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Features of Hydrography and Currents in the Faroe-Shetland Channel During Overflow 73

by

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INTRODUCTION

The contribution made by the Marine Laboratory, Aberdeen to the Overflow 73 expedition was to monitor hydrographic conditions on a section across the Faroe-Shetland Channel (figure 1). Observations consisted principally of a seven times repeated hydrographic section, and on three of these samples were collected for silicate, nitrate and phosphate. In addition current measurements were made at 5 points on this section (figure 1), the details of which are laid out in Table 1. Parachute drogue measurements were made at the south-eastern end of the section on the Scottish continental slope and these observations have been used in conjunction with the other data to examine exchange processes between the Faroe-Shetland Channel and the northern North Sea (Dooley, Martin and Payne in prep). This present paper will however restrict itself to describing the current meter and hydrographic measurements and in particular discuss how they may fit into the general framework of Overflow 73.

Hydrography

The hydrographic sections were worked on 20, 23, 28 and 30 August and 3, 9 and 14 September. Each differed considerably in points of detail but their general features were similar to those of Tait (1957). These features were warm, salty water of southerly origin in the upper 200 metres and a homogeneous mass of Norwegian Sea Deepwater (< 0°C, 34.93‰) occupying depths below about 500 metres, but their detailed distributions varied considerably with time. Figures 2 and 3 represents the contrasting salinity conditions in the Channel during Overflow 73.

Figure 2 is marked by relatively smooth isohalines with, typically, the saltiest (and warmest) water lying adjacent to the Scottish continental slope at the south-eastern corner of the section where it also penetrates to greater depths. The surface water elsewhere in the Channel has slightly reduced salinity (and temperature).

Figure 3 is a section worked on 30 August when a much more complex salinity distribution was present. These unusual features had been apparent since 26 August finally disappearing by 3 September. Although these features have been observed on previous occasions (Tait 1957) they do not occur very frequently and indicate that, in the Faroe-Shetland Channel at least, atypical conditions were prevailing during Overflow 73.

To help interpret the origin of these unusual conditions the hydrographic data were analysed by means of the water mass analysis programme available at Kiel. The data were analysed with respect to water of 3°C and 34.88‰ which was present as a distinctive feature in the section of 30 August. This water has characteristics similar to Arctic Intermediate (AI) water found over the Iceland Faroe Ridge (Meincke 1972) and for convenience it will be referred to as this although there is no evidence to support the assumption that it is AI water. The distinctive feature of this analysis (figure 4 and 5) was that the intermediate waters of the Faroe-Shetland Channel are not derived from a direct admixture of Atlantic and Norwegian Sea Deepwater which occupy the surface and bottom layers respectively. Instead high proportions of AI water are present, even in the relatively smoothly isohalined section of 20 August. Not surprisingly this proportion increases to a maximum of 90% on 30 August and advances towards the surface.

Current Meter Results

The data return from the five current meter moorings was about 70% which was sufficient to enable a reasonable picture of current conditions in the Channel. Three of the moorings were deployed in the shallower water (~200m) at the sides of the channel, (Table 1), the remaining two being deployed at the foot of the Scottish and Faroes continental slopes respectively in about 1000m of water. Hourly mean and residual progressive vectors of some of the records are presented in figures 6-9. Figure 6, from the shelf break at the south-eastern edge of the channel, shows features which are similar to a number of previous records obtained from this area, ie a current directed to the ENE along the general direction of the edge of the continental slope. This represents the flow of North Atlantic water which is always present in this part of the channel. The average flow is about 7 nm's/day but fluctuates considerably about this mean. Maximum flow was 15 nm's/day on 2 September and there was a minimum flow of only 3 nm's/days on 25 August. Drogue measurements demonstrated that this current increased to the 500m contour where it was about double these speeds.

In figure 6 it is evident that the northerly component of tidal stream is of differing character, than the easterly component. The latter clearly shows a dominant semi-diurnal oscillation with an M_2 and S_2 amplitude of 15 and 5 cm/s respectively which is quite typical of this area. On the other hand the northerly component is diurnal in character and analysis shows this to be concentrated around the K_1 component. Evidently this is further confirmation of the non-divergent shelf waves previously discussed by Cartwright (1969).

Mooring 105 was located in an area of fairly complex hydrography, the near surface current meter (110m) lying near the boundary of the North Atlantic water and the intermediate Atlantic water which occupied most of the surface layers of the channel. A malfunction resulted in no record during 4 September. Currents here were much stronger than at 103 (figure 7) but on the average flowed in substantially the same direction. Maximum north easterly flows exceeded 25 nm's/day and averaged 15 nm's/day. Variability was also much larger than at 103 with frequent strong cross-channel flows and, somewhat surprisingly, a reversal of flow near 2 September. This reversal coincides with maximum flows at 103 but in view of the atypical salinity distribution (figure 3) this variability between on and off shelf flows should be regarded also as being atypical.

