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CTD✓

RRS Frederick Russell. Cruise 5/85, 10 July - 3 August 1985.

Scientific Report

1. Personnel:

P M Holligan	MBA, Plymouth (Principal scientist)	
R P Harris	MBA, Plymouth	
S M Turner	UEA, Norwich	
S F Watts	MBA/UEA	
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C Brownlee	MBA, Plymouth	)
R N Head	MBA, Plymouth	) 1st leg only
S Groom	IC, London	)
L Mavin	MBA, Plymouth	)
G Malin	UEA, Norwich	) 2nd leg only
G Dixon	Univ. Coll., Swansea	)

2. Itinerary:

10 July	1400h	Departed Plymouth Sound
16 July	1030-1325h	Dunstaffnage - S Groom + equipment disembarked
17-19 July	0900-0800h	Broad Bay, Lewis (shelter)
23-25 July	1750-1130h	Dundee port call, exchange of personnel
2 August	2100h	Arrived Plymouth Sound

The cruise track is shown in Fig. 1.

3. Scientific Programme

Objectives: As outlined in the original proposals and programme the main objectives of the cruise were:

(a) Sampling and analysis of biogenic sulphur compounds in the sea and marine atmosphere.

(b) Studies on primary and secondary production in coccolithophore and dinoflagellate blooms.

(c) Studies on the composition and rate of sedimentation of biogenic material on the continental slope.

(d) Measurements of the optical properties of coccolithophore blooms.

The work is partially financed under contracts with MAFF and the CEC (pending).

Results

Hydrographic studies: The positions of hydrographic stations are shown in Fig. 1 and listed in Table 1. Throughout the cruise surface (3.5 m) water temperature, salinity, chlorophyll fluorescence, light transmission (Sea Tech 420 nm) and nutrients (NO_3, NO_2, NH_4, Si) were measured continuously from the ship's non-toxic pump supply. Samples were collected regularly for discrete determinations of salinity, chlorophyll a + phaeopigments, and particulate calcium (coccolithophores). At each station profiles of temperature, salinity, chlorophyll fluorescence and light transmission (Chelsea 660 nm) were obtained. Subsurface water samples for calibration and experimental purposes were collected with a rosette sampler attached to the CTD. An XBT section was made across the western edge of the Norwegian Deep starting at Station 19.

Phytoplankton studies: Phytoplankton samples were collected in parallel with dimethyl sulphide (DMS) measurements (see Fig. 2) and preserved with Lugols iodine and/or neutralised formalin.

Two series of experiments on the uptake of $^{14}CO_2$ and $^{45}Ca^{2+}$ by coccolithophores (Table 2), and the assimilation of inorganic nitrogen and CO_2 by the dinoflagellate, Gyrodinium aureolum (Table 3), were completed.

Studies on the optical properties of coccolithophore blooms were curtailed by the early failure of the 6-channel radiometer. The instrument was offloaded at Dunstaffnage on 16 July for return to Menai Bridge. Despite generally cloudy weather during the cruise, some useful satellite data was received at the Dundee Station (Table 4) which will be examined in relation to field data on the distribution of chlorophyll and coccolithophores.

Zooplankton studies: Finely-spaced vertical series of samples were obtained with the 2" Flygt pump to investigate zooplankton distribution in relation to dense surface populations of dinoflagellates both in the western English Channel and Northern North Sea (E of Orkney). In addition, microzooplankton was sampled in a series of horizontal transects through the Ushant Frontal system. Shipboard experimental work concentrated on estimation of rates of ingestion and egg production by Calanus captured within coccolithophore and dinoflagellate blooms. Over 500 samples collected along the cruise track were analyzed by Coulter Counter to investigate relationships between particle size distribution of naturally occurring particulate material, and chlorophyll content and light transmission.

Sediment sampling: Four good cores (Table 5) were obtained with the Kaston gravity corer on loan from MAFF, Lowestoft - 2 from the Rockall Trough, and 2 from the Norwegian Deep. These will be used to investigate the composition and rate of deposition of postglacial biogenic sediments.

