Food Webs in the Gulf of Trieste (Northern Adriatic Sea)

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Food webs identified in the Gulf of Trieste (Northern Adriatic Sea) are described from March 1986 to March 1990.

A long term monitoring project of plankton communities has been conducted in the Gulf of Trieste since 1970 (FONDA UMANI, 1991). Structure and temporal trend of phyto- microzoo- and netzoo-plankton communities are described from March 1986 to March 1990 based on biweekly or monthly sampling in a hydrological station 200 m offshore Miramare. Phyto- and microzoo-plankton were sampled by Niskin bottles at four levels (0, 5, 10 and 15 m), while netzooplankton by vertical hauls from the bottom (15 m) to the surface with a WP 2 net (200 µm mesh size). Data of phyto- and microzooplankton are reported as average of the whole water column.

The phytoplankton community included microflagellates, diatoms and dinoflagellates. The most abundant fraction was represented by microflagellates (Chlorophyceae, Prymnesiophyceae, Prasinophyceae, Euglenophyceae, Chrysophyceae and Cryptophyceae) throughout the period from March 1986 to February 1987. Diatoms were significant in spring and autumn, while dinoflagellates are always scarce (fig. 1). The microzooplankton community was constituted mainly by ciliates other than tintinnids throughout the year, tintinnids prevailing in winter and micrometazoa in spring, while other protozoa were very scarce (CABRINI *et al.*, 1989) (fig.2). Netzooplankton was dominated by neritic copepods in all seasons with the exception of summer when cladocerans (mainly *Penilia avirostris*) prevailed. The meroplankton fraction was more abundant during the spring while other holoplanktonic organisms such as chaetognaths, tunicates, etc. had low densities. We distinguished the netzooplankton in four trophic categories (TIMONIN, 1971; RAYMONT, 1983) : herbivores, fine filter feeders, mixed feeders and carnivores. The first was represented mostly by copepods which were more abundant in summer, the second was constituted by *P. avirostris* and tunicates and was prevalent at the end of the summer.

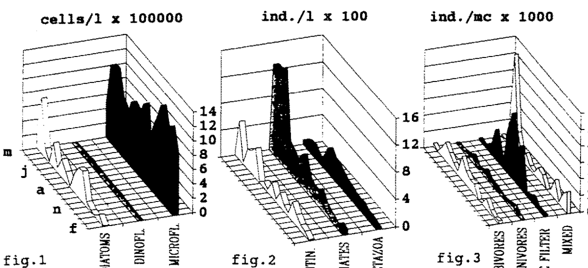

fig.1 fig.2 fig.3

The third, mainly formed by *Acartia clausi*, was dominant in spring, while the fourth (*Podon* spp., *Oncaea* spp., *Sagitta* spp., etc.) was very scarce (fig.3).

The microzooplankton fraction was supported by nanoplankton (ranging from 2 to 10 µm), mainly constituted by microflagellates. In particular, ciliates other than tintinnids seemed to be related with this fraction (fig.4). In fact the increase of nanoplankton was followed by an increase in aloricate ciliates one week later, whereas three or four months later micrometazoa and fine filter feeders substituted as consumers the aloricate ciliates. These latter two fractions seemed to be less efficient in grazing nanoplankton, which reached another maximum in autumn-winter.

Diatoms were grazed by herbivores, but by mixed feeders too (fig.5). Following the spring diatom bloom, an increase of both these components occured about one month later. An opposite trend seemed to occur for diatoms and their consumers, very similar to the preypredator model. Also between herbivores and mixed feeders an opposite trend was evident and, when diatoms decreased, herbivores were substituted by mixed feeders, which can feed on other trophic sources i.e. detritus.

In the second and the third year the microzooplankton fraction diminished and consequently the nanoplankton one increased; diatoms were quite constant, even if a winter maximum was observed. This shift may have determined a variation in the appearance of herbivores; an increase of carnivores was evident and this fact may have influenced the microzooplankton decrease.