The speed sensor on the near bottom meter at 105 failed to function for 99% of the time but the direction record indicates that its principal features are similar to those at 106 (figures 8 and 9). Mean currents here at depths of 137m and 812m were 7 nm's/day towards 190° and 4 nm's/day towards 210° respectively with maximum flows in similar directions of 30 nm's/day and 12 nm's/day. The maximum near surface flows immediately preceded the onset of the cold, less saline water (figure 3) and clearly must have been associated with the propagation of this water into the channel. Small reversals occurred around 1 September and this suggests that the temporary reversal in flow at 105 about this data was the consequence of a large scale current event. This southerly flow of (intermediate) Atlantic water on the western side of the Faroe-Shetland Channel was first reported by Lee (1963) but it is an important fact which has been ignored in subsequent analysis and descriptions of the area. Its presence may have however a profound bearing on our understanding of the Faroe-Iceland overflow process (Meincke and Dooley in prep).

Geostrophic Shear, Current Shear and Volume Transport

Geostrophic Shear from the 7 sections have been compared with the observed current shear, especially at 106. The results are by no means convincing because of the rapid time and space variations present in the hydrographic and current observations. It is clear however that there is very little shear at 106, the current being strongly barotropic there. The most intense barotropicity occurred around 7 September when geostrophic calculations demonstrated zero current and yet both near surface and near bottom instruments registered currents of 12 nm/day. In addition to this barotropicity there also occurs an area of zero current shear at the south eastern edge of the channel. This is the area occupied by the north eastward flowing Atlantic water and during Overflow 73 the current meter and drogue measurements demonstrated a mean transport of 2×10^6 m^3/s which is not too far away from Tait's (1957) estimates. On the basis of these current measurements this similarity would appear to be quite fortuitous since the choice of a level of zero current between the surface and bottom, as Tait did, would certainly appear to be at least partly invalid.

Discussion

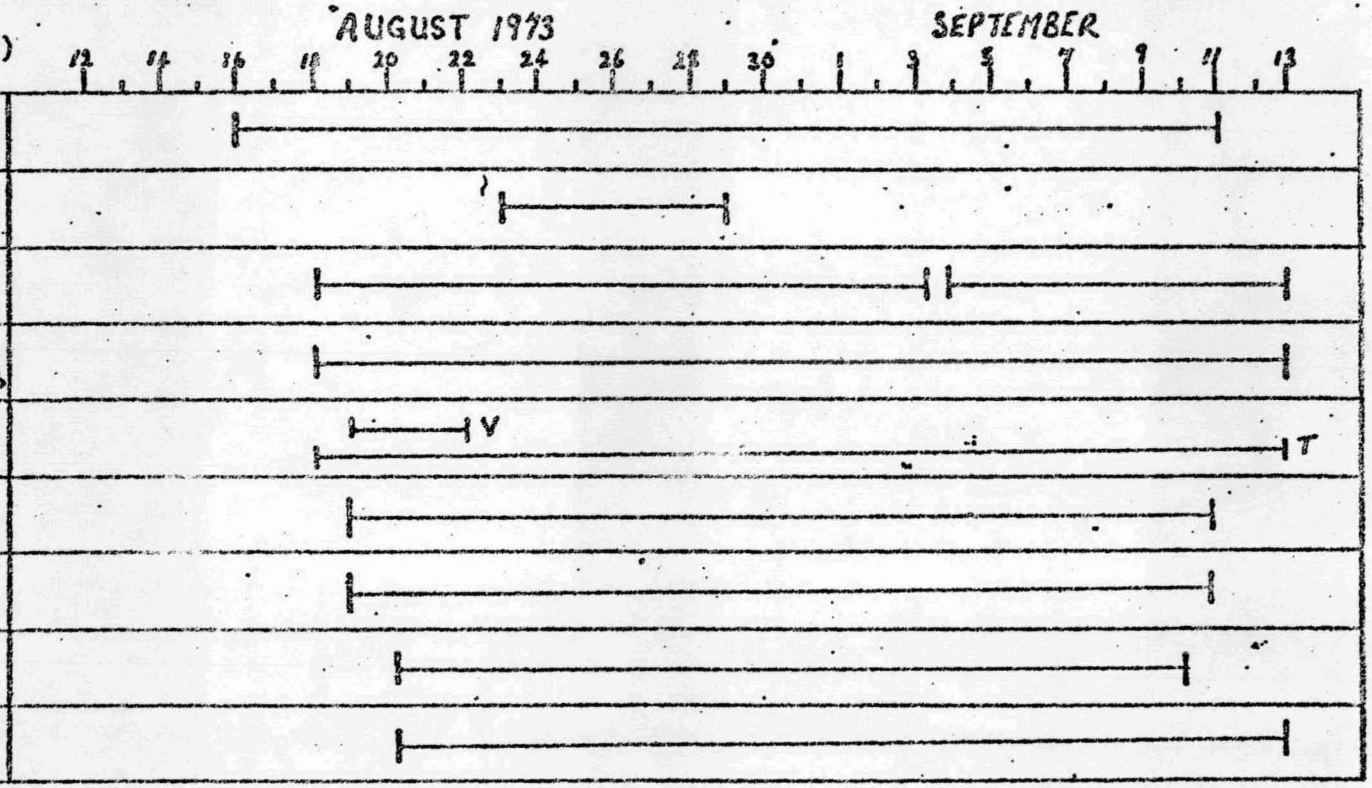
One of the main objectives of monitoring currents in the Faroe-Shetland Channel during Overflow 73 was to provide estimates on the amount of North Atlantic water entering the Norwegian Sea. On the basis of the results presented here this objective will however take on a secondary role mainly because of the apparent close similarity between water properties on the Faroe-Iceland Ridge and in the Faroe-Shetland Channel. Taking this fact with the presence of strong southerly flows of North Atlantic water on the western side of the channel and the absence of a zero surface indicates that processes on either side of the Faroe-Iceland Ridge are greatly influenced by processes in this area. This would be particularly so if a zero surface was also absent in the Faroe-Bank Channel, a possibility previously considered by Crease (1965).

