SCOTTISH MARINE BIOLOGICAL ASSOCIATION

Dunstaffnage Marine Research Laboratory.

Cruise Report

R.R.S. CHALLENGER

Cruise 13/1977

20 August - 3 September 1977

RRS CHALLENGER, Cruise 13/1977.

Duration of cruise : 1610 h 20 August to 1322 h 3 September 1977

All times BST.

Locality : Rockall Channel, $56\frac{1}{2}^{o}$ to $59\frac{1}{2}^{o}$ N & Scottish Continental Shelf.

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Aims: Cruise 13 was the second of two CHALLENGER cruises devoted to JASIN 1977 work, in preparation for the major Joint Air-Sea Interaction experiment of JASIN 1978, and had the following aims:

1) To service the SMBA shelf current meter mooring in 57^{o}N 9^{o}W (mooring R) and retrieve another to the north-west of St. Kilda (S).

2) To repeat STD profiles to 1200 m depth at a $6\frac{1}{4}$ hour interval at each apex of 12 km triangles centered upon the sites of deep moorings W1, W2 & W3 (laid on cruise 11) & station F of the Anton Dohrn STD section.

3) To make shear measurements with the RAN Gradient Richardson number meter over periods of 4 hours.

4) To work the Anton Dohrn Seamount STD section.

5) To make hourly STD lowerings to 1200 m over a period of 25 hours at a number of locations as time permitted.

6) To record surface temperature and salinity along the ship's track using the STD in a pumped flow on deck, and to record soundings at 10-minute intervals.

7) To repeat three shelf STD sections worked to the west of the Hebrides on cruise 10.

8) To take 50 litre surface samples between the shelf-edge and the Sound of Mull for 137 Caesium determinations by the Fisheries Radiobiological Laboratory, Lowestoft.

Narrative. CHALLENGER sailed from Ardrossan at 1610 h, 20 August in calm weather and reached the easternmost station of the Anton Dohrn Seamount section at 1134 h, 21 August. The current meter mooring at station R was in the position in which it had been laid on cruise 11, and was therefore left for recovery later in the cruise. Calm weather continued during the working of the section, which was completed at 0333 h, 23 August, the ship subsequently returning to station F of the section to work a set of STD lowerings around the position between 1058 & 2205 h, carrying out surface STD logging on passage. Upon completing three pairs of STD lowerings at 6¼ hour intervals at each of three positions, course was set for mooring W3, laid on cruise 11, for similar observations, again with surface sampling en route.

The south-easterly winds had risen to force 5 during the evening of 23 August, and had further increased to force 7-8 upon arrival at W3 at 0530 h, 24 August. The ship was hove to awaiting an improvement, but with increasing swell an early resumption of work appeared unlikely at this station, and advantage was taken at 2000 h of a decrease in wind speed to force 6-7 to steam north-westward to mooring W2 in the hope of continuing STD work on the morning of 25 August. Surface sampling was again carried out, but upon arrival at the station at 0100 h 25 August wind had again increased and the ship hove to in easterly force 8-9 conditions throughout the day.

On the following morning winds had decreased to force 6-7, although a moderate swell remained. A shallow STD lowering was made

at 0926 h 26 August to determine the mixed layer depth, and in improving conditions the ship returned to position for the first station of a triangle centered upon mooring W2. The RAN shear probe was tested between 1315 & 1633 h, followed by two sets of three STD stations worked from 1718 h to 0500 h, 27 August.

CHALLENGER proceeded in light southerly winds to the vicinity of moorings W1 & W4, where a third set of STD lowerings began at 0937 h. Wind and swell again increased reaching force 7 by 2000 h, when the last of six STD stations around the moorings had to be cancelled. The ship hove to in southerly winds which attained force 9 during the night. Towards noon of 28 August these became south-westerly force 5, but a heavy swell was slow to moderate. Conditions remained unsuitable for working the Australian shear probe and at 1700 h it was decided to steam for mooring W3 in the hope of starting an STD triangle at this position. However, by 2345 h the southerly winds had again increased to force 7-8 and the ship hove to. Soon after daybreak on 29 August the wind veered westerly, reaching a speed of 50 kt. at 0700 h and subsequently declining slowly to force 6-7 by mid-afternoon, with a long swell. In view of 72-hour forecasts of a further series of depressions over the working area it was agreed to run towards the shelf in order to be able to retrieve moorings S and R whenever an opportunity offered, and the ship set course towards the Butt of Lewis at 1715 h, heaving to at the edge of the shelf at 0200 h 30 August when an improvement in conditions seemed likely for the following morning.

