# PHYTOPLANKTON COMMUNITY SIMILARITY INDICES: A NEW METHODOLOGY FOR DETECTING EUTROPHICATION TRENDS IN COASTAL MARINE ECOSYSTEMS

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**Abstract**

Four similarity indices based on phytoplankton community structure were examined for their sensitivity to assess different levels of eutrophication. Two phytoplankton data sets, one from an open coastal system and one from a semi-enclosed gulf, associated with different nutrient dynamics and circulation patterns were used for evaluating the indices. The results have indicated that similarity indices, measuring interspecific association and resemblance of phytoplankton communities between discharged areas and control sites, were effective for detecting spatial and temporal dissimilarities in coastal marine ecosystems.

*Keywords: Eutrophication, phytoplankton, coastal waters, Aegean Sea.*

The changes in phytoplankton communities that can be used for water quality assessment depend on the initial structure of the community and its response to exogenous stress factors [1]. Consequently, the development of analytical procedures for the study of phytoplankton community structure should take into account both the significance of the baseline information collected from unimpacted (control) sites and the divergence between these reference levels and data from affected areas. The main objective of the present work was the evaluation of the effectiveness of four similarity indices, measuring interspecific association and resemblance of phytoplankton communities between polluted and control sites, in order to generate a sensitive methodology that detects eutrophic trends and classifies properly different pollution levels.

**Study areas**

The first study area was the gulf of Gera, Island of Lesvos, Greece, a semi-enclosed water body surrounded by an intensively cultivated and inhabited watershed. The experimental procedure and further details concerning ecosystem's properties have been described elsewhere [2]. Data collection was based on seventeen cruises that were carried out on a monthly basis from June 1996 to October 1997. Samples have been collected from eight sampling stations [GG1] to [GG8], that are shown in Figure 1; six stations [GG3]-[GG8] were located inside the gulf, whereas the rest two were situated in the entrance (station [GG2]) and outside of the gulf (station [GG1]), the latter used as control site. The second data collection was carried out on a monthly basis during May 1983-April 1984 at ten stations (Fig. 1) situated along the coastal area of the city of Rhodes, Island of Rhodes, Greece, as detailed described in a previous paper [3]. Stations [RH3], [RH4] and [RH5] were located in the vicinity of harbours, defining the upper eutrophication limits in the area. Two stations ([RH7] and [RH9]) located about one mile offshore (in an area with intense circulation and depth greater than 200 m) were chosen as the control sites (the baseline information of the system); the remaining stations were spaced out nearshore used for swimming and other recreational activities.

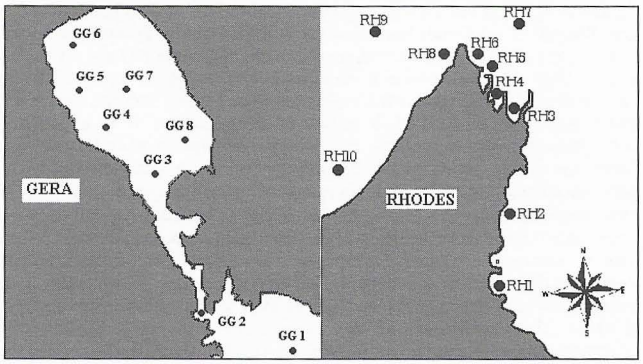


**Figure 1. The gulf of Gera and the coastal area of the city of Rhodes: station locations.**

**Phytoplankton community similarity indices.**

Four similarity indices, quantifying the contribution of each species to the total phytoplankton biomass, were used as estimators of the resemblance among discharged areas and control sites. These similarity indices were [4]:

(1) Ruzicka's index :

$$SI_{RU} = \frac{\sum_i \min(x_i, y_i)}{\sum_i x_i + \sum_i y_i - \sum_i \min(x_i, y_i)}$$

(2) Canberra metric :

$$SI_{CA} = \sum_i \left[ \frac{|x_i - y_i|}{(x_i + y_i)} \right]$$

(3) Ellenberg's index :

$$SI_{EL} = \frac{\sum_{i \in T} \min(x_i + y_i)}{2.\sum_{i \in U} x_i + 2.\sum_{i \in V} y_i - \sum_{i \in T} (x_i + y_i)}$$

(4) Bray-Curtis' index :

$$SI_{BC} = \frac{\sum_i |x_i - y_i|}{\sum_i (x_i + y_i)}$$

where $x_i$, $y_i$ the abundances of the ith phytoplankton species in the two sampling sites, T the subset of species occurring in both samples, U and V those occurring in one or other only. These indices represent wider categories of resemblance measures, varying in terms of a) the assigned priorities in the deviations among the abundant (i.e. Ruzicka's index) and rare (i.e. Camberra metric) species or b) the different (i.e. Ellenberg's index) or the same (Bray-Curtis' index) processing of the common and non-common subcategories. Cluster analysis was applied for each index to study the grouping of the stations. The Euclidean distance was used as a similarity measure and the group average distance was chosen as the clustering algorithm, since this clustering technique introduces relatively little distortion to the relationships between stations.

**Results and discussion**

The application of the similarity indices in the specific areas, which in fact implies the comparison of the discharged stations in terms of their resemblances to the control sites, is illustrated in Figure 2. This representation involves the classification results derived from Ellenberg's, index, but analogous inferences could be extracted from the rest similarity measures. It can be seen that the internal stations of Gera have formed two distinct groups: the group of the stations [GG5], [GG6], [GG7] located at the northwestern part of the gulf and the group of the stations [GG3], [GG4], [GG8] characterizing the southeastern spatial compartment of the area, whereas the station [GG2] at the entrance of the gulf exposed a discrete performance of its phytoplankton community. This clear-cut grouping of the internal stations is attributed mostly to the differences of the nutrient discharges from the respective segments of the watershed in combination with the circulation pattern of the gulf that leads to an inadequate renewal of the seawater of the inner parts, especially during the periods of limited exchanges with the open sea. In a similar way, the classification patterns of the coastal area of Rhodes indicated a clear distinction between polluted sites [RH3], [RH4], [RH5] near the harbour and the sites used for swimming and other recreational activities [RH1], [RH2], [RH6], [RH8], [RH10] which were clumped into a single group at a mean level of 40 to 50 % of similarity. Conclusively, the similarity indices, as measures of the deviations among affected and control sites, seem to be a sensitive methodology for water characterization that enables the generation of rational hypotheses concerning spatial dissimilarities in the structure of phytoplankton communities.

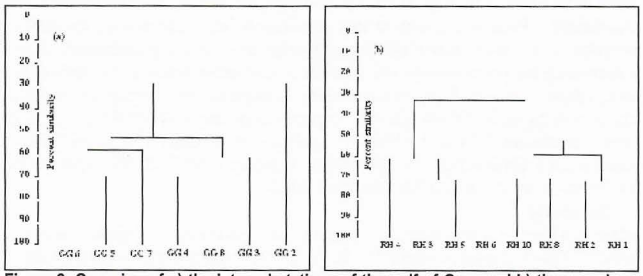


**Figure 2. Grouping of a) the internal stations of the gulf of Gera and b) the nearshore stations of Rhodes. The resemblance measure among the stations and the reference site was Ellenberg's index.**

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