Measurements of volatile organic sulphur compounds: Dimethyl sulphide (DMS) was measured by gas chromatography (flame photometric detector), using a purge and trap technique, in surface water samples along the cruise track and on vertical profiles at selected stations (Fig. 2). Surface concentrations of both DMS and chlorophyll a were very variable, with ranges of 20-1200 $\mu g\ m^{-3}$ DMS-S and 0.2 - 50.0 $mg\ m^{-3}$ chl. a respectively. These data will be used to investigate the relationship of DMS levels to the standing stock. Species composition and photosynthetic activity of phytoplankton, and allow provisional estimates of the flux of DMS to the atmosphere for shelf waters during the summer months. A large number of samples were also analysed for dimethyl sulphoniopropionate (DMSP), the precursor to DMS, and experiments carried out to determine the rate of decomposition under natural conditions of DMSP to DMS.

Atmospheric sulphur measurements: Atmospheric aerosols and particulate material were sampled throughout the cruise with a filtration system mounted on the superstructure of the ship. Typical filtration rates and sampling periods were 2.4 m^3 min^{-1} and 2-4 hours respectively. The filters were analysed for sulphur compounds by gas chromatography (flame photometric detection). Methyl sulphonic acid (MSA), sulphuric and sulphurous acids were detected in all samples, and at certain times dimethylsulphoxide was also present. Work to identify three other sulphur compounds is still proceeding. The wind speed and direction was also recorded at 20 minute intervals. Records from the ship's log (Fig. 3) indicate the changes in winds that occurred during the cruise.

4. Working up of results

Preliminary analyses of the hydrographic data, primary production experiments and sulphur measurements are now almost completed. Examination of the more important plankton samples will take about six months, and the sediment cores a further 3-6 months. On this basis it is envisaged the main results from the cruise will be prepared for publication in scientific journals during the latter part of 1986.

5. Ship operations and equipment

Despite the poor weather working conditions on the ship were generally good, particularly while stopped on station. Rolling and pitching motions caused some problems in the laboratory when steaming during heavy swell conditions or with winds > 25 knots. All work with the hydrographic winch was completed satisfactorily. Operation of the CTD system on loan from RVS Barry went smoothly apart from occasional minor technical problems.

The Kaston gravity corer with 4m or 2m barrels was used on the main winch and gave four excellent cores. However, recovery of the corer in a vertical position proved difficult with any movement of the ship, and improved methods need to be devised for any future work to avoid risks of injury to personnel or damage to the equipment. The loss of the 4m core barrel at station 6 was due to the failure of the pin attaching the barrel to the top weights. This is probably a design fault which affects deep water operations when the pin is exposed to prolonged strain and vibration.

Reasons for the failure of the radiometer borrowed from the Marine Science Laboratories, Menai Bridge are still not fully known. Support time and facilities were insufficient to properly test the instrument prior to a major cruise.

No difficulties were experienced on the ship with the use of radioisotopes (^{14}C and ^{45}Ca), compressed gases for the gas chromatographs, liquid nitrogen, or hazardous chemicals used for the analysis of atmospheric sulphur compounds.

Problems with laboratory equipment included faulty modules on each of the three ship chart recorders, and erratic baseline signals from the autoanalyser colorimeter. In both cases, these instruments must now be considered unreliable for further use at sea.

6. Conclusions

This was a successful cruise, with the scientific work receiving excellent support from the ship's officers and crew. With the exception of the optical/remote sensing studies, the main objectives of the scientific programme were satisfactorily met despite loss of time and some difficulties in undertaking laboratory experiments due to adverse sea conditions.