At 0735 h 30 August the winds had dropped to south-westerly force 4-5 and course was set for mooring S, near St. Kilda. The spar-buoy was sighted at 1010 h and Loran-C and Decca fixes of its position agreed with those taken when the mooring was laid. No pellets from the subsurface buoy were visible however, and when hauling began in a moderate swell, it became evident that the ground-wire was no longer on its original alignment. The lower of the two current meters was recovered successfully, but the upper meter had gone from its A-frame, which was badly bent. Taken as a whole, the evidence suggested that the mooring had been tampered with, rather than accidentally run down.

After raising the mooring CHALLENGER steamed westward to the shelf-edge, and from 1500 to 1916 h the shear probe was cycled through the thermocline on the hydrographic wire. Overnight the outer stations of the northern-most shelf section and one station of the central section were worked before steaming to mooring 'R' for retrieval and re-laying. Recovery between 1010 & 1049 h 31 August went smoothly in force 4 westerly winds and a much decreased swell, and after the replacement of a number of components, the mooring was re-laid between 1356 & 1427 h. After a short steam westward to soundings of 600 m, shear probe measurements were made from 1550 to 1920 h, when increasing southerly winds forced their curtailment. In view of the poor weather forecast, radiocaesium & STD stations C10 to C7 were worked to Barra Head in deteriorating conditions, after which the ship set course for shelter, heaving to at 0745 h 1 September to the northward of Canna and Rhum.

Force 7-9 winds and strong squalls continued into the morning of the following day, but decreased sufficiently by 1200 h 2 September to allow the ship to proceed southward through the Sound of Rhum. As a result of discussions with the Research Vessel Base, it had been agreed that the weather outlook gave little hope of docking at Dunstaffnage during the following few days, and course was set for Ardrossan. Surface samples were collected at radiocaesium stations C3 to C1 between 1417 and 1535 h en route through the Tiree Passage to the North Channel. An uncomfortable moderate swell remained in the open sea, but the Firth of Clyde was reached in the forenoon and the ship berthed at Ardrossan at 1322 h, 3 September.

Results. Time lost for bad weather on this cruise amounted to 4 days 23 h. out of 14 days, excluding time lost as a result of the change of port from Dunstaffnage to Ardrossan due to weather problems at the end of this and the previous cruise. In addition, the short-term vagaries of the weather were able to disrupt such aims of the programme as required even the modest span of 12 h to complete. These two factors will need to borne well in mind during the final planning for JASIN 1978.

Aim 1) The long-term SMBA current meter mooring in 57°N, 9°W was serviced on 31 August. Both current meters, at nominal depths of 36 & 106 m in depths of 135 m appeared to have functioned throughout the period of 49 days since the previous deployment, although the upper meter had jellyfish remains around its propeller shaft which are likely to have biased its velocity recording for part of the period.

The shelf mooring to the north-west of St. Kilda was retrieved on 30 August after 47½ days at sea. The upper meter was missing from its bent A-frame, which bore traces of red paint. The lower meter, at 114 m nominal depth in soundings of 143 m, was apparently running correctly. Absence of the pellets and most of the line attached to the sub-surface buoy suggests that the mooring was fouled by fishing gear and raised on a windlass by the pellet line in order to clear it. The bending of the A-frame and possible fracturing of the meter suspension shackle could have occurred against a ship's hull with the meter wire

anchor broken out of the ground. The pellet line would probably be cut free after the clearing operation.

Aim 2) Triangles of three STD stations repeated twice at an approximately $6\frac{1}{4}$ hr time interval were completed at two positions; Station F of the Anton Dohrn Seamount section, and in the vicinity of moorings W2 & B2. In addition, five out of six STD lowerings were worked close to moorings W1 & W4 before bad weather stopped the observations. Attempts to sample around mooring W3 were twice frustrated by high winds and swell.

Lowerings were made to 1200 m depth in order to provide dynamic thickness data in three depth bands, 10-200, 200-500 & 500-1100 db. Preliminary examination of the temperature structure at the three groups of stations shows smaller differences between the repeated pairs and between the three stations of each group than those encountered during Cruise 11/1977. Depth for depth differences were mostly less than 0.25 deg. C., but further comment must await full analysis of the data.

