MICROPLANKTON DISTRIBUTION PATTERNS IN THE GULF OF AQABA, RED SEA

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"Standing crop estimations of Cyanophyta, Pyrrhophyta, and Bacillariophyta of phytoplankton and of the Tintinnina of microzooplankton in several segments of the water column were determined at a reference station in the Gulf of Aqaba, Red Sea, over a one-year period. The highest numerical abundances of the leading species were recorded in the euphotic zone (200 m), gradually decreasing with depth. However, the Cyanophyta were limited to the upper 50-100 m, while the Pyrrhophyta and Bacillariophyta were more evenly distributed in the water column (600 m depth).

The two seasonal peaks caused by Cyanophyta during the cooling of the surface waters in November and their warming in May-June alternated with the major peaks of Bacillariophyta and Pyrrhophyta during February and March when relatively low homeothermic conditions prevailed in the whole water column. The Tintinnina followed closely the latter pattern, although they are known to feed chiefly on nanoplankton.

The summer months, characterized by a weakly defined thermocline located between 200-400 m, showed a low production of Bacillariophyta and Pyrrhophyta in the euphotic zone, a pattern common also to other oligotrophic marine environments such as the Sargasso Sea."

Introduction

The results presented in this contribution are based on a one-year survey of several groups of microplankton at a reference station in the northern part of the Gulf of Aqaba, designated as Station A (Figure 1). This survey was part of a multidisciplinary investigation carried out at a number of stations along the gulf, from its northern end down to its outlet into the Red Sea proper, during the years 1974-1977 under a program known as DCPE (Data Collection Program, Eilat). The program was directed and coordinated by Z. Reiss of the Department of Zoology, Hebrew University of Jerusalem (Klinker et al., 1975). It was the first time that a regular sampling program was undertaken in the gulf, covering a complete year cycle and encompassing a number of physical, chemical, and biological parameters that allow, even in its early stages of analysis, a certain measure of integration of the results. This paper covers a few selected taxonomic groups of the microplankton obtained by sampling with a 65 μm mesh net, including the Cyanophyta, Pyrrhophyta, and Bacillariophyta of phytoplankton and the Tintinnina of microzooplankton.

One of the goals of our survey was to determine whether or not there was any seasonal variation in phytoplankton abundance in the gulf. Such seasonal cycles are thought to be characteristic of temperate and cold waters in general and of neritic waters in tropical seas (Sournia, 1969). In contrast, oceanic waters in the tropics exhibit a low level of phytoplankton production throughout the year. This is due to stratification, which prevents any vertical mixing of the water, and results in a depletion or near depletion of nutrients in the photic zone (Graham, 1941). On the basis of limited available data in this field, it is difficult to establish a definite phytoplankton production pattern in tropical waters that would hold true for various regions of the world within the same latitudinal belt.

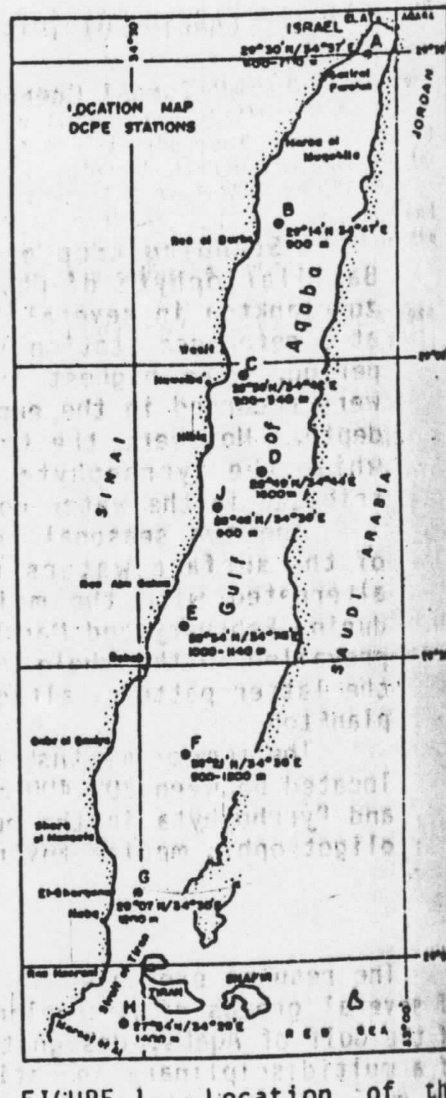

FIGURE 1. Location of the DCPE stations. Bottom depth indicated.

