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Research Article

A Net-Plankton Study in the Bosphorus Junction of the Sea of Marmara

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Abstract: A 16-month study of diatoms (>55 micrometers) and certain groups of zooplankton was carried out at 21 stations in the Bosphorus junction of the Sea Marmara on board the R/V "Bilim". The maximum diatom bloom was observed in January 1986, followed by a less frequent secondary flowering in summer. Both the diatom and zooplankton maxima were observed at 10 m. The lowest levels were attained below the halocline at a depth of 30 m.

Remarkable variations, both in the species composition and abundance of diatoms, were observed with depth throughout the research. Both the species richness D and species diversity H' were found to be relatively high in March (2.30-3.06) and October 1986 (2.23-2.97) as well as the proportional representation J' (0.96-0.91). In the distribution of diatom species at different depths, higher degrees of similarity were achieved in October, the maximum being 0.8 (Jacc. coeff.) between the surface and 10 m. Among the physico-chemical factors affecting the distribution of zooplankton with depth were temperature, salinity, dissolved oxygen, phosphate and nitrate+nitrite , which showed significant correlations.

İstanbul Boğazı Marmara Denizi Çıkışında Bir Net-Plankton Çalışması

Özet: İstanbul Boğazı Marmara Denizi çıkışında R/V Bilim araştırma gemisi seyirleri süresince 21 istasyonda 16 ay süre ile diatome (55 mikrometre üzeri) ve çeşitli zooplankton grupları üzerine çalışma yürütülmüştür. Maksimum diatome patlaması Ocak 1986'da gözlenmiş ve bunu daha düşük sıklıkla ikinci bir yaz patlaması izlemiştir. Her iki diatome ve zooplankton maksimaları 10 metrede gözlenmiştir. En düşük seviyeler haloklin tabakasının altında 30 metrede elde edilmiştir.

Araştırma süresince diatome tür kompozisyonunda ve sıklığında derinlikle belirgin farklılıklar gözlenmiştir. Her iki tür zenginliği (D) ve tür çeşitliliği (H') indeksi Mart (2.30-3.06) ve Ekim 1986'da (2.23-2.97) ve yanısıra oransal dağılım J' (0.96-0.91) açısından göreceli olarak yüksek bulunmuştur. Farklı derinlikler arasında diatom türlerinin paylaşımı açısından en yüksek benzerlikler Ekim ayında yüzey ve 10 metreler arasında 0.8 (Jacc. katsayısı) düzeyinde elde edilmiştir. Zooplanktonun derinlikle dağılımını etkileyen fiziko-kimyasal faktörlerden sıcaklık, tuzluluk, çözünmüş oksijen, fosfat ve nitrat-nitrit önemli korelasyonlar göstermiştir.

Introduction

The Turkish Straits constitute a transitional oceanographic system between the Aegean basin of the Eastern Mediterranean and the Black Sea and are subject to man-induced or natural environmental changes. In order to make a better evaluation of existing environmental changes and their impact on microbial life, data on the standing stock, community structure, species composition and distribution of diatoms are of great importance.

There is little general background data on phytoplankton species lists for the Bosphorus region. Further studies are still required on this subject.

Materials and Methods

In order to obtain data on diatoms and environmental parameters, particularly on the relationships between the seasonal cycles of these parameters and succession in phytoplankton assemblage, a baseline study of diatom composition together with zooplankton abundance and their vertical distribution was conducted in the Bosphorus junction of the Sea of Marmara (Fig. 1).

Starting in September 1985, a series of bimonthly diatom samplings were performed at 21 stations in this region on board the R/V BILIM of the Institute of Marine Sciences of Middle East Technical University

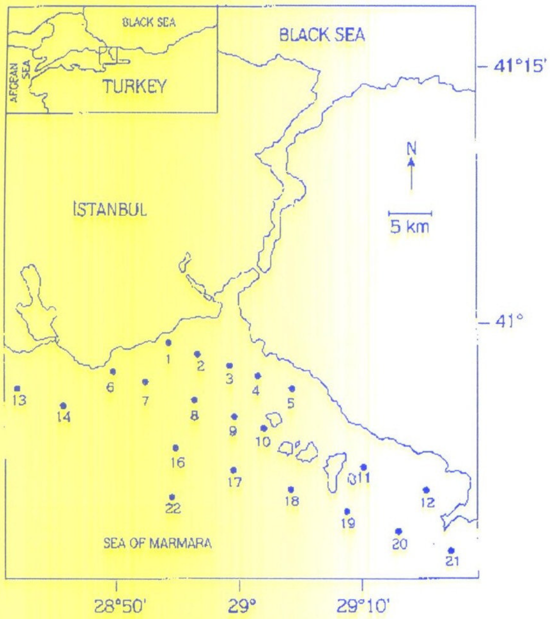

Figure 1. Map showing the location of plankton sampling stations in the Bosphorus junction of the Sea of Marmara.