We can therefore distinguish two different food webs : the first, supported by nanoplankton is the fastest one and determines the high values of ciliates found throughout the year in the Gulf and the summer abundance of fine filter feeders. The second is supported mainly by diatoms, is the slowest one and influences the temporal trend of herbivores and mixed feeders. Carnivores mostly follow the pattern for herbivore (fig.3), but may be influenced by the microzooplankton trend.

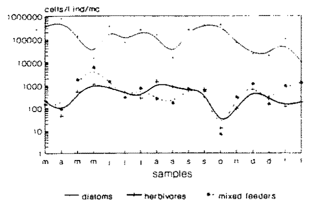

fig.4

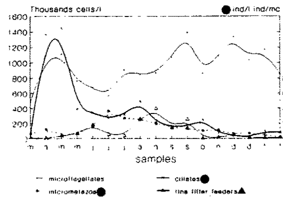

fig.5

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Nutrient and chlorophyll a concentrations in Gruz and Mali Ston Bays (Southern Adriatic)

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Nutrient and chlorophyll a concentrations were measured at two stations in Gruz (N 42°52', E 17°40') and Mali Ston (N 42°40', E 18°05') Bays, during the period February 1988 to February 1989. Secchi disk transparency, temperature, salinity and dissolved oxygen were also measured. All parameters were determined by standard oceanographic methods (STRICKLAND and PARSONS, 1972).

The Station Gruz (25 m maximum depth), is located in the Dubrovnik Harbour in the Gruz Bay, influenced by the open sea waters. The river Ombla estuary provides major quantities of fresh water to the area. The Mali Ston Bay (Usko Station, 12 m maximum depth) is a scarcely inhabited and unpolluted area favouring oyster and mussel farming. Its major eutrophication sources are dense vegetation, water from the river Neretva at the outher part of the Bay and submarine springs in the inner part of the Bay.

This paper establishes whether within the parameters investigated during the research period, there exist significant differences between these Bays. Annual range, arithmetic mean and modal class (range of the most frequent values), standard deviation and Student's t-test P-values of all the measured parameters are presented in Table 1. Low surface salinity values (26.55×10^{-3}-28.31×10^{-3}) were caused by strong precipitation in both bays. The strongest vertical salinity gradient occurred most frequently in the 0-5 m layer in the Gruz Bay ($2 \times 10^{-3} m^{-1}$) and 0-4 m layer in the Mali Ston Bay ($1.8 \times 10^{-3} m^{-1}$). Maximum annual temperature values were recorded at the surface and ranged between 10. 71°C in March and 26.15°C in July, in the Gruz Bay; and 9.51°C in January and 26.83°C in July in the Mali Ston Bay. Winter isothermy occurred in November after a fast cooling of the surface layer which had begun in October. Inverse stratification was recorded during the period December-April. The warming of the surface layer began in May. Thermic stratification of the water column was most pronounced between June and August. In both bays, mixing processes within the water column alternate with stratification. Modal class for Secchi disc transparency was 5.0-6.0 m in the Gruz Bay and 7.5-8.5 m in the Mali Ston Bay. Both bays were well oxygenated. Most frequent oxygen saturation ranged from 1.0-1.1 in the Gruz Bay and 1.0-1.2 in the Mali Ston Bay. Annual alternations between autotrophic, heterotrophic and regenerative phases affect the oxygen saturation level and the nutrient salts concentration throughout the water column. The highest concentration values of nitrates, reactive phosphorus and reactive silicate were recorded in the surface layer, which is in accordance with the maximum fresh water influx. The modal class of nutrient concentrations was higher in the Gruz Bay than the Mali Ston Bay. The N/P ratio modal class in the Gruz Bay ranged from 1-4, whereas in the Mali Ston Bay from 8-16. According to REDFIELD et al. (1963), N/P ratio of 16 is utilized by phytoplankton in forming organic matter. In this study, values between 10 and 40 may be considered as the range which promote phytoplankton growth. A 10-32 ratio was recorded in the Mali Ston Bay through most of the year, which indicates that the Bay is an ecologically stable area. In the Gruz Bay these values were recorded between November and April whereas in 40% of the cases, N/P ratio was below 10, which indicated a large inflow of phosphorus rich sewage waters. Modal class of chlorophyll a concentration ranged from 0.4-0.6 µg/l in the Gruz Bay, and 0.5-1.0 µg/l in the Mali Ston Bay. Maximum chlorophyll a concentrations (Fig. 1) were mostly recorded at the surface and to 5 m depth in the Gruz Bay, whereas in the Mali Ston Bay at 4-8 m depth which is in accordance with the nitracline and optimal N/P ratio. Relatively lower chlorophyll a concentrations in the Gruz Bay might be result of stronger surface currents and dispersion of phytoplankton populations. According to Student's t-test, statistically significant differences were observed to exist between the Gruz Bay and the Mali Ston Bay in ammonia, reactive phosphorus and chlorophyll a concentrations. Considering the results we concluded the existence of different eutrophication levels. The Mali Ston Bay is a stable, naturally eutrophicated ecosystem, whereas in the Gruz Bay, anthropogenous eutrophication prevails.