Review of Past Work

Halim (1969) has provided an extensive review of the plankton of the Red Sea, comprising the major taxonomic categories. He stressed the fact that in the past much more attention was given to hydrography, benthic communities, and fish than to plankton. In the Gulf of Aqaba, sporadic plankton sampling took place over the years prior to the DCPE program, and the samples were made available for examination to a number of local and foreign specialists. The pertinent reports have been published in the *Bulletin of the Sea Fisheries Research Station, Haifa*, since discontinued.

Mikkelsen (1973) studied the coccolithophorid component of the calcareous nanoplankton in the gulf. That paper listed 33 species of calcareous nanoplankton from water samples, with some notes on the seasonal variation in the composition of the flora. Among the microzooplankton components, Komarovsky (1959, 1962) studied the tintinnids in the Gulf of Aqaba and parts of the Red Sea from a taxonomic and ecological point of view. In all, 66 species of tintinnids were recorded from the Gulf of Aqaba, to which 10 more species were added from other parts of the Red Sea.

In a short contribution based on the examination of samples collected in the northern part of the gulf prior to the DCPE program (Kimor, 1971), I presented preliminary data on the seasonal and bathymetric distribution of the diatoms and dinoflagellates of the phytoplankton and of the tintinnids of the microzooplankton in the Gulf of Aqaba. When Reiss et al. (1974) studied the planktonic Foraminiferida, they found the assemblage of species dominated by spinose, shallow-water species. As with the tintinnids, the species in the Gulf of Aqaba were somewhat different from those in the main Red Sea and Gulf of Aden.

The Environment

The Gulf of Aqaba is situated in an arid zone with a high rate of evaporation. An excellent description of the circulation pattern in the gulf and its hydrological characteristics in relation to the general topography of this unique environment, with its narrow shelves and steep slopes, appears in Klinker et al. (1976). These hydrological features are probably responsible for the intermingling of neritic and oceanic species in regard to a number of taxonomic categories of plankton.

Materials and Methods

Station A, more than 600 m deep, located in the northern part of the gulf (Figure 1), was sampled at regular intervals of two to three weeks during the first year of the DCPE program, which started in June 1974. Plankton samples were collected over various depth intervals in a standard-size Villefranche-type net having a mouth diameter of 57 cm and fitted with a closing mechanism (UNESCO, 1968). The filtering part of the net was made of 65 μm mesh nylon netting.

Vertical tows in the DCPE program were carried out from 50-0 m, 100-50 m, and thereafter at intervals of 100 m down to a depth of 600 m. Descriptions of the procedures used in the preservation of the samples on board ship and their processing in the laboratory appear in our previous publications (Kimor and Golandsky, 1977; Kimor and Golandsky-Baras, 1981). A series of samples collected during 1970/71 in the area of Station A (vertical hauls over the water column from 50 and 200 m to the surface, respectively) provided material for comparison with the DCPE results in regard to the seasonal abundance and species composition of the tintinnids.

Counts were made of the individuals in a 1/100 aliquot of the sample representing 1 m of the advancing net within a given segment of the water column. In this manner, ranges of relative abundance at group and species level were established. Although these figures do not represent data of absolute abundance of individuals as cells/liter within the depth intervals, they do represent trends of distribution, which are intercomparable on a seasonal and bathymetric basis.

