RRS CHALLENGER

CRUISE 31

27 JUNE - 15 JULY 1988

1. Personnel

			leg 1	leg 2
R. D. Pingree	P.S.O.	IOSDL/PML	✓	✓
A. L. New		IOSDL	✓	✓
D. K. Griffiths		PML	✓	✓
R. P. Harris		PML	✓	✓
R. N. Head		PML	✓	✓
A. G. Davies		PML	✓	✓
J. Sleep		PML	✓	✓
R. L. Barrett		PML	✓	✓
G. Phillips		IOSDL	✓	✓
I. Waddington		IOSDL	✓	✓
R. Lloyd		RVS	✓	✓
P. Mason		RVS	✓	X
W. Miller		RVS	✓	✓
A. Jones		RVS	X	✓

2. Aims

1. To deploy thermistor chain moorings on the Biscay abyssal plains to examine the propagation of internal tidal energy into the ocean interior from the continental slopes.

2. To examine the effect of mixing, nutrient availability and illumination on distributions of phytoplankton and zooplankton in the area of the slope.

3. To examine the scattering layer at the 300-400m depth contour near Chapel Bank over a tidal cycle.

4. To make CTD profiles over several tidal cycles in conjunction with the ADCP to examine mixing within the water column and to investigate turbid layers near the bottom. Draw samples from the rosette for Coulter counter analyses.

5. To investigate the diurnal fluorescence rhythm.

6. Recover longterm moorings in the Porcupine Sea Bight and deploy longterm moorings on the north slopes, to investigate slope transport.

7. To make continuous underway measurements of temperature, salinity, fluorescence, inorganic nitrate, reactive silicate, light transmission and surface illumination.

3. Procedure and Scientific Programme

The R.V. Challenger sailed from Barry at 1545 hrs (GMT) on 26.6.88 with a scientific team from IOSDL, PML and R.V.S. After a slight delay in the locks due to the slowness in changing pilots, the vessel cleared the port and the pilot embarked at 1622 hrs. Cruise was then set down channel towards the Bay of Biscay and main working areas (see fig 1).

The first station E5, at position 49° 06' N 06° 29' W, consisted of a CTD profile, water sampling and zooplankton net sampling. The CTD stations positions are listed in Table 1 and the water sampling stations, zooplankton net station, light meter profiles and productivity experiments are listed in Table II.

After station E5, the R.V. Challenger entered French waters and deployed two deep current meter moorings, 116 and 117, which were accompanied by deep CTD profiles (stations 2 and 3) at positions 46° 54'N, 06° 48'N and 45° 46', 07° 35'W, on 28.6.88 and 29.6.88 respectively. (all mooring positions and mooring details are given in Table III.) On completion of the current meter moorings an acoustic survey of the slope region was undertaken on 30.6.88 to examine the scattering layer in the vicinity of the critical region for the generation of internal tides on the upper slopes at about 300-400m depth over a tidal period. A productivity experiment was conducted in conjunction with the acoustic survey. The next two days were spent on a line between 47° 34'N 06° 36'W and 47° 21'N 06° 39'W carrying out CTD tidal yoyo stations 5 and 6, water bottle sampling and zooplankton net sampling.

On the evening of Saturday 2nd July the vessel's work was interrupted by bad weather, with westerly winds increasing to 35-40kts, which prevented the recovery of the moored marker dahn buoy used for maintaining position at C.T.D. tidal yoyo station 6. When the weather moderated slightly the following morning, a search of the area indicated that the buoy had sunk and R.V. Challenger steamed southwards towards station 117. Two deep tidal yoyo stations (7,8) were completed on the 4th and 5th July at positions 46° 40'N 07° 08'W and 46° 19'N 07° 14'N and a further productivity experiment was conducted in conjunction with CTD tidal yoyo station 7. Towards the end of station 8, on 5th July, a soliton packet composed of two internal waves penetrating to 140 m depth was observed at about 2200 hrs and ships radar observations showed that these waves were propagating to the South. An XBT, ADCP and acoustic survey of this phenomenon continued until midnight.

On 6th July R.V. Challenger left French waters and headed towards the Spanish coast. As a result of the time lost because of the bad weather it was decided to forego the proposed port call at Santander and substitute instead a call, for the change of personnel, in the Isles of Scilly. In accordance with these considerations the two proposed shelf current meter moorings near Santander were repositioned nearer the main working line. These shallow moorings, 118 and 119, were laid during the evening of 6th July, a little later than planned as the vessel was delayed en route for two hours (having to standby the M/V Westmoor which had lost all power).

On completion of the Spanish long term shelf moorings, R.V. Challenger turned north once more, continuing CTD, profiling, zooplankton and water sampling and entered French waters near mooring 117 at 1700 hrs on Thursday 7th July. C.T.D. tidal yoyo station II started at 1749 hrs and continued until 0400hrs on Friday 8th July. On completion of C.T.D II, a box search was made for current meter mooring 117 which was recovered successfully by 0800 hrs on 8th July. This was then followed by a productivity experiment, which was completed at 1522 hrs, and the deployment of an Argos satellite tracked drifting buoy which was drogued at a depth of 35m and released at position 45° 54.6'N 07 30.2N at 1819 hours. R.V. Challenger then steamed southwards to recover mooring 116. Mooring 116 was recovered on the morning of 9th July at 1142 hrs after some difficulty as a result of the mooring line snagging the dual frequency acoustic fish on the post quarter. R.V. Challenger continued northwards towards the Isles of Scilly for the personnel transfer, stopping only for a zooplankton net station at 1700 hrs. The vessel left French waters on Sunday 10th July at 0200 hrs at position 49° oo'N 06° 35'W and arrived in Crow Sound at 1022 hrs on Sunday 10th July. In the Crow Sound Pete Mason disembarked and Andy Jones joined the Scientific party. Exchange of personnel and port formalities were soon completed and R.V. Challenger was once more, underway on passage at 1148 hrs Sunday 10th July. Zooplankton net sampling was carried out at 1700 hrs at 50° 19'N 07° 20'W and after further water bottle sampling the vessel proceeded towards the position of mooring 114, which was deployed in the Porcupine Sea Bight on Challenger Cruise 18/87. Arrival at this position was delayed by westerly gale force winds and it was not until Monday evening the weather moderated sufficiently to allow a successful recovery of mooring 114 which was completed by 0536 hrs on Thursday 12th July at position 51° 41'N 12° 03'W.

