I.O.S.

R R S SHACKLETON

CRUISE 6/76

27 OCTOBER – 18 NOVEMBER 1976

GEOPHYSICAL STUDIES OF SOUTH WEST BISCAY

CRUISE REPORT NO 49

1976

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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Institute of Oceanographic Sciences,
Wormley,
Godalming,
Surrey

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DATES

Sailed Barry, Glamorgan	27th October (Day 301)
Arrived Barry, Glamorgan	18th November (Day 323)

SCIENTIFIC PERSONNEL

D. G. Roberts	Principal Scientist	IOS(W)
D. G. Bishop		IOS(W)
W. Blyth		IOS(W)
P. Domanski		IOS(W)
C. Flewellen		IOS(W)
A. Gray		IOS(W)
D. Jones		IOS(Barry)
S. Jones		IOS(Barry)
J. Langford		IOS(W)
P. Mason		IOS(Barry)
P. Miles		IOS(W)
L. Peardon		Portsmouth Polytechnic
G. Rothwell		IOS(W)
M. Saunders		IOS(W)

SHIP'S OFFICERS

G. H. Selby-Smith	Master
S. D. Mayl	Chief Officer
J. T. Morse	2nd Officer
J. J. Price	3rd Officer
C. S. Storrier	Chief Engineer
D. Pennie	2nd Engineer
E. J. Peck	3rd Engineer
B. J. Entwhistle	4th Engineer
P. G. Parker	Electrical Officer
K. W. Lovick	Purser
M. L. Davies	Radio Officer

SUMMARY OF CRUISE INTENTIONS

The original objectives of this cruise were to extend the drilling results obtained during Leg 48 of Glomar Challenger by making detailed surveys in the vicinity of the drill sites and by dredging at key points on the continental slope. These profiles would also complement those taken previously during Discovery Cruises 47, 60 and 74. Permission to work in the area was not granted by the Foreign and Commonwealth Office and the principal area of operations was perforce switched to South West Biscay.

The cruise objectives in South West Biscay were to study the continental margin of Galicia shaped by the rifting of the Bay of Biscay and the subsequent Pyrenean deformation, to examine the interaction between the Pyrenean deformation and the adjacent ocean floor and to make a survey of the continent-ocean boundary in the vicinity of the Trevelyan Escarpment.

The following projects were included in the cruise:-

1. Multichannel seismic reflection profiling

The acquisition of 6-channel seismic reflection data using a Geomeccanique array consisting of 6 active and 6 passive sections made available by IOS. Two EPC recorders and a jet-pen recorder would be run continuously at different filter settings and with time varied filtering on the summed output.

2. Bathymetry, Gravity and Magnetics

Gravity, magnetics and bathymetry were to be run throughout the cruise.

3. Dredging

If the seismic profiles revealed outcrops likely to give improved geological control on interpretation, it was intended to dredge subject to time and weather.

4. Disposable sonobuoys

Disposable sonobuoys would be used with $300in^3$ and $1000in^3$ airguns to obtain refraction and reflection velocity data.

5. Airgun wave form measurement

It was intended to monitor the airgun wave form in the far field by towing a hydrophone at several hundred metres. The monitoring would be carried out whilst shooting wide angle reflection profiles as well as routinely during seismic reflection profiling to help process these data.

NARRATIVE

RRS Shackleton sailed from Barry Roads at 1800/27 (301). During the overnight transit to the shelf west of the Scillies, an echo-sounder and gravimeter watch was kept. At 0900/28 (302) the PDR fish was streamed and we made toward 49°N 8°W to test stream the seismic gear. At 1800/28 (302) the seismic gear was streamed and we turned to head southward across the Bay whilst setting up the equipment. During the 28th the time series fixed head processor in the data logger failed beyond shipboard repair and necessitating the transfer of timing data to the floating discs. Tests of the seismic gear continued through the night of 28/29th (302/303) and we tested two newly modified sonobuoys on the slope and rise of north Biscay (stns. 1748 and 1749). Massive ship's WT and RT interference severely corrupted the analogue seismic records and tape recordings. To avoid a future repetition, radio silence except at turning points was imposed by the Master. During the day, we profiled across the Trevelyan Escarpment deploying a further sonobuoy (stn. 1750) on the north edge of the Biscay Abyssal Plain.

During the 30th (304) the timing data corrupted on the fixed head processor was transferred to floating head discs though it was necessary to manually input depths and satellite fixes. The seismic profile across the Biscay seamounts showed that they consist of uplifted sediments and basement thinly covered by younger pelagic sediments. After crossing the seamounts, two sonobuoy stations (1751 and 1752) were occupied on the Iberian Abyssal Plain north of Galicia Bank and yielded refracted arrivals.

