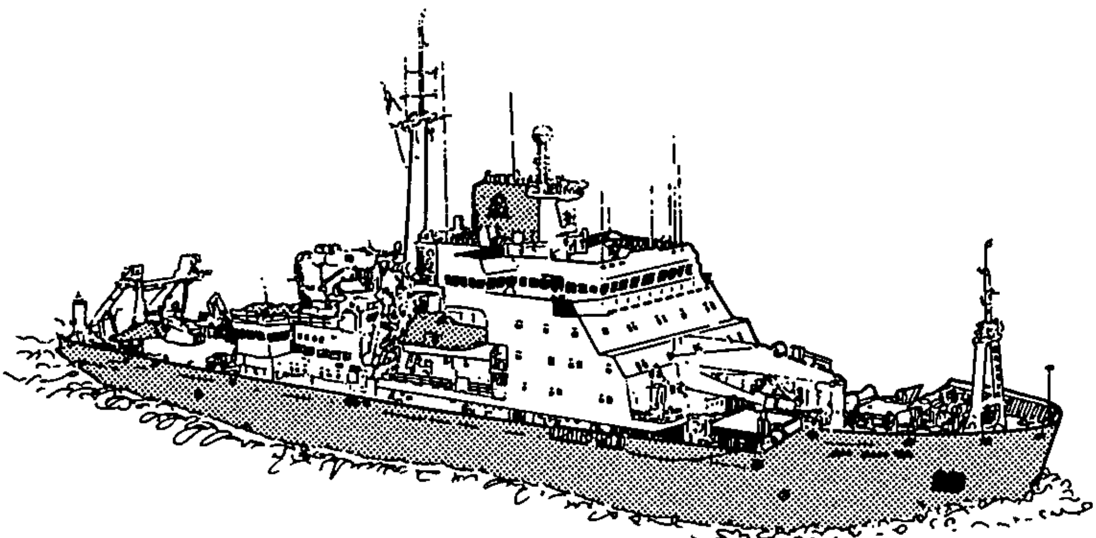
UNIVERSITY OF CAMBRIDGE

# CRUISE REPORT

BULLARD LABORATORIES
DEPARTMENT OF EARTH SCIENCES



*RRS James Clark Ross*

## RRS JAMES CLARK ROSS 05

SEISMIC SURVEY OF
THE MID-ATLANTIC RIDGE
NEAR ASCENSION ISLAND

T.A.Minshull

**CRUISE REPORT**

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**JAMES CLARK ROSS**

# Seismic Survey of the Mid-Atlantic Ridge near Ascension Island

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31st March-17th April 1993

Montevideo-Ascension

T.A. Minshull
Dept. of Earth Sciences
Bullard Laboratories
Madingley Road
Cambridge
CB3 OEZ

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**SUMMARY**

The objective of this cruise was to study the structure of the mid-Atlantic Ridge spreading centre close to the Ascension hotspot; in particular to constrain the crustal thickness and velocity structure, to investigate whether intracrustal reflectors imaged elsewhere in the Atlantic are also present in crust formed close to a hotspot, and to determine the presence or absence of an axial magma chamber reflector and associated low velocity zone. Our original plan was to acquire the wide-angle data using the Cambridge ocean bottom seismometers. Due to a lack of available acoustic releases at short notice, the OBS program was replaced by extensive use of sonobuoys.

We acquired a grid of multichannel seismic data by continuous profiling over a period of 4-5 days, to give over 1000 km of track length, using a 10-gun, 4462 cu. in. tuned airgun array. We deployed a total of 55 disposable sonobuoys, at approximately 2 hour intervals except on turns, and obtained 38 good profiles out to 30-40 km range. We also recorded underway magnetic, gravity and echosounding data in the survey area, around Ascension Island, and in transit from Montevideo.

**Crew List**

| | |
|---|---|
| Tim Minshull (PSO) | Cambridge |
| Carol Williams | " |
| Peter Carter | " |
| Wilma Allan | " |
| Nigel Bruguier | " |
| Michael McCaughey | " |
| John Brozena | NRL, Washington |
| Jonathan Kirby | Edinburgh |
| Steven Bremner | BAS |
| Graham Butcher | " |
| Andrew Hill | " |
| Mark Preston | " |
| David Richmond | " |
| David Booth | RVS |
| Anthony Cumming | " |
| Derek Lewis | " |
| Steven Whittle | IOS |
| Margaret Mackie | Nurse |
| Christopher Elliott | Master |
| John Marshall | Chief Officer |
| Geoffrey Morgan | 2nd Officer |
| Antonio Gatti | 3rd Officer |
| Charles Waddicor | Radio Officer |
| Raymond Walters | Purser |
| David Cutting | Chief Engineer |
| William Kerswell | 2nd Engineer |
| Thomas Ellison | 3rd Engineer |
| Michael Dixon | Extra 3rd Engineer |
| Norman Thomas | Electrical Officer |
| Simon Wrighy | Deck Engineer |
| John Summers | CPO Science |
| Martin Brookes | Bosun |
| James Williams | Bosun's Mate |
| David Peck | Seaman |
| Albert Bowen | Seaman |
| Jonathan Dodd | Seaman |
| Benjamin Riley | Seaman |
| Barry Wickenden | Seaman |
| David Bretland | Motor Man |
| Dennis Connell | Motor Man |
| Thomas Sweeney | Chief Cook |
| David Hunt | 2nd Cook |
| Anthony Dixon | Assistant Cook |
| Mark Jones | 2nd Steward |
| David Greenwood | Steward |
| James Newall | Steward |

# Cruise Report of Proceedings

Ship: RRS JAMES CLARK ROSS Cruise No: 05

Cruise Dates (Inclusive, port to port) 31st March-17th April 1993 (Montevideo-Ascension)

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It is requested that the following aspects of the cruise may be covered in this report of proceedings for dispatch or delivery to the Director, Research Vessel Base, immediately on return to port.

a) Main objectives of the cruise.
b) Geographical area. Reference stations or points in latitude and longitude.
c) Sea and weather conditions encountered.
d) Conduct of cruise, main problems encountered and success or otherwise of the program
e) Equipment performance.
f) Ship performance.
g) Any recommendations.
h) Signature and date.

Brief comments are preferred but if necessary please continue on another sheet.

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a) **Main objectives**

To carry out multichannel seismic reflection, sonobuoy refraction, gravity, magnetic and echosounder surveys of the mid-Atlantic Ridge in the vicinity of Ascension Island. These surveys would enable us to infer the detailed crustal and uppermost mantle structure of a hotspot-influenced slow-spreading ridge.

b) **Geographical Area**

South Atlantic 7-10°S, 12-15°W

c) **Sea and Weather Conditions**

Generally calm on passage and at start of seismic survey, increasing to Force 5-6 towards the end of seismic work.

d) **Conduct of Cruise**

The objectives were met in full, with no major problems. We collected over 1000 km of multichannel reflection data (including turns) and 38 good sonobuoy refraction profiles.

e) **Equipment Performance**

The scientific equipment performed very well. Despite rather crude balancing, the multichannel streamer generated very little noise and very few electrical faults developed. The Sercel recording system gave very little trouble, as did the compressors. Leakage faults on a few individual airguns were quickly repaired during turns. The PES Mk IV echosounder performed poorly when crossing the rough mid-ocean ridge topography at full speed, and was switched off because it interfered with the Simrad echosounder on the Bridge. There were also problems with the airgun depth sensors; only three of the six sensors were operational at the end of the cruise.

f) **Ship Performance**

Apart from an engine failure shortly after leaving Montevideo, which caused a 12-hour delay while a cylinder head was replaced, the ship performed very well, and provided an excellent environment in which to work. The officers and crew were extremely helpful throughout, and our course and speed requirements were closely followed.

g) **Recommendations**

i) A scientific echo-sounder which is logged automatically is needed in the UIC lab. The Simrad echosounder on the Bridge performed very well, with only intermittent failure to track the bottom even over rough topography at full speed. A similar echosounder should be provided for the UIC lab, or at least there should be a printout from the Bridge Simrad in the UIC lab, so that it can be monitored by scientific watchstanders.

ii) Some method is needed to control the depth of a single towed gun. With its umbilical fully extended, the 1000 cu. in. gun towed at around 8m depth (cf preferred depth of 15m). Perhaps the gun could be suspended from a towed torpedo-shaped buoy.

iii) The airgun depth sensors need to be made more reliable. If they continue to be unreliable, considerable redundancy is needed, e.g. by mounting several on each beam. The airgun depth has considerable influence on the source waveform, and it is essential that depth changes are properly monitored.

iv) A longer magnetometer cable is needed for use on RRS James Clark Ross and RRS Discovery. Ideally the cable should be longer than three times the ship's length i.e. about 400 m would be appropriate. Magnetometer deployment and recovery by hand is a slow and labour-intensive procedure. A small winch should be provided to perform this task.