After an unsuccessful attempt to locate mooring 115, R.V. Challenger steamed to mooring 112 position at 50° 47'N 11° 24'W and this current meter rig was recovered at 1832 hrs on Thursday 12th July. Mooring 113 was located overnight but found to have lost its buoyancy. After an unsuccessful grappling exercise, the vessel headed south east carrying out an ADCP survey along the Celtic sea continental shelf on Wednesday 13th July. Zooplankton net sampling was conducted at 1700 hrs and at 2100 hrs course was set for Plymouth. The vessel arrived at Plymouth pilot station at 0554 hrs on the 15th July 1988.

4. MOORINGS AND INSTRUMENTATION

Mooring operations on this cruise can be decided into four categories:

1. Deployment and recovery of an intensely instrumented short term subsurface mooring.
2. Deployment and recovery of a subsurface current measuring mooring with widely spaced current sensors.
3. Deployment of two long term (1 to 2 year) subsurface shelf slope current measuring moorings.
4. Recovery of four long term (10 month) subsurface shelf slope current measuring moorings.

The availability of instrumentation and buoyancy from IOSDL and RVS Barry this year meant that some compromises to the proposed designs had to be made.

Instrumentation losses and commitments throughout the year greatly reduced the scope of the short term deployments and resulted in the original proposal of 5 long term deployments being reduced 2.

1. MOORING 116 PML - ALLOCATIONS # 475 IOSDL

A short term subsurface mooring instrumented with current and temperature sensors from 7 m to 3357 m above sea floor in 4834 corrected metres of water.

The mooring design called for accurately positioned sensors relative to the sea floor rising to the maximum height dependent on sensor availability.

Given mooring line availability at IOSDL the previous year's kevlar K222 deployed on moorings, Challenger 18/87 450 and 451, was used as the basis of the design. This line was thoroughly inspected and remeasured at IOS for the cruise. Further kevlar was purchased of a different type, KT3 tested on long term mooring 435 Faroes Bank Channel, to extend the mooring to suit available instrumentation.

Distributed buoyancy was used on the line in the form of glass spheres mounted on 3/8" chain. These spheres were positioned to give optimum buoyancy during mooring deployment and to provide sufficient buoyancy in position and for recovery.

The quantity of buoyancy required exhausted all IOS stocks which required reduction in numbers of the original design down to a minimum acceptable level. This meant that failure of any spheres would put the mooring into a marginal recovery situation. Accordingly all spheres were most carefully inspected for any possible flaws before deployment, two units being rejected onboard.

All instrumentation packages were 'in line' with thermistor loggers mounted on through load bars fabricated at IOSDL.

The thermistor cables were attached by plastic cable grips at approximately 2 metre intervals along the kevlar line.

All Aanderaa instrumentation was modified to provide restricted range high resolution temperature functions. These units could not be precalibrated at IOSDL as much of this instrumentation has been turned around at very short notice from mooring arrays in West Porcupine and Faroes Bank Channel. Scaling of the ranges was achieved using a Vishay resistance box to simulate the Fenwal thermistor and high quality resistors to adjust the temperature range (WR14b, WR15b). Accurate calibrations are to be carried on return to IOSDL.

The EG & G VACMs were set up and recording at IOSDL and shipped to Challenger cased and sealed. This is not the normal procedure but due to restricted space and time there was no reasonable alternative.

Deployment

The mooring system was deployed buoyancy first from the trawl deck of Challenger using the vessel's auxiliary winches loaded with 'tensioned on'mooring line. The winch tail wires were replaced with 22m diameter polypropylene rope to prevent damage to the lightweight mooring lines wound onto these ropes.

Stopping off to insert instrumentation was achieved by a running line from a deck eyebolt which could be passed through the outboard mooring shackle and secured to permit 'breaking of the joint.

This system worked very well but during deployment the mooring line running from the high 'A' frame sheaves often proved difficult to pull down to deck level, necessitating the use of a boat hook.

This handling problem was successfully overcome by attaching a Boss snap hook on a 1.5 m line to the deck eyebolt with the mooring line clipped in. Thus the line was always kept at a handleable level. This method is probably preferable to using a running block as the hook is light, easy to adjust and unclip at shackle joints. However care must be taken to ensure that the load remains within reasonable bounds and that the angle formed by the diversion is not too severe as to damage the mooring line.

This method also improved the thermistor cable attachment as when clipping on to the mooring line it proved relatively simple to keep sufficient tension on the string whilst clipping on. With both mooring line and thermistor cable passed through the Boss hook the two were thus guided together, clipping on being done outboard of the hook.

The release unit and current meter were deployed using a slip line which allowed transfer of the towing mooring to the anchor on deck.

The anchor of scrap chain was then lifted outboard on a slip rope attached to the winch tail and lowered into the water.

The mooring was then towed to position manoeuvring with the mooring mostly astern. When on position the slip rope was cut through, allowing the anchor to free fall.

Mooring descent was monitored using data obtained from acoustic command release unit and transponder displayed on the PES. Initial descent rate 3 m/sec slowing to 1.4 m/sec as the mooring tension, drag increased.

The mooring was observed to 'bottom out' and by observations of the acoustic transponder, height/depth of the transponder could be determined and hence an estimate of mooring height and water depth obtained.

