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ENVIRONMENT'88: ENVIRONMENTAL SCIENCE AND TECHNOLOGY CONFERENCE, 5-9 JUNE 1988, IZMIR-TURKEY

# FATE AND DISTRIBUTION OF PLANKTON IN GOLDEN HORN

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## ABSTRACT

For a better understanding of interactions which might exist between plankton and environmental parameters, particularly on the relationships between the seasonal cycles of these parameters and succession in the phytoplankton assemblage, a baseline study of phytoplankton composition together with the zooplankton abundance and their vertical distribution was conducted at three different depths (10, 20 and 30 m) in Golden Horn.

Remarkable variations both in the species composition and abundance of diatoms were observed throughout the sampling period (September 1985- January 1987). Maximum diatom bloom was observed in January 1986 and a second but a weak bloom has also been attained in September 1986. Almost 73.7 % of the diatom species were found to occur in their centric forms based on the averages of total 20 counts in different time periods.

Both the species richness (D) and species diversity (H) were found to be relatively high in November 1985 (1.65-3.26) and in September 1986 (1.51-3.01) likewise, the proportional representation (F) was also found to be relatively high (1.24 - 1.08).

Maximum levels of similarity were obtained in March 1986 between the depths of 10-20-30 m (Jacc. coeff.= 1.0) respectively.

*Copepods* represented the major group down to 20 m depth while in the case of 30 m level the picture was just the reverse where the dominancy of *Polychaete larvae* over *Copepoda* was observed. It is a well known fact that *Polychaetes* are much tolerable to different levels of pollution. Finally significant relationships were observed between zooplankton abundance versus temperature, salinity and dissolved oxygen.

## INTRODUCTION

Turkish Straits constituting a transitional oceanographic system between the Aegean basin of the Eastern Mediterranean and the Black Seas are subject to man induced or natural environmental changes. Included in the system is one of the world's most famous and historically well known estuary -Golden Horn- which had been exposed to worst cases of environmental degradation over the years. Golden Horn, being a small estuary, terminates near the southern tip of the strait. As it was mentioned by SAYDAM *et al* (1986) the water column in Golden Horn consists of two distinct layers the upper layer being of Black Sea origin and the bottom layer of Mediterranean origin. The characteristics of

each of the layers are similar to the corresponding layers in the Bosphorus section adjacent to the Golden Horn. Although the uppermost few meters are subject to heavy load of pollution, water below allows organisms survive to a certain degree (UNLU et al., 1972).

The suspended particulate matter in the sea consists of certain living organisms so called plankton. On the basis of the definition of plankton by Hensen in 1887 it can be summarized as "plants and animals mostly of rather small size, which float and drift passively along with water movements". The plant component of plankton- the *phytoplankton*- is made up of unicellular (exceptionally multicellular) algae which are either solitary or colonial and they form the basis for all life in the sea.

No significant study has been performed to control and remedy the situation until 1953, when the Municipality of Istanbul organised a commission consisting of scientists to study the issue. Subsequently, various activities were undertaken to analyze different aspects of the problem and to recommend practical solutions. The Municipality of Istanbul have undertaken eight such studies between 1953 and 1966, basically concerned with the problems of waste discharge into the estuary where the measures recommended were never enforced since then. Similar studies of limited scope were also performed by the government at various periods from 1960 to 1972 and likewise they were never enforced. For further information on various aspects of Golden Horn especially for the identification and determination of the nature and cause of the environmental problems together with the recommendations about how to overcome the difficulties, see DAMOC, (1971); TEZCAN, (1977) and lastly SAYDAM *et al.*, (1986).

There exist some general background data on the phytoplankton species lists assembled by Hidrobiological Research Institute (HRI, 1974) for the Bosphorus region. Distribution and identification of certain groups of zooplanktonic organisms especially of *Copepods* is dealt by DEMIR, (1954, 1958, 1959). The use of phytoplankton cultures as the pollution indicators of Bosphorus, Golden Horn, Kucuk Cekmece and Marmara and Black Seas has been conducted by UNLU et al., (1972).

