S M B A

Dunstaffnage Marine Research Laboratory

**Cruise report** : RRS CHALLENGER, Cruise 12/1976

**Duration** : 0442h, 4 August - 1030h, 15 August 1976
(All times BST unless otherwise specified)

**Locality** : Rockall Channel, $56\frac{1}{2}^{o}$ - $59\frac{1}{2}^{o}$N.

**Staff**:

| | |
|---|---|
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Aims:

Cruise 12/1976 of RRS CHALLENGER had the two-fold objective of continuing the SMBA programme of work in the waters between Scotland and Rockall and of making preliminary observations to assess the suitability of the deep-water area to the north-west of Anton Dohrn Seamount for the Joint Air-Sea Interaction Projects (JASIN) of summer 1977 and summer 1978. To the latter end a party from the Institute of Oceanographic Sciences (IOS) Wormley, joined the cruise to lay deep moorings and to make detailed observations of the uppermost structure of the water-column in the area of interest, work which will be continued during cruise 16, scheduled for 6-18 October 1976. The detailed aims were as follows :

1) To re-lay the SMBA current meter mooring in 57°N, 9°W, with the object of continuing observations at this point until mid-December 1976.
2) To work the Anton Dohrn Seamount hydrographic section.
3) To lay three IOS deep moorings in the north-western sector of the Rockall Channel to obtain near-surface current measurements until mid-October 1976,
4) To make CTD observations with the batfish in the Anton Dohrn Seamount - Rockall - Lousy Bank - Rosemary Bank area to provide preliminary data for the JASIN '77 & '78 experiments.
5) To lay two additional moorings at the shelf-edge to obtain short-term observations of the horizontal velocity gradients in the vicinity of the 57°N, 9°W station.
6) To take 50 litre surface water samples at standard positions on the Scottish continental shelf for 137 Cs analysis by the Fisheries Radiobiological Laboratory, Lowestoft.

Narrative :

Challenger sailed from James Watt Dock, Greenock at 0442h, 4 August, repairs to the hydrographic winch having been completed overnight. Course was set for the Sound of Mull in fine weather, and the first 137Cs sample was taken off Tobermory at 2303h. STD lowerings were made at all subsequent Cs sample stations. After completing station C8 at 0937h, 5 August, course was set for the southernmost current meter position, R2. The depth here being somewhat too shallow for the wires already reeled onto the winch, the ship proceeded to station R1, where depths were suitable, and this mooring was laid by 1644h. R2 was subsequently laid by 2047h, and station R by 0111h, 6 August.

The Anton Dohrn Seamount section was begun at station T at 0321h, 6 August. During the day, at station M, the IOS acoustic releases were successfully tested and the section continued in light south-westerly winds without incident to station G at 1015h, 7 August. Intermittent spiking on the STD salinity traces had begun at station K, which despite attention to the instrument, it had not proved possible to rectify. At station F, commenced at 1215h, 7 August, bad spiking in both traces led to a postponement of the STD lowering for repairs whilst the launching of the first IOS deep mooring proceeded in depths of 1800 m between 1244h and 1500 h. Although this went smoothly, the sub-surface buoy remained upon the surface when launching was complete. Upon recovery of the buoy, it was found that the mooring wire had parted a few inches below the uppermost shackle as a result of a superficially innocuous tangle between the buoy chains and meter wire immediately before launching.

The Gifford and Mersey grapnels were rigged in series at the end of 400 m of spare trawl warp for attachment to the main warp, and in the interim two unsuccessful STD lowerings were attempted. Between 2021 h and 0520 h, 8 August, the grapnels were towed on eight courses through the mooring position, using the command pinger to home upon. Weather conditions remained calm and excellent satellite fixes were obtained, but no trace of the mooring was encountered, although the pinger signals showed that the ship had towed very close to the gear. After recovery of the grapnels, a legible STD trace was obtained at 700 m depth and the ship proceeded to station E at 0632 h. Despite further adjustments and

the removal of 400 m of kinked STD cable, observations were again limited to 700 m at station E, but at station D, in 1070 m depth, some improvement in the quality of the trace was achieved, and observations were made to within 20 m of the bottom. The shallower stations were worked successfully and the section was completed at station A at 1837 h, 8 August.

During 8 August winds freshened a little to become southerly, forces 5-6, but fell away again to forces 3-4 during the following day. After working station A course was set to the west of Rockall for initial batfish tests over the bank, and then northward at 0422 h, 9 August, to mooring position J1. This mooring was laid between 1312 and 1533 h in a depth of 1632 m, and after position checks an STD lowering was made to 700 m. Batfish runs were commenced from this station. Although hydraulic system failures prevented undulating tows at this stage of the cruise, adjustment of the cable length and ship's speed allowed data to be obtained at a number of levels during a steam southward, then eastward, to the third deep mooring position, J2. The mooring was set between 1020 and 1156 h, 10 August in a depth of 1891 m, and horizontal batfish tows were subsequently made to Rosemary Bank, and then westward. By 0830 h 11 August, the batfish CTD was showing serious spiking and was brought inboard for checks. The trouble was traced to a fault in the towing cable after test runs during the day. Repairs to the hydraulic control system were also completed and the instrument was re-launched at 1840 h and used successfully in the undulating mode between the surface and 50 m depth on a course towards Rockall Bank.

Upon reaching the north-east quadrant of Rockall Bank at 0220 h 12 August, the ship headed south-eastwards across the bank and into deep water. At 1010 h the batfish broke surface and upon hauling was found to have lost its propeller. A new blade was made in the course of the day, but the threat of a vigorous eastward-moving depression made it advisable to steam towards the shelf-edge moorings whilst the repairs were in progress. After mid-afternoon tests, the batfish was again launched at 1728 h, but a failure of the hydraulic system occurred shortly after, and it was retrieved at 1740 h.

In continuing calm, CHALLENGER steamed for the shelf-edge moorings and the first was sighted at 0250 h, 13 August. After checking that all three were in position and taking a water-bottle series at each, hauling began at station R2 at 0800 h. All moorings had been successfully recovered by 1530 h and the ship lay on station R whilst the current meters were checked and prepared for re-laying with the long-term mooring at this station. This was put out between 1858 and 1940 h, and after position checks had been obtained the ship set course at 2000 h. Between 2225 h and 0130 h 14 August a grid search was made around the final transmitted position of a NIMBUS F - TWERLE drifting buoy and in the vicinity of its estimated drift, but although radar-search conditions were excellent with the calm sea, it was not encountered.

Passage to Liverpool continued on 14 August in fine weather, the expected depression having been blocked by a westward - extending anticyclone. A batfish run to the west of the Isle of Man was attempted, but abandoned due to faults in hydraulic controls. CHALLENGER entered Liverpool Docks at 0830 h 15 August, and berthed at 1030 h.

Results :

Aim 1) The long-term shelf-edge current meter mooring.

The SMBA current meter mooring at 57°N, 9°W was re-established at 0111 h 6 August. Data were retrieved from meters placed at 28, 33 and 98 m from the foot of the meter-wire when the mooring was raised at 1425 h 13 August, but it was again laid with meters at 28 and 98 m above bottom by 1940 h 13 August, for recovery on cruise 15/1976.

Aim 2) The Anton Dohrn Seamount section.

The section was worked between 0351 h 6 August and 1837 h 8 August. Severe spiking troubles with the STD prevented observations below 700 m at stations F & E, and plans to repeat the western part of the section at a later stage of the cruise were abandoned when the glass liner of the conductivity cell broke during the course of repairs. Nevertheless, conditions were monitored over the major part of the section and geostrophic values can be obtained from station G eastward.

Aim 3) IOS deep moorings.

see attached (A)

Aim 4) Batfish operations.

see attached (B)

Aim 5 Short-term shelf-edge moorings.

In order to estimate Stokes' velocity corrections for residual currents obtained at the 57°N, 9°W mooring, two additional short-term moorings (R1 & R2) were laid for the period 5-13 August, forming with the long-term station (R) an equilateral triangle of side 5 n.ml. At station R Plessey current meters were placed at the usual positions of 28 and 98 m from the foot of the meter-wire, and an additional meter was

attached 33 m from the foot. At R1 & R2, two meters were placed in each case at 28 & 33 m from the bottom of the meter-wire. This pattern was chosen in the hope of ensuring a complete triangle of observations in the event of meter failures, but in fact all seven meters remained synchronised and appear to have returned good data over the period of observation.

