

9/13/68

Report on Equipment Trials aboard the R.R.S. JOHN MURRAY

19-22nd August, 13-16th Sept. 1968

Scottish Marine Biological Association,
Oceanographic Laboratory, Edinburgh.

Celtic Sea, Irish Sea, N.W. coast of Scotland.

1. S.M.B.A. Scientific Personnel

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2. Objectives of the trials

These trials were a continuation of a series of trials of the prototype undulating towed body which has been designed and constructed in the Edinburgh Laboratory. Previous tests of the 'Undulator' had been carried out aboard the S.M.B.A. Vessel, R.V. CALANUS, at speeds up to 8 knots. The Undulator is being used to identify, and where possible solve, the problems arising in the design of an Undulating Oceanographic Recorder system. It also acts as a test-bed for prototype component parts of that system which is the subject of submissions to the N.E.R.C. for the eventual replacement of the Continuous Plankton Recorder survey as the major scientific programme of the Edinburgh Laboratory.

The objectives of the first half of these trials were:-

- a) To check that the behaviour of the Undulator at a given towing speed (8 knots) was independent of the particular towing ship.
- b) To determine the effect on the stability and on the depth-keeping performance of the Undulator of increasing the towing speed above 8 knots.
- c) To determine the range of control surface settings, at various ship speeds, beyond which the Undulator became unstable.
- d) To produce records (depth, cable tension, Undulator pitch and roll angles) of a satisfactory undulation path having a close approach to the surface and the maximum amplitude in depth.

The objectives of the second half of these trials were:-

- a) To determine the effect on the Undulator performance of replacing the normal bare stranded wire towing cable with a smooth, circular, nylon-covered cable, and if necessary to adjust the control surface settings to regain the optimum undulation path.
- b) To carry out an endurance test on the nylon covered towing cable by subjecting it to normal ship-board handling procedures and to continuous towing of the Undulator for about 500 miles at maximum speed.
- c) To compare the plankton samples caught by the Undulator while undulating to its maximum depth with those taken by a normal Continuous Plankton Recorder towed simultaneously at a constant depth of 10 metres.
- d) /

- d) To carry out a reliability test of a Plessey data recorder (Prototype Oceanographic Data Recorder Mk. III) and depth and temperature sensors, by subjecting them to a 500 mile tow in the Undulator.
- e) To compare the sea temperature records obtained by the ship's engine-intake thermometer, with those taken by a thermograph carried in the Continuous Plankton Recorder, and by the data recorder carried in the Undulator.

These objectives were all essentially achieved.

3. Description of the trials 19-22nd August

The S.M.B.A. personnel and their equipment embarked in R.R.S. JOHN MURRAY at Millbay Dock, Plymouth during the morning of 19th August 1968. The ship sailed at 03.00 on 20th August, but then experienced several hours delay due to engine trouble before finally leaving Plymouth Sound at 09.49. After rounding Land's End, a direct course was steered towards the 50 fathom contour. Towing trials commenced at 20.49 at $50^{\circ}12'N$, $6^{\circ}25'W$ shortly after crossing the 50 fathom line. The course thereafter was set to keep in the centre of the deep water, within the 50 fathom contour where possible, as the ship proceeded through St. George's Channel, up the Irish Sea, and through the North Channel. The first half of the trials was terminated on reaching the approaches to the Sound of Islay ($55^{\circ}44'N$, $05^{\circ}56'W$), at 10.10 on 22nd August, having run out of deep water.

A total of 13 separate tows was performed in this period, 8 of these having the control surfaces set to produce tows at various constant depths, and 5 being set to produce undulations of varying amplitudes and varying upper and lower depth limits.

During a tow the following parameters were recorded:-

- i) Cable tension at the ship; using a Statimeter hydraulic-mechanical strain gauge.
- ii) Depth; using a Marine Advisers mechanical bathykymograph (which produces a scribed trace on pressure-sensitive paper) mounted on a short strop fixed to the towing cable 1 metre above the Undulator.
- iii) Depth; using the Plessey pressure sensor and magnetic tape data recorder, mounted inside the Undulator. This records the instantaneous depth at 35 sec. intervals.
- iv) Pitch and Roll Angles of the Undulator; using a rather crude two-pendulum device devised and constructed in the Oceanographic Laboratory. This produces two scribed traces on pressure-sensitive paper.

In addition, ship motion, and cable angles at the ship (in both the vertical and horizontal planes) were estimated visually.

The weather was fair throughout the passage, the maximum wind strength being force 5 and the sea moderate. At no time did the conditions affect the execution of the trials.

The JOHN MURRAY completed its passage via the Sound of Islay and the Firth of Lorne. The ship berthed at Oban at 15.48 on 22nd August and the S.M.B.A. personnel /

personnel and equipment were disembarked.

It is perhaps worth noting that all these trials were done while the ship was on passage between Plymouth, where she had been refitting, and Oban, the starting point for cruise 9/68. Of the total distance steamed, 520 miles, about 360 miles were in water sufficiently deep for these trials. The actual route added little more than 50 miles and a few hours to the shortest passage. These trials conveniently made use of what would otherwise have been unproductive steaming time.

13 - 16 September

The second half of the trials started and finished at Oban, and conveniently used the time between cruises 9/68 and 10/68. The S.M.B.A. personnel and their equipment embarked at 12.00 on 13 September 1968. The JOHN MURRAY sailed at 13.52 and proceeded through the Sound of Mull to the deep water in the Minches. Towing started at 19.17 at $56^{\circ}48'N$, $06^{\circ}45'W$, and continued on various courses passing well to the south of Barra Head and then heading northwards to the vicinity of St. Kilda, southwards to the latitude of Tiree, and, after a number of reciprocal north-south legs, back eastwards into the Minch where towing was stopped at 06.25 on 16th September at $56^{\circ}48'N$, $06^{\circ}47'W$. The ship then returned through the Sound of Mull, arriving at Oban at 12.00 hours. The S.M.B.A. personnel and equipment were disembarked at 13.30.