Overnight, we continued our profile southward to Galicia Bank crossing a now buried trench just to the north. At 1200/31 (305) we turned eastward reducing speed to 3.5 kts to recover the array and attach depressors. At 1300/31 (305) the array was streamed again and the airgun serviced. The source of intermittent noise on the array, observed during our outward passage, was found to be an incorrectly made-up plug in the winch junction box. Whilst manoeuvering to occupy line 2, radio transmissions at 4, 8, 12, 16 and 22mcs. were monitored to assess interference. At 1703/305, we turned west-north-west into line 2 designed to examine the Azores-Biscay Rise and north west margin of Galicia Bank. During 1st November (306) we continued north-westward in deteriorating swell conditions passing over an area covered in thin sediments and apparently uplifted. By 0700/2nd November (307) we crossed a series of deep linear troughs at the foot slopes of the Azores-Biscay Rise. The crest of the rise was crossed at 0900 and the airgun changed at 0930 enabling us to send and receive radio traffic. At 1030 we turned north-eastward to run along the crest of the rise towards anomaly 31-32. Throughout the day the vessel was rolling and pitching heavily. During the morning of 3rd November (308) we crossed the faulted northern edge of the Azores-Biscay Rise and at 0700 turned south-eastward (line 3) onto the western Biscay Abyssal Plain to tie in the age of the reflectors. At 1330 (308) the airgun trigger leadfailed but was replaced by 1630. The stern doors were damaged by a large wave during this operation. At 1845 (308) we turned south-westward beginning line 4 across the western end of the Biscay seamounts in contrast to the tectonized area to the south. Two sonobouys (stn. 1753) deployed at 1014/4th (309) gave poor results due to radio interference of unknown origin. During the day, a telegram was received from the RVB notifying us that work in Irish waters had been cleared by the FCO. However, in view of storm conditions in the South Western Approaches, we continued our programme in South West Biscay. During the night of 4/5th November (309/310), we profiled northward across the Biscay seamounts to the western edge of the Biscay Abyssal Plain. During the afternoon, sonobuoy station 1754 was occupied in the Mirrol Trough just east of the Azores-Biscay Rise. During the day, it was discovered that RT interference was corrupting the e. m. log data recorded on magnetic tape and the programming of the bridge and scientific satellite navigation computers. During the night of the 5th/6th (310/311) the weather deteriorated radically with wind speeds of 35-40 kts and an estimated 30-35ft swell. At about 0830 the discs were shut down briefly during the turn onto line 8 and the gravimeter was clamped between 1740 and 2240 (311). By the evening the swell had eased and at 0130/7th November (312) we completed line 10 and turned northward to cross the Biscay seamounts once more. In preparation for the airgun wave form monitoring experiment, the Batfish winch motor was run up. As pressure was applied to the hydraulic motor, hydraulic fluid fountained from a crack extending across the cast iron casing cover. Mr. Storrier (Chief Engineer) and Mr. Gray were fortunately able to machine a new cover from a mild steel flange of about the right dimensions. At 1651/312 a disposable sonobuoy was deployed (stn. 1755). During this station the airgun pressure fell steadily necessitating a change of airguns at the end of line 11 at 1925/312. Throughout the night of 7th and 8th November (312/313), we profiled south-eastward across the Iberian Abyssal Plain towards Coruna occupying sonobuoy stations 1751/1752. The profile again showed evidence of an infilled trench off the north-west margin of Spain. Repairs to the Batfish winch were completed successfully. Overnight (8/9th November (313/314)) we continued our profile up the continental slope with two interruptions to avoid shipping. At 0700/9th (314) the profile was ended. The array, airgun, magnetometer and PDR fish were brought inboard by 0800. Course was set for Coruna where the ship arrived alongside at 1200/9th November and a gravity base station connection was made.

RRS Shackleton departed Coruna at 1400/10th November (315) in pleasant weather. The PDR fish was streamed at 1446 en route to the shelf edge and at 1700 we reached the start of the seismic line running NNW from Coruna to the Biscay seamounts and streamed the gear to begin the line at 1809. Whilst streaming the gear, we learnt that the Catering Officer, Mr. K. Lovick, had collapsed. After placing an HF link call to the Marine Superintendent, we made an immediate return to Coruna retrieving all the gear outboard by 2026 and arriving there at 2324. Immediate hospitalisation was ordered for the Catering Officer who was transferred ashore by launch. At 0100/316 we weighed anchor and steamed to our position at 1900/10th November where we streamed the airgun, array, magnetometer and PDR fish to begin line 13 again. Our overnight profile crossed the steep continental slope off NW Spain and the narrow westward extension of the North Spanish Trough. At 1351/11th November (316) we reduced speed to 5 kts to deploy the tadpole but 50Hz interference delayed the start of the wave form monitoring experiment. Speed was therefore increased to 6. 5 kts until we deployed the tadpole at 1627/316 to a depth of 30m. As a good signal was received, the tadpole was streamed to a depth of 300m at 1740 and at 1800 we deployed a sonobuoy for the start of station 1758. However at its full depth, the airgun signal recorded by the tadpole could not be discriminated against background noise. We therefore decided to haul in the tadpole in 50m increments to optimise the signal. In hauling the cable, we found that the fairing was catching and breaking on the flange of the stern winch. The flange was removed from the winch and the cable hauled in slowly. As weather conditions were deteriorating and spray was being taken on the foredeck, the experiment was abandoned and the cable and tadpole were recovered by 1939. The sonobuoy station was completed at 2034.