Aim 6) Radiocaesium samples.

50 litre surface samples were collected at the ten standard positions between Tobermory and the shelf-edge. At stations C2-C8 and C10 STD lowerings were also made. These showed strong thermocline development at all stations except C2, although even at this station an appreciable (0.03‰) inverse halcoline was present.

D.J. Ellett
30 August 1976.

Aim 3) IOS deep moorings.

Three subsurface moorings were to have been laid at station F, J1 & J2 to obtain data on near-surface currents in preparation for JASIN 1978. VACMs were to be set at 40 and 100 m, with an Aanderaa current meter (ACM) 1 m below the upper VACMs as a test of the ACM's ability near-surface but under subsurface flotation.

Attempting to set the first mooring (IOS 214) at station F of the Anton Dohrn Seamount section, all went well until the point of releasing the sphere, when the chain under the buoy twisted around the top length of wire. When the buoy was cut free the chain slipped free producing a shock load on the wire, which broke losing the current meters below.

The two remaining moorings were successfully laid, the aim being to get the sub-surface sphere just 30 metres below the surface. Using the pinger on the command release and its associated bottom echo, the moorings were adjusted using 10 metre strops. The mooring data and instrument depths achieved are summarised in Table 2. There is a discrepancy of 10 metres between wire out and water depth on mooring 216, at station J2. Either the wire did not stretch as calculated or the mooring was at a slight angle when set. The wire lengths can be rechecked on recovery during cruise 16/1975 in October. (J. Cherriman).

Aim 4) Batfish operations

The purpose of Hermes Batfish/Neil Brown CTD tows during the cruise was to obtain information on the horizontal and vertical structure and variability of the near surface layers to aid in the planning of JASIN 1978.

The tows made are listed in Table 3 and Table 4 and marked on the track plot (fig. 2). They were very different from those planned, because of numerous technical problems. Because of hydraulic failures, it was decided to fix the wings and attempt horizontal tows. The depth could only be varied by stopping the ship and changing the length of wire out. Although this procedure was tedious it worked satisfactorily. At ship speeds below 3 kts, the batfish undulated by several metres, and sank slowly when the ship hove to, allowing partial vertical profiles to be obtained. Above 3 kts the towing depth was independent of speed and usually varied by less than 2 m.

Horizontal tows (tows 1-17) at various levels were made on the nights of 9/10 and 10/11 August. Frequent bad values on 10/11 were caused by failure of the towing cable conductors, but could be somewhat reduced by decreasing the towing speed. At the depths chosen, towards the base of a fairly well-mixed surface layer, fouling of the conductivity sensor was a serious problem. Jumps of 2‰ in salinity occurred on two occasions, but cleared spontaneously later when the towing mode was changed.

One successful undulating tow was made overnight on 11/12 August on a course running from deep water north of Rockall Bank onto the Bank and off again to the south-east (tows 18-25).

During all tows, spot values of pressure, temperature, and conductivity were logged at 5 minute intervals (horizontal tows) or at 12 m on each cycle (undulating tows). From these salinity and density were calculated on the SMEA H.P. 9820 A calculator. No time constant correction could be made, but temperature was usually fairly constant where the readings were taken. The salinity values proved a sensitive way to detect fouling of the conductivity cell. Values of 33‰ are grossly in error. When clean, salinities of about 34.6 to 35.0‰ were recorded. Only the relative variations of salinity should

be considered in fig. 3. Absolute values may be low by as much as 0.5‰. Calibration data are not yet available.

Near-surface temperatures from the ship's meteorological log (M - hull temperature), STD traces (S) and CTD traces and spot readings (no symbol) are plotted in fig. 2. No corrections have been made for intercalibration errors. Temperatures decreased gradually from around 14°C at 57°N to 13½°C at 59°N, then dropped to 12½° north of 59°N. Unfortunately there are no near-surface batfish tows to resolve the horizontal structure of the temperature drop.

More detailed horizontal resolution is provided by the 12 m values of temperature, salinity, and density (fig. 3) obtained from the batfish tows in yoyo mode (tows 18-25). Salinity decreased to the south with a mean gradient of order 0.1‰/100 km. Temperature increased slightly, and the corresponding decrease in sigma-t to the south was of the order of 0.2/100 km. The strong gradients at about 0600 h on 12 August are in deep water a few km to the south-east of Rockall Bank, and are confined to a region 10-15 km across.

Examples of vertical temperature profiles along the north-south Rockall section are shown in Fig. 4a, and corresponding contours in fig. 4b. The thermocline appears to have been about 20 m shallower over Rockall Bank than it was in deeper waters to the north and east. The 14° water to the south-east of the Bank seems to have been confined to the top 20-30 m, and may be associated with an exceptionally long-lived high dominating weather conditions over southern England for several months. During the cruise, winds from 20-25 kts were recorded close to Rockall Seamount for 18 hours on 8 August as a trough passed north-west of Rockall from south-west to north east. Note that this activity just preceded the observation period discussed here.

The most detailed horizontal resolution is provided by the horizontal tows from 9-11 August. Examples of temperature and pressure variations along three tracks are shown in fig. 5. Although the horizontal variation is confused by the vertical motion of the batfish through strong vertical gradients, considerable horizontal variation is apparent. Note, for example, the range of temperatures encountered on successive crossings of the 46 decibar pressure level between 2115 and 2130 h during Tow 1 (fig. 5a). In the same figure, note that the temperature decreases as the depth <u>decreases</u> over short distances.

Unfortunately no vertical profiles were obtained in that area. However, batfish tows in yoyo mode across the thermocline could not resolve the variations on scales less than 2 km that dominate the variations in fig. 5.

To summarize, although large scale (100 km) horizontal gradients were found to be fairly small, they may be swamped locally by large gradients in regions of order 10–20 km across. During August 1976 the area east of Rockall, and between Anton Dohrn Seamount in the south ($57\frac{1}{2}^{o}$N) and $59^{o}$N in the north seems to have been the most homogeneous, though much small scale ( ~ 1 km) variability cannot be avoided.

Recommendations for future cruises :

Mapping was seriously hampered when the batfish hydraulics and the STD both failed. Vertical profiles are important to the interpretation of horizontal tows. So

(1) always carry the CTD profiling pressure case as well as the CTD batfish pressure case. It would be preferable if a single case could be designed for both modes of use.

(2) Always carry XBTs.

Horizontal tows reveal structure on scales that are aliased in sawtooth yoyo mode, but are themselves contaminated by small vertical motions of the batfish. To give some knowledgeof vertical gradients.

(3) tow a second thermistor about 2 m below the batfish, recording on the fourth CTD channel. A second conductivity cell is also desirable, but is much more difficult to implement.

A continuous record of near-surface temperature and salinity is desirable at all times, including horizontal and yoyo batfish tows. So

(4) provide for continuous surface T/S measurements by either a pumped flow to a second CTD, or, STD in a bucket on deck, or, a towed fish designed for the purpose.

To reduce conductivity fouling problems,

(5) provide a calculator capable of calculating salinity and density from spot readings even when computer logging is not available,

(6) Calculate salinity and density from spot readings at least every 15 minutes, and change the profiling mode to attempt to free the conductivity cell if fouling is suspected.

(7) Take Nansen bottle calibration data on every launch and recovery of the batfish. If the batfish is recovered in haste after a malfunction, a calibration bottle should still be taken immediately after recovery. (R.T. Pollard, M. Carson).

