

B. O. D. S.

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I.O.S.

RV SARSIA CRUISE 15/75

27 MAY-6 JUNE 1975

TURBULENCE MEASUREMENTS ON THE SEA BED
CARRIED OUT IN START BAY, SW ENGLAND.

CRUISE REPORT NO 30

1975

**INSTITUTE OF
OCEANOGRAPHIC
SCIENCES**

NATURAL ENVIRONMENT
RESEARCH COUNCIL

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Institute of Oceanographic Sciences
Crossway
Taunton
Somerset

SCIENTIFIC STAFF

Dr K R Dyer (Principal Scientist)	27 May - 6 June
A P Salkield	27 May - 6 June
R L Soulsby	27 May - 6 June
M R Lees	27 May - 6 June
A D Heathershaw	1 June - 6 June
G Le Good	1 June - 6 June

SHIP'S OFFICERS

Captain E Dowell (Master)
C George (1st Mate)
I Jude (Fishing Mate)

OBJECTIVES

The main purpose of the cruise was to take measurements of the turbulence in the boundary layer close to the sea bed in areas of simple topography using electromagnetic flowmeters. In particular the intermittency in the turbulent momentum fluxes, the Reynold stresses, were to be examined at two levels in order to obtain data for a comparison with recently published laboratory work and for studies on sediment transport. Velocity profiles were also planned using an array of four rotor current meters and the bed shear stresses, calculated from the logarithmic profile using results averaged over one minute, would be compared with the Reynolds stress values. Additionally the turbulence data would be analysed for turbulent intensities, spectra, co-spectra and presented in the formats used by many other workers. An underwater television would be used for examining the water flow in the vicinity of the sensors, and to monitor changes in the form of the bed and sediment movement.

Experiments to measure the noise present near the sea bed in the frequency range of several kiloHertz to 400 kiloHertz were also to be carried out, as time permitted, to examine the contribution to the spectrum of the noise generated by the sediment when in motion.

Based on previous work seven positions had been chosen within Start Bay, a known area of fine/medium uniform sand with low shell content. It was anticipated that the areas would be rippled and that some of them would have small dunes present. The sands were expected to be mobile under extreme conditions.

RESULTS

The cruise can be considered as a qualified success since within the last two days of the cruise at least eight hours of almost continuous data of excellent quality was recorded. On the last afternoon, in particular, turbulence and velocity profile measurements were obtained from near slack water over the fastest run of the ebb tide, when sediment was visibly regularly moving. Two previous days of otherwise good data were marred by occasional patches of noise on the electromagnetic flowmeter records, that will make them difficult to analyse and interpret. At the beginning of the cruise trouble was experienced with EM flowmeters mainly due to water getting into several heads in succession, in spite of their being carefully chosen and tested, and also with electrical noise. Noise problems are

almost inevitable on board a ship for the first time and can only be removed by trial and error. They should be less disruptive on future cruises. Other problems with electrical noise were mainly the result of this being the first field use of a new and unproven EM electronic system. As the fundamental sources of noise have now been eliminated from the system they should not recur in future.

Measurements of self-generated noise gave inconclusive results since it transpired that system noise was too high.

The weather was generally reasonable. Easterly winds prevented the chosen experimental sites being reached during the first half of the cruise. Consequently stations in Bigbury Bay were occupied. As this was the initial phase of the cruise no real time was lost. Weather during the last few days was excellent though an occasional long swell from the south-west will provide some interesting problems of interpretation.

INSTRUMENTATION

The two Colnbrook electromagnetic flowmeter heads were mounted on a weighted frame between 1 and 2 metres above the sea bed, on the same pivoted vane as four Braystoke rotor flowmeters. These were spaced at logarithmically increasing separations starting about 15 cm above the bed. The rig oriented itself relative to the current flow on lowering and the sensors could be allowed to re-orient to short term fluctuations in current direction by unbolting the pivoted vane. The attitude and movement of the rig could be monitored with a pitch/roll sensor (inclinometer) and the underwater TV was set up so that the lowermost sensors and the sea bed just forward of the rig were within the field of view.