References

Cartwright D E	1969	Extraordinary tidal currents near St Kilda. Nature 223(5209): 928-932
Crease J	1965	The flow of Norwegian Sea water through the Faroe Bank Channel. Deep Sea Res 12: 143-150.
Lee A J	1963	The hydrography of the European Arctic and Subarctic Seas. Oceanogr. Mar. Biol. Ann. Rev., 1: 47-76.
Meincke J	1972	The hydrographic section along the Iceland-Faroe Ridge carried out by R V 'Anton Dohrn' in 1959-1971. Ber. dt. wiss. Kommn Meeresforsch. 22: 372-384.
Tait J B	1957	Hydrography of the Faroe-Shetland Channel, 1927-1952. Mar. Res. 1957 (2): 309 pp.

Table 1 Current meter details Overflow 73
(V = velocity, T = Temperature)

Record No	Parameters measured	Depth (metres)
103/2	V, T	194
104/4	V, T	242
105/1	V, T	110
105(T)	T	285 - 335 5M INTERVALS
105/2	V, T	885
106/1	V, T	137
106/2	V, T	812
107/1	V, T	58
107/2	V, T	258



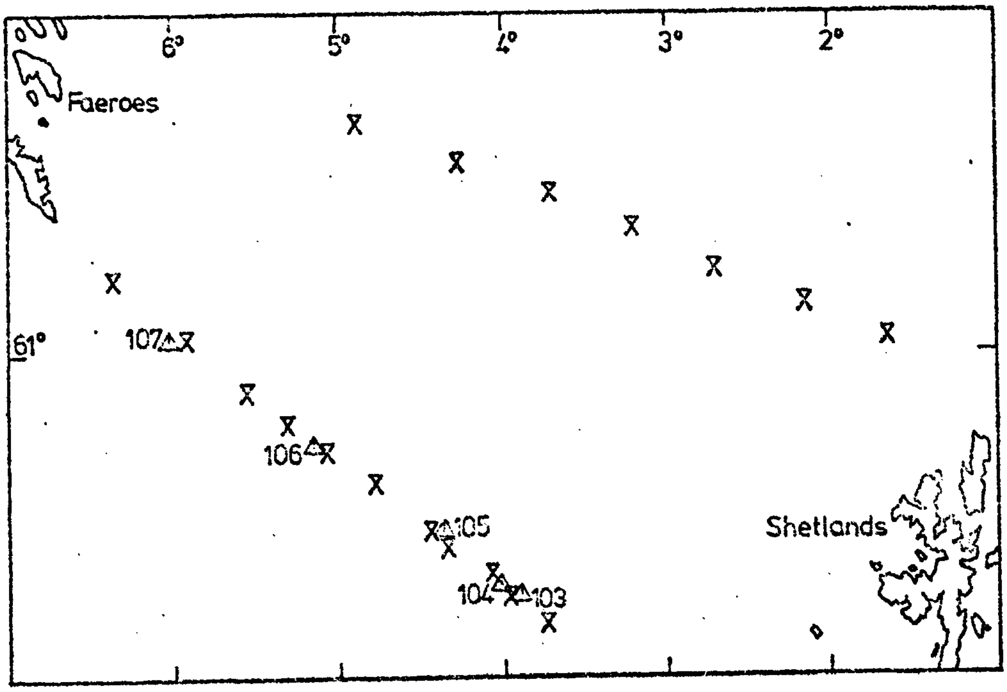


Fig 1

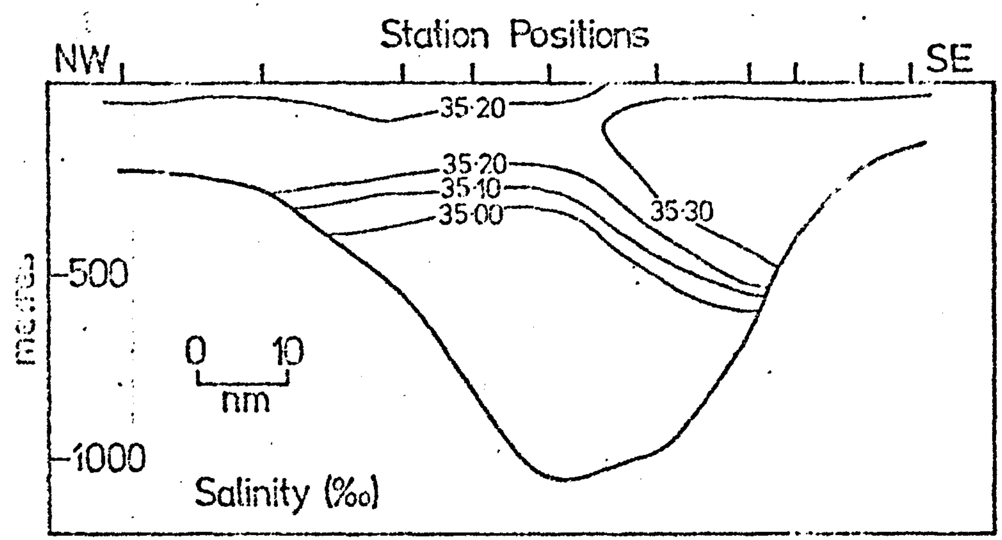


Fig 2 Salinity distribution 20/8/73

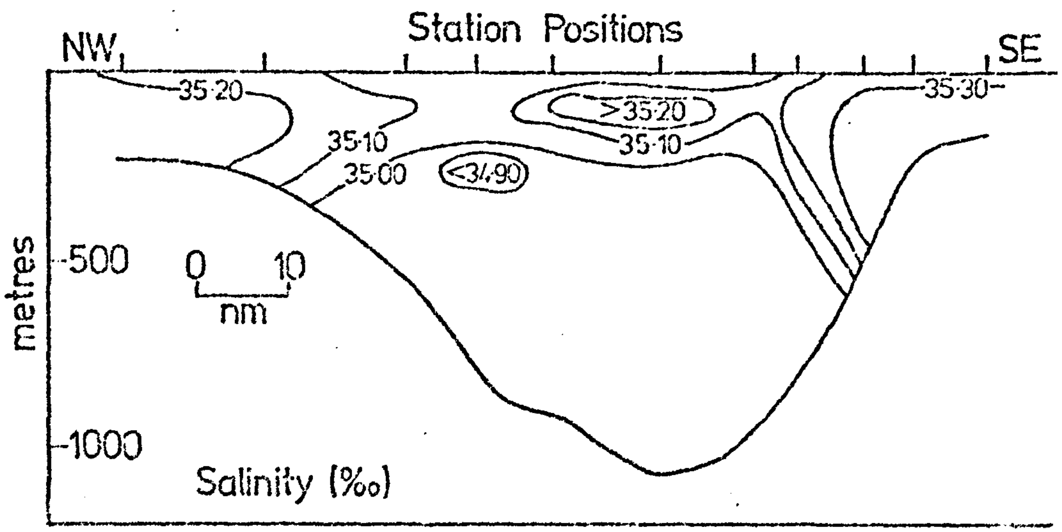


Fig 3 Salinity distribution 29/8/73

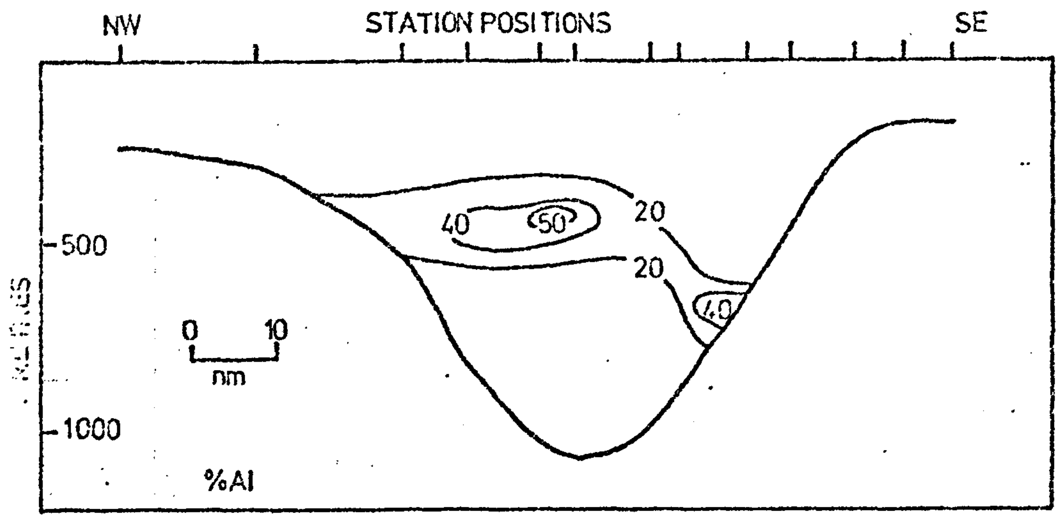


Fig 4 %AI distribution 20/8/73

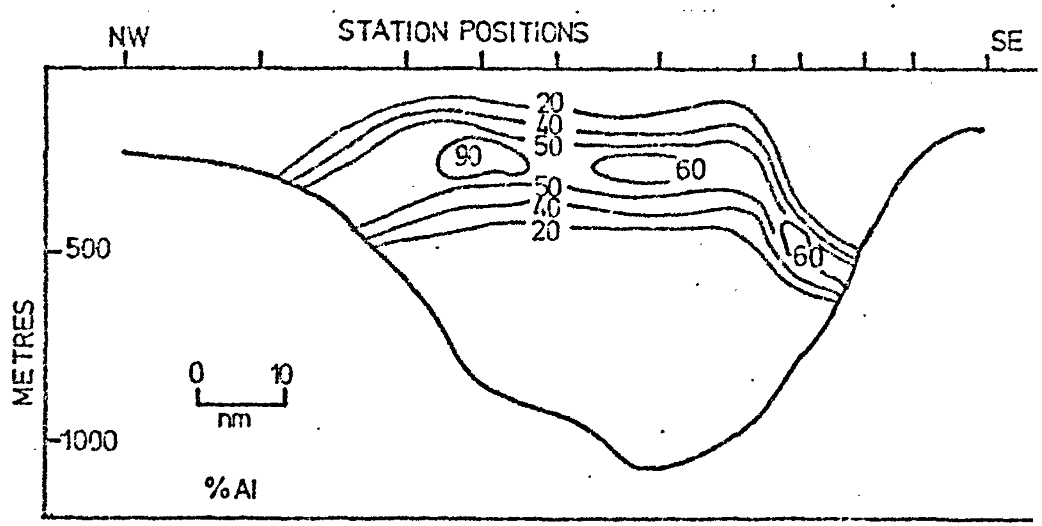
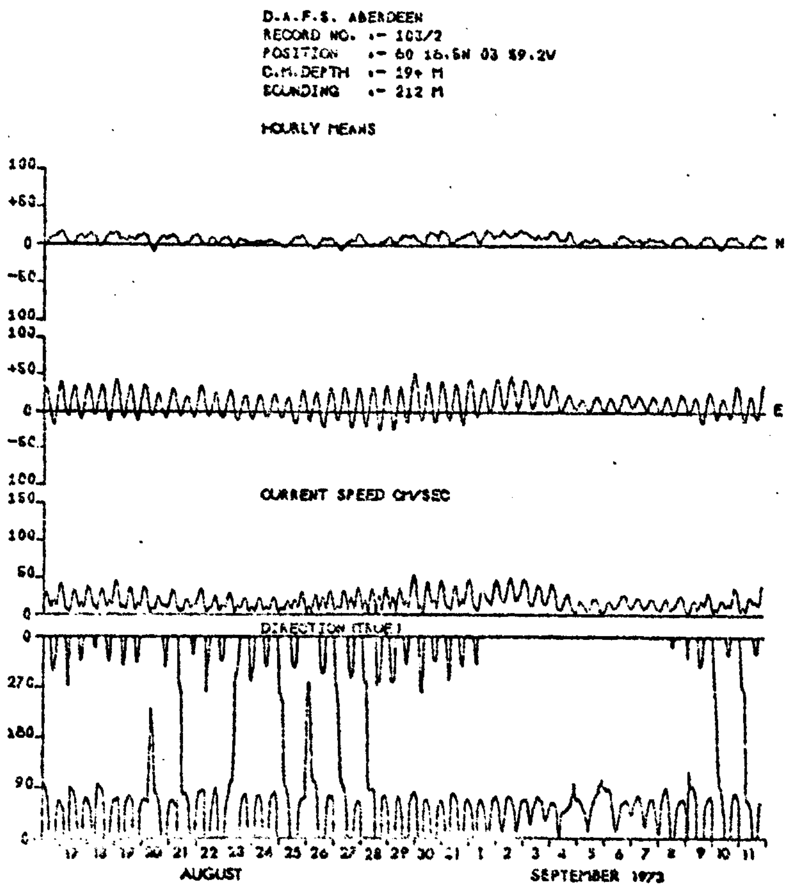