## MATERIAL and METHODS

In this study plankton samples were collected during the cruises of R/V BILIM of the IMS-METU from September 1985 to January 1987. In order to collect sufficient amount of planktonic organisms 5 liters of water samples were taken with the aid of Nansen bottles from four permanent stations at three different depths 10-20 and 30 m respectively (Figure 1). Water samples were then filtered on board through a net of 55 µm mesh size and filtrates were concentrated using 4 % seawater - formalin solution.

For the counting of diatom cells, aliquots of 0.05 ml were examined over a Palmer-Maloney chamber under microscope. In each counting at least 400 cells were tried to be counted as indicated in Venrick (1978). Microscope magnifications of ×100 and ×400 were applied for diatom cell counts and ×1000 for identification of smaller cells.

The phytoplankton community was characterized using either Margalef's index D, which is a measure of species richness diversity

$$D = (S-1)/\ln N \qquad \text{(MARGALEF, 1978)}$$

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

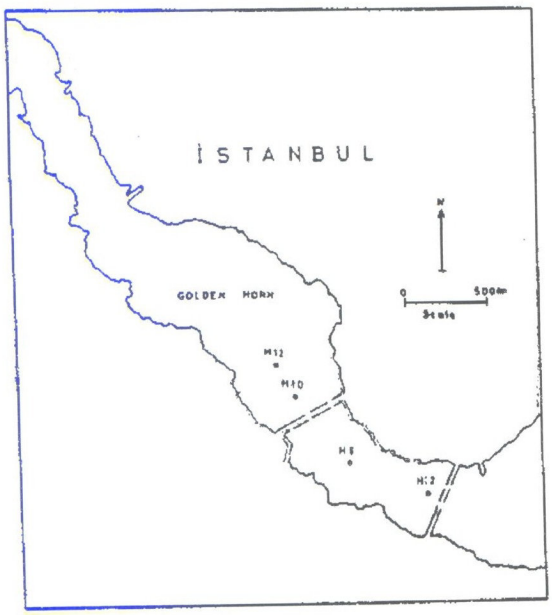


Figure 1. Location of plankton sampling stations in Golden Horn.

or the Shannon-Weaver diversity index H', (MARGALEF, 1978)

$$H' = -\sum_{i=1}^{n} pi \log_2 pi$$

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

For a measure of proportional representation, the evenness function $f$ was calculated (PIELOU, 1977 cited in NASH and GIBSON, 1982):

where $f = H'/\log_e S$

Similarity between diatom species lists from each sampling region was tested using Jaccard's similarity coefficient for presence and absence (LEGENDRE and LEGENDRE, 1978).

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's rank correlation analysis (SNEDECOR and COCHRAN, 1967) with the significance

levels at $P_{.05}$ and $P_{.01}$. Spearman's rank correlation coefficient is computed for data arranged in a similar manner. There is no simple mathematical relation between the two coefficients. Spearmans' coefficient, $r_s$ can be computed directly from the differences between the ranks R1 and 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

Variations in the aundance of both diatoms and zooplankton are shown in Figures 2 and 3 respectively.

### PHYTOPLANKTON

Remarkable variations both in the species composition and abundance of diatoms were observed throughout the sampling period. As clearly shown in Figure 2 maximum diatom bloom was observed in January 1986 and a second but a weak bloom has also been attained for the late summer. As the sampling intervals permit, it is hard to decide on a specific time period for the outburst of diatoms in general. That is, there might be significant blooms taking place between two sampling periods which indeed the time gap corresponds to 2 months period. With the extension of sampling period to January 1987 a second but less abundant bloom than the first one was observed for the following year in September 1986.

Starting in the mids of November 1985, enrichment of diatoms to a great extend till January 1986 has been clearly demonstrated in Figure 2. From January to July 1986 a noticeable decrease in the diatom abundancy at all depths was observed. Based on the averages of all the stations visited the maximum cell count was recorded as 250111 cells/l for 10 m depth in January 1986 (Table 1). Each depth possessed unique features in terms of diatom dominancy. While much cell production was attained for 10 m depth in January-March 1986 period, lowest levels were also available in September 1986 and in January 1987 for the same layer.