The main part of the EM flowmeter electronics was attached to the rig in an underwater housing. The preamplified output of all four channels was recorded on board ship on the Bell & Howell seven-track FM magnetic tape recorder and filtered signals displayed on the seven-track Bell & Howell ultra-violet recorder, together with the inclinometer outputs. The Braystoke flowmeter counts were recorded by averaging over one minute intervals by the PDP 8 computer controlled by a digital clock. The computer was also available for direct analysis of the incoming turbulent velocity data.

INSTRUMENT PERFORMANCE

Electromagnetic flowmeters

The electromagnetic flowmeters (Heads 28 and 31) had been calibrated on 19 May 1975 by towing through still water in the towing tank at Southampton College of Technology. Sensitivities of about 3.5 volts/m sec

were obtained. Head No 31 (a brand new head) leaked on being lowered to 29 m depth, though it had been satisfactory at 3 m. This became noticeable by the zero offsets increasing to 11 v and it caused an integrated circuit op amp in the amplifier stage to cease working. It transpired that the manufacturers had omitted to Araldite the cable gland into the junction box.

Head 31 was replaced by Head 24 which also leaked with immersion to depth. However this appeared to be water leaking into micro-cracks in the Araldite of the head around one of the electrodes, probably the result of machining the electrodes flush. Replacement of Head 24 by Head 21 proved unsuccessful as the head was eventually found to move on the shaft. An unnumbered head was found to be satisfactory.

Microphonic noise was experienced between the heads and the electronics housing which was removed by strapping the cable in tubing to the fin of the rig. Other electrical noise due to earth pick-up was eventually eliminated by connecting the braid of the signal cable to the 0 volt line which was in turn connected to the case earth, chassis earth and via a 10 F capacitor.

The most difficult fault to trace, however, was intermittent spikiness that appeared particularly on the Y channels. This was eventually traced to a PC board edge holder bearing on one of the tracks. This was happening on two boards in the underwater unit and affecting only the Y channel. After removal of the holders satisfactory results were obtained. Calibration in the towing tank at IOS Wormley gave very good comparison for Head 28 with the calibration prior to the cruise.

Braystoke flowmeters

These worked well throughout, though location of the reed switches seemed particularly sensitive.

TV camera

This also worked well and is proving extremely valuable for examining the sediment surface and both sediment and water movement. A 'pan' facility would be an extremely useful additional facility.

Inclinometer

This worked well, though it may not be the best way of monitoring movement of the rig because of its heavily damped response.

Underwater Rig

The rig performed reasonably well though several modifications will be needed before its next use. These include: a new instrument mounting to

give easier fitting and moving of sensors, a relocated TV mounting and a vane indicator of current direction within the camera view.

SHIP PERFORMANCE

Previous cruises with the same objectives had been largely unsuccessful because of inability of the ship to anchor sufficiently tightly not to drag the rig across the sea bed. On RV Sarsia a three point anchoring system had been devised using a heavy stern anchor and chain and two bow anchors. Laying of two bow anchors was considered practicable using the recently installed bow thrust propellor. RV Sarsia has proved to be a very good working platform for this type of experiment. The three point mooring system was adequate in even quite windy conditions and anchoring and raising the anchors could be done in less than twenty minutes. The ship was sufficiently stable for the experiments to be unhindered by dragging of the rig.

On one occasion the starboard anchor started dragging in a beam wind of Force 7 gusting 8, though the waves were only about 2 feet high. It was only then that the experiment had to be abandoned, in case the starboard anchor overrode the port one.

The wide side decks were convenient for storage and for laying out cables though there was some inconvenience in manhandling the rig over the side. The voltage regulator on the scientific supplies within the laboratory was most useful. The laboratory accommodation was slightly cramped, but proved adequate. A platform will be built to rest the rig on during later cruises to avoid fouling the stern anchor cables on deck.

ACKNOWLEDGMENTS

We are extremely grateful to Captain E Dowell, the Officers and crew of the RV Sarsia and to Captain M Perry, for their help and unstinted co-operation in making the cruise a success. Also we are grateful to Dr E Denton, Director of the Marine Biological Laboratory for permission to carry out this work on RV Sarsia.

