
7884		1148	1334	47°26'.9	8°21'.9	PROTAS
7885		1530	1704	47°18'.3	8°17'.4	PROTAS
7886		1735	2026	47°18'.1	8°18'.0	TSD, MS, velocimeter (2000m)

/continued.........

TABLE 1 (continued)

Station Number	Date	Time Start	(BST) Finish	Latitude N	Longitude W	Gear used
7886		1735	2026	47°18'.1	8°18'.0	TSD, MS, velocimeter (2000m)
7887		2155		47°08'.0	8°18'.7	TSD, MS (2800m)
	15		0110			
7888	16	1552	1718	49°24'.9	11°59'.4	PROTAS
7889	18	0930	1240	52°29'.0	17°45'.0	Mooring 117 (CM), PROTAS
7890		2130	2331	52°29'.5	19°52'.4	TSD, MS (2000m)
7891	19	0106	0148	52°29'.6	19°26'.7	TSD (500m)
7892		0230	0340	52°30'.2	19°14'.0	TSD (500m)
7893		0433	0813	52°31'.9	18°59'.8	TSD, MS (2000m), PROTAS
7894		1115	1320	52°33'.3	18°38'.0	PROTAS
7895		1337	1702	52°33'.1	18°35'.5	Mooring 118 (CM), PROTAS
7896		1831	2152	52°26'.6	18°14'.4	TSD, MS (2500m), PROTAS
7897	20	0147	0350	52°28'.0	17°25'.0	TSD, MS (2250m)
7898		0644	0854	52°24'.4	16°32'.8	TSD, MS (2250m)
7899		1031	1305	52°23'.2	16°18'.0	PROTAS
7900		2008	2245	52°30'.2	15°44'.0	TSD, MS (2250m)
7901	21	1708	1936	50°41'.4	12°34'.0	TSD, MS (2200m)
7902	22	2058		47°29'.4	8°30'.5	TSD (2050m) } 2 dips
	23		0204			TSD, MS (2035m) }
7903		0335	0451	47°39'.5	8°12'.1	TSD (1300m)
7904		0554	0635	47°47'.5	7°59'.0	TSD (600m)
7905		0740	0800	47°55'.0	7°52'.0	TSD (250m)
7906		1048	1134	48°15'.4	7°18'.4	TSD (150m)
7907		1417	1436	48°34'.3	6°45'.9	TSD (135m)
7908	23	1736	1751	48°56'.2	6°12'.0	TSD (114m)
7909		2105	2124	49°16'.4	5°38'.8	TSD (100m)
7910	24	0021	0040	49°37'.0	5°05'.0	TSD (80m)
7911		0335	0357	49°15'.2	4°32'.8	TSD (90m)
7912		0647	0704	49°35'.7	3°59'.0	TSD (76m)
7913		1006	1022	49°58'.0	4°31'.2	TSD (65m)

Abbreviations:

- TSD – Temperature, salinity and depth probe
- PROTAS – Probe recording ocean temperature and shear
- MS – Rosette multisampler
- CM – Current meters

TABLE 2

Current Meter Moorings Cruise 46, legs 2 and 3

NIO Mooring No.	DISCOVERY Station No.	Position	Water Depth (m)	Time (BST) and Date set	Time (BST) and Date recovered	CM No.	Depth (m)	Remarks
108	7775	47°32'.3 N 8°23'.4 W	2048	1428/10.12.71	1059/6.5.72	73	2026	(1)
116	7869	47°29'.9 N 8°24'.6 W	2052	1621/6.5.72	1935/15.5.72	222	738	(2)
						153	1649	
117	7889	52°29'.0 N 17°45'.0 W	4060	1214/18.5.72	-	154	158	
						219	466	
						111(B)	1995	(3)
						420	3010	
118	7895	52°33'.1 N 18°35'.5 W	4023	1632/19.5.72	-	153	222	
						222	440	
						112(B)	1964	(3)

(1) Clock stopped on launching, no record.

(2) Transponder in this mooring at 841m depth.