It is a noteworthy phenomenon that within the period of March 1986 - January 1987 centric diatoms were found to predominate the pennates at all depths (except that in January 1986). This phenomenon possibly emerged from the differences in the nutrient uptake efficiencies of these major groups while pennates are favoured in nutrient rich media. Since pennate diatoms have lower ratios of surface to volume, they are adopted to grow better at high nutrient concentrations than centrics do (MORRIS, 1980). Relatively high levels of nutrients in the euphotic zone in the region (BASTURK et al.,1986) in January 1986 allowed pennates predominate over centrics.

The relative contribution of centric diatoms to diatoms in general reached to maximum (89.3 %) in September 1986 at a depth of 10 m and decreased to minimum (10.3 %) at the same depth in January 1986. Almost 73.72 % of the diatom species were found to occur in their centric forms in Golden Horn based on the averages of total 20 counts in different time periods. During the July 1986 sampling period pennates disappeared almost totally at depths of 10 and 20 meters. Similarly, they have been found lacking below the halocline in July 1986 in the Sea of Marmara.

The most important species during the January 1986 flowering were *Nitzschia delicatissima* (98878 cells/l), *Chaetoceros decipiens* (6986 cells/l), *C.*

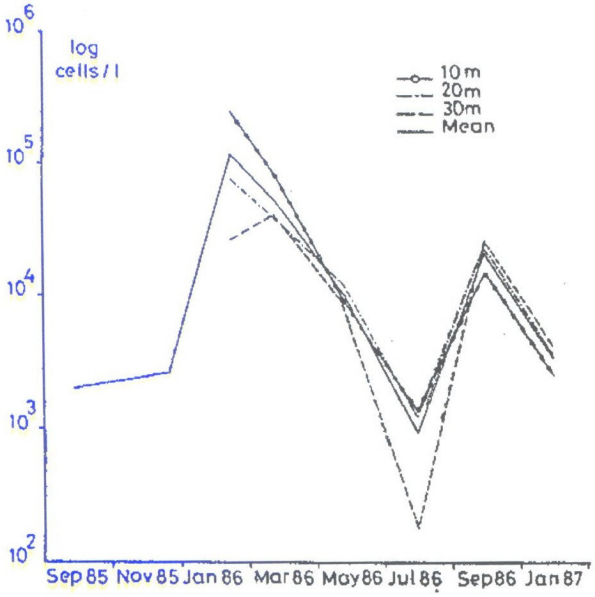


**Figure 2.** Bimonthly changes in abundance of diatoms at different depths in Golden Horn.

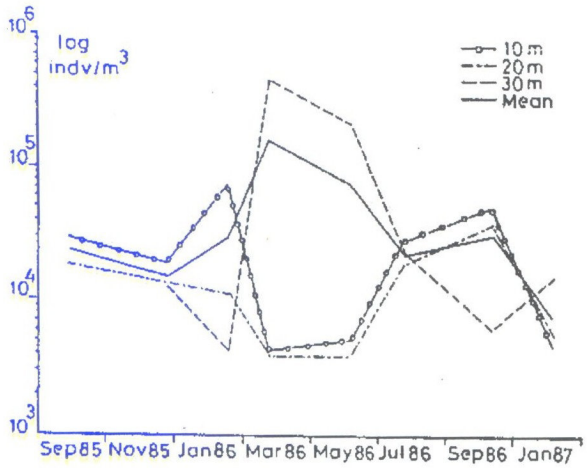


**Figure 3.** Variations in abundance of zooplankton with time and depth in Golden Horn.

TABLE 1. Diatom species composition and abundance with time and depth in Golden Horn.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sampling time: | Sep.85 | Nov.85 | Jan.86 | Jan.86 | Jan.86 | Mar.86 | Mar.86 | Mar.86 | May.86 | May.86 | May.86 |
| Depth (m): | Mixed | Mixed | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 |
| CENTRIC DIATOMS | | | | | | | | | | | |
| Cerataulina bergonii | - | - | - | - | - | - | - | - | 2705 | 4186 | 1166 |
| Chaetoceros affinis | 1137 | - | - | - | - | - | - | - | - | - | - |
| C. curvisetus | - | 253 | - | - | - | - | - | - | - | - | - |
| C. decipiens | - | 253 | 11638 | 8648 | 673 | - | - | - | 1030 | 242 | 269 |
| C. densus | 98 | - | - | - | - | - | - | - | - | - | - |