The end of line 13 was reached at 0030/12 and we altered course southward to cross again the Biscay seamounts in heavy swell. At 0400, the wind speed was 45 kts and seas and swell were increasing. At 0520, the airgun was stopped and the vessel hove to heading 270°. By 1300/13 (317) the weather had moderated sufficiently for us to resume profiling and at 1329 we altered course eastward profiling to our 0510 position. During the day, the cause of the weak airgun signal recorded on the hydrophone was found - the cable had apparently been broken beneath the winch drum on a previous occasion and the broken wires had been wrongly reconnected. The break was remade and the hydrophone yielded good signals.

At 0128/13th November (318), we altered course westward to begin the airgun wave form monitoring experiment in calm seas and moderate weather. At 0400 speed was reduced to 3 kts and the $1000in^3$ gun deployed. At 0450 speed was increased to 5 kts and a sonobuoy deployed at 0503 yielded refracted arrivals. On completion of the station at 0658 we executed a Williamson turn whilst deploying the tadpole to return along our course to monitor the airgun wave form whilst reversing the refraction line. The sonobuoy at station 1760 was was deployed at 0850 but transmitted weak signals. As we passed the start of station 1759, another sonobuoy (stn. 1761) again yielded weak signals. Another Williamson turn was executed at 1059 and the $300in^3$ gun deployed during the turn. After the turn we increased speed to 6.5kts to monitor the wave form under normal profiling conditions. During our return course, good signals were received from buoy 1761 and we occupied station 1761A until radio contact was lost. At 1430 the tadpole was hauled inboard in 50 metre increments to monitor the change in signal with depth. After the tadpole was brought inboard, we altered course southward crossing the trench north of Galicia Bank at 2000. Line 16 was completed at 2330/318 when we altered course north-westward to begin our northward return across the Bay of Biscay. On a flat portion of the Biscay seamounts sonobuoy station 1762 was occupied at 1915/319. After crossing the Biscay seamounts we continued northward toward the Trevelyan escarpment occupying station 1763 at 0849/320. An airgun failure occurred at 1230/320 and whilst speed was reduced to change airguns, the tadpole was streamed to further monitor the airgun wave form. Sonobuoy station 1764 was occupied at the foot of the Trevelyan escarpment at 1507/320 and at 1926 we altered course along the crest of the Trevelyan escarpment occupying sonobuoy station 1765 between 2118 and 2312/320. At 2335/320 we altered course south across the escarpment and at 0348 turned westward along the foot of the escarpment occupying sonobuoy station 1765 between 0544 and

0817/321. At 0817 we altered course northward to cross the Trevelyan escarpment again. At 1219/321 course was altered toward Barry and trials were made to assess noise levels on the array at speeds of 6.9, 7.5, 8.0 and 8.5 kts. The tadpole was brought inboard at 1900 and the array at 2322/321. Overnight 321/322 we made for Barry running magnetics, gravity and echo-sounding. At 0918/322 the PDR fish and magnetometer were brought inboard and we continued toward Barry running the gravimeter only. At 0535 RRS Shackleton arrived in Barry Roads and was alongside Barry Dock at 0715/323.

This was a most successful cruise. Approximately 2800 miles of good quality seismic profiles were occupied as well as 21 sonobuoy stations. Nine hours were lost due to bad weather and a further eight hours in returning to Coruna to land the Catering Officer.

It is a pleasure for me to record my thanks and appreciation for the friendly support and help of Captain G. Selby-Smith, the officers and crew. In particular, I would like to thank the scientific party for their hard work at sea.

PROJECT REPORTS

1. Seismic Reflection Profiling

The day after we left Barry the 6 channel Geomechanique array and 300in^3 airgun were streamed. To allow common depth point processing the gun was fired at a 15 sec. repetition rate and the ship's speed kept at 6.5kts. Allowing the compressors output to settle down, a pressure of between 1600 and 1800 psi was maintained.

During the first run two problems arose. The array depth indicators were inoperative and the first three sections of the array became intermittently open circuit. At the end of the run the array was brought inboard and checked. The open circuit sections were traced to a faulty drum connector. To overcome the depth indicator problem, two Ashbrook depth controllers, set to a depth of 30 ft., were fitted on the passive tail section and between the two front spring sections respectively.

With the array streamed, all sections were operative again, although section 1 gave trouble during most of the cruise especially during bad weather. An interesting point to note here is that the addition of the depth controllers did not noticeably increase the noise level on the array.

As well as being recorded on a Bell & Howell CPR 4010 tape recorder, the 6 array channels were summed and displayed on 2 EPC recorders and a Cambridge jet pen recorder. The first EPC displayed a normal band-passed signal from 5Hz to 100Hz and gave a general overall picture. The band-passed signal was then passed through a bottom-triggered, time varied filter, and displayed on the second EPC to give higher resolution in the first second of penetration whilst maintaining the low frequencies of the deep reflectors.