Fig 5 %AI distribution 29/8/73


D.A.F.S. ABERDEEN
RECORD NO. :- 103/2
POSITION :- 60 16.5N 03 59.2W
C.M.DEPTH :- 194 M
SOUNDING :- 212 M
HOURLY MEANS
N
E
CURRENT SPEED CM/SEC
DIRECTION (TRUE)
17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11
AUGUST
SEPTEMBER 1973

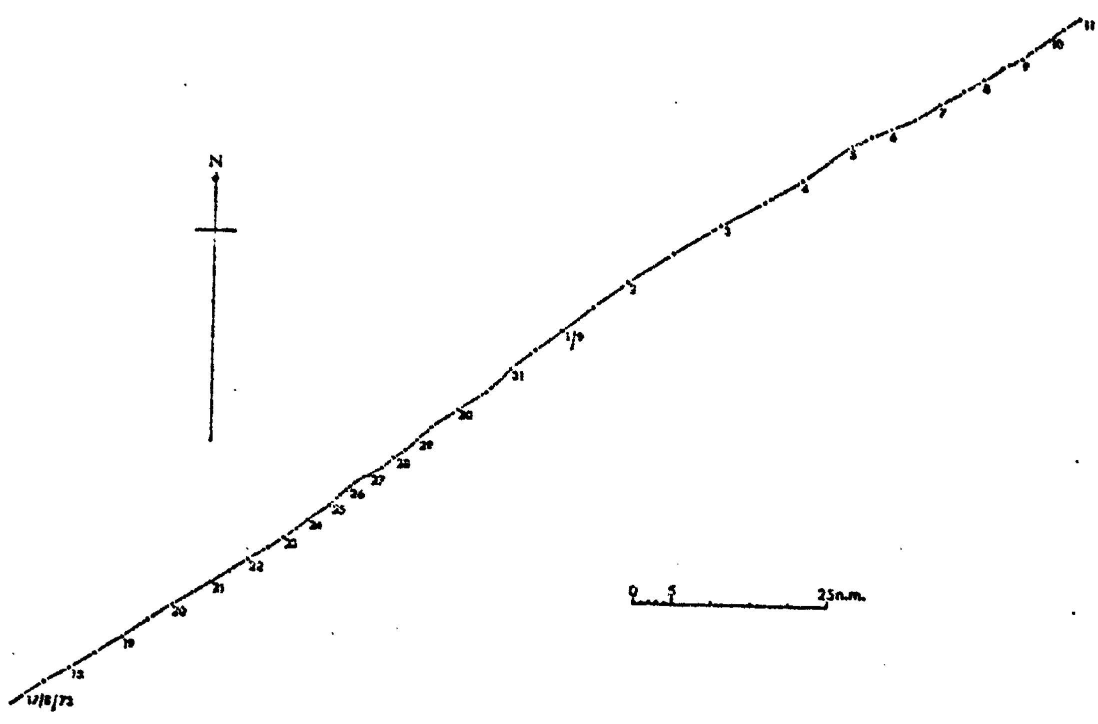

N
17/8/73
25n.m.

