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FULL LENGTH ARTICLE

Diversity of Copepoda in a Stressed Eutrophic Bay (El-Mex Bay), Alexandria, Egypt

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Abstract Seasonal abundance, biomass, and taxonomic composition of copepods in El-Mex Bay (Southeastern Mediterranean region) were studied from autumn 2011 to 2012. Most species within the copepod communities displayed a clear pattern of succession throughout the investigation period. Generally copepods were the predominant group. They contributed numerically 57% of the total zooplankton counts with an average of 5083 organisms/m^3 and a total number of 203,333 individuals. The bay harbored 50 species belonging to 28 genera within 19 families and 4 orders under one class. Calanoids were represented by 24 species which formed 31.6% of total copepods predominantly *Acartia clausi*, *Calocalanus pavo*, *Clausocalanus furcatus*, *Eucalanus crassus*, *Nannocalanus minor*, *Paracalanus parvus*, *Eucalanus subcrassus*, and *Temora longicornis*. Cyclopoids comprised 13 species of which *Acanthocyclops americanus*, *Halicyclops magniceps*, *Oithona attenuata*, and *Oithona nana* were the most abundant adult copepods. Eleven Harpacticoid species were also recorded with *Euterpina acutifrons*, *Microsetella norvegica*, *Onychocamptus mohammed* being the most prevalent. It was found however, that two Poecilostomatoida species were rarely encountered in the plankton *Oncaea minuta* and *Corycaeus typicus*. Copepod larvae and copepodite stages formed the main bulk of copepod Fauna as noticed in the El-Mex Bay during the investigation period. Their percentage was 36.7% of the total count and their total numbers were 74,629 individuals with an average of 1866 organisms/m^3. The persistent relationships between total copepod counts, copepod orders, and physico-chemical variables suggested that physical factors operate on the copepod communities, either directly to limit maximum distribution along the bay, or indirectly on abundance.

Introduction

Coastal marine areas are considered ecologically, as well as economically important and socially interesting (Calbet et al., 2001). These areas are extremely variable systems, due

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to changes in the circulation patterns of water and land fluctuations (e.g. rivers, sewage flow) which induce great temporal variability on a scale which ranges from a minimum of hours to the maximum of seasons (Walsh, 1988). Dynamics of the populations may be the result of this variability, as in planktonic forms, in particular, which thrive in coastal systems, and can hide the underlying patterns of seasonality abundance and biomass of organisms (Calbet et al., 2001).

El-Mex Bay is considered as one of the most important coastal regions in the Mediterranean Sea. It has been continuously subjected to several severe pollution problems (Dorgham, 2011 and Hendy, 2013). In spite of reducing of the industrial loads by several biological treatments and minimizing wastes from 1984 to 1995, the domestic wastes have doubled as a result of population increase in areas around the bay. That is why the load of the total discharge released into the bay had not significantly changed during this period.

Copepoda production in any natural water body is considered an equivalent to secondary producers as most of them, particularly the direct food of their larval and copepodite stages are phytoplanktons. They usually numerically and diversely outnumber other planktonic groups. Copepods, in turn contribute considerably to the food chain of many carnivores. Some fish are also largely dependent on the abundance of copepods particularly calanoids (Cushing, 1953; Cushing and Burd, 1957; Wimpenny, 1966; El-Rashidi, 1987).

Metazooplankton copepods are considered the most numerous group among the various animal species; therefore, information about their biology and physiology is key to understanding the different metazooplankton functions in the marine ecosystems (Ikeda et al., 2001).

Several studies on zooplankton abundance, composition and seasonal variations have been carried out in the coastal water of Alexandria by El-Maghraby and Halim (1965), Dowidar and El-Maghraby (1970a,b), Aboul Ezz (1975), El-Zawawy (1980), Dowidar et al.(1983), Khalil et al. (1983), Aboul Ezz et al. (1990), Aboul Ezz and Zaghloul (1990), and Abdel Aziz (1997).

