I.O.S.

GREAT METEOR EAST
AN INTERIM REPORT ON BIOLOGICAL SAMPLING AND GENERAL RELATIONSHIP TO PHYSICAL OCEANOGRAPHY

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OCEAN DISPOSAL OF HIGH LEVEL RADIOACTIVE WASTE
A RESEARCH REPORT PREPARED FOR THE DEPARTMENT
OF THE ENVIRONMENT

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF OCEANOGRAPHIC SCIENCES

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RADIOACTIVE WASTE MANAGEMENT

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Abstract (100-200 words as desired)

This report deals with work carried out in June/July 1985 on RRS *Discovery* Cruise 156 to GME. The general physical oceanography of the area and the vertical distribution of chlorophyll a and nutrients are described. Primary production measurements and results are discussed in detail. Biological sampling of benthic and pelagic animals is described together with the subsequent laboratory treatment of the samples and some preliminary data on midwater biomass.

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225 - Ocean sites
141 - Environmental modelling

This work has been commissioned by the Department of the Environment as part of its radioactive waste management research programme. The results will be used in the formulation of Government policy, but at this stage they do not necessarily represent Government policy.

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INTRODUCTION

Sampling at Great Meteor East (GME) was done in and around a 10km square centred at 31°17'N, 25°24'W. This square was chosen by IOS in response to a DoE request to concentrate work at GME within a 100km^2 area. Of necessity our trawling extended beyond this square, but both this and the physical observations were concentrated within the smallest practical area - bounded by 30°49'-31°35'N and 24°51'-25°37'W (Figs 1, 2, Table 1).

Work at GME commenced on 27 June 1985 and was completed on 21 July. In addition to site specific studies, shallow CTD casts with chlorophyll *a* and nutrient observations were made on passage to GME (Table 1), and Expendable Bathythermograph (XBT) transects were worked *en route* to and from the site.

This interim report describes the general physical oceanography of the area from the CTD and XBT data and the vertical distributions of chlorophyll *a* and nutrients. Primary production measurements and results are discussed in detail. The biological sampling of benthic and pelagic animals is described, together with the subsequent laboratory treatment of the samples and some preliminary data on midwater biomass.

PHYSICAL OCEANOGRAPHY

The GME investigations were carried out in a box contained within latitudes 30°49'N and 31°35'N and longitudes 25°37'W and 24°51'W. According to Siedler, Zenk and Emery (1985) this would put it to the south of the subtropical front (Fig. 3) that represents the eastwards extension of the Azores Current (Gould, 1985). This front is typified by a marked change in the depth of the isotherms and the XBT survey carried out *en route* to and from GME showed that the front was crossed at around 33°5'N, 23°3'W (Fig. 4). Note that the depth of the 16°C isotherm changes by 200m across the front. No significant change in the depth of the 16°C isotherm was observed during the work at the GME site, indicating that there was no southerly movement of the front during the cruise.

Stramma (1984) has used historical temperature and salinity data to calculate the integrated volume transport between 0 and 800m in the south-eastern Atlantic (Fig. 5). These show that in the GME area the prevailing current direction is likely to be south-easterly.

Deep CTD profiles down to 5424m were made on five occasions during the cruise. The profiles of potential temperature, salinity and sigma T against depth for station 11262#7 are shown in Fig. 6 and the potential temperature versus salinity plot in Fig. 7. These show the familiar water mass structure for this part of the North Atlantic with North Atlantic Central Water in the top 800m overlying Mediterranean Water which shows up as a salinity maximum at around 1100m. Below 3000m the temperature and salinity show the uniform characteristics of Atlantic Deep Water.

VERTICAL DISTRIBUTION OF CHLOROPHYLL AND NUTRIENTS

On the initial leg out to the GME site a series of vertical profiles of temperature, salinity, chlorophyll a and nutrients were made. There was a marked change in the vertical distribution of chlorophyll a on crossing the front at 33°5'N (Fig. 8). North of the front the Deep Chlorophyll Maximum (DCM) was at a depth of between 28 and 70m (mean = 50m, s. dev. = 17m) and had a magnitude between 0.6 and 1.2 mg m^{-3} chlorophyll a (mean = 0.68, s. dev. = 0.19). Whereas to the south ofthe front the DCM was at a depth between 88 and 105m (mean = 98, s. dev. = 9.7) and had a magnitude between 0.38 and 0.52 mg m^{-3} chlorophyll a (mean = 0.46, s. dev. = 0.07). A similar reduction in the magnitude of the DCM on passing southwards across the front has been observed farther west in the Azores Front (Fasham *et al*, 1985) and is considered to be a permanent feature of the phytoplankton chlorophyll distribution.

Shallow CTD dips to 300m were made on eleven occasions on the first leg of the cruise which provided vertical distributions of temperature, salinity, density, chlorophyll a concentrations and underwater irradiance. A typical vertical distribution of these variables for GME is shown in Figs 9 and 10 for station 11261#42. There was a very shallow mixed layer of approx. 6m below which the seasonal thermocline extended down to around 100m. The DCM was at a depth of 95m with a magnitude of 0.47 mg m^{-3} chlorophyll a. The 1% light level was at 86m. Good underwater irradiance profiles were obtained on six occasions and the mean depth of the 1% light level was 87m with a standard deviation of 4m. There was a significant difference at the 1% level between the depth of the 1% light level and the depth of the DCM.

Some nutrient samples were taken and showed the usual structure of high values at depth (5.5 to 6.0μM of nitrate/nitrite at 300m), decreasing through a nutricline to values of less than 1μM nitrate/nitrite within the DCM and in the surface 100m.

PRIMARY PRODUCTION

Primary production experiments

Four experiments were run at the GME site to estimate the daily rate of carbon fixation due to phytoplankton photosynthesis. The method used was the Carbon-14 technique (Steeman Nielsen, 1951, 1952) in which known amounts of radioactively labelled sodium bicarbonate ($^{14}CO_3^-$) are added to seawater samples containing natural phytoplankton communities. If the total amount of CO_2 in the sample water is known and a measured amount of $^{14}CO_2$ is added, then by determining the amount of ^{14}C incorporated into the phytoplankton after an incubation period the total amount of carbon assimilated can be calculated.

Sampling

Water samples for light saturation experiments were collected with 7 litre Niskin bottles using the hydrographic winch. The bottles, together with all sample water containers used during the experiment had been thoroughly cleaned prior to going to sea, first using acid washes (0.25M nitric followed by 0.25M hydrochloric) then rinses with double distilled water. This precaution was taken to remove trace metals which would have had a detrimental effect on the algal communities being measured (Fitzwater, Knauer and Martin, 1982). Most of the samples were obtained from the deep chlorophyll maximum layer (DCM) but two samples were taken about 20m above this depth. Small volumes were drawn off from the samples for the determination of chlorophyll a concentration and additional sub-samples were taken and stored in Lugols and in 2% formaldehyde solutions for qualitative analysis of the flora.

Size fractionation

Post-incubation phytoplankton cultures were removed using two types of filter. To obtain estimates of total productivity samples were filtered through Whatman GF/F glass fibre discs, these effectively remove all phytoplankton (nominally >0.4µm). Nuclepore 1µm filters were also used and in three of the four experiments estimates of picoplankton productivity (ie. cells <1µm diameter) were obtained by subtraction of Nuclepore from GF/F results.

Incubation methods

Sample water was immediately transferred from niskin bottles to darkened Nalgene carboys and all subsequent sample handling was performed in subdued lighting. The incubation chamber essentially consisted of an insulated box taking two files of culture bottles with a light source in front enabling two productivity determinations to be carried out simultaneously. A Thorn 2000W halogen lamp was used as the light source; temperature control was achieved by three separate circulating water chambers - the main one being the incubation box itself. Cooling water was obtained from the ships seawater supply. Prior to filling, 60ml transparent polycarbonate culture vessels were first rinsed with the sample water and then injected with 0.1ml of sodium bicarbonate ^{14}C solution made up to give a "spike" of 10µCi per container. The vessels were then completely filled with the sample water, shaken and placed in the incubator. 1 ml extracts of the spiked samples were then taken from a number of cultures to obtain a more accurate measure of the specific activity of the ^{14}C added. These extracts were preserved in Fisosorb 2 scintillatiion cocktail for later measurement in the UK.

Each experiment comprised two light saturation runs of 36 cultures, filed behind the light source. The culture vessels attenuated the light over two and a half orders of magnitude ranging from about 500W m^{-2} in front of the light to 2W m^{-2} at the back: 33 cultures of each run were used for the light uptake and the remaining three blacked out to measure the dark reaction. Each culture bottle was carefully positioned and labelled so that later, when the ^{14}C uptake had been measured for each culture, corresponding light values could be ascribed. Incubation by exposure to the light source was set at 3hrs, after which the apparatus, complete with culture vessels, was removed to a darkened laboratory. Using a filtration rack and a mild vacuum pressure (< 10kPa) the phytoplankton in the cultures were deposited on to filters as quickly as possible. The filters were placed in glassine envelopes and stored at -20°C for later measurement in a scintillation counter. The culture vessels were then refilled with more water from the same sample and replaced in the incubation chamber.

Light attentuation curves were obtained by switching back on the light source and measuring the light level behind each culture bottle with a Crump lightmeter working from the back towards the lamp.

Sample analysis

^{14}C uptake by the cultures was measured at the radiological facilities at IMER, Plymouth. Unassimilated carbonate/bicarbonate was removed from the filters by exposing them to HCL fumes for 10 minutes prior to being transferred to vials containing Fisofluor 3 scintillation cocktail. Counting was performed using a Packard scintillation counter which provided data automatically corrected for quench. Carbon uptake was calculated using the method described by Strickland and Parsons (1972) and converted to specific production by dividing by the chlorophyll concentration of that sample.

Photosynthetic parameters

From the measurements of specific production, P^B and irradiance, I, a non-linear regression technique was used to estimate the parameters in the production-irradiance curve given by the equation

$$P^B = P_s(1 - e^{-\alpha I/P_s})e^{-\beta I/P_s} \tag{1}$$

derived by Platt et al (1981) where P_s (mg C mg chl a^{-1} h^{-1}) is the light saturated rate of specific production in the absence of photoinhibition, α (mg C [mg chl a]$^{-1}$ h^{-1} W^{-1}m^{-2}) is the initial slope of the curve and β (same units as α) is a parameter characterising the photoinhibition in light saturation conditions. An example of the experimental data and a fitted curve is given in Figure 11. P_{max}, the chlorophyll-specific photosynthesis at light saturation, or assimilation number, can be calculated from the parameters α, β and P_s using the equation

$$P_{max} = P_s \left(\frac{\alpha}{\alpha + \beta}\right)\left(\frac{\beta}{\alpha + \beta}\right)^{\beta/\alpha} \tag{2}$$

and I_m, the irradiance at which photosynthesis is optimal can be calculated from the equation

$$I_m = \left(\frac{P_s}{\alpha}\right) \ln \left(\frac{\alpha + \beta}{\beta}\right) \tag{3}$$

Parametric data for all four productivity runs are given in Table 2. Several points emerge from these data, firstly that phytoplankton from the DCM were photoadapted to a lower light regime than those from nearer the surface; I_m for three GF/F filtered samples from the DCM (ca 90-100m) varied between 23.23 and 61.8W m^{-2} whereas values for GF/F filters from the two samples 20m or more above the DCM were 74.4 and 80.35W m^{-2}. Secondly, in the DCM, P_{max} for GF/F filtered samples (ie. all phytoplankters >0.4µm) was considerably greater than corresponding values of P_{max} for 1µm Nuclepore filters. This implies that, in the DCM, the <1µm phytoplankton fraction had a greater photosynthetic efficiency than the >1µm component. This difference in efficiency was much less marked in a sample taken well above the DCM.

A third point worth noting is that, in the DCM, we have calculated values of 62% and 70.2% for the proportion of production attributed to the <1µm phytoplankton component, this agrees well with Platt _et al_ (1983) value of 60% for picoplankton to the west of the Azores. However, it is interesting to note that, for above the DCM, we have obtained a value of 56.6% for the proportion of productivity due to the >1µm fraction. This does indicate some difference in the relative importance of the two size fractions at different depths in the euphotic zone.

Calculation of daily production

It is obviously of interest to estimate the total daily net primary production in the euphotic zone. If the chlorophyll _a_ concentration at depth z (measured using the _in situ_ fluorometer) is C(z) and the chlorophyll specific net production is P(z) then, assuming that there is no net growth of phytoplankton during the day, the daily production P_T is given by

$$P_T = \int_0^{24} \int_0^{z_e} P(z,t)C(z)dz\,dt \qquad (4)$$

where z_e is the depth of euphotic zone. It is generally considered (Dring and Jewson, 1982) that ^{14}C primary production measurements of duration 3-4 hours are estimates of gross rather than net production. An estimate of respiration rate is required to convert this to net production and it is usually assumed that the respiration rate is one tenth of the maximum photosynthetic rate P_{max} (Steeman

Nielsen and Hansen 1959). P_{max} can be calculated from equation (2).

Using equation (1) for the gross production, the net production at depth z is given by

$$P(z,t) = P_s\,(1 - \exp(-\,\alpha I(z,t)/P_s))\,\exp(-\beta I(z,t)/P_s) - 0.1P_{max} \qquad (5)$$

where I(z,t) is the irradiance at a depth z and time t. It is now necessary to determine a parameterisation for I(z,t).

Fasham _et al_ (1983) have shown that observed irradiance-depth profiles can be very well fitted using the equation

$$I(z,t) = \gamma I_o(t)(a_1 e^{-k_1 z} + a_2 e^{-k_2 z})\,\exp(-k_c \int_o^z C(z)dz) \qquad (6)$$

In this equation $I_o(t)$ is the surface irradiance at time t and γ the surface transmittance, k_1 and k_2 are the attentuation coefficients for two main components of the visible spectrum, and it is assumed that $k_1 < k_2$. a_1 and a_2 are the proportion of these components in the total irradiance and k_c is the phytoplankton self-shading coefficient which parameterises the light absorption of the phytoplankton. The surface irradiance at time t was calculated using the methods described in Brock (1981).

Fasham _et al_ (1983) have shown how these parameters can be estimated from an irradiance-depth profile and such estimates were made for stations 11261#49 and 11261#59 for which good irradiance profiles were available (see Table 3). Stations 11261#25 and 11261#42 were observed very early in the morning and so parameters could not be estimated for these stations. The parameters for station 11261#59 were used for these stations when calculating P_T.

Using the equations given and the estimated parameters of the production-irradiance curves (Table 2, GF/F filtered samples) and irradiance-depth profiles (Table 3), the total daily production can now be calculated for the four stations from the profiles of chlorophyll _a_ concentration. The depth of euphotic zone z_e was taken to be the depth above which the total net daily production was positive. A trial integration showed that this was approx. 87m, which interestingly was the same depth as mean depth of the 1% light level, which is often taken as representing the depth of the euphotic zone.