Results

Bathymetric Distribution

The pattern of the vertical distribution of the phytoplankton as a whole showed a general decrease in cell numbers with increasing depth. The drop in abundance was particularly obvious below 100 m, and this trend applied in general to the three taxonomic categories of phytoplankton studied in this investigation: Cyanophyta, Bacillariophyta, and Pyrrhophyta. However, the Cyanophyta -- represented in the phytoplankton by four taxa, including *Trichodesmium* sp. -- occurred mainly in the upper 50 m. This may be due to the presence of gas vacuoles in the cytoplasm of members of this algal group, which impart to them greater buoyancy in the water mass.

The bathymetric distribution of the phytoplankton in the gulf revealed at times pulses of certain species within the aphotic zone at depths ranging from 200 to 400 m. This was the case, for example, with the colonial form of the small diatom *Thalassiosira subtilis*, which showed a peak over the 300-400 m depth interval in March 1975, and with the dinoflagellate *Pyrophacus horologicum*, whose cysts occurred in high numbers during April 1975 in the 200-300 m depth interval (Figure 2).

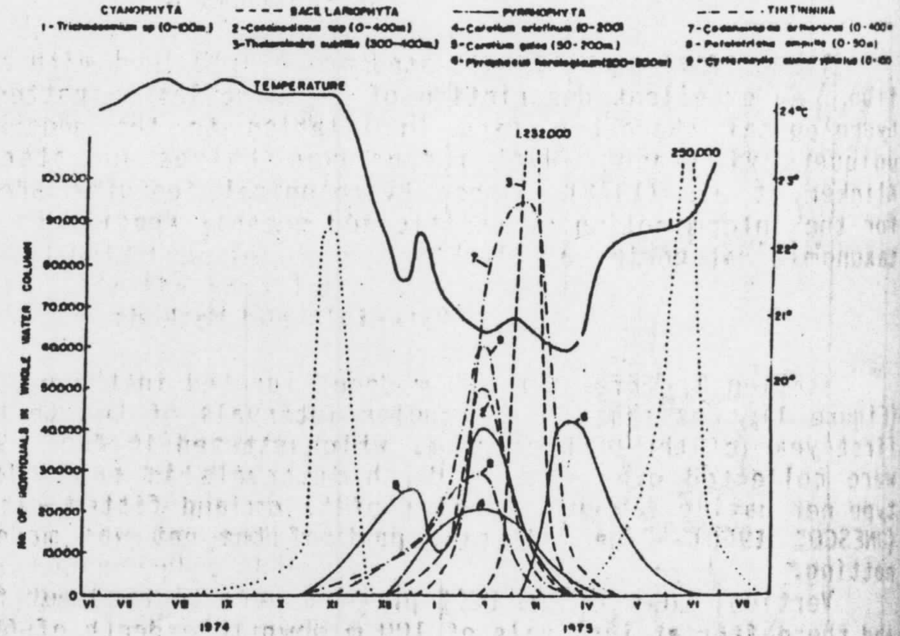

FIGURE 2. Seasonal succession and numerical abundance of the principal microplankton species in the whole water column during 1974-1975 at Station A. Highest concentrations were noted at depth intervals in parentheses in the key.

In general, the dinoflagellates in the plankton of the Gulf of Aqaba occurred at greater depths than the diatoms over the water column. The latter were largely restricted to the photic zone extending to 170 m, according to Levanon-Spanier et al. (1979). A number of species of both groups, however, occurred at times over the whole water column down to 400 m or well below the photic zone. Such species constituted the "shadow flora" in oligotrophic waters, referred to by Hasle (1959) in her study of the phytoplankton from the equatorial Pacific. A number of *Ceratium* species among the dinoflagellates, as well as *Coscinodiscus* species and *Planktoniella sol* among the diatoms, belong to this category of phytoplankton.

The same pattern of vertical distribution was evident in regard to the tintinnids. Most of the leading species were abundant in the well-illuminated 100 m of the photic zone, thereafter decreasing in numbers with depth. Aspects of nutritional dependence of the tintinnids on the smaller components of the phytoplankton were apparently responsible for the similarity in their vertical distribution, subject to temperature preferences of the leading species.