(3) Current meters marked (B) are Braincon. Others are Aanderaa.

TABLE 3

Neutrally Buoyant Float Trajectories, Cruise 46 legs 2 and 3

Serial No. 233

Launched 2329A/11.5.72, recalled 1034/15, recovered 1148/15.
Nominal depth 1800m. Minimum range observed 1875m.
Probable depth 1830-1875m.

First fix	0435A/12	$47^{\circ}23'.2$ N	$8^{\circ}14'.2$ W
Last fix (No.6)	1034A/15	$47^{\circ}26'.6$ N	$8^{\circ}23'.0$ W

Mean velocity, fixes 1-6: 4.5 cm/sec, 300°T

Serial No. 234

Launched 0057A/12.5.72, recalled 0602/15, recovered 0725/15.
Nominal depth 1800m. Minimum range observed 1835m
Probable depth 1790-1835m.

First fix	0514A/12	$47^{\circ}15'.0$ N	$8^{\circ}24'.1$ W
Last fix (No.6)	0520A/15	$47^{\circ}13'.6$ N	$8^{\circ}18'.0$ W

Mean velocity, fixes 1-6: 3.1 cm/sec, 109°T

Serial No. 235

Launched 0257A/12.5.72, recalled 1333/15, recovered 1443/15.
Nominal depth 1800m. Minimum range observed 1815m.
Probable depth 1775-1815m.

First fix	0523A/12	$47^{\circ}23'.2$ N	$8^{\circ}34'.2$ W
Last fix (No.6)	1322A/15	$47^{\circ}27'.3$ N	$8^{\circ}43'.4$ W

Mean velocity, fixes 1-6: 4.8 cm/sec, 303°T.

SCIENTIFIC PERSONNEL

Leg 1

M.J. Tucker	NIO	Principal Scientist
J. Crease	NIO	
B.S. McCartney	NIO	
A.R. Stubbs	NIO	
N. Kenyon	NIO	
A. Voss	NIO	
F. Bilimoria	NIO	
Mrs. M. Olliff	NIO	
Miss J. Broadway	NIO	
G. Bryan	NIO	
R. Summers	NIO	

Legs 2 and 3

J.C. Swallow	NIO	Principal Scientist
T.R. Barber	NIO	
F. Bilimoria	NIO	
D. Boon	University College of North Wales Marine Science Laboratories	
J.W. Cherriman	NIO	
C.H. Clayson	NIO	
I. Crofts	University College of North Wales Marine Science Laboratories	
R. Dobson	NIO	
M.J.R. Fasham	NIO	
C. Flewellen	NIO	
Lt.Cdr.T. McAndrew	Ministry of Defence, Hydrographic Department London	
B.S. McCartney	NIO	
N.W. Millard	NIO	
G.K. Morrison	NIO	
R.D. Pingree	NIO	
G.R.J. Phillips	NIO	
T. Sankey	NIO	
J.H. Simpson	University College of North Wales Marine Science Laboratories	
R. Summers	NIO	
R.F. Wallace	NIO	