Two separate undulating tows were carried out. The first, of $1\frac{1}{2}$ hours duration, was fully instrumented as in the first half of the trials, and was used to determine the effect of the nylon-covered towing cable. It was found that the drag of this cable, which was heavier, about 50% larger in diameter, and of smooth circular cross-section, was significantly larger than that of the bare cable. This had the effect of significantly reducing the amplitude of undulation, but had little effect on the stability.

Throughout the second undulating tow, of $56\frac{1}{2}$ hours duration, at maximum speed, a Continuous Plankton Recorder was towed simultaneously at a constant depth of about 10 metres. The Undulator now carried a Continuous Plankton Sampling Mechanism, and the Plessey depth and temperature sensors, and data recorder. The Continuous Plankton Recorder carried a similar plankton sampler and a thermograph. As before, the Undulator cable tension was measured by a strain gauge aboard the ship. This was the only instrument giving a real-time indication of the operation of the Undulator. Apart from one brief occasion when the two bodies were hauled in for adjustment of the undulating mechanism and for checking of the instruments, this tow of 512 miles was continuous and uneventful. It provided a satisfactory check on the reliability of the system. The magnetic tape, thermograph film, and plankton samples were taken back to the laboratory for translation, development and analysis.

The weather was fine throughout the cruise but the wind rose briefly to force 7 during 14th September in the vicinity of St. Kilda, producing a rough sea and a moderate swell. When heading into the sea on the northerly leg towards St. Kilda, the ship pitched heavily and for a short time had to be eased down to about 6 knots. The ship motion apparently had little effect on the Undulator or the instruments and did not hinder the execution of the trials.

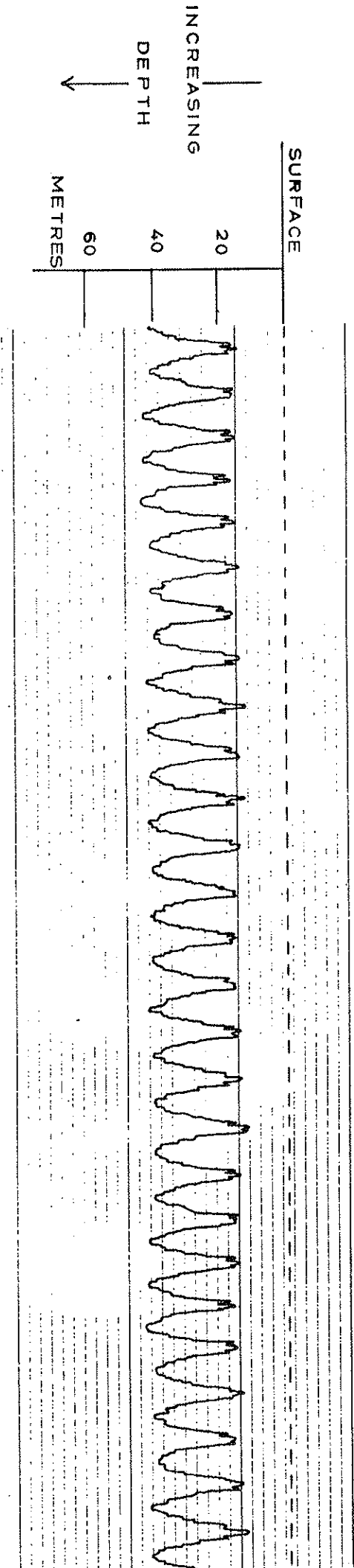
4. Conclusions

Detailed analysis of the results of the trials is not yet complete, but the following general conclusions can be stated.

- i) R.R.S. JOHN MURRAY is eminently suitable for extended towing trials at speeds up to 10 knots.
- ii) The behaviour of the Undulator at 8 knots is independent of the particular towing ship.
- iii) As expected, the margin of stability decreases with increase of towing speed. Nevertheless, at 10 knots the Undulator still has a sufficient margin of stability to allow a satisfactory undulation path to be achieved.
- iv) The optimum undulation obtained at 10 knots consisted of slow regular climbs and dives between depth limits of about 10 and 60 metres, with a repetition length of about 5 miles.
- v) The increase in drag due to the larger diameter of the nylon-covered cable outweighs the decrease in drag due to its smoother cross-section. The effect of the net increase is to reduce the amplitude of the undulations, so that the depth limits when using the nylon-covered cable were about 20 and 45 metres.
- vi) The nylon-covered cable withstood the ship-board handling and the 500 miles of towing without apparent wear or corrosion.
- vii) The Plessey prototype equipment worked reliably throughout the trials. Out of a total of more than 20,000 individual measurements, only a handful had obviously incorrect values.

5. Acknowledgements

The S.M.B.A. personnel would like to acknowledge the very willing and helpful cooperation shown by the Captain, Officers and Crew of the R.R.S. JOHN MURRAY throughout the course of the trials.



A typical portion of the depth record obtained during the 500 mile tow. This trace is an analogue translation (used for preliminary analysis only) of the 10 bit binary record produced on magnetic tape by the Plessey prototype Oceanographic Data Recorder. (Some of the small step-like features are produced by the prototype analogue translating equipment, rather than by the behaviour of the Undulator or of the Data Recorder.)

Each undulation represents about 5 miles of towing.