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GEOGRAPHIC AND VERTICAL DISTRIBUTION OF EUPHAUSIID SPECIES IN THE WARM WATERS OF THE NORTH ATLANTIC*

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ABSTRACT

The vertical and geographic distributions of euphausiid species are described for 6 stations spaced at intervals of 10° latitude between 11° N and 60° N, 20°-25°W ; and 5 stations in the vicinity of the Azores front at 30°-35°N, 30°-34°W. The data suggest that spatial patterns in species distribution occur, some species having a much wider distribution than others. Factors which may affect species distribution are discussed including the influence of the hydrograpnic regime.

INTRODUCTION

THE GEOGRAPHIC and vertical distribution of euphausiids in the Atlantic Ocean were described by various authors including Hansen (1905 a, b), Ruud (1936), Einarsson (1945), Baker (1970). Following the development of opening/closing net systems, the Institute of Oceanographic Sciences Deacon Laboratory has undertaken an extensive midwater sampling program which has provided data on the geographic distributions of various taxa including euphausiids. Some of these data were published previously (James, 1973, 1983, 1987 a ; Hargreaves, 1984), but due to the large amounts of information, were not fully summarised ; others are unpublished including those obtained in the vicinity of the Azores front. In this account a summary is given of the geographic and vertical distribution of euphausiid species with emphasis on distribution in the tropical and subtropical Atlantic.

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MATERIAL AND METHODS

During the early to late 1970, specimens were taken with a Rectangular Midwater Trawl (RMT1+8) consisting of two nets, RMT1 and RMT 8 combined within the same framework. The RMT 1 net is nominally of 1 m^2 mouth area, mesh size 0.32 mm and is designed to sample macroplankton ; the RMT 8, nominal mouth area 8 m^2, mesh size 4.5 mm, is designed to sample micronekton (Baker, *et al.*, 1973). The nets are opened and closed acoustically using a net monitor which activates the release gear. Information on the depth of the net, its speed and distance travelled and water temperature is telemetered back to the ship.

During the 1969 cruise (11°N) a TMT net was deployed which approximated to the RMT 8. During the mid 1970s a multiple version of the net system (RMT 1+8 m) was developed (Roe and Shale, 1979; Roe *et al.*, 1980) and has been used successfully since 1978. Three pairs of RMT 1+8 are deployed within the same framework and can be operated in sequence at the required depth.

Generally nets were fished for 1 hour at 100 m depth intervals down to 900-1000 m and for 1 or 2 hours at greater depth intervals below this. The sampling regime ensured that the total water column was sampled although the surface 10 m will have been undersampled because of the ship's wake.

During 1969-1972, at various times of the year, a series of vertically dicrete day and night hauls were taken at 6 widely separated positions roughly at 10° intervals of latitude between 11°N and 60°N and close to the 20°—25°W