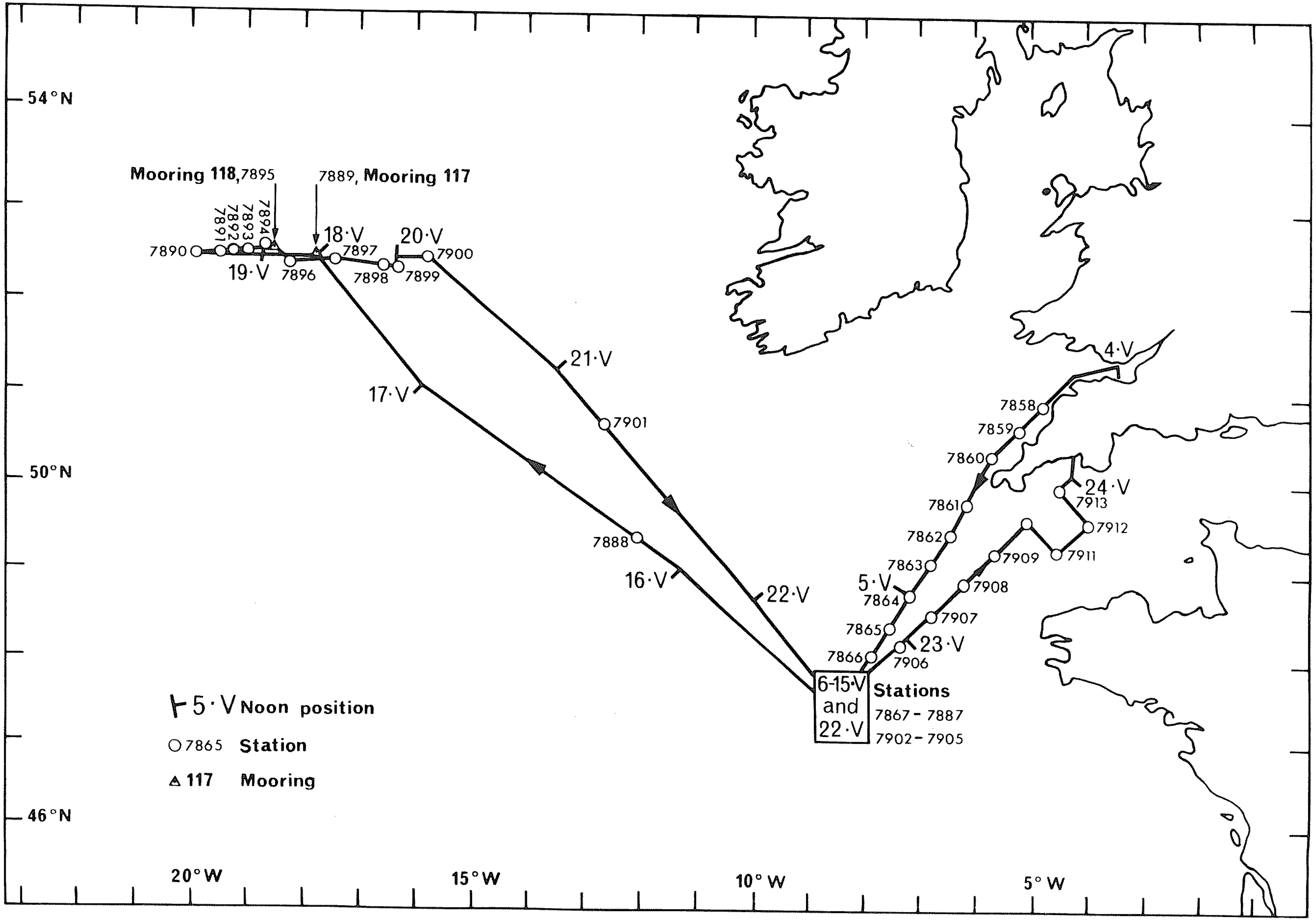
/continued........

SCIENTIFIC PERSONNEL (continued)