The Cambridge jet pen recorder was used to monitor either of these two displays but in their true perspective, depending on the level of background noise. It proved to be an extremely useful recorder, which unfortunately ran out of ink half way through the cruise.

Despite bad weather and a large swell, the quality of the records was excellent, except under following sea conditions. This condition is particularly noticeable with the longer arrays. Tension is taken off the array allowing it to follow the contour of the swell, resulting in excessive noise when the tension is taken up again.

Acoustically, RRS Shackleton is very quiet and during a 15 hour period the ship's speed was increased to 7 kts with a gun firing rate of 14 secs. No degradation of the record was observed.

A total of 2800 n. miles was surveyed with no loss of data due to breakdown of the equipment.

2. Disposable sonobuoys

In order to obtain vertical interval velocity information and discernible refraction arrivals, 23 SB6E4 disposable sonobuoys were deployed during the cruise, only 4 proving unsuccessful owing to transmission/reception problems. Before deployment, the acoustic sensitivity of each sonobuoy was reduced by a factor of ten, previous experience showing that the normal sensitivity was too high and caused overloading. In addition each sonobuoy was tested for reception in a salt water container immediately before use.

The data were recorded with the intention of applying digital signal processing techniques on return to the laboratory to increase signal quality and improve interpretation potential. About one third of the successful stations provided good, low noise reception owing to favourable sea conditions, reception being maintained to a range of 15km. Many of the stations occupied during the early part of the cruise suffered poor signal to noise from continuous swell but provided interpretable results although at this stage refraction signals were not satisfactory. An intended reversed refraction line using a $1000in^3$ airgun source proved disappointing owing to poor low frequency reception and necessitated improvising a split spread line. Results suggested that the 300ft sonobuoy hydrophone depth was not compatible with the lower range frequency spectrum of the $1000in^3$ airgun pulse. Results from the use of a 60ft hydrophone depth proved inconclusive because of weak reception. It became apparent that systematic 'timing' of the sonobuoy system must be made and documented for consistent results.

3. Gun monitor experiment

The objectives of this experiment were to record the output from the airgun sound source (using a monitor hydrophone) and associated data from the SRP system and Disposable Sonobuoys (DSBs). Two capacities of airgun ($1000in^3$ and $300in^3$) were used, working at a range of depths. The monitor hydrophone was also towed at a range of depths from 50m to approximately 250m to determine the optimum towing depth in terms of minimising distortion of the observed gun signal and maximising the signal to noise ratio. The data obtained will be used to aid signal processing of SRP and DSB data.

The second objective was to discover the problems and /or limitations of attempting to monitor the airgun output in a routine way as a means of controlling the airgun signal and subsequent use in signal processing.

A number of mechanical problems associated with the winch were overcome before the gun monitor hydrophone could be deployed. A fault in the electrical conductors of the towed cable was also rectified. The monitor hydrophone was towed for a number of hours without trouble and initial conclusions are that the airgun output could be monitored in this way on a routine basis, but the towed vehicle in which the hydrophone was housed generated tow noise and would need to be improved.

4. Signal processing

A number of programs were written and tested which it is hoped will be useful for general signal processing of SRP and DSB data. These programs were

(a) to compute the Power Spectral Density of a time series. The program is designed to work in real time under interrupt control and includes a routine to generate square or hanning windows,

(b) the compensation of move out, which is compensated via a cross-correlation routine, so that the velocity hyperbola can be computed and running averaging can be applied to improve signal strength,

(c) to estimate the impulse response of a system. This will be used to deconvolve SRP data in an attempt to improve resolution.

5. Sensitivity Setting of the Ultra DSB

Experience with the Ultra disposable sonobuoys has shown that the original gain setting of the sonic amplifier is too high, resulting in limiting of the amplifier output from normal sea noise. There are two adjustments which are made to the sonic amplifier: gain and output drive level. The procedure is as follows:

Remove the electronics package from the main body of the buoy after removing the drain plug from the side of the canister. Disconnect the supply lead (yellow) from the sonic amplifier circuit board. Disconnect the input cable from the sonic amplifier circuit board. Connect a signal generator to the amplifier input, and monitor the amplifier output with an oscilloscope. Connect an external power supply at 10V to the amplifier. Apply an input of 10mV rms to the amplifier and using the oscilloscope, check that the output shows a limiting or clipped signal of 3V peak to peak amplitude. This level is set by the potentiometer at the output side of the circuit board. Use the second potentiometer mounted on the input side of the circuit board to reduce the output to a 1V peak to peak undistorted sine wave. Disconnect the signal generator, reconnect the hydrophone and check the hydrophone and associated preamplifier by tapping the hydrophone casing and monitoring the amplifier output. Normally the output will be clipping from ship's vibration. Disconnect the external power supply, reconnect the internal power supply and replace the electronics package inside the buoy casing. Before the buoy is used check (a) that the drain plug has been refitted, (b) the depth setting of the hydrophone is correct, (c) the time switch is set to 8 hrs.

