INSTITUTE OF OCEANOGRAPHIC SCIENCES
WORMLEY, GODALMING, SURREY

R. R. S. DISCOVERY
Cruises 56 and 58

30 October - 7 November 1973
and 5 December - 15 December 1973

INTERNATIONAL COMPARISON OF TIDAL PRESSURE SENSORS
NORTH BAY OF BISCAY

I. O. S. CRUISE REPORT No. 4

(Issued February 1974)

INSTITUTE OF OCEANOGRAPHIC SCIENCES

WORMLEY, GODALMING, SURREY

R.R.S. DISCOVERY

CRUISES 56 AND 58

30 OCT - 7 NOV 1973

AND 5 DEC - 15 DEC 1973

International comparison of tidal pressure sensors

North Bay of Biscay

I.O.S. CRUISE REPORT No. 4

(Issued February 1974)

Index

Objectives

The cruises were entirely devoted to an international exercise organised by SCOR/IAPSO/UNESCO Working Group no. 27 on 'tides of the open sea' (Chairman, D.E. Cartwright, IOS). Most of the organisations in the world which use or have developed a pelagic sea bed pressure sensor were invited to compare their instruments in close proximity for a recording period of a little more than a month. Since some instruments were designed for oceanic depths, while others were restricted to shelf depths, the testing area was chosen to be near a steep shelf-edge within easy reach of Brest (from which port some possible assistance from a French naval hydrographic ship was planned). The deep sensors were to be placed on the Meriadzec Terrace - position B, depth 2200 m - and the shelf sensors near the edge of La Chapelle Bank - position A1, depth 180 m - about 60 n. miles distant. At a late stage of negotiations, the 'Service Hydrographique et Oceanographique de la Marine' offered to supply a sensor which was limited to about 150 m, and so a third position - A2, depth 140 m - was added, another 60 n. miles nearer Brest along the line BA1. Allowances can be made for the small differences in the amplitude and phase of the tide between the three positions. The object was, however, not only to see whether the instruments gave comparable results, but also for mutual comparison of the many techniques for recording, mooring and recovery which were covered by the various instruments. Parallel to the sea-going exercise, meetings were held at IOS Wormley to discuss methods of analysing tidal records of about one month's duration.

As far as RRS 'Discovery' was concerned, the main activity for cruise 56 was to lay the instruments in the appropriate positions, and for cruise 58 to recover them.

Organisations and brief details of their equipment

Deep sensors

1. University of California (IGPP, La Jolla)
   Hewlett-Packard crystal pressure and temperature sensors in single compact 2-sphere unit, with elaborate acoustic data transmission to ship for monitoring purposes. Explosive bolt and solenoid release systems, controlled by coded acoustic signalling, and by 'back-up timer'.

2. National Ocean Survey (NOAA), Rockville, Maryland.
   'Filloux' bourdon tube, adapted to 'Rustrak' recorder, mounted in single sphere. Release from heavy tripod base by AMF system, using separate syntactic float unit for additional buoyancy.

3. Centre Oceanologique de Bretagne (CNEXO), Brest.
   Vibrating wire sensors recording temperature and differential pressure against Nitrogen pressure reference. Miniature cassette tape recording. Current rotor adapted from Aanderaa system. $3\frac{1}{2}$ km nylon ground line, buoyed every 500 m, with anchor, AMF release and Corning glass spheres for recovery.

Shelf sensors

4. Institute of Oceanographic Sciences (Bidston).
Multi-sensor package in heavy protective cage, including two Hewlett-Packard crystals and 'Vibrotron' wire, with crystal temperature control. Recording on 22-channel computer-compatible tape developed by 'Marconi'. Single acoustic 'command pinger' for homing-in, but no buoyant release device. Recovery from $1\frac{1}{2}$ m toroidal surface buoy attached to 1000 lb anchor and via 500 m steel warp ground line to main capsule, which also has a small dan buoy directly above it.

5. Institute of Oceanographic Sciences (Wormley).
Capacitance-plate and strain-gauge sensors with platinum thermistors, recording on Normalair-Garrett tape deck in single sphere capsule, which provides all necessary buoyancy. IOS (Wormley) acoustic command pinger and release system. A deep strain gauge sensor package was also intended for the experiment, but was not available at the proper time.