(v) The SIE Oscillograph should be replaced forthwith with a more modern device. Both on this cruise and on CD70 last summer it required considerable attention to keep it working, and it uses large quantities of freon, an environmentally unfriendly CFC which should not be used in the Antarctic or anywhere else.

(vi) Once again, with no means of demultiplexing or processing the multichannel data on board, we were largely profiling blind. Equipment to do this should have been purchased many years ago. It may be that the time has come for an upgrade of the entire multichannel system. If so, facilities for offline processing should be regarded as an integral part of any new system.

(vii) Some of the spare hydrophone sections were in poor condition; these should be thoroughly checked before sending off to sea.

(viii) More light is needed on the port quarter of the afterdeck; the lighting from the Boat Deck is obscured by the hydrophone drum, leaving insufficient light during hydrophone deployment and recovery at night.

(ix) Even with the broad afterdeck of the James Clark Ross, there are space problems when towing the multichannel streamer and a large airgun array. Some way should be devised to hold all the airguns well outboard, so that the hydrophone and magnetometer can be streamed without danger of entanglement.

contd.

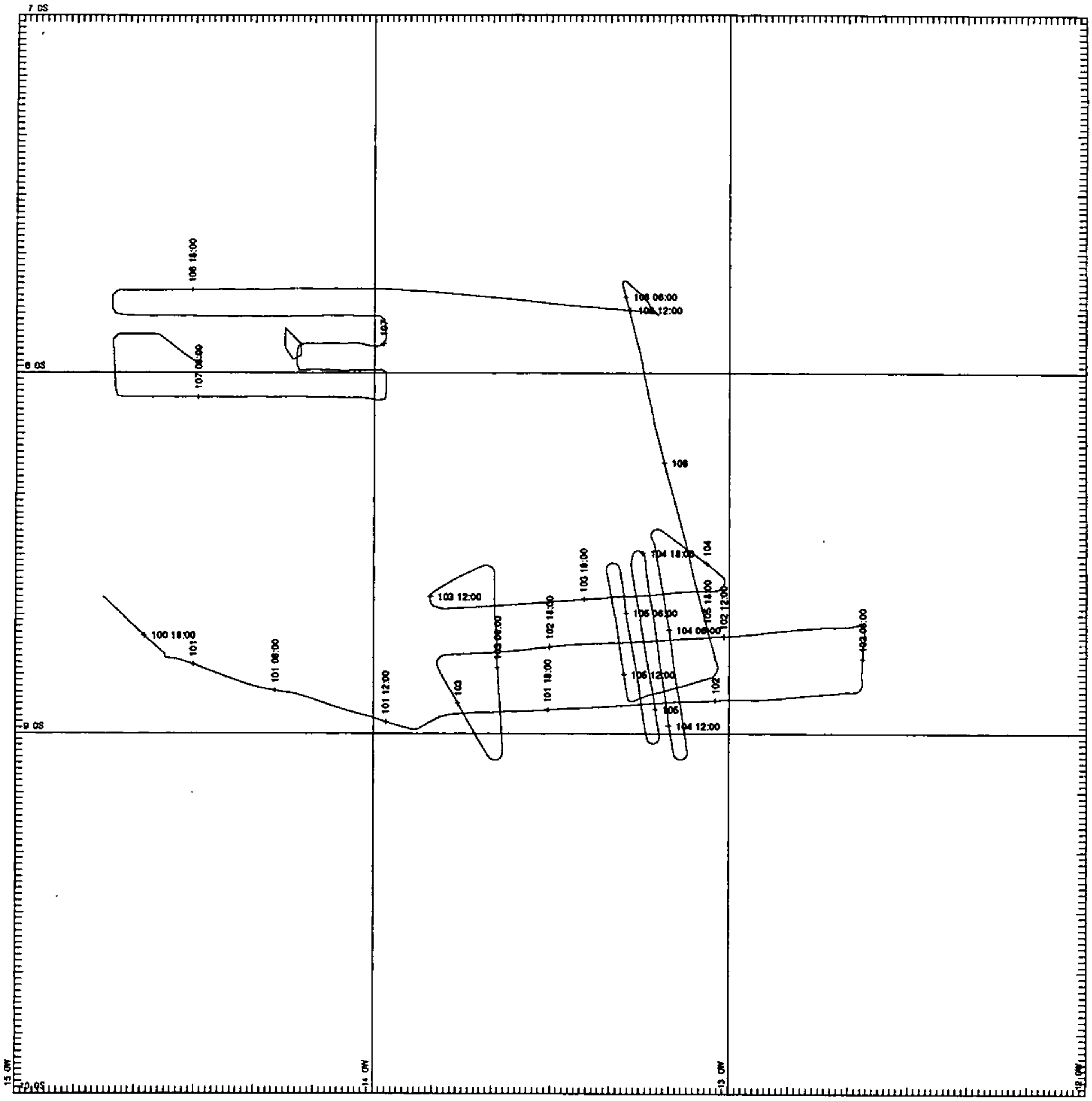
(x) Use of the main aft crane for sonobuoy deployments gained us an extra few metres over deployment by throwing, and this probably made a significant difference to the success rate. Ideally, however, a launcher should be built, for example using high-pressure air. Lamont-Doherty Geological Observatory have such a device and seem happy to supply design details. A launcher would become a necessity if the previous recommendation is followed up.

h) **Other comments**:

In addition to the scientific success, this was an extremely enjoyable cruise, due to the helpfulness and dedication of all those with whom we worked. The technicians from RVS, BAS and IOS worked well together and with the ship's officers and crew, and set about solving the problems which arose with dedication and good humour. It will be sad indeed if NERC loses the services of many of the RVS team by imposing on them conditions of service which are unacceptable to them.