Table 1

Station List

R.R.S. CHALLENGER, Cruise 12/1976

| Stn. No. | Date 1976 | Time GMT | Initial position Lat. N. ° | ' | Long. W. ° | ' | sounding (m) | Gear worked |
|---|---|---|---|---|---|---|---|---|
| 1 (C1) | 4 Aug | 2203-2210 | 56 | 40 | 06 | 08 | 181 | $C_o$, $S_o$ |
| 2 (C2) | | 2300-2337 | 56 | 41 | 06 | 17 | 30 | $C_o$, STD, w/b |
| 3 (C3) | 5 Aug | 0020-0040 | 56 | 44 | 06 | 27 | 67 | $C_o$, STD, w/b |
| 4 (C4) | | 0155-0235 | 56 | 44 | 06 | 45 | 44 | $C_o$, STD, 2 w/b |
| 5 (C5) | | 0336-0353 | 56 | 44 | 06 | 59 | 134 | $C_o$, STD, 2 w/b |
| 6 (C6) | | 0503-0518 | 56 | 44 | 07 | 18 | 144 | $C_o$, STD, $S_o$ |
| 7 (C7) | | 0646-0657 | 56 | 44 | 07 | 40 | 55 | $C_o$, STD, 2 w/b |
| 8 (C8) | | 0824-0839 | 56 | 47 | 08 | 01 | 119 | $C_o$, STD, 2 w/b |
| 9 (R1) | | 1429-1544 | 56 | 58 | 08 | 49 | 127 | SMBA mooring, 2 c/m. |
| 10 (R2) | | 1645-1947 | 56 | 54 | 08 | 57 | 115 | SMBA mooring, 2 c/m. |
| 11 (R) | | 2312-0011 | 57 | 00 | 09 | 00 | 130 | SMBA mooring, 3 c/m. |
| 12 (T) | 6 Aug | 0251-0318 | 56 | 51 | 08 | 22 | 132 | STD, w/b. |
| 13 (C9) | | 0345-0347 | 56 | 53 | 08 | 30 | 134 | $C_o$, $S_o$ |
| 14 (S) | | 0515-0536 | 56 | 57 | 08 | 48 | 128 | STD, 2 w/b. |
| 15 (R, CIC) | | 0638-0700 | 57 | 00 | 09 | 01 | 132 | $C_o$, STD, w/b. |
| 16 (Q) | | 0815-0848 | 57 | 03 | 09 | 13 | 498 | STD, 2 w/b. |

Table 1 cont.

| Stn. No. | Date 1976 | Time GMT | Initial position Lat. N. ° | ' | Long. W. ° | ' | sounding (m) | Gear worked |
|---|---|---|---|---|---|---|---|---|
| 17 (P) | 6 Aug | 0950-1030 | 57 | 06 | 09 | 25 | 1455 | STD, 2 w/b. |
| 18 (O) | | 1129-1238 | 57 | 09 | 09 | 42 | 1904 | STD, 2 w/b. |
| 19 (N) | | 1423-1531 | 57 | 14 | 10 | 03 | 2120 | STD, 2 w/b. |
| 20 (M) | | 1709-2112 | 57 | 18 | 10 | 23 | 2224 | STD, 2 w/b, command release tests. |
| 21 (L) | | 2222-2332 | 57 | 22 | 10 | 42 | 1924 | STD, 2 w/b. |
| 22 (K) | 7 Aug | 0016-0105 | 57 | 23 | 10 | 52 | 860 | STD. |
| 23 (J) | | 0220-0322 | 57 | 27 | 11 | 07 | 570 | STD, 1 w/b. |
| 24 (I) | | 0425-0549 | 57 | 28 | 11 | 20 | 770 | STD, 1 w/b. |
| 25 (H) | | 0557-0658 | 57 | 29 | 11 | 32 | 2020 | STD, 2 w/b. |
| 26 (G) | | 0816-0915 | 57 | 30 | 11 | 51 | 1800 | STD, 1 w/b. |
| 27 (F') | | 1115-1400 | 57 | 29 | 12 | 12 | 1820 | IOS mooring laid & lost. |
| 28 (F) | 8 Aug | 0508-0532 | 57 | 30 | 12 | 15 | 1816 | STD to 700 m. |
| 29 (E) | | 0715-1012 | 57 | 32 | 12 | 30 | 1652 | STD to 700 m. |
| 30 (D) | | 1121-1238 | 57 | 33 | 12 | 55 | 1070 | STD, 1 w/b. |
| 31 (C) | | 1330-1408 | 57 | 33 | 13 | 02 | 290 | STD, 2 w/b. |
| 32 (B) | | 1545-1600 | 57 | 34 | 13 | 21 | 180 | STD, 2 w/b. |
| 33 (A) | | 1723-1737 | 57 | 35 | 13 | 38 | 105 | STD, 1 w/b. |
| 34 | | 1829-1838 | 57 | 35 | 13 | 40 | - | 1 w/b, batfish shot for tests. |

Table 1 cont.

| Stn. No. | Date 1976 | Time GMT | Initial position Lat. N. ° | ' | Long. W. ° | ' | sounding (m) | Gear worked |
|---|---|---|---|---|---|---|---|---|
| 35 | 8 Aug | 1910 | 57 | 33 | 13 | 42 | - | Batfish hauled. |
| 36 | | 2020 | 57 | 33 | 13 | 54 | - | Batfish shot for tests. |
| 37 | | 2130 | 57 | 36 | 13 | 59 | - | Batfish hauled. |
| 38 | 9 Aug | 0200 | 58 | 03 | 13 | 27 | - | Batfish shot for tests. |
| 39 | | 0322 | 58 | 10 | 13 | 26 | - | Batfish hauled. |
| 40 (J1) | | 1205-1523 | 59 | 19½ | 11 | 58 | 1632 | IOS mooring, 3 c/m. |
| 41 | | 1621-1653 | 59 | 17 | 11 | 57 | 1678 | STD to 700 m, 1 w/b. |
| 42 | | 1723 | 59 | 17 | 11 | 55 | - | Batfish shot for tests. |
| 43 | | 1753 | 59 | 15 | 11 | 55 | - | Batfish hauled. |
| 44 | | 1920 | 59 | 12 | 11 | 56 | - | Batfish shot for tows 1-6. |
| 45 | 10 Aug | 0815 | 58 | 30 | 11 | 39 | - | Batfish hauled. |
| 46 (J2) | | 0900-1056 | 58 | 30½ | 10 | 32 | 1891 | IOS mooring 3 c/m. |
| 47 | | 1229-1254 | 58 | 31 | 10 | 39 | 1877 | 1 w/b, batfish shot for tows 7-14. |
| 48 | 11 Aug | 0330-0345 | 59 | 08 | 11 | 40 | - | 1 w/b, batfish tows 15-17 follow |
| 49 | | 0758 | 59 | 06 | 12 | 18 | - | Batfish hauled. |
| 50 | | 1234 | 59 | 20 | 12 | 34 | - | Batfish shot for tests. |
| 51 | | 1340 | 59 | 16 | 12 | 35 | - | Batfish hauled. |
| 52 | | 1740 | 58 | 50 | 12 | 37 | - | Batfish shot for tows 18-25. |

Table 1 cont.

| Stn. No. | Date 1976 | Time GMT | Initial position Lat. N. ° | ' | Long. W. ° | ' | sounding (m) | Gear worked. |
|---|---|---|---|---|---|---|---|---|
| 53 | 12 Aug | 0910 | 56 | 56 | 12 | 20 | - | Batfish hauled |
| 54 | | 1450-1520 | 56 | 49 | 11 | 31 | - | 2 w/b, batfish shot for tow 26 |
| 55 | | 1600 | 56 | 50 | 11 | 35 | - | Batfish hauled. |
| 56 | | 1628 | 56 | 50 | 11 | 34 | - | Batfish shot for tests. |
| 57 | | 1640 | 56 | 50 | 11 | 32 | - | Batfish hauled. |
| 58 (R) | 13 Aug | 0320-0343 | 56 | 59 | 09 | 00 | 134 | 8 w/b. |
| 59 (R1) | | 0444-0500 | 56 | 57 | 08 | 49 | 129 | 8 w/b. |
| 60 (R2) | | 0550-0800 | 56 | 53 | 08 | 56 | 117 | 8 w/b, SMBA mooring recovered. |
| 61 (R1) | | 0945-1037 | 56 | 57 | 08 | 48 | 129 | SMBA mooring recovered. |
| 62 (R) | | 1325-1428 | 56 | 59 | 09 | 00 | 134 | SMBA mooring recovered. |
| 63 (R) | | 1753-1900 | 57 | 00 | 08 | 59 | | SMBA mooring re-laid, 2 c/m. |

Table 2

IOS subsurface moorings, RRS CHALLENGER, cruise 12/1976.

| Mooring Number | 215 | 216 |
|---|---|---|
| Date set | 9 August 1976 | 10 August 1976 |
| Position | 59°19.30'N<br>11°57.81'W | 58°30.24'N<br>10°31.90'W |
| Water depth | ~~1632 m~~ 1623 m | 1891 m |
| Subsurface sphere | 25 m | 23 m |
| VACM no.<br>Depth | 2151<br>38 m | 2161<br>36 m |
| ACM no.<br>Depth | 2152<br>39 m | 2162<br>37 m |
| VACM no.<br>Depth | 2153<br>82 m | 2163<br>110 m |

