Microplankton of the Red Sea, the Gulf of Suez and the Levantine Basin of the Mediterranean

by

B. KIMOR

*Technion – Israel Institute of Technology,
Faculty of Agricultural Engineering,
Haifa 32000, Israel*

ABSTRACT

The microplankton of the Levantine Basin, the Suez Canal and the Red Sea has been studied over the years by scientists from the coastal states of the region. The groups studied included the major components of nano and net phytoplankton and the ciliates and sarcodinans of the microzooplankton. A general feature of these various taxonomic categories is the presence of a fairly large number of circumtropical and subtropical species together with a more limited number of cosmopolitan and autochthonous forms. The eastern Mediterranean, exposed to the influence of the Suez Canal for well over a century and during the past two decades to the effects of the Aswan High Dam, has revealed the gradual intrusion of microplankton biota, although not as numerous as in the case of the larger metazoans, fishes in particular. The presence of symbiotic and commensalic associations among the various microplankton components appears to be characteristic of oligotrophic seas such as the Levantine Basin and the Red Sea. The existence of one or more deep chlorophyll maximum layers has been confirmed both in inshore and offshore waters of the Levantine Basin. Most of the chlorophyll in these layers has been found to be associated with cells smaller than 3 µm, largely cyanobacteria.

Le microplancton de la mer Rouge, du golfe de Suez et du bassin Levantin de la Méditerranée

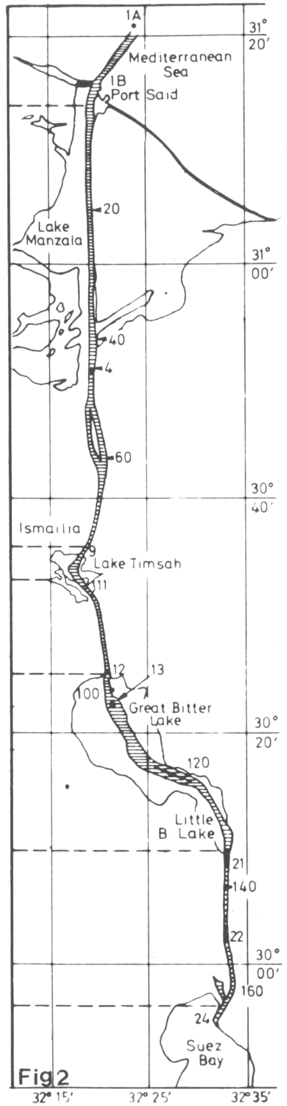
RÉSUMÉ

Le microplancton du bassin Levantin de la Méditerranée, du Canal de Suez et de la mer Rouge a été étudié pendant de nombreuses années par des chercheurs des pays riverains de la région. Les groupes étudiés comprennent les principaux composants du nano- et du phytoplancton de grande taille, ainsi que les ciliés et les sarcodiniens du microzooplancton. Une caractéristique générale de ces différentes catégories taxonomiques est la présence d'un assez grand nombre d'espèces circumtropicales et subtropicales et d'un nombre plus limité de formes cosmopolites et autochtones. La Méditerranée orientale, exposée à l'influence du Canal de Suez pendant plus d'un siècle et soumise aux effets du grand barrage d'Assouan depuis une vingtaine d'années, a révélé l'intrusion progressive d'organismes microplanctoniques, moins importante cependant que celle des groupes supérieurs, les poissons en particulier. La présence d'associations symbiotiques et commensales parmi les différents composants du microplancton semble être caractéristique des mers oligotrophes, comme le bassin Levantin et la mer Rouge. L'existence d'une ou de plusieurs couches d'eau profonde présentant un taux élevé de chlorophylle a été confirmée dans le bassin Levantin tant dans les zones côtières qu'au large. Il a été établi que la majeure partie de la chlorophylle de ces couches est associée à des cellules de taille inférieure à 3 µm, essentiellement des cyanobactéries.

