EUTROPHICATION ASSESSMENT BASED ON PHYTOPLANKTON COMMUNITY ANALYSIS

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Although multivariate methods based on nutrient and chlorophyll concentrations have been widely used for eutrophication assessment (KARYDIS, 1992), few efforts have been made for the evaluation of water quality based on phytoplankton community analysis (CLARKE, 1993). In the present work, a number of scaling methods and resemblance measures were tested, in order to maximize the discrimination between an eutrophic and an oligotrophic system. Water samples were collected from February 1992 to May 1993, on a monthly basis, from two stations, M1 and M2, in the strait of Lesvos. The first one was sampled at 1, 5 and 10 m (experimental units A), while the other was sampled at 1, 5, 10, 20 and 30 m (experimental units B). M1 and M2 were characterized as eutrophic and oligotrophic respectively, in previous work (KARADANELLI *et al.*, 1992). A mean abundance was calculated for each species, during summer (May-October) and winter (November-April), dividing the original data-set into two subsets (summer and winter); the three sampling depths of station M1 and five of station M2 formed the eight columns of the data matrix. Numerical classification of the eight sampling units was performed by the group-average clustering algorithm, based on euclidean and absolute distances and Bray-Curtis similarity measure, since they have shown efficiency in discriminating polluted sites (KARYDIS, 1992; SIOKOU-FRANGOU & PAPATHANASSIOU, 1991). Data scaling was also applied, using metric (no scaling) and binary scaling. Values of species abundance exceeding the mean value of a sample were expressed by the state 1, otherwise state 0. Elimination of the data matrices was also performed, excluding species which occurred in the sampling units less than 10 times annually. Two clusters were formed, a eutrophic and an oligotrophic, and the differences between them, were tested by the non-parametric randomization test ANOSIM (CLARKE & GREEN, 1988). The results are presented in Table 1. Phytoplanktonic community data showed good resolution between the eutrophic and oligotrophic sites in most of the cases. It was observed that the discrimination was better when the rare species were excluded, which supports the view that these species add noise to the signal carried by the phytoplanktonic community structure. The resolution between the eutrophic and oligotrophic sites was almost the same, either using metric or binary scaling; similar classification trends were shown by both euclidean and absolute distances. The best discrimination, both in the summer and winter period, was achieved using the Bray-Curtis coefficient of resemblance, on the reduced data matrix with no scaling of the original values (Figure 1).

	Metric	Binary
I. Summer period		
A. Species elimination. all species considered		
	Scales	
B.C.	0.797*	0.345
E.D.	0.705*	0.698*
A.D.	0.673*	0.698*
B. Species elimination: rare species excluded		
	Scales	
B.C.	0.806*	0.286
E.D.	0.721*	0.906*
A.D.	0.673*	0.906*
II. Winter period		
A. Species elimination: all species considered		
	Scales	
B.C.	0.894*	0.400
E.D.	0.667*	0.523*
A.D.	0.667*	0.523*
B. Species elimination: rare species excluded		
	Scales	
B.C.	0.903*	0.318
E.D.	0.667*	0.670*
A.D.	0.667*	0.670*

Tab. 1. ANOSIM test significance levels for differences between clusters (B.C. Bray-Curtis similarity measure, E.D. and A.D. euclidean and absolute distances, respectively).
** Statistically different clusters at the 0.05 probability level..*

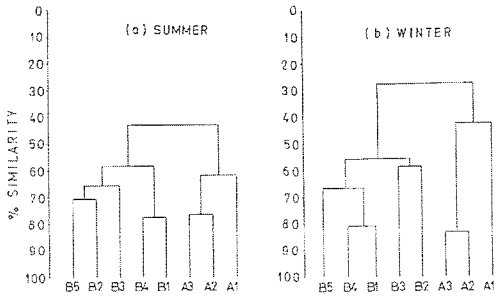

Fig.1. Dendrograms for group average clustering of the reduced data matrix with the Bray-Curtis coefficient in summer (a) and winter (b) period; (A1, A2, A3 and B1, B2, B3, B4, B5, represent different depths of the eutrophic and oligotrophic stations, respectively).

Numerical classification by the group average clustering algorithm, based on phytoplanktonic community data seems to be an efficient method to assess water quality. As a conclusion, the following stepwise procedure is proposed: a) reduction of the original data matrix by removing the rare species, b) no scaling of the original data values, c) use of the Bray-Curtis coefficient of resemblance, d) identification of distinct groups of sites with objectivity by the non-parametric randomization test ANOSIM.