With the exception of station 11261#59 the estimates of daily production (Table 4) are very similar giving us some confidence in the mean value of 227mg C m^{-2} day^{-1}. However, it is worth remembering the many assumptions implicit in this method of calculating daily production, viz.

1) The production-irradiance curve parameters measured for a sample at single depth are assumed to apply to the total population.

2) Vertical mixing is ignored.

3) Diel changes in the production-irradiance parameters are not considered.

4) The phytoplankton population is assumed to be in equilibrium.

In view of assumption (1) it is encouraging to note that the estimates for daily production for station 11261#49 using productivity data from two different depths are not too dissimilar.

BENTHIC AND PELAGIC SAMPLING

Benthic sampling/photography

Five successful trawls were made with the semi balloon otter trawl (OTSB 14 - Merrett and Marshall, 1980). A sixth tow fouled the bottom, destroying the net.

Four successful tows were made with the IOS multiple epibenthic sledge (Rice et al, 1982), three of which also produced photographic transects of the area. Three different size fractions are sampled by the sledge, >4.5mm, >1.0mm and >0.32mm (this last by the suprabenthic net mounted above the sledge).

Two time lapse camera systems (Bathysnap - Lampitt and Burnham, 1983) were deployed for recovery early in 1986. One was in the 10km square (31°15.2'N, 25°25.4'W) using a standard Mk IV camera and a frame interval of 512 minutes. The second was further east (31°19.9'N, 24°53.9'W) using a half frame camera and a time interval of 256 minutes.

Midwater sampling

Discrete depth samples were taken throughout the water column with the IOS opening/closing multiple rectangular midwater trawl (RMT 1+8M - Roe and Shale, 1979; Roe et al, 1980). One hundred metre depth layers were fished by both day and night between the surface and a depth of 1500m (the 0 to 100m depth layer was also subdivided into 0-25, 25-50 and 50-100m layers). Four hundred metre depth layers were fished between 1500m and the bottom (ca. 5440m), irrespective of the time of day or night. Close to the sea bed a near-bottom echo-sounder (NBES) was used in conjunction with the RMT 1+8M (Roe and Darlington, 1985). Three repeat hauls were made with this system, fishing between 90 and 10m above the bottom.

Plankton is sampled by the 0.32mm mesh RMT 1 and micronekton by the 4.5mm mesh RMT 8. A multiple cod end was used on the RMT1s fished between 0 and 1500m. This cod end separates 3 size fractions - >4.5mm, >1.0mm and >0.32mm. The >4.5mm fraction is not quantitatively sampled by the RMT 1 and animals from this fraction are only of passing interest. Aboard 'Discovery' the two smaller size fractions were each divided into two with a plankton splitter; one half was preserved in formalin, the other was deep frozen. The multiple cod end was not used for deeper tows and the catches of these were so small that it was impossible to subdivide them. The total catches of RMT 1 hauls made between 1500m and the bottom were therefore preserved in formalin, except for three duplicate hauls made between 3900-5100m which were frozen. Subsequent laboratory analysis depended upon the depth of the sample and the mode of preservation.

Laboratory analysis

Benthic samples have been sorted to individual animal groups and these groups are now being identified and counted. The sledge transect photographs have been processed. The Bathysnap deployed at 31°15.2'N, 25°25.4'W has been recovered and redeployed at 31°33.3'N, 24°43'W. The camera operated successfully and the film has been processed; it is now being analysed. Unfortunately the second Bathysnap has so far not been recovered.

The RMT 8 samples have been volumed and the different groups counted and sorted. These groups are now being identified.

The RMT 1 samples have been processed as follows. Those taken below 1500m (without the multiple cod end) were passed through a 4.5mm mesh to remove large animals. These large animals were not further analysed. The deep samples therefore consist of animals within the size range 0.32-4.5mm. Each sample was drained and the catch placed upon absorbent paper to remove any adherent surface water. The sample was then transferred to a preweighed foil boat and its wet weight measured. It was then placed in a known volume of water and its displacement volume measured. Finally each sample was sorted to individual groups.

The formalin preserved subsamples of RMT 1 catches between 0-1500m were treated in the same way as the deep hauls - except that they were not passed through a 4.5mm filter. The frozen subsamples of the shallow RMT 1 catches, and the duplicate deep samples, were thawed and their displacement volumes and wet weight determined as above. The samples were then dried in an oven at 100°C for 24 hours and transferred to a desiccator for a further 24 hours. They were then weighed - giving a dry weight. The dry samples were then homogenised with a pestle and mortar and the carbon/nitrogen content of a subsample determined by gas chromatography, (see Hull 1985, for details). A further subsample was ashed in a muffle furnace at 450°C for 24 hours and subsequently weighed to give an ash-free dry weight.

Midwater biomass results

The relationships between the various biomass measurements have been examined by subjecting the data to major axis regression (Yorke, 1966; Hull, 1985). The slopes of the regression lines using $\log_{10}$ transformed values have been calculated and the significance of the difference in slope between the various lines tested according to the formula:

$$t = \frac{x_1 - x_2}{\sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}}$$

where x_1 and x_2 are the slopes and s_1 and s_2 are the sample variances of the independent samples of size n_1 and n_2 respectively. The data have been corrected for volume of water filtered using the equations developed by Roe *et al* (1980).

The results are still being analysed but some preliminary observations can be made.

Most of the biomass of both plankton and micronekton is contained within the top 1500m of the water column (Figs 12, 13). Accumulative percentages (Table 5) show that >80% of the total planktonic biomass and >95% of the total micronekton occurred between 1000-0m. Overall diel changes in biomass were confined to the top 1000m for plankton and the upper 1500m for micronekton.

The micronektonic biomass within the top 1000m was dominated by massive swarms of the tunicate *Pyrosoma*. *Pyrosoma* occurred in very large numbers between 700-900m by day and migrated up to the surface at night - when they were abundant between 200-0m with a residual population between 500-600m.

Various regression coefficients for planktonic biomass are shown in Table 6. Volume and wet weight data were available throughout the water column, dry weight was measured between 0-1500m and on the three duplicate samples taken between 3900-5100m. There was no significant difference between the volume/WW regressions for different size groups or for depths above and below 1500m. Similarly there was no significant difference in the Vol/DW and WW/DW regressions between size groups; the deep dry weight data fit well with that taken between 0-1500m. Consequently single regressions for total plankton

(0.32-4.5mm) have been used, and these single regressions have been used throughout the water column.

The volume of micronekton (excluding Pyrosoma) has been converted to dry weight using the plankton regression. The validity of this procedure is questionable but whilst the absolute values obtained are dubious they do accurately reflect both the relative changes through the water column and the very low biomass. (Pyrosoma has been excluded because it is gelatinous and its volume/dry weight relationship will certainly be lower than that of the crustacea and fish which make up the bulk of the remaining catches; it also occurred in only 2 day and 3 night hauls, all above 1000m).

Profiles of dry weight against depth are shown (Fig. 14). Day data have been used for the hauls above 1500m. The similarity between the plankton and micronekton profiles below 1700m is striking. The total biomass is extremely low. The total dry weight of plankton beneath one square metre of sea surface is 1.52g (day) and 1.25g (night); of micronketon it is 0.61g (day) and 0.52g (night). The total pelagic biomass at GME therefore amounts to ca. 2g beneath each m^2 of sea surface. These figures do not include phytoplankton or zooplankton smaller than 0.32mm, neither do they include Pyrosoma nor any large pelagic animals.

There is an exponential decrease in biomass with depth for both plankton and micronekton. Linear regression coefficients between the logarithm of biomass and depth have been calculated for depths between 0-1000m and between 1000-5440m (the bottom) (Table 7). The day and night regressions for depths >1000m combine the day (or night) data between 1000-1500m with the >1500m data. Comparisons with similar data from the Atlantic (Fig. 15, Table 8) show that the biomass at GME is lower than elsewhere. Wishner (1980a) included data from 3 stations fished close to GME between 1958 and 1961 and her values are closest to the present estimates. The higher values of Angel and Baker (1982) reflect the greater productivity further to the north and east of GME. Seasonal variations in biomass will be greater in the northern data (taken in April/May), but the effects of seasonality on the biomass at depth are uncertain. Although the intercepts differ markedly most of the slopes in Fig. 15 are similar. (The major exception at 49°N was perhaps influenced by a storm). This similarity suggests that the processes controlling the distribution of biomass in the deep oceans are similar despite differences in the overlying surface production.

Previous deep water column studies have found an increase in pelagic biomass within about 100m of the bottom (e.g. Wishner 1980a,b, Hargreaves 1984, 1985). The present data are rather ambivalent (Fig. 16). Three hauls were made between 10 and 90m above the bottom. The micronekton biomass shows a fairly consistent increase with increasing proximity to the bottom but the plankton data are erratic.

FUTURE WORK

The biomass data will be further analysed and comparisons made with other areas.

The plankton will be analysed to the numbers of individual groups per depth throughout the water column. Within the available time it may be possible to identify some plankton groups in more detail.

The micronekton will be identified to species and the distributions of these will be described throughout the water column.

The numbers, distributions and biomass of benthic animals will be described.

The feeding of near bottom/bottom living fish and decapods will be analysed.

The photographic data obtained by the sledge and Bathysnap will be analysed.

The results of these analyses, plus the physical data reported on here, will be assembled into a final report establishing a biological characterisation of GME.

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REFERENCES

Angel, M.V. and A. de C. Baker (1982) Vertical distribution of the standing crop of plankton and micronekton at three stations in the northeast Atlantic. Biological Oceanography, 2, 1-30.

Brock, T.D. 1981. Calculating solar radiation for ecological studies. Ecological Modelling, **14**,1-19.

Dring, M.J. and D.H. Jewson (1982) What does ^{14}C uptake by phytoplankton really measure? A theoretical modelling approach. Proceedings of the Royal Society of London, Series B, **214**, 351-368.

Fasham, M.J.R., Holligan, P.M. and P.R Pugh (1983) The spatial and temporal development of the spring phytoplankton bloom in the Celtic Sea, April 1979. Progress in Oceanography, **12**, 87-145.

Fasham, M.J.R., Platt, T., Irwin, B. and K. Jones (1985) Factors affecting the spatial pattern of the deep chlorophyll maxima in the region of the Azcres front. Progress in Oceanography, **14**, 129-165.

Fitzwater, S.E., Knauer, G.A. and J.H. Martin (1982) Metal contamination and its effect on primary production measurements. Limnology and Oceanography, **27**, 544-552.

Gould, W.J. (1985) Physical oceanography of the Azores Front. Progress in Oceanography, **14**, 167-190.

Hargreaves, P. (1984) The distribution of Decapoda (Crustacea) in the open ocean and near-bottom over an adjacent slope in the northern north-east Atlantic Ocean during Autumn 1979. Journal of the Marine Biological Association of the United Kingdom, **64**, 829-857.

Hargreaves, P. (1985) The distribution of Mysidacea in the open ocean and near-bottom over slope regions in the northern north-east Atlantic Ocean during 1979. Journal of Plankton Research, **7**, 241-261.

Hull, R.M. (1985) Biomass analysis of zooplankton collected at 39°30'N 15°W to 46°N 14°W. Institute of Oceanographic Sciences, Internal Document, No. 242, (unpublished manuscript).

Lampitt, R.S. and M.P.Burnham (1983) A free fall time lapse camera and current meter system (Bathysnap) with notes on the foraging behaviour of a bathyal decapod shrimp. Deep-Sea Research, **30**, 1009-1017.

Merrett, N.R. and N.B. Marshall (1980) Observations on the ecology of deep-sea bottom-living fishes collected off northwest Africa (08°-27°N). Progress in Oceanography, **9**, 185-244.

Platt, T., Gallegos, C.L. and W.G. Harrison (1981) Photoinhibition of photosynthesis in natural assemblages of marine phytoplankton. Journal of Marine Research, **38**, 687-701.

Platt, T., Subba Rao, D.V. and B. Irwin (1983) Photosynthesis of picoplankton in the oligotrophic ocean. Nature (London), **300**, 702-704.

Rice, A.L., Aldred, R.G., Darlington, E. and R.A. Wild (1982) The quantitative estimation of the deep-sea megabenthos; a new approach to an old problem. Oceanologica Acta, **5**, 63-72.

Roe, H.S.J., Baker, A. de C., Carson, R.M., Wild, R. and D.M. Shale (1980) Behaviour of the Institute of Oceanographic Sciences' rectangular midwater trawls: theoretical aspects and experimental observations. Marine Biology, **56**, 247-259.

Roe, H.S.J. and E. Darlington (1985) A new acoustic control system for deep pelagic trawling close to the sea bed. Journal of the Society for Underwater Technology, **11**, 2-6.

Roe, H.S.J. and D.M. Shale (1979) A new multiple rectangular midwater trawl (RMT 1+8M) and some modifications to the Institute of Oceanographic Sciences' RMT 1+8. Marine Biology, **50**, 283-288.

Siedler, G., Zenk, W. and W.J. Emery (1985) Strong-current events related to a subtropical front in the northeast Atlantic. Journal of Physical Oceanography, **15**, 886-897.

Steeman Nielsen, E. (1951) Measurement of the production of organic matter in the sea. Nature (London), **167**, p. 684.

Steeman Nielsen, E. (1952) The use of radioactive carbon (C-14) for measuring organic production in the sea. Journal du Conseil International pour l'Exploration de la Mer, **18**, 117-140.

Steeman Nielsen, E. and V. Hansen (1959) Measurements with the Carbon-14 technique of the rates of respiration in natural populations of phytoplankton. Deep-Sea Research, **5**, 222-233.

Stramma, L. (1985) Geostrophic transports in the warm water sphere of the eastern subtropical North Atlantic. Journal of Marine Research, **42**, 537-558.

Strickland, J.D.H. and T.R Parsons (1972) A practical handbook of sea-water analysis. Bulletin of the Fisheries Research Board of Canada, **167**, 311pp.

Wishner, K.F. (1980a) The biomass of the deep-sea benthopelagic plankton. Deep-Sea Research, **27A**, 203-216.

Wishner, K.F. (1980b) Aspects of the community ecology of deep-sea benthopelagic plankton, with special reference to gymnopleid copepods. Marine Biology, **60**, 179-187.

Yorke, D. (1966) Least-squares fitting of a straight line. Canadian Journal of Physics, **44**, 1079-1086.