Table 1 Physical-chemical characteristics of the seawater in the Gruz and Mali Ston Bays

	GRUZ BAY (n=40)				MALI STON BAY (n=82)				
	Range	Mean	SD	Modal class	Range	Mean	SD	Modal class	P-values
z_s/m	3.0 -13.0	5.9	2.08	5.0 - 6.0	5.0 - 9.0	7.2	1.8	7.5 - 8.5	<0.001
t/°C	10.72-26.15	17.36	4.09	12.0 -16.0	9.51-26.83	16.67	4.62	12.0 -14.0	<0.001
$S \times 10^3$	26.55-38.69	37.21	2.67	37.5 -38.5	28.31-38.69	36.75	2.08	37.0 -38.0	<0.001
γ/kg/m³	19.50-28.68	26.75	2.04	27.0 -28.0	18.50-28.86	26.8[illegible]	2.25	27.0 -28.0	NS
O_2/O_2'	0.75- 1.36	1.06	0.26	1.0 - 1.1	0.86- 1.32	1.09	0.10	1.0 - 1.2	<0.001
$c(NH_4)$/µmol/l	0.01- 4.25	0.63	0.79	0.20- 0.40	0.01- 3.98	0.71	0.73	0.01- 0.20	<0.05
$c(NO_2)$/µmol/l	0.03- 0.25	0.09	0.04	0.08- 0.12	0.01- 1.11	0.15	0.25	0.02- 0.04	NS
$c(NO_3)$/µmol/l	0.04-21.90	2.25	4.66	0.01- 0.40	0.01- 9.73	0.97	1.54	0.01- 0.20	NS
$c(PO_4)$/µmol/l	0.01- 2.26	0.27	0.48	0.02- 0.10	0.01- 0.33	0.09	0.06	0.05- 0.07	<0.01
$c(SiO_4)$/µmol/l	0.44-13.08	3.21	2.57	2.00- 3.00	0.21- 7.15	2.93	1.77	1.50- 2.50	NS
N/P	0.97-47.46	16.63	12.64	1.00- 4.00	2.00-74.00	24.88	22.93	8.00-16.00	-
chl a/µg/l	0.22- 6.15	0.89	1.02	0.40- 0.60	0.21- 6.73	1.47	1.54	0.50- 1.0	<0.05

SD-standard deviation, NS-not significant, P-values (Student's t-test)

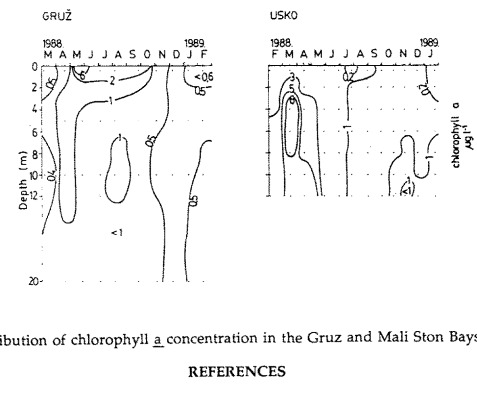

Fig. 1 Distribution of chlorophyll a concentration in the Gruz and Mali Ston Bays

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