Round Table on Indicator species in marine phytoplankton

II. Background presentation

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Resume

Especes indicatrices du phytoplancton marin

Le sujet relatif aux espèces indicatrices appartenant au phytoplancton marin est abordé sous différents aspects qui sont rappelés dans la présentation liminaire. Le volume des connaissances concernant la distribution spatiale et globale des principaux groupes de phytoplancton conduit à la nécessité d'une redéfinition de ce que doit être une bonne espèce indicatrice. Bien qu'il existe un consensus pour l'utilisation de certaines espèces qui sont considérées comme des indicatrices dignes de confiance, il apparaît, des arguments présentés à la table ronde, qu'il est préférable d'utiliser dans ce but des associations phytoplanctoniques plutôt que les espèces considérées isolement.

Abstract

The topic of indicator species in marine phytoplankton is discussed under several topics outlined in the preamble of the presentation. The mass of evidence regarding the spatial and global distribution of the major groups of

phytoplankton points to the need to redefine the very notion of what a good indicator species is as applied to phytoplankton. While a consensus seems to exist on the use of certain phytoplankton species as fairly reliable indicators of water masses, it appears, particularly following the discussions at the Round Table, that it is preferable to use phytoplankton associations rather than individual species for this purpose.

The general subject of indicator species in Mediterranean plankton was dealt with extensively during a symposium devoted to this topic (C.I.E.S.M., 1970). However, as in other parts of the world, the main stress during that symposium was put on indicator species derived from among zooplankton groups, primarily chaetognaths, pteropods and copepods. The few contributions dealing with phytoplankton dealt with distribution aspects in the western and eastern basins of the Mediterranean and the Black Sea.

The need to apply some of the accepted principles of the notion of indicator species to phytoplankton components at the community and species levels arose from numerous instances in which the same species was described as abundant or even dominant under clearly different and at times divergent environmental conditions. For this reason it was thought desirable to discuss the problems of phytoplankton distribution under several important headings and to see to what extent the concept of indicator species can serve as a useful tool in their relationship to known properties of the water masses (see Part I of this presentation: topics for discussion).

It would be very difficult to encompass in a review paper all of the significant contributions relevant to the subject of indicator species in marine plankton not only from the world oceans but even from the Mediterranean Sea alone. However, within the framework of the list of topics in the attached document, it was thought desirable to redefine some of the principles applicable to indicator species as outlined so brilliantly by Furnestin (1970) in her opening address of the C.I.E.S.M. Symposium on this topic (1970).

"The concept of indicator organisms is borne out of the joint study of certain planktonic organisms in relation to the environmental characteristics of a given area. Only those species should be retained as indicators which do not show any degree of tolerance to changing environmental conditions, which have a definite habitat, a predictable reaction to changes in the environment and a well defined distribution pattern." In pursuing this line of approach to the concept of indicator species, the same author (Furnestin, 1966) drew attention to the gear and procedures in sampling operations in order to avoid selectivity bias such as could be caused by certain plankton nets which might tend to favour one group at the expense of another.

To these basic principles applying to the concept of indicator species, Sverdrup et al. (1970) added a few more grounds for caution when attempting to find meaningful correlations between the organism and its reaction to and dependence on the environment.

a. A correct identification of the species or variety involved.

b. Satisfactory knowledge of the propagative and sterile distribution of the organism.

c. Developmental stages in the life history of the species concerned.

d. Ecological adjustment: to what extent an organism would tend to undergo vertical migration in order to obtain optimal conditions for its existence at certain times of the year.

Although Sverdrup et al. (1970) applied these considerations to marine animals, they can be equally applied to phytoplankton components of the pelagic ecosystem. Thus, for example, the well known phenomenon of the sinking of winter epipelagic organisms to deeper levels during the summer must be kept distinct from the concept of a shade flora, which envisages the existence of phytoplankton species showing a pronounced tolerance or even preference for oligotrophic conditions (Jorgensen, 1920; Kimor, 1971; Kimor and Wood, 1975; Sournia, 1982).

Let us first consider the concept of neritic versus oceanic species in regard to the larger phytoplankton such as the relatively large dinoflagellate and diatom taxa. On the one hand we may note such species as Skeletonema costatum, Prorocentrum balticum and P. micans as shallow water forms (Smayda, 1958). Due to their wide range of distribution, they may be described as cosmopolitan, eurythermal and euryhaline species. By contrast, the centric diatom Planktoniella sol, normally encountered in offshore waters, is described as circumtropical and stenohaline. However, the latter species is very common in the Gulf of Aqaba even at a distance of a few hundred meters from the coast, due to the steep incline of the continental shelf prevailing in that particular body of water (Kimor, 1972). This shows that the widely accepted concept of indicator species as related to proximity or distance from continental coastlines is not without exception. In the same context, Smayda (1958) points out that while a considerable number of coastal species among the diatoms produce resting spores, this is not true of such inshore species as Asterionella glacialis (japonica), Guinardia flaccida, Skeletonema costatum and Thalassionema nitzschioides. In his view, the use of the terms neritic and oceanic for phytoplankton should be supplemented by more precise ecological groupings of species in one province or another.