Table 1 Station list of work carried out en route to GME and at the site

Gear abbreviations:-

CTD - Conductivity Temperature Depth Probe
MS - Multi-sampler
Trans M - Transmissometer
UFL - Underwater Fluorometer
LMD - Light Meter Diode
W/B - Water Bottle
RMT 1+8M - Multiple Rectangular Midwater Trawl with 3 pairs of (nominally) $1m^2$ mouth area nets, mesh 0.32mm (RMT 1) and $8m^2$ mouth area nets, mesh 4.5mm (RMT 8).
RMT 1+8 - As above but with a single pair of nets
CCE - Closing Cod End (used on RMT 8)
NN - Neuston Net
NBES - Near Bottom Echo Sounder
OTSB 14 - Semi-balloon Otter Trawl
BN1.5/3M/SBN - Bottom sledge with 3 nets plus a 0.32mm mesh suprabenthic net.
BN1.5/P - Photosledge - no nets
BN1.5/Q - Bottom sledge modified as a rock dredge.
B'SNAP - Bathysnap V

STN.	DATE 1985	POSITION LAT	 LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11252 # 0	19/ 6	46 56.8N 46 56.8N	9 47.0W 9 47.0W	CTD MS TRANSM UFL	0- 300	2207-2322 NIGHT	
11253 # 0	20/ 6	45 41.7N 45 41.7N	12 11.3W 12 11.3W	CTD MS TRANSM UFL LMD WB7.4	0- 300	1204-1250 DAY	
11254 # 0	21/ 6	43 52.9N 43 52.9N	14 22.6W 14 22.6W	CTD MS TRANSM UFL LMD WB7.4	0- 300	0911-0955 DAY	
11255 # 0	21/ 6	42 18.0N 42 18.0N	15 51.7W 15 51.7W	CTD MS TRANSM UFL LMD WB7.4	0- 300	2107-2145 NIGHT	
11256 # 0	22/ 6	40 41.2N 40 41.2N	17 22.6W 17 22.6W	CTD MS TRANSM UFL LMD WB7.4	0- 300	0907-0945 DAY	

STN.	DATE 1985	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11257	22/ 6	39 1.8N	18 58.7W	CTD	0- 300	2107-2150	
# 0		39 1.8N	18 58.7W	MS		NIGHT	
				TRANSM			
				UFL			
				LMD			
				WB7.4			
11258	23/ 6	37 25.8N	20 19.8W	CTD	0- 300	0908-0951	
# 0		37 25.8N	20 19.8W	MS		DAY	
				TRANSM			
				UFL			
				LMD			
				WB7.4			
11259	23/ 6	35 36.8N	21 51.0W	CTD	0- 300	2106-2148	
# 0		35 36.8N	21 51.0W	MS		NIGHT	
				TRANSM			
				UFL			
				LMD			
				WB7.4			
11260	24/ 6	33 53.8N	23 20.1W	CTD	0- 300	0905-0946	
# 0		33 53.8N	23 20.1W	MS		DAY	
				TRANSM			
				UFL			
				LMD			
				WB7.4			
11261	27/ 6	31 28.5N	24 54.2W	RMT1M/1	300- 400	1128-1228	
# 1		31 27.6N	24 56.3W	RMT8M/1		DAY	FLOW DIST. 3.26 KM.
11261	27/ 6	31 27.6N	24 56.3W	RMT1M/2	400- 500	1228-1329	
# 2		31 27.1N	24 58.4W	RMT8M/2		DAY	FLOW DIST. 3.35 KM.

STN.	DATE	POSITION		GEAR	DEPTH	FISHING TIME	REMARKS
	1985	LAT	LONG		(M)	GMT	
11261	27/ 6	31 27.1N	24 58.4W	RMT1M/3	500- 600	1329-1429	
# 3		31 26.2N	25 0.8W	RMT8M/3		DAY	FLOW DIST. 3.94 KM.
11261	27/ 6	31 24.5N	25 4.8W	RMT1M/1	600- 700	1605-1705	
# 4		31 23.5N	25 7.3W	RMT8M/1		DAY	FLOW DIST. 3.70 KM.
11261	27/ 6	31 23.5N	25 7.3W	RMT1M/2	700- 800	1705-1805	
# 5		31 22.4N	25 9.5W	RMT8M/2		DAY	FLOW DIST. 3.77 KM.
11261	27/ 6	31 22.4N	25 9.5W	RMT1M/3	800- 900	1805-1906	
# 6		31 21.2N	25 11.6W	RMT8M/3		DAY	FLOW DIST. 3.71 KM.
11261	27/ 6	31 20.5N	25 13.8W	CTD	0- 300	2025-2102	
# 7		31 20.5N	25 13.8W	MS		DUSK	
				TRANSM			
				UFL			
				LMD			
				WB7.4			
11261	27/ 6	31 20.2N	25 17.3W	RMT1M/1	600- 700	2209-2309	NETS FAILED
# 8		31 19.6N	25 19.9W	RMT8M/1		NIGHT	
11261	28/ 6	31 19.6N	25 19.9W	RMT1M/2	0- 700	0049-0354	NETS FAILED
# 9		31 18.2N	25 27.2W	RMT8M/2		NIGHT	
11261	28/ 6	31 17.5N	25 31.6W	RMT1M/1	0- 320	0422-0456	NETS FAILED
#10		31 17.3N	25 33.3W	RMT8M/1		NIGHT	
11261	28/ 6	31 17.8N	25 33.6W	CTD	0-5296	0542-1008	
#11		31 17.8N	25 33.6W	MS		DAWN	
				TRANSM			
				UFL			
				WB7.4			
				LMD			

STN.	DATE 1985	POSITION LAT	 LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11261	28/ 6	31 18.6N	25 31.7W	RMT1M/1	200- 300	1046-1146	
#12		31 17.8N	25 29.1W	RMT8M/1		DAY	FLOW DIST. 4.09 KM.
11261	28/ 6	31 17.8N	25 29.1W	RMT1M/2	100- 200	1146-1247	
#13		31 16.9N	25 26.7W	RMT8M/2		DAY	FLOW DIST. 4.09 KM.
11261	28/ 6	31 16.9N	25 26.7W	RMT1M/3	0- 100	1247-1347	
#14		31 16.0N	25 24.2W	RMT8M/3		DAY	FLOW DIST. 4.07 KM.
11261	28/ 6	31 14.4N	25 20.5W	RMT1M/1	900-1000	1509-1609	
#15		31 13.1N	25 18.3W	RMT8M/1		DAY	FLOW DIST. 3.55 KM.
11261	28/ 6	31 13.1N	25 18.3W	RMT1M/2	1000-1100	1609-1709	
#16		31 11.8N	25 16.1W	RMT8M/2		DAY	FLOW DIST. 3.82 KM.
11261	28/ 6	31 11.8N	25 16.1W	RMT1M/3	1100-1200	1709-1809	
#17		31 10.0N	25 14.2W	RMT8M/3		DAY	FLOW DIST. 3.82 KM.
11261	28/ 6	31 10.2N	25 13.4W	CTD	0- 300	1917-2006	
#18		31 10.2N	25 13.4W	MS		DUSK	
				TRANSM			
				UFL			
				LMD			
				WB7.4			
11261	28/ 6	31 12.9N	25 14.6W	RMT1M/1	910-1000	2146-2246	
#19		31 14.7N	25 15.7W	RMT8M/1		NIGHT	FLOW DIST. 2.87 KM.
11261	28/ 6	31 14.7N	25 15.7W	RMT1M/2	1000-1110	2246-2356	
#20		31 17.1N	25 17.0W	RMT8M/2		NIGHT	FLOW DIST. 3.91 KM.
11261	28/ 6	31 17.1N	25 17.0W	RMT1M/3	1100-1200	2356-0057	
#21	29/ 6	31 19.0N	25 18.0W	RMT8M/3		NIGHT	FLOW DIST. 3.50 KM.

STN.	DATE 1985	POSITION LAT	 LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11261 #22	29/ 6	31 22.4N 31 24.6N	25 19.5W 25 20.1W	RMT1M/1 RMT8M/1	300- 400	0235-0335 NIGHT	FLOW DIST. 3.28 KM.
11261 #23	29/ 6	31 24.6N 31 26.5N	25 20.1W 25 20.8W	RMT1M/2 RMT8M/2	400- 500	0335-0436 NIGHT	FLOW DIST. 3.64 KM.
11261 #24	29/ 6	31 26.5N 31 29.0N	25 20.8W 25 22.0W	RMT1M/3 RMT8M/3	500- 600	0436-0536 NIGHT	FLOW DIST. 3.59 KM.
11261 #25	29/ 6	31 29.8N 31 29.8N	25 22.3W 25 22.3W	CTD MS TRANSM UFL LMD WB7.4	0- 300	0639-0702 DAWN	
11261 #26	29/ 6	31 28.1N 31 26.1N	25 23.4W 25 22.4W	RMT1M/1 RMT8M/1	1200-1300	0840-0940 DAY	FLOW DIST. 2.77 KM.
11261 #27	29/ 6	31 26.1N 31 24.1N	25 22.4W 25 22.1W	RMT1M/2 RMT8M/2	1300-1400	0940-1040 DAY	FLOW DIST. 3.07 KM.
11261 #28	29/ 6	31 24.1N 31 22.2N	25 22.1W 25 21.7W	RMT1M/3 RMT8M/3	1400-1500	1040-1140 DAY	FLOW DIST. 3.40 KM.
11261 #29	29/ 6	31 20.6N 31 18.1N	25 20.5W 25 20.5W	RMT1M/1 RMT8M/1	2- 25	1314-1414 DAY	FLOW DIST. 3.68 KM.
11261 #30	29/ 6	31 18.1N 31 15.6N	25 20.5W 25 20.3W	RMT1M/2 RMT8M/2	25- 50	1414-1514 DAY	FLOW DIST. 4.52 KM.
11261 #31	29/ 6	31 15.6N 31 13.3N	25 20.3W 25 20.1W	RMT1M/3 RMT8M/3	50- 100	1514-1614 DAY	FLOW DIST. 4.04 KM.

STN.	DATE 1985	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11261 #32	29/ 6	31 12.3N 31 11.8N	25 21.3W 25 23.4W	RMT1M/1 RMT8M/1	400- 500	1708-1808 DAY	FLOW DIST. 3.32 KM.
11261 #33	29/ 6	31 11.8N 31 11.3N	25 23.4W 25 25.9W	RMT1M/2 RMT8M/2	500- 600	1808-1908 DAY	FLOW DIST. 3.73 KM.
11261 #34	29/ 6	31 11.3N 31 10.5N	25 25.9W 25 27.3W	RMT1M/3 RMT8M/3	0- 600	1908-2009 DAY	FLOW DIST. 3.98 KM.
11261 #35	29/ 6	31 10.1N 31 10.1N	25 27.5W 25 27.5W	CTD MS TRANSM UFL LMD WB7.4	0- 300	2033-2115 NIGHT	
11261 #36	29/ 6	31 9.8N 31 9.8N	25 29.1W 25 31.2W	RMT1M/1 RMT8M/1	600- 700	2204-2304 NIGHT	RMT 8 1 & 2 FISHED TOGETHER FLOW DIST. 3.23 KM.
11261 #37	29/ 6 30/ 6	31 9.8N 31 10.1N	25 31.2W 25 33.3W	RMT1M/2 RMT8M/2	700- 800	2304-0004 NIGHT	FLOW DIST. 3.01 KM.
11261 #38	30/ 6	31 10.1N 31 10.5N	25 33.3W 25 35.5W	RMT1M/3 RMT8M/3	800- 895	0004-0104 NIGHT	FLOW DIST. 3.14 KM.
11261 #39	30/ 6	31 11.6N 31 13.7N	25 37.4W 25 37.4W	RMT1M/1 RMT8M/1	0- 100	0208-0308 NIGHT	FLOW DIST. 3.73 KM.
11261 #40	30/ 6	31 13.7N 31 15.9N	25 37.4W 25 37.1W	RMT1M/2 RMT8M/2	100- 200	0308-0409 NIGHT	FLOW DIST. 3.82 KM.
11261 #41	30/ 6	31 15.9N 31 17.8N	25 37.1W 25 37.0W	RMT1M/3 RMT8M/3	200- 300	0409-0509 NIGHT	FLOW DIST. 3.91 KM.

STN.	DATE 1985	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11261 #42	30/ 6	31 24.2N 31 24.2N	25 36.5W 25 36.5W	CTD MS TRANSM UFL LMD VB7.4	0- 300	0647-0707 DAWN	
11261 #43	30/ 6	31 6.7N 31 5.7N	25 8.7W 25 7.6W	OTSB14	5440-5440	1535-1600 DAY	LOG DIST. 17.90 KM.
11261 #44	1/ 7	31 7.0N 31 12.6N	25 5.2W 25 11.1W	OTSB14	5440-5440	0541-0830 DAWN	LOG DIST. 13.40 KM.
11261 #45	1/ 7	31 15.3N 31 15.3N	25 14.3W 25 14.3W	CTD MS UFL LMD TRANSM VB7.4	0- 300	1343-1434 DAY	
11261 #46	1/ 7 2/ 7	31 18.4N 31 22.3N	25 21.0W 25 24.5W	RMT1M/1 RMT8M/1 NBES	5325-5427	2245-0045 NIGHT	FLOW DIST. 7.82 KM.
11261 #47	2/ 7	31 22.3N 31 25.9N	25 24.5W 25 27.9W	RMT1M/2 RMT8M/2 NBES	5325-5233	0045-0245 NIGHT	FLOW DIST. 8.49 KM.
11261 #48	2/ 7	31 25.9N 31 35.0N	25 27.9W 25 35.7W	RMT1M/3 RMT8M/3 NBES	5233-5132	0245-0445 NIGHT	FLOW DIST. 8.45 KM.

STN.	DATE 1985	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11261 #49	2/ 7	31 35.0N 31 35.0N	25 35.7W 25 35.7W	CTD MS LMD UFL TRANSM WB7.4	0- 300	0836-0932 DAY	
11261 #50	2/ 7	31 12.8N 31 18.5N	25 18.3W 25 25.5W	OTSB14	5440-5440	1900-2200 DUSK	LOG DIST. 17.10 KM.
11261 #51	3/ 7	31 25.1N 31 25.1N	25 33.0W 25 33.0W	CTD MS TRANSM	0-5461	0336-0835 NIGHT	
11261 #52	3/ 7	31 12.6N 31 6.6N	25 12.5W 25 5.4W	OTSB14	5440-5440	1454-1805 DAY	LOG DIST. 15.80 KM.
11261 #53	3/ 7	30 59.7N 30 59.7N	24 56.9W 24 56.9W	CTD MS UFL TRANSM LMD WB7.4	0- 300	2316-2350 NIGHT	
11261 #54	4/ 7	31 8.9N 31 11.7N	25 7.1W 25 11.3W	RMT1M/1 RMT8M/1 NBES	5347-5388	0607-0808 DAWN	49-90M ABOVE BOTTOM FLOW DIST. 6.69 KM.
11261 #55	4/ 7	31 11.7N 31 14.7N	25 11.3W 25 14.6W	RMT1M/2 RMT8M/2 NBES	5388-5415	0808-1009 DAY	24-55M ABOVE BOTTOM FLOW DIST. 7.01 KM.