Mooring recovery

The release operation was carried out successfully. However rise rate was considered slow at 0.24 m/sec. This had been anticipated to some extent due to the restrictions on buoyancy and drag of the mooring.

The pickup buoy was observed with some difficulty at the surface with the main buoyancy just beneath the surface.

On attempting to retrieve the buoy on the starboard side, the mooring went under the ship and the pickup buoy fouled the Cort nozzle. The main buoyancy appeared on the port side and the line between grappled. This line was cut and two eyes made, one attached to the main buoyancy which was then hauled in by auxiliary winch, the pickup buoy line being tied off for later recovery. The main buoyancy was recovered easily but on attempting to haul the top ACM inboard it became apparent that the mooring had fouled around the tow cable of the multi-frequency echo sounder fish which was being lifted by the mooring line.

The mooring was payed out to allow the weight of the fish to come off and the fish was then recovered. It was found that the mooring line was lying across the top of the fish which when rotated at sea surface permitted the mooring to come free. The fish was then recovered as damage was noticed on the towing cable.

Mooring recovery then proceeded normally with the thermistor chains being easily stripped off the line, a sharp tug being required to spring the clips off.

The recovery buoy was freed after the mooring had been recovered and hauled inboard undamaged.

Instrumentation

ACM 3622	No rotor on recovery fouled on fish cable.
TL602/TC1537	Flooded TL, possible failure of acoustic transducer. Some recording tape had run which was washed in distilled water then dried.

Otherwise all instrumentation appears to have performed normally.

Mooring observations

Deployment of this mooring proved relatively straightforward. Personnel involved were all experienced in similar types of operations and a simple 'team' structure fell easily into place.

Recovery of the mooring was hampered by the rig fouling the overside multi-frequency fish and Cort nozzle. This was overcome and once normal operations commenced no significant problems arose.

Buoyancy in the system should be increased as the recovery visibility was marginal. With a very slow rise time this could be very critical in areas of high current shear where mooring drag would prevent surfacing.

MOORING 117 PML - ALLOCATED # 476, IOSDL

A short term mooring instrumented with Aanderaa current meters from 7 m to 2981 m above sea floor in 4800 m water depth.

The mooring was all fibre line, the majority of which was prestretched polyester accurately measured on Discovery Cruise 169.

Mooring buoyancy was all glass spheres semi distributed on the mooring line, more as an aid deployment to reduce instrumentation loading and to provide 'drag' to pull out the line when deployed buoy first.

The Aanderaa current meters were all modified to provide expanded resolution temperature functions.

29-06-88 Deployment was as mooring 116 and was carried out with no problems.

08-07-88 Recovery proved straightforward, relocation both acoustically and visually on surfacing was normal.

Grappling and retrieval of the mooring line was successfully achieved by grappling midships and allowing the rig to carry clear, well out from the ship and around to the stern.

Instrumentation

ACM 7063 Timing appears to have jumped or drifted 2 or 3 minutes.

ACM 6456 Lower rotor pivot loose in end cap may cause 'sticking' of the rotor. Recorded values should be closely scrutinised.

MOORING 118 PML - ALLOCATED # 477 IOSDL

A long term mooring instrumentated with Aanderaa current meters at 50 m, 500 m, 750 m above sea floor in 970 m water depth.

The mooring was all fibre line of the KT3 type successfully tested in the Faroe Bank Channel from 1987 to 1988. Swivelled at buoyancy and acoustic release with pressure balanced swivels.

Buoyancy was steel spheres chained together and swivelled.

06-07-88 Deployment

Anchor first method was employed to permit accurate positioning of the mooring on steep shelf slope. All mooring lines pretensioned onto the port auxiliary winch by taking turns around the securing cleats on the main 'A' frame. Stopping off to insert instruments was achieved by using the starboard auxiliary with a Boss hook to permit fast attachment. With the spheres in the water supported by a cut/tow line the mooring was towed to the correct depth determined by PES. Release of the mooring was by cutting through this tow line using a sharp knife. Descent to sea floor of the anchor monitored by acoustic release on the PES display. Descent rate monitored at

1.6 m/sec.

MOORING 119 PML - ALLOCATED # 477 IOSDL

A long term mooring as 118 with instruments at 7 m and 252 m above sea floor supported by a steel buoyancy sphere.

Deployment method as 118.

Descent rate monitored at 2.45 m/sec.

MOORING 112 PML - ALLOCATED # 453 IOSDL

Recovery 13-07-88

Deployed as a long term mooring Challenger Cruise 18/87 18-9-87.

Relocation and release was achieved successfully with the mooring rising to the surface within half a mile of the ship.

The mooring was successfully grappled and the buoy hauled inboard on the recovery line. This line was 14 mm polypropylene rope normally used on much lighter weight buoys but with a sea state of 4 to 5 and light instrumentation weight recovery was within safety limits.

Jacket damage was observed on the upper lengths of kevlar with much abrasion and green paint on the jacket. The lower polyester ropes were also similarly abraded with far more severe damage on the lowest length. Here the outer braid was completely destroyed and the mooring was thus only supported on the inner braid. With the then very light load the strength remaining was just within safety limits.

On investigation this damage could be attributed to deployment, the green paint being evidently from the winches used on deployment. poorly tensioned fibre resulting in melting of the fibre causing localised weakness and breaking of the outer braid.

Instruments

ACM 7401 and 7643	Timing within limits. All data tapes run. Battery voltages in excess of end of life.
ACM 7643	Severe corrosion apparently crevice type beneath damaged paint coating on stainless steel spindle reducing diameter by 50%.

Conductivity sensor nor orientated correctly 90° to water flow.

Biological fouling

The subsurface steel sphere and upper instrument, no observed fouling.