6. Marine Sciences Directorate (Ottawa).
Bellows transducer recording differential pressure against air reference supplied by external rubber tyre system and timed isolating valves. Registers on paper tape. Stainless steel unit strapped to 500 lb concrete block. 500 m polypropylene groundline (buoyant), weighted at 100 m intervals, to chain anchor weight, AMF release, and IOS-supplied buoyant cylinder 50 m below surface. Two Canadian assemblies were brought, one of which was moored in the shallowest site, A2.

7. Service Hydrographique et Oceanographique de la Marine, Brest.
A vibrating wire, similar to 3, but without backing pressure. Photographic digital recording, controlled by electronic storage system, in heavy metal frame. 500 m steel groundline, chain anchor, AMF release, buoyancy from 24 metal pellets.

Scientific Personnel

	Cruise(s)
IOS (Wormley)	
D.E. Cartwright (Principal Scientist)	56, 58
D.I. Gaunt (Principal Engineer)	56, 58
P.G. Collar	56
R. Spencer	56, 58
T.J.P. Gwilliam	56, 58
A. Madgwick (Photographer)	56, 58
W. Strudwick (Computer operator)	56
J. Smallbone (Computer operator)	58
IOS (Bidston)	
L.M. Skinner	56, 58
J.B. Rae	56, 58
NOAA (Rockville, Md)	
C.A. Pearson	56, 58
W. Iseley	56
L. Iseley	56
University of California/Nova University	
F.E. Snodgrass	56, 58
M. Wimbush	56, 58
Marine Sciences Directorate (Ottawa)	
G.C. Dohler	58
L.F. Ku	56, 58
M. Baron	56
Centre Oceanologique de Bretagne (Brest)	
J.L. Hyacinthe	56, 58
M. Auffret	56
M. Perchoc	58
Service Hydrographique et Oceanographique de la Marine (Brest)	
A. Quelen	56
M. Gournay	56

Narrative - Cruise 56

Southampton was chosen as the port of departure, to facilitate contact with IOS Wormley for the benefit of the many scientists joining from abroad. Laboratory- and deck-space and most of the heavier items of hardware had been organised in advance by Mr Gaunt. 60 Hz transformers were wired to some labs. for those groups which required mains power at that frequency. Most groups spent 4-7 days prior to sailing in assembling their gear and generally 'settling in'. By the day of sailing, the after deck was filled with an impressive array of underwater units in varied designs and colours.

We left Southampton 1400/30 Oct, and proceeded at full speed to Brest (24 hours' passage), where the French personnel joined with their equipment. In the evening of 31 Oct, the scientific party with the 1st mate were conducted round the new CNEXO (COB) laboratories near Brest. The following day, M. 1'Ingenieur en chef Pierretti, head of the tidal branch of SHOM, visited the ship.

We left Brest 1500/1 Nov, and proceeded overnight to the furthest station B. PDR Fish launched 1645. Since 'Decca' was useless at night (see notes on navigation), each of the three working areas had to be reached soon after sunrise and fixed by dan buoy. Work on the mooring sites, all about 3 miles from the dan, could then proceed by radar, with satellite fixes as checks on dan position as they appeared. Dr Laughton's large dan buoy with radar transponder was used for this purpose. This was first launched about 0900/2 Nov. We started to launch the NOAA apparatus at 1030 in order to clear the considerable area of deck space which it occupied. The first attempt was abortive, since a AMF release unit 'fired' accidentally when it hit the side of the ship. The mooring array was therefore brought inboard, and the Snodgrass/Wimbush capsule launched in its place at 1130. An hour spent on acoustic monitoring confirmed that it was recording satisfactorily, at least initially.

By 1345/2 Nov we were ready to relaunch the NOAA capsule in the second of the three positions round site B. The launch was apparently successful, but acoustic checks at 1425 suggested a leak or some faulty signalling (later found to be due to water in an electrical plug), so the whole array was brought on deck again. Retrieval, without firing the release and thereby losing the basal tripod, was possible because a mooring line was initially buoyed up with surface floats, but the whole operation was difficult and even hazardous in the 3 m swell, and gave credit to Dick Burt and the Bosun. The whole mooring was inboard by 1640.