APPENDIX I

Narrative

- Tuesday 27 May, The scientific party joined RV Sarsia at Millbay Dock, Plymouth at about 1330. The transport was then unloaded. K Dyer went to the Marine Laboratory to see Dr J Gilpin-Brown and clear the cruise arrangements. M Moore drove the Transit back to Taunton leaving at about 1500. The rig went in the water to test the electronics housing. The equipment was installed in the forward laboratory and setting up began. Knocked off at 2030. Overnight in Plymouth.
- Wednesday 28 May Overcast. Easterly wind Force 5-6. 0830 Sarsia moved out of the dock and moored portside to an outer berth. Setting up continued. The inverter for the teletype overheated and blew a fuse. At 1145 the rig went over the side to test the instruments. Two Braystoke rotors were not working. The rig was brought inboard at 1245 and at 1315 sailed for Bigbury Bay. Arrived Bigbury Bay 1500. The wind was Force 6 ESE and it was decided there was no possibility of anchoring. Returned to Plymouth berthing at 1715, mooring portside to. The rig was put in the water at 1830 and the EM flowmeter system fully checked out. Flowmeter offsets were of the order of 30 mV (1 cm sec^{-1}). The rig was lifted inboard at 2105 and the scientists knocked off at 2130. Overnight in Plymouth.
- Thursday 29 May Fine and clear. Wind ENE Force 4-5. 0830 Sarsia sailed from Plymouth for Bigbury Bay. Arrived at 1015 and commenced three point anchoring. Anchoring complete at 1045 at position Decca Green A37.52 Purple A58.51 (Lat 50 15.1'N 3°53.8'W) Burgh Island bearing 358° 1.45 miles. Depth of water 29 m. The rig with shrouds over the EM heads was put on to the sea bed, composed of flat rocks and sand, at 1120. The upper head (No 31), a brand new one, was giving an offset on both channels of 11V. Head 28, the bottom one, was giving

offsets of about $\frac{1}{2}V$. The rig was brought inboard at 1140 and there was a small amount of water in the head junction box of No 31.

Head 31 was replaced by Head 24. The offsets on both heads were now about 5V. At 2100 it was discovered that an integrated circuit op.amp in the amplified stage had gone down. Replacement of this lead to both heads working in the laboratory and on deck in a bucket. Knocked off 2230. Overnight anchored in Bigbury Bay.

Friday 30 May

Calm, clear, wind E Force 2-3.

0830 the EM heads were replaced on the rig and the offsets were between 30-160 mV. The shrouds were put on and the rig put into the water at 0930. The offsets were checked near the surface and on the bottom. The upperhead (24) offsets about trabled over the depth. The rig was returned to the surface, the offsets remaining rather high, but reasonably constant.

At 1920 the trouble was located with the upperhead 24. Sea earth gave a low resistance to one electrode and low resistance between coil and the same electrode. It appears that water must have leaked in around the electrode. Head 24 was replaced by head 21 at 2100, however this was noisy and it was eventually found that the head moved on the shaft. Head 21 was replaced by an unnumbered head at 2230 which seemed satisfactory except for several hundred millivolts of mains pickup.

Knocked off at 2345. Overnight in Bigbury Bay.

Saturday 31 May

Cloudy. Wind NE Force 4.

At 0830 the EM flowmeter electronics were stripped down and some connections resoldered. By 1300 both heads were going satisfactorily and mounted on the rig. At 1353 the rig was placed overboard at the sea surface and the outputs checked. Recording Run 204 started at 1354 and the rig was lowered to sea bed at 1359. The bed was of flat rocks with multitudes of fish visible on the TV. The X channels were in antiphase so one of them was incorrectly oriented. The rig bounced at 1432 and the TV camera twisted on the frame. Consequently the rig was lifted to the surface for inspection at 1435 and replaced on the bottom at 1444. After 1452 the flow was low and often came from behind the rig. The rig was frequently lifted and reoriented. At

1524 the cables pulled tight and the sheath on the inclinometer cable was damaged. The rig was brought up to mid-water and the Run 204 finished at 1528. The cable was mended.