Fig 6

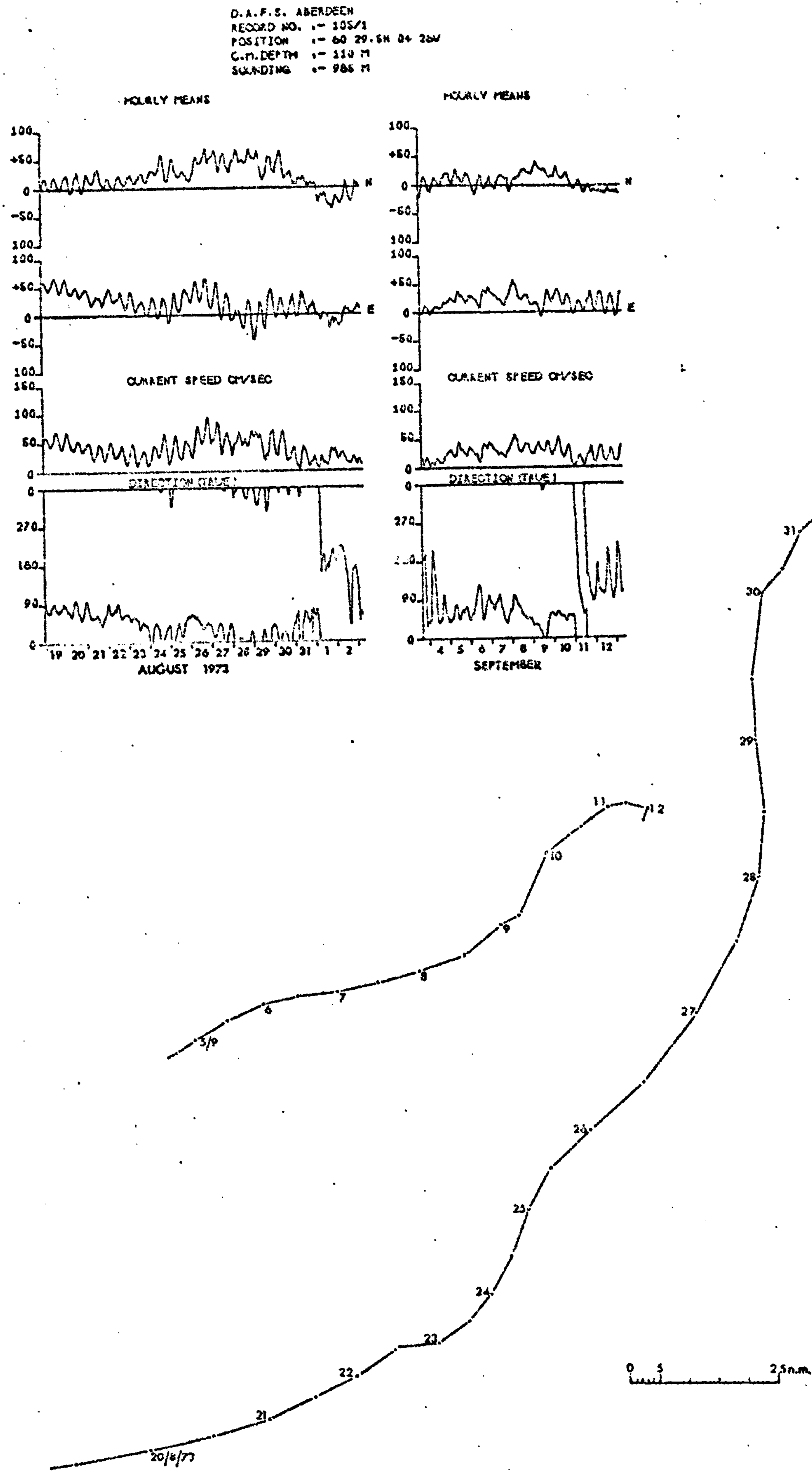

D.A.F.S. ABERDEEN
RECORD NO. :- 105/1
POSITION :- 60 29.5N 04 26W
C.M.DEPTH :- 110 M
SOUNDING :- 985 M
HOURLY MEANS
HOURLY MEANS
CURRENT SPEED CM/SEC
CURRENT SPEED CM/SEC
DIRECTION (TRUE)
DIRECTION (TRUE)
AUGUST 1973
SEPTEMBER
20/8/73
3/9
1/9
0 5 25 n.m.