6. Gravity Meter

The LaCoste Romberg gravity meter functioned well except on two occasions. During heavy rolling on 12th November the inertial platform was found pivoting out of its securing battens resulting in severe jarring of the platform. The platform was bolted down to the deck and smoother data were obtained thereafter.

The cross gyro failed at 0110/319 and was restarted at 0600/319.

7. Data logger and 1130 computer

Shortly after leaving Barry, the fixed head disc (FXHD) became inoperative most probably due to an intermittent track of a variable resistor controlling a power rail. This minor fault caused a much more serious problem for it corrupted the sector formatting rendering the FXHD unusable for the remainder of the cruise. This is because the necessary hardware to determine the correct sector by writing a timing clock on a pre-defined track no. of a specialised nature is not available in the lab or at sea. This fault has now occurred on three occasions in three years and emphasises the need to consider the cost effectiveness of buying or building such hardware.

The normal effect of the loss of the FXHD is to slow processing time by 10%. However during the cruise this figure was exceeded because it was necessary to reconfigure the system on Flying Head Discs (FHD) due to the control role of the FXHD. The reconfiguration necessitated rebuilding a number of the tape control programmes onto FHDs along with other system programmes whilst allowing sufficient working storage for the temporary files used during tape transfer. A comparable system was in use prior to the use of the FXHD.

After this was achieved, the system ran reasonably well with only a number of programmes (magnetics and gravity) taking significantly longer (30%). Prior to the major problem a fault occurred on the console printer (1055). A spring fell off the cycle shaft clutch, which controls the carriage action. The spring proved to be a nuisance throughout the cruise and eventually broke. Luckily (since no spares are carried with a maintenance contract) another was found and the printer worked until our return to Barry.

One of the FHDs (drive 2) also gave trouble shown as occasional sector address errors and data corruptions. The worst case was the corruption of the disc identifier which meant the disc could not be recognised on the system. A patching program was used to overcome this fault and the data recovered. This problem meant that every 5 days the data disc had to be copied at various stages thereby again increasing processing time.

Drive 2 has always exhibited recalcitrant tendencies, namely the drive band slipping off. The voice coil indent mechanism was inspected and showed no obvious signs of wear or damage. Diagnostics run on the drive did not fail either, suggesting an intermittent fault, probably on the drive rotation system.

The read/write heads required cleaning and could do with changing by IBM when in Barry. Drive 1 and 0 gave only minor problems in that the disc retaining arm micro switch had to be repaired on drive 1.

Two shut downs occurred during the cruise, firstly a short data break caused by the failure of one of the tape drives. The brake disc of the supply was scored and caused juddering of the supply spool. Although not serious in itself this fault had repercussions in that it caused a tape roller on the tension arm to strip its thread and will now require refitting and setting up for skew again on return to Barry. The second failure was in the order of a couple of hours and was due to an i. c. failing in the monitor unit, controlling the enabling of the tape units. After repair the system worked for the rest of the cruise.

One disadvantage has been the RF interference, especially in the mid HF band (8kHz). This problem requires urgent investigation to obviate this interference.

Probably causes have been mentioned in earlier reports namely redundant aerials and cables strewn from the bridge and lab areas, supply earthing faults, insufficient RF filters and equipment mains supplies.

The time taken to recover data corrupted in this manner was considerable.

8. Satellite Navigator

The Magnavox set was prone to RT interference. Consistently wet weather conditions and dampness may have increased capacitive coupling between the ship's transmitter aerials and redundant cables and aerials.

Generally the system worked well. Future improvements include the installation of additional memory to allow use of new programmes. These programmes will give time ordered alerts and improve fix accuracy by calculating velocity north. A disadvantage of the system is the limited information displayed on the video monitor. The proposed programme changes should allow the following display if agreed by Magnavox.

TIME: GMT
LAT
LONG
LAST SAT. UPDATE:
SPEED: HEADING:
SPEED MADE GOOD: COURSE MADE GOOD:
WAY POINT:
ETA

Live track charts would have been useful during this cruise.

SEISMIC REFLECTION PROFILES
(all profiles were also run with gravity and magnetics)