T.A. Minshull

**T.A. Minshull**



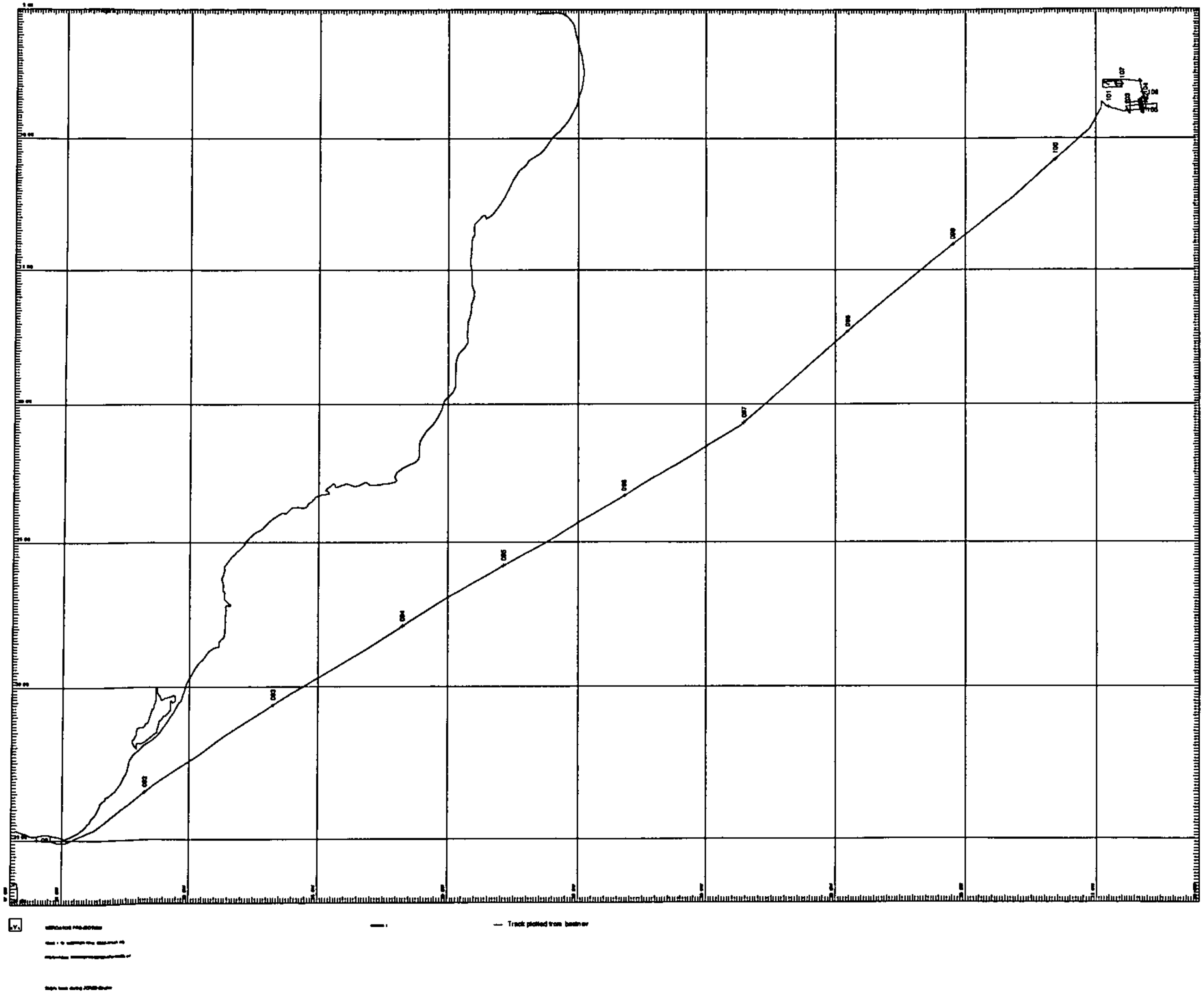

MERCATOR PROJECTION

— Track plotted from bestnav

Ship's track during JCR05 Cruise after 931001400



Scaled to fit


Track plotted from bestnav

## Cruise Narrative

### Monday 29th March

The Cambridge party boarded the James Clark Ross in Montevideo at around 1200 (all times local = GMT - 3 hours at start of cruise). We were all very impressed by the ship. Our container had not arrived yet. The multichannel acquisition system was already installed in the UIC lab from the previous cruise, with very little room left.

### Tuesday 30th March

Our container was due alongside at 0800, so everyone was up early. It finally arrived at about 1050. Meanwhile Mr. J. A. Melconian Arrambide of the Uruguayan Antarctic Survey arrived to assist us with a gravity base station reading. This was suggested by the agent, since the base station was right in front of a naval base, and an RVS technician had on a previous occasion been arrested when trying to take a reading. The Worden gravimeter required a lot of adjustment.

The container was unloaded very quickly just before noon - we provided a list of where we wanted each item, and they were delivered there by the crew, with the list ticked off by Simon Wright, the Deck Engineer. The afternoon was spent unpacking equipment, rearranging the UIC lab to fit it in, and erecting our VHF aerials on the railing of the platform halfway up the main mast. In the evening, our two aerial amplifiers were installed, and coax cable was run to two of the aerials. Each required about 75 m.

### Wednesday 31st March

Most of the Cambridge party were up at 0600 to finish cabling the aerials and hence minimise work up the mast after we sailed. Boat drill included a spin round the harbour in one of the lifeboats. We sailed at 1030. At about noon, we lost speed due to engine problems, and at 1400 the ship headed out of the main channel of the River Plate to anchor for repairs. There were some valve problems with the main engine, and the other main engine was out of action due to an earlier major electrical problem. The engine was repaired by replacing one of the cylinder heads, which took until 2300. Meanwhile we finished fixing down our equipment; everything in the UIC lab except for the Cambridge clocks and 4-channel Jet-Pen, which were put in the Main Lab below.

### Thursday 1st April

We began unreeling the hydrophone, for repairs and addition of lead, on the afterdeck at 0800. This took about four hours. There are several damaged sections, due to shark/killer whale bites on the last cruise. The ship slowed to 5 knots for engine room checks at 0900, and the 10 kHz fish was deployed. The magnetometer was deployed off the starboard quarter at 1040, just before we went back up to full speed (approx. 12.5 knots), since the water depth was 30-40 m and increasing. It gave a very noisy record, due to interference from the ship's cathodic protection system. The record was fine when this was switched off, and an electrical fault in the bottle was diagnosed. The spare magnetometer was deployed on the port quarter, and this gave a perfect record. We did not run the 3.5 kHz echosounder since it interfered with the Simrad on the Bridge, which was our only automatically logged depth. We did log data from the Ocean Logger (temperature, salinity and fluorescence of surface water), since it costs us nothing and may be of interest to someone. One of our aerial amplifiers had an intermittent fault, so Peter Carter brought it down for repair.

**Friday 2nd April**

Work continued on the hydrophone - mainly correcting electrical faults. We headed obliquely off the continental shelf, on a course to pass to the east of the Vitoria-Trinidade seamount chain. Sea state 3-4.

**Saturday 3rd April**

Tony Cumming and co began adding lead to the hydrophone, first doing the seven 100 m sections which were accessible on the deck. Based on an Antarctic surface water temperature of 0°C, a temperature in the work area of 27°C, a density at 15°C of 0.786 g/cc and a thermal expansion coefficient of $7.2 \times 10^{-4}/^{\circ}C$ for Isopar M, and a volume of 255 l of oil in each active section, we should add roughly 4 kg per section. I decided to add alternately 3 kg and 4 kg. The front 14 sections were wound back onto the drum in the afternoon. At about 1945, a major problem arose in the logging system. The logged time displayed on the level B monitor jumped by a whole number of hours (1 or 4) for almost all the instruments. This was diagnosed as a software bug in all the new Level A's - there was no problem with the old Level A on the magnetometer, which is older. The ship's master clock was reset, but this did not help.

**Sunday 4th April**

Work continued on the hydrophone on the afterdeck. There was more of a swell, and the ship was only able to make 11.5-12 knts over the ground. The 10 kHz fish was retrieved since it does not give good data at this speed.

**Monday 5th April**

The sea was calmer again and we were back up to full speed. Work continued on the hydrophone, and began on setting up the airgun array. Some of the spare hydrophone sections were in poor condition, and one burst near the connector when pulled out of its drum. Peter got the SAQ up and running.

**Tuesday 6th April**

Work continued on the hydrophone, including replacing contaminated oil in one of the sections, and on the airgun array. We passed Ilha da Trinidade and Ilha Martin Vaz in the early evening. Little swell, so made good speed (12.8-13 knts).

**Wednesday 7th April**

The last few hydrophone sections were leaded and wound onto the drum. A short length was unwound and rewound to try to take off some of the slack. Mark Preston did a test XBT deployment in a hydrophone drum filled with seawater on the afterdeck, to test operation of the deck unit. This worked fine.

**Thursday 8th April**

Work continued on the airguns and airgun firing system, plus wiring up in the UIC lab. A test sonobuoy deployment was carried out by dropping a sonobuoy tube filled with lead and water from the main aft crane.

**Friday 9th April**

The Sercel triggering system was completed and tested, and the airgun array was complete.

**Saturday 10th April**

The Cambridge sweep Jet-Pen was found to be faulty, and was replaced by an EPC. We were at the work area at 1330 (now on GMT), pulled in the magnetometers, deployed an XBT, and deployed the streamer at 2 knts, which took about three hours. The ship's galley refuse was diverted to holding tanks to avoid encouraging sharks. One airgun beam was deployed, but meanwhile it became clear that the streamer was much too buoyant, since it would not respond to the birds. An alternative calculation, based on the amount of buoyancy added on the previous cruise to adjust from the last use on CD70/92, suggested that an extra 5 kg per section of weight might be needed. The airgun beam and streamer were pulled in, which took until 2300. One of the depth control birds had not dived, and the streamer was holed in two places, presumably by shark bites.

**Sunday 11th April**

The hydrophone was redeployed during the small hours, bleeding 20 l. of oil from each active section and about 10 l. from the spring sections. The portion of the streamer around depth section 7 was found to be still too buoyant, so 600 m had to be pulled in once more, and the float from retriever 6 was removed. The deployment was then completed without further incident, taking a total of about 10 hours. Airgun deployment was fairly quick, but about 90 mins were lost due to a persistent leak in the 200 cu. in. gun. The first seismic line, CAM83, was started at 1326, and the first sonobuoy was deployed shortly thereafter. All ten airguns were firing, but the single 1000 cu. in. gun was at only about 6 m. depth. CAM 83 was a long flowline profile across the southern part of the work area. The streamer was very quiet, and 7 good sonobuoy records were obtained. Watch-keeping was very hectic, and three watchkeepers were needed for the first few hours.

**Monday, 12th April**

We turned north at the end of CAM83 and ran another long flowline profile, CAM84, back through the middle of our survey area. The EPC monitor record showed no sign of a high amplitude magma chamber reflector, but a number of intracrustal reflectors could be discerned. Sonobuoy deployments continued to be successful. At the end of this line we turned SE on a short oblique line (CAM85), before turning north just after midnight for a ridge-parallel reference line (CAM 86) well away from the spreading centre. Good sonobuoy data continued to come in even on the turn, despite the directionality of our backward-facing aerials.