A similar approach in regard to nano phytoplankton and especially coccolithophorids in terms of their being useful as indicator forms for oceanic environments and marginal seas has been applied in recent years by Okada and Hongo (1973, 1975) and Okada and McIntyre (1979).

The ecology of marine planktonic diatoms has recently been reviewed by Guillard and Kilham (1977). These authors refer also to the aspect of seasonal succession in marine phytoplankton as an extremely complex physiological phenomenon. In their view contemporary scientists have focused their research on such community properties as primary productivity, biomass, chlorophyll a content and particle concentration and not on intricate biological properties of the organisms which actually make up the community.

In the eastern Mediterranean the Rhizosolenia-Bacteriastrum association is characteristic of what are considered as nutrient-poor waters. Thus, species such as Rhizosolenia calcar avis and Hemiaulus hauckii, considered by Margalef (1962, 1967) as characteristic of stratified nutrient-poor waters, are among the most common components of the oligotrophic waters of this marine environment. According to Ignatiades (1969), R. alata, H. hauckii and Chaetoceros decipiens remain in the plankton after the spring diatom bloom. On the other hand, the ubiquitous Nitzschia seriata is found, often in bloom condition, both in the highly oligotrophic waters of the eastern Mediterranean as well as in the eutrophic waters of the Adriatic Sea (Pucher-Petkovic, 1966). Biological associations of diatoms with blue-green algae and diatoms with protozoa are considered to be an additional characteristic of oligotrophic waters (Guillard and Kilham, 1977). This is the case with the well known association of Rhizosolenia spp. with the cyanobacterial cytobiont Richelia intracellularis common in tropical and subtropical waters. According to Venrick (1974), certain diatoms such as Hemiaulus hauckii, normally occurring in low concentrations, show marked increase in abundance when R. intracellularis reaches bloom condition, presumably due to the ability of the latter species to perform molecular nitrogen fixation.

Other associations commonly reported in oligotrophic waters involve oceanic diatoms and tintinnid protozoans (Guillard and Kilham, 1977; Taylor, 1982). A typical association of this type, Chaetoceros dadayi and Tintinnus inquilinus, was frequently encountered by us in the offshore plankton of the eastern Mediterranean.

Photosynthetic cytobionts in the form of zooxanthellae associated both with acantharians and spumellarians are often very abundant in tropical and subtropical oligotrophic waters (Taylor, 1982). As such, they may constitute an important contribution to the primary productivity of such marine environments. A vivid example of such an association occurred in April 1982 where the colonial spumellarian radiolarian Sphaerozoum punctatum dominated the surface waters at all inshore and offshore stations along the Mediterranean coast of Israel during an oceanographic cruise in that region. Such occurrences are, however, ephemeral and do not constitute a predictable periodic phenomenon as is the case, at times, with seasonal diatom blooms.

The next aspect we should examine when discussing the subject of indicator species in phytoplankton is that of their spatial distribution. Are there species or species assemblages which are uniformly distributed over the whole water column in the euphotic zone as distinct from others showing a distinct epipelagic, mesopelagic or bathypelagic preference?

A review by Sournia (1982) pointed to a list of about 20 species among diatoms and dinoflagellates on which there seems to be general consensus that they are constituents of the so-called "shade flora" occurring mostly at the base of the photic zone. Prominent among them are Planktoniella sol and Gossleriella tropica among the diatoms, a number of Ceratium species among the dinoflagellates and Halosphaera viridis among the Prasinophyceae. However, Sournia emphasized the fact that there is no morphological similarity between these forms that might explain their adaptation to such limited levels of light penetration. The existence of such deep living functional autotrophs remains, therefore, largely an enigma. This is even more startling when considering the existence in the eastern Mediterranean of free living viable algal cells such as Halosphaera viridis, Ceratium carriense var. volans and C. vultur, the latter species at times in division stages at depths 500-4000 m as seen in samples from Van Dohrn type samplers and in opening and closing nets from both vertical and horizontal hauls (Wood, 1966; Kimor and Wood, 1975). The same authors also reported the presence of acantharians and radiolarians from similar depths with fluorescent zooxanthellae recorded in one of the deepest depressions of the Mediterranean Sea, east of the Island of Rhodes. While the presence of deep living viable algal cells is sparse as compared to phytoplankton abundance in the photic zone, some of them, such as the phycomata of Halosphaera viridis, can constitute a potential energy source for deep sea benthos (Wiebe et al., 1974). The subject of phytoplankton assemblages in high chlorophyll fronts in coastal waters requires further study. The phenomenon itself has been confirmed in the findings of a recent study of the biological productivity of the eastern Mediterranean (Berman et al., 1984; Dowidar, 1984). The deep chlorophyll maxima established during this study were located at 70-150 m and agree with the earlier findings of Kimor and Wood (1975), who reported phytoplankton maxima based on cell counts located at about 100 m at stations occupied during a plankton study of the eastern Mediterranean. A secondary phytoplankton maximum was reported by the same authors at about 40 m.

