I.O.S.

RRS DISCOVERY

CRUISE 130

25 JUNE – 5 AUGUST 1982

SOUND RANGING TRIALS AND A STUDY OF DISCOVERY GAP

CRUISE REPORT NO 136

1982

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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INSTITUTE OF OCEANOGRAPHIC SCIENCES

WORMLEY

R.R.S. DISCOVERY

Cruise 130

25 June - 5 August 1982

Sound ranging trials and a study of Discovery Gap

Principal Scientist

Leg 1

W.J. Gould

Leg 2

P.M. Saunders

I.O.S. Cruise Report No. 136

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The work described in this report has, in part, been carried out under contract for the Department of the Environment as part of its radioactive waste management programme. The results will be used in the formulation of Government policy but at this stage they do not necessarily represent that policy.

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The work reported here has, in part, been carried out under contract for the the Department of the Environment, as part of its radioactive waste management research programme. The results will be used in the formulation of Government policy but at this stage they do not necessarily represent Government policy. We wish also to acknowledge the wholehearted co-operation of the Master (Captain P.A. Maw), Officers and Crew of the RRS Discovery.

OBJECTIVES OF CRUISE

The principal objectives of the cruise were as follows:

(1) To conduct sound ranging trials in the region of the eastern Atlantic between 30 and 45°N. The experiment was designed to investigate the feasibility of the long range detection of neutrally buoyant floats at depths of three to four thousand metres from listening stations moored in the Sound Channel axis.

(2) To investigate the exchange of abyssal water between the Madeira and Iberian basins. The basins, both 5300 m deep, are separated at depths near 4500 m by the East Azores Fracture Zone. A narrow channel near 37 30N and 15 30W named 'Discovery Gap' connects these basins. Our purpose was to conduct a bathymetric survey of the gap and study the flow through it using neutrally buoyant floats and CTD lowerings. Six year-long moorings were to be deployed and two recovered.

All objectives were met on a very successful cruise: Figs 1 and 2 show where the work was accomplished.

NARRATIVE

Leg 1 Sound Ranging Trials

RRS Discovery sailed from Santa Cruz, Tenerife at 0800Z 25th June (day 176) and proceeded at full speed towards the site of two moorings deployed in a gap (Discovery Gap) between the Madeira and Iberian abyssal plains (near 37°20'N 15°50'W) in the summer of 1981. En route a wire test of two acoustic release units and a CTD station (10555) were successfully completed. Passage resumed and the moorings were approached via a series of echo sounding lines. Both moorings were found to be in place and a CTD station (10556) was worked some 2 miles to the west of the moorings near the centre of the channel. On the morning of 28th June (day 179) Mooring 310 was recovered uneventfully but Mooring 309 refused to surface despite satisfactory acoustic signals. The mooring appeared to be upright but could not be separated from its anchor. Its release beacon was locked on and course was set towards a site to deploy a VACM camera and tripod in the channel. This was carried out (station 10557, IOS Mooring 318) at 1430 28th June. The ship then returned to the position of Mooring 309 which was still on the sea bed and the command release was reset to turn off.

Course was set towards a suitable position on the Azores-Gibraltar ridge for the deployment of a mooring carrying two 250 Hz sound sources at depths of 700 and 1900 m (close to the local minima in the sound speed profile). The mooring was to have been of "full depth" design with buoyancy provided by a 48" diameter sphere at a depth of 200 m and with the uppermost 1000 m of the mooring made up of 8 mm dia. wire. During the anchor-first deployment of this mooring a splice in a 12 mm dia rope failed as the full tension came on it with the consequent loss of the acoustic release and anchor.

This suspected weakness of the mooring line prompted a redesign of the mooring with glass sphere buoyancy at 700 m, a lighter anchor and an all rope mooring. A new release was tested and the deployment proceeded. Unfortunately a further splice failed, this time resulting in the loss of both the acoustic release and the 1900 m sound source.

By this time the mooring team had been at work for about 12 hrs and so the ship proceeded to survey a new mooring site, and a replacement release was wire tested. An investigation of the splices on the remaining rope lengths showed them to be capable of failure at low loads if the outer jacket of the rope were loose. In view of this the splices were cut off and the rope ends knotted around thimbles.

A suitable site was found and the mooring deployed successfully at station 10559 at 2006 29th June (day 180).

A series of combined listening and CTD stations to within a few metres of the sea bed was commenced, initially at rather small (~30 km) spacings but later increasing to 200 km.

These stations 10560 to 10569 consisted of listening to the arrivals of the sound signals at 500 m intervals during the descent and then switching to the CTD at the bottom of the cast for the ascent. On station 10566 a fault developed on the hydrophone at 4500 m and in view of the subsequent damage found on its recovery the station was repeated using a new hydrophone.

On completion of this work course was set towards Madeira. The ship anchored off the mole in Madeira at 0800 7th July (day 188). A berth alongside was not available until the morning of 9th July. The two laboratory containers which had been shipped from Tenerife were loaded and secured.

<u>Leg 2 Sound Ranging Trials</u>

On the first section of leg 2 sound ranging trials were continued. RRS Discovery left Funchal at 0900 on 10th July (day 191) and steamed northwards, arriving at the location of Mooring 319 at 0300 12th July (day 193). From a short PES survey it was determined that the same site was suitable for the relayed mooring. At 0600 the release was fired, half an hour later the surface buoyancy was grappled and by 0815 all was inboard. Further echo sounding was undertaken whilst the battery pack of the sound sources was refurbished and at 1430 the ship was on station 10570 to begin laying Mooring 320. The laying did not go smoothly - numerous minor incidents meant that the buoyancy was not released until 1800.

Since both sound sources (635 m and 1954 m) were operating normally RRS Discovery steamed NE to the first listening station 100 km distant. On station 10571, 02-08Z on 13th July (day 194), a release was successfully tested at full depth and employed to bring a CTD unit near the bottom: an oxygen sensor was installed for the first time on Cruise 130. Station 10572, 00-10 on 14th July (day 195), was 400 km distant from the sound source and was lengthy because of a failure of the hydrophone at 1500 m. The replacement unit was installed and the station recommenced at 0330. Listening was good to 5000 m. A release was again successfully tested and on the upcast when CTD data was gathered multisampler stops were made for oxygen samples. Because of the loss of the hydrophone we elected to proceed to a station at 800 km from the mooring. RRS Discovery continued to make slow progress in the face of the steady northerly 20 kt winds experienced to date on this leg and arrived on 15th July (day 196) at site for station 10573. After a short delay for an open circuit connector lowering commenced at 1200: the station was completed by 1830. Because sofar signals were received at all depths to 4500 m it was decided to proceed to 1000 km. At 0700 on 16th July (day 197) station 10574, the last of the CTD listening stations began and after a further release test (see Fig 1) was completed soon after 1300.

The interrogator fish was launched and in calm seas and light winds RRS Discovery headed south. On both 17th and 18th the passage was interrupted by wire tests of pairs of Mk III floats* and releases so that we arrived at the sound source mooring on 19th July (day 200). The release was fired at 0745, the mooring grappled at 0820 and by 0924 the ship steamed away to begin the study of currents in 'Discovery Gap'.