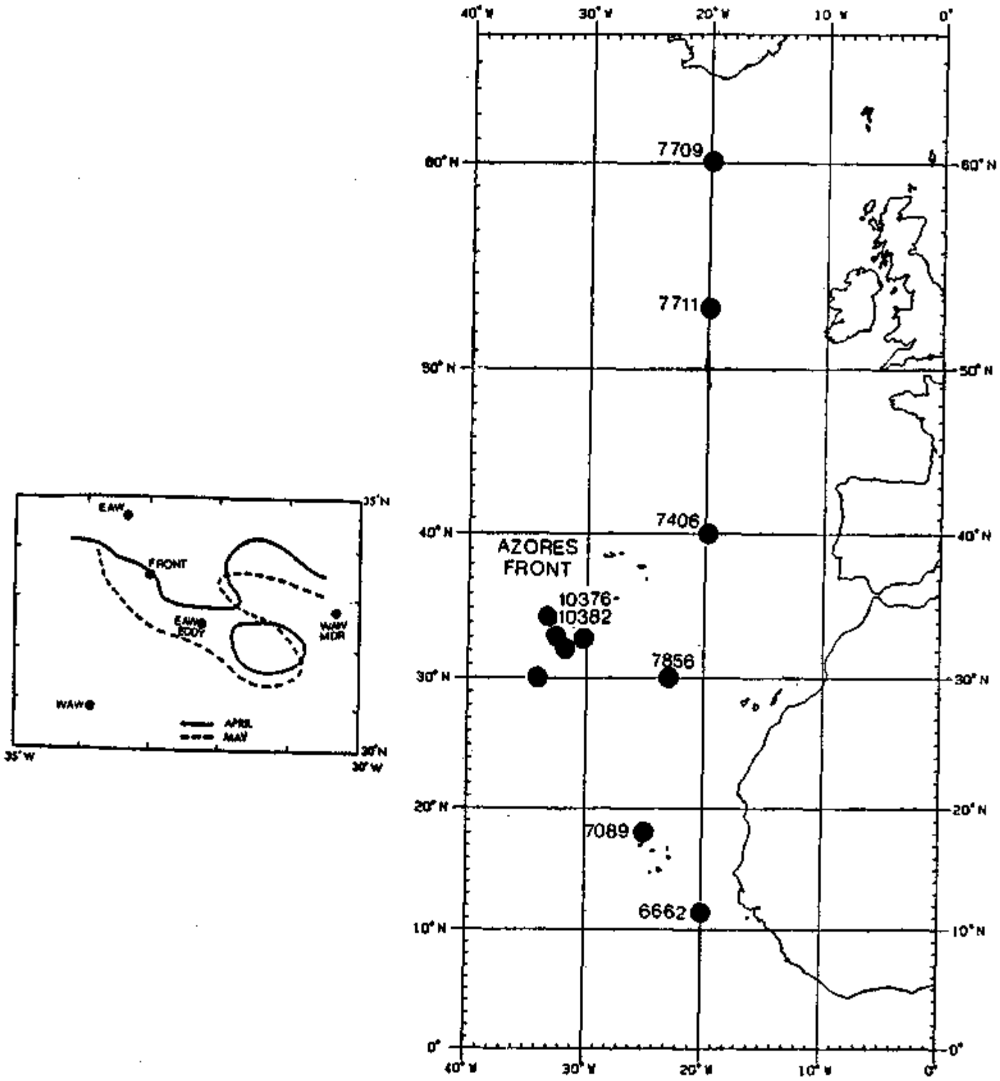

FIG. 1. Station positions: six stations close to the 20°—25° W meridians; five stations in the vicinity of the Azores front. Also shown are the positions of stations relative to the Azores front during spring 1981 as defined by the location of the 16°C isotherm at 200 m.

TABLE 1. *Depth of maximum abundance and maximum numbers in any one RMT 8 haul for species which occurred between 11°N and 60°N close to the 20°—25°W meridians. The sepcies are grouped depending on geographic range.* D=day, N=night

Species	11°N		18° N		30°N		40°N	
	Depth (m) of max. abundance	Max. No./ $10^4 m^3$ in any haul	Depth (m) of max. abundance	Max. No./ $10^4 m^3$ in any haul	Depth (m) of max. abundance	Max. No./ $10^4 m^3$ in any haul	Depth (m) of max. abundance	Max. No./ $10^4 m^3$ in any haul
Group 1								
Euphausia hanseni	110—205D	1.5	—	—	—	—	—	—
	810—890N	0.6	—	—	—	—	—	—
E. mutica	210—290D	13.4	—	—	—	—	—	—
	0—100N	9.4	700—785N	0.2	—	—	—	—
Thysanopoda orientalis	405—500D	0.2	410—500D	5.3	—	—	—	—
	205—300N	1.3	300—400N	5.0	—	—	—	—
E. pseudogibba	405—500D	2.3	410—500D	65.7	—	—	—	—
	0—100N	16.7	49—100N	43.8	—	—	—	—
Group 2								
E. americana	320—410D	2.1	305—400D	14.1	—	—	—	—
	0—100N	4.7	10—25N	4000.8	10— 25N	0.3	—	—
Th. monacantha	405—500D	6.4	20—50D	17.1	500—600D	0.3	—	—
	0—100N	9.3	49—100N	43.8	—	—	—	—
E. tenera	320—695D	0.3	210—290D	17.6	405—505D	0.6	—	—
	320—415N	0.4	10—25N	264.0	10— 25N	2.3	—	—
E. gibboides	210—290D	22.8	210—290D	39.7	205—300D	36.7	—	—
	10—100N	3395.8	49—100N	28.4	50—100N	102.9	—	—
Th. tricuspidata	320—410D	29.8	305—400D	21.1	—	—	—	—
	0—100N	4.7	10—25N	206.1	50—100N	0.3	—	—
Stylocheiron carinatum	*		55—100D	114.7	55—100D	3.1	—	—
			10—100N	433.0	25— 50N	5.2	—	—
S. affine	*		110—200D	13.4	102—203D	18.3	—	—
			49—100N	14.2	100—200N	43.9	—	—
S. suhmii	*		50—100D	21.9	55—100D	4.6	—	—
			49—100N	75.8	50—100N	13.4	—	—
Group 3								
Nematobrachion sexspinosus	—	—	—	—	305—400D	0.6	—	—
	—	—	210—300N	1.2	100—200N	10.6	—	—

Group 4								
S. robustum	—	—	305—400D	3.3	500—600D	0.3		
	—	—	110—200N	6.5	300—400N	0.2		
Th. aequalis	—	—	410—600D	34.0	405—505D	45.7	502—610D	1.4
	—	—	49—100N	115.5	25—100N	96.5	52—100N	0.9
Th. obtusifrons	—	—	515—600D	1.9	500—600D	39.9	710—800D	0.9
	—	—	110—200N	0.8	100—200N	18.8	52—100N	0.9
E. brevis	—	—	*		305—400D	230.5	310—400D	0.7
	—	—			10— 25N	2007.4	10— 27N	34.3
T. parva	—	—	800—890D	0.3	—	—	410—500D	0.1
	—	—	610—700N	0.6	900—1000N	0.2	990—1250N	0.9
Group 5								
T. gregaria	*		410—500D	0.3	305—400D	1.1	410—500D	0.1
	*		110—200N	3.7	205—300N	20.2	—	—
E. hemigibba	*		410—500D	20.2	405—505D	472.8	410—500D	5.1
			49—100N	110.2	25—50N	1329.9	10—27N	23.7
Th. cristata	—	—	110—200D	0.8	102—203D	1.3	—	—
	205—300N	0.1	110—200N	1.5	100—200N	1.5	210—300N	0.1
Th. pectinata	—	—	515—600D	0.6	102—203D	1.3	550—655D	0.2
	320—415N	0.2	110—200N	1.6	205—300N	0.4	210—300N	0.1
Nematoscelis tenella	405—500D	5.4	410—500D	24.1	500—600D	20.1	502—610D	1.7
	100—200N	5.3	49—100N	18.9	405—500N	6.7	400—500N	0.8
N. microps	405—500D	23.1	410—500D	41.0	405—505D	184.2	500—600D	2.3
	0—100N	20.2	110—200N	50.3	100—200N	223.3	52—100N	2.6
N. atlantica	320—500D	54.0	410—500D	223.8	500—600D	19.3	410—500D	4.7
	320—415N	37.9	110—200N	106.5	100—200N	18.4	52—100N	4.5
Ne. flexipes	210—290D	4.4	305—400D	13.3	205—300D	26.6	310—400D	0.7
	320—415N	1.9	110—200N	5.3	100—200N	90.0	52—100N	11.4
S. abbreviatum	110—205D	23.0	110—200D	62.1	205—300D	12.5	50—100D	5.7
	100—200N	72.8	110—200N	53.9	100—200N	25.3	52—100N	1.7