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THE PHYTOPLANKTON CYCLE IN THE SOUTH-WEST OF THE MAJORCAN SHELF (BALEARIC ISLANDS) : SEASONAL DISTRIBUTION

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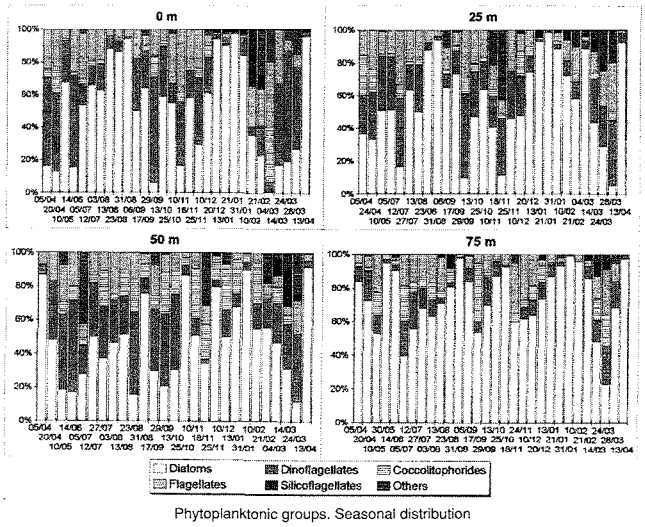
The purpose of this paper is to show the phytoplanktonic results of the HERCULE project planktonic study carried out at a sampling station situated in the southwest of Mallorca Island (39°28'59 N; 2°25'63 E). Samples were collected every 10 days approximately from a station 75 m depth and 5 miles off the coast, between April 1993 and April 1994. The main aim of this paper is to describe seasonal variation of the phytoplankton communities, nevertheless other oceanographic parameters have been studied and related as temperature, salinity, nutrients and chlorophyll "*a*" pigment. The phytoplankton samples were collected using a hydrographical bottle (Niskin 5 l) at 0, 15, 25, 50 and 75 m depth. The collected organisms were fixed in a 2% formaldehyde solution. The method used is the Utermöhl method (SOURNIA, 1978). However, it only shows the data corresponding to 0, 25,50 and 75 m depth.

During the year of our study the surface temperature varied from 26°7 C in August to 13°5 C in February, observing from May to November a strong thermocline between 20 and 40 m depth. Salinity values ranged from 36.5‰ in September to 38.0‰ in February. The higher values of -NO3 appeared during spring and autumn, with the exception of the bottom where higher values were found all year round. Furthermore a single maximum chlorophyll "*a*" was seen in January (1.11 mg/m^3), in relation to higher numbers of phytoplankton cells. The highest diversity (upper to 3.0-3.5 Bits) was common during the year of our study. The cellular abundance was reduced considerably throughout the year. The highest cellular concentrations were reached at the deepest level (75 m, they never exceeded 70 cells/ml). In the upper levels the amounts range between 4-40 cells/ml, excepting the surface layer where we found higher values (65 cells/ml in January, in relation to large colonial species of genus: *Chaetoceros, Thalassiothrix, Rhizosolenia, Bacteriastrum* and *Nitzschia*).

The colonial diatoms are the main phytoplanktonic group; it was during winter that higher concentrations appeared (occasionally up to 90% of community). *Nitzschia pungens, Nitzschia fraudulenta* and *Thalassiothrix frauenfeldii* dominate among the pennates. *Leptocylindrus danicus, Rhizosolenia stolterfothii, Rh. fragilissima* and great quantity of species of genus *Chaetoceros* dominate among the centrics (mainly during spring and winter). In summer a maximum of colonial diatom *L. danicus* was observed in the water column (values ranging from 18 cells/ml in surface to 50 cells/ml in the bottom layer). The diatoms are more than 85% of all the individuals observed throughout the year at the deepest level; similar situations have been observed in other nearby areas of the Mediterranean sea (MARGALEF, 1989). Dinoflagellates present important percentages at the surface levels (values ranging between 15-60% of the total community) reaching their highest diversity and abundances at the beginning of the summer and the middle of autumn. Usually they coincide with the periods of smaller cellular concentration (abundances around to 4-10 cells/ml). Several species of the genus *Oxytoxum, Ceratium* and *Alexandrium* are constantly present throughout the year. The rare noctilucal *Kofoidinium velelloides* appears frequently in the depth as was noted by other authors (BALECH, 1988). A lot of cyst forms of dinoflagellates appear at depths of 50 and 70 m, sometimes difficult to recognize. Coccolithophorids and silicoflagellates reach their maximum at the deepest levels. *Calciosolenia murrayi, Discosphaera tubifera* and *Rhabdosphaera clavigera* are common at these levels, particularly the first one, at times reaching 15% of the species present. The most abundant silicoflagellate is *Dyctiocha fibula* mostly during winter (at the surface, values of 15% of the community total are reached).

Finally the presence of species of different groups (cyanophytes, cryptomonadals, etc.) occurs occasionally, but it is not strange to find them at the 50 and 75 m levels. The genus Synechocystis reaches important abundances during the winter months at the 50 m level, and the genus Spirulina regularly appears at the 75 m level.



Phytoplanktonic groups. Seasonal distribution

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