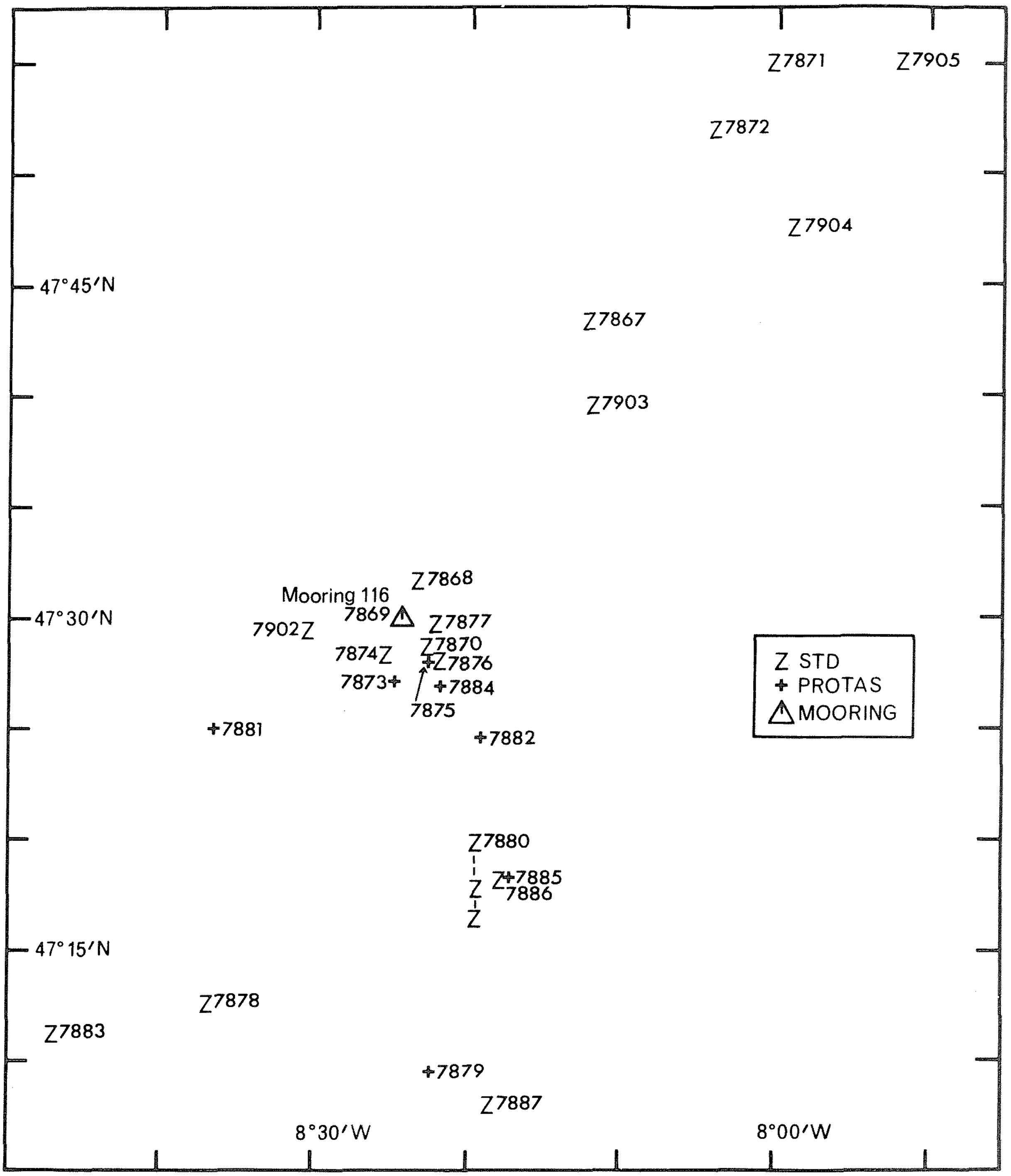
Leg 4

M.J. Tucker	NIO	Principal Scientist
J. Crease	NIO	
B.S. McCartney	NIO	
A.R. Stubbs	NIO	
N. Kenyon	NIO	
A. Voss	NIO	
F. Billimoria	NIO	
Mrs. M. Olliff	NIO	
Miss J. Broadway	NIO	
G. Bryan	NIO	
J. McCune	NIO	
E.G. Pitt	NIO	
Mrs. P. Edwards	NIO	
M.P. Smith	NERC - HQ	
N. Kelland	Unit of Coastal Sedimentation	
D.W. Colvin	MATSU, AERE, Harwell	
E.E. Aldridge	MATSU, AERE, Harwell	
D. Mansfield	Imperial College of Science and Technology	
Lt. Cdr. T. McAndrew	Ministry of Defence, Hydrographic Department, London.	

Discovery Cruise 46   Track Chart 4-24·V·72



Discovery Cruise 46 Stations 6-15·V, 22·V·72



Discovery Cruise 46 Track Chart 27–29/4 and 26-30/5/72