* Species recorded in the RMT 1 in low numbers, but not in the RMT 8.

TABLE 1 *contd.*

Species	11°N		18°N		30°N		40°N		53°N		60°N	
	Depth (m) of max. abundance	Max. No./ 10^4m^3 in any haul	Depth (m) of max. abundance	Max. No./ 10^4m^3 in any haul	Depth (m) of max. abundance	Max. No./ 10^4m^3 in any haul	Depth (m) of max. abundance	Max. No./ 10^4m^3 in any haul	Depth (m) of max. abundance	Max. No./ 10^4m^3 in any haul	Depth (m) of max. abundance	Max. No./ 10^4m^3 in any haul
Group 6												
S. longicorne	110—205D	0.2	210—290D	23.9	102—203D	34.7	50—100D	49.3	700—800D	0.1	—	—
	110—205N	0.9	210—300N	107.6	205—300N	64.5	110—195N	20.8	100—200N	0.7	—	—
S. elongatum	210—290D	0.2	210—290D	45.3	205—300D	30.3	310—400D	0.7	205—300D	0.6	1525—2000D	0.1
	325—415N	0.5	110—200N	22.9	205—300N	98.3	310—400N	7.9	100—200N	0.3	—	—
Group 7												
S. maximum	510—590D	6.3	305—400D	7.6	205—300D	1.2	310—400D	11.2	205—300D	4.6	310—400D	0.7
	320—415N	8.0	210—400N	18.9	300—400N	6.7	210—300N	29.6	200—300N	3.1	205—300N	1.2
Th. microphthalma	405—500D	12.0	515—600D	0.9	405—505D	14.0	650—745D	16.4	300—400D	1.6	310—3400D	0.6
	320—415N	12.4	300—400N	1.4	405—500N	11.4	110—195N	6.1	200—300N	0.3	300—400N	0.3
Bentheuphausia amblyops	900—1040D	3.8	910—1020D	2.0	910—1000D	3.5	805—900N	2.8	900—1000D	1.4	1250—1500D	0.9
	1000—1250N	1.7	1000—1200N	2.9	800—895N	2.1	910—1000	5.7	1020—1250N	1.4	1250—1500N	1.7
Ne. boopis	320—410D	5.7	410—500D	6.6	500—600D	15.1	500—610D	82.8	300—400D	23.4	300—500D	19.1
	320—415N	13.2	300—400N	4.6	405—500N	22.9	400—500N	83.3	310—400N	12.4	300—400N	11.5
Group 8												
Meganyctiphanes norvegica	—	—	—	—	500—600D	0.3	310—400D	0.4	300—400D	0.2	500—600D	3.3
	—	—	—	—	—	—	52—100N	191.8	50—100N	2.0	9—25N	756.3
E. krohnii	—	—	—	—	*		310—400D	470.4	205—300D	50.2	310—400D	2.2
	—	—	—	—			10—27N	460.1	200—300N	15.5	25—50N	2.0
N. megalops	—	—	—	—	—	—	650—700D	385.1	200—300D	13.1	410—500D	2.4
	—	—	—	—	—	—	610—700N	62.0	100—200N	28.9	55—100N	9.0
T. longicaudata	—	—	—	—	—	—	805—900D	1.3	300—400D	0.6	10—25D	269.8
	—	—	—	—	—	—	900—1000N	0.6	10—100N	3.3	9—25N	1393.2
Thysopoda acutifrons	—	—	—	—	—	—	1460—2000D	0.2	500—600D	7.8	910—995D	15.0
	—	—	—	—	—	—	1260—1500N	0.1	900—1000N	6.9	900—1000N	17.1

meridians. At each position the samples were taken from the surface to a maximum of 2000 or 2500 m with the exception of the series at 18°N where the maximum was 1250 m. Full details of the sampling are given in cruise reports (David, 1970 ; Foxton 1971).