**Tuesday, 13th April**

Line CAM86 was completed with all guns firing. On the turn to CAM87 (another oblique line), the 650 cu. in. lost amplitude, so the starboard outer beam was pulled in for repairs during CAM87. The repair was completed successfully (replaced shuttle seal) before the next turn, but unfortunately the 'cherry picker' crane on the starboard quarter seized up during redeployment of the beam. Hence redeployment was delayed until 1400, about two hours into CAM88, the third and final long flowline profile. At 1410 the 400 cu. in. gun began autofiring approximately every 4.5s, and this gun was switched out until the end of line CAM88.

**Wednesday, 14th April**

The port beam was brought in for repairs to the 400 cu. in. gun during another oblique line, CAM89, and redeployed with the gun repaired before the turn onto CAM90, the first of a series of closely spaced ridge parallel lines. Three sonobuoys in succession failed during CAM90. The magnetics record also became very noisy. The 400 cu. in. gun began intermittently autofiring again at about 0320, and was switched out at 0415. At 0330 the magnetometer was pulled in for checks, and the cable was severed, with consequent loss of the bottle. At the end of CAM90, we turned 180° to starboard at 5° per minute, onto CAM91 about 3.5 km away. During the morning the oil was changed in the other magnetometer; this was deployed at 1500 and gave good data. There were further sonobuoy failures during the afternoon and evening. At the end of CAM91, we again turned 180° onto a reciprocal bearing about 3.5 km away (CAM92).

**Thursday, 15th April**

Two more ridge-parallel lines were shot (CAM93 and 94), cutting CAM94 short to allow time for the final line across the propagating rift tip. During CAM95, an oblique line across to the spreading centre, the port beam was brought in for repairs to the 400 cu. in. gun (replacement of an O-ring). All ten guns were firing again at 1440, before the turn onto the final line (CAM96), which began at 1630. The weather, which started clear and still, had deteriorated gradually during seismic work, and all the towed equipment was streaming to starboard. There was no gap left to thread the magnetometer through, so it was not deployed during this line. The 300 cu. in. gun was lost at about 1930. At 2320, two of the three compressors in use were lost, and the air pressure dropped. There was no apparent reason for this, and they were up and running again about ten minutes later. During the downtime, the shot interval was increased to 40s, and the Reftek switched into 'static' mode, since the gun signals at reduced pressure were out of specification. This left two guns firing about 4 ms late until the Reftek was put back into automatic time-shift mode at 2350.

**Friday, 16th April**

Line CAM96 continued up the ridge axis and across the rift tip, with three successful sonobuoys to give good velocity control. The airguns were shut down at 0445, at 30 km range from the final sonobuoy. The airguns and hydrophone were inboard at 1100. All three guns on the starboard outer beam were found on recovery to be twisted around the beam; this does not appear to have affected their performance significantly. A final XBT was deployed, and then the magnetometer was streamed once more. We then went up to full speed (12-12.5 knots) for a small gravity, magnetics and bathymetry survey around Ascension Island while the seismic gear was packed away. The PES was switched off during this survey to avoid interference with the Simrad.

**Saturday, 17th April**

The survey around Ascension Island was completed in the early morning and was followed by a slow approach to the anchorage. The scientific party was picked up by a launch at 1545.

## NAVIGATION

Scientific navigation was from a Trimble GPS unit located on the Bridge, which gave 24 hour coverage. GPS fixes tend to jump erratically from fix to fix, so smoothing was required for computation of speed made good etc. The Bridge Voyage Management System uses a Shipmate GPS system (RS5103), which was not logged, but was displayed in the UIC lab and used by watchkeepers to monitor position and speed. The two GPS systems generally differed in position by less than 50 m. The VMS provided a live track plot in the UIC lab, with the planned tracks between waypoints, a zoom function, and displays of the distance off track, the speed from GPS, the time to the next waypoint at this speed, and various other data. This system was extremely useful during seismic data acquisition. There was also a Transit system (RS5100), requested as a backup in case of interference with the GPS. Logging of Transit data was not fully operational until 11th April.

## DATA LOGGING

Underway data were logged every 10 s using the RVS Level A, B and C system. Data were time tagged with times from the ship's master clock, except for the Trimble, which was tagged with GPS time. Data from the period of Level A clock jumps on 3rd-4th April were mostly retrieved, since the error was a whole number of hours and hence easily recognised. Apparently the software bug was associated with the change to daylight saving time in the USA.

## GRAVITY

Gravity data were obtained with a LaCoste and Romberg S84 shipboard gravimeter, with a self-annotating paper record. The logging system assumed a calibration constant of 1.0 SO ALL LOGGED DATA WILL NEED CORRECTION FOR THE METER CONSTANT.

A gravity base station tie was taken at Montevideo, at bollard 38 on Muelle B, at 1100 (local) on 30th March.

| | |
|---|---|
| Shipboard meter reading | = 10972.7 |
| S84 calibration constant | = 0.9967 |
| g at base station | = 979745.40 mgal |
| g at meter on ship | = 979746.28 mgal |
| g at Port Stanley 23/3/93 | = 981227.68 mgal) |
| Reading at Port Stanley | = 12458.7 mgal |
| g at Port Stanley 1/2/93 | = 981227.94 mgal |
| Reading at Port Stanley | = 12460.6 |
| g at Grimsby 10/9/92 | = 981370.6 |
| Reading at Grimsby | = 12617.6 |

Drift rate is +0.30 mgal over 7 days since Port Stanley 23/3/93
-1.33 mgal over 57 days since Port Stanley 1/2/93
+15.15 mgal over 201 days since Grimsby

## MAGNETOMETER

Two Varian V-75 proton magnetometer were used. The magnetometer initially deployed was found to be faulty. On passage, the working magnetometer was towed from the port quarter, with its sensor head about 210 m behind the stern of the ship. During seismic work, it was towed from amidships, between the streamer and the 1000 cu. in. gun. The magnetometer cable was severed during recovery on 14th April, and the bottle lost. Presumably it had become entangled with the 1000 cu. in. airgun. The fault in the first magnetometer was rectified by replacing the oil, which was contaminated.

## ECHO SOUNDERS

The PES Mk IV 10 kHz echosounder had no automatic logging facility, and depths had to be manually read from the Waverley chart recorder and entered into the logging computer. The fish was deployed on the starboard side, but gave no useful data at full speed, so the hull transducer was used on passage. The Simrad 12 kHz echosounder on the Bridge could not track the bottom in deep water when the PES was switched on. The PES record was very poor in the rough topography close to the ridge, and was therefore powered down at 1630/098, so that the Simrad could be used. Once we had slowed to 4-5 knts for seismic work, the PES no longer interfered with the Simrad, so it was switched on again and the fish deployed. All logged depths assumed a water velocity of 1500 m/s, but a value of 1471 m/s was used by the Simrad inkjet plotter, which was switched on when the PES was switched off.

## XBTs

The XBT probes used gave data to 750 m depth.

| XBT number | Latitude | Longitude | Comments |
|---|---|---|---|
| 1 | 8°37'S | 14°45'W | Successful |
| 2 | 8°48'S | 14°33'W | " |
| 3 | 7°50'S | 13°12'W | " |

## TELEDYNE STREAMER

There was insufficient time for full streamer balancing, but a total of 84 kg of lead (alternately 3 kg and 4 kg per 100 m section) were added prior to deployment to compensate for the extra buoyancy in equatorial waters. On deployment, the streamer was still very buoyant, so 20 l of oil were drained from each (100 m) active section, about 10 l were drained from the spring section, and the float on retriever 6 was removed, to give a reasonably well balanced streamer which towed at 15 m depth with appropriate adjustment of the depth control birds. The streamer had 96 25 m channels, each consisting of 25 hydrophones spaced at 1 m intervals, and was towed at 15 m depth. Adjacent channels were summed for input to the 48-channel acquisition system. The streamer layout, starting at the stern of the ship, was as follows:

Tow cable - 115 m
3 x spring sections, nominally 50 m each but stretched to 55-57 m when deployed
Depth sensor 1
Water break hydrophone (1 m)
Active channels 1-8 (50 m each)
Depth 2
Active 9-14
Depth 3
Active 15-22
Depth 4
Active 23-28
Depth 5
Active 29-36
Depth 6
Active 37-42
Depth 7
Active 43-48
Depth 8
Spring section (approx. 55 m)
Tow rope
Tail buoy

Depth control birds were located at the front of channels 1, 5, 9, 13, 17, 21, 25, 29, 33, 37, 41, 49 and the back of channel 48. Retriever floats were located at the front of channels 3, 11, 19, 27, 35, and 43.