(IMS-METU). In order to collect a sufficient amount of planktonic organisms, 5 l of water samples were taken with the aid of Nansen bottles from the surface and from depths of 10 and 30 m at each station. The water samples were then filtered on board through a net with a mesh size of 55 microns and the residues were preserved using a 4 % seawater-formalin solution.

In the counting of the diatom cells, aliquots of 0.05 ml were examined over a Palmer-Maloney chamber under a microscope. Each time an attempt was made to determine 400 cells [1]. Microscope magnifications of *100 and *400 were used in the diatom cell counts and * 1000 was used for the identification of smaller cells.

The diatom community was characterized using both Margalef's index D. which is a measure of species-richness diversity [2]

$$D = (S-1) / \ln$$

where S = number of species and N = number of individuals

and the Shannon-Weaver diversity index H'.

$$H' = \sum_{i=1}^{S} pi \log2 pi$$

where pi is the proportion of the i'th species of the whole sample.

In measuring the proportional representation, the evenness function J was calculated [3], where

$$J = H'/\log_e S$$

The similarity between diatom species lists from each sampling region was calculated using Jaccard's similarity coefficient for presence and absence [4].

Jaccard's similarity coefficient = a/a+b+c where,

a = sum of species occurring at both stations (a&b)

b = sum of species occurring at station a but not b

c = sum of species occurring at station b but not a.

All correlation coefficients were determined by station, using the Spearman rank-correlation analysis [5] with the significance levels at P.05. and P.01. Spearman's rank-correlation coefficient was computed for data arranged in a similar manner. There is no simple mathematical relation between the two coefficients. Spearman's coefficient rs can be computed directly from the differences between the ranks R1 ve R2 of paired variables 1 and 2 as follows:

$$r_s = 1 - [(6\Sigma (R1-R2)^2) / n (n^2 - 1)]$$

where n = size of sample.

Results and Discussion

Remarkable variations both in the species composition and abundance of diatoms were observed throughout the sampling period. The maximum diatom bloom was observed in January 1986 and a second but relatively weak flowering also occurred during the summer. With the extension of the sampling period to January 1987 a second but less abundant bloom than the first was observed in October 1986 (Fig. 2).

The maximum cell count was recorded as $1555*10^2$ cells/l at the 10 m depth in January 1986 (Table 1). Throughout the sampling period the 10 m depth was the most abundant layer in terms of diatom prevalence. The lowest level were attained in the May - July period of at the same depth. At the 30 m depth the maximum level was in October 1986 ($395*10^2$ cells/l) and fell to its minimum in July 1986.

It is a noteworthy phenomenon that within the period of September 1985 - January 1987 centric diatoms were found to predominate over tha pennates

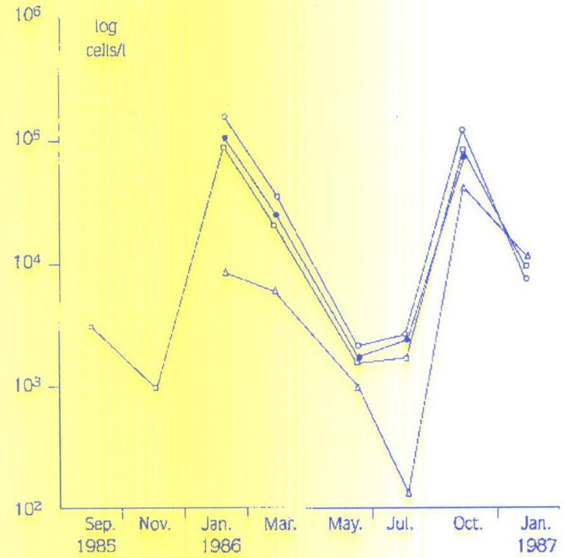

Figure 2. Bimonthly changes in abundance of diatoms at different depths (: -Surface; o-10 m; Δ-30 m; ⊐ - Mean).