The length of mooring line immediately above the lower ACM was fouled with hydroids up to 40 mm in length in two isolated patches at 40 m and 45 m above sea bed. This growth was cut out and preserved for future identification.

Similar growth 10 mm in length on the lower ACM stainless steel and C/R titanium parts.

MOORING 114 PML - ALLOCATED # 454 IOSDL

Recovery 13-07-88, Deployment 19-09-87

Recovery as 112. No damage to the mooring line observed. At first this appeared to contradict the evidence of 112 which was so severely damaged. However, on investigation from deployment notes it was apparent that this mooring had been deployed buoy first and 112 anchor first. Hence low load and deployment of 114, high load on 112.

The mooring recovery line was again 14 mm but with 5-6 sea state well within safety limits.

Instruments

ACM 7451 and 7765	Timing within limits. All data tapes run. Battery voltages in excess of end of life.
ACM 7765	Severe corrosion of stainless steel spindle rod of similar type to that observed on 7643 but in one location above suspension gimbal a deep vertical cleft of corrosion.

Biological fouling

The subsurface buoy was fouled with immature scallops 10 mm across with 2 per 150 mm square.

The mooring line had isolated anemones attached at approximately 30 m spacing from the subsurface buoy as far as the lower 50 m of kevlar, i.e. 550 m depth, the dimensions being 17 mm diameter, 16 mm height.

ACM 7765 had hairy fouling on the pressure case and spindle rod up to 10 mm in length with the C/R titanium having similar fouling up to 20 mm in length.

MOORING 113 PML - ALLOCATED # 452 IOSDL

Deployed 18-09-87, Recovery Attempt

Located on position with the Acoustic release unit indicating tilt, i.e. mooring on its side, buoyancy lost. A dragging attempt was made with no contact on the mooring. Site abandoned.

This site was checked on Discovery 173 07-05-88 at which time numerous trawlers were observed in the vicinity. The mooring at this time was detected on its side.

Mooring suspected trawled. Trawling pattern observed 07-05-88 appeared off shelf as far out this site. It would thus be possible for the trawl warps to cut through the kevlar line rather than drag the mooring off site as would happen with a steel wire mooring line.

However this mooring was deployed anchor first as 112, which could cast some doubt as to the integrity of the system above the C/R, ACM combination chained to the mooring anchor.

MOORING 115 PML - ALLOCATED # 455 IOSDL

Deployed 19-09-87

No acoustic contact made with this mooring. 12-07-88 after box pattern search. This confirmed the lack of contact when site check Discovery 173 08-05-88.

Site abandoned with no drag attempt made as no acoustic target. This loss must be presumed either total acoustic failure or trawling taking mooring off site. Failure of the mooring line could only occur above the C/R as the unit was chained to the anchor. Failure at this point would be highly improbable.

5. <u>Mooring Acoustics</u>

Short term deep moorings in Biscay - 116 and 117: Both moorings used special versions of the CR 200 deep water acoustic command release, one of which was built during the early days of this cruise (no other serviceable units being available). The special modification to these releases consisted of the addition of transistor switches in series with the firing contacts of the electro mechanical relay used to trigger the release mechanism. The modification was necessary to prevent premature firing due to the high mechanical vibration experienced by the release during the initial descent phase of buoy first mooring deployments; this was expected to be particularly bad on these moorings due to the high drag of the mooring components. Both units had their operating bandwiths and firing characteristics tested at their planned deployment depths and temperatures while attached to the CTD frame during two deep CTD casts (4700 m). Both units used stainless steel mechanical assemblies rated to 1000 kg safe working load. Initial descent rates were about 3 metres per second. Deployments were for 11 and 9 days as required by the scientific programme. Both units used twin retractor release units for recovery and performed normally.

Both moorings were fitted with standard 10 kHz transponders in the top sections. These were required to provide a direct measure of range so they were also used to check the stretch of the moorings and to position CTD stations relative to the moorings.

A third transponder was built on the cruise and suspended 500 meters below a dhan buoy anchored to the sea bed. This was used to assist the positioning of a CTD YO-YO series and illustrated the problems associated with holding a ship in a fixed position over the ground while maintaining a vertical wire for a CTD system deployed to full ocean depth 3000 metres); after 5 hours the ship has moved from the required 1000 metres range to 4500 metres. After 18 hours the system was recovered and transferred to a deeper site for another series of CTD YO-YOs. During this station the weather blew up requiring recovery of the CTD and contact was lost with the transponder. 16 hours later we began searching for the transponder, which was detected at a range in excess of 6000 metres. During the subsequent homing in process the range could not be decreased below that of the seabed echo - that is the transponder was lying on the seabed. The site was then abandoned.

Long term shallow moorings on the Spanish shelf edge: Two serviceable shallow CR 200 sea units were available for these two moorings, a third could have been built on board (with a day's delay in the programme) if either had proved faulty. On unit was recovered after a year in the Faroe Bank Channel just 5 weeks before the start of this cruise, and both units were successfully used on short term experimental moorings during that cruise (the ATTOM pair). Both units were thoroughly checked and repowered during the early part of this cruise. Both units were simultaneously tested for operating bandwith and firing function at 2000 metres depth and 4°C on a CTD cast before deployment. Both units were fitted with 1000 kg titanium mechanics and twin pyrolease release units. Both moorings were laid on steep slopes so acoustically navigated boxes were worked to establish probable final deployment depths (~970 and 510 acoustic metres).

Long term moorings in the north of the Porcupine Sea Bight: Four moorings were laid on the shelf break during Challenger Cruise 18/87. An attempt was made to relocate these during a transit leg of Discovery Cruise 173; two were found in position and upright, one was in position and on its side (60° tilt firmly indicating), and fourth had vanished - a box search was carried out to no avail. The same situation was found on this cruise.