Streamer drum circumference 3.85 m

## SERCEL ACQUISITION SYSTEM

Multichannel data were recorded in multiplexed SEG-B format at 1600 bpi on 1200 ft 9-track tapes, using a Sercel SN 358 acquisition system, with modifications by RVS, including driving the system from a dedicated PC. 10 s of data were recorded at 4 ms sample interval, with no deep water delay, to give 60 shots per tape. Auxiliary channels were as follows:

1. Water-break hydrophone.
2. Unused.
3. Cambridge cream clock.
4. Cambridge silver clock.

A printout of the Sercel header format follows.

Sercel Header

| Byte | Data | Type |
|---|---|---|
| 1 - 10 | Record Number (5 times) | BCD (MSB:LSB) |
| 11 | Sample Rate (H) & Type of record (L) | |
| 12 | Fixed Gain (L) | |
| 13,14 | Trace Count | |
| 15,16 | Shot Point Number | |
| 17,18 | Null Bytes | |
| 19 - 22 | Identification | |
| 23,24 | Reel Number (Fixed at start of line & NOT changed) | |
| 25,26 | Day ( " " " " " & " " ) | |
| 27,28 | Month ( " " " " " & " " ) | |
| 29,30 | Year ( " " " " " & " " ) | |
| 31 - 39 | Null Bytes | |
| 40 | Recording Delay (Refraction) | |
| 41 | Null Byte | |
| 42 | Filters (On or Off Status) | |
| 43 - 58 | Additional Control Panel Information | |

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| Byte | Data | fdata | ldata | Type |
|---|---|---|---|---|
| 59,64 | Position Number (3 times) | | | 4 |
| 65 | Year | | | |
| 66,67 | Day | | | |
| 68 | Hours | | | |
| 69 | Mins | | | |
| 70 | Secs | | | |
| 71 | | | | |
| 72 | | | | |
| 73,74 | Ship ID | 1,2 | | |
| 75,76 | Cruise Number | | 3 | |
| 77 | Line Number | 5 | | |
| 78 | Line Type 0 | 6 | | |
| 79,80 | Tape Number (actual) | | 3 | |
| 81 - 96 | Client's Name | | 7-22 | |
| 97,98 | Intended Ships Heading | 23 | | |
| 99,100 | Actual Heading (Gyro) | | | |
| 101,102 | Tail Buoy Heading | | | 6 |
| 103 | Ship's Speed (1/10s) | | | |
| 104 | | | | |
| 105,106 | Latitude Degrees & tens Mins | | | |
| 107,108 | Latitude Mins (1/1000s) | | | |
| 109,110 | Longitude Degrees & tens Mins | | | |
| 111,112 | Longitude Mins (1/1000s) | | | |
| 113 | WB 1 Position | 25 | | |

| | | | |
|---|---|---|---|
| 114 | WB 2 Position | | 26 |
| 115,116 | WB 1 Time | | (mS) |
| 117,118 | WB 2 Time | | |
| 119,120 | Length of first seismic block (mS) | | 32 |
| 121 | Record Length (Secs) | | 5 |
| 222 | Intended Shot Spacing (m) | | 27 |
| 123 | Reference to Stern distance | | 28 |
| 124 | Gun Sync Delay | | 29 |
| 125 | Manifold Pressure 1 (10 PSI) | | 30 |
| 126 | Manifold Pressure 2 | | 31 |
| 127,128 | Strain Gauge Reading | | |
| 129 | Depth (H'Phone) | 1 | |
| 130 | Depth | 2 | |
| 131 | Depth | 3 | |
| 132 | Depth | 4 | |
| 133 | Depth | 5 | |
| 134 | Depth | 6 | |
| 135 | Depth | 7 | |
| 136 | Depth | 8 | |
| 137 | Depth Position | 1 | Section No. 33 |
| 138 | Depth | 2 | 34 |
| 139 | Depth | 3 | 35 |
| 140 | Depth | 4 | 36 |
| 141 | Depth | 5 | 37 |
| 142 | Depth | 6 | 38 |
| 143 | Depth | 7 | 39 |
| 144 | Depth | 8 | 40 |
| 145 | Gun Depth | 1 (in m) | 41 |
| 146 | Gun Depth | 2 | 42 |
| 147 | Gun Depth | 3 | 43 |
| 148 | Gun Depth | 4 | 44 |
| 149 | Gun Depth | 5 | 45 |
| 150 | Gun Depth | 6 | 46 |
| 151 | Gun Depth | 7 | 47 |
| 152 | Gun Depth | 8 | 48 |
| 153 | Gun Depth | 9 | 49 |
| 154 | Gun Depth | 10 | 50 |
| 155 | Gun Depth | 11 | 51 |
| 156 | Gun Depth | 12 | 52 |
| 157 | Gun Depth | 13 | 53 |
| 158 | Gun Depth | 14 | 54 |
| 159 | Gun Depth | 15 | 55 |
| 160 | Gun Depth | 16 | 56 |
| 161 | Gun Position (X) | 1 (in m) | 57 |
| 162 | Gun Position (X) | 2 | 58 |
| 163 | Gun Position (X) | 3 | 59 |
| 164 | Gun Position (X) | 4 | 60 |
| 165 | Gun Position (X) | 5 | 61 |

| | | | |
|---|---|---|---|
| 166 | Gun Position (X) 6 | 62 | |
| 167 | Gun Position (X) 7 | 63 | |
| 168 | Gun Position (X) 8 | 64 | |
| 169 | Gun Position (X) 9 | 65 | |
| 170 | Gun Position (X) 10 | 66 | |
| 171 | Gun Position (X) 11 | 67 | |
| 172 | Gun Position (X) 12 | 68 | |
| 173 | Gun Position (X) 13 | 69 | |
| 174 | Gun Position (X) 14 | 70 | |
| 175 | Gun Position (X) 15 | 71 | |
| 176 | Gun Position (X) 16 | 72 | |
| 177 | Gun Position (Y) 1 | 73 | |
| 178 | Gun Position (Y) 2 | 74 | |
| 179 | Gun Position (Y) 3 | 75 | |
| 180 | Gun Position (Y) 4 | 76 | |
| 181 | Gun Position (Y) 5 | 77 | |
| 182 | Gun Position (Y) 6 | 78 | |
| 183 | Gun Position (Y) 7 | 79 | |
| 184 | Gun Position (Y) 8 | 80 | |
| 185 | Gun Position (Y) 9 | 81 | |
| 186 | Gun Position (Y) 10 | 82 | |
| 187 | Gun Position (Y) 11 | 83 | |
| 188 | Gun Position (Y) 12 | 84 | |
| 189 | Gun Position (Y) 13 | 85 | |
| 190 | Gun Position (Y) 14 | 86 | |
| 191 | Gun Position (Y) 15 | 87 | |
| 192 | Gun Position (Y) 16 | 88 | |
| 193 | Gun Size 1 (x10 Cubic ins) | 89 | |
| 194 | Gun Size 2 | 90 | |
| 195 | Gun Size 3 | 91 | |
| 196 | Gun Size 4 | 92 | |
| 197 | Gun Size 5 | 93 | |
| 198 | Gun Size 6 | 94 | |
| 199 | Gun Size 7 | 95 | |
| 200 | Gun Size 8 | 96 | |
| 201 | Gun Size 9 | 97 | |
| 202 | Gun Size 10 | 98 | |
| 203 | Gun Size 11 | 99 | |
| 204 | Gun Size 12 | 100 | |
| 205 | Gun Size 13 | 101 | |
| 206 | Gun Size 14 | 102 | |
| 207 | Gun Size 15 | 103 | |
| 208 | Gun Size 16 | 104 | |
| 209 | Guns Online Array 1 | 105 | 7 |
| 210 | Guns Online Array 2 | 106 | 8 |

---

| | |
|---|---|
| 248-255 | Record Number (5 Times) |

## AIRGUNS

A 10-gun array was used, totalling 4462 cu. in. (see diagram). The ship was equipped with four Hamworthy compressors with a capacity of 327 cfm each, able to supply up to 1400 cu .in. of air at 2000 psi per 20 s. Hence the array required all four compressors, but could run off three at slightly reduced pressure (1900 psi), so that one could be down for maintenance without unduly affecting the source. The beams were supported from hippo buoys by 14 m of polypropylene rope, for a nominal airgun towing depth of 15 m. The 1000 cu. in. gun was towed amidships from a wire over a pulley on the stern gantry, without a buoy. The umbilical was unfortunately not long enough to let out the gun to the desired depth, and it was at 8-10 m depth throughout seismic work. Beam depths were displayed on the Reftek monitor and monitored by watchkeepers. Only five depth sensors were working on deployment, so the port beam had one each end, with one on the centre of each of the other two beams and one on the single 1000 cu. in. gun. Two of these sensors failed during seismic work. At 15 m depth and low-pass filtered to 64 Hz, the airgun array has an expected peak-to-peak amplitude of 40 bar-m and a primary-to-bubble ratio of about 2:1. Air pressure was monitored from a meter in the UIC lab, which read about 15 bar below the true pressure.