While the NOAA team were diagnosing their fault, we prepared to launch the COB capsule in its place. This was a fairly lengthy operation, since $3\frac{1}{2}$ km of nylon groundline had to be paid out by hand with the ship proceeding at about 1 knot, before the anchor and release assembly were finally lowered. The laying operation took about an hour, and by 2120 acoustic tests proved the AMF release 'active'.

We then proceeded to the 3rd position on the 3' radius circle centred on the dan buoy at B, for another attempt with the NOAA mooring. This time, the mooring assembly was simplified by removal of the line to the surface floats. The mooring was merely released and allowed to 'free fall' to the bottom. The operation proved satisfactory and by 2345/2 Nov the mooring was pronounced OK. By 0130/3 Nov the dan buoy was recovered and its position confirmed by a final satellite fix.

At 0215/3 Nov the first site was revisited for final acoustic tests on the Snodgrass/Wimbush capsule, but instead of acoustic signals, radio signals were being transmitted from the surface, showing that the capsule had released itself from the bottom and was now freely floating. It was soon located from its antenna and flashing light, and brought inboard by 0250, not without some damage to its protruding current sensors. The cause of release was found to be a small leak due to a fragment of hair caught in the main O-ring seal, which automatically activates the releasing circuits. We decided to proceed with the next day's moorings then return for a relaunch, thus giving ample time for overhaul.

The dan buoy was relaunched in the A2 position (La Chapelle Bank) by 1010/3 Nov. We first dealt with the IOS (Bidston) capsule, which required a good deal of wire laying and preliminary winding of wire on to the winch. By 1230 the anchor and large surface buoy were moored; by 1410 the sensor capsule and its dan buoy surface attachment were away. During the latter operation, the dan's radar reflector was accidentally knocked off under the ship's hull. The recorder was monitored for a further half hour by means of a direct cable connection to the ship which was finally cut adrift.

The IOS (Wormley) capsule took the least time of all moorings. It was lowered into the sea at 1555; by 1605 it had been released to the bottom and its command pinger switched off.

The third mooring at the A2 site was one of the two Canadian capsules, which again required some time and difficulty in paying out its rope groundline, at the same time manoeuvring the ship to avoid tension in the rope. The whole operation took from 1810 to 2005/3 Nov.

The dan buoy was recovered 2145. Satellite fixes on laying and recovery differed by about a mile. Fixes during the day suggested that the first fix, on laying the dan, was most likely to be erroneous, since the rest were close to the last value.

Having dealt with the three moorings at A2, we then returned overnight to the first B position (satellite fixes without dan buoy) to relaunch Dr Snodgrass's capsule, which was ready again with a spare ballast frame. The casule was released into the water at 0927/4 Nov, and a first sequence of acoustic tests ended satisfactorily at 1030. To safeguard against a repetition of the episode of 2-3 Nov, we arranged for two further periods of acoustical monitoring, at about 1500 and 2130. There being no signs of a leak or any other malfunctioning by 2150, the capsule was deemed safely moored. At other times during the same day, the COB and NOAA sites were checked acoustically, and some 600 metres of nylon cord was wound onto the winch for the SHOM mooring the next day.

During the night of 4/5 Nov the weather, so far very moderate, worsened to wind force 6/7. It was not feasible to lay complicated groundlines in such winds, so on arrival at the last mooring area A1, we had to heave-to for some hours to wait for the wind to subside. It was considered unnecessary to lay a dan buoy here, because day-time Decca was reckoned to be more reliable than in the other areas. By 1300/5 Nov the wind had dropped to 22 knots, so the operations for laying the SHOM mooring were started. The most complicated operation, paying out 500 m of steel groundline by hand from the deck with the ship keeping about 1 knot on constant heading, was accomplished without trouble, and the only mishap was the parting of a double nylon cord, causing the release and anchor assembly to free-fall instead of being lowered gently to the bottom.

The second Canadian mooring was exactly similar to the first, and was carried out without mishap between 1540 and 1650.

During the whole day's operations (5 Nov), 'Discovery' appeared to be 'shadowed' by a Russian vessel which maintained about 3 miles distance during all manoeuvres, and made no reply to radio calls. The same pattern was repeated during the recovery operations in December, with a different Russian vessel. Their significance is unknown, but could possibly be associated with the fact that the Canadian capsule was never seen again, and the SHOM release assembly was recovered about a mile from position with its steel cable parted. On the other hand, there were numerous trawlers seen later in the area, which could have been responsible for wrecking the moorings.