Leg 2 Flow of abyssal water through 'Discovery Gap'

At 1201 on 19th a pilot float was launched at the sound end of 'Discovery Gap' near the VACM/camera tripod deployed on leg 1. A float ballasting level of 4700 m was selected as the working level - it was deemed likely to be within the swift eastward current and might also prove shallower than the sill depth (which was not known at the commencement of the work). A wire test of a fifth Mk III was made nearby but the echosounder behaviour was erratic. After fixing the float (viz finding its geographical position by ranging from the known position of the ship) we began a CTD yo-yo station steaming at between 0.5 and 0.8 kt NW over the south side of 'Discovery Gap'. Hampered by wind and current slow progress was made; station 10575 lasted from 2018 on the 19th to 1012 on the 20th (day 201). Repeated

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*Footnote: Mk III floats have a buoyancy package of a 17" glass sphere unlike the aluminuium cylinders designated Mk I and Mk II.

lowerings was made from 4000 db generally within 10 m of the bottom. At 1100 a second yo-yo station was begun on the north bank of the gap, lying-to in winds of only 7-12 kts: this proved very successful so that by 1845 we had completed the desired section. After returning to the pilot float 3 more floats were added between 2100-2300 on the same day and 3 more added on the following afternoon 21st July (day 202) between 16-1730. Between float launchings two CTD stations were occupied, numbers 10582 and 83 to SE and NW of the earlier drift stations respectively. Float fixing was 2-4 times a day. On the afternoon of 22nd July (day 203) a Mk III float was launched twice (the first was recovered after a ballasting error was detected) and a series of echo sounding surveys were begun in extraordinarily calm seas. The next morning, at 11/23rd July (day 204) the Mk III float was released as it was sitting on the bottom. On its arrival at the surface the acoustic signal disappeared because of the shallow stratification in the upper few meters: fortunately this problem disappeared later in the leg after winds exceeding 20 kt had stirred the upper 10-20 m. The float was sighted visually and recovered by 1330. Unfortunately a second float 5 Hz different in release frequency was also released and a short visual search recovered channel 8 float by 1540. In between (12Z) a second Mk III float channel 11 was launched. After an echo sounding run early the next morning a CTD lowering was made (station 10584) revealing the existence of cold water over the NW sill of 'Discovery Gap'. Around 11 on 24th July (day 205) we recovered Mk II float channel 11 which was released from 4000 m because it was 10 miles behind the swift running floats. Two replacement floats were added, channel 8 reballasted for 4700 m and accidentally released the previous day, and a Mk I channel 2 float ballasted for 4000 m to replace the one at its depth. By 1430 an echo sounding run was begun which terminated at 2330 followed by float fixing. There were now 8 floats in the water 7 at 4700 ± 50 m and 1 at 4000 m.

At 0430 on 25th July a CTD yo-yo lowering was made about 10 km north east of the main exit to 'Discovery Gap'. The station 10585 was made initially in 4900 m of water about 1.5 miles east of a steep slope rising to 4300 m and 6 lowerings were made as the ship steamed eastward at a speed of 0.5 kt. A wedge of cold water was discovered against the boundary, with temperature similar to that entering 'Discovery Gap'. After this station we returned to the floats, fixed them and launched Mk III channel 15 float. An echo sounding survey was then made of the NW basin, 18-01/26th July (day 207), followed by a lowering of the CTD near the NW sill (station 10586). A short echo sounding survey (08-11) preceded float fixing and in turn was followed by a CTD station in the cold water outflow from the NW exit (1540-2130), station 10587.

Float fixes were obtained at 12 hr intervals during the remainder of the experiment interspersed with CTD stations and echo sounder runs, the latter to fill in bathymetric data gaps. A break in this routine was provided on 27th July (day 208) by recovery of the VACM/camera unit (13-15.30) and a bottom mooring (#325, 16-17.30) with one Aanderaa current meter. A Mk III float channel 6 was added to the group at 22Z the same evening and early next morning a CTD station (10588) was occupied near the entrance to 'Discovery Gap', 02-06 28th July (day 209). Two moorings were laid later, the first #326 with a single VACM near the NW sill (14-14.30) and the second with a single Aanderaa near the NE sill (16.45 - 17.15). 2 km from the second mooring a CTD lowering was made, station 10591 (18-21).

On 29th and 30th July (days 210/211) those of the ten floats not providing new information were released and recovered - channel 11, 16 floats between 13 and 17 / 29 and channel 17, 15 floats between 09.30 and 1200/30. The latter two were lodged at the foot of a 200 m cliff - which was also to capture float channel 10 the same day. Three yo-yo stations (10592-4) were occupied in the following three days; the first on the western side of the discharge basin beyond the NE sill, the other two in the discharge region beyond the NW sill. The latter two revealed that the cold water had ceased to overflow. Consequently on 31st July (day 212) the remaining six floats were recovered between 06.30 and 18.30 (see Fig 2).

In the final two working days of the cruise 1st and 2nd August (days 213-214) 5 CTD stations were occupied at locations 30-150 km from the exit of 'Discovery Gap'. The influence of the cold water could not be seen on stations 10596, 10597 the more distant, but on the three nearer stations 10595, 10598 and 10599 it was clearly present. RRS Discovery set sail for Gibraltar at midnight 2nd August and docked at 0930 on 5th August (day 217).

NOTES ON EQUIPMENT AND OBSERVATIONS

Sound Ranging Trials - B.S. McCartney and N.W. Millard

(a) The objective of these trials was primarily to observe the long range sound propagation in the North Eastern Atlantic from deep floats to receivers in the Sofar channel: in fact the experiment was performed for convenience in a reciprocal way, mooring sources at two depths in the channel and listening at 500 m depth intervals surface to bottom at a number of ranges out to 1,000 km. A secondary, but by no means unimportant, objective was to gain practical experience of glass float/transducer assembly and of digital correlator reception techniques.

On leg 1 the loss of a sound source to the sea bed at 4400 metres due to a splice failure during the mooring operation, had beneficial aspects since it provided an extra source at a depth from which poor propagation would have been predicted. Mooring 319 (see Fig 3) with sources at 669 m, near the depth of the sound speed minimum above the "Mediterranean water maximum" speed, and at 1925 m, near the depth of the sound speed minimum below it was successfully laid (20/29th June) and ranging began. Listening stations combined with CTDs were made at 30, 65, 100, 200, 400, 800 and 1000 km roughly in a line SW from the source position (37°27'N, 16°35'W) near 'Discovery Gap' and mainly over the Madeira abyssal plain. Another station at 266 km east of the source with intervening topography and off the line was made principally for a CTD profile. The sound sources behaved well as did the listening system, except for the loss initially of half the 600 km station data due to a hydrophone failure; the station was repeated successfully with a spare hydrophone and the broken one repaired.

(b) Results, leg 1

The receiving system using a W.H.O.I. 'shore' station receiver, output to a CRO and pen recorder, essentially consists of A.G.C. then band limiting followed by a 2 bit (clipped) digital signal correlator. Under high signal-to-noise conditions the output correlation peak (>3 volts) is 100%; when the signal is more than about 15 db below the input noise the signal is undetectable (<0.8 volts), whilst for the majority of the work correlation voltages between 0.8 and 2.9 were obtained depending upon signal-to-noise ratio in a non-linear but monotonic way. Thus it is difficult to work back precisely to obtain a measure of the signal level, particularly since the noise level is variable due to ambient weather-dependent noise, to own ship noises, to other shipping noises and to hydrodynamic noises caused by heave induced hydrophone motions. However, for the ultimate purpose of float tracking it is detectability which is paramount and all that can be added in respect of noise is that these ship based detections will be conservative in comparison with what can be expected from a quietly moored hydrophone A.L.S.

Detection levels are summarised in table 1 A, B and C for sources at 669 m, 1925 m and 4400 m (sea bed). Referring first to table C it is clear that reliable detection of the bottomed source is limited to 200 km, with only occasional detections to 600 m. This is not surprising since there are no totally refracted paths from this source, so surface and bottom reflections are necessary, and these may be lossy and/or incoherent.

The data in Tables A and B are very similar, and the picture which emerges is that, for this ocean site at this time of year, signalling from floats between 500 and 3500 m in depth is entirely reliable to A.L.Ss at 669 to 1925 m out to ranges of at least 1000 km. Floats at 4000 m may well be feasible also despite occasional misses at 400 km and 1000 km. However, deeper floats at 4500 or 5000 m would be very doubtful beyond 266 km; detailed observations of signals received at these depths show long spread out or multiple correlations, indicative of surface bottom bounce multipaths. All these results are entirely consistent with propagation modelled on ray paths calculated from the measured sound speed profile. Table D gives at each station a near surface sound speed and the deep depth where the sound speed is the same defining the channel carrying totally refracted rays. The channel thickness increases by about 500 m from NE to SW. Though the correspondence of data with theory is only based on this one experiment, the quality of the correspondence gives confidence that detectability may be assessed for other sites and seasons where reliable sound speed data is available. Seven pulses received at 3500 m depth and 1000 km range give some idea of the natural fluctuations expected in signals above but near marginal conditions.

(c) Results, leg 2

Mooring 319 containing the two sound sources was recovered 08 12th July (day 193) to replace the sound source batteries. It was relayed some ten hours later as mooring 320 with the same sound sources at depths of 635 m and 1954 m. Measurements of the battery pack voltages showed that although the sound sources had exceeded their design life of 12½ days by more than a day there was an estimated 2 days life left.