Table 3

Batfish tows - RRS Challenger cruise 12/1976

| Tow No. | Date (August, 1976) | Start (GMT) | Stop (GMT) | Depth (m) | Audio tape no. | Audio tape side | Notes |
|---|---|---|---|---|---|---|---|
| 1 | 9 | 2017 | 2210 | 46±2 | 1 | 1 | 2201 conductivity jump (fouled) |
| 2 | 9 | 2245 | 0037 | 40±1 | 1 | 2 | Conductivity still fouled |
| 3 | 10 | 0115 | 0308 | 32±1 | 2 | 1 | Conductivity still fouled |
| 4 | 10 | 0352 | 0546 | 36±1 | 2 | 2 | Conductivity cell cleared, some spiking |
| | | | | 50-34 | | | Profile at start |
| | | | | 35-25 | | | Profile at end |
| 5 | 10 | 0559 | 0617 | 36-40 | 3 | 1 | |
| 6 | 10 | 0627 | 0803 | 49±1 | 3 | 1 | Spiking bad in parts |
| | | | | 65-48 | | | Profile at start |
| | | | | 49-43 | | | Profile at end |
| 7 | 10 | 1229 | 1325 | 24, 29, 33, 40, 45, 48, 55, 60, 100 | 3 | 2 | Short records at 9 levels to obtain a partial profile |
| 8 | 10 | 1327 | 1502 | 43±1 | 3 | 2 | |
| | | | | 100-44 | | | Profile at start |
| 9 | 10 | 1516 | 1710 | 39±1 | 4 | 1 | 1545 conductivity cell fouled, spiking at end |

Table 2 cont.

| Tow no. | Date (August, 1976) | Start (GMT) | Stop (GMT) | Depth (m) | Audio tape no. | side | Notes |
|---|---|---|---|---|---|---|---|
| 10 | 10 | 1716 | 1900 | 35±1 | 4 | 2 | Conductivity still fouled, bad spiking |
| 11 | 10 | 1915 | 2107 | 35±1 | – | – | Not recorded in error; some spiking, cond. fouled |
| 12 | 10 | 2110 | 2302 | 34±1 | – | – | Not recorded in error, severe spiking in parts, conductivity fouled. |
| 13 | 10 | 2321 | 0115 | 26±1 | 6 | 1 | Slow ship speed (5 kts), some spiking, cond. fouled |
| | | | | 26-20 | | | Profile at end |
| 14 | 11 | 0125 | 0315 | 29±1 | 6 | 2 | Some spiking, conductivity fouled |
| 15 | 11 | 0325 | 0336 | 7 | 7 | 1 | Calibration, conductivity fouling cleared while spot readings were being taken |
| 16 | 11 | 0405 | 0545 | 36±2 | 7 | 1 | Serious spiking |
| 17 | 11 | 0557 | 0749 | 31±1 | 7 | 2 | Serious spiking |
| 18 | 11 | 1752 | 1945 | 10-50 yoyo | 8 | 1 | Record volume set too low until 1801 |
| 19 | 11 | 1947 | 2140 | 10-50 yoyo | – | – | Not recorded in error |
| 20 | 11 | 2143 | 2336 | 10-55 yoyo | – | – | Not recorded in error |
| 21 | 11 | 2338 | 0129 | 5-55 yoyo | 9 | 2 | Isolated showers on radar |
| 22 | 12 | 0132 | 0325 | 5-55 yoyo | 10 | 1 | |

Table 3 cont.

| Tow no. | Date (August, 1976) | Start (GMT) | Stop (GMT) | Depth (m) | Audio tape no. | side | Notes |
|---|---|---|---|---|---|---|---|
| 23 | 12 | 0328 | 0519 | 5-55 yoyo | 10 | 2 | |
| 24 | 12 | 0521 | 0713 | 5-55 yoyo | 11 | 1 | |
| 25 | 12 | 0716 | 0907 | 5-55 yoyo | - | - | Not recorded in error. Run aborted when propeller lost |
| 26 | 12 | 1450 | 1550 | 10 90-10 | 12 | 1 | Calibration and profile |
| 27 | 14 | 1845 | 1900 | 10-50 yoyo | 13 | 1 | Irish sea run, aborted due to Batfish failure |

Table 4

Batfish tow tracks - RRS Challenger cruise 12/1976

| Tow no. | Start position | | End position | |
|---|---|---|---|---|
| | Lat. (N) | Long. (W) | Lat. (N) | Long. (W) |
| 1 | 59° 9.6' | 11°57.2' | 58°53.6' | 11°58.6' |
| 2 | 58°49.7' | 11°58.4' | 58°33.1' | 11°57.8' |
| 3 | 58°29.8' | 11°58.6' | 58°27.6' | 11°35.1' |
| 4 | 58°27.8' | 11°32.9' | 58°29.6' | 11°08.7' |
| 5 | 58°29.7' | 11°06.9' | 58°29.8' | 11°04.2' |
| 6 | 58°29.8' | 11°03.4' | 58°30.0' | 10°39.0' |
| 7 | 58°31.2' | 10°38.9' | 58°31.5' | 10°40.5' |
| 8 | 58°31.5' | 10°40.5' | 58°44.5' | 10°32.7' |
| 9 | 58°45.0' | 10°32.5' | 58°58.5' | 10°23.9' |
| 10 | 58°58.8' | 10°23.7' | 59°12.7' | 10°15.3' |
| 11 | 59°14.1' | 10°14.4' | 59°15.3' | 10°35.3' |
| 12 | 59°15.3' | 10°35.9' | 59°13.5' | 10°59.7' |
| 13 | 59°13.3' | 11°01.0' | 59°11.8' | 11°18.1' |
| 14 | 59°11.8' | 11.19.1' | 59°08.9' | 11°38.3' |
| 15 | 59°08.6' | 11°39.7' | 59°08.4' | 11°39.8' |
| 16 | 59°08.0' | 11°41.9' | 59°06.4' | 11°57.4' |
| 17 | 59°06.2' | 11.58.8' | 59°06.2' | 12°17.4' |
| 18 | 58°49.3' | 12°38.4' | 58°36.7' | 12°53.6' |
| 19 | 58°36.7' | 12°53.6' | 58°22.6' | 13°06.2' |
| 20 | 58°22.6' | 13°06.2' | 58°07.3' | 13°21.3' |
| 21 | 58°07.3' | 13°21.3' | 57°51.6' | 13°32.6' |
| 22 | 57°51.6' | 13°32.6' | 57°33.6' | 13°20.7' |
| 23 | 57°33.6' | 13°20.7' | 57°19.0' | 12°59.9' |
| 24 | 57°19.0' | 12°59.9' | 57°06.1' | 12°39.5' |
| 25 | 57°06.1' | 12°39.5' | 56°56.2' | 12°19.9' |
| 26 | 56°48.6' | 11°31.3' | 56°50.1' | 11°35.0' |

## Figures

Fig. 1 General track chart, RRS CHALLENGER, cruise 12/1976, 4–15 August 1976.

Fig. 2 Surface temperatures along the ship's track from 6 to 12 June.

M - meteorological office sensor attached to interior of hull.

S - STD surface value.

n - CTD temperature at a depth of n metres.

Midnight and midday positions are marked.

Start and end of batfish tows, underlined numbers, are marked by squares on the track.

Fig. 3 Temperature, salinity, and density at a depth of 12 m along the track of batfish tows 19–25 (see fig. 2). Temperature and salinity are scaled so that unit change in either gives approximately the same contribution to sigma-t.

The position of the Rockall Bank plateau (about 200 m deep) is shown at the bottom of the figure.

Fig. 4 (a) Examples of temperature profiles along the Rockall section (tows 19–25, fig. 2).

(b) Corresponding temperature contours. The position of the Rockall Bank plateau is marked.

Fig. 5 Temperature and pressure traces for three "horizontal" batfish tracks.

(a) Tow 1 - 46 m ± 2 m

(b) Tow 2 - 40 m ± 1 m

(c) Tow 3 - 32.5 m ± 1 m

Note that pressure in decibars (i.e. depth in metres, approximately) increases upwards.