(except in January 1986 when the pennates formed a slightly more abundant group). This possibly emerges from the differences in the nutrient-uptake efficiency of these major groups. Since pennate diatoms tend to have lower ratios of surface to volume, they are better adapted to grow in high nutrient concentrations than centrics [6].

Relatively high levels of nutrients in the euphotic zone in January 1986 allowed pennates to predominate over centrics, but this was only the case for that winter period. Within the region surrounding the Bosphorus-Marmara junction, the marked reduction in phosphate from 0.46 to 0.22 µg-at/l occurred during the January -March 1986 period and was associated with the concurrent diatom outburst. This is, in fact, difficult to follow precisely, but it is inevitable that such sudden growth in diatom numbers should result in a corresponding fall in phosphate [7].

The relative contribution of centric diatoms to diatoms in general reached its maximum (92 %) in September 1985 and decreased to its minimum (47 %) at

Table 1. Variations in the composition and mean abundance of diatoms with time and depth in the Bosphorus junction of the Sea of Marmara.

Sampling time:	Sep.85	Nov.85	Jan.86	Jan.86	Jan.86	Mar.86	Mar.86	Mar.86	May.86	May.86	May.86
Dept (m):	Mixed	Mixed	Surf	10	30	Surf	10	30	Surf	10	30
CENTRIC DIATOMS											
Cerataulina bergonii	-	-	-	-	-	-	-	-	593	891	636
Chaetoceros affinis	178	-	-	-	-	-	-	-	-	-	-
C. decipiens	-	-	5414	11109	584	263	245	-	40	331	58
C. didymus	-	13	-	-	-	-	-	-	-	-	-
C. diversus	-	-	-	-	-	75	-	-	-	-	-
C. lauderi	-	-	8367	6279	487	-	-	-	-	-	-
C. sp	14	77	984	-	-	263	1516	193	-	103	-
Coscinodiscus centralis	164	-	-	-	-	-	-	-	-	-	-
C. excentricus	-	-	-	-	-	3984	5121	422	-	-	-
C. granii	-	-	-	-	-	37	205	-	-	-	-
C. lineatus	-	-	-	-	-	-	205	-	-	-	-
C. radiatus	-	-	-	-	-	-	123	-	-	-	-
Ditylum brightwellii	-	13	-	966	97	1766	2704	193	-	-	-
Guinardia flaccida	-	-	-	-	-	-	205	-	-	-	-
G. sp	-	-	-	-	24	-	-	-	-	-	-
Lauderia borealis	-	-	-	-	-	-	164	-	178	-	-
Leptocylindrus danicus	178	-	-	-	-	488	615	-	-	-	-
L. sp	-	-	-	-	-	-	205	-	-	-	-
Rhizosolenia alata	110	77	-	483	-	151	-	-	-	-	-
R. alata fo. gracillima	1779	26	-	-	24	-	-	-	59	-	-
Rhizosolenia calcaravis	-	-	-	-	24	37	41	-	-	21	14
R. delicatula	-	-	-	-	-	-	81	-	119	-	-
R. hebetata	-	-	-	1449	-	-	-	-	-	-	-
R. setigera	178	320	33962	54579	3093	8758	12084	3692	79	83	-
R. stolterfothii	14	-	-	-	-	-	-	-	-	-	-
R. styliformis	178	-	-	-	-	-	-	-	-	-	-
Schroederella delicatula	-	-	-	483	-	-	-	-	-	-	-
Skeletonema costatum	-	-	-	-	-	-	369	270	-	-	-
Thalassiosira decipiens	-	-	-	3864	49	1916	1229	154	-	-	-
T. gravida	-	-	-	-	-	300	2457	193	-	-	-
T. nordenskioldii	-	-	-	-	-	639	943	-	-	-	-
T. sp	-	13	-	-	-	-	-	-	-	-	-
TOTAL (Centrics)	2793	539	48727	79212	3355	18677	28512	5271	1068	1429	708
PENNATE DIATOMS											
Asterionella bleakeleyi	-	-	-	-	-	-	-	-	40	83	87