Seasonal Distribution

A salient feature in the seasonal distribution of the microplankton in the gulf was the simultaneous thriving of the diatoms, dinoflagellates, and tintinnids during February-March (Figure 2). At this time of the year, homeothermic conditions prevailed over the whole water column, with temperatures dropping close to 20°C, the lowest during the year. The blue-green algae, on the other hand, formed two main peaks in November and June, coinciding with the cooling down and warming up, respectively, of the seawater during the transition periods. The summer months were generally characterized by a low standing crop of phytoplankton and similarly low stocks of tintinnids (Figure 2).

Nutrients

According to Klinker et al. (1978), the Gulf of Aqaba is poor in essential nutrients such as nitrate and phosphate during both summer and winter. This proved particularly true in the photic zone during the winter peak of phytoplankton in 1975, when nitrate nitrogen became lower in the upper 200 m (1 μ g-at/l^{-1}) at the surface, increasing in depth (2.5 μ g-at/l^{-1}).

The two annual peaks of Cyanophyta took place at a time when the photic zone was almost devoid of inorganic nitrogen. In fact, the blue-green algae may actually have been indirectly aided in the development of their bloom by the low levels of inorganic nitrogen recorded in the surface layer, due to the ability of some species to fix atmospheric nitrogen; *Tichodesmium* species formed the bulk of these blooms. In this way these algae may have "outcompeted" forms requiring inorganic nitrogen.

Discussion and Conclusions

A distinct seasonal pattern appeared to exist in the abundance of the microplankton in the gulf. The main peak in phytoplankton abundance, consisting of diatoms and dinoflagellates, occurred in February-March, chiefly in the upper 100 m. The blue-green algae exhibited bimodal pulses at the end and onset of the stratification period during November and June, which alternate with the main phytoplankton peak in February-March.

The low phytoplankton production lasted through the summer, apparently due to depletion in nutrients of the upper water strata during the stratification period. The disappearance of the seasonal thermocline between December and March presumably increased the release of nutrient supply from the deeper strata during that season, thus favoring the development of the main annual phytoplankton peak. Riley (1957) reported a similar pattern in phytoplankton periodicity from the north-central Sargasso Sea, to which the Gulf of Aqaba seems to show a certain resemblance.

Levanon-Spanier et al. (1979) reported a similar pattern of seasonal variations in phytoplankton abundance during the monitoring of the same free-living algal groups at the same station during the years 1976 and 1977, with a conspicuous peak in February, brought about primarily by diatoms. They correlated the winter peak in phytoplankton abundance with increased chlorophyll a and primary production values during this season, as compared to oligotrophic conditions existing in the gulf during most of the year (April-November).

The coccolithophore assemblages (not considered here because their size is smaller than sampled with a 65 μ m mesh net) undoubtedly play a key role in primary production in the gulf, as shown by the quantitative and qualitative study of this group by Winter et al. (1979) at the same station. The pattern of distribution of the coccolithophores, both seasonal and bathymetric, proved generally similar to that reported for the larger phytoplankton (> 65 μ m) discussed in this paper. In this light, it seems natural for the tintinnids, as the first link in secondary production, to thrive in the same water layer and at the same time of the year as the phytoplankton groups. Although their food is known to consist of the smaller components of the phytoplankton, particularly coccolithophores and microflagellates, they may also feed on larger cells such as diatoms and peridinians (Balech, 1970; Lebour, 1922).

There seems to exist, therefore, a direct feeding relationship between phytoplankton and tintinnids in the Gulf of Aqaba. Both communities appear to occupy the same niche in the water column, chiefly the upper 100 m. However, although the vertical distribution and temporal variations of the tintinnids follow closely those of the phytoplankton, the species composition of the annual peaks differs from year to year and from season to season (Kimor and Golandsky-Baras, 1981) (Figure 3).