STN.	DATE 1985	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11261	4/ 7	31 14.7N	25 14.6W	RMT1M/3	5415-5425	1009-1206	11-25M ABOVE BOTTOM
#56		31 17.6N	25 18.3W	RMT8M/3		DAY	FLOW DIST. 7.37 KM.
				NBFS			
11261	4/ 7	31 22.2N	25 25.3W	CTD	0- 300	1601-1637	
#57		31 22.2N	25 25.3W	MS		DAY	
				UFL			
				LMD			
				TRANSM			
				WB7.4			
11261	4/ 7	31 6.0N	25 3.7W	OTSB14	5440-5400	2345-0309	
#58	5/ 7	30 58.5N	24 57.6W			NIGHT	LOG DIST. 17.80 KM.
11261	5/ 7	30 49.5N	24 50.6W	CTD	0- 300	0900-0943	
#59		30 49.5N	24 50.6W	MS		DAY	
				UFL			
				LMD			
				TRANSM			
				WB7.4			
11261	5/ 7	31 4.0N	25 9.7W	OTSB14	5440-5400	1620-1920	NET FAST
#60		31 8.1N	25 14.6W			DAY	
11261	6/ 7	31 13.2N	25 16.9W	RMT1M/1	600- 700	0152-0252	
#61		31 14.8N	25 19.1W	RMT8M/1		NIGHT	FLOW DIST. 3.28 KM.
11261	6/ 7	31 14.8N	25 19.1W	RMT1M/2	700- 800	0252-0352	
#62		31 16.4N	25 21.4W	RMT8M/2		NIGHT	FLOW DIST. 3.91 KM.
11261	6/ 7	31 14.4N	25 21.7W	RMT1M/1	5345-5385	1325-1524	48-90M ABOVE BOTTOM
#63		31 19.2N	25 21.4W	RMT8M/1		DAY	FLOW DIST. 7.24 KM.
				NBFS			

STN.	DATE 1985	POSITION LAT	POSITION LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11261 #64	6/ 7	31 19.2N 31 24.3N	25 21.4W 25 21.3W	RMT1M/2 RMT8M/2 NBES	5385-5410	1524-1735 DAY	25-48M ABOVE BOTTOM FLOW DIST. 8.71 KM.
11261 #65	6/ 7	31 24.3N 31 28.9N	25 21.3W 25 21.9W	RMT1M/3 RMT8M/3 NBES	5410-5430	1735-1929 DAY	11-31MABOVE BOTTOM FLOW DIST. 7.64 KM.
11261 #66	7/ 7	31 33.0N 31 30.5N	25 25.8W 25 26.1W	RMT1M/1 RMT8M/1	1200-1300	0112-0212 NIGHT	FLOW DIST. 3.59 KM.
11261 #67	7/ 7	31 30.5N 31 28.4N	25 26.1W 25 25.5W	RMT1M/2 RMT8M/2	1300-1400	0212-0312 NIGHT	FLOW DIST. 4.18 KM.
11261 #68	7/ 7	31 28.4N 31 26.3N	25 25.5W 25 25.2W	RMT1M/3 RMT8M/3	1400-1520	0312-0412 NIGHT	FLOW DIST. 3.82 KM.
11261 #69	7/ 7	31 11.2N 31 7.9N	25 25.3W 25 25.2W	RMT1M/1 RMT8M/1	3900-4300	1153-1311 DAY	FLOW DIST. 4.22 KM.
11261 #70	7/ 7	31 7.9N 31 4.7N	25 25.2W 25 25.2W	RMT1M/2 RMT8M/2	4300-4700	1311-1423 DAY	FLOW DIST. 4.35 KM.
11261 #71	7/ 7	31 4.7N 31 2.3N	25 25.2W 25 25.2W	RMT1M/3 RMT8M/3	4700-5100	1423-1516 DAY	FLOW DIST. 3.15 KM.
11261 #72	7/ 7	30 53.7N 30 53.7N	25 22.7W 25 22.7W	CTD MS LMD UFL TRANSM	0- 300	1923-2004 NIGHT	

STN.	DATE 1985	POSITION LAT	LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11261	7/ 7	30 59.7N	25 21.2W	RMT1M/1	0- 25	2147-2247	
#73		31 1.3N	25 19.2W	RMT8M/1		NIGHT	FLOW DIST. 4.04 KM.
11261	7/ 7	31 1.3N	25 19.2W	RMT1M/2	25- 50	2247-2347	
#74		31 2.8N	25 17.1W	RMT8M/2		NIGHT	FLOW DIST. 3.68 KM.
11261	7/ 7	31 2.8N	25 17.1W	RMT1M/3	50- 100	2347-0047	
#75	8/ 7	31 4.4N	25 15.1W	RMT8M/3		NIGHT	FLOW DIST. 3.46 KM.
11262	12/ 7	31 23.5N	25 6.7W	RMT1M/1	1500-1910	2225-0025	
# 1	13/ 7	31 23.2N	25 13.3W	RMT8M/1		NIGHT	FLOW DIST. 8.18 KM.
11262	13/ 7	31 23.2N	25 13.3W	RMT1M/2	1910-2315	0025-0227	
# 2		31 22.8N	25 19.8W	RMT8M/2		NIGHT	FLOW DIST. 8.94 KM.
11262	13/ 7	31 22.8N	25 19.8W	RMT1M/3	2310-2700	0227-0429	
# 3		31 21.8N	25 25.3W	RMT8M/3		NIGHT	FLOW DIST. 8.22 KM.
11262	13/ 7	31 19.7N	25 17.0W	RMT1M/1	2700-3110	1030-1230	
# 4		31 19.4N	25 10.8W	RMT8M/1		DAY	FLOW DIST. 7.91 KM.
11262	13/ 7	31 19.4N	25 10.8W	RMT1M/2	3110-3500	1230-1518	
# 5		31 18.6N	25 2.4W	RMT8M/2		DAY	FLOW DIST. 11.38 KM.
11262	13/ 7	31 18.6N	25 2.4W	RMT1M/3	3330-3910	1518-1737	
# 6		31 23.0N	24 58.1W	RMT8M/3		DAY	FLOW DIST. 9.60 KM.
11262	13/ 7	31 28.4N	24 56.3W	CTD	0-5424	2042-0135	
# 7	14/ 7	31 28.4N	25 56.3W	MS		NIGHT	
				TRANSM			
11262	14/ 7	31 27.4N	24 56.3W	RMT1M/1	500- 600	0227-0329	
# 8		31 25.0N	24 56.5W	RMT8M/1		NIGHT	FLOW DIST. 3.91 KM.

STN.	DATE 1985	POSITION LAT	 LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11262 # 9	14/ 7	31 25.0N 31 22.5N	24 56.5W 24 56.5W	RMT1M/2 RMT8M/2	495- 600	0329-0432 NIGHT	FLOW DIST. 4.67 KM.
11262 #10	14/ 7	31 14.2N 31 13.5N	25 10.8W 25 16.7W	RMT1M/1 RMT8M/1	3900-4295	1050-1253 DAY	FLOW DIST. 6.47 KM.
11262 #11	14/ 7	31 13.5N 31 12.7N	25 16.7W 25 22.4W	RMT1M/2 RMT8M/2	4295-4720	1253-1453 DAY	FLOW DIST. 7.28 KM.
11262 #12	14/ 7	31 12.7N 31 12.4N	25 22.4W 25 27.9W	RMT1M/3 RMT8M/3	4720-5110	1453-1653 DAY	FLOW DIST. 8.09 KM.
11262 #13	14/ 7 15/ 7	31 12.1N 31 16.0N	25 34.0W 25 4.6W	NN	0- 0	2030-0630 NIGHT	SERIES OF 12 TOWS
11262 #14	15/ 7 16/ 7	31 14.6N 31 14.6N	25 27.9W 25 27.9W	CTD MS TRANSM	0-5349	2115-0130 NIGHT	
11262 #15	16/ 7	31 14.7N 31 13.2N	25 8.6W 25 3.9W	BN1.5/3M SBN 0.5	5432-5432	0839-1109 DAY	LOG DIST. 0.47 KM.
11262 #16	16/ 7 17/ 7	31 9.1N 31 8.7N	25 12.6W 25 9.6W	BN1.5/3M SBN 0.5	5432-5432	2320-0051 NIGHT	LOG DIST. 2.16 KM.
11262 #17	17/ 7	31 13.3N 31 11.5N	25 14.4W 25 9.5W	BN1.5/3M SBN 0.5	5432-5432	1214-1417 DAY	LOG DIST. 4.08 KM.
11262 #18	17/ 7	31 6.4N 31 6.4N	25 31.9W 25 31.9W	CTD TRANSM	0-2000	2157-2354 NIGHT	
11262 #19	18/ 7	31 19.8N 31 34.0N	25 29.0W 25 26.9W	BN1.5/3M SBN 0.5	5432-5432	0539-1224 DAY	LOG DIST. 7.95 KM.

STN.	DATE 1985	POSITION LAT	 LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11262 #20	19/ 7	31 28.0N 31 31.7N	25 12.8W 25 8.7W	BN1.5/P	5110-5220	0444-0742 DAWN	
11262 #21	19/ 7	31 15.2N 31 15.2N	25 25.4W 25 25.4W	B.SNAP	5376-5376	1447-1651 DAY	
11262 #22	19/ 7	31 15.3N 31 14.6N	25 22.1W 25 19.0W	RMT1 RMT8 CCE	680- 800	1812-1912 DAY	FLOW DIST. 4.40 KM.
11262 #23	19/ 7	31 11.2N 31 9.7N	25 18.3W 25 20.3W	RMT1 RMT8 CCE	665- 800	2157-2257 NIGHT	FLOW DIST. 3.77 KM.
11262 #24	20/ 7	31 10.0N 31 12.5N	25 19.4W 25 16.4W	RMT1 RMT8 CCE	585- 800	0146-0316 NIGHT	FLOW DIST. 5.48 KM.
11262 #25	20/ 7	31 15.3N 31 16.7N	25 10.5W 25 5.7W	RMT1M/1 RMT8M/1 NBES	5340-5375	1647-1847 DAY	51-90M ABOVE BOTTOM FLOW DIST. 7.10 KM.
11262 #26	20/ 7	31 16.7N 31 18.0N	25 5.7W 25 1.9W	RMT1M/2 RMT8M/2 NBES	5375-5415	1847-2047 DAY	25-51M ABOVE BOTTOM FLOW DIST. 7.19 KM.
11262 #27	20/ 7	31 18.0N 31 19.4N	25 1.9W 24 58.8W	RMT1M/3 RMT8M/3 NBES	5415-5430	2047-2247 DUSK	10-25M ABOVE BOTTOM FLOW DIST. 7.73 KM.
11262 #28	21/ 7	31 28.4N 31 29.3N	25 13.7W 25 10.7W	BN1.5/O	5200-5400	1156-1310 DAY	LOG DIST. 1.10 KM.

STN.	DATE 1985	POSITION LAT	 LONG	GEAR	DEPTH (M)	FISHING TIME GMT	REMARKS
11262 #29	21/ 7	31 19.9N 31 19.9N	24 53.9W 24 53.9W	B.SNAP	5433-5433	2026-2216 DUSK	

*

Table 2 Parameters for production-irradiance curves and associated information. DCM = Chlorophyll maximum layer. Nominal filter size for GF/F is 0.4μm.

Run/Station No.	Depth (m)	Filter	Chlorophyll a retained ($mg\ m^{-3}$)	P_s (1)	α (2)	β (2)	P_{max} (1)	I_m (Wm^{-2})	Absolute MgC at P_{max} (3)	Percentage Production of size fraction
11261#25	90 (DCM)	GF/F	0.34	11.208	0.174	0.108	3.812	61.82	1.296	<1μm 62%
		1μm Nuclepore	0.20	5.892	0.117	0.048	2.517	62.18	0.493	>1μm 38%
11261#42	∿95 (DCM)	GF/F	0.39	5.741	0.218	0.061	2.931	40.04	1.143	<1μm 70.2%
		1μm Nuclepore	0.19	2.915	0.129	0.022	1.793	43.53	0.341	>1μm 29.8%
11261#49	96 (DCM)	GF/F	0.30	4.052	0.456	0.036	3.055	23.24	0.917	n/a
	71 (above DCM)	GF/F	0.14	12.625	0.183	0.083	5.121	80.35	0.647	
11261#59	70	GF/F	0.12	8.768	0.235	0.037	5.533	74.43	0.647	<1μm 43.4%
	(above DCM)	1μm Nuclepore	0.06	12.017	0.239	0.068	6.093	75.79	0.366	>1μm 56.6%

(1) mgC mgChl $\underline{a}^{-1}\ hr^{-1}$

(2) mgC mgChl $\underline{a}^{-1}\ hr^{-1}\ W^{-1}\ m^{-2}$

(3) mgC $hr^{-1}\ W^{-1}\ m^{-2}$

Table 3. Estimated parameters of the irradiance-depth profile

Station	k_1 (m^{-1})	k_2 (m^{-1})	a_1	a_2	k_c (m^2[mg Chlor a]$^{-1}$)
11261#59	0.02499 ±0.00006	0.0470 ±0.0005	0.102 ±0.001	0.898 ±0.03	0.089 ±0.014
11261#49	0.02705 ±0.00005	0.058 ±0.001	0.140 ±0.002	0.860 ±0.06	0.082 ±0.008

Table 4. Total daily net primary production

Station	Depth of sample used for production estimates (m)	Daily production ($mg\ C\ m^{-2}\ day^{-1}$)
11261#25	90	190.2
11261#42	95	190.6
11261#49	71	233.3
11261#49	96	200.4
11261#59	70	321.9

Mean value = 227 ±55

Table 5. Accumulative percentages of biomass (cc $1000m^{-3}$ water) throughout the water column. The depths are the midpoint depths of the various hauls

	Plankton (0.32-4.5mm)		Micronekton (>4.5mm)	
Depth (m)	Day	Night	Day	Night
50	11.5%	22.2%	0.2%	14.8%
250	34.5	43.7	0.9	85.5
550	57.2	55.5	1.9	92.8
750	69.3	66.7	94.6	93.9
1050	81.5	82.6	98.6	96.4
1250	87.4	88.0	99.1	97.7
1450	94.9	94.0	99.6	98.6
5376	100.0	100.0	100.0	100.0

Table 6 Values of slope (A) and intercept (B) for pairs of planktonic biomass measurements using major axis regression. Different size groups and depths are shown. Dry weight can be calculated from volume as: $\log_{10} Y = A(\log_{10} X) + B$ where Y is dry weight and X is the volume.

