

## Review article

### Zooplankton in Arabian Sea, India

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#### ABSTRACT

The abundance of zooplankton in marine environment has direct influence on fishery resources and it is influenced by environmental parameters such as circulatory movements (eddies) and vertical turbulent mixing. The important role of plankton including both microzooplankton and macrozooplankton in supporting life in the sea was recognized in the past, but the study related to ecology of these organisms has still recently formed as intractable aspect in marine ecosystem. Life in the sea has been broadly classified into three groups, viz., the plankton, the nekton and the benthos. The majority of the faunal assemblages of the plankton consist of zooplankton. Among the various levels of production in the sea the secondary production, i.e., production of zooplankton, attains significance as it serves as a link between primary production and tertiary production. The zooplankton chiefly consumes the primary producers and form the major food source for tertiary producers. Zooplankton plays an important role in coral reef ecosystem. They serve as food for corals, and variety of other invertebrates and reef fishes. From the fishery point of view zooplankton form food of important batfishes belonging to the families Clupeidae, Caesionidae and Apogonidae. Some fishes are exclusively zooplankton feeders and therefore their abundance is directly linked to the presence of zooplankton.

Keywords: zooplankton, oceanography, crustacean, ecology.

#### RESUMEN

La abundancia de zooplancton en el ambiente marino tiene una influencia directa en los recursos pesqueros y está influenciada por parámetros ambientales como los movimientos circulatorios (turbulencias) y la mezcla turbulenta vertical. El papel importante del plancton, incluido el microzooplancton y el macrozooplancton, en el apoyo a la vida en el mar, fue

reconocido en el pasado, pero el estudio relacionado con la ecología de estos organismos se ha formado recientemente como aspecto intratable en el ecosistema marino. La vida en el mar ha sido ampliamente clasificada en tres grupos, a saber, el plancton, el necton y el bentos. La mayoría de los conjuntos faunísticos del plancton consisten en zooplancton. Entre los diversos niveles de producción en el mar, la producción secundaria, es decir, la producción de zooplancton, alcanza importancia, ya que sirve como un enlace entre la producción primaria y la producción terciaria. El zooplancton consume principalmente los productores primarios y constituye la principal fuente de alimento para los productores terciarios. El zooplancton juega un papel importante en el ecosistema de los arrecifes de coral. Sirven como alimento para corales, y variedad de otros invertebrados y peces de arrecife. Desde el punto de vista de la pesca, el zooplancton forma alimento de importantes peces pertenecientes a las familias Clupeidae, Caesionidae y Apogonidae. Algunos peces son exclusivamente alimentadores de zooplancton y por lo tanto su abundancia está directamente relacionada con la presencia de zooplancton.

Palabras clave: zooplancton, oceanografía, crustáceos, ecología

The word plankton (Greek-drifting) introduced by Victor Hensen in 1887 distinguishes all organisms passively floating in water. They include bacterioplankton, phytoplankton and zooplankton. Zooplankton (Greek: Zoon-animal. Plankton-wandering) are animal plankton which live on the basic productivity directly or indirectly (by larger carnivore zooplankton) and are usually more than 500µm in size. Zooplankton serve as the primary consumers or secondary producers or transformers. As herbivores the zooplankton remove a part of production by grazing, and as carnivores they eliminate some of grazers also. They are broadly divided into microzooplankton (20-200µm) and macrozooplankton (200µm to 20mm). Based on life-cycle zooplankton may be classified as holoplankton or permanent plankton which include representatives of every major group of aquatic animals with the exception of sponges, bryozoans, brachiopods, ascidians and mammals. Meroplankton or temporary plankton which include eggs, larvae and juveniles of benthos and nektons, they are seasonal in occurrence and abundance and principally neritic in distribution

Many species of zooplankton are also known to be indicators of the specific water masses in which they are abundant. The appearance of *Sagitta elegans* in the North Sea is always associated with the inflow of Atlantic waters, resulting in good fishery. The association of copepods, in particular *Calanus* spp., with rich herring shoals is also worth mentioning. The

abundance of krills of the species *Euphausia superba* helps fishermen in locating baleen whales, seals and squids. Besides the above, some organisms like *sagitta setose*, *Eucalanus elongates*, *Crescis acicula*, *Diphyes* etc. serve as indicators of different water masses. In addition zooplankton play a key role in the formation of deep sea sediments. The calcareous, siliceous test and shells that contribute to the bottom sediments of the ocean floor are radiolarian, foraminifera and pteropods. The zooplankton are also used as indicator of pollution. The rotifers and some cladocerans like *Daphnia magna* are excellent materials to test aquatic toxicity.