Table 1. continued

Nitzschia closterium	-	64	-	3864	-	-	-	-	59	21	-
N. delicatissima	-	-	-	-	-	976	1557	230	-	-	-
N. longissima	-	-	1477	2898	49	602	1188	-	40	21	-
N. pungens	-	218	-	-	-	-	-	-	-	-	-
N. seriata	233	-	52173	69552	3823	4286	4793	576	435	476	160
Thalassionema nitzschioides	-	38	-	-	-	-	-	-	-	-	-
TOTAL (Pennates)	233	320	53650	76314	3872	5864	7538	806	574	601	247
GRAND TOTAL (C+P)	3026	859	102377	155526	8327	24541	36050	6077	1642	2030	955

Sampling time:	July. 86	Jul.86	Jul.86	Oct. 86	Oct.86	Oct.86	Jan. 87	Jan. 87
Depth (m):	Surf	10	30	Surf	10	30	10	40
CENTRIC DIATOMS								
Bacteriastrum hyalinum	-	-	-	395	315	246	-	-
Cerataulina bergonii	-	-	-	2300	3706	2546	4676	5592
Chaetocerus decipiens	-	-	-	4600	10095	4600	-	-
C. densus	-	-	-	200	-	-	-	-
C. didymus	-	-	-	7555	19872	17168	695	695
C. rostratus	-	-	-	22015	33120	7310	180	465
C. sp	-	-	70	525	-	-	-	-
C. excentricus	-	-	-	526	395	410	-	-
C. sp	-	-	-	-	-	-	185	-
Ditylum brightwellii	-	-	-	788	946	245	-	-
Guinardia flaccida	-	-	-	66	160	80	-	-
Hemiaulus hauckii	-	-	-	197	1340	246	-	-
H. sinensis	-	-	-	-	236	245	-	-
Leptocylindrus danicus	-	-	-	1050	2996	164	210	1165
L. minimus	-	-	-	131	-	-	-	-
R. alata fo. gracillima	33	481	-	200	315	80	-	210
Rhizosolenia calcaravis	1755	1066	56	263	235	80	195	160
R. fragilissima	364	413	-	723	235	165	-	-
R. setigera	33	34	-	395	315	-	-	-
R. styliformis	33	-	-	-	-	-	-	-
Skeletonema costatum	-	103	-	11435	9148	492	-	-
Thalassiosira decipiens	-	-	-	130	1262	-	-	-
T. nordenskioldii	-	-	-	460	158	-	-	-
T. rotula	-	-	-	-	80	-	-	-
T. sp	-	-	-	-	-	165	-	-
TOTAL (Centrics)	2218	2097	126	53954	84929	34242	6141	8287
PENNATE DIATOMS								
Asterionella bleakeleyi	66	-	-	-	-	-	-	-
Nitzschia closterium	33	-	-	-	-	-	-	-
N. delicatissima	-	172	-	2694	2523	985	454	1865
N. longissima	-	-	-	130	710	82	233	-
N. seriata	-	138	-	11630	29885	4190	420	930
TOTAL (Pennates)	99	310	-	14454	33118	5257	1107	2795
GRAND TOTAL (C+P)	2317	2407	126	68408	118047	39499	7248	11082

Note: Numbers represent cells/l. Counts reflect the means of total 21 stations.

the surface in January 1986. Almost 76 % of the diatom species were found to be centric forms in the region, which agrees well with the findings of Sorokin (8), who found 80% in the coastal waters of the Black Sea. During the July 1986 sampling period pennates almost totally dissappeared at the depth of 30 m.

Based on seasonal distribution patterns, the net flora may be grouped into four categories.

1. Constants, collected all, the year round. The two most important species were *Nitzschia seriata* Cleve and *Rhizosolenia setigera* Brightwell.

2. Vernal-serotinal species, present bimodally in spring and in late summer. The only species confined to these particular seasons was *Asterionella bleakeleyi* W. Smith.

3. Serotinal species, collected in late summer. The two major species were *Rhizosolenia fragilissima* Bergon and R. styliformis Brightwell.

4. Hiemal species, dominant in winter. Among these *R. setigera* and *Nitzschia seriata* were found to be the most numerous and widely distributed species. In addition to these two *Chaetocerus Lauderi* (Ralfs) Lauder *Thalassiosira decipiens* (Grunow) Jorgensen, *Nitzschia closterium* (Ehrenberg) W.Smith and *N. longissima* (Breb.) Ralfs were the other species in decreasing importance.

In addition to the above classification, *Chaetoceros affinis* Lauder, *Coscinodiscus centralis* Ehrenberg and *Rhizosolenia* stolterfothii H. Peragallo can be counted among the Autumnal species.