Displacement volume/wet wt	Depth (m)	Slope (A)	Intercept (B)
0.32-1.0mm	0-1500	0.97 (±0.02)	0.02 (±0.13)
1.0 -4.5	0-1500	0.95 (±0.04)	0.02 (±0.14)
0.32-4.5	0-1500	0.96 (±0.02)	0.02 (±0.13)
0.32-4.5	1500-5440	0.97 (±0.02)	0.03 (±0.04)
0.32-4.5	0-5440	0.98 (±0.02)	0.02 (±0.12)
Displacement volume/dry wt			
0.32-1.0m	0-1500	0.85 (±0.03)	-0.75 (±0.14)
1.0 -4.5	0-1500	0.94 (±0.09)	-0.80 (±0.25)
0.32-4.5	0-1500 + 3900-5100	0.88 (±0.04)	-0.78 (±0.17)
Wet wt/Dry wt			
0.32-1.0mm	0-1500	0.89 (±0.03)	-0.77 (±0.13)
1.0 -4.5	0.1500	0.96 (±0.07)	-0.82 (±0.20)
0.32-4.5	0-1500 + 3900-5100	0.90 (±0.03)	-0.79 (±0.14)

Table 7 Linear regression coefficients for biomass (cc $1000m^{-3}$) as a function of depth. Log_{10} biomass = A(x) + B where x is the depth.

Depth (m)			Slope (A)		Intercept (B)
0-1000	Plankton	Day	-0.00047	(±0.0002)	1.05 (±0.12)
		Night	-0.00056	(±0.0003)	0.99 (±0.17)
	Micronekton	Day	+0.00034	(±0.0003)	0.43 (±0.16)
		Night	-0.00045	(±0.0002)	0.81 (±0.13)
1000-5440	Plankton	Day	-0.00036	(±0.00004)	0.81 (±0.14)
		Night	-0.00033	(±0.00004)	0.70 (±0.13)
	Micronekton	Day	-0.00041	(±0.00005)	0.99 (±0.16)
		Night	-0.00036	(±0.00004)	0.77 (±0.15)

Table 8 Linear regression coefficients for biomass (cc $1000m^{-3}$) as a function of depth below 1000m in the N. Atlantic. Wishner's data are from 6 stations taken over a period of 6 years - 3 of her stations were close to GME; N70V has a mouth area of $70cm^2$, mesh 0.23mm.

Postition/Time	Group	Net	Slope	Intercept	Source
31°17'N 25°24'W	Plankton	RMT 1	-0.00036 (±0.00004)	0.805	Present data
GME, June-July	Micronekton	RMT 8	-0.00041 (±0.00005)	0.991	" "
20°N 21°W April	Micronekton	RMT 8	-0.00038 (±0.00007)	2.150	Angel & Baker (1982)
42°N 17°W	Plankton	RMT 1	-0.00047 (±0.00004)	1.985	" " "
May	Micronekton	RMT 8	-0.00044 (±0.00004)	1.587	" " "
49°40'N 14°W	Plankton	RMT 1	-0.00076 (±0.00004)	2.150	" " "
April-May	Micronekton	RMT 8	-0.00053 (±0.00004)	1.606	" " "
30-62°N 02-23°W April-Oct.	Plankton	N70V	-0.00047 (±0.00008)	1.361	Wishner (1980a)

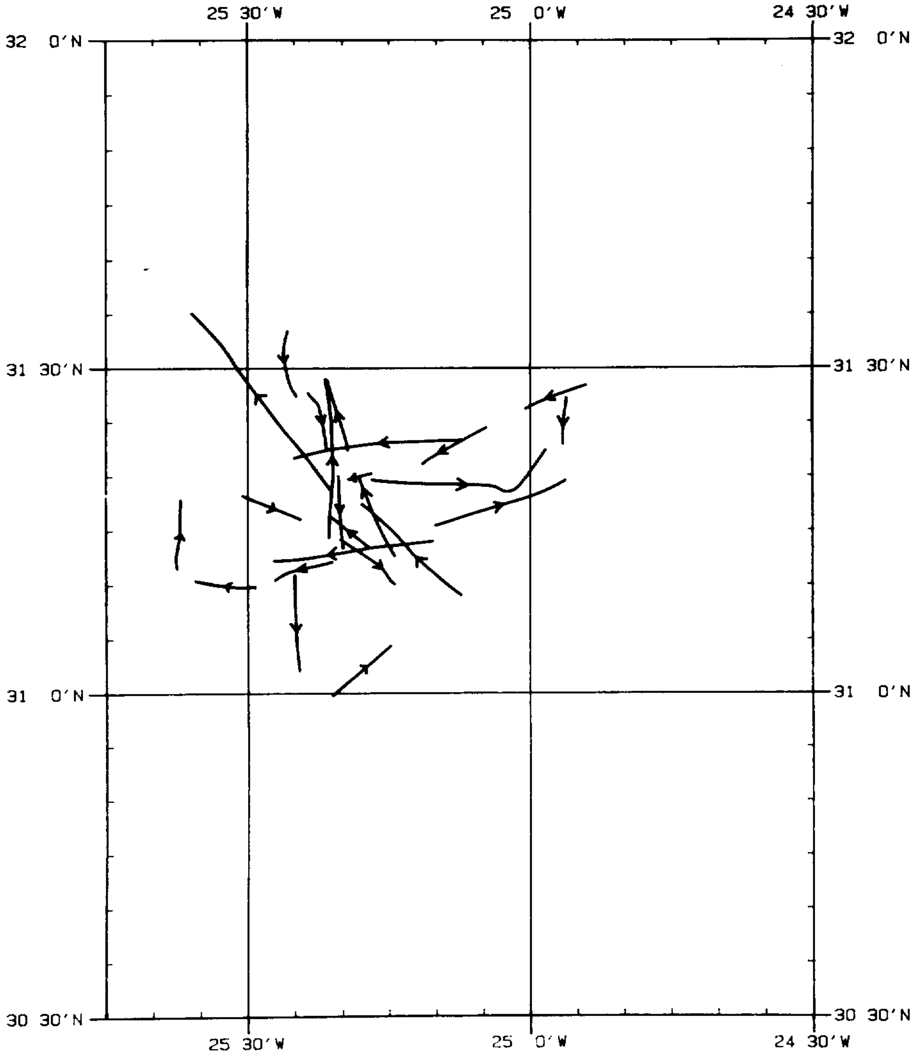

Fig. 1. Great Meteor East: track charts of the midwater sampling.

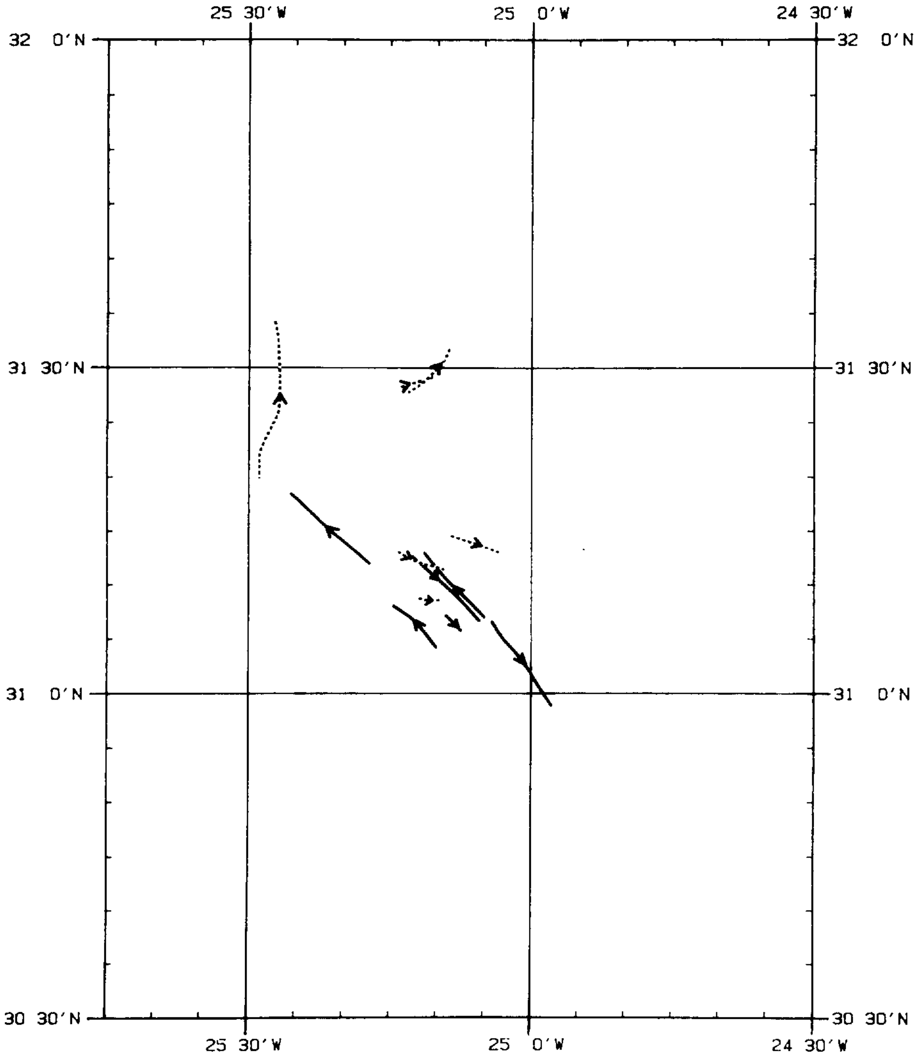

Fig. 2. Great Meteor East: track charts of the benthic sampling; ⋰ = sledge hauls, ╱ = Otter trawl hauls.

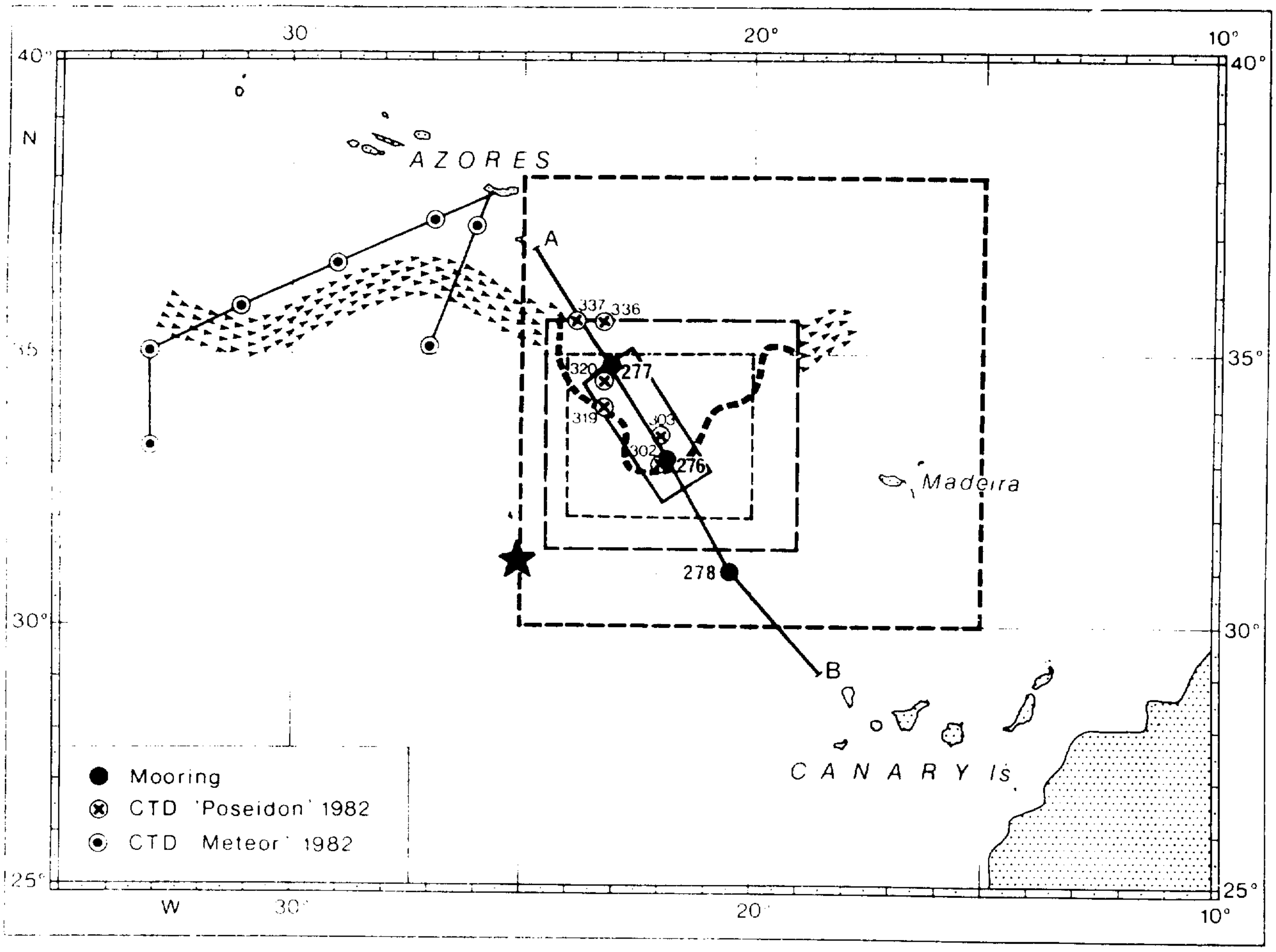

Fig. 3. Position of a subtropical front (arrows) as determined by Siedler <u>et al</u> (1985, their fig. 1). The site of the GME survey is marked by a star.