The ship steamed in a roughly northly direction for 100 km to the first listening station (10571) which followed the same proceedure as those on leg 1 of the cruise. Neither at the first nor at any subsequent station were any correlations recorded from the sound source on the bottom (4400 m) and it was presumed to have stopped working. Other stations (10572, 3 and 4) were carried out continuing northwards at 400, 800 and 1000 km. At the 400 km station the hydrophone failed at 1500 m and consequently the array was recovered and replaced with the spare. The failure was due to a leak between the oil filled array and the pressure housing containing the preamplifier. The summary of results is not significantly different from the pattern of the southern section.

The mooring was recovered after 7 days at 0930 19th July (day 200).

Current meter and sound source moorings - W.J. Gould, J.W. Cherriman and I. Waddington

The primary tasks involving moorings were:

(a) The recovery of two moorings set on cruise 122 (July 1981)

(b) The deployment of two sound sources (250 Hz) to be used in the acoustic ranging trials

(c) The deployment and recovery of a tripod carrying a Vector Averaging Current Meter (VACM) and camera

(d) The deployment of current meters in'Discovery Gap' for recovery in the summer of 1983.

(a) Both moorings set on cruise 122 were located acoustically when 'Discovery Gap' was first reached 28th June. Mooring 310 was recovered without difficulty and its current meter yielded a record of almost one year duration which was translated and partially analysed onboard. Mooring 309 on the north side of the channel responded to the release frequency transmission but did not separate from its anchor. The acoustic signals showed no directionality and it was assumed that the mooring was still upright but that the release mechanism had jammed or both pryolease units failed to fire. The mooring was checked on several occasions but on 20th July it could not be located: the previous detection was 9 days earlier so a search was not justified. The mooring was assumed to have broken free from its anchor and drifted away. A message was broadcast on Ch. 16 VHF for shipping passing through the area to report any sightings but no reports were received from the few ships in the area despite good visibility and sea conditions.

(b) Two sound sources (each consisting of a 10' long frame containing 2 x 17" glass spheres and a 7' long aluminium resonant tube) were required to be laid at depths of 700 and 1900 m. The original intention had been to deploy these in a full depth mooring with buoyancy provided by a 4' dia steel sphere at 300 m, the upper part of the mooring being of 8 mm wire and the remainder of 10 and 12 mm dia braided terylene rope. The moorings were to be laid anchor first using the double-barrelled winch on the foredeck in order to ensure accuracy of mooring depth in the rough topography in which the sources were to be set.

During the first attempted deployment a splice in the braided rope failed as it took the full anchor load (1600 lb) and the anchor and acoustic release were lost. In order to reduce the anchor weight a new design of mooring was attempted using glass spheres for buoyancy at approx. 700 m depth and an entirely rope mooring line. Anchor weight was reduced to 700 lb. During the deployment of this mooring a splice again failed this time with the loss of the deep sound source and an acoustic release and anchor.

Some of the rope splices were then tested to destruction and it was discovered that two factors had played a role in the equipment loss.

(1) Some splices (which had been made by the rope manufacturers) were improperly constructed, and

(2) During handling around the double barrelled winch the outer rope jacket on the inboard splices on each rope length tended to be loosened.

The tests showed that splices with a loose outer jacket could be broken at loads of only 700 lb whereas with a tight outer braid the splices did not break at over

2500 lb.

The unreliable splices were cut from the rope ends and replaced by a series of half hitches around the thimbles and each termination was sewn into place.

The mooring 319 was deployed without incident (Fig 3) recovered at the start of leg 2 and relaid and recovered as 320 on leg 2.

(c) The VACM tripod was constructed with rigid (Key Klamp) interconnections between the scaffolding tube lengths but was otherwise of the same design as previous deployments. The deployment was altered slightly from previous attempts in that the buoyancy was floated away astern, the tripod then lowered to well below the surface and the whole rig slipped from the mid point of the buoyancy line. This worked very well and resulted in less stress to the rather complex and flimsy frame than would have occurred with the fame being released when just below the water surface (Fig 4).

The VACM and camera were recovered towards the end of the cruise when it was discovered that the camera flash unit had leaked through the seal on the pressure light cover. The VACM data tape was not decoded at sea.

(d) A total of five near bottom moorings were deployed on July 21st, four in a cross channel section and one upstream from the section. All used braided terylene rope and titanium release hardware. Buoyancy was provided by 17" Benthos spheres shackled to chain. All were deployed without problems. It was later decided that the upstream mooring would be better deployed in one of the outflow gaps and on 27th July Mooring 325 was recovered. It and a further mooring carrying a single VACM were deployed, one on each of the exit sills on 28th July.

Throughout the cruise the double barrelled winch worked well. The deployment of short rope moorings is very simple but the handling of the long rope lengths needs the rope to be fed to and from the driven drums by hand - a situation which contributed to the loss of the two acoustic releases. The construction of bigger drums capable of holding up to 2000 m of 12 mm rope should be put in hand.

Details of the moorings deployed and recovered are given in Table 2.

Acoustic command release system - M.G. Sawkins

There were twelve units supplied for use on Cruise 130, details of each unit are given overleaf.

NUMBER	OPERATING FREQUENCIES (Hz) BEACON	RELEASE	BEACON PERIOD (SECONDS)
CR2101	320	380	1.16
CR2106	320	340	1.04
CR2157	320	440	1.02
CR2158	320	460	0.98
CR2175 ✝	320*	240	1.10
CR2176	320*	260	1.08
CR2177	320	280	1.06
CR2178	320	300	1.04
CR2179✝	320	340	1.02
CR2302	320	280	1.12
CR2308	320	440	1.12# 0.96
CR2314	320	340	1.02

* Fitted with 20° tilt indicator

✝ Lost 1st leg of cruise

\# Beacon period changed before use

Ten sets of hardware were supplied for the cruise, of these ten, six were of titanium (for long term moorings) and the remainder were heat treated 316 516 stainless steel. Two units were supplied fitted with 20° tilt indicators for use on the VACM tripod frame. Two sets of heat treated stainless steel were lost on the first leg of the cruise.

On leg 2 of the cruise release tests were made on CTD/listening stations. The release was hung just below the hydrophone and when the listening trials were complete, the release was tested and then used for bottom finding for the CTD. Four releases were tested in this way. The remainder were tested with Mk III float lowerings.

Of the five moorings recovered (310, 318, 319, 320 and 325) all pyros successfully fired.

Checks of 3 deck units and 2 H-type beacons, gear permanently aboard the ship, were made during the cruise. The former units were found in good working order. Major overhauls should be made on the latter on their return to the U.K.

Near bottom echo sounder - M.G. Sawkins

The 35.5 KHz near bottom echo sounder with a range of 150 m was used on 8 CTD stations (32 hours) on the first leg and 18 stations (103 hours) on the second. There was one failure (station 10584) which was rectified for the next station. Battery replacement was required every 50 hours.

Neutrally buoyant floats - J.C. Swallow

The primary purpose of using floats on this cruise was to obtain trajectories of the near-bottom water moving between the Madeira and Iberian basins. A secondary objective was to make further tests on the Mk III floats, first used on cruise 117 last year. From a year-long record obtained from a current meter recovered at the beginning of the cruise, it was clear that near-bottom water flowed most of the time northeastwards along a deep channel from the Madeira to the Iberian basin, as expected, with an average speed about 5 cm s^{-1}. The floats revealed a narrow energetic (about 10 cm s^{-1}) transient current at depths near 4700 m, strongly controlled by the topography. They appeared to be heading at first for a sill at the northeastern end of the channel, but slowed down, changed direction and tried to go north over another sill about 4600 m deep (see Fig 5). Three floats stopped at the sill, two passed over but grounded on a steep slope not far beyond it. Information about the float trajectories can be found in Table 3. The observed depths are provisional; in such rough terrain there are difficulties in combining bottom reflections with water depths derived from a wide-beam echo sounder.

Most of the work was done with Mk II floats, which had not been re-weighed since before cruise 117. They went to within 100 m of their nominal depths, as did one of the two remaining Mk I floats. Three Mk III floats were launched, one of them twice, and they all went much deeper than expected. It is hard to believe that the initial weighings were in error by so much (about 50 grams), and although a certain amount of rebuilding had to be done at sea the changes in weight were carefully noted. It must be concluded that the effective compressibility of the whole float is appreciably greater than the value calculated for the glass sphere alone. One of the Mk III floats stabilized at approximately 4900 m and its echo sounder registered various distances off bottom from 300 m to 150 m before it was carried into an area slightly shallower than its stable depth. Where comparisons could be made, the echo sounder gave heights above bottom consistently smaller than those calculated from the 5 KHz bottom reflections, by 10 to 20 m. This is most probably due to the weak 5 KHz reflected signals being read systematically late.