On the basis of species structure in a community species richness D was found to be low at the surface (0.43), almost twice as high (0.84) at 10 m and the highest (1.11) at the 30 m depth (Table 2a) in January 1986. Conversely, species richness was found to be highest (1.22) at the surface, high (1.05) at 10 m and lowest (0.58) at the 30 m depth in May and such a phenomenon could be adapted for the others, J' and H', as well when expressed in detail at certain depths. Diversity is considered to be low if only one or a few species are dominant, followed by rapidly decreasing numbers of others.

Both the species richness D and diversity H' were found to be relatively high in March (2.30-3.06) and October 1986 (2.23-2.97) (Table 2b), whereas the proportional representation J' was found to be relatively low (0.96-0.91). This phenomenon simply stems from the fact that the apportionment of total diatom cells among the total species is not quite uniform.

Besides the overall inspection of diatom species, individuals of different zooplankton groups formed by Copepods, Siphonophores, Chaetognaths, Polychaete larvae, Cladocerans and Appendicularians were enumerated at each depth and station. Fig. 3 shows the distrubiton of zooplankton at three depths. Higher numbers were recorded in September 1985, January 1986, and July 1986. The distribution of both zooplankton and diatoms showed similar trends and consequently a significant positive correlation was obtained (Tablo 3).

The percentage distribution of zooplankton groups revealed that the predominance of Copepods persists throughout the year in the region. The ratio of Copepods to the remaining zooplankton groups reached its maximum in January 1986 (98 %) at a depth of 10 m and fell to its minimum (62 %) in July 1986 at the same depth (Table 4).

The highest recorded zooplankton level for the upper layer was 125400 indv. /m^3 in September 1985, and the lowest was 3980 indv/m^3 in May 1986. The maximum number of individuals at the 10 m depth was observed in January 1986 as 107180 indv/m^3 and the minimum once again in May 1986 as 12190 indv./m^3. Except for the relatively higher level obtained in May at the 30 m depth, a lower abundance of individuals was found below the halocline throughout the sampling period (Fig. 3). This was, indeed, expected in the lower

Table 2. Variations in the three species-diversity indices, namely Margalef's species-richness diversity (D), Pielou's evenness function (J) and the Shannon-Wiener diversity index (H') utilizing diatom-species lists obtained at each sampling depth (a) and for the whole water column (b).

(a)

Time	Depth (m)	J	H'	D
Sep. 1985	0-30	0.94	2.17	1.12
Nov. 1985	0-30	1.11	2.56	1.33
Jan. 1986	Surface	0.95	1.70	0.43
Jan. 1986	10	0.85	2.04	0.84
Jan. 1986	30	0.77	1.85	1.11
Mar. 1986	Surface	1.02	2.84	1.48
Mar. 1986	10	1.05	3.19	1.91
Mar. 1986	30	0.93	2.15	1.03
May. 1986	Surface	1.13	2.61	1.22
May. 1986	10	1.02	2.24	1.05
May. 1986	30	0.91	1.47	0.58
Jul. 1986	Surface	0.63	1.22	0.77
Jul. 1986	10	1.14	2.21	0.77
Jul. 1986	30	1.43	0.99	0.21
Oct. 1986	Surface	0.96	3.00	1.98
Oct. 1986	10	0.93	2.87	1.80
Oct. 1986	30	0.87	2.57	1.70
Jan. 1987	10	0.88	1.94	0.90
Jan. 1987	40	1.06	2.21	0.75

(b)

Time	Depth (m)	J	H'	D
Sep. 1985	0-30	0.94	2.17	1.12
Nov. 1985	0-30	1.11	2.56	1.33
Jan. 1986	0-30	0.70	1.95	1.32
Mar. 1986	0-30	0.96	3.06	2.30
May. 1986	0-30	0.99	2.45	1.50
Jul. 1986	0-30	0.84	2.00	1.35
Oct. 1986	0-30	0.91	2.97	2.23
Jan. 1987	10-40	0.95	2.19	0.99

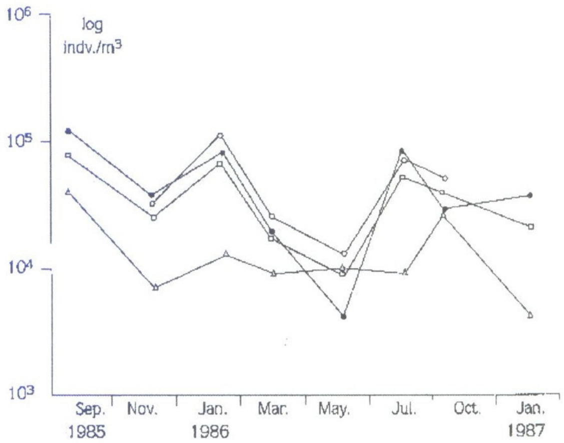

Figure 3. Bimonthly variations in abundance of zooplankton at different depths (●-Surface: 0-10 m; Δ - 30 m; ❑ - Mean).