During May/June 1981 several vertical series of horizontal hauls were taken between 30°N and 35°N, 30°W and 34°W to examine the distributions of taxa associated with a permanent front southwest of the Azores in which there is separation of East Atlantic Water (EAW) from West Atlantic Water (WAW) (Gould, 1985 ; Fasham *et al.*, 1985). It is thought that this front extends eastwards to join the Canaries Current and is an integral part of the North Atlantic Gyre (Kase and Seidler, 1982). EAW is typified by a 16°C isotherm depth of <150 m while the WAW 16°C isotherm depth is >300 m. Fasham *et al.*, (1985) reported that WAW was generally poorer in nutrients and had approximately 50-60% of the deep chlorophyll levels of EAW. There was no evidence for higher productivity immediately at the front. 5 stations were worked, 1 in WAW, 1 in a WAW meander, 1 at the front, 1 in EAW and 1 in an EAW eddy. At each station a day and night series of hauls were fished over 100 m depth horizons to at least 1200 m depth.

Temperature and salinity data were obtained at all stations throughout the water column by means of temperature/salinity/depth recorders or conductivity/temperature/depth recorders.

Specimens were identified using taxonomic characters given by Boden *et al.* (1955). The RMT 8 net samples all species of euphausiid, but specimens < 15 mm length are likely to pass through the net. The RMT 1 although of small mouth size is used for sampling smaller specimens (<15 mm). The result presented here is based mainly on RMT 8 net data but, where appropriate, RMT 1 net data will be given. No attempt has been made to evaluate contaminants entering the net while it is closed either through the mouth or, in the case of very small specimens, through the meshes of the net. Some of the distributions have 'tails' extending deeper into the water column than the bulk of the population. These 'tails' are considered to be real although they may include an element of artifact caused by contamination.

RESULTS

Results 11°—60°N, 20°—25°W

Biomass and numerical abundance : The biomass profiles of total euphausiids measured by wet displacement volume (RMT 8) are given in Fig. 2. Daytime maxima occurred at 300—400 m (11°N), 400—500 m (18°N), 400—600 m (30°N), 300—700 m (40°N), 200—300 m (53°N), surface 50 m (60°N). By night after diel migration had taken place the depth of the biomass maxima generally decreased by 10—200 m except at 53°N where the biomass was relatively low, (this coincided with the occurrence of large quantities of salps in the top 600 m of the water column). At all latitudes at depths below 700—800 m there was a decrease in biomass with increasing depth ; below 1200 m values hardly exceeded 1 ml per 10^4m^3 water filtered. Profiles for numerical abundance were similar to those for biomass. There were noticeable maxima by night in the surface 50 or 100 m at 11°N, 18°N, 30°N and 60°N sometimes as a result of swarming. Below 1000 m abundances rarely exceeded 10 specimens per 10^4m^3. The most frequently recorded species between 11°N and 60°N together with maximum numbers and the depths at which they occurred are given in Table 1 ; several rare species *e.g. Thysanopoda cornuta* and *Thysanopoda egregia* are excluded. For clarity species are grouped depending on their geographic range as recorded mainly by the RMT 8 net. Group 1 : South of 18°N (4 species), group 2 ; 11°—30° N(8 species), group 3 : 18°—30°N (1 species), group 4 : 18°—40°N (5 species), group 5 : 11°—40°N (9 species), Group 6 : 11°—53°N (rare at 60°N) (2 species), group 7 :11°—60°N (4 species), group 8 : mainly 40°—60°N (5 species) (Fig. 3).

ubiquitous and of these one was *Bentheuphausia amblyops* which is a bathypelagic species. The greatest change in species composition occurred between 40°N and 53°N. Of 25 species recorded at 40°N (Table 1). only 11 extended their range to 53°N and 5 of

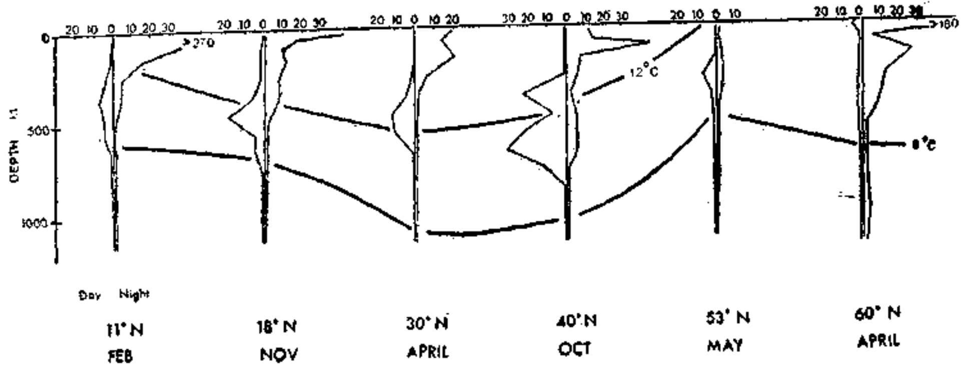

FIG. 2. Euphausiid biomass profiles (ml. displacement volume, per $10^4 m^3$ water filtered) recorded at six stations close to 20°—25° W (RMT 8). Superimposed are the 8°C and 12°C isotherms.