CTD and Multisampler P.M. Saunders and G. Griffiths.

For stations 10555 to 10574 lowerings which were made from the midship winch were shared between the CTD-multisampler and a 14 m long hydrophone employed in listening for moored sound sources. A coded pulse transmitted from a surface unit switched between the hydrophone and the CTD-multisampler. Listening was performed on lowering and hydrographic observations made on recovery. Because of the length of the hydrophone the closest approach of the CTD to the bottom was rarely less than 25 m.

For stations 10575 to 10599 the hydrophone was removed and CTD data was gathered on the lowering with multisampler use on recovery. During the course of the cruise adjustments to and refurbishment of the level wind gear brought the winch operation back to a very satisfactory state.

A Sea-Tech 1 m path transmissometer was interfaced with the CTD and used for all 34 stations, including 7 deep yo-yo casts where repeated lowerings (56) were made between about 400 dB and the bottom. An oxygen sensor was found to be faulty at the start of leg 1 and was replaced with a new sensor at the start of the second leg: it worked well. A station list is found in Table 4.

The CTD sea and deck units and the Digidata recording system performed reliably with no electronic faults. Comparison of the CTD temperature with the reversing thermometers showed the CTD to be stable. However, frequent conductivity jumps equivalent to .003 PSU in salinity were noted. Larger jumps of up to .01 PSU occurred infrequently, generally recovering later, and could relate to bio-fouling of the cell. The transmissometer optical surfaces were cleaned in accordance with the manufacturers instructions before each lowering, and on the first leg only two stations gave problems. Fouling at a depth of about 1000 m on the up cast gave reduced transmission for the remainder of one station, and the other showed low transmission probably due to contamination from the water surface. Initially, stations on the second leg gave reduced and variable transmission, and a very thin film of oil was noticed on the surface of the porro prism, which reappeared even after vigorous cleaning. As the prism housing was pressure balanced, a leak was thought likely. No repair was attempted, however, due to the absence of engineering drawings for the instrument. Once identified, a modified cleaning procedure gave acceptable results.

The multisampler water bottles were in poor repair, only five out of twelve being serviceable initially. Spares on board and those received at the start of the second leg eventually enabled nine bottles to be used. The sea unit performed well, but tangling of the lanyards and thermometer frames was a problem. Spacing of the thermometer bottles was hampered by additional hardware mounted on the protective cage.

Guildline salinometer - J.A. Moorey

The Guildline salinometer worked extremely well. The changes in standardisation values over the six week period were very small, indicating (a) a very stable thermostat bath temperature and (b) minimal changes in cell constant. However, on one occasion trouble was experienced. A series of samples were being measured when it was noticed that on "standby" position, (where a fixed resistor replaces the cell) the digital readout was about 150 digits higher than the value normally indicated. By remeasuring some of the samples it was possible to determine that (a) the instrument was now recording conductivities 150 digits higher than at start of measurements and (b) to determine at what precise stage in the sequence of samples that this jump of 150 digits occurred. Consequently it was possible to apply a correction to the samples. The fault had occurred about 15 minutes before it was noticed and remained in faulty condition for about another 15 minutes when it reverted to normal working. There is no obvious explanation of cause of the fault. During the fault condition some samples had conductivity ratios of 1.9... and others of 2.0... so the amplifier responsible for the last four digits of signal would be operating on very different signals, but all the samples had an indicated conductivity of 150 digits higher than true value.

Reversing Thermometers worked satisfactorily. There is a report elsewhere of the functioning of Niskin bottles and reversing frames.

Oxygen There was a bad start due to not fully understanding the techniques of oxygen titration. Consequently various tests were made on surface water samples where it was learnt by trial and error, what one should and what one should not do to the samples. The literature was also reread. From then on the titration values looked reasonable. Duplicate oxygen samples were taken from each Niskin bottle and pairs (titrated at different times) agreed, usually to much better than 1%.

Computer support - D.S. Collins and E. Lawson

(a) General description

The RVS PDP 11/34 data acquisition system was employed to sample, calibrate, plot and archive CTD, depth and navigation data, the IBM 1800 not being used. The PDP system performed extremely well with no loss in recording CTD data and with only small losses in navigation. There was one hardware fault, a failure of power transistors in the line printer. This was quickly rectified. There were three system crashes in the last few days of the cruise. These occurred when a variety of programs were running, some new programs. All crashes had the common feature that the line printer and terminal TT6 were both in use. It is possible that the problem may result from a IO driver error or an error in CAMAC tables. This should be investigated. A number of software bugs were corrected and several software additions made. Details of these have been circulated.

The RSX 11M version 3.1 system was perpared in Barry immediately prior to the cruise so that use could be made of the latest software corrections and additions. A tested version 3.2 system was not available in time for the cruise, but this was known well in advance and presented no difficulties. The 3.1 system was carried to the ship on duplicate tapes and loaded to disk prior to leg 1.

Some difficulty resulted from lack of up-to-date concise documentation. In particular, the starting of navigation sampling was troublesome and although a write-up exists, it is split over several memos, some no longer applicable. A potential DTS problem proved difficult to investigate through absence of documentation describing the common block. Programs were difficult to modify and debug because of a paucity of comments.

Difficulty also resulted from several pieces of software which had been modified previously but had not been tested as they did not function. Such faults were annoying but, in these cases, easily rectified. Most annoying was a fault in the control program (CON) which did not allow the modification of any calibration coefficient without stopping all sampling including navigation. This was frustrating and unnecessary. CON had other errors, e.g., an error in the sequence at the end of an archive file.

(b) Navigation

Navigation was by satellite fixes with dead reckoning using the port e.m. log and gyro between fixes. The calibration coefficients for the log were assumed from the previous cruise but no documentation could be found describing how and when these were obtained. The output from the port log was recalibrated by Brian McCartney, the method and results being entered in the Instrumentation log book. The initial coefficients were used for the whole cruise as convincing evidence for a log bias could not be found. However the predicted currents were different on station and when steaming, an indication of an error in the assumed calibrations. This was established late in the cruise but as consistency in the data set was important, changes were not made.

A new version of GETFIX, the program which reads satellite fixes into a disk file, was used without problem. This version is capable of accepting differing fix formats and is thus more general.

A number of software faults were discovered and rectified. Details of changes have been sent to Barry for modification of the basic software set. Additions were necessary to eliminate radio transmission noise from the e.m. log, this significantly upsetting the dead reckoned position. Additions were also made so as to optionally include the latest estimated current in the dead reckoning update as printed. The terminal which prints navigation every 6 minutes (TTO) was moved into the plot to be monitored by the watch. The terminal status was set to slave to eliminate electrical interference which stops navigation sampling by preventing output to the terminal. This change gave much improved reliability and useful information for scientific work.

The navigation was adequate but could be improved to meet current scientific requirements, especially a better ability to edit and re-edit the final data set.

(c) CTD data

CTD with oxygen and transmittance was logged without problem. The raw sampling program (CTDSAM) lost a high proportion of raw data values (about 30%), an undesirable feature. CTD programs also needed modification for better editing of data spikes. An addition was made to the CTD suite of programs. This was program STNLST which produces standard lists of parameters at specified pressure levels.

(d) Additional programs

A new program became available to read Aanderaa current meter tapes and to convert to a standard format on computer tape (program AARDVARK). A program to plot sound rays (PRAY) was converted from the IBM 1800 and was used extensively. A program for the manual input of echo sounder depths (DEPTH), after adjustment for the Carter area, was written and a new version of a mercator plotting program (CART) was also prepared. The old mercator plot program (MERCCA) has been reorganized and extended to include options to plot current vectors and to plot crossing points of contours.

Another new program, MONI or MONITOR, will display the current status of sampling and archiving, updating every second. Several other programs were written for specialized requirements.

(e) Archive of data

Files 7, 9, 21, 23 and 27 (i.e. 1 second CTD values, edited navigation and depth data) were archived to computer tape for transfer to Wormley at the end of the cruise. The final software system, including all modifications, was also written to tape such that one copy can be returned to Barry and another kept at IOS, Wormley.