| C. diadema | - | - | - | - | - | 1008 | 1361 | 1578 | - | - | - |
| C. didymus | - | 638 | - | - | 583 | 3415 | 936 | 112 | - | - | - |
| C. lauderi | - | - | 9522 | 4865 | - | - | - | - | - | - | - |
| C. sp | - | 84 | - | - | 493 | - | - | - | 129 | 805 | - |
| Coscinodiscus centralis | 74 | - | - | - | - | - | - | - | - | - | - |
| C. excentricus | - | - | - | - | - | 11258 | 7318 | 4057 | - | 81 | 90 |
| C. granii | - | - | - | 162 | 45 | - | - | - | - | - | - |
| C. lineatus | - | - | 159 | - | - | - | - | - | - | - | - |
| C. stellaris | - | - | 212 | - | - | - | - | - | - | - | - |
| Ditylium brightwellii | - | 21 | 952 | 162 | 358 | 5692 | 4170 | 2818 | 129 | 81 | 449 |
| Lauderia borealis | - | 84 | - | - | - | - | - | - | - | - | - |
| Leptocylindrus danicus | - | 21 | - | - | - | - | - | - | - | - | - |
| R. alata gracillima | 25 | 211 | 53 | - | 135 | - | - | - | - | - | - |
| Rhizosolenia calcaravis | 25 | 63 | 105 | 162 | - | - | - | - | 258 | 81 | - |
| R. fragilissima | 25 | - | - | - | - | - | - | - | - | - | - |
| R. hebetata | 25 | - | - | - | - | - | - | - | - | - | - |
| R. setigera | 148 | 443 | 3174 | 2270 | 7041 | 1191 | 255 | 451 | - | - | 179 |
| Schroederella delicatula. | 25 | - | - | 270 | 89 | - | - | - | - | - | - |
| Skeletonema costatum | - | 105 | - | - | - | 4192 | 16189 | 23104 | 2640 | 4347 | 4933 |
| Thalassionira decipiens | - | 63 | - | 1081 | 89 | - | - | - | - | - | - |
| T. aardeenskioldii | - | - | - | - | - | 5819 | 2723 | 4395 | 193 | 242 | - |
| TOTAL (Centrics) | 1582 | 2239 | 25815 | 17620 | 9506 | 70075 | 32932 | 36515 | 7084 | 10065 | 7086 |
| PENNATE DIATOMS | | | | | | | | | | | |
| Asterionella blaakeleyi | - | - | - | - | - | - | - | - | - | 81 | - |
| Licmophora sp | - | - | - | - | - | - | - | - | 129 | - | - |
| Navicula sp | - | - | - | - | - | - | - | - | 64 | - | 90 |
| Nitzschia delicatissima | 222 | - | 221122 | 59455 | 16056 | 5313 | 1021 | 2029 | 902 | 1369 | 987 |
| N. longissima | - | 84 | 3174 | 1081 | 493 | 126 | 170 | 112 | - | 161 | 269 |
| N. seriata | 247 | 316 | - | - | - | 5945 | 4340 | 2704 | 1288 | 886 | 628 |
| Thalassiothrix longissima | 25 | - | - | - | - | - | - | - | - | - | - |
| TOTAL (Pennates) | 494 | 400 | 224296 | 60536 | 16549 | 11384 | 5531 | 4845 | 2383 | 2497 | 1974 |
| GRAND TOTAL (C+P) | 2076 | 2639 | 250111 | 78156 | 26055 | 81459 | 38463 | 41360 | 9467 | 12562 | 9060 |

Note: Numbers represent cells/lt.