At 1537 recording restarted (Run 205) and the rig was replaced on the bottom at 1543. The bottom was of silty sand and the tide was ebbing. Run finished at 1608. Anchors raised and left Bigbury Bay at 1700 for Dartmouth. Throughout Runs 204, 205 there were intermittent patches of noise on the EM flowmeters lasting from a few seconds to several minutes interspersed in the generally fairly satisfactory record. This was eventually traced to a microphonic noise in the cables. Docked Kingswear at 2030. Knocked off. Overnight in Kingswear.

Sunday 1 June.

Crew leave-day in Kingswear.

Between 0915 and 1145 the magnetic tape unit of the PDP8 was checked out, sleeving was put around the EM flowmeter head cables and they were screwed to the rig. A D Heathershaw and G P Le Good arrived at 1615 in the Land Rover and M R Lees left at 1745. From 1700 until 2100 the work of the morning was completed and two non-functional Braystokes made to work. Overnight in Kingswear.

Monday 2 June

Cloudy, wind SW Force 4.

Departed Kingswear 0815. Anchored position 1 in Start Bay Decca B Red 4.49 A Purple 76.03 NNE Start Point. Stern anchor chain bearing on rudder so re-anchored 1030 at position Red B 4.57 Purple A 75.76 in 11 m of water. Start Point lighthouse bearing 205° T at 1.15 miles.

1036 Rig placed overboard near surface with vane fixed.

Start of flood tide. Run 206 started at 1040. Rig lowered to sea bed at 1103. Sea bed slightly rippled sand and moving seaweed. Velocity about 25m sec^{-1} .

EM flowmeters noisier on the sea bed than in midwater.

Run continued with occasional lifting to reorientate the rig. The bottom Braystoke became fouled with seaweed and the earths of the system were experimented with to remove noise. Rig was raised to midwater at 1251 and EM outputs were much less noisy. At 1306 Run 206 was ended.

The rig was lifted inboard, the swivel taken out of the lifting cable and an electrical connection made between the cable and the rig. The rig was then placed on the

bottom at 1340. Run 207 commenced at 1347. The earthing system was then made up so that the braid of the signal cable was connected to the 0 Volt line which was in turn connected to the case earth, chassis earth and via a 10 F capacitor to the sea earth. This appeared to work satisfactorily and the run continued. Quite appreciable wave motion was apparent at the bottom with surface waves of 1-2' height. The rig lifted at 1447 and at 1510. The rig was lifted inboard at 1512 and recording finished (Run 207) at 1514. Intermittent noisy patches had again developed on the record. The electronics case was shorted to the rig and number 1 Braystoke rotor was replaced, the blade having broken on lifting inboard. The starboard anchor was dragging at 1540 and the wind had increased to Force 7 gusting 8 WNW. At 1558 the rig was put over with shrouds on for zero check, Run 208. The zero check finished at 1611, and the rig was lifted inboard at 1615.

Because of the worsening weather and the possibility of the starboard anchor dragging across the port one, the anchors were lifted at 1625 and the vessel sailed for Kingswear, berthing at 1830.

During the evening the TV camera support on the rig was relocated, the inclinometer was wired up so that the output could be recorded on magnetic tape and displayed on the UV recorder and computation exercises on some of the results were carried out.

Knocked off 2100. Overnight in Kingswear.

Tuesday 3 June

Cloudy, wind NW force 6.

Departure from Kingswear delayed until 1020 by visit of Captain to hospital. Anchored 1145 at Position 1 in Start Bay Decca Red 4.43 Purple 75.37 Depth 14 m.

Hydrophone for noise measurements fastened to rig and cables made in.-

At 1243 the rig was lowered to mid water with shrouds on for zero check. Run 209 started at 1245. Zero check completed at 1305. The upper head had large offsets.

The rig was lifted, the shrouds removed and put down on the sea bed at 1320. The tide was flooding.

Run 210 started at 1322. Again intermittent noisy periods and spikes on the EM outputs developed a while after immersion. Run 210 ended at 1450.