INTRODUCTION

The microplankton communities considered in this contribution refer to the major groups of marine biota comprising the phytoplankton and the free-living protozoa. Sizewise they include such heterogeneous groups as the pico-, nano- and net-plankton among the primary producers, and the tintinnids, radiolarians and acantharians among the secondary producers. Given the wide size range among these microbiota, it is difficult to set a definite upper limit to their dimensions beyond stating that the method of collection was based on samples obtained by Nansen bottles, differential filtration systems [BERMAN & KIMOR, 1983] and fine mesh (65 µm) closing nets. Yet very few of the organisms exceeded the 200 µm mark considered as the upper limit for the microplankton.

Not less heterogeneous is the actual environment covered by this review (Fig. 1). On the one hand, there is the Red Sea, with particular reference to the Gulf of Aqaba, as the most northerly extension of the tropical environment with all its inherent physical, chemical and biological characteristics. On the other hand, there is the eastern Mediterranean as part of the sub-



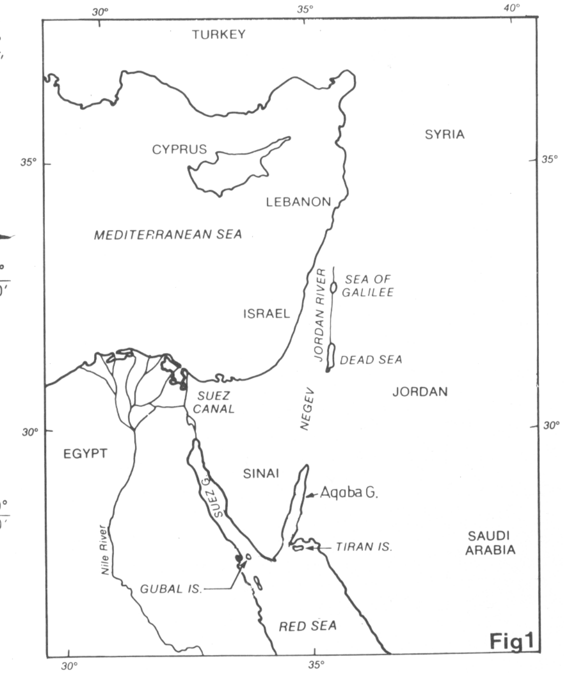


FIG. 1. - General map of the study area.

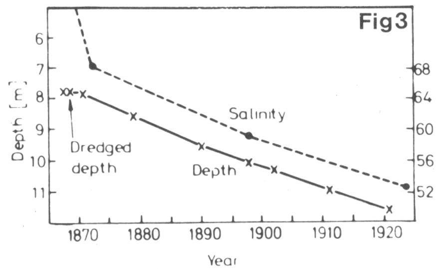


FIG. 2. - The Suez Canal.

FIG. 3. - Increasing depth and decreasing salinity of the Great Bitter Lake over the years 1872-1924.

tropical belt, yet subject to particular impacts induced by two man-made perturbations, the Suez Canal, completed in 1869, providing a link with the Red Sea (Fig. 2), and the Aswan High Dam, on the Nile, constructed a century later.

The canal itself is 162 km long and cuts through the salt bed of the dry basin of what became the Great Bitter Lake (Fig. 2). The salinity of the Lake was considerably higher at the time of the completion of the canal (Fig. 3). The salt bed started to dissolve quickly by the continuous current which was flowing mainly from Suez to the Mediterranean end of the canal at Port Said. During the first decade following the opening of the Suez Canal, this current was dominantly northward and stronger from October to June compared with the southward weak flow prevailing during July to September. This reversal of current in the canal in a southward direction was mainly due to the accumulation of the Nile water in front of Port Said during the flood season from July to September. This is accentuated by the prevailing NW wind during the season. The accumulation of this water was greatly reduced or eliminated after the stoppage of the seasonal flow of water from the Damietta branch of the Nile after the construction of the Aswan High Dam in 1965. The decrease in salinity on the salt bed (and the increase in depth of the Great Bitter Lake over the salt bed) was very noticeable during the first decades following the opening of the canal. It became slower in recent years due to several factors, including the isolation of the salt bed from the overlying water due to the accumulation of sediments from the surrounding deserts, as well as the insoluble parts of the salt bed itself. Moreover, the salt bed decreased in surface and volume with the gradual dissolution of the upper layers [MORCOS, personal communication; WÜST, 1934; MORCOS, 1960; OREN, 1969, 1970b; ARON & SMITH, 1971].