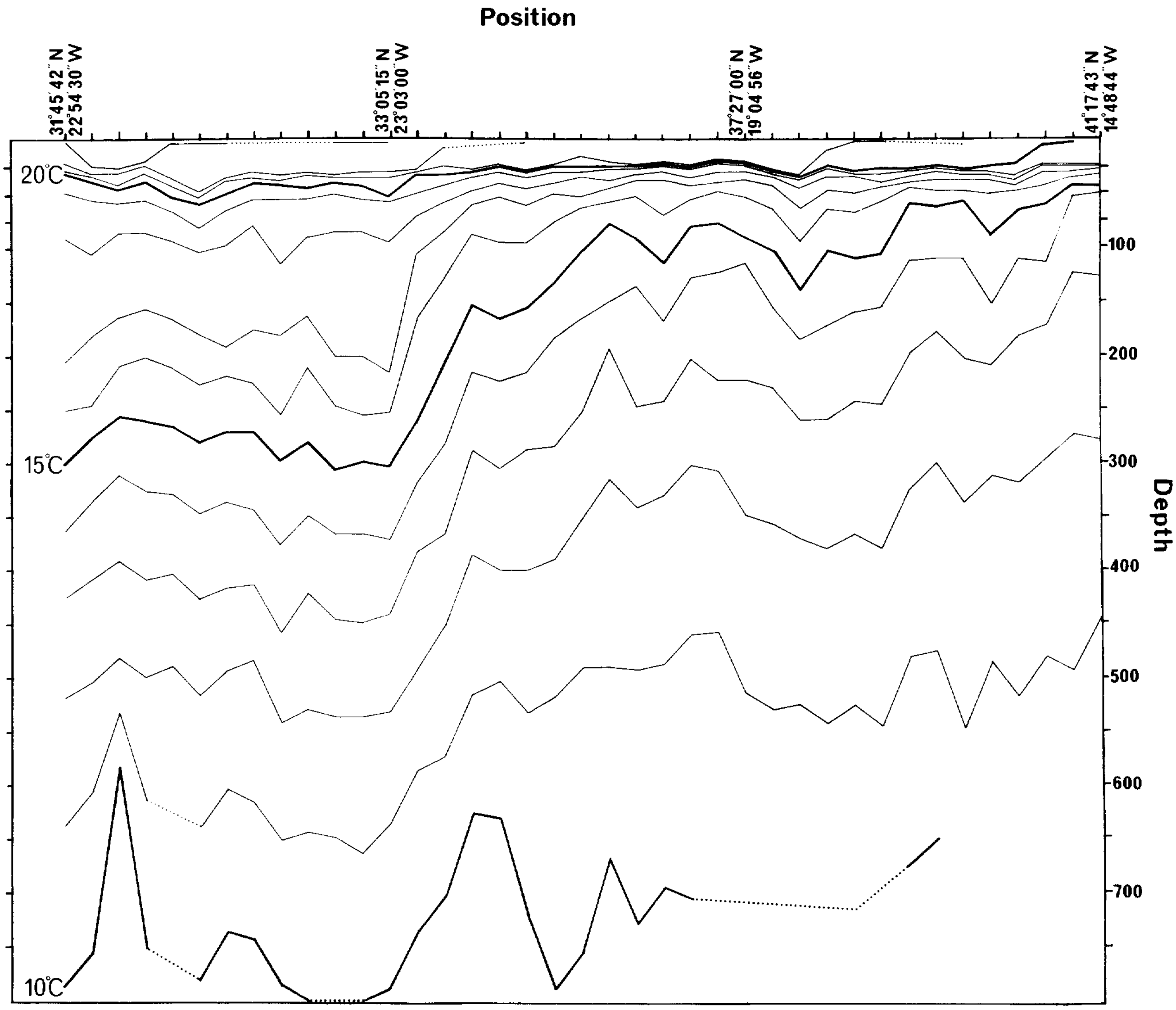

Fig. 4. XBT profile taken at GME and on passage in a northeasterly direction. The front at 33°05'N, 23°03'W was crossed on 22 July 1985.

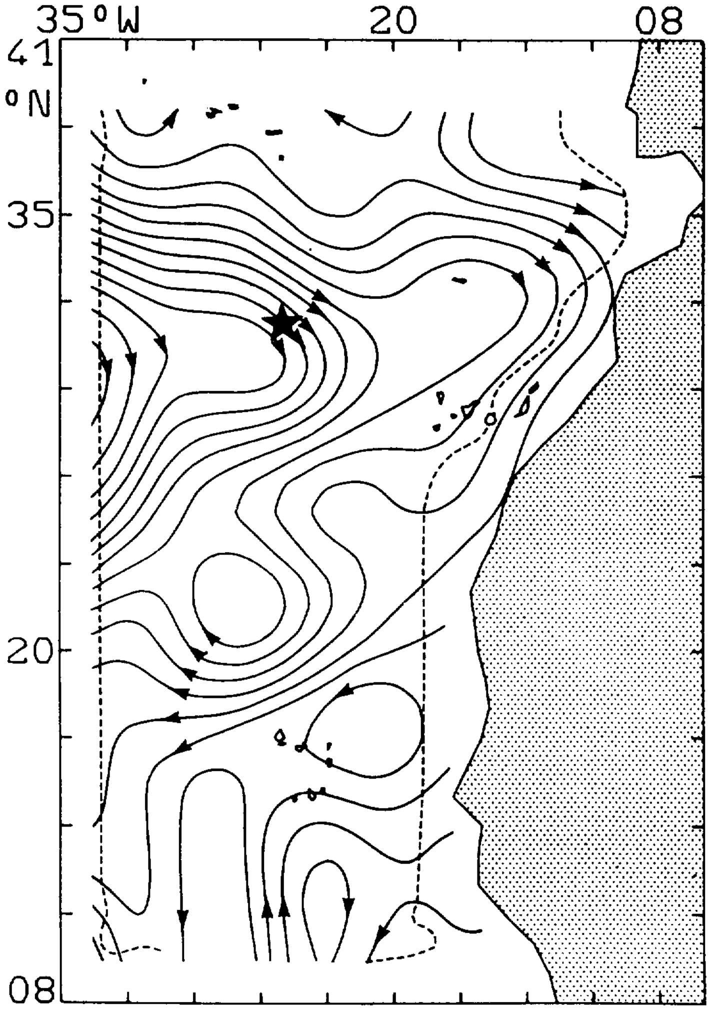

Fig. 5. The integrated volume transport (0-800m) determined from mean density profiles by Stramma (1984, his fig. 7). Each flow line between the broken lines represents $10^6 m^3 s^{-1}$; outside the broken lines errors are greater than $1 \times 10^6 m^3 s^{-1}$. The site of the GME survey is marked with a star.

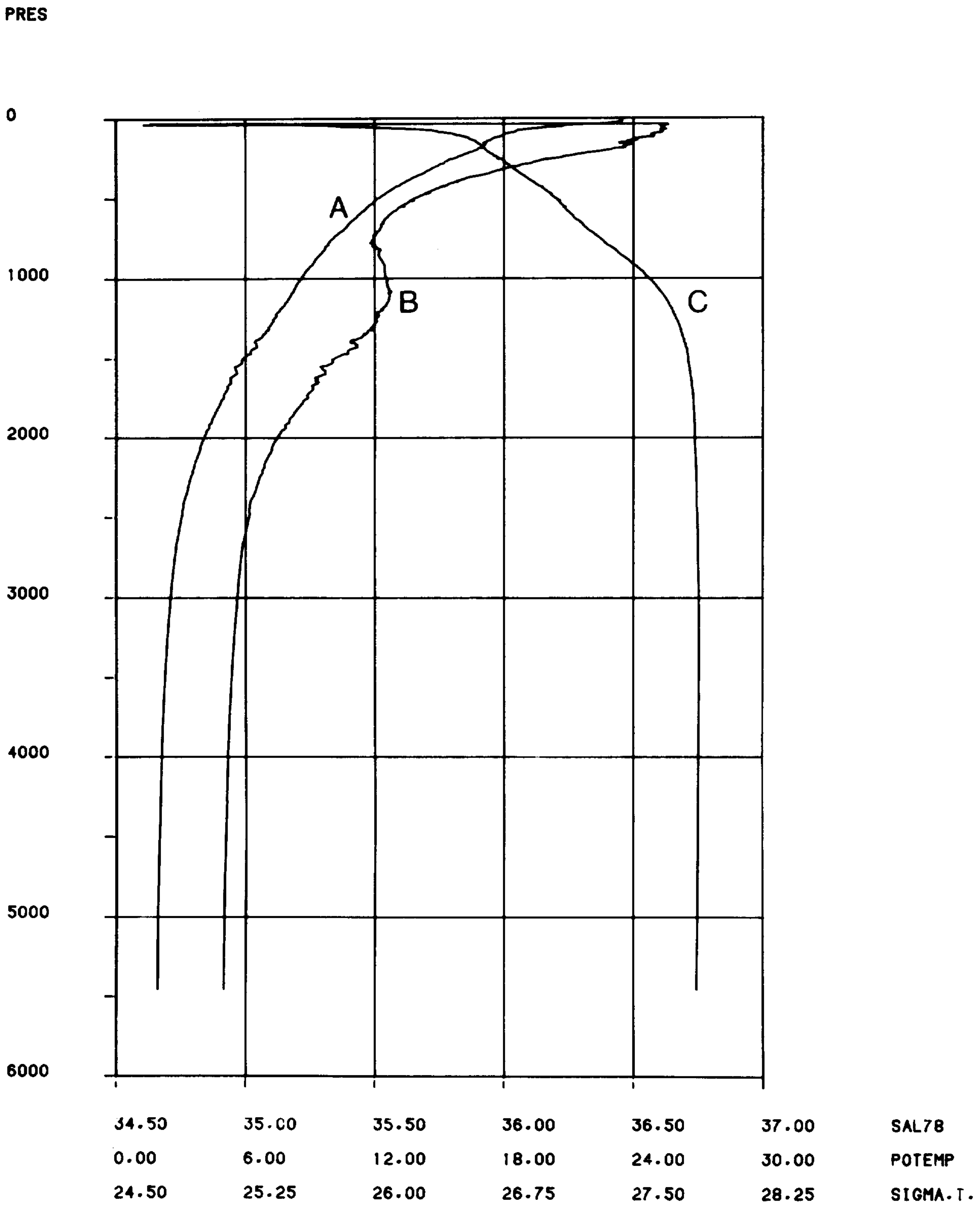

Fig. 6. Vertical profiles of potential temperature (A, °C), salinity (B, °/₀₀) and sigma theta (C, kg m^{-3}) against depth (dB) at station 11262#7.

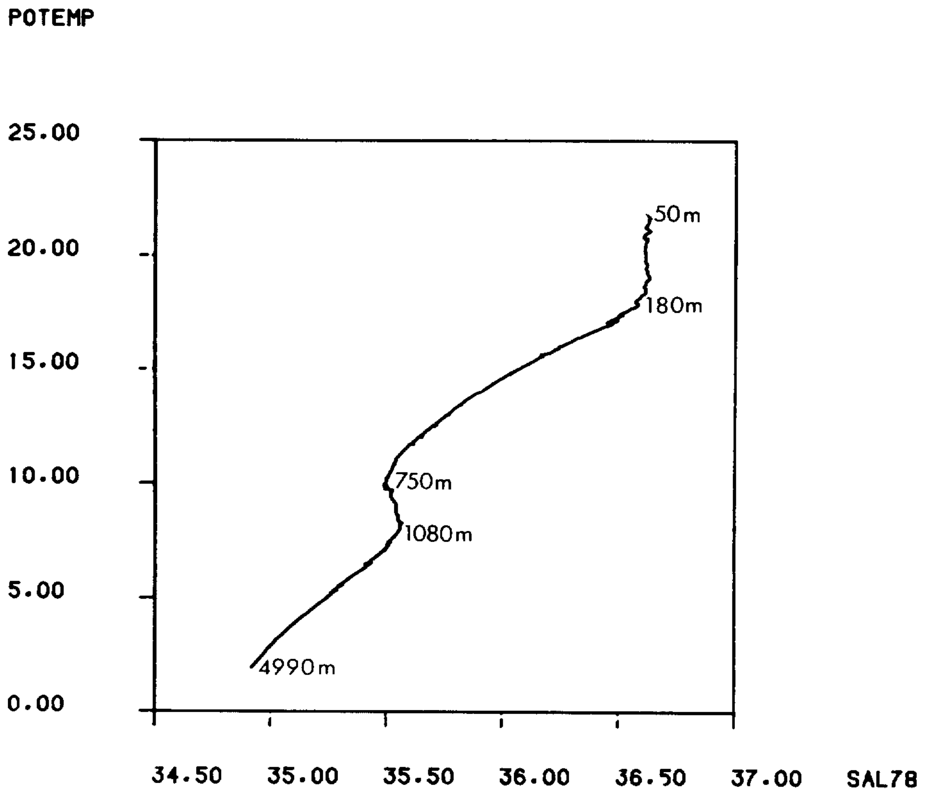

Fig. 7. Potential temperature-salinity plot for station 11261#7.

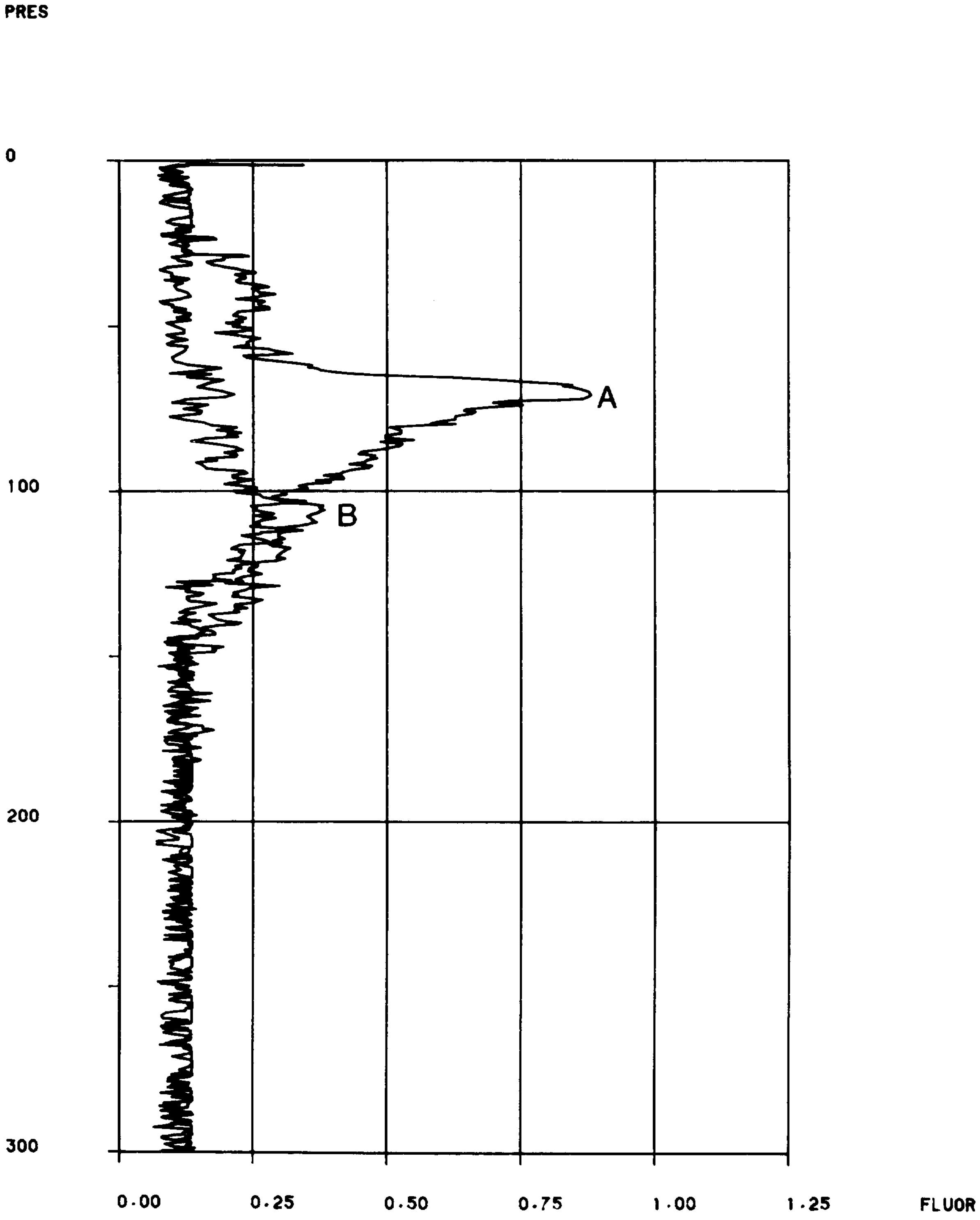

Fig. 8. Vertical profiles of phytoplankton chlorophyll (mg m^{-3}, chlorophyll a) against depth (dB) for stations 11259 (A) and 11260 (B).