TABLE 1

Leg 1. Correlator Output Voltages

Average of 2 Receivers V > 3 100% Correlation
Detectability v ⩾ 0.8

A. From Source at 1925 m

Ave.	Depth \ Range (km)	30	65	100	200	(266)	400	600	800	1000	2 hours at a depth of 3500 m
1.9	0.5	1.7	2.1	2.5	1.1	2.7	1.8	2.1	2.1	0.8	
2.1	1	2.4	2.3	2.8	2.3	2.4	1.3	2.0	2.6	0.8	
2.1	1.5	2.5	1.9	1.7	2.5	2.7	2.5	1.2	2.6	1.1	1.15
2.2	2	2.9	2.5	1.8	2.1	2.1	2.5	2.5	2.3	1.0	1.0
2.4	2.5	2.8	3.1	2.7	3.0	2.7	2.2	2.2	1.6	1.0	1.15
2.2	3	2.4	2.2	2.9	2.5	2.6	2.8	0.9	2.4	0.9	1.1
1.9	3.5	2.4	2.8	2.8	2.9	1.2	1.3	1.1	1.5	1.0	1.1
1.6	4	3.1	1.8	2.5	2.4	1.3	-	1.4	1.2	0.8	1.55
1.4	4.5	2.5	2.4	1.9	1.9	1.2	0.8	1.1	0.9	-	1.2
1.1	5	No data	1.7	No data	1.4	1.5	-	No data	No data	No data	

B. From Source at 669 m

Ave.	Depth \ Range (km)	30	65	100	200	(266)	400	600	800	1000	
1.9	0.5	2.1	2.1	2.7	1.7	2.1	2.4	2.4	2.3	1.6	
2.1	1	2.4	2.7	2.9	1.9	2.8	0.7*	1.9	2.7	1.1	1.65
2.3	1.5	2.1	1.9	2.7	2.5	2.6	2.9	2.0	2.3	1.3	0.9
2.3	2	2.7	2.3	2.2	2.5	2.8	2.3	2.5	2.3	1.5	1.65
2.2	2.5	2.9	2.2	2.5	2.3	3.2	1.8	2.2	1.8	1.1	1.4
2.3	3	2.5	2.2	2.9	2.7	2.5	2.5	2.8	1.5	0.9	1.4
2.0	3.5	2.7	2.4	2.6	2.7	1.3	1.7	1.7	1.5	1.1	1.7
1.6	4	3.0	2.0	2.7	2.4	1.0	1.0	1.0	1.3	-	1.1
1.3	4.5	2.6	2.2	2.0	1.9	1.3	-	-	1.3	-	
1.1	5	No data	1.9	No data	1.4	1.0	-	No data	No data	No data	

*Multiples interfering

TABLE 1 continued

C. From Bottomed Source at 4,400 m

Range (km) / Depth	30	65	100	200	(266)	400	600	800	1000
0.5	1.0	1.5	2.2	0.7	-	-	1.0	-	-
1	No data	2.7	2.0	1.1	-	-	-	-	-
1.5	2.0	2.0	1.9	1.0	-	-	-	-	-
2	2.8	1.9	2.7	1.6	-	1.3	-	-	-
2.5	2.8	2.4	1.7	1.0	-	0.9	-	-	-
3	2.5	2.7	2.2	0.7	-	1.5	-	-	-
3.5	0.8	2.1	1.9	0.8	0.9	-	-	-	-
4	1.1	3.0	2.8	2.8	1.7	-	-	-	-
4.5	0.8	2.5	2.7	2.5	-	-	0.9	-	-
5	No data	2.9	No data	2.3	1.1	-	No data	No data	No data

D

Stn	10560	10561	10562	10563	10564	10565	10567	10569	10568
Range	30	65	100	200	(266)	400	600	800	1000
Sound Speed (m/s)	1524	1525	1525	1525	1525	1525	1528	1528	1530
At Depth (m)	14	15	16	10	10	10	10	10	10
Depth for same speed	3780	3780	3830	3860	(3800)	3800	4000	4030	4180

TABLE 1 continued

Leg 2. Correlator Output Voltages

E. From Source at 635 m

Range (km) / Depth	100	400	800	1000
0.5	2.8	2.1	0.8	1.5
1	2.5	2.4	2.3	0.8
1.5	2.1	1.7	1.4	1.7
2	2.6	1.5	1.2	1.3
2.5	2.8	1.7	1.8	1.2
3	3.0	2.1	1.4	1.0
3.5	1.7	1.8	1.5	0.6
4	1.6	2.3	1.8	0.6
4.5	2.0	0.8	1.1	-
5	1.2	1.9	0.6	1.0

F. From Source at 1954 m

Range (km) / Depth	100	400	800	1000
0.5	2.6	2.4	2.0	1.2
1	2.7	2.6	1.5	1.1
1.5	2.6	2.6	1.3	1.5
2	3.0	1.8	1.5	1.2
2.5	2.8	2.5	0.8	0.7
3	2.5	1.9	1.3	-
3.5	2.7	2.3	0.8	1.2
4	2.4	2.7	0.9	1.0
4.5	1.4	1.4	0.9	-
5	1.8	1.1	0.6?	0.9

TABLE 2. Mooring details

Mooring No.	Set Recovered	Long.	Lat.	Date/ Time(z)*	Water depth(m)	Instuments & depth	Release Unit
309	Not recovered (see narrative)	37°22.4N	15°48.2W		5046	Aa 3340 4823 m	2152
310	Recovered	37°21.1N	15°45.7W	0816 28.VI	5046	Aa 3726 4823 m	2306
318(Tripod)	Set	37°15.6N	16°05.6W	1430 28.VI	4845	V 0156 4844 m	2175
	Recovered	"	"	1320 27.VII	"	" "	"
319	Set	37°26.8N	16°35.4W	1955 29.VI	3528	SS 700 669 m SS 1900 1925 m	2177
	Recovered	"	"	0602 12.VII	"	" "	"
320	Set	37°26.9N	16°34.6W	1802 12.VII	3504	SS 700 616 m SS 1900 1904 m	2177
	Recovered	"	"	0748 19.VII	"	" "	"
321	Set	37°20.7N	15°41.4W	0801 21.VII	4686	Aa 5204 4357 m V 0132 4673 m	2177
322	Set	37°22.0N	15°43.1W	1018 21.VII	4947	Aa 5203 4295 m V 0429 4612 m Aa 5206 4934 m	2101
323	Set	37°23.9N	15°47.5W	1231 21.VII	5009	V 0629 4673 m Aa 5205 4996 m	2158
324	Set	37°25.1N	15°50.9W	1401 21.VII	4429	Aa 5202 4416 m	2178
325	Set	37°20.0N	15°57.1W	1550 21.VII	4911	Aa 5201 4898 m	2308
	Recovered	"	"	1616 27.VII	"	" "	"
326	Set	37°31.0N	15°40.4W	1522 28.VII	4613	V 0627 4601 m	2308
327	Set	37°27.6N	15°25.4W	1810 28.VII	4820	Aa 5201 4808 m	2106

*Times refer to time mooring reaches sea bed on deployment and time release fired on recovery.

TABLE 3. Neutrally Buoyant Floats, Discovery Cruise 130 (all dates are July 1982)

Float	Mk	Launch time/date	Nom. depth (m)	Obs. depth (m)	First fix time/date	First fix Lat.N	First fix Long.W	Last fix time/date	Last fix Lat.N	Last fix Long.W	Remarks
5	II	1201/19	4700	4603	1724/19	37°47.7	16°06.5	1604/31	37.40.1	15.31.2	Grounded before 1306/30
1	II	2212/20	4700	4703	0318/21	37°18.6	15°58.6	0900/31	37°29.3	15°36.2	
7	II	2229/20	4700	4687	0318/21	37°19.6	15°58.6	0615/31	37°31.3	15°34.9	
10	II	2246/20	4700	4687	0318/21	37°20.6	15°58.5	1328/31	37°34.5	15°38.8	Grounded before 1214/30
8	II	1652/21	4700	4662	0236/22	37°17.7	15°57.9	0900/23	37°18.8	15°50.6	Released accidentally at same time as 15
17	II	1707/21	4700	4781	0236/22	37°17.9	15°58.2	0936/30	37°34.4	15°39.4	Grounded before 0936/30
11a	II	1723/21	4000	4009	0236/22	37°20.0	15°58.7	1050/24	37°20.7	15°54.4	
15	III	1458/22	4700	-	2300/22	37°18.7	15°55.1	0900/23	37°18.6	15°54.6	Went to the bottom
11b	III	1216/23	4000	4896	2240/23	37°24.9	15°45.6	1330/29	37°25.9	15°40.2	Grounded before 2154/28
8	II	1353/24	4700	4640	2330/24	37°23.6	15°42.6	1604/31	37°40.1	15°31.3	Grounded before 1604/31
2	I	1423/24	4000	4097	2330/24	37°22.0	15°40.6	0615/31	37°24.2	15°31.5	
15	III	1730/25	4000	-	0230/26	37°25.8	15°38.7	0936/30	37°34.3	15°39.5	Went to the bottom
16	III	2156/27	3600	-	1110/28	37°25.4	15°38.5	1441/29	37°25.7	15°39.0	Went to the bottom