At 1453 everything on the rig was switched off for an examination of the sediment self-generated noise. There were a number of narrow frequency spikes particularly one at 350 kHz with a general noise background peaking at about 200 kHz. The rig was raised progressively towards the surface. The magnitude of the background noise decreased and the frequency became slightly higher. No sediment was visibly moving though there was seaweed in motion occasionally. At 1600 the EM heads were cleaned and the rig placed on the bottom. The flood flow was easing. Run 211 started at 1623. Wave motion was apparent on the Braystoke rotors and at the end of the run at 1653, there was virtually no flow. Occasional spikes were still occurring, mainly on the Y channels, developing about half an hour after starting a run. At 1820 the heads were again cleaned and the rig replaced on the bottom, which was rippled sand. The rig appeared to be on the slope of a small sand wave. Run 212 was started at 1835. The ebb current was about 20 cm sec⁻¹ and though the current was N-S, the movement at the bed as shown by moving weed, was E-W. The run ended at 1914.

The rig was raised and the heads rotated through 90° to see if the spikiness changed direction too.

At 1958 the rig was replaced on the bottom. The bottom was more regularly rippled than the last run. Run 213 started at 1959 tape footage 2088 feet.

Rig lifted and reoriented at 2011 tape footage 2144. The rig was almost on the crest of a sandwave trending about 45° to rig. Rig lifting at 2041 and at 2058 record became spikey again. Rig eventually lifted and Run 213 ended at 2115.

Knocked off 2200. Overnight Position 1 in Start Bay.

Wednesday

Fine and clear, wind S force 2-3. Low swell.

4 June

At 0745 the EM electronics was removed from the rig, the anchors were raised and the vessel left position 1 in Start Bay for Position 4. At 1000 anchored at position 4, Decca Red B 9.96 Purple B 58.05 Lat 50° 16.3' N Long 3° 34.3' W Depth 15 m. Two integrated circuits in the EM electronics were replaced and this seemed to remove the spikes. The electronics were replaced on the rig and the rig lowered on the sea bed at 1037. The rig appeared to be resting on the crest of a small sand wave possibly about 1½ m high. Tide ebbing. Run 301 was started at 1042. The run continued until 1227, with occasional lifting for reorientation. The current diminished to slack water at about 1210. Run 302 commenced at 1249, and ended at 1341, after spikiness again appeared on the vertical channels. After a cooling-off period Run 303 started at 1411, but the records

were still spikey. Run 303 finished at 1419. The rig was lifted and the heads cleaned. The rig was lowered again onto a bottom of fairly rippled shell and sand. Run 304 started at 1437. The general current speed was about 30 cm sec^{-1} , but the records were still spikey. The run ended at 1520, and the rig was lifted. At 1543 the rig was replaced in the water with the stem of the EM heads (sea earth) connected to the rig and the electronics tube not connected to the rig. The noise was much worse. Eventually the source of the noise was located as a PC board edge holder bearing on one of the tracks. This was happening on two boards and affecting only the Y channels. These holders were removed. At 1800 the anchors were raised and the vessel moved to Position 8 in Start Bay, deeper water where wave motion was anticipated at negligible. Anchored at Position 8 at 1900. Decca Red 12.05 Purple 66.15 Depth 33 m. The rig was placed on the sea bed at 2037. The bottom was an indistinctly rippled silty sand. Tide ebbing. Run 305 commenced at 2042. The rig was occasionally lifted and reoriented. Measurements of acoustic noise were also recorded between 2120 and 2200.

Run 305 finished at slack water at 0059 hours. Overnight anchored at Position 8, Start Bay.

Thursday

Mist and rain, wind S force 3-4.

5 June

At 0845 the anchors were raised and echo sounding was completed over Positions 8 and 4. At 1000 anchored off Slapton to put the cook ashore. Anchored at Position 1 at 1130 Decca Red 4.19 Purple 75.52. $50^{\circ} 14.3'N$, $3^{\circ} 37.9'W$.

Rig placed on bottom at 1139. Tide ebbing.

Run 401 commenced at 1202. Run continued with occasional lifting of rig and reorientation. Slack water occurred at about 1300. Tide then commenced flooding.

Run continued with occasional lifting and reorienting. After about 1500 sand started occasionally moving off the ripples in the foreground. It was noticeable how the bed movement appeared to be towards the east whereas the flow was S-N. The orientation of the ripple crests changed slowly to adjust to this movement. Large bursts of sediment movement occurred up to end of Run 401 at 1600. Acoustic noise measurements were taken at times during the run. The anchors were raised at 1630 and echo sounding was completed over Position 1 in fog. At 1705 sailed for Plymouth stripping down equipment on the way. Berthed in Plymouth at 2100. Overnight alongside at Plymouth moving to inner dock at 0130.