Prof. No. and dist. (n. m.)	Equipment	Start	End	Latitude From	Longitude To	Latitude From	Longitude To	Depth Range UCF		UCM		CM		Comments
1 405	300in^3 airgun 6ch Geomecc.	2000 /302	1156 /305	48°56.0'N	08.03.5'W	42°34.0'N	11°37.5'W	78	2652	142.6	4850	148	5016	Armorican shelf -Galicia Bank
2 265	300in^3 airgun 6ch Geomecc.	1703 /305	0930 /307	42°41.25'N	11°30.26'N	44°42.14'N	16°21.17'W	376	2788	687.6	5098.7	709	5281	Galicia Bank - Azores/Biscay Rise
3 124	300in^3 airgun 6ch Geomecc.	1145 /307	0700 /308	44°38.27'N	16°23.18'W	44°51.5'N	14°11.9'W	1292	2558	2362.8	4678.1	2424	4834	Azores-Biscay Rise-Anomaly 31-32
4 66	300in^3 airgun 6ch Geomecc.	0730 /308	1845 /308	44°51.9'N	14°09.6'W	45°34.6'N	12°36.1'W	2500	2553	4572	4668.9	4721	4824	Anomaly 31-32 Porcupine AP - Biscay AP
5 114	300in^3 airgun 6ch Geomecc.	1910 /308	1430 /309	45°33.9'N	12°35.4'W	44°13.10'N	14°45.01'W	1237	2789	2262.2	5100.5	2320	5283	Biscay AP -Biscay Seamounts
6 69	300in^3 airgun 6ch Geomecc.	1502 /309	0238 /310	44°9'N	14°47'W	45°23.52'N	14°49.30'W	2018	2760	3690.5	5047.5	3796	5226	Biscay Seamounts -Azores-Biscay Rise
7 43	300in^3 airgun 6ch Geomecc.	0304 /310	0947 /310	45°24.29'N	14°52.11'W	44°55.3'N	15°34.6'W	1497	2557	2737.7	4676.2	2809	4832	Azores - Biscay Rise
8 23	300in^3 airgun 6ch Geomecc.	0952 /310	1300 /310	44°54.7'N	15°34.8'W	44°32.57'N	15°33.01'W	1776	2590	3248	4736.6	3336	4896	Azores - Biscay Rise
9 114	300in^3 airgun 6ch Geomecc.	1300 /310	0822 /311	44°31.42'N	15°31.46'W	44°27.75'N	14°19.05'W	1800	2908	3291.8	5318.2	3382	5516	Azores - Biscay Rise - Biscay AP

Prof. No. and dist. (n. m.)	Equipment	Start	End	Latitude From	Longitude To	Latitude From	Longitude To	Depth Range UCF		Depth Range UCM		Depth Range CM		Comments
10 116	300in^3 airgun 6ch Geomecc.	0848 /311	0130 /312	44°29.3'N	14°16.0'W	44°01.86'N	13°17.84'W	1212	2642	2216.5	4831.7	2274	4997	Biscay AP - Iberian AP
11 113	300in^3 airgun 6ch Geomecc.	0130 /312	1925 /312	43°59.71'N	13°15.68'W	45°32.85'N	12°35.80'W	1628	2642	2977.3	4831.7	3057	4997	Iberian AP - Biscay AP
12 227	300in^3 airgun 6ch Geomecc.	1955 /312	0700 /314	45°33.99'N	12°33.80'W	43°27.3'N	09°06.4'W	97	2656	177.4	4857.3	184	5024	Biscay AP - Coruna
13 113	300in^3 airgun 6ch Geomecc.	0445 /316	0030 /317	43°45.2'N	08°42.0'W	45°26.95'N	09°51.18'W	169	2612	309.1	4776.8	322	4938	Coruna - E. Biscay Seamount
14 18, 60	300in^3 airgun 6ch Geomecc.	0153 /317	0520 /317	45°27.18'N	09°59.43'W	45°11.7'N	10°07.02'W	1940	2146	3547.9	3924.6	3648	4041	E. Biscay Seamount -Iberian AP v/l hove to 0520/ 317-1309/317
		1549 /317	0100 /318	45°04.35'N	10°13.32'W	44°07.38'N	10°34.92'W	2198	2632	4019.7	4813.4	4140	4977	
15 63	300in^3/1000in^3 airgun 6ch Geomecc.	0100 /318	1537 /318	44°05.2'N	10°36.52'W	44°03.08'N	11°32.89'W	2630	2656	4809.7	4857.3	4973	5024	Reflection- refraction line on Iberian AP
16 49	300in^3 airgun 6ch Geomecc.	1600 /318	2330 /318	44°02.27'N	11°35.55'W	43°14.93'N	11°43.96'W	906	2658	1656.9	4861	1700	5028	Iberian AP - Galicia Bank
17 33	300in^3 airgun 6ch Geomecc.	2349 /319	0500 /319	43°14.39'N	11°46.24'W	43°29.3'N	12°26.1'W	1104	2678	2019	4897.5	2071	5067	Galicia Bank - W. Iberian AP
18 69	300in^3 airgun 6ch Geomecc.	0534 /319	1609 /319	43°31.4'N	12°29.5'W	44°40.4'N	12°17.6'N	1734	2696	3171.1	4930.5	3257	5102	Iberian AP - Biscay Seamounts