P.M. Holligan
MBA, Plymouth
11 September, 1985

Table 1. <u>Hydrographic Station Details</u>

No	Date	Time (BST)	Lat.	Long.	Water depth (m)	Secchi depth (m)
1	11/7	0730-1234	50°31'N	06°56'W	100(90)	
2	13/7	0926-1405	55 46	08 08 W	106(90)	8-9
3	14/7	0910-1510	57 00	12 01 W	2130(2000)	10
4		2003-2345	57 20	10 23 W	2200(2000)	9
5	15/7	0742-1150	58 22	10 22 W	1930(1800)	9
6		1400-1707	58 12	09 47 W	1865	9
7	18/7	1000-1400	58 16	06 16 W	19(16)	6.5
8	19/7	1840-1930	59 00	03 54 W	80(70)	
9	20/7	1130-1215	60 00	01 01 E	120(110)	12
10		1340-1354	60 00	01 30 E	98(90)	9.5
11		1515-1530	60 00	02 00 E	104(95)	14
12		1650-1718	60 00	02 30 E	108(100)	14
13		1845-1905	60 00	03 00 E	116(105)	11
14		2028-2053	60 00	03 30 E	260(250)	8-9
15		2216-2240	60 00	04 00 E	285(275)	
16	21/7	0000-0022	60 00	04 30 E	260(250)	-
17		0135-0150	60 00	04 55 E	240(230)	-
18		0545-0830	59 49	03 39 E	276(260)	10
19		1154-1330	59 14	03 51 E	276(260)	11
20		1455-1539	59 11	03 26 E	200(190)	
21	22/7	0805-0840	58 47	01 25 W	124(115)	12
22		0958-1015	58 52	01 50 W	88(80)	9.5
23		1108-1122	58 55	02 07 W	76(65)	9
24		1149-1206	58 57	02 14 W	86(75)	8
25		1302-1316	59 00	02 30 W	66(55)	7.5
26		1520-1945	58 51	01 50 W	87(75)	9-8
27	28/7	1747-1900	49 58	04 01W	74(65)	
28		2100-2140	50 00	04 34 W	72(65)	-
29	29/7	0800-1230	49 27	03 58 W	82(70)	5.5
30	30/7	1154-1328	49 05	06 31 W	120(110)	15
31		1510-1550	49 05	06 03 W	115(100)	15
32		1700-1905	49 05	05 38 W	112(100)	13
33	31/7	0807-2345	49 28	03 52 W	88(80)	4.5
34	1/8	0800-2400	49 28	03 55 W	88(86)	3
35	2/8	0855-1545	49 28	03 58 W	88	-

Table 2. Experiments on Coccolithophore populations

No.	Date	Station	Sample depth (m)	Chl a (mg m^{-3})	Experiment
1	13/7	2	23	0.78	^{14}C uptake vs.light. Intact cells, decalcified cells and filtrates collected.
2	14/7	3	21	1.39	^{14}C, ^{45}Ca uptake vs.time. Intact cells, decalcified cells and filtrates collected.
3	15/7	5	10	1.57	^{14}C, ^{45}Ca uptake vs.light. Intact cells, decalcified cells and filtrates collected.
4	18/7	7	5	1.62	As for expt. 2.
5	21/7	19	21	1.18	As for expt. 3.
6	22/7	24	19	2.96	As for expt. 3 (ambient temp. $\sim 5^{\circ}$).
7	23/7	leg 15	3	0.75 ($\leq 35 \mu m$)	As for expt. 3.

Table 3. Experiments on *G. aureolum* populations

No.	Date	Station	Sample depth (m)	Chl *a* (mg m^{-3})	Experiment
1	29/7	29	3	26.7	Uptake of NO_3, NH_4.
2	31/7	33	5	23.0	Uptake of NO_3, NH_4.
3(1)					Effect of NO_3, NH_4 on $^{14}CO_2$ fixation in light and dark.
4(2)					Effect of light on $^{14}CO_2$ fixation.
5(3)			5	50.1	Effect of NO_3, NH_4 on $^{14}CO_2$ fixation in dark.
6(4)	1/8	34	5	35.4	Effect of NO_3, NH_4 on short term light fixation of $^{14}CO_2$.
7(5)		(33)	5	26.9/26.7*	Effect of NO_3, NH_4 on $^{14}CO_2$ fixation in dark.
8(6)					Effect of NO_3, NH_4 on $^{14}CO_2$ fixation in light.
9	2/8	35	5	16.6	Uptake of NO_3, NH_4.
(7)		(34)/35	5	30.0/30.2* 16.6	Effect of NO_3, NH_4 on carbon excretion (^{14}C) in light and dark.

*Chlorophyll *a* values for water incubated overnight with the addition of 7 µM NO_3/NH_4.

Table 4. Useful Satellite images for period of cruise

Czcs Scenes :

6/7/85	N139/10	W. English Channel, N of Scotland
8/7	N139/11-12	W. English Channel, NW North Sea
28/7	N139/14 N140/01	NW North Sea
9/8	N140/08	W. English Channel, NW North Sea

NOAA 8/9 Scenes : For the above dates and also

17/7	537/04B	NW North Sea
21/7	537/14B	NW North Sea
22/7	538/03A	Moray Firth
23/7	538/05A	NW North Sea
25/7	538/10B	"
4/8	540/04B	"

Table 5.