Aim 3) Dr. I.S.F. Jones has contributed the following report upon the observations taken with the Australian Navy shear probe:

"Three series of profiles were obtained with the RAN Research Laboratory Gradient Richardson Number Meter (GRNM) during the cruise. The instrument was yo-yoed on a one minute cycle 5 meters above and below the base of the mixed layer during the environmental conditions shown in Table 1.

Table 1

Time	Water Depth (m)	Lat & Long N W	Wind Speed m/sec	Mixed Layer depth (m)	Wave height (m)	Station Number	Temp. Grad. °C/m
26 Aug	1600	58°, 12°	7	~50	3	J1	1.0
30 Aug	200	58°, 9°	7.5	~57	2	J2	0.8
31 Aug	500	57°, 9°	9	~30*	2	J3	0.4

*possibly weak thermocline at smaller depth.

The GRNM measures the depth of the mixed layer, the temperature gradient across the base of the layer, the velocity difference across the layer and the intrument orientation. The later ensures that the instrument is vertical (observed values $\pm 1^{\circ}$).

During the first station the mixed layer depth (defined as the depth of the isotherm $0.1^{\circ}C$ below the mixed layer temperature) varied rapidly, increasing 10 m in 10 minutes on one occasion. This reinforces the need to make very frequent CTD dips during periods of high wind during JASIN 1978 if the details of the deepening of the mixed layer are to be understood.

One interesting parameter that was immediately available is the first maximum velocity gradient at the base of the mixed layer. This we defined as the largest gradient detected by our sensor between the base of the mixed layer and the distance below the

layer where the gradient was one half the maximum. This represented no problem in practice as the gradient (measured between sensors 78 cm apart) increased rapidly and fairly smoothly to a maximum and then at a greater depth decreased. The values in Table 1 show a representative figure of 1 $^{o}C/m$ or an approximate Brunt-Väisälä frequency, N, of $\sqrt{2 \times 10^{-3}}$ sec^{-1} (salinity gradient was not measured).

It is interesting to speculate on the value of velocity gradient required to make the gradient Richardson number unity at the base of the mixed layer i.e.,

$$\text{Richardson Number} = N^2 / \left(\frac{\partial U}{\partial Z}\right)^2 = 1$$

$$\left(\frac{\partial U}{\partial Z}\right)^2 = N^2$$

Thus velocity shears of 4×10^{-2} sec^{-1} or order 10 cm/sec would be required across this region (order 2 metres thick) of high temperature gradient. While the resolution of the electromagnetic current meter used in this instrument is much better than this, the signal is "contaminated"by surface wave motions. In the present case these were of order of 20 cm/sec peak to peak with periods of order 7 seconds. We will attempt 1 minute averages of the velocity difference $\pm$ 5 m of the interface to see if such a "mean" shear existed."

Aim 4) The Anton Dohrn Seamount STD section was worked between 1134 h 21 August and 0333 h 23 August in calm conditions. Apart from the unusually deep extent of the 9.5°C isotherm at the Scottish continental slope (>400 m), rough plots of the data show typical features, such as the 300-400 m increase in depth of the 9°C isotherm over the deep water vis á vis the Scottish and Rockall Bank continental shelves.

Aim 5) No opportunity existed to make a 25-hour series of STD lowerings in one position. The rapid sequence of depressions which passed across the area made this an impractical proposition.

Aim 6) Surface temperature and salinity were recorded from the STD on deck using the non-toxic pump and the Bidston tank during the longer periods of steaming, but the data were interrupted by the need to disconnect the pump during heavy weather. The temperature range was small; values exceeding 15°C were found along latitude 57°30'N during the calm early days of the survey, but thereafter, along the tracks to the north of this, temperatures of 13.0° to 14.5° were found. Discontinuities were few, and seldom exceeded 0.5 deg. C.