The near shore waters west of Alexandria have attracted the attention of some investigators such as Hussein (1997), who studied the zooplankton standing crop and community structure in relation to the impact of waste discharge in the El-Mex Bay. Another investigator is Abdel Aziz (2000) who studied zooplankton community at the El-Dekhelah Harbor. She also studied the impact of the circulation of water and the discharge of wastes on the dynamics of zooplankton in the Alexandria Western Harbor in 2002. In 2005 she studied the short term variations in the zooplankton community in the El-Noubaria Canal (Abdel Aziz, 2005).

The characteristics of water, in relation to the populations of phytoplankton and zooplankton of El-Mex Bay and El-Umum Drain were previously studied (Soliman and Gharib, 1998; Gharib, 1998; El-Sherif, 2006; Hussein and Gharib, 2012). The results showed that, continuous discharges polluted the bay water, caused massive development of algal blooms, and gradually deteriorated the water quality, Zakaria et al. (2007) had also illustrated the effect of salinity changes and their influence on zooplankton abundance and their community structure in El-Mex Bay waters.

The distribution of copepods in the El-Mex Bay was first estimated by Dorgham (1987). Later on (Hussein, 1997) found that the zooplankton assemblages were mainly dominated by crustacean copepods. The copepods constituted 45.8% of the total zooplankton. Zakaria et al. (2007) found that in the water type ''M'' (mixed water, salinity ranged between 10‰ and 30‰) copepods constituted about 13.45% of the total zooplankton counts.

El-Mex Bay area was and still is being subjected to continuous major and drastic changes as a result of human activities. These changes are consequences of growing heavy industries (chloro-alkali plant, petrochemicals, pulp, metal plating, industrial dyes, and textiles) and of uncontrolled disposal of resulting wastes, they are also due to the huge amounts of untreated industrial wastes (Hendy, 2013) dumped in the coastal waters of the El Mex Bay. All that of course affects the ecological and biological conditions prevailing in the bay and can cause the flourishment or absence of some organisms, including zooplankters. Unfortunately, no detailed studies for the impact of environmental conditions on the distribution of zooplankton communities especially copepods along El-Mex Bay have been performed so far. Therefore, the present study is meant to deal with the distribution and relationship of copepod communities to the environmental variables in the El-Mex Bay as an important contribution to the bay biota database which is necessary in planning for optimum exploitation and sustainable development of the bay and its water resources.

Materials and methods

Study area description

El-Mex Bay is located west of the Alexandria City; it borders an industrial zone, and is one of the most densely populated cities with 6 million people (Fig. 1). The bay extends for about 7 km between longitude 29°45′ and 29°54′ E and latitude 31°07′ and 31°15′ N, from the Agami headland (west) to the Western Harbor (east). The bay occupies an area of 19.4 km^2 with a mean depth of 10 m, and water volume of 190.3×10^6 m^3. As a consequence of growing heavy industries (chloro-alkali, cement, chemicals, textile, tanneries, industrial dyes, ink, petroleum refining, meat processing, fish production, and iron or steel industries) and the uncontrolled disposal of resulting wastes, the coastal water of the El-Mex Bay receives huge amounts of untreated industrial wastes that contain heavy metals like Fe, Mn, Cu, Zn, Cd, Pb and Ni. These wastes are dumped directly into the southern part of the bay via pipelines. In addition to all that, El-Dekhelah Harbor has been recently constructed at the western side of the El-Mex Bay (Halim et al., 1995).

The bay receives about 2.547×109 $m^3\,y^{-1}$ of agricultural wastes mixed with water effluents (surplus water) from a neighboring sewage-polluted lake (Lake Mariut) with a rate of 262.8×10^6 $m^3\,y^{-1}$ via El-Umum Drain (Halim et al., 1995). The bay also receives 13×10^6 $m^3\,y^{-1}$ of industrial discharge, as well as water from the Western Harbor amounting to 1.13×10^6 $m^3\,y^{-1}$. The residence time of the El-Mex Bay water was found to be around 28 days (Halim et al., 1995). Accordingly, this bay is considered as an estuarine zone of the huge agricultural El-Umum Drain.

The seasonal variations in the current patterns in the El-Mex Bay depend mainly on the wind regime prevailing at the time. There were pronounced differences in both direction