Table 1 (Continued).

| | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|
| Sampling time: | Jul.86 | Jul.86 | Jul.86 | Sep.86 | Sep.86 | Sep.86 | Jan.87 | Jan.87 | Jan.87 |
| Depth (m): | 10 | 20 | 30 | 10 | 20 | 30 | 10 | 20 | 30 |
| CENTRIC DIATOMS | | | | | | | | | |
| Cerataulina bergonii | - | - | - | 6900 | 8722 | 5060 | 1375 | 2760 | 2300 |
| C. decipiens | - | - | - | 450 | - | - | - | - | - |
| C. didymus | - | - | - | 690 | 1150 | 1150 | - | 455 | 920 |
| C. excentricus | - | - | - | 1150 | 2830 | 920 | - | - | - |
| Ditylium brightwellii | - | - | - | 230 | 710 | 910 | - | - | - |
| Guinardia flaccida | - | - | - | 225 | - | - | - | - | - |
| R. alata gracillima | - | - | - | 435 | - | 225 | - | - | - |
| Rhizosolenia calcaravis | 1357 | 1178 | 150 | - | 240 | - | - | - | - |
| R. setigera | - | 110 | - | 2485 | 11886 | 1610 | - | - | - |
| Skeletonema costatum | - | - | - | 2760 | 4010 | 7590 | - | - | - |
| Thalassiosira decipiens | - | - | - | 470 | 470 | 1400 | - | - | - |
| T. nordenskioldii | - | - | - | - | 1175 | 1380 | - | - | - |
| T. polychorda | - | - | - | - | - | 220 | - | - | - |
| TOTAL (Centrics) | 1357 | 1288 | 150 | 13555 | 21193 | 20456 | 1375 | 3215 | 3220 |
| PENNATE DIATOMS | | | | | | | | | |
| Asterionella bleakeleyi | - | - | 30 | - | - | - | - | - | - |
| Nitzschia delicatissima | - | - | - | 1165 | 1415 | 2760 | 685 | - | 230 |
| N. longissima | - | - | - | - | 235 | 215 | - | 210 | - |
| N. seriata | - | - | - | 460 | 1180 | 1200 | 700 | 435 | 910 |
| TOTAL (Pennates) | - | - | 30 | 1625 | 2830 | 4175 | 1385 | 645 | 1140 |
| GRAND TOTAL (C+P) | 1357 | 1288 | 180 | 15180 | 24023 | 24631 | 2760 | 3860 | 4360 |

Note: Numbers represent cells/lt.

lauderi (4795 cells/l) *Rhizosolenia setigera* (4160 cells/l) and *Nitzschia longissima* (1583 cells/l). Numbers based on the averages of the counts performed at 3 depths.

For the distribution patterns of obtained net flora among the:

*Constants* were *Rhizosolenia setigera* and *Nitzschia delicatissima* and *Vernal-serotinal* species was *Asterionella bleakeleyi*. For the *Hiemal* species, dominant in winter were *Nitzschia delicatissima* and *Chaetoceros decipiens* being the most numerous and widely distributed species. In addition to these two *Chaetoceros lauderi*, *Rhizosolenia setigera*, and *Nitzschia longissima* were the other species of decreasing importance.

In addition to the foregoing classification, *Chaetoceros affinis*, *Chaetoceros densus*, *C. curvisetus*, *Coscinodiscus centralis*, *Rhizosolenia fragilissima*, *Rhizosolenia hebetata* and *Thalassiothrix longissima* can be given among the *Autumnal* species.

Collection of a year round data on the armoured dinoflagellate *Ceratium* revealed that blooming time of this genera imitates that of the Sea of Marmara being less numerous. Maximum values were obtained in January 1986 as 1301500 cells/$m^3$ at 20 m depth. Towards the late summer an increase in the *Ceratium* abundancy was observed.

In the case of *Noctiluca miliaris* the highest recorded level so far in Golden Horn during the study period was $1313*10^2$ cells/$m^3$ at 10 m depth in July 1986 where they were almost found to be lacking in March 1986. Both *Noctiluca* and *Ceratium* occured to some extent throughout the year in Golden Horn.

For the evaluation of species structure in a community three species diversity indices have been utilized. Computations were based mainly on the bimonthly distribution of diatom species within certain depths (Table 2) and in the whole water column sampled (10 to 30 m depth) (Table 3).