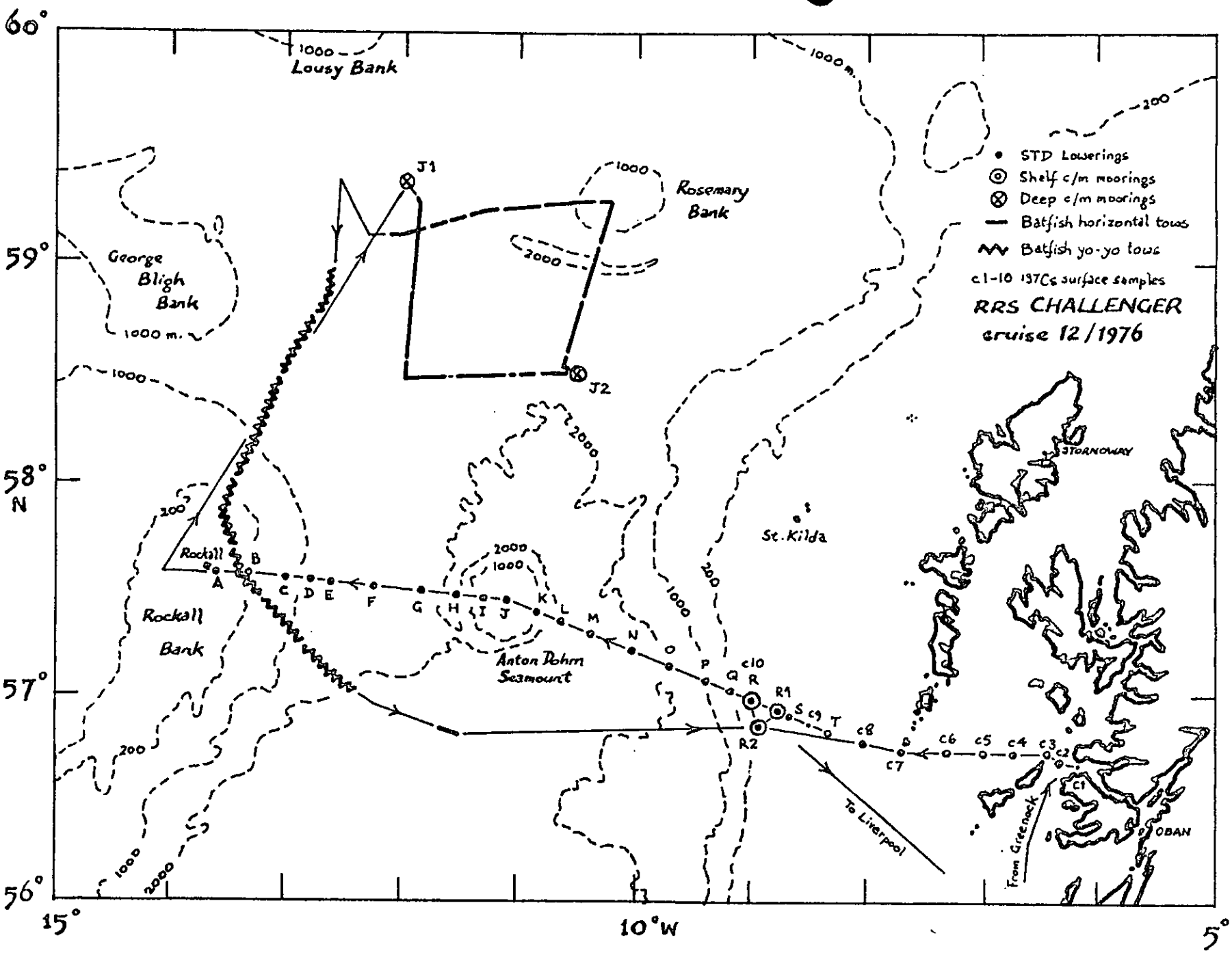
60°
59°
58°
N
57°
56°
15°
10°W
5°
Lousy Bank
1000
George Bligh Bank
1000 m.
Rosemary Bank
2000
J1
J2
200
Rockall
Rockall Bank
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
R1
R2
S
T
c10
c9
c8
c7
c6
c5
c4
c3
c2
c1
Anton Dohrn Seamount
St. Kilda
STORNOWAY
OBAN
To Liverpool
From Greenock
STD Lowerings
Shelf c/m moorings
Deep c/m moorings
Batfish horizontal tows
Batfish yo-yo tows
c1-10 137Cs surface samples
RRS CHALLENGER
cruise 12/1976

Figure 1

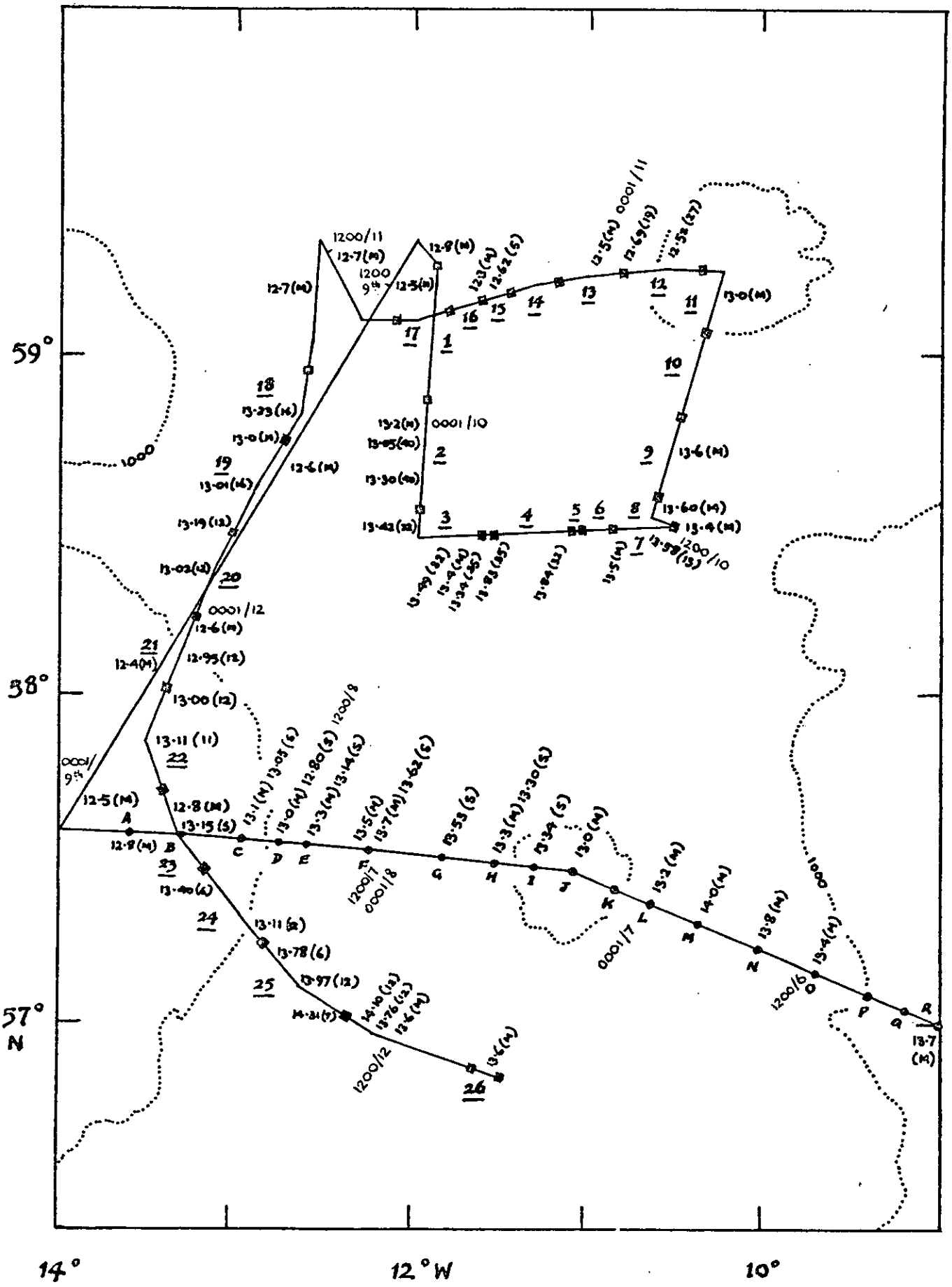
59°
58°
57° N
14°
12° W
10°
1000
1200/11
12·7(M)
12·9(M)
1200
9th
12·5(M)
12·7(M)
12·3(M)
13·62(5)
13·5(M) 0001/11
13·69(19)
13·58(27)
13·0(M)
17
1
16
15
14
13
12
11
10
18
13·23(14)
13·0(M)
19
13·01(14)
12·6(M)
13·19(12)
13·02(12)
20
0001/12
12·6(M)
21
12·4(M)
12·95(12)
13·00(12)
13·11(11)
22
0001/9th
12·5(M)
A
12·8(M)
13·15(5)
12·9(M) B
23
13·40(4)
24
13·11(8)
13·78(6)
25
13·97(12)
14·10(12)
13·76(12)
13·6(M)
14·31(9)
1200/12
13·6(M)
26
13·2(M) 0001/10
13·05(10)
13·30(10)
13·42(12)
2
3
4
5
6
8
9
7
13·6(M)
13·60(14)
13·4(M)
13·98(13)
1200/10
13·49(12)
13·4(10)
13·34(15)
13·83(15)
13·84(12)
13·5(M)
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
13·7(M)
13·1(M) 13·05(6)
13·0(M) 12·80(5) 1200/8
13·3(M) 13·14(5)
13·5(M)
13·7(M) 13·62(5)
13·53(5)
13·3(M) 13·30(5)
13·34(5)
13·0(M)
1200/7
0001/8
0001/7
15·2(M)
14·0(M)
13·8(M)
13·4(M)
1200/6