Moorings 453 and 454 both used deep CR 200 units moored in about 1000 meters, were located easily and recovered normally. Isolated pockets of corrosion on the aluminium pressure cases, none on the titanium, extensive hydroid growth over all the surfaces but none likely to impede release. The set of RVS titanium used on 454 was returned.

Mooring 455: This used a shallow CR 200 unit owned by RVS. The nominal position and depth were occupied transmitting alternately on both sea unit channels. A box search covering approximately 9 square nautical miles was worked again transmitting alternately on the two channels. No contact was made so the site was abandoned.

Mooring 452: This used a shallow CR 200 acoustic packaged owned by IOS and a set of titanium release mechanics owned by RVS. It was located in position with 60° tilt firmly making. It was decided to attempt to drag for whatever was left of this mooring; this could be from a minimum of a 2 metre current meter and release package attached by a 10 metre strop to the anchor to a maximum of the full mooring including imploded buoyancy.

Dragging for Mooring 452: Dragging in depths below 200 m in general poses a variety of problems in addition to uncertainty over target size. Principally these are lack of accurate real time navigation (Transit is useless in this type of application) and uncertainties of drag line position and behaviour. Weather, time, topography and ship facilities also impose further constraints.

At this site ideally a dhan buoy mooring fitted with an acoustic transponder would have been deployed about 1000 metres from the best estimate of the target's position; this would have given the bridge a fixed reference to line courses up with and enabled an accurate plan of ship's track over the ground to be established acoustically. The weather did not allow this option.

A simple dragging philosophy was adopted as the target was known to be on the seabed. The basic idea was to repeatedly tow the grapnels smoothly through the target position using a plot of topography and the acoustic beam passes to gradually refine the accuracy of the runs. Tow large grapnels were deployed at the end of 300 metres of old trawl warp; this was then connected to the main towing warp by a short length of chain from which was hung a depressor weight; twice the water depth of towing warp was then paid out and a target towing speed of 2.5 knots. To maintain a smooth tow courses were originally run parallel to the contours. Five tows were run parallel to the contours but by the fourth the deteriorating weather had resulted in a large upwind wire angle between drag line and ship; that is the drag line was not following the ship's track over the ground. The sixth run was considerably off the intended course as well as being accompanied by heavy rolling so it was changed half way through to a correcting upwind course to a position selected on the topographic map built up on the previous runs. The subsequent run downwind produced the straightest tow and closest approach of the night however the attempt to run a reciprocal course was totally thwarted by the weather (35 knot winds and 10 metre swell). The drag line was recovered without incident and further attempts abandoned.

<u>Acoustic monitoring of scatterers - instrument performance</u>

Three echo sounder systems operating at four frequencies were used to monitor the vertical position of scattering layers with varying degrees of success.

Datasonic dual frequency system (lent by ARE:) Previous attempts to use this system had been unsuccessful but prior to the cruise the faults were isolated to overrun the system to run until other unrelated problems intervened. The system comprises two completely separate echo sounders housed in the same rack using separate cores of a common cable to drive separate transducers in the same towfish. The towfish used was a standard IOS PES design using a standard 110 ft tow cable; this posed a problem both in deployment where the cable had eventually to be laid carefully on an auxiliary winch barrel or rather small diameter and in deployment depth. The depth at zero ship's speed was 30 metres and underway about 20 metres thus scatterers occurring at ranges less than the surface overlapped confusing interpretation. The display provided by ARE (a tow channel EPC) had a faulty marking amplifier, time and likely available spares did not allow its repair so two single channel displays provided by RVS were used. One of these displays failed after several days but as the high frequency (123 kHz) was not picking up any scatterers although tracking the seabed and deployed instruments to ranges of 400 metres its use was discontinued. The 50 kHz sounder tracked the seabed and deployed instruments to ranges of 750 metres and some scatterers; it was used continuously until the towfish was recovered on the run to the Scillies.

On recovery of the towfish the towing cable was found to be badly damaged; two lengths of fairing were damaged and the cable badly kinked and scarred. This probably occurred due to the hydrographic wire plus 'bongo' net fouling the cable when the ship fell off the wind and overran the cable during several bongo net stations. Several bongo nets had red and white plastic bits (fairing clips) in the cups and finally the bongo net was lost when it fouled something under the ship.

Simrad medium frequency sounder (~30 kHz): For the early part of the cruise the handbook was mislaid and so the signal settings were far from optimum resulting in poor performance. When it was discovered and the deck unit properly aligned it produced some very good records. The acoustic transducer was deployed on the end of a pole amidships on the starboard rail and while it proved perfectly adequate acoustically it makes mooring recovery difficult and potentially disastrous.

IOS precision echo sounder mark III (10 kHz): The standard systems worked reasonably throughout the trip. The plot Mufax was only used briefly being inaccessible due to the sea of computing equipment. The main laboratory Mufax experienced a number of problems associated with its age and the degree of maintenance possible nowadays; a helix motor bearing started moving in its housing, the spring pressure on the sacrificial writing edge required major adjustment, the take up roller mountings required adjustment and a bulb went in the optical trigger circuit. The towfish cable was damaged by long lines near the Spanish shelf edge; temporary repairs were made using fibreglass tape and replacing 3 white and 12 red fairing clips - this repair survived a violent storm in the latter part of the trip but in the long term the cable will require replacement.

Special system: For several extended periods the laboratory Mufax was used only as a display unit, the transmission and reception of signals being handled by a special version of the IOS Acoustic Command System Mk IV deck unit. There were several reasons for this. Primarily it greatly eased the location and recovery of moorings both because of the command facility in the deck unit and the special low noise receiver fitted which has much better rejection of electrical noise than the standard system; equivalent to a 12 db improvement in obtainable signal to noise. It also allowed a second facsimile display to be driven in parallel - the Waverley thermal facsimile; this has extra facilities enabling among other things a greatly expanded view of scatterer movements.