Table 2. Variations in the three species diversity indices namely Margalef's species richness diversity (D) Pielou's evenness function (F) and in Shannon - Wiener diversity index (H') utilizing diatom species lists obtained for each sampling depth in Golden Horn.

| Time | Depth (m) | F | H' | D |
|---|---|---|---|---|
| Sep. 1985 | 10-30 | 0.92 | 2.30 | 1.44 |
| Nov. 1985 | 10-30 | 1.24 | 3.26 | 1.65 |
| Jan. 1986 | 10 | 0.33 | 0.76 | 0.72 |
| Jan. 1986 | 20 | 0.57 | 1.30 | 0.80 |
| Jan. 1986 | 30 | 0.67 | 1.61 | 0.98 |
| Mar. 1986 | 10 | 1.02 | 2.35 | 0.80 |
| Mar. 1986 | 20 | 1.08 | 2.48 | 0.85 |
| Mar. 1986 | 30 | 0.94 | 2.17 | 0.85 |
| May. 1986 | 10 | 1.11 | 2.65 | 1.09 |
| May. 1986 | 20 | 0.97 | 2.42 | 1.17 |
| May. 1986 | 30 | 0.97 | 2.23 | 0.99 |
| Jul. 1986 | 10 | 0.00 | 0.00 | 0.00 |
| Jul. 1986 | 20 | 0.61 | 0.42 | 0.14 |
| Jul. 1986 | 30 | 0.94 | 0.65 | 0.19 |
| Sep. 1986 | 10 | 1.05 | 2.62 | 1.14 |
| Sep. 1986 | 20 | 1.16 | 2.88 | 1.09 |
| Sep. 1986 | 30 | 1.18 | 3.03 | 1.19 |
| Jan. 1987 | 10 | 1.37 | 1.50 | 0.25 |
| Jan. 1987 | 20 | 0.93 | 1.29 | 0.36 |
| Jan. 1987 | 30 | 1.19 | 1.66 | 0.36 |

Species richness (D) was found to be low at 10 m depth (0.72) and a bit higher (0.8) at 20 m and highest (0.98) at 30 m depth in January 1986. Species richness was found relatively low at 10m layer throughout the sampling period.

Both the species richness (D) and species diversity (H') were found to be relatively high in November 1985 (1.65-3.26) and in September 1986 (1.51-3.01) likewise, the proportional representation (F) was also found to be relatively high (1.24-1.08). Lowest values were found in July 1986 (D = 0.29, H'=0.32 and F=0.29) period. This phenomenon is simply emerged from the fact that apportionment of total diatom cells among the total species is not fairly uniform.

Table 3 . Variations in the three species diversity indices in the whole water column in Golden Horn.

| Time | Depth (m) | F | H' | D |
|---|---|---|---|---|
| Sep. 1985 | 10-30 | 0.92 | 2.30 | 1.44 |
| Nov. 1985 | 10-30 | 1.24 | 3.26 | 1.65 |
| Jan. 1986 | 10-30 | 0.38 | 1.03 | 1.20 |
| Mar. 1986 | 10-30 | 1.03 | 2.37 | 0.83 |
| May. 1986 | 10-30 | 0.96 | 2.59 | 1.51 |
| Jul. 1986 | 10-30 | 0.29 | 0.32 | 0.29 |
| Sep. 1986 | 10-30 | 1.08 | 3.01 | 1.51 |
| Jan. 1987 | 10-30 | 1.05 | 1.69 | 0.49 |

Golden Horn possessed great fluctuations in the diatom species lists obtained for each depth in different time periods (Table 4).