Friday Finished stripping down equipment, packing and loaded onto transport.
6 June K Dyer met Dr E Denton (Director of the Marine Biological Laboratory),
Captain M Perry and Captain E Dowell and discussed the performance of
the ship and the success of the cruise.
Left ship about 1100 and returned to Taunton.

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APPENDIX I

Narrative

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Wednesday 28 May

Overcast. Easterly wind Force 5-6.
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Thursday 29 May

Fine and clear. Wind ENE Force 4-5.
0830 Sarsia sailed from Plymouth for Bigbury Bay. Arrived at 1015 and commenced three point anchoring. Anchoring complete at 1045 at position Decca Green A37.52 Purple A58.51 (Lat 50 15.1'N 3°53.8'W) Burgh Island bearing 358° 1.45 miles. Depth of water 29 m.
The rig with shrouds over the EM heads was put on to the sea bed, composed of flat rocks and sand, at 1120. The upper head (No 31), a brand new one, was giving an offset on both channels of 11V. Head 28, the bottom one, was giving

offsets of about $\frac{1}{2}$ V. The rig was brought inboard at 1140 and there was a small amount of water in the head junction box of No 31.

Head 31 was replaced by Head 24. The offsets on both heads were now about 5V. At 2100 it was discovered that an integrated circuit op.amp in the amplified stage had gone down. Replacement of this lead to both heads working in the laboratory and on deck in a bucket. Knocked off 2230. Overnight anchored in Bigbury Bay.

Friday 30 May

Calm, clear, wind E Force 2-3.

0830 the EM heads were replaced on the rig and the offsets were between 30-160 mV. The shrouds were put on and the rig put into the water at 0930. The offsets were checked near the surface and on the bottom. The upperhead (24) offsets about trabled over the depth. The rig was returned to the surface, the offsets remaining rather high, but reasonably constant.

At 1920 the trouble was located with the upperhead 24.

Sea earth gave a low resistance to one electrode and low resistance between coil and the same electrode. It appears that water must have leaked in around the electrode.

Head 24 was replaced by head 21 at 2100, however this was noisy and it was eventually found that the head moved on the shaft. Head 21 was replaced by an unnumbered head at 2230 which seemed satisfactory except for several hundred millivolts of mains pickup.

Knocked off at 2345. Overnight in Bigbury Bay.

Saturday 31 May

Cloudy. Wind NE Force 4.

At 0830 the EM flowmeter electronics were stripped down and some connections resoldered. By 1300 both heads were going satisfactorily and mounted on the rig. At 1353 the rig was placed overboard at the sea surface and the outputs checked. Recording Run 204 started at 1354 and the rig was lowered to sea bed at 1359. The bed was of flat rocks with multitudes of fish visible on the TV. The X channels were in antiphase so one of them was incorrectly oriented. The rig bounced at 1432 and the TV camera twisted on the frame. Consequently the rig was lifted to the surface for inspection at 1435 and replaced on the bottom at 1444. After 1452 the flow was low and often came from behind the rig. The rig was frequently lifted and reoriented. At

1524 the cables pulled tight and the sheath on the inclinometer cable was damaged. The rig was brought up to mid-water and the Run 204 finished at 1528. The cable was mended.

At 1537 recording restarted (Run 205) and the rig was replaced on the bottom at 1543. The bottom was of silty sand and the tide was ebbing. Run finished at 1608. Anchors raised and left Bigbury Bay at 1700 for Dartmouth. Throughout Runs 204, 205 there were intermittent patches of noise on the EM flowmeters lasting from a few seconds to several minutes interspersed in the generally fairly satisfactory record. This was eventually traced to a microphonic noise in the cables. Docked Kingswear at 2030. Knocked off. Overnight in Kingswear.

Sunday 1 June.

Crew leave-day in Kingswear.