<u>Comments on other ship's equipment</u>

Em logs: In the early part of the cruise this played some strange tricks - 10.5 knots with the ship stopped, 0 knots with the ship at 10 knots, self retraction of the EM log head - all these disappeared after the control unit's cards were removed, inspected and firmly replaced?

Transit navigator and Weather fax units were both cleaned with no apparent change in performance.

CTD wire has damaged and missing strands at around 3700 metres for 200 metres; these were retaped and carefully monitored during all hauls.

Ship's (RVS) pingers: One unit was fitted with 60° tilt during the latter part of the trip.

6. Acoustic Doppler Current Profiler

Once again the Doppler Profiler (software version 2.34, RVS deck unit) produced high quality data in both deep and shallow water, and output was to the PDP/PSTAR system, which enabled contour plots to be obtained.

The main drawback with this version of the software was that it has so far proved impossible to input navigation data directly to the IBM PC, and, where required, it was necessary to merge the navigation with the ADCP data on the PDP. This, however, had the advantage that the deck unit was pinging nearly continuously rather than waiting for, say 30 seconds in each ensemble period (3 minutes) for the navigation fix to come in. The other defect of note with this system was that the transmission of weather reports on the HF radio caused the software to crash with a "profiler not connected" message. The system could then be re-booted by switching the IBM box off and on. The problem once diagnosed, was rectified by sending the weather reports via SATCOM.

A recent improvement is the ability to reset the Doppler clock by using a DOS diagnostic disc (supplied by G. Griffiths), so that the time was kept accurate to within about 5 secs. Throughout the cruise. Also, following Discovery cruise 174, a method was discovered (by J. Perrott) of increasing the maximum bottom tracking depth to over 700 m. This was achieved by setting the second parameter in the DC menu to FB00003.

Configurations were set up as follows:

aln 50 (25 x 2 m) bins, aln 100 (50 x 2 M), aln 200 (50 x 4 m), aln 400 (50 x 8 m), aln 600 (75 x 8 m), and rdp 100 (25 x 4 m), all bottom tracking; also, alnsurf (50 x 4 m) and alndeep (75 x 8 m), both water tracking. The configurations rdp 100 and alnsurf were found to be particularly suitable for studying velocities near the thermocline.

Typically, percent good data was 40% for aln 50, 50% for aln 100, 70% for aln 200, 95% for aln 600 (with 60 pings per ensemble (ppe)), 70% for rdp 100 (80 ppe), 90% for alnsurf (330 ppe), and 95% for alndeep (125 ppe). The maximum bottom tracking depth observed was 766m, and the ship's heading as recorded by the ADCP agreed with the ship's gyro to typically ±0.5° (after averaging over a 1 minute interval).

7. ARE Surface Thermistor

This was deployed as early as practical in the cruise (28.6.88) from the port bow, as far forward as possible. The thermistor, suspended from a length of positively buoyant rope, was made to tow in the first breaking wave of the ship's bow wake. The data, sampled at 1 Hz, was logged on a spare BBC system, which had also been set up to show the data graphically.

Whilst on deck in direct sunlight, the thermistor recorded a constant 17.92°C (obviously the maximum measurable temperature), but when surrounded by crushed ice the temperature fell to close to 0°C. During deployment, the temperatures recorded with the system seemed to be about 0.03°C warmer than the ship's thermosalinograph (at a depth of 3 m). We deduce that the in-built calibration was reasonable, and note that the maximum temperature was only rarely limiting. However, the thermistor would occasionally be lifted clear of the water by the ship's motion (i.e. in rougher weather), and this would cause a negative temperature spike, presumably due to evaporation.

On 3.7.88, after about 5 days continuous towing, the system failed in rough weather (force 8), and delivered a steady temperature of 17.92° (the true water temperature being 16.4°C, from the thermosalinograph). The probe was recovered when the weather allowed and the thermistor needle was found to be slightly bent (possibly due to the rotation of one of the cable ties).

The back-up surface thermistor was cable-tied to the rope in place of the original and deployed on 7.7.88. Initially, it recorded stable temperatures which appeared to be about 0.2°C low. By 9.7.88, after some 30 hours towing, the recorded temperature was seen to be oscillating unphysically (e.g. -2°C, 15°C, 7°C for consecutive readings), and this time no rough weather had occurred since deployment. The temperature became stable when the probe was recovered (14.30°C rising slowly to 17.92°C, presumably on drying out), but failed again on deployment, this time reading mostly -2.15°C, with occasional excursions up to higher temperatures (e.g. 10°C0.

The cause of the above problems is unknown, but water-logging of the probes would seem to be a candidate.

8. Data collection and processing

Data during RRS Challenger cruise 31 was logged on two major computer systems and a variety of smaller dedicated systems. The RVS levels A/B/C system was used for navigation, CTD data capture, and some surface nutrients. Displays of the CTD data were produced on the pen plotter in the form of time and depth plots.

Also installed was a PDP11/34 computer running under the operating system RSX11-M. The PSTAR suite of programs (Pollard R.T 1983) was used to collect, display and archive data. It was necessary to include the PSTAR system as the Level A/B/C computer cannot in its present configuration log the Acoustic Doppler Current data or perform the essential task of contouring CTD and ADCP data.

CTD Data reduction

Data from the RVS CTD (Neil Brown Instrument Systems) were passed at the rate of 16hz to a level A microcomputer, where editing and reduction (Pollard 1986) to a 1hz rate with output in the ship message protocol (SMP) format took place. The data was displayed for the operator of the CTD by RVS programs running on a BBC computer. The SMP CTD messages are captured on both the Level B/C system and by the PDP11/34. Raw data is held on the PDP as RSX11-M data files with a new file starting on the odd hour. Each two hour record is converted to PSTAR format. Initially the program used to perform this task, LEVAIN, failed because the SMP expected was for the IOSDL CTD but the RVS CTD produced extra variable fields. A modification of LEVAIN was used to produce the PSTAR data files. The data was subjected to the following programs from the PSTAR suite:

DGPRES to remove data cycles with anomalous pressure values

PCOPYA to remove unwanted variables, (up and down irradiation)

CTDCAL using the best calibrations known in files BARILEVA

PLOTHP to plot the data as a time series, to identify errors

PEDITA, PEDITB and PSPIKE in the combination needed to remove errors

PARCH at the raw and at the corrected data stages to save the data on magnetic tape that can be later read on the PSTAR system at DLIOS.