## DIMENSIONS

| | |
|---|---|
| Height of sonobuoy aerials above sea surface | 28 m |
| Distance of GPS aerial from stern | 62 m |
| Estimated distance of airgun beam centres astern: | |
| Starboard outer beam | 68 m |
| Starboard inner beam | 76 m |
| Single gun (1000 cu. in.) | 46 m |
| Port beam | 80 m |

## TIMING

The seismic triggering sequence was as follows:

1. On seconds 0, 20 and 40 of each minute, the Sercel was triggered from the RVS clock, which drifted a few ms per day compared to the ship's master clock.

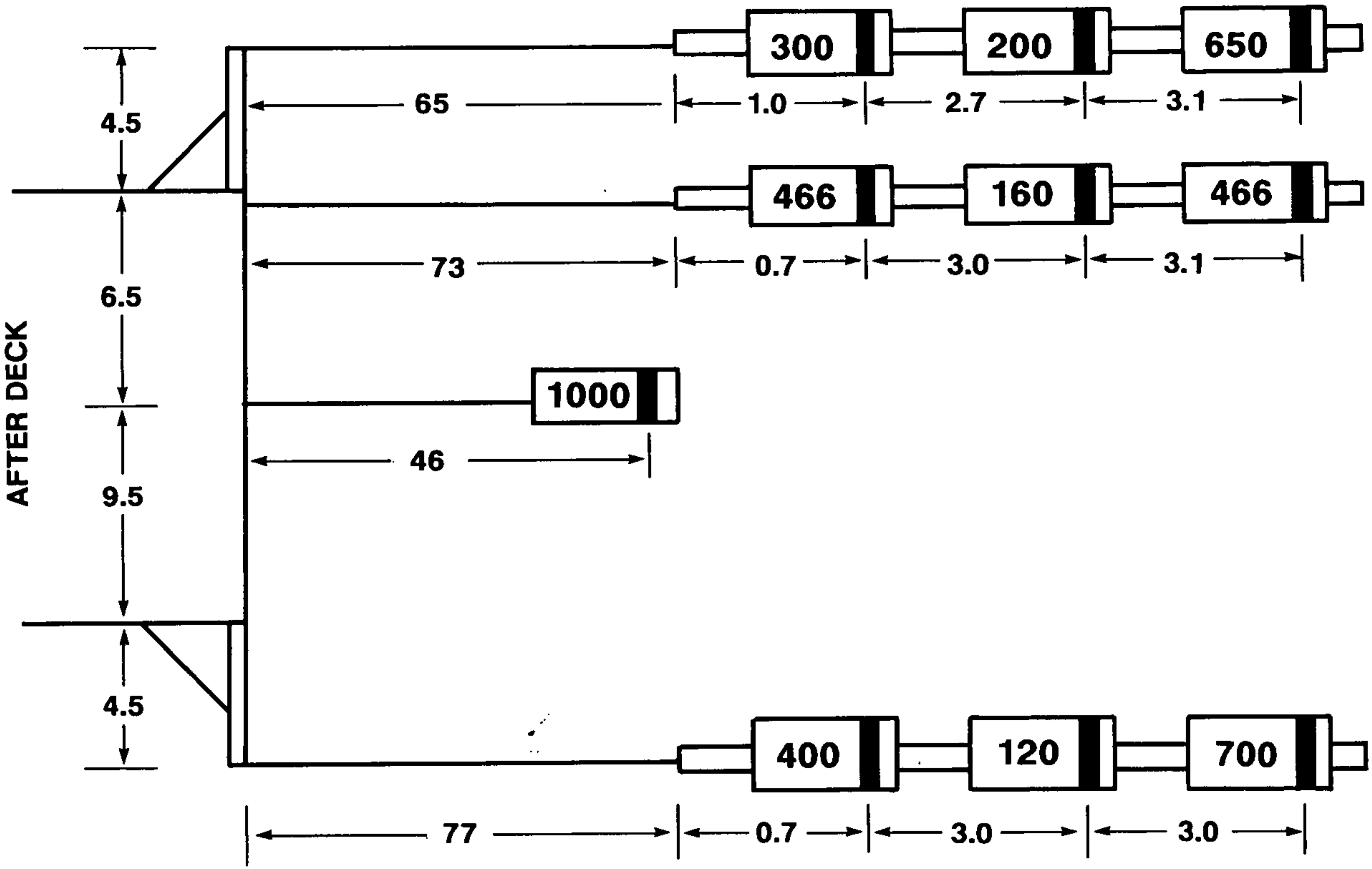
2. Once the Sercel tape was up to speed (about 0.3 s later), a trigger pulse was passed to the Cambridge randomiser unit, which was modified by Peter Carter to accept a pulse rather than contact closure input.

3. After a pseudo-random delay time of 1-255 ms, a contact closure was returned to the main firing box, which was modified by Dave Booth to receive this input.

4. This box generated the main trigger pulse, which triggered the start of recording on the Sercel and SAQ, the start-up of the Reftek gun synchronisation unit, the Jet-pen recorder and three of the EPC's.

5. 100 ms later, the airguns were fired.

The Sercel read after write EPC was triggered independently at the start of seismic work, and therefore displayed the jitter from the randomiser. It was later connected to the main trigger pulse, to give a usable record.




Schematic diagram of airgun array. Nominal towing depth was 15m.
Airgun chamber sizes are in cu in., distances in m.

## MULTICHANNEL SEISMIC LINES

| Line Number | First shot | Last shot | First tape | Last tape | Comments |
|---|---|---|---|---|---|
| CAM83 | 1326:00/101 | 0729:20/102 | 1A | 54B | On line at 1400 |
| CAM84 | 0729:40/102 | 2158:40/102 | 55A | 98B | |
| CAM85 | 2159:00/102 | 0248:00/103 | 98B | 112B | |
| CAM86 | 0248:20/103 | 0908:20/103 | 113A | 131A | |
| CAM87 | 0908:40/103 | 1228:20/103 | 132B | 141A | Starboard outer beam in for repairs |
| CAM88 | 1228:40.103 | 2327:00/103 | 142B | 174B | 400 cu. in. gun autofiring 1410-1440/103 |
| CAM89 | 2332:20/103 | 0232:00/104 | 176A | 184A | No tape 175. Port beam in for repairs |
| CAM90 | 0232:20/104 | 1052:00/104 | 185B | 209B | 400 cu. in. gun autofiring 0320-0420/104 |
| CAM91 | 1052:20/104 | 1852:00/104 | 210A | 233B | |
| CAM92 | 1852:20/104 | 0112:00/105 | 234A | 252A | |
| CAM93 | 0112:20/105 | 0732:00/105 | 253B | 271B | |
| CAM94 | 0732:20.105 | 1312:00/105 | 272A | 288A | |
| CAM95 | 1312:20/105 | 1652:00/105 | 289B | 299B | Port beam in for repairs |
| CAM96 | 1652:20/105 | 0447:00/106 | 300A | 335B | Compressor failure at 2324/105 |