Between 0915 and 1145 the magnetic tape unit of the PDP8 was checked out, sleeving was put around the EM flowmeter head cables and they were screwed to the rig. A D Heathershaw and G P Le Good arrived at 1615 in the Land Rover and M R Lees left at 1745. From 1700 until 2100 the work of the morning was completed and two non-functional Braystokes made to work. Overnight in Kingswear.

Monday 2 June

Cloudy, wind SW Force 4.

Departed Kingswear 0815. Anchored position 1 in Start Bay Decca B Red 4.49 A Purple 76.03 NNE Start Point. Stern anchor chain bearing on rudder so re-anchored 1030 at position Red B 4.57 Purple A 75.76 in 11 m of water. Start Point lighthouse bearing $205^{\circ}T$ at 1.15 miles. 1036 Rig placed overboard near surface with vane fixed. Start of flood tide. Run 206 started at 1040. Rig lowered to sea bed at 1103. Sea bed slightly rippled sand and moving seaweed. Velocity about 25m sec^{-1} . EM flowmeters noisier on the sea bed than in midwater. Run continued with occasional lifting to reorientate the rig. The bottom Braystoke became fouled with seaweed and the earths of the system were experimented with to remove noise. Rig was raised to midwater at 1251 and EM outputs were much less noisy. At 1306 Run 206 was ended. The rig was lifted inboard, the swivel taken out of the lifting cable and an electrical connection made between the cable and the rig. The rig was then placed on the

bottom at 1340. Run 207 commenced at 1347. The earthing system was then made up so that the braid of the signal cable was connected to the 0 Volt line which was in turn connected to the case earth, chassis earth and via a 10 F capacitor to the sea earth. This appeared to work satisfactorily and the run continued. Quite appreciable wave motion was apparent at the bottom with surface waves of 1-2' height. The rig lifted at 1447 and at 1510. The rig was lifted inboard at 1512 and recording finished (Run 207) at 1514. Intermittent noisy patches had again developed on the record. The electronics case was shorted to the rig and number 1 Braystoke rotor was replaced, the blade having broken on lifting inboard. The starboard anchor was dragging at 1540 and the wind had increased to Force 7 gusting 8 WNW. At 1558 the rig was put over with shrouds on for zero check, Run 208. The zero check finished at 1611, and the rig was lifted inboard at 1615.

Because of the worsening weather and the possibility of the starboard anchor dragging across the port one, the anchors were lifted at 1625 and the vessel sailed for Kingswear, berthing at 1830.

During the evening the TV camera support on the rig was relocated, the inclinometer was wired up so that the output could be recorded on magnetic tape and displayed on the UV recorder and computation exercises on some of the results were carried out.

Knocked off 2100. Overnight in Kingswear.

Tuesday 3 June

Cloudy, wind NW force 6.

Departure from Kingswear delayed until 1020 by visit of Captain to hospital. Anchored 1145 at Position 1 in Start Bay Decca Red 4.43 Purple 75.37 Depth 14 m.

Hydrophone for noise measurements fastened to rig and cables made in..

At 1243 the rig was lowered to mid water with shrouds on for zero check. Run 209 started at 1245. Zero check completed at 1305. The upper head had large offsets.

The rig was lifted, the shrouds removed and put down on the sea bed at 1320. The tide was flooding.

Run 210 started at 1322. Again intermittent noisy periods and spikes on the EM outputs developed a while after immersion. Run 210 ended at 1450.

At 1453 everything on the rig was switched off for an examination of the sediment self-generated noise. There were a number of narrow frequency spikes particularly one at 350 kHz with a general noise background peaking at about 200 kHz. The rig was raised progressively towards the surface. The magnitude of the background noise decreased and the frequency became slightly higher. No sediment was visibly moving though there was seaweed in motion occasionally. At 1600 the EM heads were cleaned and the rig placed on the bottom. The flood flow was easing. Run 211 started at 1623. Wave motion was apparent on the Braystoke rotors and at the end of the run at 1653, there was virtually no flow. Occasional spikes were still occurring, mainly on the Y channels, developing about half an hour after starting a run. At 1820 the heads were again cleaned and the rig replaced on the bottom, which was rippled sand. The rig appeared to be on the slope of a small sand wave. Run 212 was started at 1835. The ebb current was about 20 cm sec^{-1} and though the current was N-S, the movement at the bed as shown by moving weed, was E-W. The run ended at 1914.