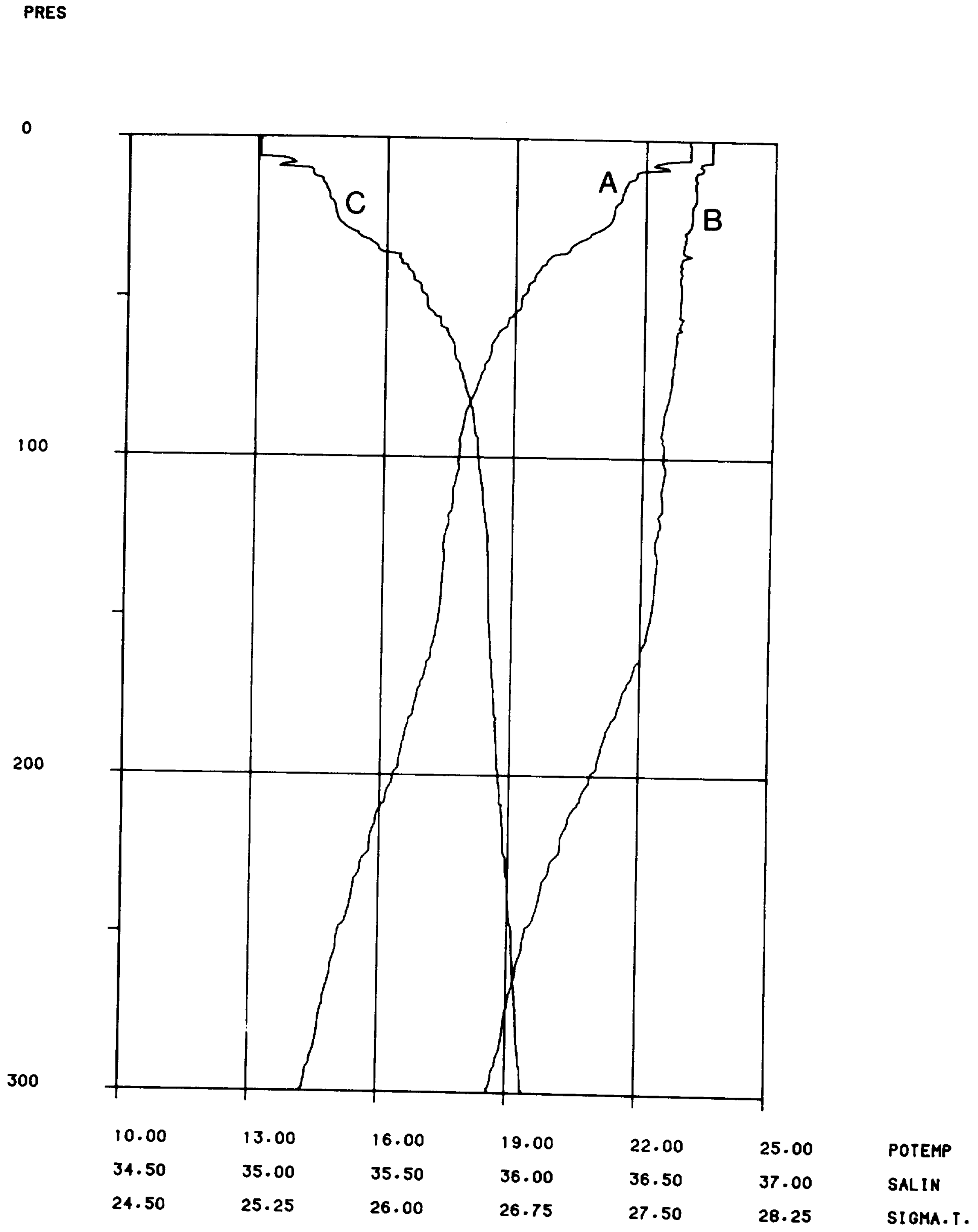

Fig. 9. Vertical profile of potential temperature (A, °C), salinity (B, °/$_{oo}$) and sigma theta (C, kg m^{-3}) against depth (dB) at station 11261#42.

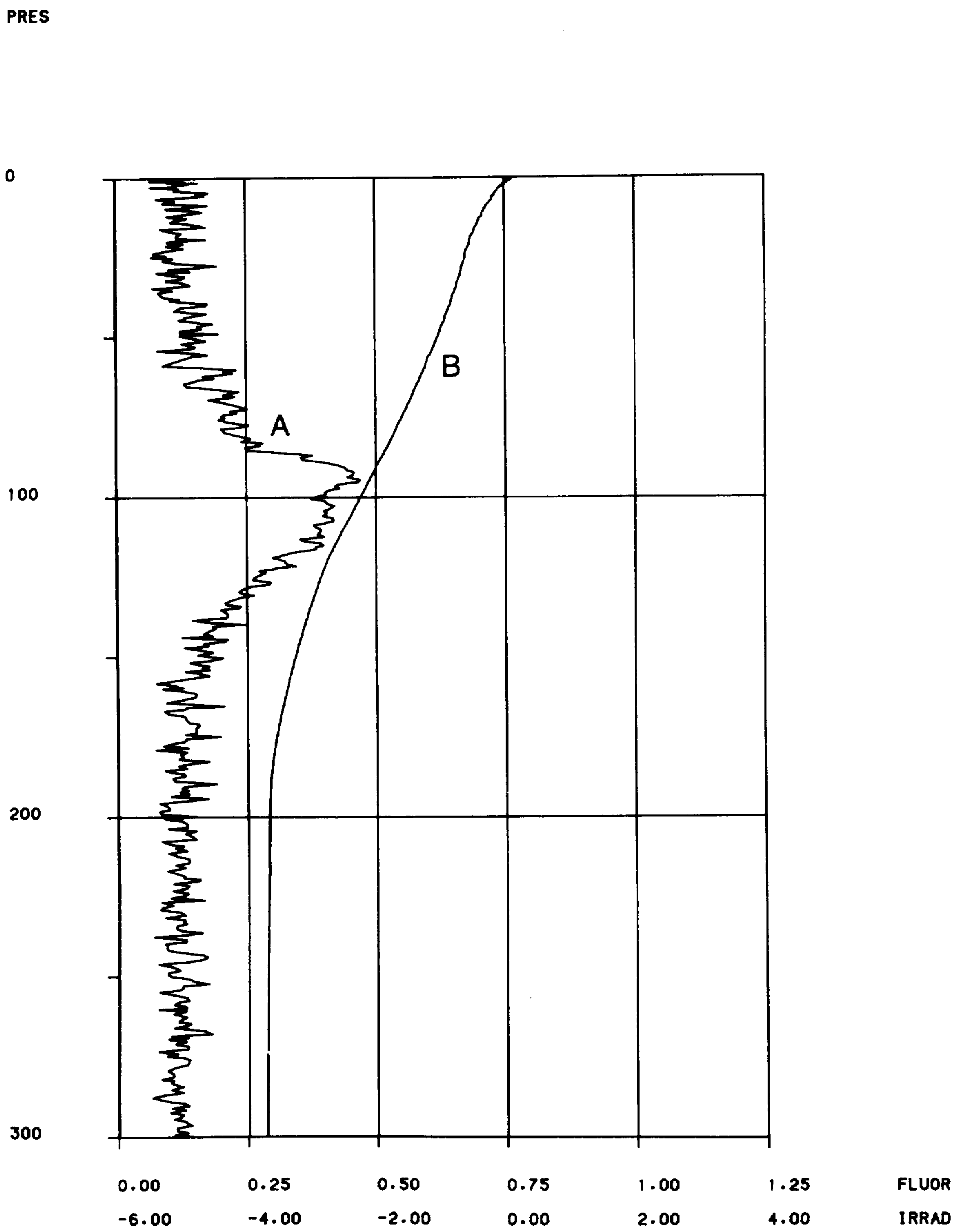

Fig. 10. Vertical profile of phytoplankton chlorophyll (A, mg m^{-3} chlorophyll a) and the log of irradiance (B, $\log_{10}$ (Watts m^{-2}) against depth (dB) at station 11261#42.

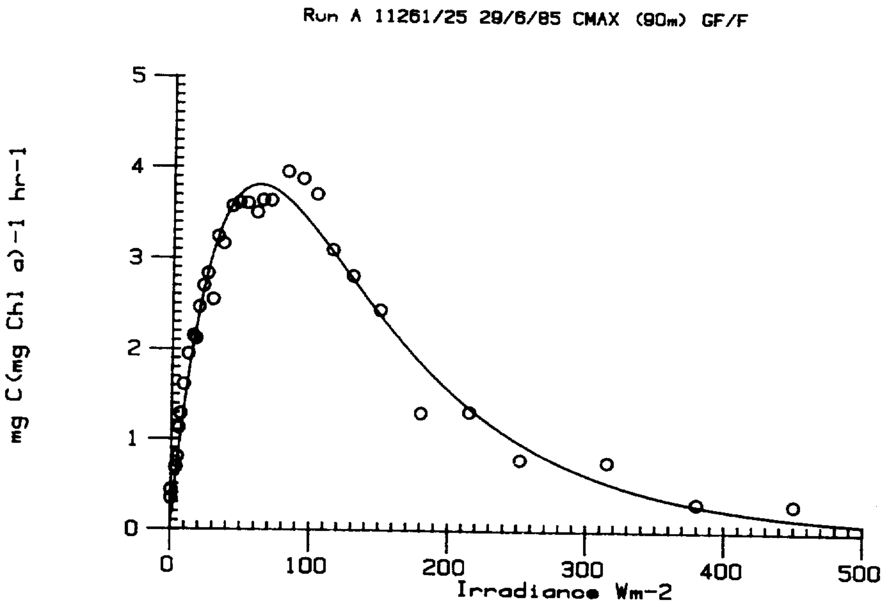

Fig. 11. Production-irradiance curve for station 11261#25, the open circles are the observed levels of productivity. The solid line is the fitted curve.

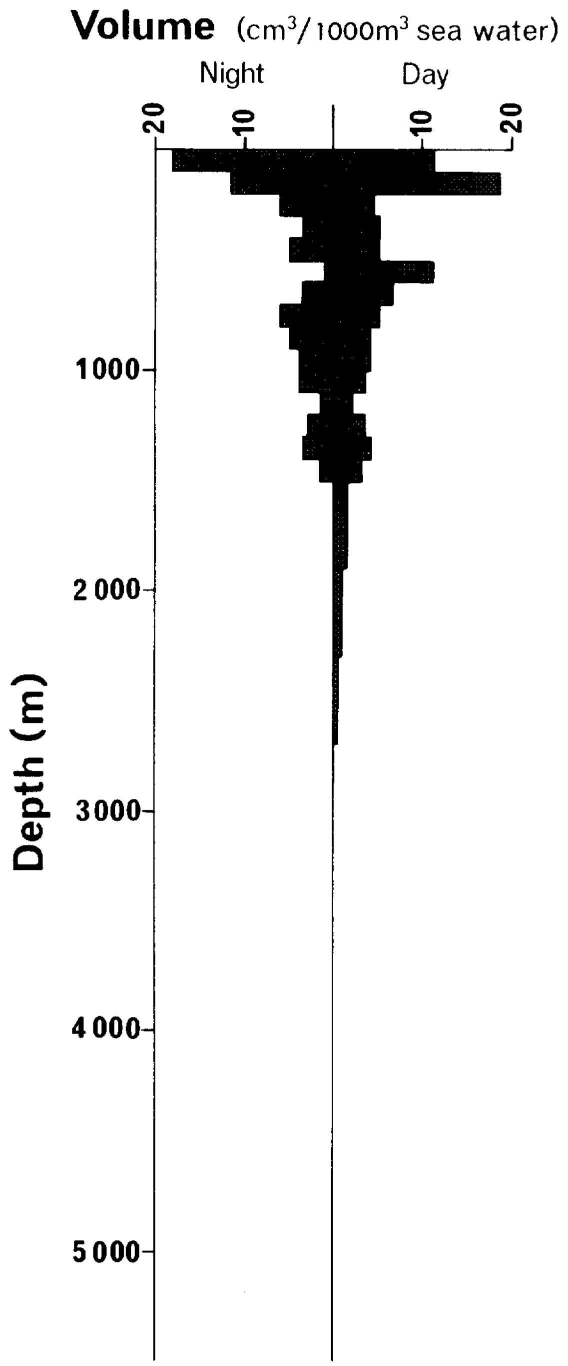

Fig. 12. Displacement volume/depth of plankton caught by the RMT 1 (size range 0.32-4.5mm).