The contributions reviewed in this presentation refer primarily to the author's involvement in the various phases of research into the microbiota referred to above and that of contemporary colleagues in Israel, Egypt and Lebanon. Obviously, not all contributions could be referred to individually except in cases where specific reference was made to any particular aspect. However, the review papers mentioned in the text and included in the bibliography should enable the reader to trace the major sources of information available on the subject of this contribution.

GENERAL CHARACTERISTICS OF THE ENVIRONMENTS

Both the Levantine Basin of the Mediterranean and the northern Red Sea can be described as highly oligotrophic on the basis of data on the chlorophyll *a* values and primary productivity measurements carried out by several investigators in recent years [SOURNIA, 1977; LEVANON-SPANIER *et al.*, 1979 in the Gulf of Aqaba, Red Sea, & OREN, 1970a; BERMAN *et al.*, 1984; AZOV, 1986 in the neritic and offshore waters of the Mediterranean coast of Israel]. However, DOWIDAR [1984] estimated that the primary productivity values for the southeastern Mediterranean were about 30% higher than those

recorded off the Israeli coast, although still lower than the average level of production found in the coastal zone of the world oceans.

Following are some examples:

Primary productivity measurements

Location	*C g m^{-2} year^{-1}*	*Reference*
Tira (off Haifa)	36	OREN, 1970a
Southeastern Mediterranean	55.5	DOWIDAR, 1984

Chorophyll *a* concentrations

Location	*mg m^{-3}*	*Reference*
Levant Basin	0.024-0.076	BERMAN *et al.*, 1984
Levant Basin	0.073-0.522	AZOV, 1986
Sargasso Sea	0.05-0.10	MENZEL & RYTHER, 1960
Sargasso Sea	0.50-1.00	MENZEL & RYTHER, 1960

The low productivity of the northern Red Sea and the Levantine Basin is characterized by a great abundance of species, as is usually the case with warm water environments [HALIM, 1965; RUSSELL-HUNTER, 1970]. The high mean salinities and temperatures prevailing in the northern Red Sea and in the Levantine Basin are determining factors for these common characteristics and general floristic and faunistic affinities between the two environments.

MICROPLANKTON OF THE RED SEA WITH SPECIAL REFERENCE TO THE GULF OF AQABA

The plankton of the Red Sea in general has been reviewed by HALIM [1969] who reported *inter alia* on existing information, at the time, on the larger (net) phytoplankton and on the radiolarians and tintinnids of the microzooplankton. He stressed in particular the tropical-subtropical character of the dinoflagellate populations, which include a number of autochthonous species such as *Dinophysis caudata* f. *maris rubri*, *D. miles* f. *maris rubri* and f. *triposoides* which are not known outside the Red Sea. The systematic study of the microplankton of the Gulf of Aqaba began with the distribution and ecology of the tintinnids in the northern part of the Gulf and later in the Straits of Tiran and the Massawa regions of the Red Sea [KOMAROVSKY, 1959, 1962]. A total of 76 species of tintinnids were recorded in this study in the three regions belonging to 25 genera, only two of which are not reported from the plankton of the Levantine Basin – *Epiorella* and *Epicancella*. There are, so far, no published records of radiolarians and acantharians from the Gulf of Aqaba, although observations relating to species belonging to these groups during routine collections are quite numerous. However, the presence of *Medusetta inflata*, one of the few epipelagic phaeodarian radiolarians mentioned by HALIM [1969] from the Gulf of Suez, is noteworthy.