The calibrated data files were appended together (PCOPYA,PAPEND) for the period of the CTD YOYOs usually greater than 14 hours, extra variables sigma-p sigmat and potential temperature derived (PEOS83) and the data averaged onto various grids (PGRIDS) for contouring (PCONTR). The plotting had to be done on the HP plotter, as using the Calcomp though much faster resulted in occasional random pen movements.

ADCP Data collection

The acoustic doppler current profiler was run continuously during the cruise. The data, in the form of three minute averages were displayed graphically on the console and logged on the hard disc, and hence archived to floppy disc files. As with the CTD, the ADCP data were captured by the PDP computer as two hour files by the program PADPIN and archived to tape (PARCH). The data consists of east and north components of velocity relative to the ship, the return echos being averaged into bins typically of 4 m depth each. Extra data for each ensemble including temperature and, when in bottom tracking mode, the vessels' velocity relative to the bottom were obtained (ADPBOT). The two hour files were joined in suitable sections (PCOPYA and PAPEND) and archived. At this stage the raw data is relative to ship velocity. Program ADPREL was used to produce velocities relative to a selection of depth bins, usually those between 100 and 200m. When on shelf in bottom tracking mode, data was merged with the bottom velocities (PMERGE) and PARITH used to obtain velocity relative to the bottom. The data was clipped to remove excessively large values and then averaged onto a depth time grid and contoured (PEDITA, PGRIDS and PCONTR). The relative and gridded files were archived as PSTAR data files.

9. Conclusions

This was a tight but successful cruise, with the scientific work benefiting from the full cooperation of the ships' officers and crew. The main scientific objectives of the cruise were fully met.

10. Table I

DAY	Date 1988	Time	Position	CTD station	Dips	water depth acoustic metres	CTD depth
179	27/6	1446 1505	49°06.1'N 06°29.8'W	1(E.5.)	1	125	103
180	28/6	0910 1236	46°54.1'N 06°48.3'W	2	1	4180	4322
	29/6	- 0657 1115	45°46.8'N 07°34.8'W	3	1	4800	4920
182	30/6	0906 0935	47°28.7'N 06°31.1'N	4	1	470	450
183	1/7	0120 1750	47°17.0'N 06°40.0'W	5	5	3109	3093
184	2/7	0510 1730	47°02.5'N 06°43.2'W	6	4	4147	4186
186	4/7	1352 0501	46°40.0'N 07°07.8'W	7	6	4499	(4607)/2336
187	5/7	0938 2323	46°18.8'N 07°14.3'W	8	7	4701	2489
188	6/7	1417 1616	44°27.1'N 07°07.5'W	9	1	4815	1935
189	7/7	0700 1048	45°05.4'N 07°21.6'W	10	1	4742	4868
189 190	7/7 8/7	1749 0358	45°51.5'N	11	3	4785	4909
192	10/7	1729 1744	50°18.0'N 07°20.4'W	12	1	110	92

11. Table II

Water Sampling Stations

Date	Position	
27.6.88		
1437 - 1855	49° 06'N 06° 29'W	Z, W
28.6.88		
2004 - 2041	46° 58'N 06° 49W	Z, W
29.6.88		
1753 - 1851	46° 09'N 07° 21'W	Z, W
30.6.88		
0801 - 0837	47° 27'N 06° 28'W	L
1018 - 1610	47° 30'N 06° 36'W	P
2012 - 2025	47° 33'N 06° 38'W	W
2035 - 2043	47° 33'N 06° 38'W	Z
1.7.88		
1722 - 1750	47° 18'N 06° 41'W	W
2101 - 2238	47° 32'N 06° 39'W	Z, W
2.7.88		
1730 - 1810	47° 03'N 06° 43'W	Z
3.7.88		
18.00 - 1812	46° 33'N 07° 38'W	Z
4.7.88		
0815 - 0833	46° 38'N 07° 07'W	L
0851 - 0858	46° 38'N 07° 07'W	W
0902 - 0920		Z
1015 - 1509	46° 38'N 07° 07'W	P
5.7.88		
0810 -	46° 19'N 07° 13'W	Z
1708 - 1728	46° 19'N 07° 14'W	Z
1730 - 1857	46° 19'N 07° 14'W	W
6.7.88		
1701 - 1722	44° 20'N 07° 05'W	Z
7.7.88		
1200 - 1254	45° 12'N 07° 23'W	L
1700 - 1720	45° 50'N 07° 32'W	Z