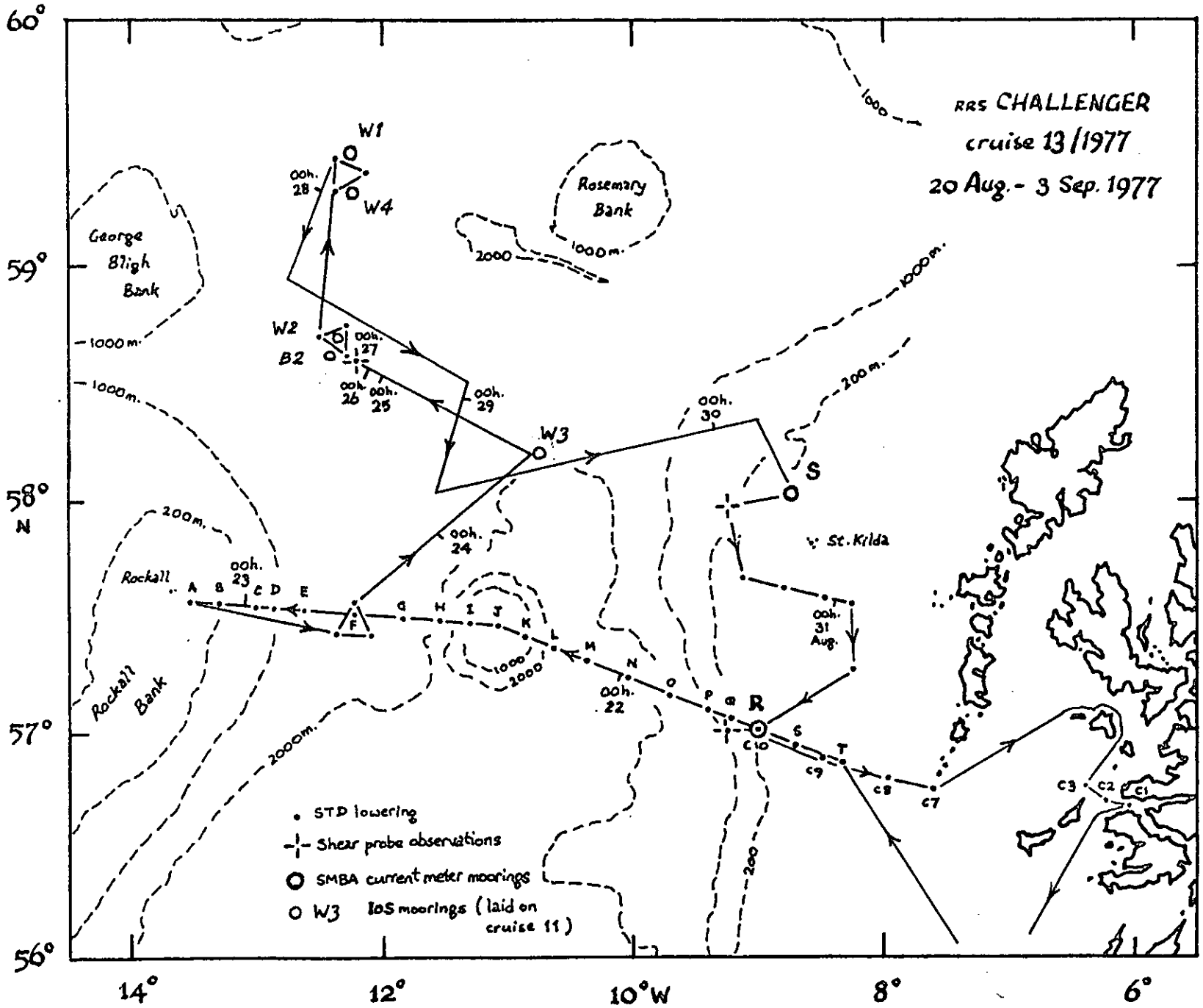
Aim 7) Of the shelf sections, only that between the mooring and Barra Head was completed. Five of the outer shelf stations of the remaining two sections were worked on 30-31 August, but no opportunity occurred subsequently for the working of the inshore

stations. Stations on the outer shelf still retained a bottom layer of temperature below 9°C formed in the previous winter.

Aim 8) Surface samples for radiocaesium determination were taken at stations C10-C8 on 31 August - 1 September and at C3-C1 on 2 September. STD lowerings were made at C10-C8 in conjunction with the previous aim.

D.J. Ellett

3 September 1977.


RRS CHALLENGER
cruise 13/1977
20 Aug. - 3 Sep. 1977
60°
59°
58° N
57°
56°
14°
12°
10°W
8°
6°
W1
W2
W3
W4
B2
S
R
St. Kilda
George Bligh Bank
Rosemary Bank
Rockall
Rockall Bank
1000m.
2000
200m.
2000m.
200
ooh. 22
ooh. 23
ooh. 24
ooh. 25
ooh. 26
ooh. 27
ooh. 28
ooh. 29
ooh. 30
ooh. 31 Aug.
A B C D E F G H I J K L M N O P Q R S T
C1 C2 C3 C7 C8 C9 C10
STD lowering
Shear probe observations
SMBA current meter moorings
W3 IOS moorings (laid on cruise 11)