Table 4. Similarity between the diatom species lists obtained for each depth in different time periods in Golden Horn.

| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .18 | .22 | .22 | .21 | .16 | .16 | .16 | .15 | .14 | .16 | .08 | .17 | .08 | .2 | .2 | .19 | .15 | .07 | .14 | 1 |
| | .33 | .33 | .47 | .33 | .33 | .33 | .32 | .37 | .33 | .07 | .14 | .07 | .44 | .44 | .42 | .06 | .2 | .13 | 2 |
| | | .54 | .4 | .25 | .25 | .25 | .24 | .29 | .33 | .1 | .2 | .09 | .29 | .29 | .28 | .08 | .08 | .08 | 3 |
| | | | .62 | .25 | .25 | .25 | .24 | .29 | .33 | .1 | .2 | .09 | .29 | .38 | .28 | .08 | .08 | .08 | 4 |
| | | | | .31 | .31 | .31 | .22 | .28 | .31 | - | .08 | - | .44 | .35 | .41 | .08 | .15 | .15 | 5 |
| | | | | | 1 | 1 | .31 | .47 | .54 | - | .09 | - | .47 | .69 | .64 | .18 | .27 | .27 | 6 |
| | | | | | | 1 | .31 | .47 | .54 | - | .09 | - | .47 | .69 | .64 | .18 | .27 | .27 | 7 |
| | | | | | | | .31 | .47 | .54 | - | .09 | - | .47 | .69 | .64 | .18 | .27 | .27 | 8 |
| | | | | | | | | .44 | .5 | .09 | .08 | .08 | .35 | .44 | .33 | .27 | .15 | .25 | 9 |
| | | | | | | | | | .57 | .08 | .08 | .17 | .41 | .6 | .47 | .23 | .23 | .23 | 10 |
| | | | | | | | | | | - | .09 | - | .57 | .57 | .53 | .35 | .27 | .27 | 11 |
| | | | | | | | | | | | .5 | .5 | - | .08 | - | - | - | - | 12 |
| | | | | | | | | | | | | .33 | .08 | .17 | .67 | - | - | - | 13 |
| | | | | | | | | | | | | | - | .88 | - | - | - | - | 14 |
| | | | | | | | | | | | | | | .6 | .67 | .25 | .23 | .33 | 15 |
| | | | | | | | | | | | | | | | .39 | .25 | .33 | .33 | 16 |
| | | | | | | | | | | | | | | | | .23 | .31 | .31 | 17 |
| | | | | | | | | | | | | | | | | | .4 | .75 | 18 |
| | | | | | | | | | | | | | | | | | | .6 | 19 |

Numbers through 1 to 20 each corresponding to a certain depth and time period (see Table 1) were compared with each other to observe variations in the repetition of diatom species with depth within consecutive sampling periods in Golden Horn. Maximum levels of similarity were obtained in March 1986 between the depths of 10-20-30 m (Jacc. coeff.= 1.0) respectively, and in September 1986 between 10-20 m (Jacc. coeff.=0.6) 10-30 m (Jacc. coeff.= 0.67) and between 20-30 m Jacc. coeff.=0.79).

## ZOOPLANKTON

Individuals of different zooplankton groups formed by *Chaetognaths Appendicularians, Copepods, Polychaete larvae, Cladocerans* and *Siphonophores*

were enumerated at each depth and station. Bimonthly distribution and percent composition of different groups of zooplankton are given in Figure 3 and in Table 5, respectively.

Table 5. Percentage distribution of zooplankton groups at 10, 20 and 30 m depths in Golden Horn.