Figure 2

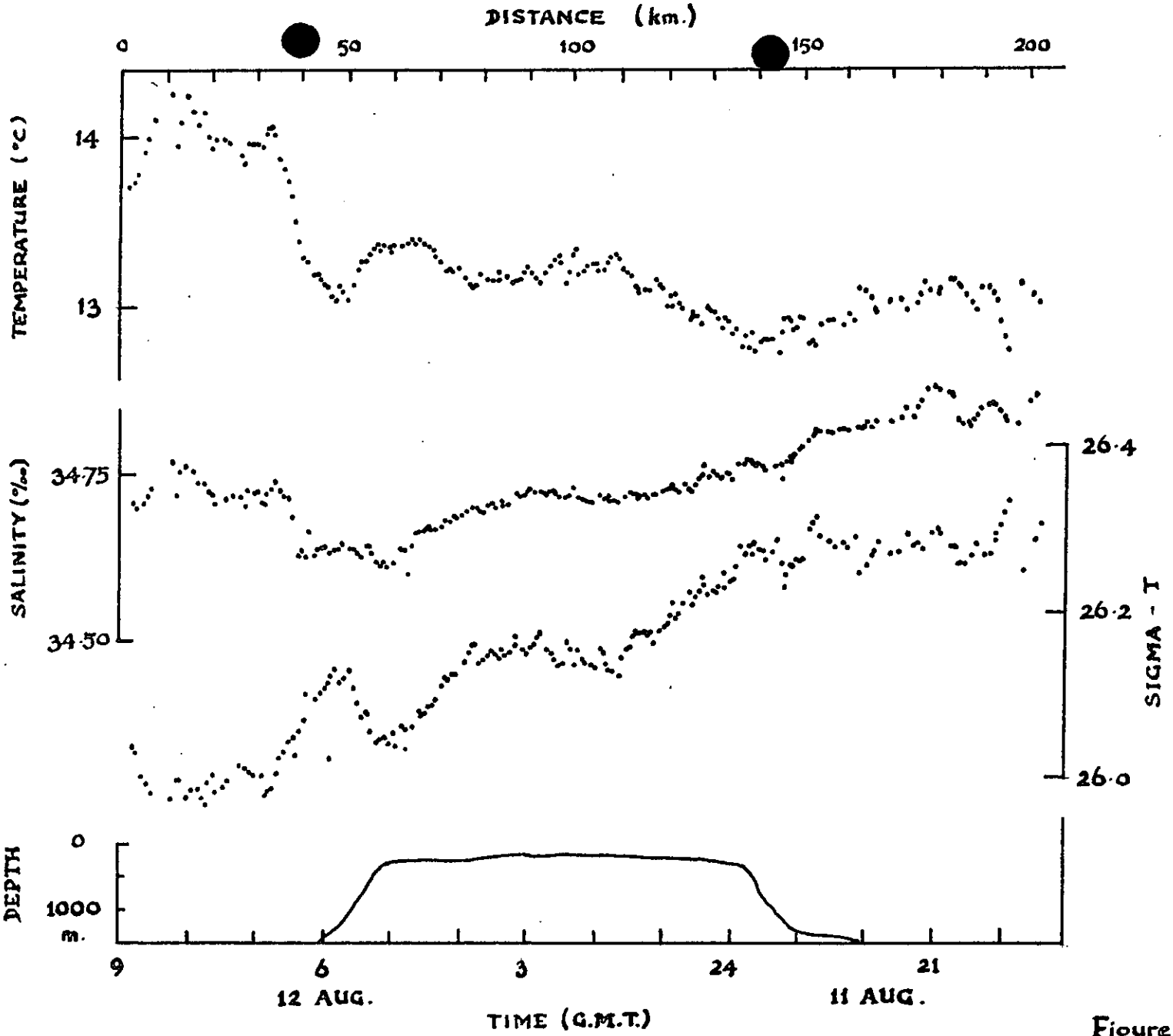
DISTANCE (km.)
0
50
100
150
200
TEMPERATURE (°C)
14
13
SALINITY (‰)
34·75
34·50
26·4
26·2
26·0
SIGMA - T
DEPTH
0
1000
m.
9
6
3
24
21
12 AUG.
11 AUG.
TIME (G.M.T.)