**Notes**

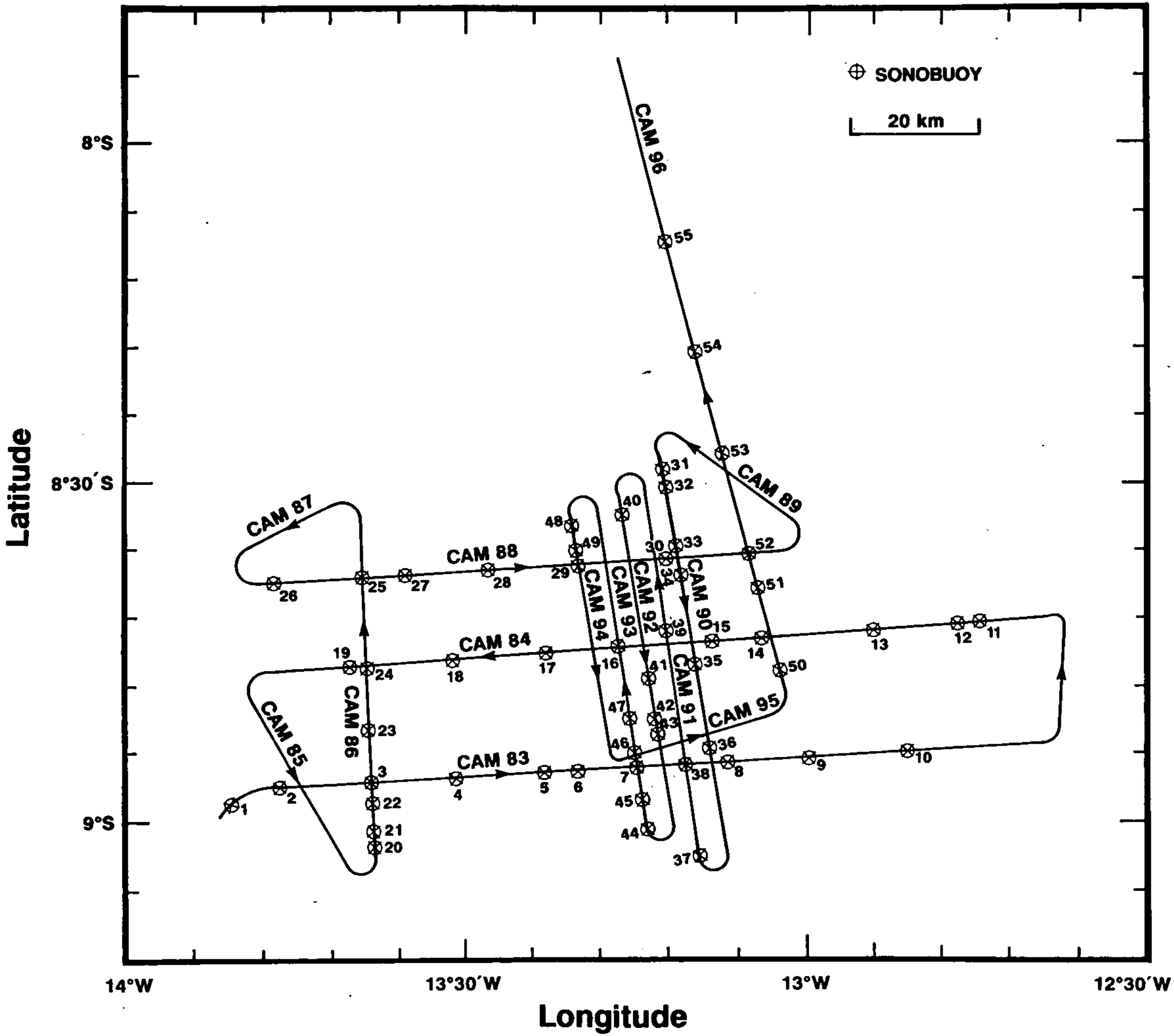
1. All lines were shot at 20s shot interval for nominal 100 m spacing at 4.85 knots.

2. Data recording continued through turns. Lines 85, 87, 89 and 95 were short oblique lines during turns.

3. Records were 10s long, with no delay. The seabed reflection was generally between 2 and 3s two-way time. 60 shots were recorded on each tape.

4. Filter setting was out on the Sercel throughout, so data are bandpass filtered 3-77Hz.

5. Sercel auxiliary channels:
   1. Water break
   2. Unused
   3. Cambridge cream clock
   4. Cambridge silver clock


SONOBUOY
20 km
CAM 96
CAM 89
CAM 87
CAM 88
CAM 84
CAM 83
CAM 85
CAM 86
CAM 90
CAM 91
CAM 92
CAM 93
CAM 94
CAM 95
8°S
8°30′S
9°S
14°W
13°30′W
13°W
12°30′W
Latitude
Longitude

## DISPOSABLE SONOBUOYS

A total of 56 sonobuoys were available, 48 US Navy ones provided by NRL and 8 assorted types from Cambridge. The sonobuoys were deployed about 10-12 m from the ship by dropping them from the large crane on the aft end of the Boat Deck, using a release mechanism suggested by Chris Elliott. This consisted of a rope strop around the sonobuoy, from which it was suspended from the crane, and a large tapered wooden peg on the end of long rope pulled from the deck. A variety of different channels was available, and some care was taken in the order of deployment, to avoid trying to record similar frequency channels at the same time.

The sonobuoy data acquisition system was complex and required constant attention to be sure of recording good data. To record a maximum of three sonobuoys simultaneously, we installed four aerials, two with masthead amplifiers, and five receivers. We used two Eddystone 990R receivers (nos 2 and 3) and an ICOM IC R7000 receiver (no. 1), all provided by RVS. The aerials with masthead amplifiers were connected to the Eddystone receivers. A Racal-Dana 9082 signal generator, which sent a VHF signal modulated at 400 Hz to the aerial input of the receivers, was used for tuning in advance of sonobuoy deployment. The sonobuoy signals were filtered 3-70 Hz prior to recording, using a Kemo V8F/8 filter on receiver 1, and Krohn-Hite 3550 filters on receivers 2 and 3.

The sonobuoys were recorded digitally on the Cambridge SAQ system, with 16 s records sampled at 4 ms, and channel 4 recording the coded 1 Hz square wave from the Cambridge cream clock, and three sonobuoy channels. This was the longest record we could reliably record, because the SAQ sometimes took more than 3 s to download a shot to disk. For most seismic lines, data from a whole line could fit on the 60 Mb of available space on the hard disk of the SAQ. On longer lines, acquisition had to be interrupted after about 10 hours to download the disk to cartridge tape.

This process took 30-40 minutes. Ideally, we would have recorded continuously on the SAQ throughout seismic work, since there were very few times when we were receiving no sonobuoy data. This would be possible if the disk capacity were much larger (e.g. 1Gb) or if downloading could be done without interrupting acquisition. Alternatively, if the data were written direct to cartridge, the down time during cartridge changes would be much less. The SAQ crashed a number of times, sometimes requiring a reboot of the PC, and always with considerable downtime before data acquisition was resumed. Some crashes were induced by attempts to change the display; others had no apparent external cause, but may have been associated with false triggers, which were noticed on a number of occasions.

Sonobuoys were also recorded on Ampex 2300 ft tapes on the Store 4DS analogue recorder. A 250 kHz flutter signal and a trigger signal were recorded on channel 4 (DR), with three sonobuoy channels (FM). The recorded signal was monitored on a two-channel storage oscilloscope. At the start and end of each tape, the Cambridge cream clock code was recorded on channel 1 for two minutes to time stamp the tape. Tapes lasted about 8 hours, again long enough for most of the seismic lines. During long lines, tape changes were arranged not to coincide with the SAQ downtime, so that continuous recording was obtained, and also to avoid periods when we were 24-30 km from any sonobuoy, since the water wave at this range (at 16-20 s) does not appear in the SAQ record. Tape changes took about 6 minutes. After further, narrower band filtering, and amplification, the sonobuoy records were displayed on EPC recorders.

The sonobuoys were generally successful, with only 17 failures. Six of these were Navy Channel 17 sonobuoys, which all failed within 30 minutes of deployment, and appear to have been from a faulty batch. Most of the remainder probably had their hydrophone wire severed by the streamer or tailbuoy. Most successful sonobuoys gave good signals out to beyond 30 km, and we received signals from some sonobuoys during and after turning, despite the directionality of the backward-facing receiving aerials. Hence we obtained reversed refraction profiles on parts of some lines. Most of the failures occurred towards the end of seismic work, when the sea state had deteriorated significantly and the wind was stronger.