For 11°—30°N a total of 27 to 30 species are listed (Table 1), compared with only 10 to 11 species at 53°—60°N. Only 5 species were

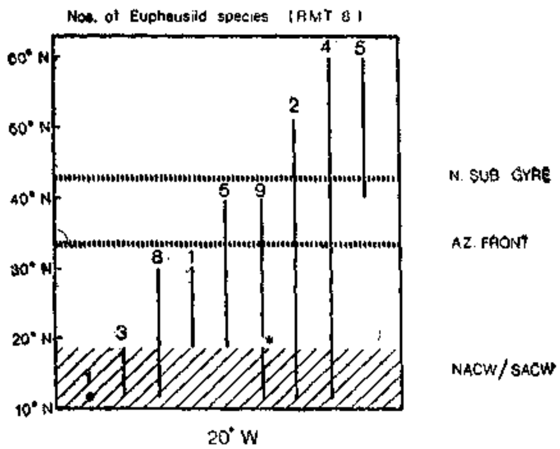

FIG. 3. Numbers of euphausiid species throughout the water column recorded at 11°—60°N, 20°—25° W (RMT 8). Also shown are the positions of the northern boundary of the subtropical gyre, the Azores front and the transition zone between North Atlantic Central water (NACW) and South Atlantic Central Water (SACW), * represents an area where there is morphological variation within three species.

these are known from previous data to have a wide geographic range. There were also, changes in species composition between 30°N and 40°N. Of 30 species identified from 30°N only 21 were found at 40°N. Similarly, of the 32 species identified from 18°N, 6 were not found to the south at 11°N. The geographic range and numbers of species are given in Fig. 3.

There was sexual dimorphism in *Nematoscelis atlantica*. *Nematoscelis tenella* and *Nematoscelis microps* based on saddle shaped thickenings of chitin on the abdominal segments of the males. These species were recorded mainly between 11°N and 30°N, but were sparse at 40°N. The geographic distribution of these different forms were described by James (1973) and are given in Fig. 4 (for clarity RMT 1 data are given). At 11°N males of *N. microps* form 1/2, *N. tenella* form 3/4 and *N. atlantica* form 1, 2/2, 3 were recorded. At 30° N these forms were replaced by *N. microps* form 0/0, *N. tenella* form 1, 2/2, 3 and by *N. atlantica* form 3/4.

At 18°N both forms of *N. microps* and *N. atlantica* occurred, but only one form of *N. tenella* (3/4), although both forms of the latter were recorded previously as far as 28°N (James, 1973).

The widely distributed species were sometimes the most numerically dominant within a given haul; in other instances species recorded within a relatively narrow geographic range were numerically dominant. Numbers of

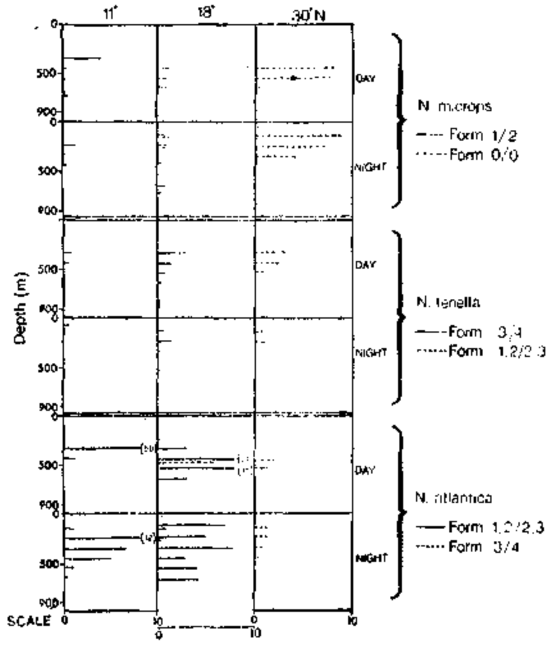

FIG. 4. Numbers per $10^4 m^3$ water filtered of males of *Nematoscelis microps*, *Nematoscelis tenella*, *Nematoscelis atlantica* at 11°—30° N (RMT 1).

dominant species, expressed as percentage of the total number of specimens in each haul are shown in Fig. 5. (11°—30°N) and Fig. 6. (40°—60°N). For clarity only those species contributing >20% in each haul are given. In some instances there was no single dominant species in a haul, but instead a relatively large number of species were recorded each contributing much less than 20% to the total numbers. In other instances the catch was dominated by large numbers of immature specimens which were identifiable to genus, but not to species, for clarity these are not shown.

Generally between 11°N and 60°N there was a change in the pattern of numerically dominant species. At 11°N these included *Euphausia gibboides*, *Stylocheiron abbreviatum*, *N. atlantica* and *N. microps*. At 18°N *N. atlantica* became increasingly dominant, there was little change in the percentage contribution of *S. abbreviatum* and *N. microps*, but that of *E. gibboi es* and *Stylocheiron maximum* diminished while that of *Stylocheiron carinatum* increased. At 30°N dominant species varied throughout the depth range and included *N. microps*, *Euphausia hemigibba* and *Thysanopoda aequalis*.

At 40°N *Stylocheiron longicorne*, *Euphausia krohnii*, *Nematobrachion boopis* and *Nematoscelis megalops* were dominant. At 53°N *N. boopis* and *E. krohnii* continued to be dominant, but in hauls below 400 m *N. megalops* tended to be replaced by *Thysanopoda acutifrons*. At 60°N *T. acutifons* and *N. boopis* continued as dominant species by day below 300 m while above 300 m *Thysanoessa longicaudata* was numerically important. Temperature data for the 20°-25°W transect are given in Fig. 7.

Some preliminary results from several factor analyses based on the occurrence of non-rare species confirm that there are changes in species assemblages between 11°-18°N, 18°-30°N, 30°-40°N and 40°-53° N at depths of 500-1000 m. However there appeared to be fewer changes in species assemblage from 11°-30°N at depths of 200-400 m.