The rig was raised and the heads rotated through 90° to see if the spikiness changed direction too.

At 1958 the rig was replaced on the bottom. The bottom was more regularly rippled than the last run. Run 213 started at 1959 tape footage 2088 feet.

Rig lifted and reoriented at 2011 tape footage 2144. The rig was almost on the crest of a sandwave trending about 45° to rig. Rig lifting at 2041 and at 2058 record became spikey again. Rig eventually lifted and Run 213 ended at 2115.

Knocked off 2200. Overnight Position 1 in Start Bay.

Wednesday

Fine and clear, wind S force 2-3. Low swell.

4 June

At 0745 the EM electronics was removed from the rig, the anchors were raised and the vessel left position 1 in Start Bay for Position 4. At 1000 anchored at position 4, Decca Red B 9.96 Purple B 58.05 Lat $50^\circ 16.3'$ N Long $3^\circ 34.3'$ W Depth 15 m. Two integrated circuits in the EM electronics were replaced and this seemed to remove the spikes. The electronics were replaced on the rig and the rig lowered on the sea bed at 1037. The rig appeared to be resting on the crest of a small sand wave possibly about $1\frac{1}{2}$ m high. Tide ebbing. Run 301 was started at 1042. The run continued until 1227, with occasional lifting for reorientation. The current diminished to slack water at about 1210. Run 302 commenced at 1249, and ended at 1341, after spikiness again appeared on the vertical channels.

After a cooling-off period Run 303 started at 1411, but the records

were still spikey. Run 303 finished at 1419. The rig was lifted and the heads cleaned. The rig was lowered again onto a bottom of fairly rippled shell and sand. Run 304 started at 1437. The general current speed was about 30 cm sec⁻¹, but the records were still spikey. The run ended at 1520, and the rig was lifted. At 1543 the rig was replaced in the water with the stem of the EM heads (sea earth) connected to the rig and the electronics tube not connected to the rig. The noise was much worse. Eventually the source of the noise was located as a PC board edge holder bearing on one of the tracks. This was happening on two boards and affecting only the Y channels. These holders were removed. At 1800 the anchors were raised and the vessel moved to Position 8 in Start Bay, deeper water where wave motion was anticipated at negligible. Anchored at Position 8 at 1900. Decca Red 12.05 Purple 66.15 Depth 33 m. The rig was placed on the sea bed at 2037. The bottom was an indistinctly rippled silty sand. Tide ebbing. Run 305 commenced at 2042. The rig was occasionally lifted and reoriented. Measurements of acoustic noise were also recorded between 2120 and 2200.

Run 305 finished at slack water at 0059 hours. Overnight anchored at Position 8, Start Bay.

Thursday
5 June

Mist and rain, wind S force 3-4.

At 0845 the anchors were raised and echo sounding was completed over Positions 8 and 4. At 1000 anchored off Slapton to put the cook ashore. Anchored at Position 1 at 1130 Decca Red 4.19 Purple 75.52. 50° 14.3'N, 3° 37.9'W.

Rig placed on bottom at 1139. Tide ebbing.

Run 401 commenced at 1202. Run continued with occasional lifting of rig and reorientation. Slack water occurred at about 1300. Tide then commenced flooding.

Run continued with occasional lifting and reorienting. After about 1500 sand started occasionally moving off the ripples in the foreground. It was noticeable how the bed movement appeared to be towards the east whereas the flow was S-N. The orientation of the ripple crests changed slowly to adjust to this movement. Large bursts of sediment movement occurred up to end of Run 401 at 1600. Acoustic noise measurements were taken at times during the run. The anchors were raised at 1630 and echo sounding was completed over Position 1 in fog. At 1705 sailed for Plymouth stripping down equipment on the way. Berthed in Plymouth at 2100. Overnight alongside at Plymouth moving to inner dock at 0130.

Friday Finished stripping down equipment, packing and loaded onto transport.
6 June K Dyer met Dr E Denton (Director of the Marine Biological Laboratory),
Captain M Perry and Captain E Dowell and discussed the performance of
the ship and the success of the cruise.
Left ship about 1100 and returned to Taunton.