## Disposable Sonobuoys

| Sonobuoy No. | Type | Channel | Frequency MHz | Depth ft. | Receiver No. | Deployment Time | Latitude | Longitude | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Ultra | 20 | 164.875 | 450 | 2 | 1342:01/101 | 8°58.20'S | 13°50.99'W | Test Sonobuoy: signal lost at 1640/101 |
| 2 | Navy | 2 | 163.000 | 400 | 1 | 1436:30/101 | 8°56.72'S | 13°46.62'W | Excellent |
| 3 | Navy | 7 | 166.750 | 400 | 3 | 1616:38/101 | 8°56.34'S | 13°38.61'W | Excellent |
| 4 | Navy | 11 | 169.750 | 400 | 2 | 1756:03/101 | 8°56.04'S | 13°30.81'W | Good |
| 5 | Navy | 17 | 162.625 | 400 | 1 | 1936:55/101 | 8°55.62'S | 13°22.88'W | Hydrophone lost at 2002/101 |
| 6 | Navy | 26 | 169.375 | 400 | 1 | 2010:24/101 | 8°55.46'S | 13°20.02'W | Good |
| 7 | Navy | 2 | 163.000 | 400 | 3 | 2116:22/101 | 8°55.11'S | 13°15.22'W | Good |
| 8 | Navy | 7 | 166.750 | 400 | 2 | 2256:01/101 | 8°54.59'S | 13°7.27'W | Excellent |
| 9 | Navy | 11 | 169.750 | 400 | 1 | 0035:42/102 | 8°54.31'S | 12°59.56'W | Good |
| 10 | Ultra | 20 | 164.875 | 450 | 3 | 0216:59/102 | 8°54.02'S | 12°51.12'W | Good |
| 11 | Navy | 17 | 162.625 | 400 | 1 | 0834:25/102 | 8°42.14'S | 12°44.88'W | Hydrophone lost at 0845/102 |
| 12 | Navy | 12 | 170.500 | 400 | 1 | 0856:05/102 | 8°42.24'S | 12°46.55'W | Excellent |
| 13 | Navy | 2 | 163.000 | 400 | 3 | 1035:12/102 | 8°43.07'S | 12°54.36'W | Excellent |
| 14 | Navy | 7 | 170.500 | 400 | 2 | 1234:42/102 | 8°43.81'S | 13°3.93'W | Good |
| 15 | Navy | 11 | 169.750 | 400 | 1 | 1332:45/102 | 8°44.61'S | 13°8.33'W | Excellent |
| 16 | Navy | 26 | 169.375 | 400 | 3 | 1517:28/102 | 8°44.62'S | 13°16.63'W | Excellent |
| 17 | Navy | 12 | 170.500 | 400 | 2 | 1630:41/102 | 8°44.83'S | 13°22.75'W | Excellent |
| 18 | Navy | 2 | 163.000 | 400 | 1 | 1811:20/102 | 8°45.48'S | 13°31.23'W | Excellent |
| 19 | Navy | 7 | 166.750 | 400 | 3 | 1952:33/102 | 8°46.33'S | 13°39.37'W | Excellent |
| 20 | Navy | 11 | 169.750 | 400 | 2 | 0308:22/103 | | | Hydrophone lost at 0318/103 |
| 21 | Navy | 17 | 162.625 | 400 | 2 | 0326:04/103 | | | Hydrophone lost at 0345/103 |
| 22 | Navy | 2 | 163.000 | 400 | 2 | 0400:04/103 | 8°58.00'S | 13°38.50'W | Good |
| 23 | Navy | 7 | 166.750 | 400 | 1 | 0518:45/103 | 8°51.98'S | 13°38.89'W | Good |
| 24 | Navy | 12 | 170.500 | 400 | 3 | 0630:14/103 | 8°46.39'S | 13°39.22'W | Good |

| Sonobuoy No. | Type | Channel | Frequency MHz | Depth | Receiver No. | Deployment Time | Latitude | Longitude | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 25 | Navy | 11 | 169.750 | 400 | 2 | 0808:24/103 | 8°38.59'S | 13°39.58'W | Interference from Sonobuoy 26; switched to narrow band at 1355/103 |
| 26 | Navy | 26 | 169.375 | 400 | 1 | 1303:52/103 | 8°38.97'S | 13°47.27'W | Excellent |
| 27 | Dowty | 14 | 172.000 | 140m | 3 | 1531:34/103 | 8°38.23'S | 13°35.87'W | Good |
| 28 | Navy | 2 | 163.000 | 400ft | 2 | 1710:21/103 | 8°37.70'S | 13°28.22'W | Excellent |
| 29 | Navy | 7 | 166.750 | 400ft | 1 | 1849:51/103 | 8°37.70'S | 13°20.30'W | Excellent |
| 30 | Navy | 11 | 169.750 | 400ft | 3 | 2034:55/103 | 8°36.60'S | 13°12.24'W | Good |
| 31 | Dowty | 13 | 171.250 | 140m | 2 | 0254:40/104 | 8°28.75'S | 13°12.44'W | Hydrophone lost almost immediately. |
| 32 | Navy | 17 | 162.625 | 400ft | 2 | 0314:16/104 | 8°30.17'S | 13°12.22'W | Signal lost soon after deployment. |
| 33 | Navy | 7 | 166.750 | 400ft | 1 | 0428:32/104 | 8°35.77'S | 13°11.22'W | Hydrophone lost at 0440/104 |
| 34 | Navy | 11 | 169.750 | 400ft | 1 | 0501:12/104 | 8°38.14'S | 13°10.80'W | Excellent |
| 35 | Dowty | 15 | 172.750 | 140m | 2 | 0642:58/104 | 8°45.88'S | 13°9.65'W | Good |
| 36 | Navy | 2 | 163.000 | 400ft | 3 | 0820:33/104 | 8°53.46'S | 13°8.51'W | Excellent |
| 37 | Navy | 7 | 166.750 | 400ft | 1 | 1110:25/104 | 9°2.68'S | 13°9.40'W | Excellent |
| 38 | Navy | 12 | 170.500 | 400ft | 2 | 1251:43/104 | 8°54.50'S | 13°10.61'W | Excellent |
| 39 | Navy | 26 | 169.375 | 400ft | 1 | 1516:55/104 | 8°43.10'S | 13°12.29'W | Excellent |
| 40 | Navy | 2 | 163.750 | 90ft | 3 | 1915:10/104 | 8°33.52'S | 13°16.22'W | Switch left set to 1 hr; lost at 2030/104 |
| 41 | Navy | 7 | 166.750 | 400ft | 2 | 2207:58/104 | 8°47.07'S | 13°13.91'W | Hydrophone lost at 2219/104 |
| 42 | Navy | 17 | 166.625 | 400ft | 2 | 2259:53/104 | 8°51.15'S | 13°13.17'W | Lost at 2311/104 |
| 43 | Navy | 7 | 166.750 | 400ft | 2 | 2322:19/104 | 8°52.90'S | 13°12.86'W | Lost at 0010/105 |
| 44 | Navy | 11 | 169.750 | 400ft | 3 | 0140:07/105 | 9°0.35'S | 13°13.85'W | Lost at 0204/105 |
| 45 | Old Navy | 9 | 168.250 | 400ft | 3 | 0213:46/105 | 8°57.71'S | 13°14.37'W | Lost at 0231/105 |
| 46 | Navy | 17 | 162.625 | 90ft | 1 | 0249:21/105 | 8°54.80'S | 13°14.80'W | Lost at 0310/105 |
| 47 | Navy | 12 | 170.500 | 400ft | 2 | 0329:52/105 | 8°51.59'S | 13°15.22'W | Excellent |
| 48 | Navy | 7 | 166.750 | 400ft | 3 | 0842:50/105 | 8°34.62'S | 13°20.24'W | Lost at 0851/105 |
| 49 | Dowty | 10 | 169.000 | 140m | 3 | 0904:55/105 | 8°36.42'S | 13°19.92'W | Lost at 1050/105 |
| 50 | Navy | 2 | 163.000 | 400ft | 1,3 | 1658:20/105 | 8°41.27'S | 13°2.35'W | Excellent |
| 51 | Navy | 12 | 170.500 | 400ft | 2 | 1844:21/105 | 8°39.15'S | 13°4.50'W | Lost at 1856/105 |
| 52 | Dowty | 11 | 169.250 | 140m | 2 | 1920:13/105 | 8°36.35'S | 13°5.30'W | Lost at 1932/105 |
| 53 | Navy | 29 | 171.625 | 400ft | 2 | 2101:18/105 | 8°28.28'S | 13°7.21'W | Excellent |
| 54 | Navy | 2 | 163.000 | 400ft | 1,3 | 2315:14/105 | 8°18.25'S | 13°9.97'W | Excellent |
| 55 | Navy | 11 | 169.750 | 400ft | 3 | 0119:14/106 | 8°8.64'S | 13°12.52'W | Good |

**TABLE OF JULIAN DAY NUMBERS**

| | | |
|---|---|---|
| Wed | 31st March | 090 |
| Thur | 1st April | 091 |
| Fri | 2nd April | 092 |
| Sat | 3rd April | 093 |
| Sun | 4th April | 094 |
| Mon | 5th April | 095 |
| Tues | 6th April | 096 |
| Wed | 7th April | 097 |
| Thur | 8th April | 098 |
| Fri | 9th April | 099 |
| Sat | 10th April | 100 |
| Sun | 11th April | 101 |
| Mon | 12th April | 102 |
| Tue | 13th April | 103 |
| Wed | 14th April | 104 |
| Thur | 15th April | 105 |
| Fri | 16th April | 106 |
| Sat | 17th April | 107 |