Azores front stations: At the five stations across the Azores front the euphausiids were a relatively important component of the micronekton. Peaks in biomass profiles (wet displacement volume) occurred at 400-500 m and 700—800 m (day) and at 100—200 m (night) except at the station in the WAW

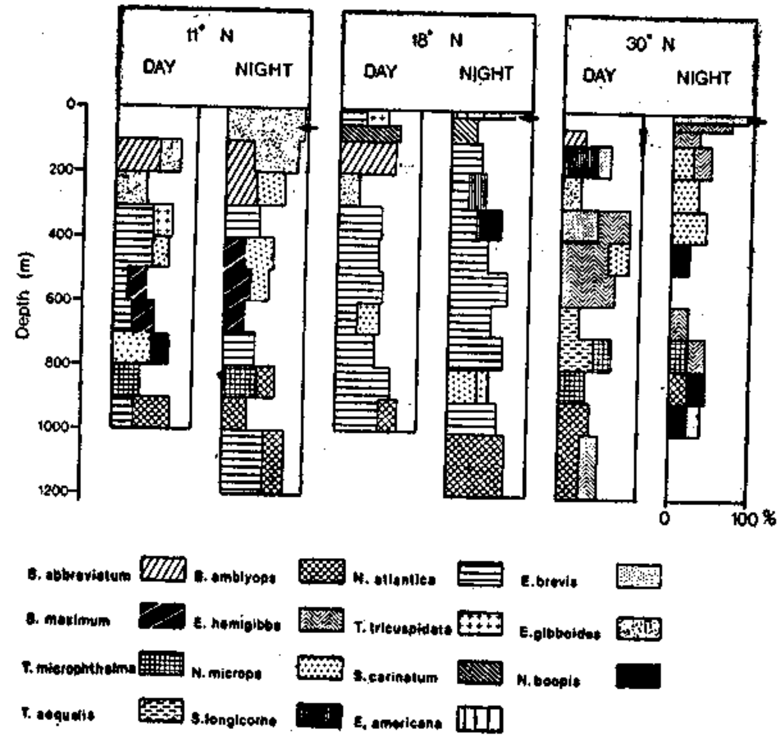

FIG. 5. Numerically dominant species expressed as percentage of the total number of specimens in each haul at 11°—30°N (RMT 8). Only values>20% are shown. (Arrows indicate swarms)

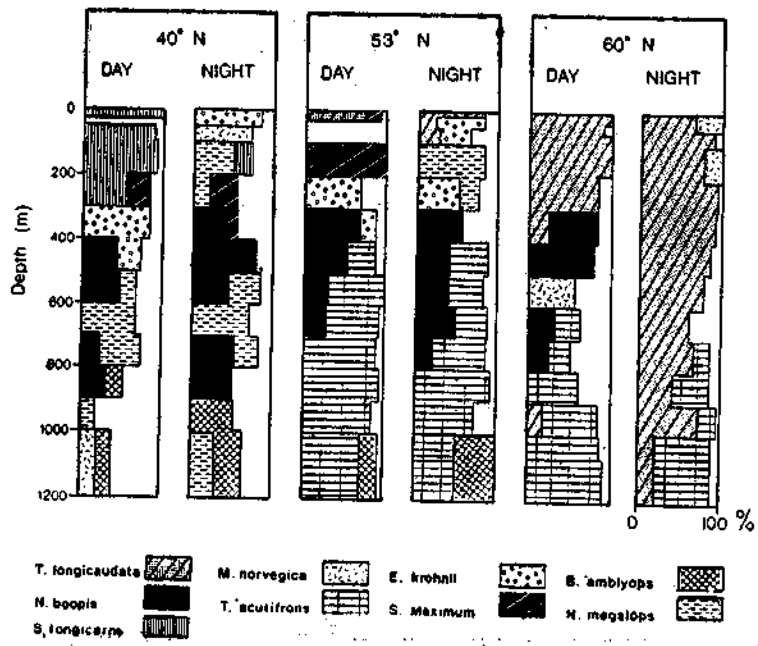

FIG. 6. Numerically dominant species expressed as percentage of the total number of specimens in each haul at 40°—60° N (RMT 8).

meander; abundances were highest at the front and EAW stations and lowest in WAW. A diagram showing biomass at each station together with the position of the 8°C and 16°C isotherms is given in Fig. 8. At all except the WAW station average biomass values throughout the top 1000 m of the water column were 2.7-5.2 ml per $10^4 m^3$ water filtered (day/night). In WAW biomass was lower with values of 1.5-2.5 ml per $10^4 m^3$.

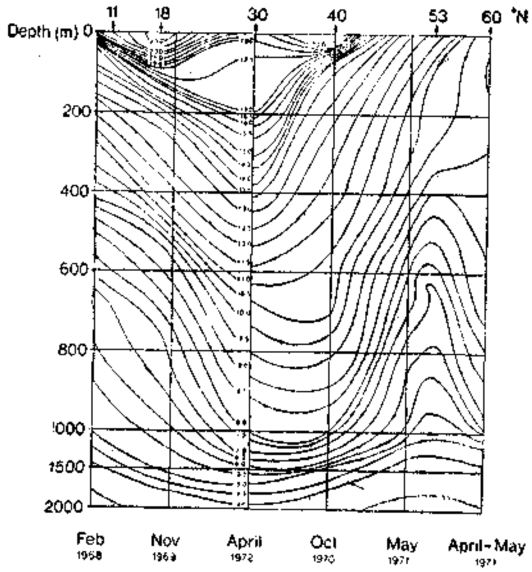

Fig. 7. Temperature data (°C) at six stations close to the 20—25° W meridians.