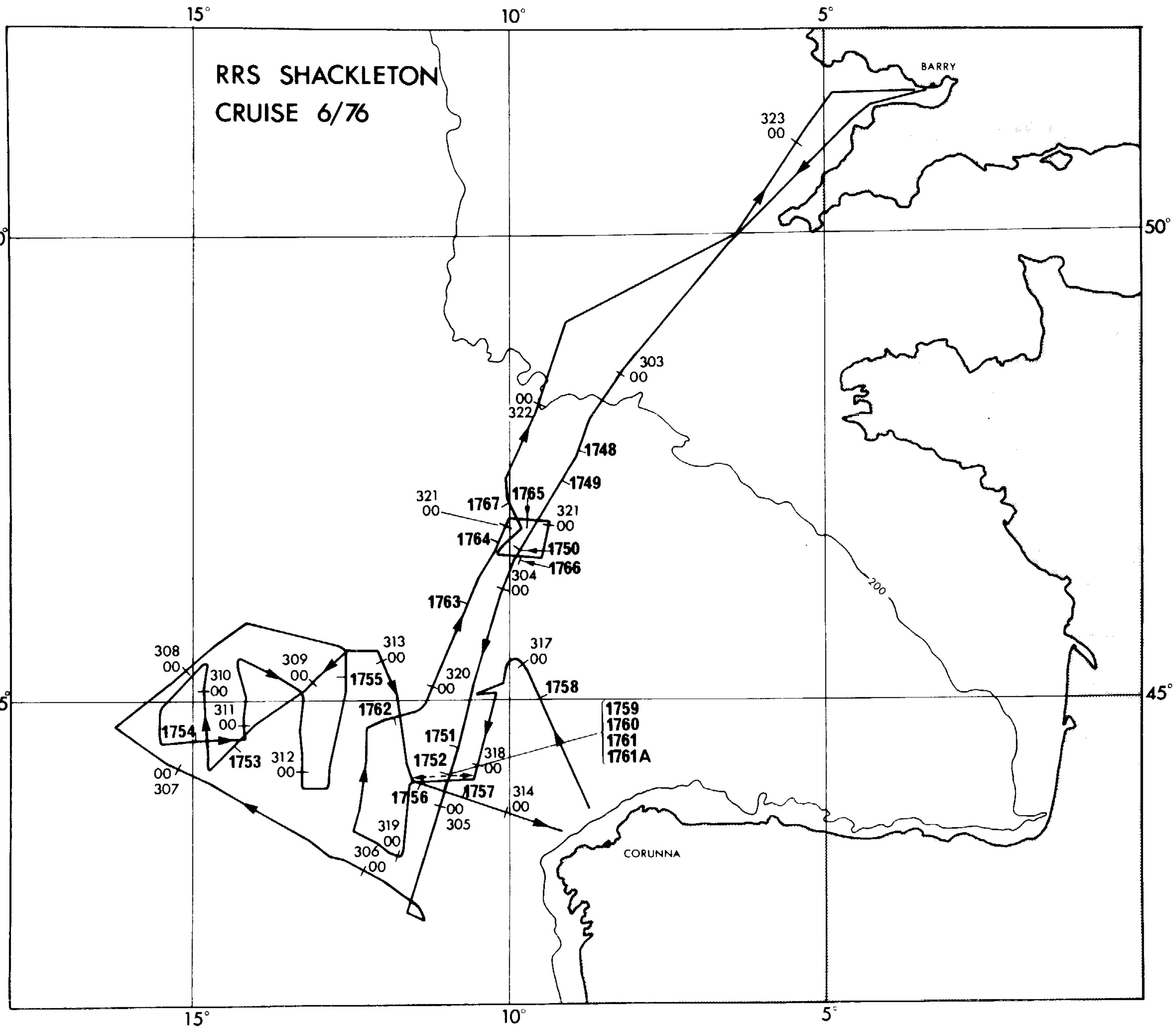
Prof. No. and dist. (n. m.)	Equipment	Start End	Latitude From	Longitude To	Latitude From	Longitude To	Depth Range UCF		Depth Range UCM		Depth Range CM		Comments
19 38.5	$300in^3$ airgun 6ch Geomecc.	1625 2202 /319 /319	44°41.7'N	12°15.9'W	44°53.83'N	11°25.79'W	1791	2394	3275.4	4378.2	3365	4517	E - W Biscay Seamounts
20 138	$300in^3$ airgun 6ch Geomecc.	2211 1910 /319 /320	44°54.38'N	11°24.92'W	46°59.1'N	10°00.00'W	1822	2600	3332.1	4754.9	3424	4915	Biscay Seamounts -Trevelyan Escarpment
21 26	$300in^3$ airgun 6ch Geomecc.	1926 2312 /320 /320	46°59.8'N	09°57.9'W	46°56.98'N	09°21.0'W	2242	2398	4100.2	4385.5	4224	4524	Trevelyan Escarpment
22 27	$300in^3$ airgun 6ch Geomecc.	2335 0330 /320 /321	46°55.14'N	09°19.64'W	46°32.03'N	09°29.51'W	2160	2500	3950.2	4572	4067	4721	Trevelyan Escarpment
23 29	$300in^3$ airgun 6ch Geomecc.	0348 0817 /321 /321	46°31.22'N	09°31.03'W	46°37.58'N	10°10.43'W	2472	2501	4520.8	4573.8	4667	4723	Trevelyan Escarpment
24 26	$300in^3$ airgun 6ch Geomecc.	0839 1219 /321 /321	46°39.6'N	10°11.48'W	46°56.83'N	09°48.96'W	2312	2488	4228.2	4550.1	4359	4698	Trevelyan Escarpment
25 100	$300in^3$ airgun 6ch Geomecc.	1230 2322 /321 /321	46°57.55'N	09°49.68'W	48°06.41'N	09°37.92'W	558	2436	1020.5	4455	1049	4598	Hydrophone speed trials