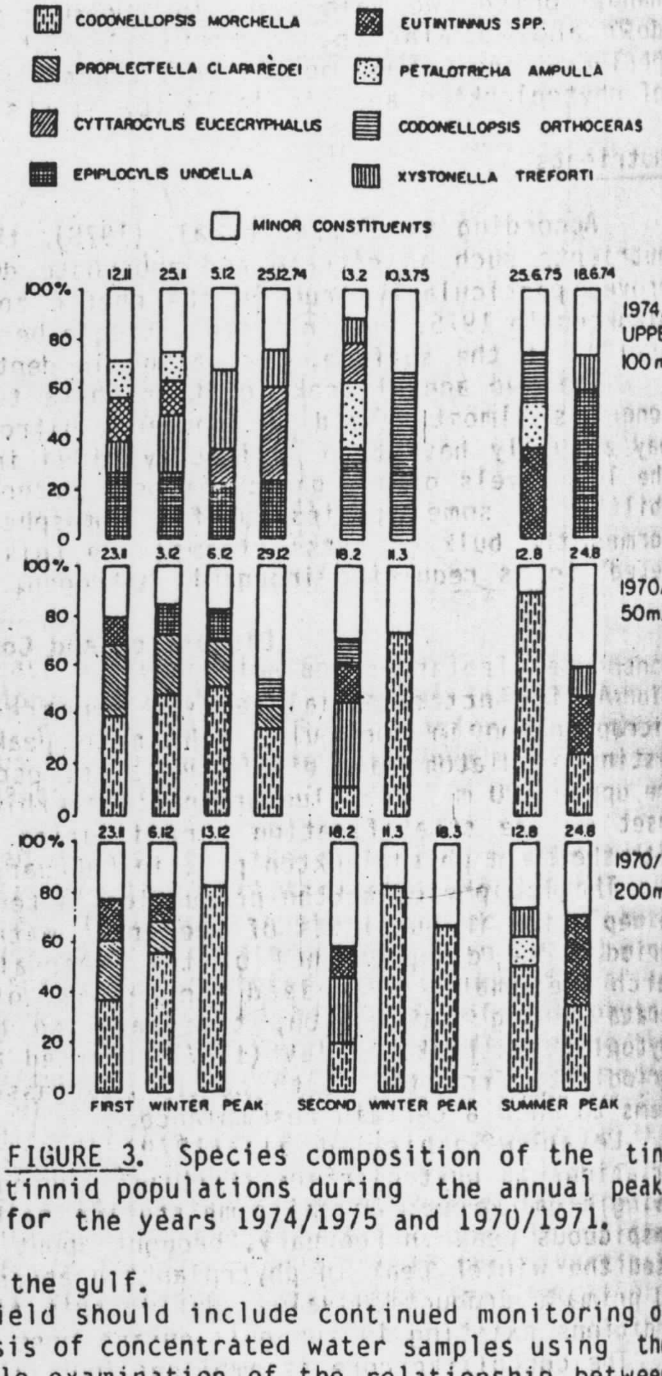

FIGURE 3. Species composition of the tintinnid populations during the annual peaks for the years 1974/1975 and 1970/1971.

On the whole, the microplankton of the Gulf of Aqaba, based on the groups studied and monitored in the course of the DCPE project, show strong affinities to areas of tropical seas with pronounced seasonal cycles. This is primarily due to the particular topography and hydrological characteristics of the gulf.

Future research work in this field should include continued monitoring of microplankton populations on the basis of concentrated water samples using the Utermöhl technique. This will enable examination of the relationship between the contribution of the nanoplankton n compared to the net plankton in the standing crops of the area. Furthermore, there should be parallel examinations of live samples from the same stations and depths with a view to establishing the potential presence of fragile organisms such as nonthecate dinoflagellates, generally not detectable in preserved samples. Such organisms, depending on their autotrophic, osmotrophic, or phagotrophic mode of nutrition, may have a marked impact on the food web in general and on the primary and lower levels of secondary production in particular.

Acknowledgments

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