With few exceptions species occurrence and distribution was similar at all five stations (max. of 32 species identified) except that *Thysanopoda tricuspidata* was abundant in WAW reaching values >30 specimens per $10^4 m^3$ in the surface 100 m, but this species was either sparse or not recorded at the other stations in the vicinity of the Azores front. In contrast *Thysanoessa parva* and *T. gregaria* were abundant at all stations except in WAW where numbers were moderate. Most specimens of *Thysanoessa* were immature and difficult to identify with

Table 2. *Rank order of* 12 *numerically dominant species at stations in the vicinity of the Azores front* (*RMT* 8)

	WAW	WAW MDR	Front	EAW EDDY	EAW
T. parva/gregaria	10	2	1	1	1
E. hemigibba ..	1	8	2	3	5
N. microps 0, 0	5	3	3	4	6
N. atlantica 3/4 ..	7	7	4	9	3
S. abbreviatum ..	4	1	5	5	2
T. obtusifrons ..	3	5	6	6	7
N. tenella 1, 2/2, 3	6	4	7	8	9
T. aequalis ..	2	9	8	7	10
E. brevis ..	8	6	9	2	4
S. elongatum ..	12	10	10	10	15
S. robustum	21	19	11	15	19
N. flexipes ..	16	17	12	14	13
Total No. species	28	27	32	28	13

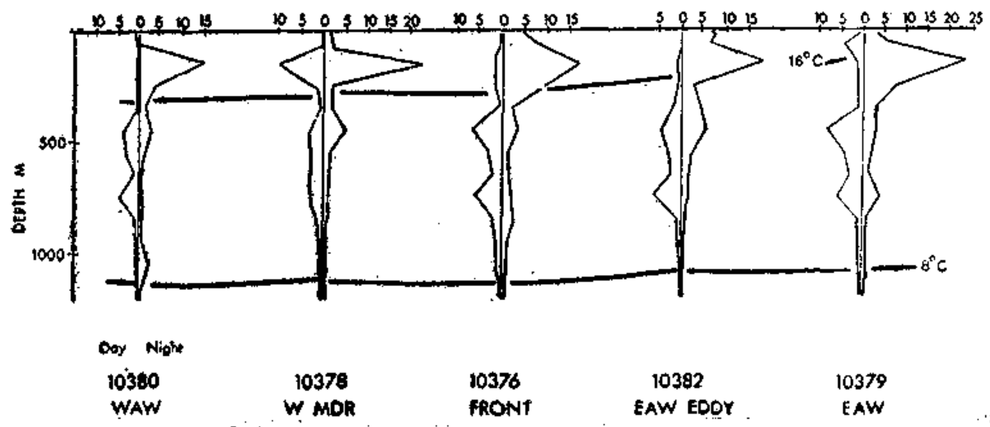

Fig. 8. Biomass profiles (ml.) per $10^4 m^3$ water filtered at five stations close to the Azores front (RMT 8). Superimposed are the 8°C and 16°C isotherms.

certainty, but it is thought that those in the surface 300-400 m were *T. gregaria* while those in deeper water were *T. parva*.

The rank order of twelve numerically dominant species in the vicinity of the front is given in Table 2. The percentage contribution of dominant species to the total number of specimens in each haul is given in Fig. 9 (for clarity only values >15% are shown). Maximum numbers of specimens coincided with peaks in biomass. Most of the euphausiid species recorded at the Azores front were found also at 30°N, 23°W. At the Azores front station (10376) the numerically dominant species included *S. abbreviatum*, *E. brevis*, *N. microps*, *N. atlantica*, *E. hemigibba* and *Thysanoessa parva* and *T. gregaria*). However at 30°N *N. atlantica* and *Thysanoessa* spp. were not numerically important.

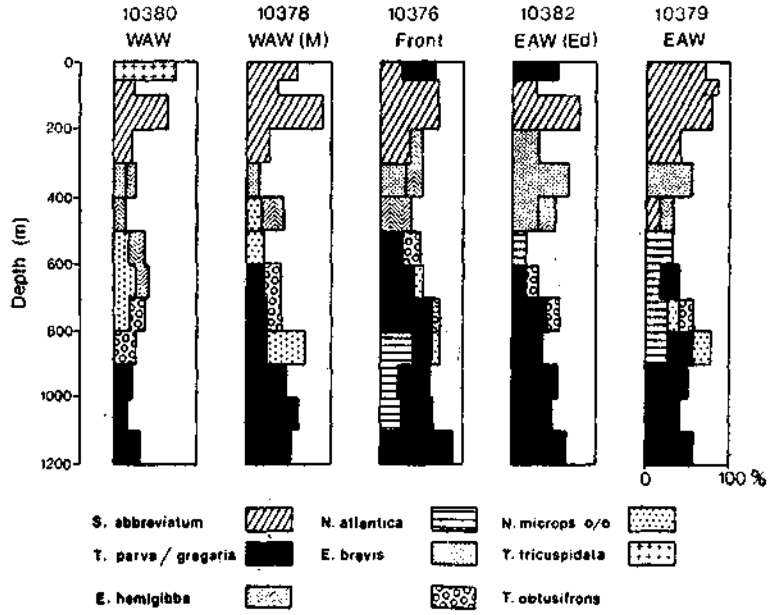

FIG. 9. Numerically dominant species expressed as percentage of the total number of specimens in each haul at five stations close to the Azores front. Only values >15% are shown (day data).