Having laid all moorings, we proceeded to Brest (arrived 2200), where the French and some other scientists left the ship for a speedy return home. 'Discovery' finally reached Barry at 0600/7 Nov.

Narrative - Cruise 58

In order to make maximum use of the allotted time, to allow for bad weather and possibly difficult recoveries, we left Barry on the early morning tide of 5 Dec, and proceeded directly to area B, arriving mid-morning of the 6th. We aimed first for the NOAA position, since NOAA had an AMF range and bearing indicator, which could detect from some miles away. The capsule was soon contacted, released from the bottom, and its buoy sighted at the surface. The mooring was inboard by 1215/6 Dec.

Having confirmed our navigation by the NOAA position, we then turned to the Snodgrass/Wimbush capsule, which again contacted perfectly, released, and was inboard by 1435.

After these two early successes, however, nearly the whole of the rest of the cruise was beset with difficulties, in spite of remarkably good weather for the season. The COB capsule responded acoustically with the appropriate 'released' signal, but it was soon apparent that it had failed to rise to the surface, presumably because of some mechanical defect or rope entanglement with the anchor. The pinger's position was located

with the towed hydrophones, fairly close to the estimated lay position, and by 1810 we had launched a dan buoy, which satellites later showed to be 1' south of the pinger position. Our first drag operation (using a pinger to keep hooks 40 m from the bottom) was wasted because we had not yet enough fixes to confirm this 1' error in dan position. Our second, 2310/6 to 0155/7 Dec, went very close to the AMF pinger, judging from the acoustic signals. There were signs that the rope had been caught, by a marked rise in the drag-pinger position and in the tension, but if so, it released itself again before reaching surface. At 0200/7 Dec we retired, to give the Netman and winch driver some rest.

At 0800/7 Dec, the radio officer reported some occasional 'swishes' at the COB surface transmitter frequency of 27.045 MHz. These were not repeated, and were later thought to be pick ups from the radar transmitter. The bottom pinger was still detectable, and everything pointed to its being still on the sea bed. We fixed it again with towed hydrophones, obtaining a triangle of error, and at 1020, started a circular drag path about $\frac{3}{4}$ mile radius round the centre of the triangle. By 1400, the dan buoy could no longer be seen on the radar, making the last $\frac{1}{4}$ circle rather dubious in navigation. We thought this was due to the rising wind, which had reached Force 6-7, but on hauling in the drag line we found some dan buoy wire caught in the hooks, showing that we had fouled the dan buoy mooring.

A second dan was launched 1900 and supposedly fixed by satellite. A fourth drag operation, using Gifford grapnels along the bottom, lasted 1930-2330/7 Dec. It was fruitless, but satellite fixes received during this time gave erratic estimates of the dan buoy position, so the line traversed by the drag was dubious. After this, we gave up the COB capsule until later, and proceeded towards the A2 area. The captain advised us not to attempt to recover the dan buoy, since winds were near gale force.

Heavy rolling on the NE course prevented progress during the early morning of the 8th, and we had to spend several hours hove-to. About the same time, it was noticed that the E/M log, which had behaved suspiciously from the start, was now giving speeds of 27 knots, and so spoiling the satellite fixes. J. Smallbone therefore altered the computer program to feed 'zero speed' into future satellite fixes, so we then had to heave-to for any reliable fix.

At 1600/8 Dec the weather had abated sufficiently for the course to be resumed. We reached the IOS (Bidston) mooring site at 2230. There was no sign of its surface buoy lights, and we failed to switch on its command pinger. (The surface buoy was later reported brought to Concarneau by a French trawler, and we now think the pinger scroll may have been buried in the sand). In view of the uncertainties in navigation, we decided to wait until good Decca fixes could be obtained in the daylight.

At 0950/9 Dec, after some further negative searches for signs of the IOS (Bidston) capsule, we tried the IOS (Wormley) site. Both pingers were soon switched on, the capsule released, and the capsule sighted by 1050 in good visibility with low swell.

