

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 outer 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 ($2 \times 10^{-3} \text{m}^{-1}$) and 0-4 m layer in the Mali Ston Bay ($1.8 \times 10^{-3} \text{m}^{-1}$). 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 disk 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)				P-values
	Range	Mean	SD	Modal class	Range	Mean	SD	Modal class	
<i>z</i> / <i>m</i>	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
<i>t</i> / <i>°C</i>	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
<i>S</i> / <i>10³</i>	26.55-28.69	27.21	2.67	37.5-38.5	28.31-38.69	36.75	2.08	37.0-38.0	<0.001
<i>ρ</i> / <i>kg/m³</i>	19.50-28.68	26.75	2.04	27.0-28.0	18.50-28.86	26.55	2.25	27.0-28.0	NS
<i>O₂</i> / <i>O₂</i>	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
<i>c</i> (<i>NH₄</i>)/ <i>µmol/l</i>	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
<i>c</i> (<i>NO₃</i>)/ <i>µmol/l</i>	0.03-0.25	0.09	0.04	0.09-0.12	0.01-1.11	0.15	0.25	0.02-0.04	NS
<i>c</i> (<i>NO₂</i>)/ <i>µmol/l</i>	0.04-21.90	2.25	4.06	0.01-0.40	0.01-9.73	0.97	1.54	0.01-0.20	NS
<i>c</i> (<i>PO₄</i>)/ <i>µmol/l</i>	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
<i>c</i> (<i>SiO₄</i>)/ <i>µmol/l</i>	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
<i>N/P</i>	0.97-47.46	16.63	12.64	1.00-4.00	2.00-74.00	24.88	22.93	8.00-16.00	-
<i>chl a</i> /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)

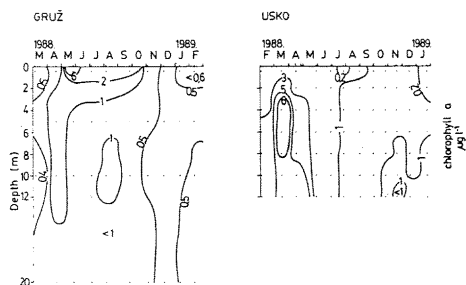


Fig. 1 Distribution of chlorophyll *a* concentration in the Gruz and Mali Ston Bays

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