TABLE 4. CTD station list

Station	Time Down	Date 1982	Lat.N	Long.W	water Depth(m)	CTD ht above bottom (m)	Salinity samples	Thermometer frames	Comments
10555	1339	27.6	36°39.3	16°02.2	3998	2200	8	4	Test
10556	0542	28.6	37°21.0	15°49.9	5056	4	8	4	7.5km west of mooring 310 No hydrophone
10560	0104	30.6	37°16.7	16°50.3	4613	23	5	3	30km from sound source
10561	0837	30.6	37°03.9	17°09.9	5005	19	0	0	65km from sound source
10562	1615	30.6	36°56.3	17°33.1	5328	24	5	3	100km from sound source
10563	0441	1.7	36°29.0	18°31.2	5546	21	5	3	200km from sound source
10564	1849	1.7	37°16.4	19°38.8	5265	22	4 (*)	2 (*)	266km from sound source (*) 10m NIO bottle used here and on subsequent casts
10565	1308	2.7	35°17.5	20°11.4	5242	24	6	5	400km from sound source
10566	0655	3.7	33°54.0	21°46.5	5335	22	5	4	600km from sound source
10567	1707	3.7	33°56.3	21°46.1	5340	780	0	4	Repeat of 10566. Echo sounder removed.
10568	2006	4.7	30°49.3	24°11.3	5428	930	6	4	1000km. Station interrupted for two hours at 3500m.
10569	1942	5.7	31°29.7	21°50.7	5049	24	6	5	800km. Echo sounder replaced by release. Drop in transmittance at 1000m:biofouling?
10571	0540	13.7	38°19.3	16°00.1	5233	24	9	3	100km. Release wire tested. Oxygen sensor fitted.
10572	0706	14.7	40°50.6	15°29.8	5252	25	9	3	400km. Low transmission. Release tested.
10573	1609	15.7	44°18.9	13°43.6	4986	26	10	2	800km. Release tested.
10574	1041	16.7	46°20.2	13°57.8	4829	22	10	3	1000km. Low transmission. Listening at 3500m on up cast also. Release tested.
10575	1st 2148 last 0810	19/20.7	37°19.0 37°22.3	15°39.0 15°43.6	1st 4480 last 5038	10	0	0	No hydrophone. Echo sounder on frame. 20Kg wight 8m below frame. 17 yo-yos steaming 0.5 kt.
10576	1st 1218 last 1647	20.7	37°26.3 37°24.3	15°42.8 15°41.3	1st 4378 last 5244	10	0	0	8 yo yos as above. Lying to. 0.5 kt athwartships.
10582	2110	21.7	37°15.5	15°34.8	4184	9	9	3	
10583	0732	22.7	37°31.0	15°47.4	4526	9	9	3	
10584	0420	24.7	37°40.3	15°37.2	5059	10	8	3	
10585	1st 0556 last 1120	25.7	37°34.0 37°33.2	15°21.1 15°17.0	1st 4917 last 4178	10	0	0	6 yo yos.
10586	0552	26.7	37°29.3	15°37.7	4624	10	9	2	Test of 0_2 sensor response.

TABLE 4 continued

Station	Time Down	Date 1982	Lat.N	Long.W	Water Depth(m)	CTD ht above bottom (m)	Salinity samples	Thermometer frames	Comments
10587	1st 1710 last 1926	26.7	37°35.5 37°32.95	15°39.2 15°37.6	1st 4883 last 4526	9	0	0	8 yo yos
10588	0346	28.7	37°3.8	16°15.4	5285	10	7	3	
10591	1920	28.7	37°28.6	15°24.5	4802	9	0	0	
10592	1st 2300 last 0151	29/30.7	37°43.4 37°44.5	15°28.0 15°30.85	1st 4808 last 4565	10	0	0	5 yo yos
10593	1st 1534 last 1948	30.7	37°39.5 37°38.7	15°33.8 15°32.6	1st 4995 last 4405	10	0	0	5 yo yos
10594	1st 2109 last 0144	31.7 - 1.8	37°35.7 37°37.2	15°38.5 15°39.4	1st 4922 last 4959	9	0	0	6 yo yos
10595	0957	1.8	37°41.9	15°18.5	4914	7	9	4	Modification of multi-sampler bottle 11T tested.
10596	2032	1.8	37°49.8	16°30.6	5183	9	7	3	
10597	0935	2.8	38°39.7	15°15.1	5538	6	7	3	
10598	1648	2.8	38°4.5	15°10.4	5031	8	0	0	
10599	2219	2.8	37°55.5	14°45.2	4916	9	0	0	