The fact that it was first sighted about 2 miles away, with the ship in the supposed lay position, gave us our first suggestion that Decca was even less reliable than it is supposed to be in this area in December. The IOS (Wormley) capsule was inboard by 1210.

We then turned to the Canada site near A2, hoping for an early recovery before starting a rigorous search for the Bidston mooring. There was no certain response to the AMF signals, but soon after they were transmitted a faint pinger was detected on the Mufax. On tracking this pinger with hydrophones, it was found to be located some 4 miles away from the Canada lay position, and also 3 miles from the Bidston position. It was a very powerful source, and had the wrong repetition rate for either pinger. A dan buoy was laid 1755. After some hours spent on acoustic tests, we decided it might be a 'red herring', and went back to the Canada mooring area and conducted a pattern survey, transmitting and listening. After 5 hours of negative results, we gave this up, and returned to the dan buoy. On arrival, at 0200/10 Dec, the pinger was found to have stopped! This could be the AMF system run out of power, or the pinger could have belonged to another agency. (The Russian ship, mentioned under Cruise 56, was definitely working in the area). 0330 to 1000/10 Dec was spent dragging round the dan buoy, with no result, other than catching a very old piece of submarine cable. We now felt it was time to start dragging for the IOS (Bidston) mooring, so we moved to that area with careful checks on navigation. After further fruitless acoustic searching, a drag pattern was started 1440, rather complicated by tidal currents and obvious wandering of the Decca signals. At 1835 1 ton tension was registered, and about the same time the Bidston command pinger suddenly switched on. The capsule was recovered by its steel groundline, and was inboard by 1955/10 Dec.

The company was considerably heartened by this recovery, after so many hours of fruitless searching, so we set to for another drag pattern, in the Canada lay area. The dan buoy was left in position because well fixed, and sea conditions were calm enough to see it by radar at 6-7 miles. The bottom drag lasted 2140/10 to 0350/11 Dec, and produced nothing more than some more pieces of old cable and other sea bed debris.

0900 to 2000/11 Dec was spent in the area of the second Canada mooring, at site A1. Results were entirely negative, with no acoustic response. A bottom drag at 1345 brought up (without damage) a telegraph cable which did not look particularly old. To avoid catching this again, the drag line was thenceforward kept off the bottom with the aid of a pinger. The groundline of the mooring is buoyant, so would be caught up by such a drag if there; the ship could also maintain a greater speed (3-4 knots) and cover more ground.

The SHOM mooring laid at A1 during cruise 56 was to be recovered by a SHOM ship out of Brest, so did not concern 'Discovery'. We later heard that it had been only partially recovered, in damaged condition.

The COB release had been timed to fire at 1100/12 Dec, so it was appropriate to return to area B and spend some more time dragging there, listening for surface radio transmission, etc. We had a calm day, and the utmost care was spent in navigating with the greatest possible precision. Between 0830 and 2330/12 Dec, we traversed the lay position of the $3\frac{1}{2}$ km groundline three times with bottom and off-bottom drag hooks. On at least two occasions there were certain signs that the line had been caught, but it slipped off or otherwise escaped before the long trawl warp had been brought inboard. The mooring was finally abandoned, and the dan buoy recovered by midnight, in order to try the two Canada sites again when their 'back up releases' fired at 1100/13 Dec.

The dan buoy which had been left at A2 (6 mm mooring wire and 800 lb anchor chain) was still there on arrival 0600/13 Dec, but it disappeared during the first few hours of dragging, possibly because of the rising sea, possibly because of trawlers. We abandoned it, and navigated as well as possible by Decca. Relays of watchers were kept on the bridge to look for float released by back-up timer, while an off-bottom drag pattern was kept up in the lay area. At 1520, the search was abandoned, and we proceeded to the A1 Canada position. A similar search was kept up here between 2030 and 2230/13 Dec, with the look-out parties searching for the flashing light in Force 6-7 winds and rising sea. The result was again negative. During the day, the Gifford grapnels, pinger, and 100 metres of trawl warp were lost when the drag line caught in some rocks.