Table 3. Relationships between physico-chemical parameters, plankton (as abundance and biomass) and other parameters based on the Spearman Rank-Correlation analysis in the region

Variables Y1	Y_2	N	r_s values
Diatoms	Zooplankton	14	0.587*
Diatoms	Chlorophyll	18	0.253
Diatoms	Rain fall	6	0.429
Diatoms	o-PO_4	15	-0.039
Diatoms	Dry-weight+	19	0.667**
Diatoms	Humic matter	19	-0.161
Diatoms	TSS	19	-0.016
Zooplankton	Chlorophyll	15	0.218
Zooplankton	o. PO_4	15	-0.336
Zooplankton	Rain fall	6	0.371
Zooplankton	Dry-weight+	14	0.591*
Zooplankton	Humic matter	17	-0.007
Zooplankton	TSS	17	-0.017
Chlorophyll	NO_2+NO_3	12	-0.357
Chlorophyll	o.PO_4	18	-0.655**
Chlorophyll	Dry-weight+	18	0.579*
Chlorophyll	TSS	21	0.137
Chlorophyll	Humic matter	20	0.408
Chlorophyll	Rain fall	5	-0.5
NO_2+NO_3	o. PO_4	9	0.85**
NO_2+NO_3	Dry-weight	11	-0.246
NO_2+NO_3	Humic matter	11	-0.327
o.PO_4	Dry-weight	15	-0.218
o.PO_4	Humic matter	17	-0.564*
o. PO_4	TSS	18	0.170
Dry-weight$^+$	Rain fall	6	0.371
Dry-weight$^+$	Humic matter	19	0.026
Dry-weight$^+$	TSS	19	0.044
Rain fall	Humic matter	6	-0.543
Rain fall	o. PO_4	5	0.8
Humic matter	TSS	23	0.034
TSS	Rain fall	6	-0.528

** rs significant at P. 01.
* rs significant at P. 05.

Note: TSS is the abbreviation of Total Suspended Sediment. (+) Total plankton biomass as dry-weight. Correlation is based on year-round data collection in the Sea of Marmara.

layer which provides unfavorable conditions for planktonic organisms. The vertical migration of the organisms across the halocline is strongly inhibited. This is well reflected in the relatively low levels of the phytoplankton and consequently in the zooplankton abundancy at the 30 m depth.

As has been stated [9], zooplankton could have been higher when PO4-P was low because zooplankton phosphorus excretion (lipid reserves) was low when phytoplankters were abundant and vice versa. Although no statistical correlation was observed for zooplankton ver-

Table 4. Percentage composition of certain zooplankton groups at the surface, and at depths of 10m and 30m in the Bosphorus junction of the Sea of Marmara

Sampling time:	Sep. 85	Nov.85	Jan.86	Mar.86	May.86	Jul. 86
Surface						
Chaetognatha	-	0.22	0.06	0.00	0.24	1.76
Appendicularia	-	13.47	1.23	0.10	1.20	19.44
Cladocera	-	1.66	1.52	0.88	7.66	7.76
Polychaeta larvae	-	3.10	0.36	1.50	1.20	0.41
Copepoda	-	80.20	96.83	97.51	89.71	70.04
Siphonophora	-	1.34	0.00	0.00	0.00	0.59
10 meters	Sep. 85	Nov. 85	Jan. 86	Mar.86	May. 86	Jul. 86
Chaetognatha	2.51	0.32	0.06	0.04	0.08	1.52
Appendicularia	20.59	9.22	0.21	0.07	0.23	30.65
Cladocera	6.67	1.88	1.86	1.50	9.92	4.10
Polychaeta larvae	1.64	7.21	0.19	1.64	1.02	1.22
Copepoda	65.43	80.34	97.69	96.75	88.75	61.87
Siphonophora	3.16	1.03	0.00	0.00	0.00	0.63
30 meters	Sep. 85	Nov. 85	Jan. 86	Mar. 86	May.86	Jul.86
Chaetognatha	0.40	0.16	0.39	0.20	0.39	1.08
Appendicularia	14.38	1.91	1.83	2.11	3.79	23.83
Cladocera	1.03	0.00	0.58	0.40	0.88	0.72
Polychaeta larvae	1.70	19.87	12.04	14.00	9.92	17.37
Copepoda	80.69	77.90	85.16	83.28	85.02	56.89
Siphonophora	1.80	0.16	0.00	0.00	0.00	0.12