Fig 7

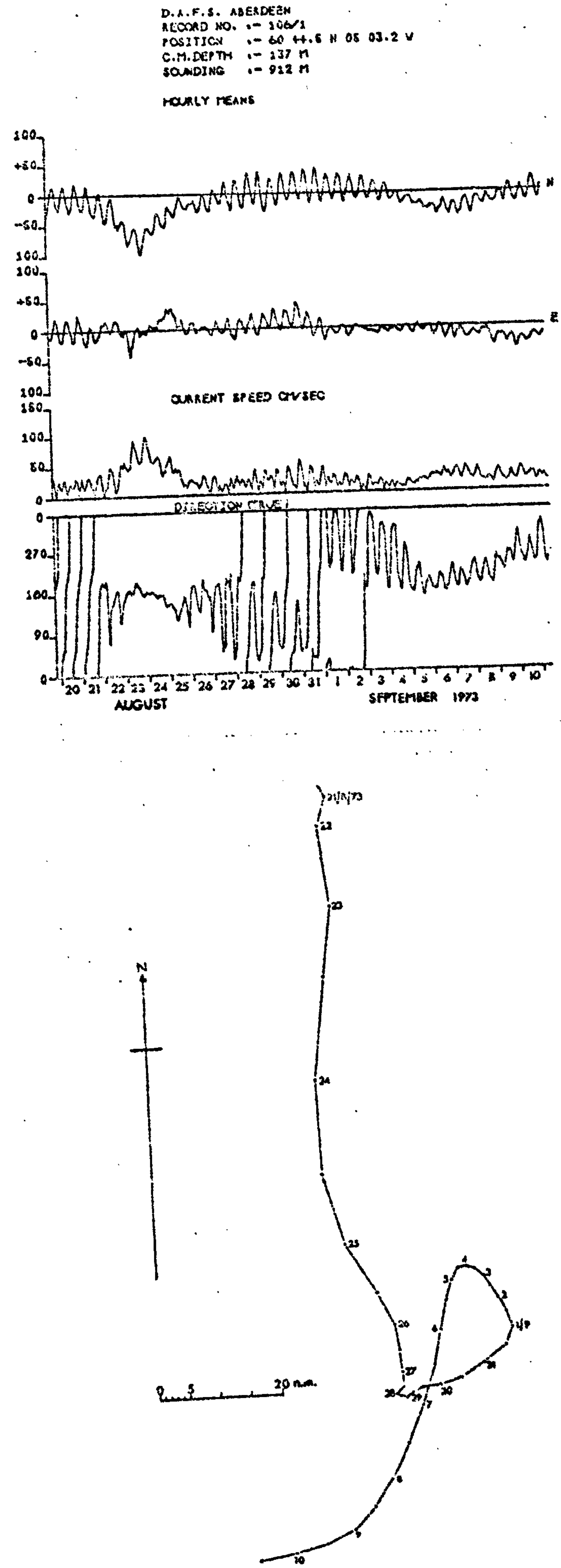
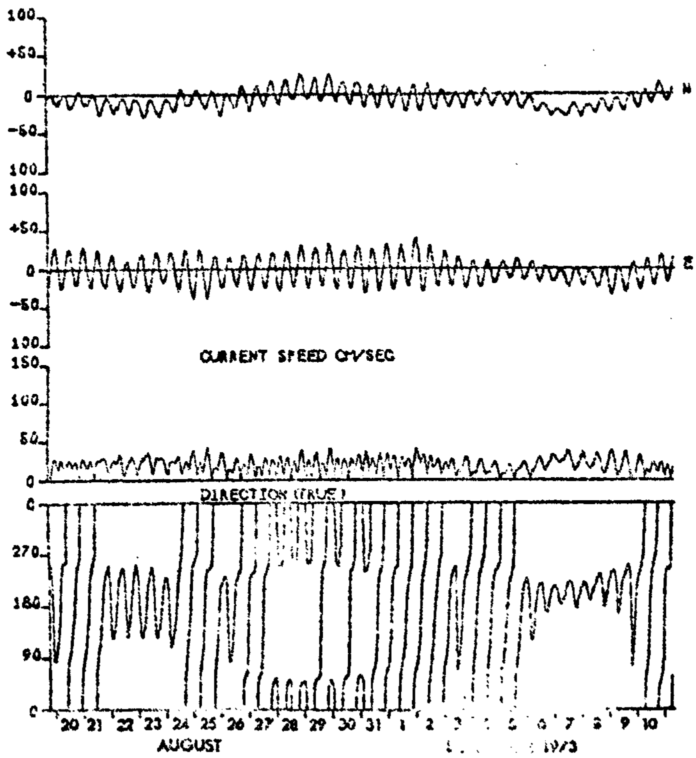

D.A.F.S. ABERDEEN
RECORD NO. :- 106/1
POSITION :- 60 44.6 N 05 03.2 W
C.M.DEPTH :- 137 M
SOUNDING :- 912 M
HOURLY MEANS
N
E
CURRENT SPEED CM/SEC
DIRECTION (TRUE)
AUGUST
SEPTEMBER 1973
21/8/73
N
0 5 20 n.m.

Fig 8

D.A.F.S. ABERDEEN
RECORD NO. :- 106/2
POSITION :- 60 44.5 N 06 03.2 W
C.M.DEPTH :- 812 M
SOUNDING :- 912 M

HOURLY MEANS



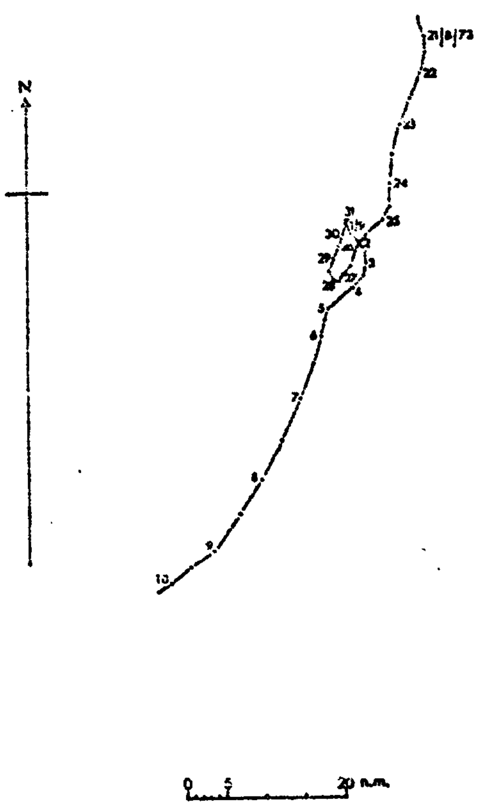


Fig 9