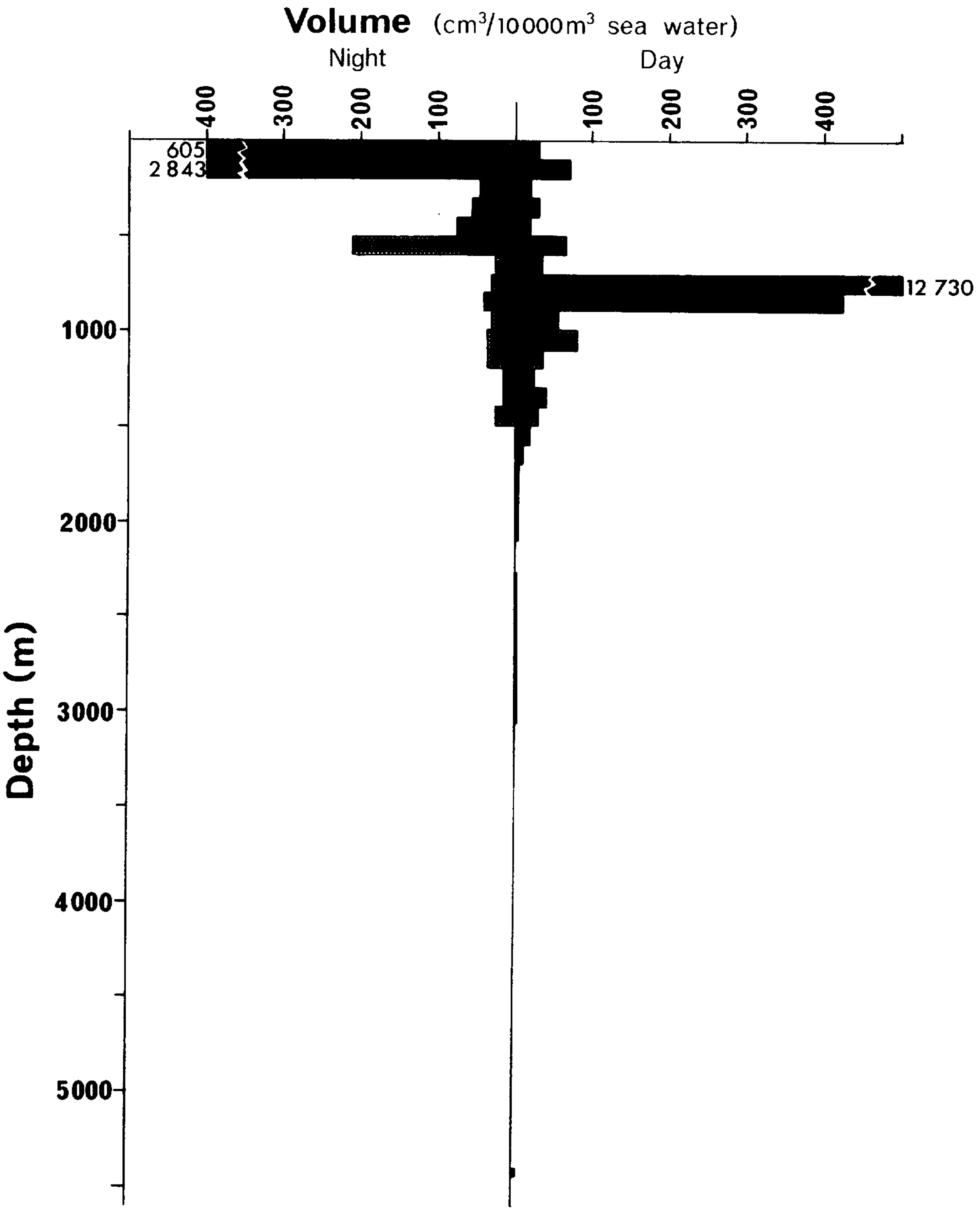

Fig. 13. Displacement volume/depth of micronekton caught by the RMT 8 (size range (>4.5mm).

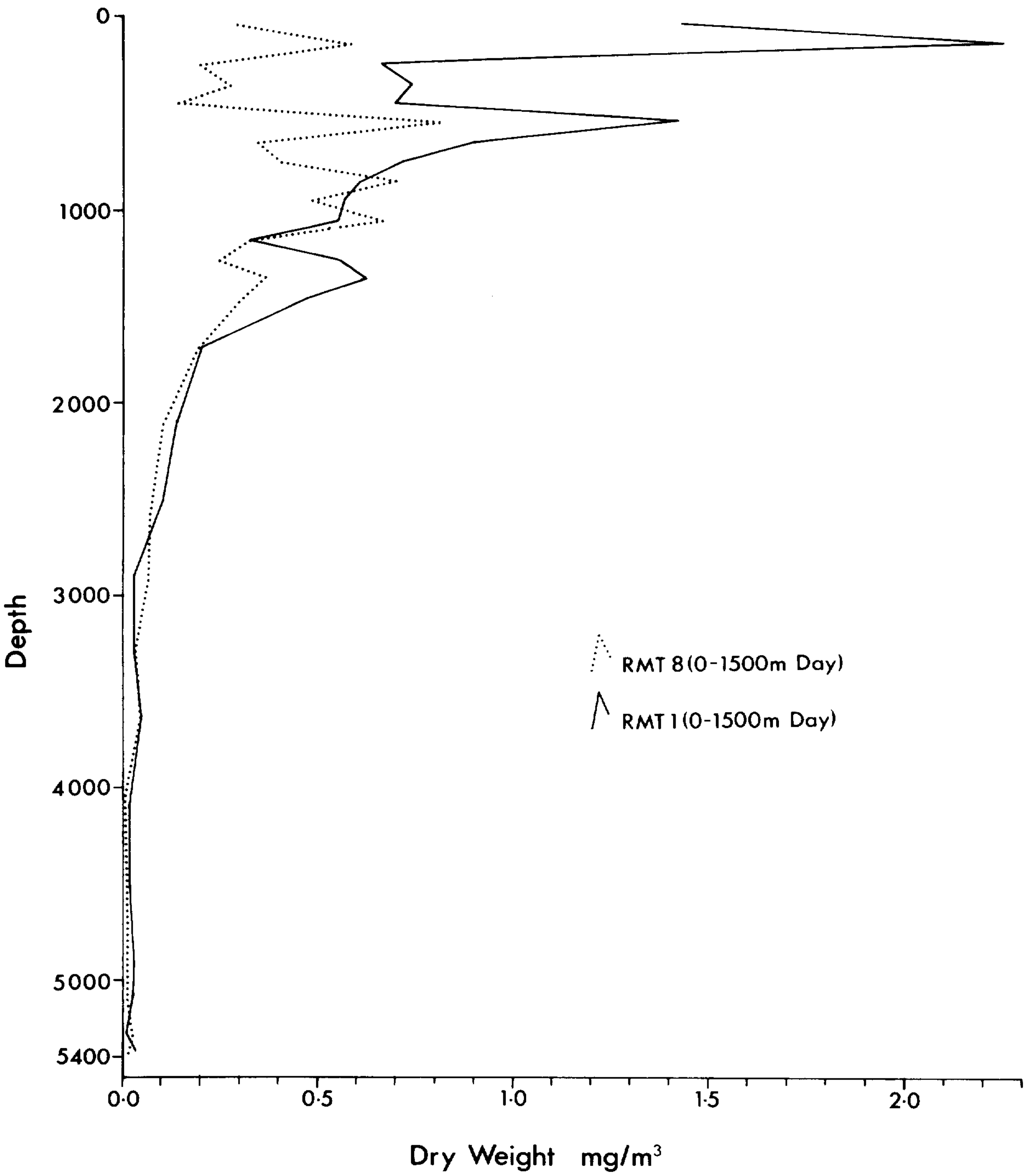

Fig. 14. Dry weight/depth for plankton (0.32-4.5mm) and micronekton (>4.5mm). Above 1500m the day data are used.

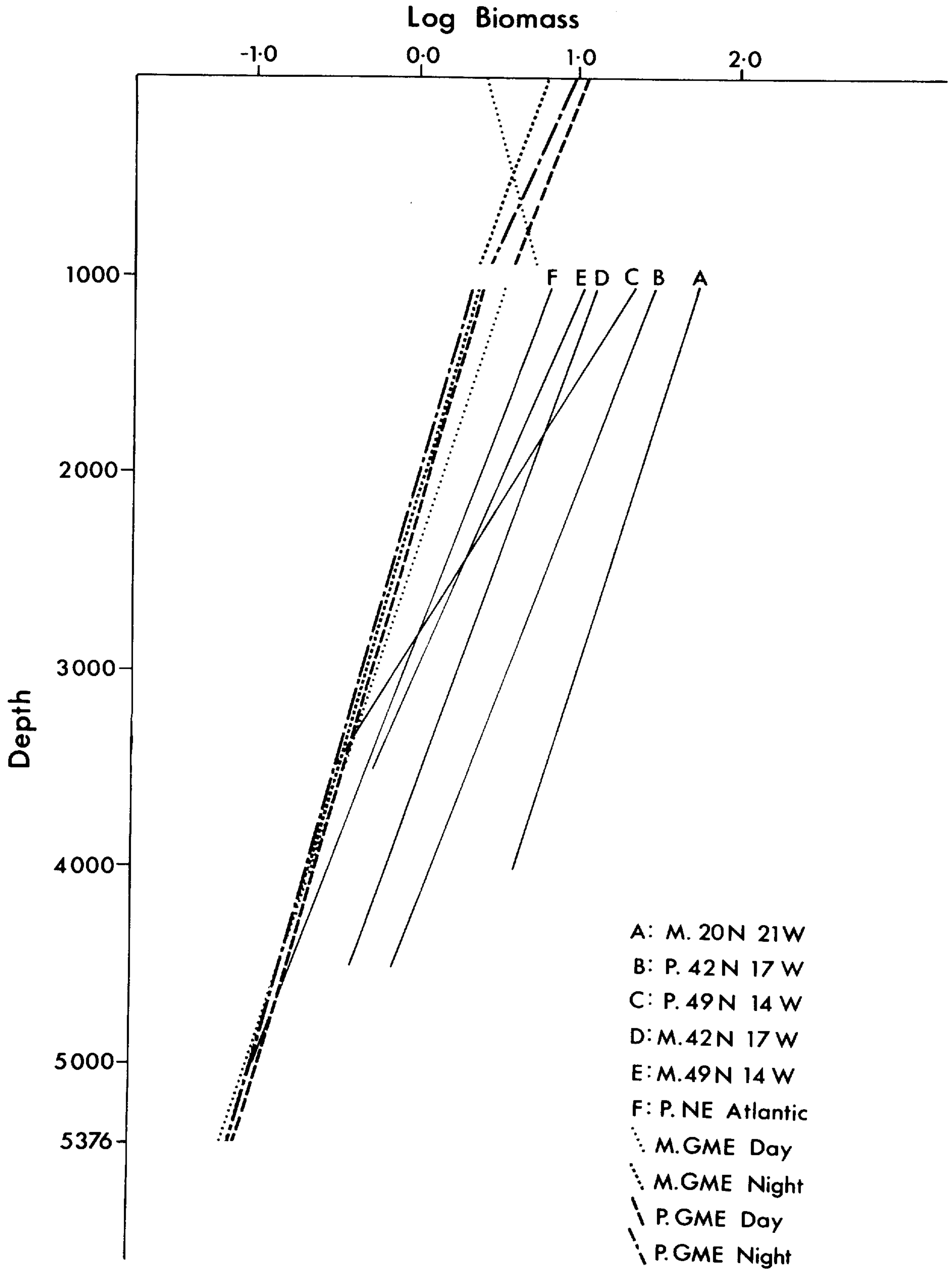

Fig. 15. Regression lines for biomass profiles at GME and elsewhere in the Atlantic (see Table 8). P = plankton; M = micronekton. Separate regressions have been calculated for GME data above and below 1000m.

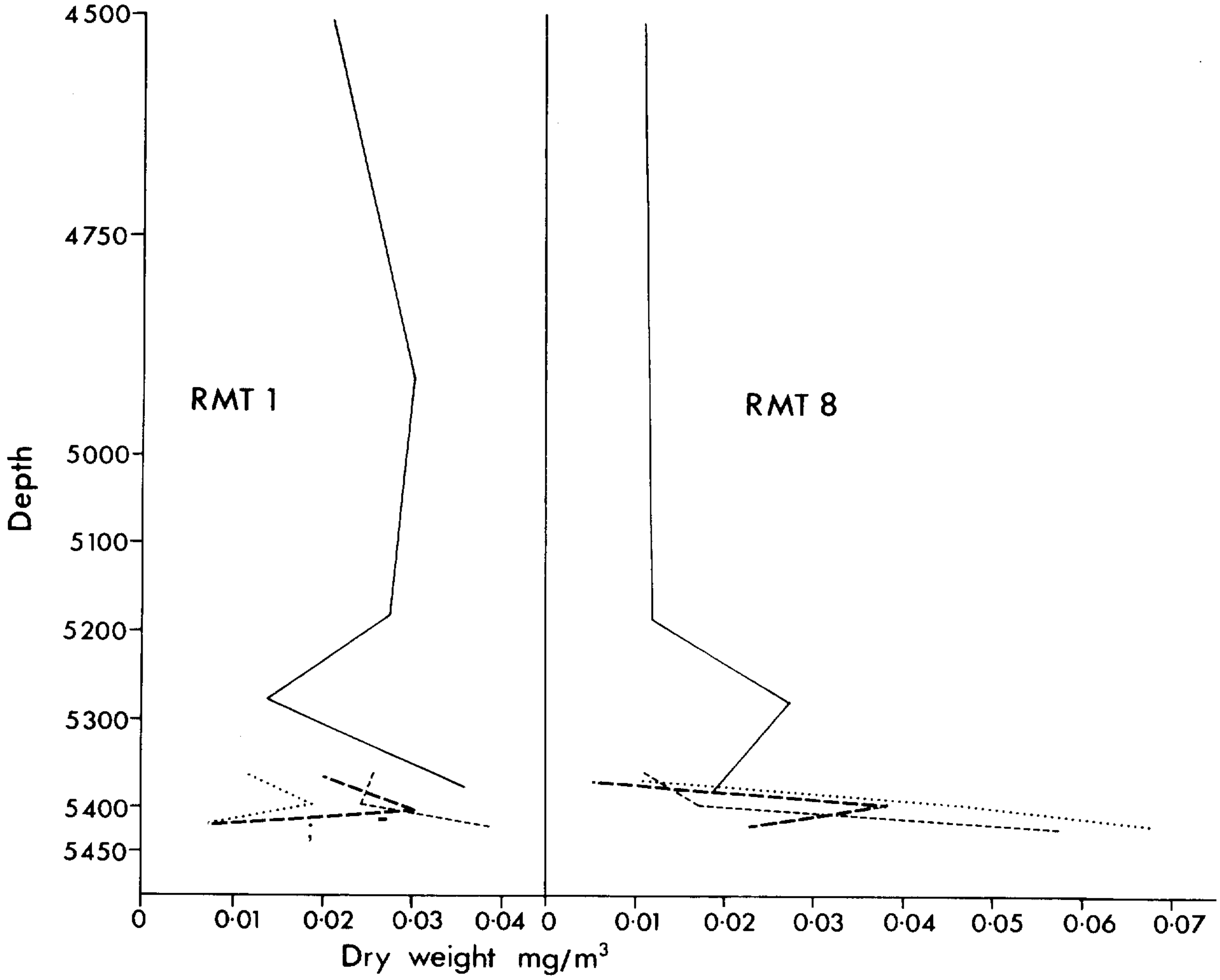

Fig. 16. Dry weight/depth for near-bottom plankton (RMT 1) and micronekton (RMT 8). In each case the solid line represents data from the water column hauls, and the three hatched lines are data from each of the three hauls made between 10 and 90m above the bottom.