Figure 3

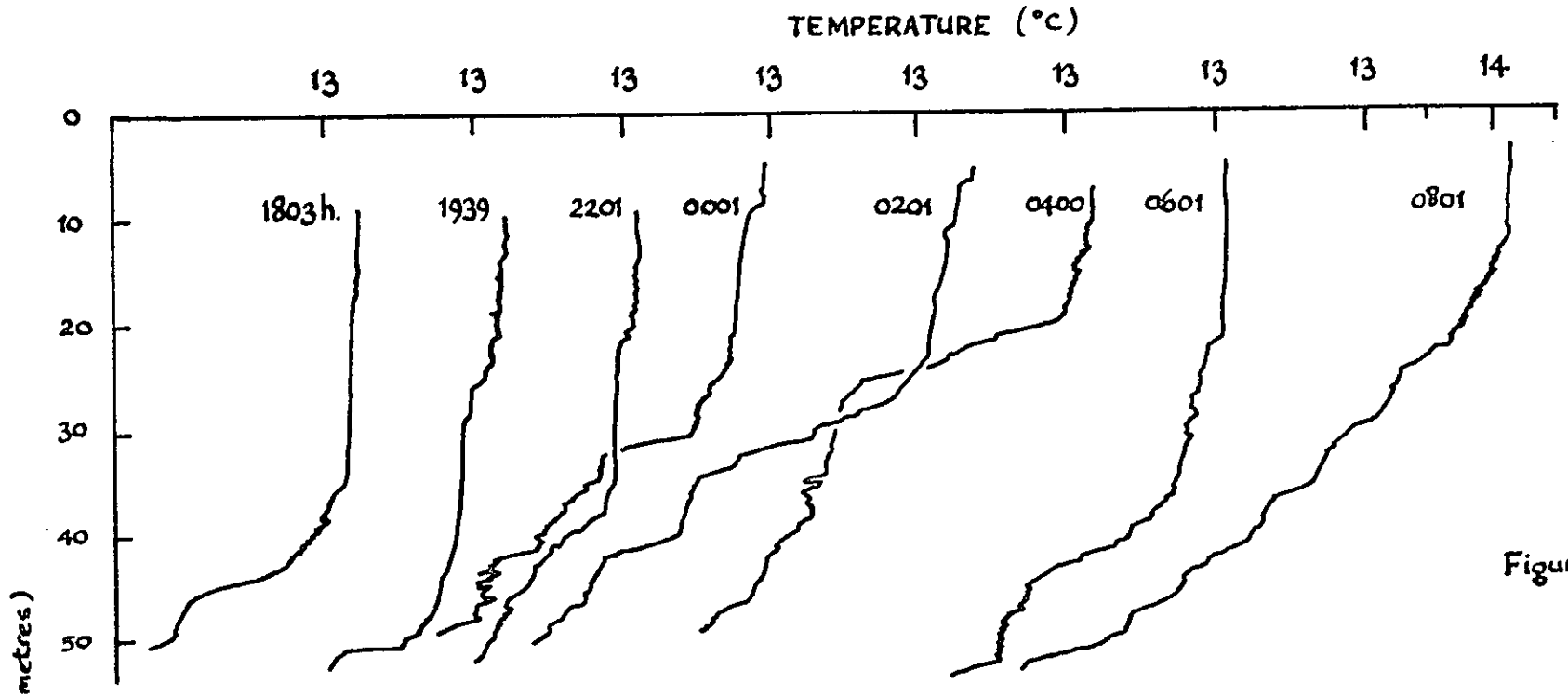


Figure 4a

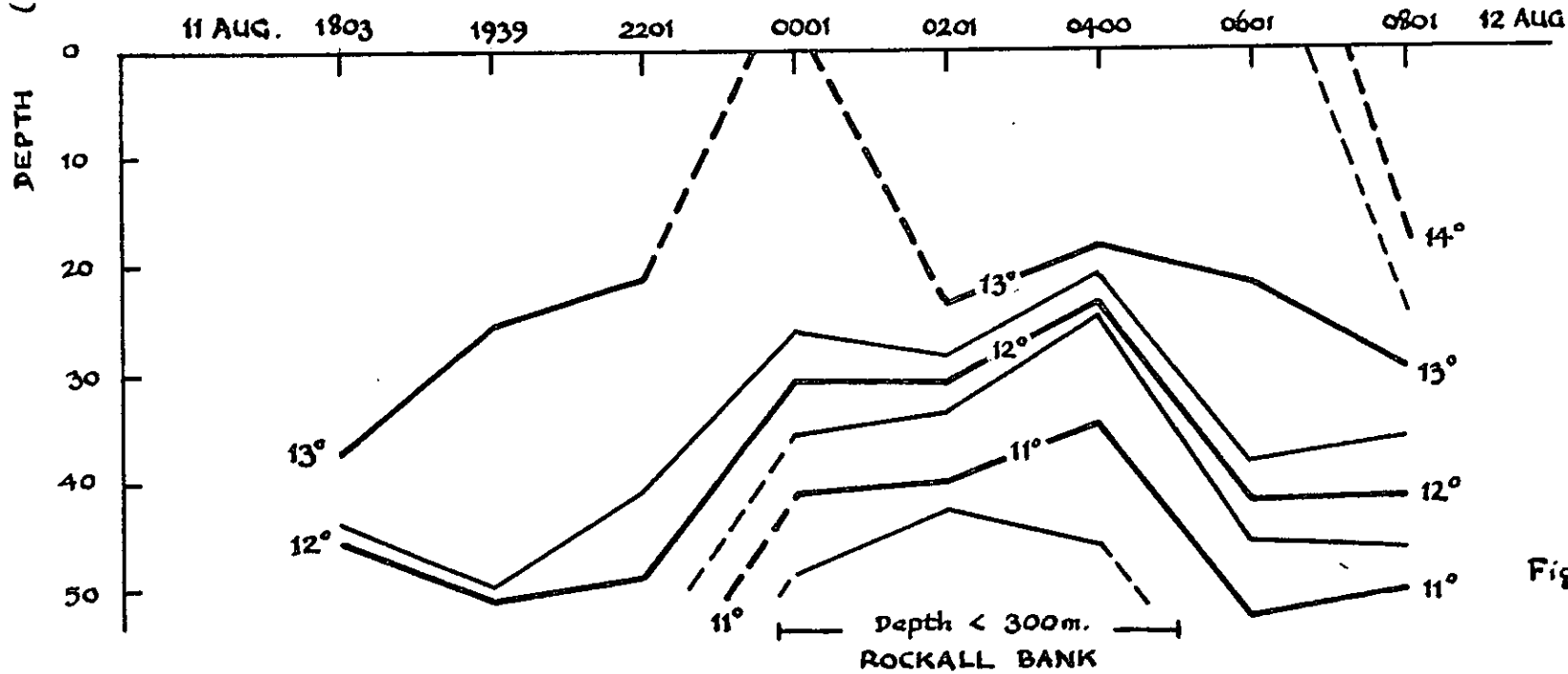


Figure 4b

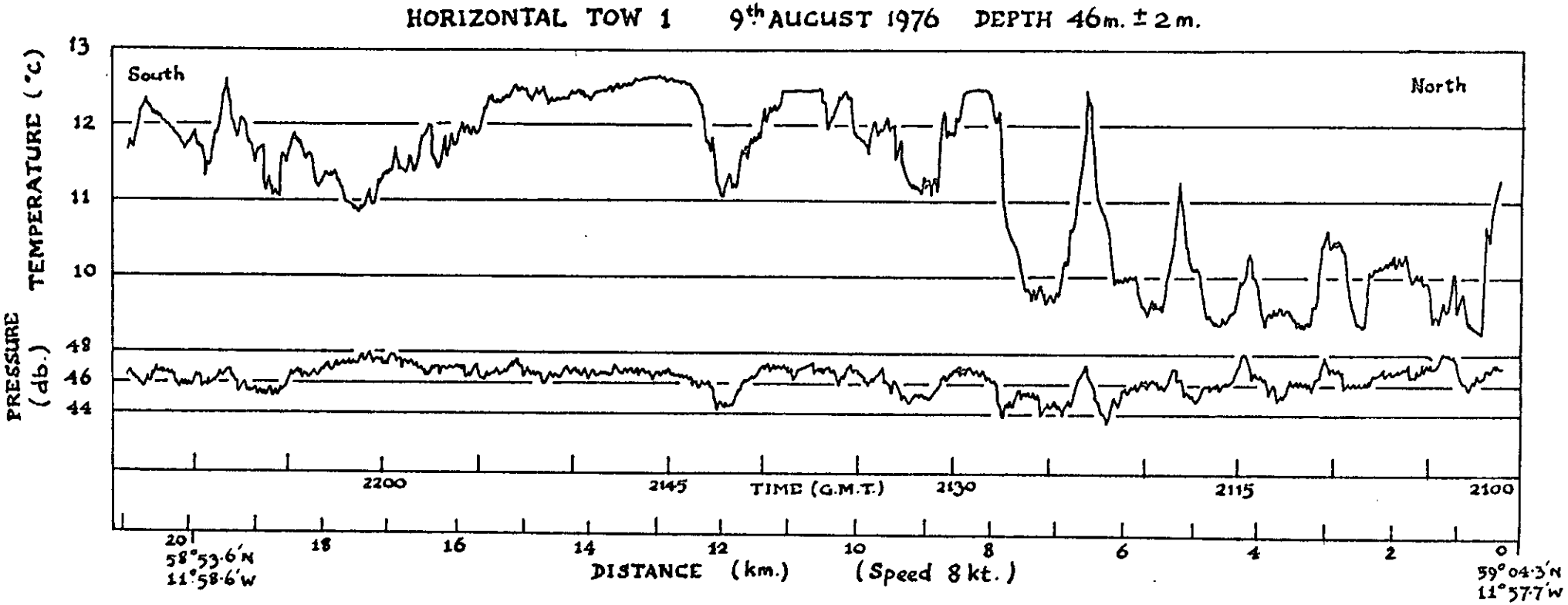
HORIZONTAL TOW 1 9th AUGUST 1976 DEPTH 46m. ± 2m.
TEMPERATURE (°C)
PRESSURE (db.)
South
North
13
12
11
10
48
46
44
2200
2145
TIME (G.M.T.)
2130
2115
2100
20
18
16
14
12
10
8
6
4
2
0
58°53·6'N
11°58·6'W
DISTANCE (km.) (Speed 8 kt.)
59°04·3'N
11°57·7'W