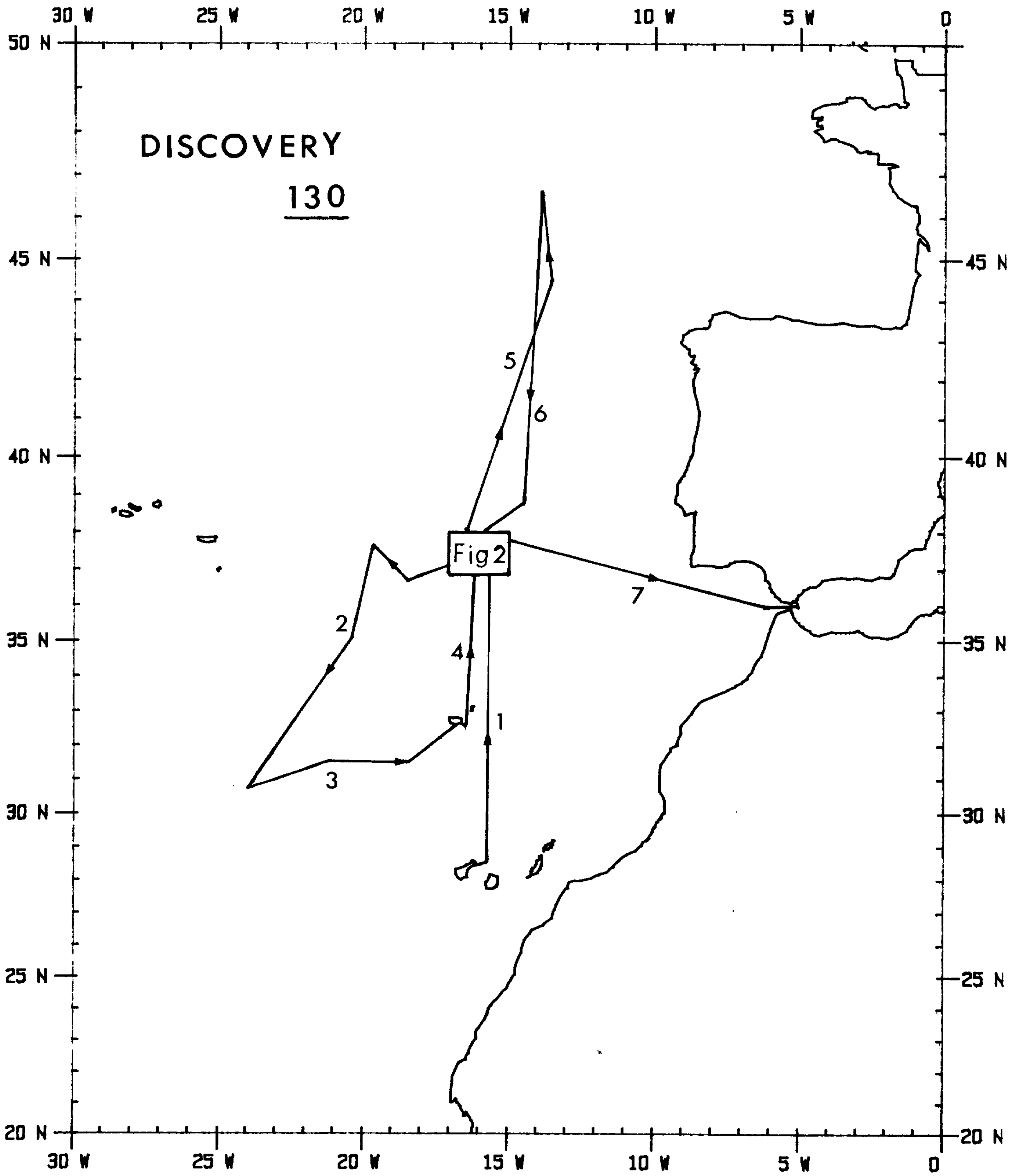

Figure 1. 25 June - 5 Aug 82

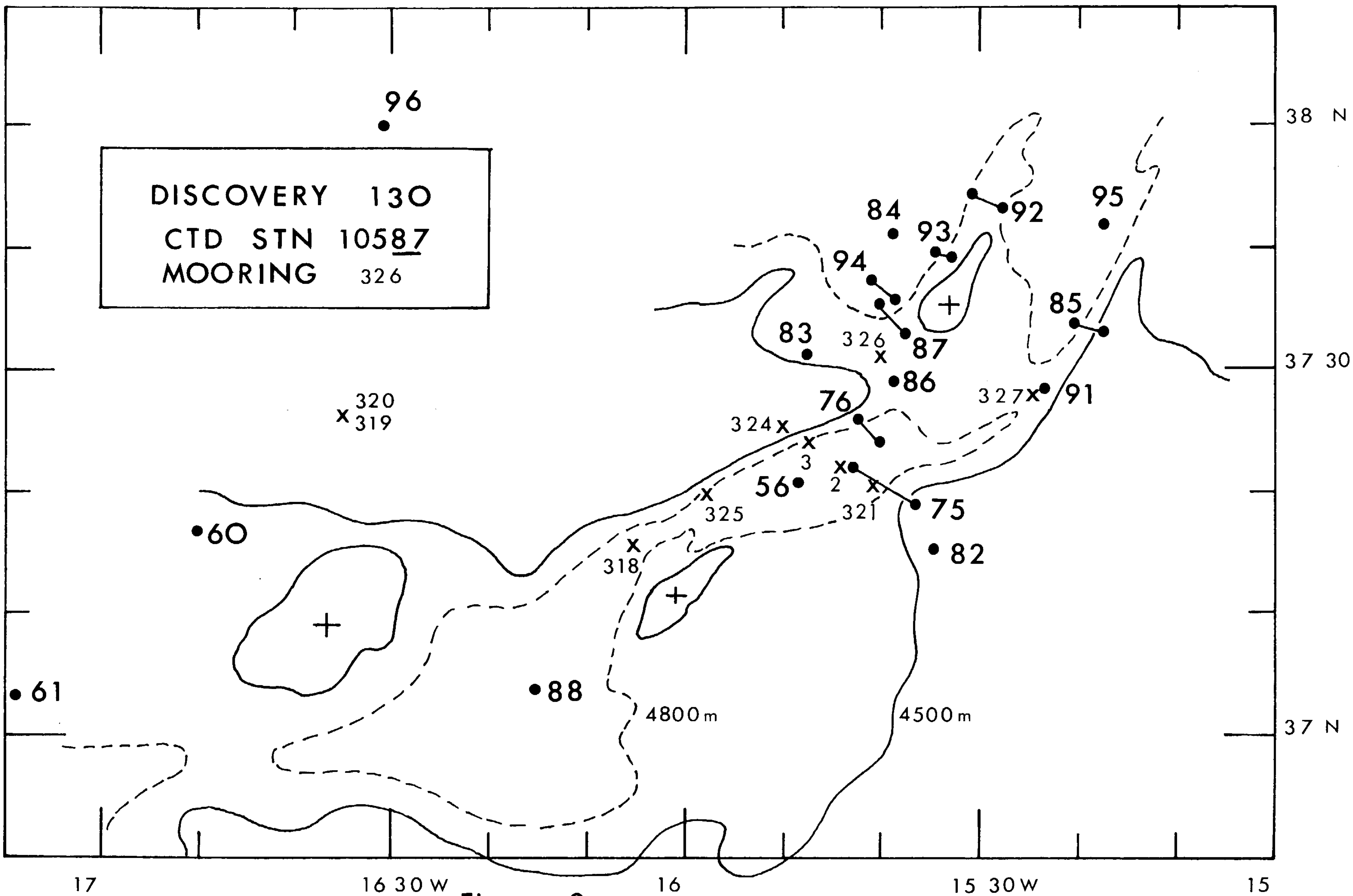
DISCOVERY 130
CTD STN 10587
MOORING 326
96
95
92
84
93
94
85
83
326
87
86
91
327
76
324
3
2
56
75
325
321
82
320
319
60
318
61
88
4800 m
4500 m
38 N
37 30
37 N
17
16 30 W
16
15 30 W
15

Figure 2.