Sediment Cores

Date	Station	Position Lat N	Long	Water depth(m)	Length of core (m)
14/7	3	57° 00′	12° 01′W	2130	2.35
14/7	4	57 20	10 23W	2200	2.84
15/7	5	58 22	10 22W	1930	Surface sample only
15/7	6	58 12	09 47W	1865	" " "
21/7	18	59 49	03 39E	276	1.11
[illegible]/7	19	59 14	03 51E	276	1.08

Samples for each core were stored at -20°C and +3°C.

FIG. 1

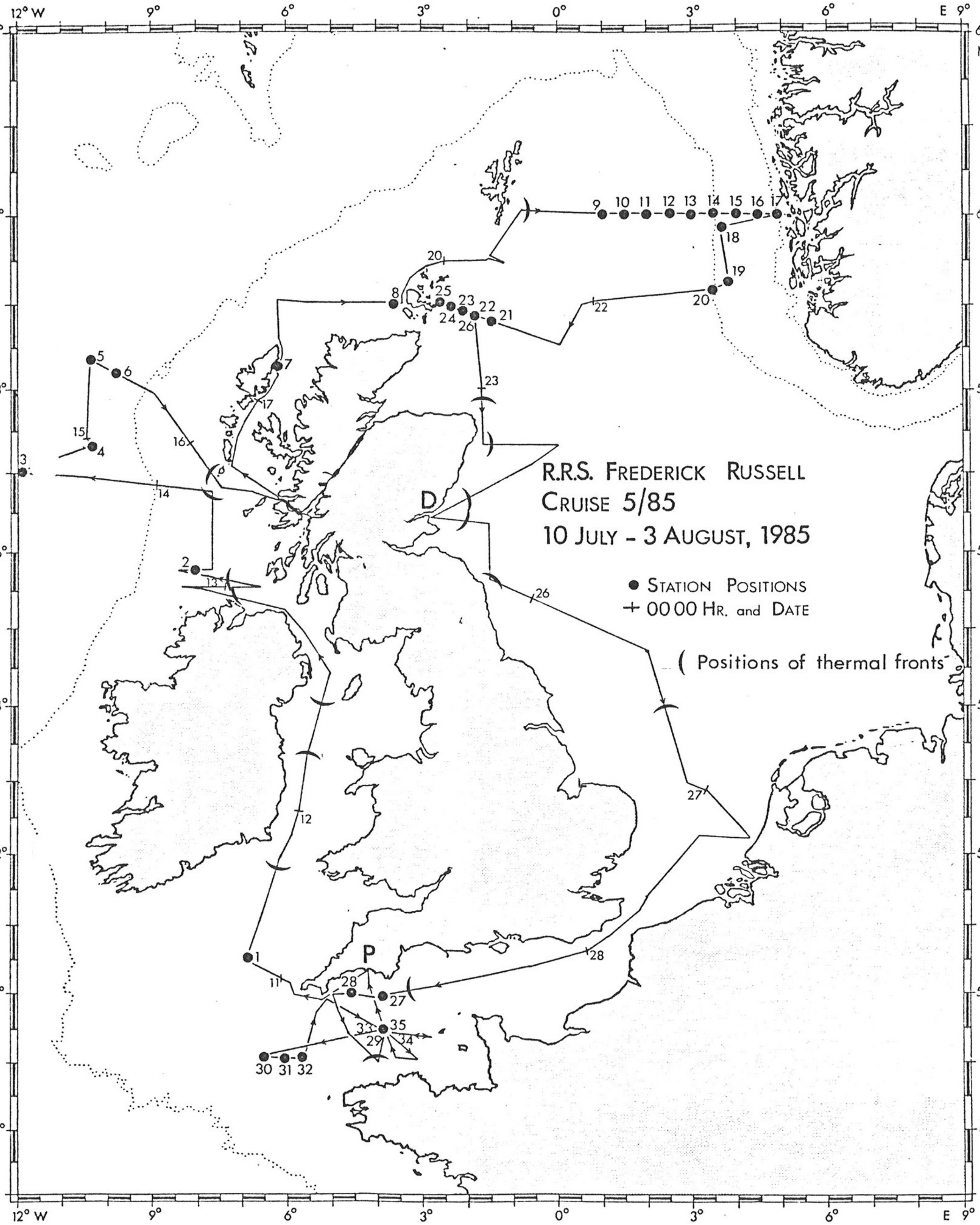
R.R.S. FREDERICK RUSSELL
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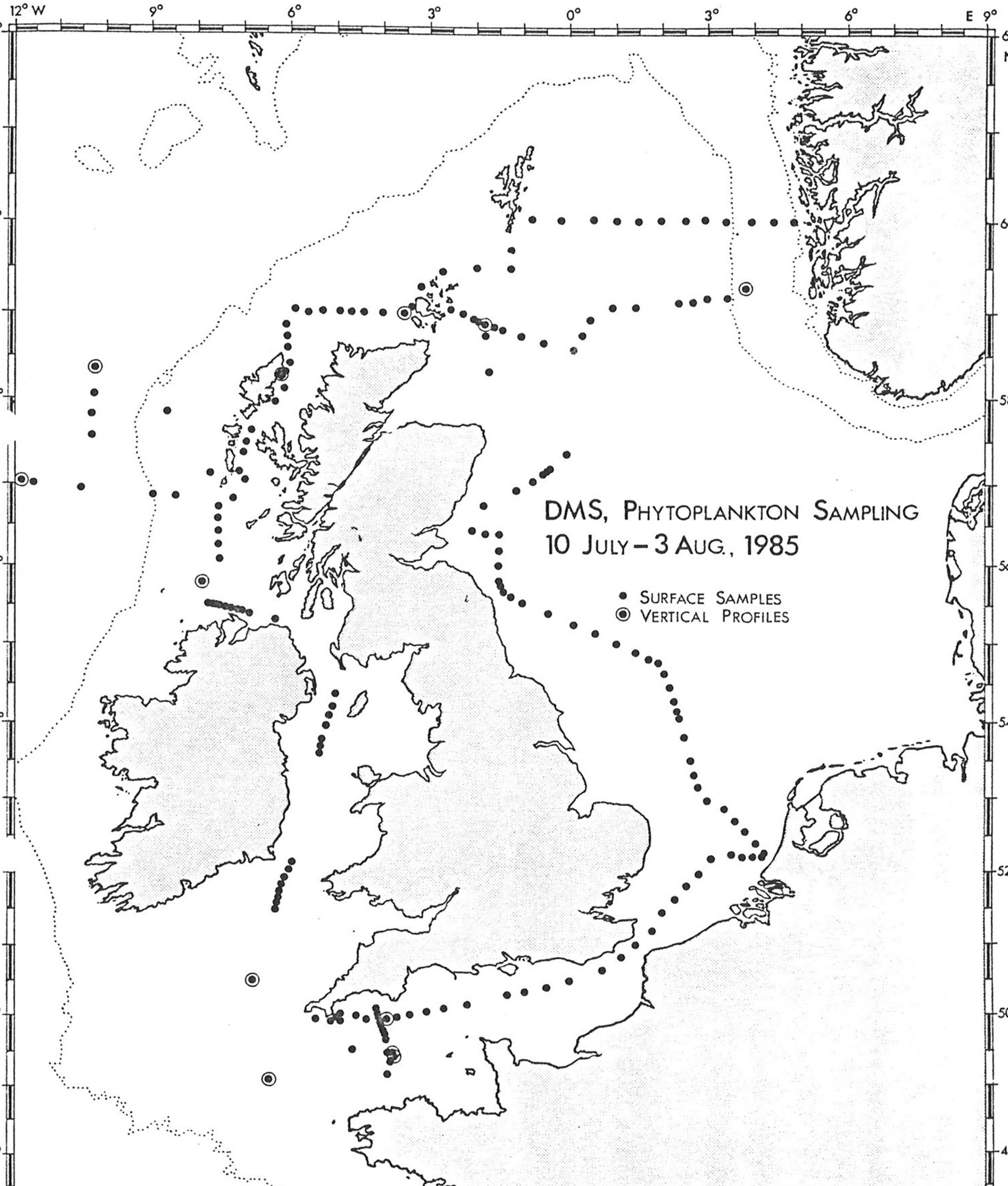
FIG. 2