Table 5. Relationships between zooplankton abundance versus nutrient levels (a) and physical parameters (b) with depth.

Variables Time	Y_1	Y_2	N	r_s values
Nov.1985	Zooplankton	o-PO_4	48	-0.509**
Jan. 1986	"	o-PO_4	48	-0.614**
Mar. 1986	"	o-PO_4	33	-0.048
May 1986	"	NO_3+NO_2	54	0.174
Jul. 1986	"	o-PO_4	48	-0.615**
(b)				
Nov. 1985	Zooplankton	Temperature	50	-0.921**
Nov. 1985	"	Salinity	50	-0.795**
Nov. 1985	"	DO	50	-0.214
Jan. 1986	"	Temperature	39	-0.525**
Jan. 1986	"	Salinity	39	-0.371*
Jan. 1986	"	DO	39	0.298
Mar. 1986	"	Temperature	42	-0.158
Mar. 1986	"	Salinity	42	-0.199
Mar. 1986	"	DO	42	0.149
May. 1986	"	Temperature	39	-0.380*
May. 1986	"	Salinity	39	0.478**
May. 1986	"	DO	39	0.092
Jul. 1986	"	Temperature	51	0.537**
Jul. 1986	"	Salinity	51	-0.004
July. 1986	"	DO	51	0.439**

** r_s significant at $P_{.01}$.
* r_s significant at $P_{.05}$.

sus NH_3-N by Walker and Steidinger [9], a significant negative correlation was attained in July 1986 for zooplankton versus NO_3+ NO_2 (Table 5a). Variations in the nutrient content of the upper layer in the region are expected to be greatly influenced by the nutrient levels in the Black Sea and by land-based sources.

In order to detect possible factors responsible for the vertical distribution of zooplanktonic organisms, a correlation analysis was performed utilizing temperature, salinity and dissolved-oxygen (DO) data obtained at each plankton-sampling depth. Significant inverse relationships were observed between zooplankton abundance versus temperature and salinity (Table 5b). In addition to these a significant positive relationship was also established between zooplankton abundance and DO in July 1986.

Light is also suggested to be one of the most important factors responsible for the vertical distribution in the Sea of Marmara. The compensation depth is estimated to be 26 m and it is concluded that halocline defines the lower limit of the euphotic zone in the Sea of Marmara. This is also well supported by the plankton dry-weight measurements (Fig. 4) at different depths above and below the halocline. As indicated above, much of the production takes place within the upper 10 m where the highest biomass measurements were taken. The higher levels observed in January 1986 and 1987 correspond well with the blooming times of planktonic organisms when both diatom and zooplankton abundancy showed significant correlations with dry-weight measurements.

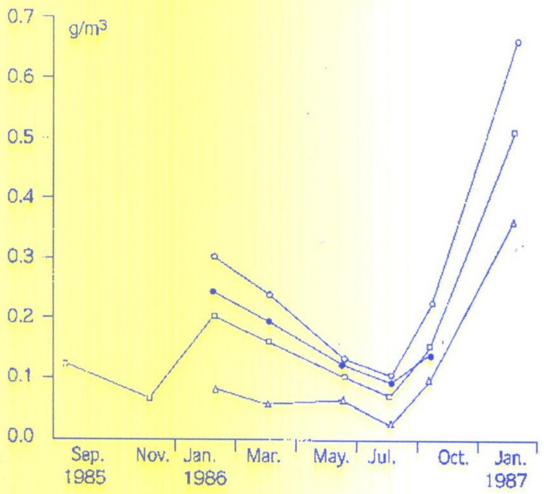

Figure 4. Variations in the biomass (as dry weight) of total plankton with time and depth (●-Surface; o-10 m; Δ-30 m; ◻-Mean).

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