The seasonal distribution of the larger phytoplankton: diatoms, dinoflagellates and some cyanophytes, and of the tintinnids in the Gulf of Aqaba, were studied within the framework of a multidisciplinary project – Data Collecting Program in the Gulf of Elat (DCPE) in the mid seventies [KIMOR, 1971a, 1983a; KIMOR & GOLANDSKY, 1977; KIMOR & GOLANDSKY-BARAS, 1981; REISS & HOTTINGER, 1984]. The tintinnids were found to occupy the same niche as the diatoms and dinoflagellates within the euphotic zone, gradually decreasing with depth and reaching a peak in numerical abundance during February-March at the time of the winter overturn. The cyanophytes, represented primarily by *Trichodesmium* sp. in the upper 100 m, peaked during May-June and November at the time of the warming up and cooling down of the surface waters in the Gulf, respectively [KIMOR & GOLANDSKY, 1977].

A similar pattern in the distribution of coccolithophore assemblages as representatives of the nanoplankton was first described by MIKKELSEN [1973] in a short note and subsequently by WINTER *et al.* [1978], who found that standing crop was highest at the surface, decreasing gradually with depth. In view of the correlations found by the latter authors between the abundance of coccolithophorids and the chlorophyll *a* values, the importance of this group of nanoplankton cannot be overestimated.

MICROPLANKTON OF THE SUEZ CANAL

There are only a few reports dealing with selected groups of microplankton of the Gulf of Suez [DOWIDAR, 1974, 1976; DORGHAM, 1985] and with the general characteristics of this waterway [KIMOR, 1972; OREN, 1969, 1970b]. Most of the species are typically euryhaline, characteristic of shallow estuarine habitats as well as of hyperhaline lagoons [KIMOR, 1975]. Among the most common dinoflagellates in the plankton of the Suez Canal are *Ceratium furca* and *C. fusus,* the same species which play a leading role as primary producers in the Bardawil Lagoon.

The presence of *Ceratium egyptiacum* in the phytoplankton of the Suez Canal is significant, as it is considered a new immigrant from the Red Sea into the Levantine Basin [DOWIDAR, 1971; KIMOR, 1975].

MICROPLANKTON OF THE LEVANTINE BASIN

The microplankton of the Levantine Basin has been reviewed in a series of contributions dealing either with specific taxonomic categories or with the plankton as a whole [KIMOR & BERDUGO, 1967; KIMOR & WOOD, 1975; LAKKIS & NOVEL-LAKKIS, 1975, 1985; HALIM, 1976; KIMOR, 1983b]. These contributions include both checklists of species in the coastal and offshore waters of the eastern Mediterranean as well as particular aspects of research.

Following are some considerations of both a general and specific nature:

In so far as the microplankton communities are concerned, there is a great measure of affinity between the microbiota of the Red Sea and the Levantine Basin. This does not preclude, however, the existence of autochthonous species endemic to the Red Sea already referred to, or of species of Indo-Pacific origin of a wider geographical distribution which are absent from the plankton of the eastern Mediterranean. At the same time, over the years, several species of dinoflagellates of Red Sea origin [HALIM, 1965; ARON & SMITH, 1971; DOWIDAR, 1971; BEN-TUVIA, 1973; KIMOR, 1983b] appeared in the plankton of the coastal waters of the eastern Mediterranean along with many more species of fishes and higher invertebrates via the Suez Canal. A case in point is the commensalic association of the diatom *Chaetoceros coarctatus* and the ciliate protozoan *Vorticella microstoma,* generally considered as characteristic of tropical plankton, whose gradual appearance was found in recent times in the plankton of the Levantine Basin [KIMOR, 1983b].