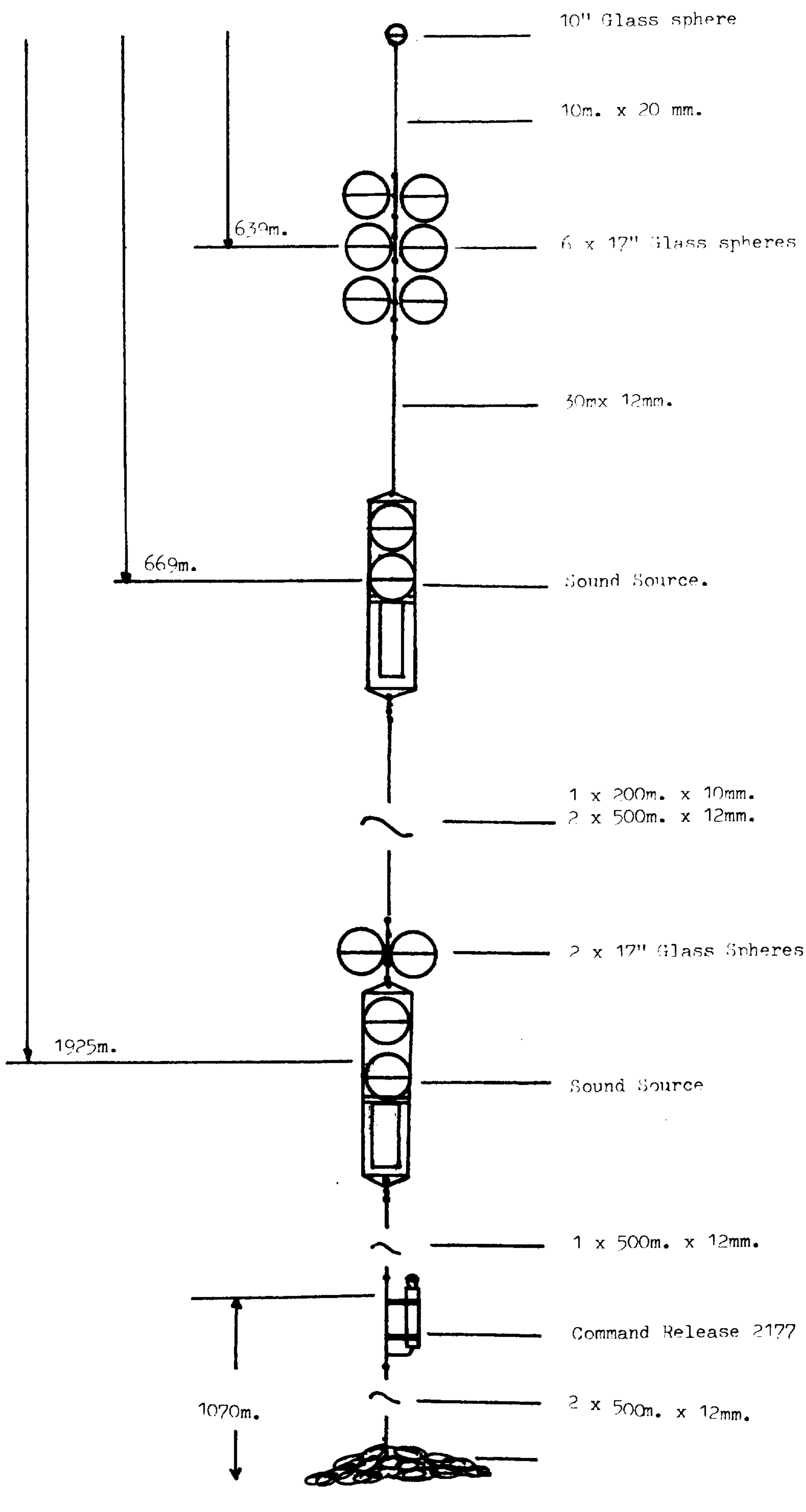

Figure 3. SOUND SOURCE MOORING

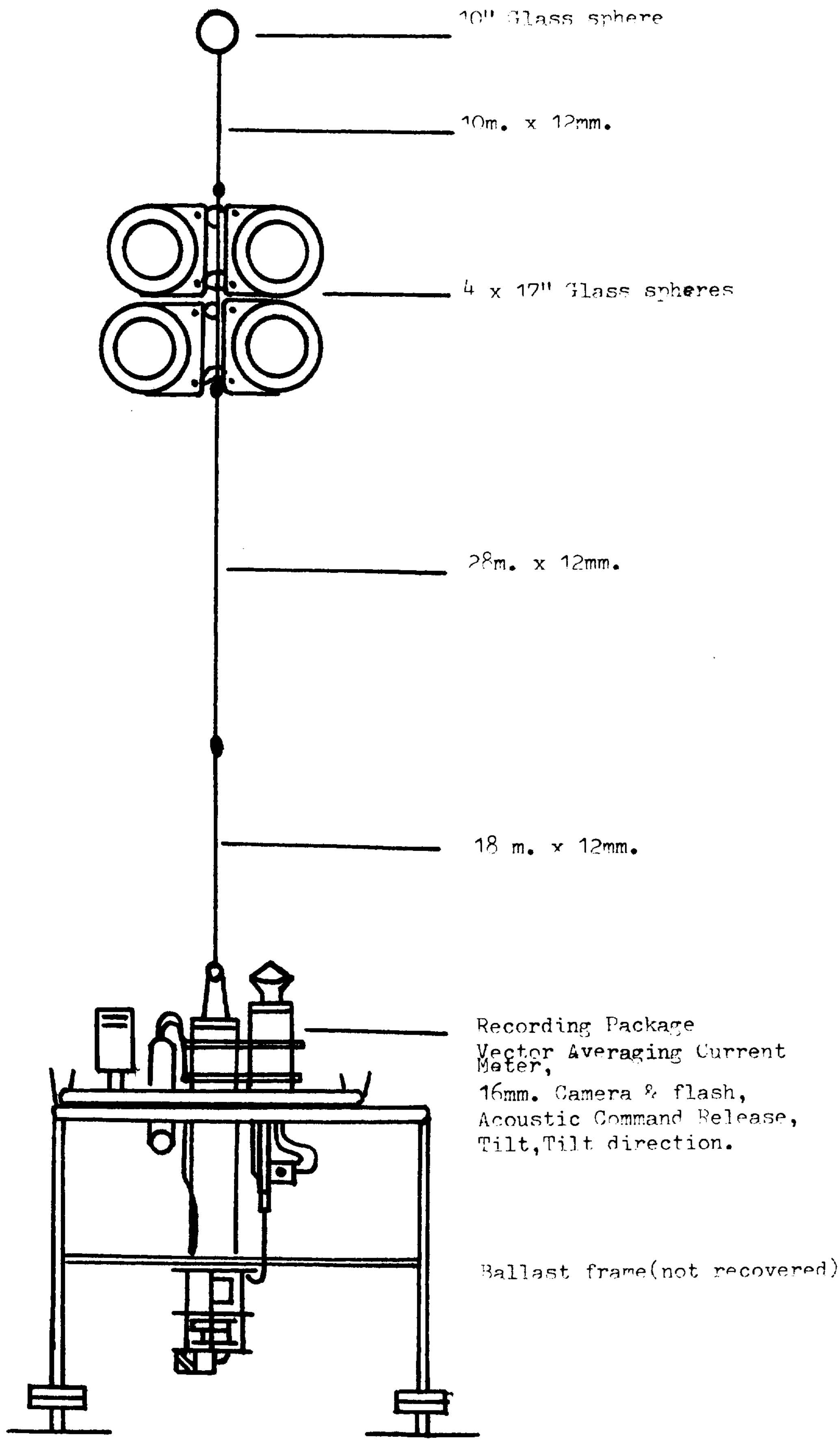

Figure 4 Mooring 318
VACM-CAMERA TRIPOD

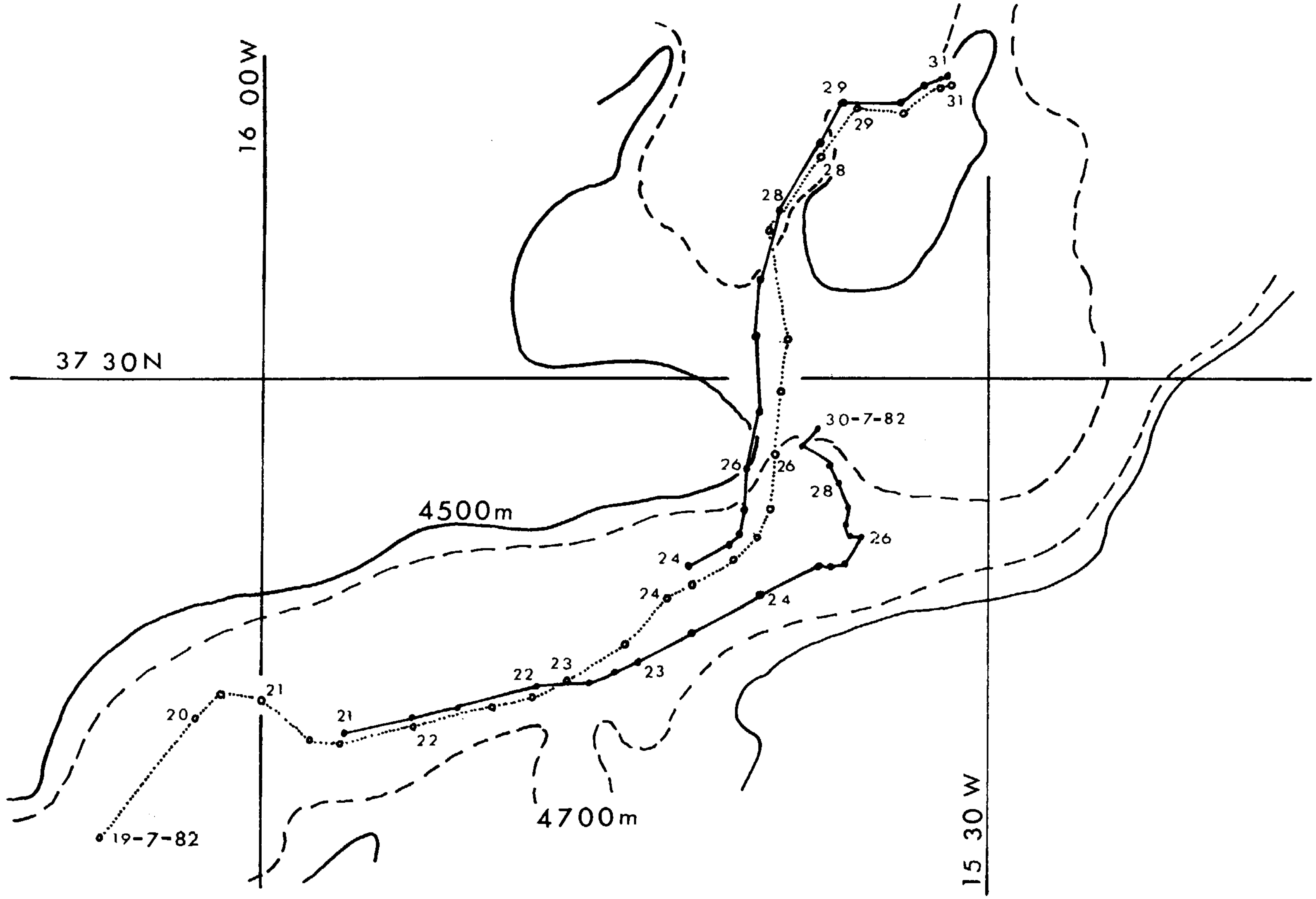

Figure 5. Selected float tracks; fixes for 22-24z of date