| 10 meters | Sep.85 | Nov.85 | Jan.86 | Mar.86 | May.86 | Jul.86 |
|---|---|---|---|---|---|---|
| Chaetognatha | 1.73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.74 |
| Appendicularia | 6.07 | 22.14 | 0.97 | 0.00 | 3.96 | 3.16 |
| Cladocera | 5.55 | 0.26 | 0.28 | 0.00 | 20.79 | 0.74 |
| Polychaeta larvae | 20.80 | 24.74 | 1.17 | 49.41 | 11.88 | 24.35 |
| Copepoda | 65.86 | 52.86 | 97.58 | 50.59 | 63.37 | 71.00 |
| Siphonophora | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **20 meters** | | | | | | |
| Chaetognatha | 0.00 | 0.00 | 0.45 | 0.00 | 0.00 | 0.00 |
| Appendicularia | 10.84 | 16.11 | 1.34 | 0.00 | 7.69 | 3.57 |
| Cladocera | 1.36 | 0.37 | 0.90 | 0.00 | 6.41 | 15.94 |
| Polychaeta larvae | 47.97 | 31.09 | 26.91 | 46.15 | 10.26 | 29.12 |
| Copepoda | 39.84 | 52.43 | 70.40 | 53.85 | 75.64 | 51.37 |
| Siphonophora | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **30 meters** | | | | | | |
| Chaetognatha | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Appendicularia | - | 0.41 | 0.00 | 0.00 | 0.02 | 0.00 |
| Cladocera | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Polychaeta larvae | - | 54.25 | 87.95 | 99.81 | 99.74 | 95.16 |
| Copepoda | - | 45.34 | 12.05 | 0.19 | 0.24 | 4.84 |
| Siphonophora | - | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Among the selected group of organisms, Copepods represent the major group down to 20 m depth in Golden Horn. In the case of 30 m level, the picture was just the reverse where dominancy of *Polychaeta larvae* over *Copepoda* was observed. levels of pollution and widely exist at the bottom layers of Golden Horn. It is also indicated by UNSAL (1987) that the number of *Polychaets* increases in enormous numbers during spring. This was also apparent from the plankton dry weight measurements where higher biomass measurements were obtained in March and May 1986 both indicating rapid increase in reproduction rate of *Polychaeta larvae* at the bottom layers. Besides this *Siphonophores* disappeared totally in the whole water column.

The ratio of copepods to the remaining zooplankton groups attained its maximum in January 1986 (97.58 %) at a depth of 10 m and reduced to minimum (50.59 %) in March 1986. At 30 m depth, highest ratio was found in November 1985 (45.34 %) and lowest again in March 1986 (0.19 %).

The highest recorded zooplankton level for the upper 10 m layer was 72400 indv./$m^3$ in January 1986 and lowest 4250 indv./$m^3$ in March 1986. The maximum number of individuals at 20 m depth has been obtained in September 1985 as 18450 indv./$m^3$ and minimum once again in March 1986 as 3900 indv./$m^3$.

For the detection of possible factors responsible for the vertical distribution of zooplanktonic organisms, correlation analysis was made

utilizing temperature, salinity and DO data obtained for each plankton sampling depth. Significant inverse relationships were observed between zooplankton abundance versus temperature and salinity (Table 6). In addition to these two, significant positive relationship was also established between zooplankton abundance versus DO in September 1985 and negative correlation in March 1986.

Table 6. Relationships between zooplankton abundance and physical parameters with depth in Golden Horn.

| Time | Variables $Y_1$ | $Y_2$ | N | $r_s$ values |
|---|---|---|---|---|
| Sep.1985 | Zooplankton | Temperature | 8 | -0.452 |
| Sep.1985 | " | Salinity | 8 | 0.280 |
| Sep.1985 | " | DO | 8 | 0.762* |
| Nov.1985 | " | Temperature | 12 | -0.350 |
| Nov.1985 | " | Salinity | 12 | -0.343 |
| Jan.1986 | " | Temperature | 12 | -0.965** |
| Jan.1986 | " | Salinity | 12 | -0.902** |
| Mar.1986 | " | Temperature | 12 | 0.386 |
| Mar.1986 | " | Salinity | 12 | 0.308 |
| Mar.1986 | " | DO | 12 | -0.622* |
| May.1986 | " | Temperature | 12 | 0.170 |
| May.1986 | " | Salinity | 12 | -0.090 |
| May.1986 | " | DO | 12 | 0.220 |
| Jul.1986 | " | Temperature | 12 | 0.498 |
| Jul.1986 | " | Salinity | 12 | -0.538 |
| Jul.1986 | " | DO | 12 | -0.075 |

** $r_s$ significant at P.01.
* $r_s$ significant at P.05.

ACKNOWLEDGEMENT

I would like to express my deep gratitude to Assoc. Prof. Dr. Mustafa UNSAL under whose supervision this study was carried out, for his ready advice and helpful criticisms. My sincere appreciations are also due to Assoc. Prof. Dr. Ferit BINGEL for his guidance and helpful suggestions throughout the study.

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