DISCUSSION

It is clear that the greatest diversity of euphausiid species occurred at the more southernly stations within the sampling area while there was a decline in numbers of species towards the north which may be associated with increased expressions of seasonality. Pugh (1986), investigating the distribution of Siphonophora at the same stations along 20°W, also found that numbers of siphonophora species tended to decrease towards north.

The distribution of each species over a wide geographic range could not be linked with given isotherm depths. However, as James (1983) has discussed, the geographic distribution of mature euphausiids may depend on the distribution of their larval forms and the latter may be less able to tolerate wide ranges in temperature. Further data obtained during various seasons are needed to investigate this aspect.

Various authors including Fasham and Angel (1975), Angel and Fasham (1975), Fasham and Foxton (1979) investigating the distribution of micronekton and macroplankton have shown that in the Atlantic faunal zones based on species assemblages may be correlated with the hydrographic regime including oceanic circulation. From the present data it may be inferred that species vary in geographic distribution, some having a much wider range than others and that there may be some association between species assemblages and the occurrence of the three biogeographic boundaries as indicated in Fig. 3.

To the south of approximately 18°N is a zone where mixing of North Atlantic Central Water (NACW) and South Atlantic Central Water (SACW) occurs (Sverdrup *et al.*, 1942), which may be associated with the boundary between Atlantic tropical and N. Atlantic subtropical regions (Backus *et al.*, 1977). Also shown, at 34°N is the boundary represented by the Azores front. A further front is shown to the north of 40°N which coincides with the northern boundary of the subtropical gyre. The change in species assemblage between 40° and 53°N may be associated with this boundary and confirms previous data including that of Fasham and Foxton (1979) who considered that the northern boundary of the gyre represented a faunal boundary. There is also evidence that species assemblages for euphausiids previously sampled at 44°N 13°W were similar to those from 53°N 20°W (northern species) and there was less similarity with species assemblages at 40°N 20°W (Roe *et al.*, 1984).

At 18°N during February 1968 the mixed NACW/SACW seemed to represent an important boundary to some euphausiid species. There was considerable variation in the geographic range of species recorded there; some seemed to have a very narrow range, others extended to 30°N and others were found as far north as 40°N. Fasham and Angel (1975) investigating ostracod distribution based on the same hauls along 20°-25°W point out that at 18°N there was probably a mixture of northern and southern faunas at mesopelagic depths. Indeed there is some evidence from data on *N. microps, N. atlantica* and *N. tenella* that some mixing of morphologically different types usually present to the north or south of 18°N occurs there. Backus *et al.* (1965) also found that a faunal boundary existed at approximately 18°N and Foxton (1972) found that at 18°N some northern species of *Acanthephyra* were replaced by southern species. Johnson (1986) recorded distinct morphological 'types' in one species of fish recorded close to 20°N, 20°W. Mackie *et al.* (1987) investigating the geographic distributions of the Siphonophora in the Northeast Atlantic found that there was relatively little change in species assemblage between 18°N and 30°N, but there was a discontinuity at depths of 300-500 m between 11°N and 18°N.

At most stations across the Azores species occurrence was similar to that recorded at 30°N, 23°W. Further, most of the dominant species recorded at the Azores front were those known, from the previous sampling, to inhabit a relatively wide geographic range. Clearly *Thysanoessa parva* and *T. gregaria* were more abundant in the vicinity of the front; this confirms previous data, Brinton (1962), James (1987 b), which showed that *Thysanoessa parva* tended to be associated with fronts and also with Mediterranean Water. The similarity in species composition between WAW and the EAW stations suggests that the Azores front forms a relatively weak zoogeographic boundary to species. Domanski (1985) investigating crustacean decapod species from the hauls described also found that, with few exceptions, there were similarities in decapod species assemblages between EAW and WAW in the vicinity of the front. Various authors including Angel (1979) have reported changes in species dominance, but little change in species composition from east to west in the vicinity of the mid-Atlantic Ridge close to 30°N, an area which may be influenced by the Azores front. James (1983) investigating the distribution of euphausiids in a series of oblique hauls at 32°N, 16°—60°W concluded that a weak front existed in the vicinity of 27°—34°W which formed a boundary between EAW to the east and Sargasso Sea Water to the west. It is possible that this front was an extension of the Azores frontal system. It is clear from these data that the Azores front represents a weak barrier to some euphausiid species, but does not fully explain difference in species assemblages between 30° and 40° N.

From the data it may be inferred that the distribution of some euphausiid species may be correlated with oceanic circulation and with frontal systems while that of other euphausiid species seem to be unaffected. The factors which cause these different patterns are not evident. It seems unlikely that the rather subtle abiotic changes are sufficient in themselves to limit the spread of pelagic species except possibly at the boundary of warm and cold water systems. There must also be other factors which affect species distribution such as food supply or predation patterns. Further data, obtained during various seasons need to be obtained to investigate the effects of water mass boundaries.

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