Figure 5a

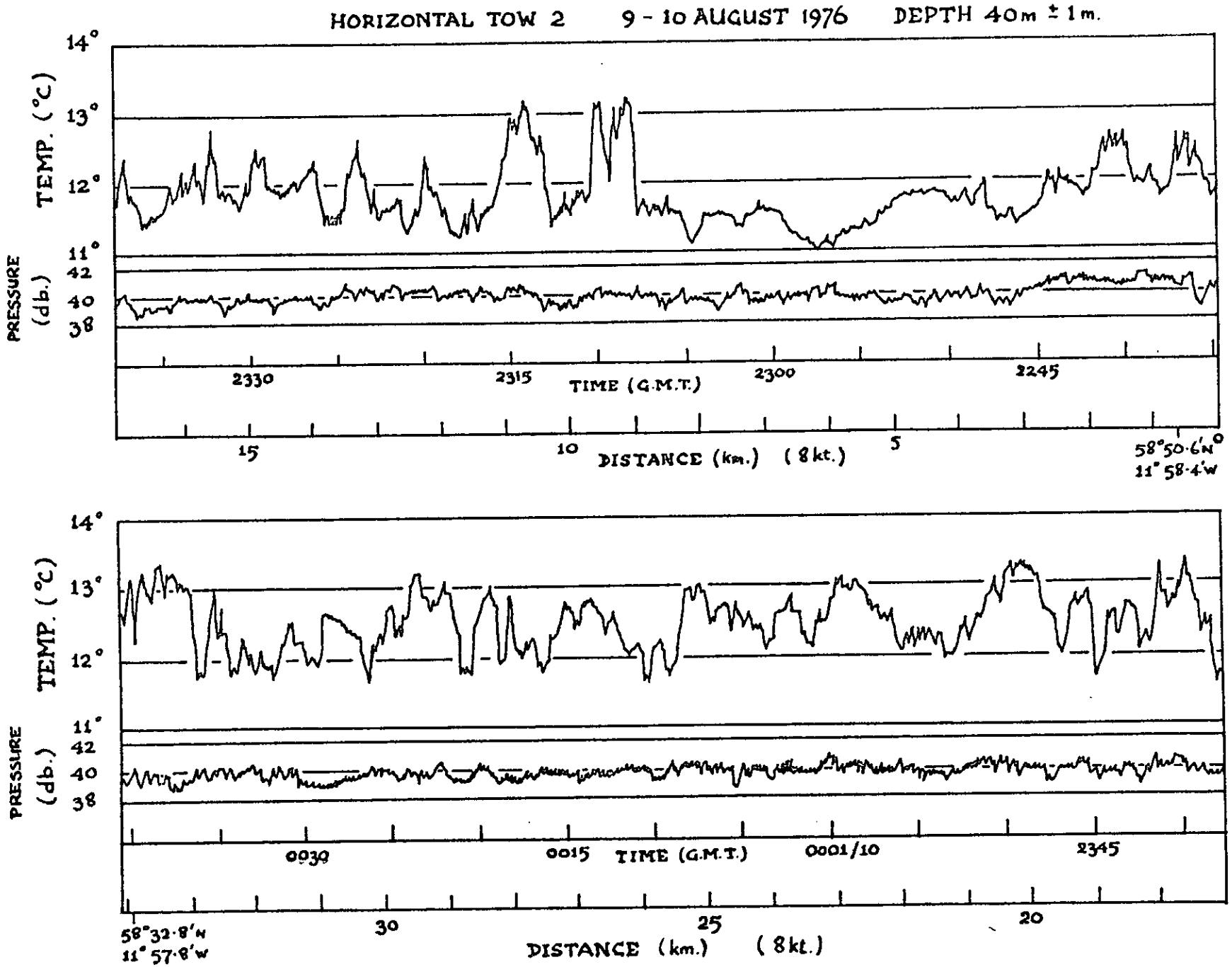
HORIZONTAL TOW 2 9 - 10 AUGUST 1976 DEPTH 40m ± 1m.
TEMP. (°C)
14°
13°
12°
11°
PRESSURE (db.)
42
40
38
2330
2315
TIME (G.M.T.)
2300
2245
15
10
DISTANCE (km.) (8kt.)
5
58°50·6'N
11°58·4'W
TEMP. (°C)
14°
13°
12°
11°
PRESSURE (db.)
42
40
38
0030
0015
TIME (G.M.T.)
0001/10
2345
58°32·8'N
11°57·8'W
30
25
DISTANCE (km.) (8kt.)
20

Figure 5b

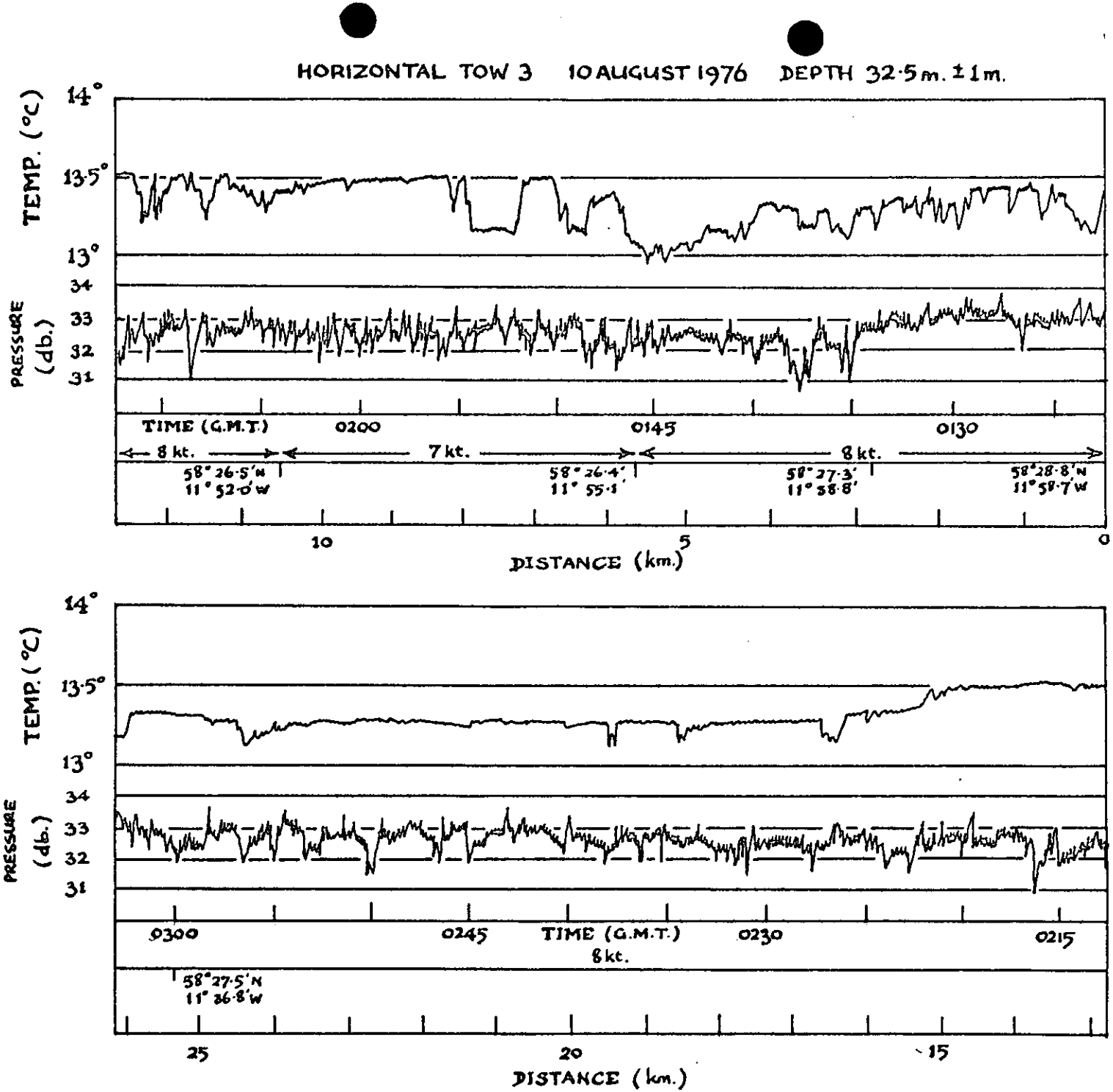
HORIZONTAL TOW 3 10 AUGUST 1976 DEPTH 32·5m. ± 1m.
TEMP. (°C)
14°
13·5°
13°
PRESSURE (db.)
34
33
32
31
TIME (G.M.T.)
0200
0145
0130
8 kt.
7 kt.
8 kt.
58° 26·5'N 11° 52·0'W
58° 26·4' 11° 55·1'
58° 27·3' 11° 58·8'
58° 28·8'N 11° 59·7'W
10
5
0
DISTANCE (km.)
TEMP. (°C)
14°
13·5°
13°
PRESSURE (db.)
34
33
32
31
0300
0245
TIME (G.M.T.)
0230
0215
8 kt.
58° 27·5'N 11° 36·8'W
25
20
15
DISTANCE (km.)

Figure 5c