The phenomenon of deep chlorophyll maxima observed at all offshore stations in the Levantine Basin was proved to be associated with the nano and picoplankton fractions of the primary producers as the dominant components [BERMAN *et al.,* 1984; DOWIDAR, 1984; KIMOR *et al.,* 1987]. A detailed analysis of the phytoplankton assemblages, both at the deep chlorophyll maxima and at the near surface layers, showed that on the basis of numerical abundance, the cells referred to as monads and thought to belong largely to cyanobacteria ($<3\mu m$), together with the nanoplankton fraction, chiefly coccolithophorids, constitute over 90% of the phytoplankton biomass [KIMOR *et al.,* 1987]. An earlier study of the plankton of the eastern Mediterranean [KIMOR & WOOD, 1975] proved the existence of two such layers of greater numerical abundance of the larger phytoplankton components, located at about 40 and 100 m at most of the stations occupied during a synoptic plankton survey of the whole Levantine Basin. A similar pattern of vertical phytoplankton distribution was recorded by KREY [1967] from the Arabian Sea.

The existence of potentially photosynthetic microalgae, consisting of dinoflagellates *(Ceratium carriense* var. *volans),* prasinophytes *(Halosphaera viridis)* as well as radiolarians and acantharians with functional fluorescent zooxanthellae, was recorded deep into the aphotic zone at two stations in the eastern Mediterranean [KIMOR, 1971b]. This suggests that potentially viable phytoplankton populations can survive and play a yet undefined role in the aphotic zone of the oceans [WOOD, 1966; KIMOR & WOOD, 1975]. This, however, is not to be confused with the well-known phenomenon of summer submergence of winter epipelagic species common among numerous dinoflagellates and free-living protozoans, which sink to deeper levels during summer with the warming up of the surface waters.

Finally, the fairly large numbers of symbiotic and commensalic associations between microplankton components such as diatoms and various blue-green algae as endophytes, diatoms with ciliates, tintinnids in particular, and actinopods with functional algal symbionts, are a common occurrence in the Mediterranean plankton as in oligotrophic warm water seas in general [TAYLOR, 1982].

CONCLUDING REMARKS

The microplankton communities of the northern Red Sea and of the Levantine Basin share a number of basic characteristics in regard to the tropical-subtropical species composition of the biota as discussed in this contribution. The high mean temperatures and salinities prevailing in the Levantine Basin of the Mediterranean, compared to its western basin, constitute an important factor in the general similarity of the microbiota of this environment as compared with that of the northern Red Sea. Yet, there are a number of limited floristic and faunistic differences between the two environments which reflect the distinctive character of the two areas, despite the existence of the Suez Canal as a connecting link for well over a century. A slow and gradual process of migration of particular microplankton components has occurred, although not on such a dramatic scale as in the case of fishes and macro-invertebrates [STEINITZ, 1967].

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A proposed vertical distribution pattern of micronekton in the deep Levantine Sea, Eastern Mediterranean, and its applicability to the Red Sea

by

HORST WEIKERT

Institut für Hydrobiologie und Fischereiwissenschaft der Universität Hamburg, D-2000 Hamburg 50, FRG

ABSTRACT

For the first time, results are presented on the numerical standing stocks, vertical distribution and composition of organisms >0.5 cm in the 4000 m water column off Crete. Most nongelatinous groups studied so far were congregated from 400 to 2000 m forming a sub-surface maximum of abundance between 450 and 900 m. Below, total numbers decreased exponentially with increasing depth. Diel migrations did not change the successive dominances of five major groups with depth. Euphausiids were conspicuous migrants. Unlike in other seas, no organisms were collected below 2250 m except small chaetognaths, which are probable contaminants, implying that a true bathypelagic fauna was absent. The impoverishment of the pelagic deep-sea fauna was paralleled by the deep benthopelagic fauna. The results on the micronekton and the vertical distribution patterns of the zooplankton in the Levantine and Red Seas are discussed. It is predicted that the vertical distribution of micronekton in the Red Sea will prove to be similar to the peculiar distribution of these organisms in the Levantine Sea.