'Discovery' arrived at Brest at 0530/14 Dec, where the remaining French equipment was unloaded and 5 scientists left the ship to return home. There was a possibility of taking on board the Bidston buoy, which was being brought from Concarneau by van, but this would have entailed a few hours' wait, and the ship's company were eager to catch the Saturday midday tide at Barry. We therefore left Brest 0700 and proceeded at full speed through heavy weather, to reach Barry docks by 1100/15 December.

Notes on navigation

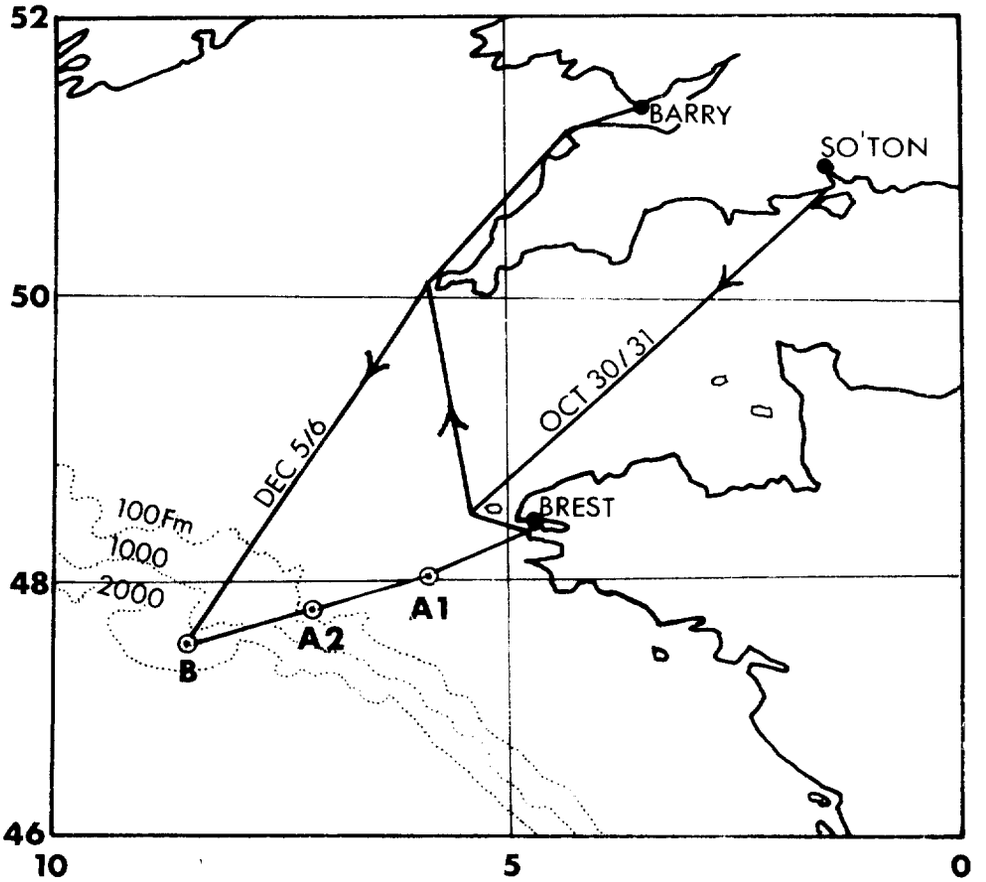
The laying and recovery of the moorings, and especially the dragging operations, depended critically on accuracy of navigation. In fact satellite fixes were our principal use of the computer. Particularly useful were the forecast lists of times of satellite passes, since the necessity to heave-to or keep on a steady course during the 20 minutes or so necessary to establish the fix frequently determined the overall plan for a manoeuvre. The value of the satellite fixes however depended on the signal from the E/M log, and it was unfortunate that this became completely unreliable during the December cruise. The remedy adopted, to feed zero speed into the computations, was not very satisfactory, since it was not always convenient to heave-to at the appropriate time, and even so, the process was often invalidated by strong currents, giving the ship a non zero ground speed. For the very tight manoeuvring involved in some of the dragging operations, we found there was no adequate substitute for detailed hand-plotting (by a scientist) of radar bearings, with reference of all satellite