RRS SHACKLETON CR. 6/76

STATION POSITION LIST

Stn. No.	Type	Start	End	START Latitude	START Longitude	END Latitude	END Longitude	Depth Range UCF	Depth Range UCM	Depth Range CM	Comments
1748	DSB	0719 /303	0919 /303	47°46.3'N	08°52.2'W	47°38.05'N	08°56'W	1206 2088	2205.5 3818.5	2262 3930	First sonobuoy aborted
1749	DSB	1148 /303	1305 /303	47°25.2'N	09°09.8'W	47°16.33'N	09°16.35'W	2278 2374	4166 4341.6	4294 4478	Successful
1750	DSB	1915 /303	2039 /303	46°41.5'N	09°45.9'W	46°34.4'N	09°54.06'W	2463 2478	4504.3 4531.8	4650 4679	"
1751	DSB	1651 /304	1751 /304	44°32.2'N	10°48.1'W	44°21.7'N	10°51.3'W	2629 2633	4807.9 4815.2	4971 4979	"
1752	DSB	2000 /304	2130 /304	44°09.77'N	10°57.15'W	44°01.5'N	11°01'W	2639 2643	4826.2 4833.5	4991 4999	"
1753	DSB	1014 /309	1114 /309	44°32.4'N	14°16.38'W	44°29.0'N	14°18.50'W	2788 2789	5098.7 5100.5	5281 5283	Weak signals on 1st sonobuoy. 2nd sonobuoy abortive.
1754	DSB	1653 /310	1810 /310	44°32.7'N	14°59.1'W	44°33'N	14°48'W	2390 2678	4370.8 4897.5	4509 5067	Successful
1755	DSB	1651 /311	1810 /311	45°17'N	12°36'W	44°33'N	14°47'W	1989 2032	3637.5 3716.1	3741 3823	"
1756	DSB	1327 /313	1520 /313	44°03.66'N	11°30.11'W	43°59.56'N	11°14.61'W	2649 2656	4844.5 4857.3	5010 5024	"
1757	DSB	1826 /313	2000 /313	43°52.5'N	10°48.8'W	43°49.2'N	10°35.6'W	2632 2640	4813.4 4828.0	4977 4993	"

Stn. No.	Type	Start	End	START Latitude	START Longitude	END Latitude	END Longitude	Depth Range UCF	Depth Range UCM	Depth Range CM	Comments
1758	DSB	1816 /316	2021 /316	45°00.00'N	09°31.56'W	45°08.64'N	09°36.16'W	2593 2598	4742.1 4751.2	4901 4911	Successful
1759	DSB	0503 /318	0658 /318	44°04.0'N	11°03.3'W	44°03.8'N	11°17.6'W	2645 2652	4837.8 4850	5002 5016	"
1760	DSB	0850 /318	1000 /318	44°03.76'N	11°11.20'W	44°03.76'N	11°02.99'W	2644 2648	4835.4 4842.7	5000 5008	Reversal of Stn. 1759 1000in^3 airgun (1760–1761)
1761	DSB	1000 /318	1049 /318	44°03.76'N	11°02.99'W	44°03.56'N	10°59.76'W	2641 2644	4829.9 4835.4	4995 5000	
1761A	DSB	1230 /318	1403 /318	44°03.19'N	11°04.90'W	44°03.40'N	11°18.13'W	2644 2651	4835.4 4848.2	5000 5014	Return passage past Stn. 1761
1762	DSB	1915 /319	2021 /319	44°48.6'N	11°51.1'W	44°50.76'N	11°41.11'W	2264 2394	4140.4 4378.2	4267 4517	Successful
1763	DSB	0927 /320	1107 /320	46°03.5'N	10°39.4'W	46°13.5'N	10°32.6'W	2537 2547	4639.7 4658	4793 4812	1st buoy abortive. 2nd buoy successful
1764	DSB	1507 /320	1656 /320	46°35.50'N	10°16.56'W	46°45.6'N	10°09.0'W	2470 2500	4517.2 4572	4663 4721	Good refractions
1765	DSB	2118 /320	2312 /320	46°57.7'N	09°40.4'W	46°56.98'N	09°21.0'W	2236 2328	4089.2 4257.5	4213 4390	" "
1766	DSB	0544 /321	0817 /321	46°34.2'N	09°48.4'W	46°57.58'N	10°10.43'W	2472 2494	4520.8 4561	4667 4710	" "
1767	DSB	1446 /321	1630 /321	47°09.0'N	10°00.50'W	47°18.3'N	10°10.5'W	2294 2355	4195.3 4306.8	4324 4442	



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3	(Expedition)	Royal Society
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[1] NIO CR — National Institute of Oceanography, Cruise Report.

[2] IOS CR — Institute of Oceanographic Sciences, Cruise Report.

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