The composition of the phytoplankton assemblages at these deep chlorophyll maxima are not conclusive and, so far, cannot be considered exclusively characteristic of these layers. A wide variety of phytoplankton and microzooplankton components were recorded in this layer as shown by on-board examination of plankton samples derived from water pumped from those depths by the differential filtration method (Berman and Kimor, 1983) and by the Utermohl technique (1958) on preserved samples in the laboratory. The presence in these layers at times, in relatively high numbers, of the coccolithophorid *Calciosolenia murrayi* is of interest as it is typically associated with warm water oceanic environments (Reid et al., 1978). Our last consideration in the context of indicator species in phytoplankton is concerned with visitor or allochthonous forms as distinct from indigenous or autochthonous ones making up the normal phytoplankton community as defined by Smayda (1958). Such visitor species are important in the sense that they can identify intrusions into a given area of water masses with which they are associated.

In a dynamic marine environment such as the Mediterranean Sea with natural or man-made connections with adjacent seas, such intrusions of species are of particular interest and importance and affect almost the whole spectrum of marine biota. Cases of phytoplankton species considered as indicators of water masses have been reviewed by Halim (1970), Dowidar (1971), Lakkis and Lakkis (1980) and Kimor (1983), regarding intrusions of Indo-Pacific and Red Sea forms into the Mediterranean area; by Bernard and Taleb (1970) regarding Atlantic intrusions into the western basin of the Mediterranean, and by Skolka (1970) regarding penetration of Mediterranean species into the Black Sea.

Such visitor species may ultimately bring about a long lasting impact on the flora of the new environment by forming stable populations within the community. They are different from hydrographic indicator species, as in their case the determining factors affecting their distribution are basic environmental parameters, particularly light, temperature and salinity (Smayda, 1958; Furnestin, 1966). In conclusion, the whole subject of indicator species in phytoplankton is still in need of further elucidation in the light of the various aspects discussed above and of the particular characteristics of a given marine environment.

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Discussion

Dr. Sotto di Carlo raised the question of a possible confusion between the concept of indicator species as understood by phytoplanktologists and zooplanktologists.

Dr. Rampal, in her answer, stressed the difference between hydrological and ecological indicator species in marine phytoplankton. There seems to be, however, in her view, a certain overlapping in the evolution of the term in recent times. Furthermore, in reference to a comment by Dr. Ghirardelli on the importance of indicator communities as distinct from indicator species, Dr. Rampal stressed that in both cases the region must be well defined.

Dr. Ignatiades emphasized the use of ecological patterns in the behaviour of species rather than the presence or absence of such species in a given environment. Dr. Berman asked if the proportion of picoplankton relative to the larger phytoplankton could be used as an ecological indicator as to the degree of eutrophication of the water masses. In this context Dr. Tomas emphasized the need to study the picoplankton in greater detail in the Mediterranean in the light of its apparent reduction in importance in inshore waters relative to the increased biomass of net plankton.

Dr. Kimor commented further on the same topic by quoting data from recent studies on the relative importance of picoplankton versus net plankton in the inshore and offshore waters of the eastern Mediterranean.

Dr. Estrada mentioned the fact that while there was a peak in primary production at the deep chlorophyll maximum layer, light was a limiting factor and hence the amount of carbon fixed at that level was lower than at the surface. Furthermore, Dr. Estrada stressed the difficulty of extrapolating the results of phytoplankton assemblages considered as good indicators for one region to other areas.

Dr. Dowidar provided some details on the high proportion of the picoplankton fraction in the waters of the Mediterranean coast of Egypt, stressing the fact that this fraction of the phytoplankton is more common in oligotrophic waters.

In some concluding remarks, Dr. Vives mentioned that some species could be considered both as hydrological as well as ecological indicators, in accordance with the physical and chemical characteristics at a given time. However, in his view, the animal species, due to their longer life span, constitute better hydrological indicators whereas the vegetal species are better ecological indicators.