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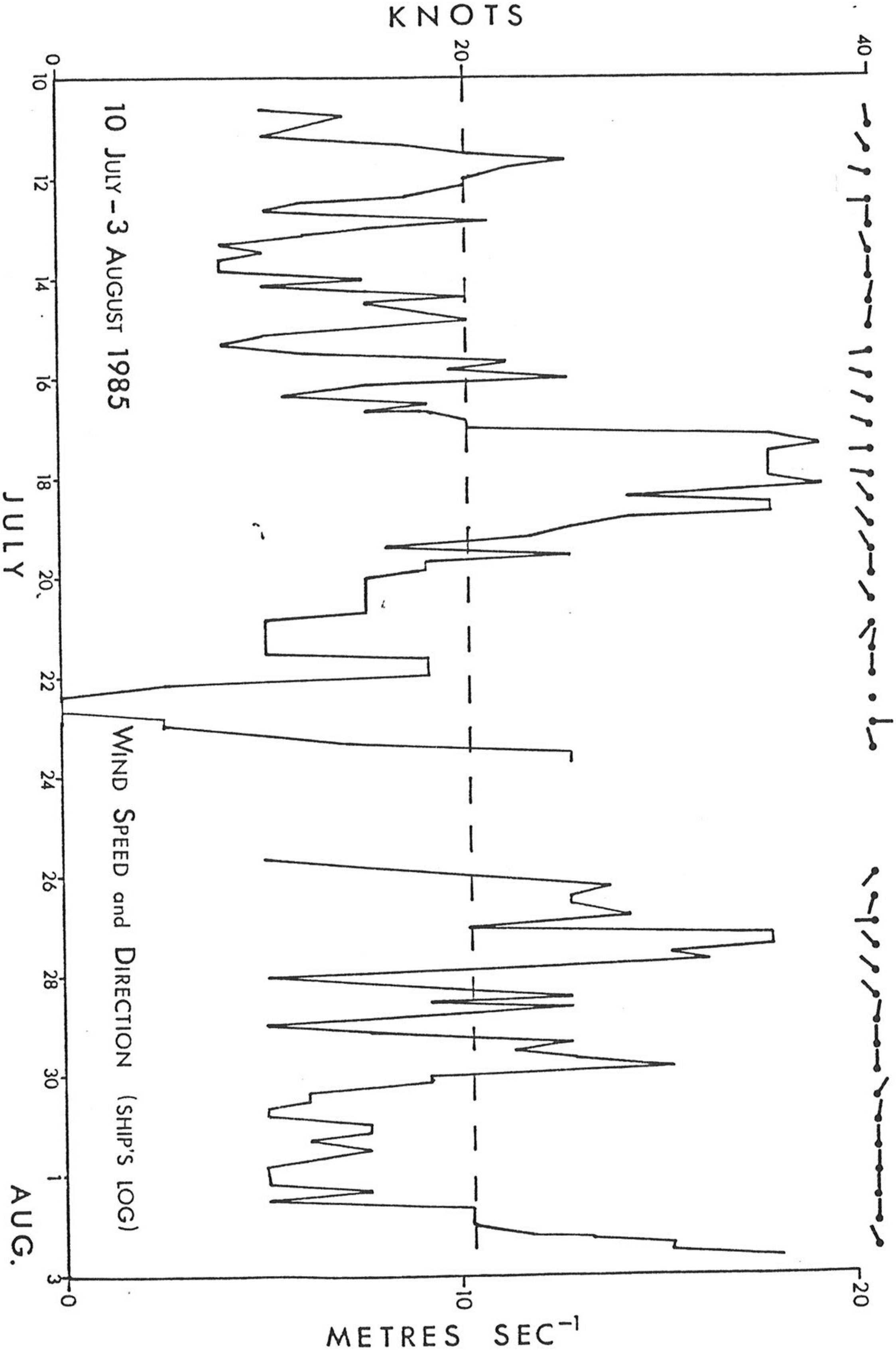
DMS, PHYTOPLANKTON SAMPLING
10 JULY – 3 AUG., 1985
SURFACE SAMPLES
VERTICAL PROFILES

FIG. 3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