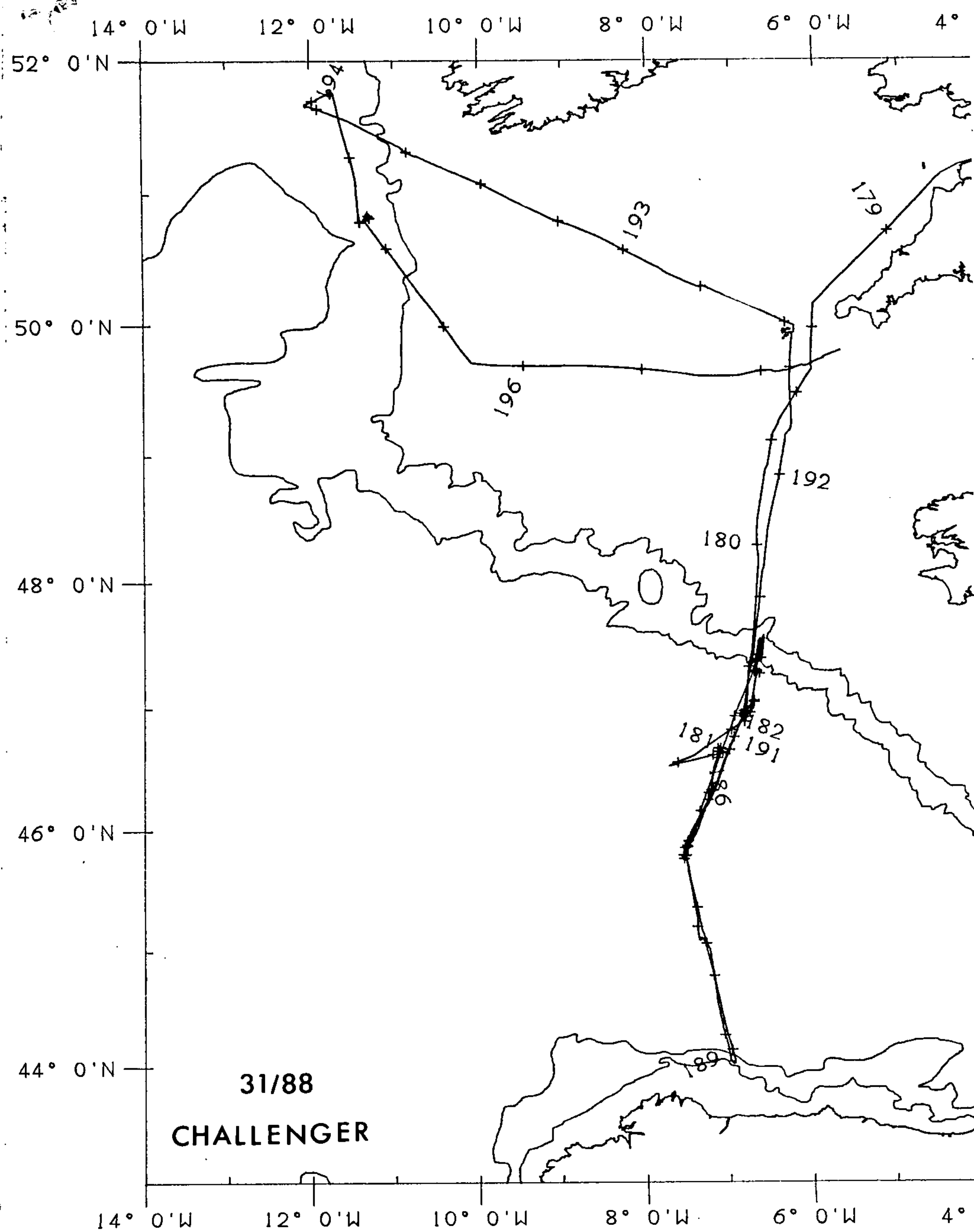
Date	Position	
8.7.88		
0916 - 1522	45° 51'N 07° 31'W	P
1659 - 1725	45° 54'N 07° 30'W	Z
9.7.88		
1701 - 1725	47° 48'N 06° 39'W	Z
10.7.88		
1700 - 1719	50° 19'N 07° 20'W	Z
1730 - 1915	50° 18'N 07 21'W	W
11.7.88		
1700 - 1724	51° 17'N 10° 44'W	Z
12.7.88		
1700- 1718	50° 48'N 11° 26'W	Z
13.7.88		
1708 - 1726	50° 02'W 10° 26'W	Z

P Productivity experiments
Z Zooplankton sampling with nets
W Water sampling and collection.

12. Table III

Mooring Number Depth	Date Deployed	 Recovered	Equipment	Depth off Bottom m
112				
960 m 50° 47.4'N 11° 24.5'W	18.9.87	12.7.88	ACM 7401 ACM 7643	499 8
114				
1000 m 51° 40.5'N 12° 02.6'N	19.9.87	12.7.88	ACM 7451 ACM 7765	499 8
116 4200m 46° 56.5N 06° 49.0W	28.6.88	9.7.88	ACM 3622 ACM 7517 ACM 7947	3389.5 2899.5 2657.5
			10khz TRANS- PONDER	2655.5
			TL 925] TC 1402]	2495
			ACM 7948	2184.5
			TL 879] TC 1388]	2085
			TL 691] TC 1392]	1910
			ACM 7946	1719.5
			TL 772]+ TC 1403]	1620
			VACM 627	1305.5
			TL 602]+ TC 1537]	1206

Mooring Number Depth	Date deployed	Recovered	Equipment	Depth off Bottom m
			VACM 429	649.5
			TL 806]	549.5
			TC 1536]	
			VACM 666	203
			VACM 629	50.5
			ACM 4738	7
			C/R 2417	5
+ no useful data				
117	29.6.88	8.7.88	ACM 5228	2980
			ACM 3308	2533
4824			10khz TRANS-PONDER	2532
45° 48.0'N			ACM 8250	2087.5
07° 31.3'W			ACM 7063	1534.5
			ACM 6750	1010
			ACM 6456	510
			ACM 2109	7
			CR 2438	5
118	6.7.88		ACM 5908	752
980 m			ACM 7945	501
44° 02.1'N			ACM 3624	50
06 58.7'W			AR 2462	48
119	6.7.88		ACM 6942	253
505m			ACM 3311	7
44° 01.0'N			AR 2416	6
06° 57.2'W				


14° 0'W
12° 0'W
10° 0'W
8° 0'W
6° 0'W
52° 0'N
50° 0'N
48° 0'N
46° 0'N
44° 0'N
194
193
179
196
192
180
182
181
191
189
31/88
CHALLENGER