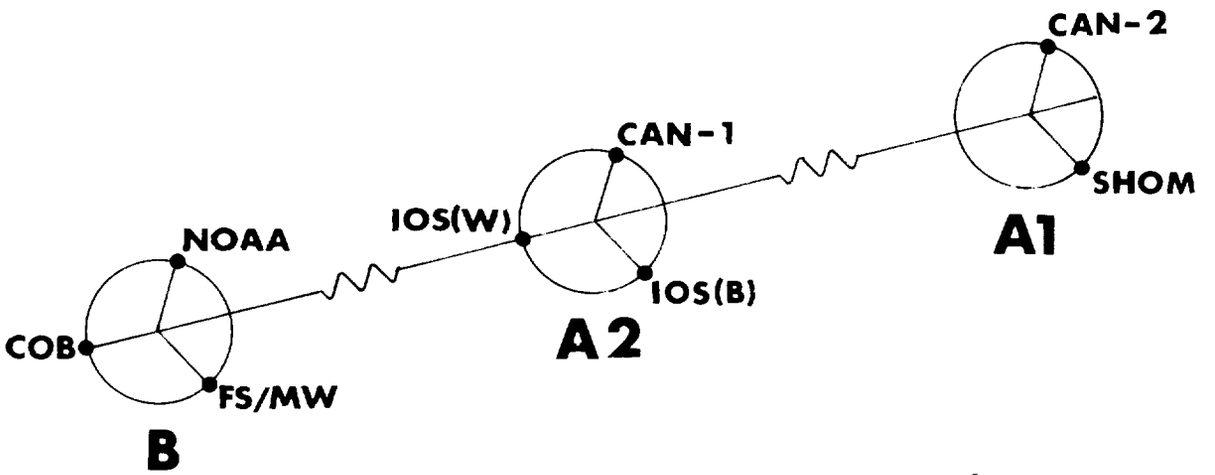
fixes to the dan buoy position. It is also significant to note that the officer on watch on the bridge has too many other duties to perform to be able to carry out the more detailed plots adequately.

Decca Chain 1B (SW British) is generally reckoned to be fairly reliable in daylight hours in our areas of work, although the official handbook quotes typical errors of 0.5 miles in winter months. In fact, after several suspicious anomalies, a close plot of Decca alongside radar bearings near a well fixed dan buoy in area A2 revealed fluctuating errors of between 0.5 and 1.5 miles during the period 1100 to 1500/10 Dec, which is normally supposed to be trustworthy. The errors were in the Decca signals themselves, since we had two independent Decca receivers together, giving essentially identical readings. There was no question of the dan buoy having drifted.

Station numbers and mooring positions

'DISCOVERY' STATION NUMBER	OWNER OF MOORING	TIME OF LAUNCH	DEPTH (M)	CAPSULE POSITION R - DECCA - G	ANCHOR POSITION DECCA	BEARING OF ANCHOR RE CAPSULE
8462	SNODGRASS/WIMBUSH	NOV 4 0927 Z	2160	47°26.8' 8°26.5' F8.16 F30.15	-	-
8463	C.O.B.	NOV 2 1931 Z	2175	47°28.6' 8°34.7' F5.46 F32.41	47°28.1' 8°33.3' F6.19 F31.94	0.8' 120°
8464	N.O.A.A.	NOV 2 2259 Z	2010	47°32.2' 8°29.0' F4.35 F32.04	-	-
8465	I.O.S.(B)	NOV 3 1300 Z	165	47°43.7' 7°05.0' F23.4 D44.4	47°44.0' 7°05.2' F23.1 D44.5	0.3' 324°
8466	I.O.S.(W)	NOV 3 1605 Z	171	47°45.0' 7°14.0' F19.28 E30.51	-	-
8467	CANADA-1	NOV 3 2005 Z	164	47°49.9' 7°8.0' F18.0 D47.6	47°49.5' 7°7.8' F18.42 D47.36	0.5' 170°
8468	S.H.O.M.	NOV 5 1344 Z	129	47°57.6' 5°46.8' H00.30 B40.55	47°57.6' 5°47.1' H00.17 B40.75	0.2' 270°
8469	CANADA-2	NOV 5 1648 Z	126	48°02.1' 5°50.3' G18.70 B43.70	48°02.5' 5°49.9' G18.35 B43.47	0.4' 040°





RADIUS OF CIRCLES - 3′
DISTANCE BETWEEN CENTRES - 60′