Zooplankton is the vital link in the trophic tier of aquatic environment. In addition it is well known that the abundance and availability of plankton has direct influence on the fish population in any particular area. The study of zooplankton both in quality (Species) and quantity (biomass) reveals the productivity and also the health of the marine ecosystem. Hence it is necessary to widen our knowledge about plankton to assess the fertility of water as well as the management of the fishery resources. In temperate waters, extensive studies have been carried out on different aspects of zooplankton. Since a complete review is impossible, only recent studies are presented here. Grant (1977) reported the seasonal distribution and abundance of Chaetognatha in the lower Chesapeake Bay. Grant (1978) made elaborate surveys and studied the zooplankton in middle Atlantic Bight. Wenyullee and MC Alice (1979) investigated the sampling variability of marine zooplankton in tidal estuary. Ackefors and Lindahl (1979) studied the relationship between primary production and secondary production in the Baltic proper during 1973-76. Skryabin (1980) reported the occurrence of microzooplankton of southeast Atlantic.

Raymont (1980) observed the plankton and productivity in the Oceans. Jacob *et al.* (1980) observed the plankton and hydrology of Kuwait waters. Beers *et al.* (1980) made a detailed study on the microplankton population structure in southern California near shore waters in the spring. Smetacek (1981) studied the annual cycle of protozooplankton in the Kiel Bight. Information is available on the diurnal variation and relative abundance of planktonic larvae (Ayyakkannu, 1989), diversity of meroplankton in Palk Bay and Gulf of Mannar (Krishnamoorthy, 1997), diversity of zooplankton in the east coast of India (Maruthanayagam, 1998), meroplankton production in the Gulf of Mannar and Palk Bay on the south east coast of India (Krishnamoorthy and Subramanian, 1997) and organization of meroplankton in Palk Bay and Gulf of Mannar (Krishnamoorthy and Subramanian, 1999). Reasonable extents of information on the seasonal distribution of zooplankton from Parangipettai coastal waters are also available (Subbaraju, 1970; Krishnamurthy and Santhanam, 1975; Santhanam *et al.*, 1975 and Kumar, 1993). During 1993-95 a study was carried

out on the seasonal variations and species association of the meroplankton from Palk bay and the Gulf of Manner (Krishnamoorthy and Subramanian, 2003).

The waters along the west coast of India are well-known for their high productivity (Prasad, 1966; Prasad *et al.*, 1970; Nair *et al.*, 1973; Currie *et al.*, 1973) and fishery yield (Silas, 1969; Jones and Banerji 1973; Silas *et al.*, 1976) for a long time. A vast amount of oceanographical and biological data have been collected in these waters by the Central Marine Fisheries Research Institute ever since the year 1957 on board vessels R.V.Kalava and R.V.Varuna. Quantitative abundance of zooplankton biomass, fish eggs and fish larvae in relation to oceanographic features had been processed and discussed for a period of nearly seven years (1963-1969). Although a perfect correlation was not claimed, noticeable relationships between the correlated properties had been observed. These are presented in a series of charts and a brief write-up therein. Studies on the diurnal variation of zooplankton from the west coast of India are made by Pillai *et al.*, (1973a,b); Madhupratap, (1979); Goswami *et al.*(1979); Gajbhiye *et al.*(1984). Preliminary investigations were made on diurnal variations of some physico-chemical factors in Mandovi-Zuari estuarine system (Singbal, 1973).

The role of microzooplankton in the `food web` of aquatic environment is being increasingly realized as they are found to be fed by organisms of higher trophic levels (Santhanam *et al.*, 1975). It acts as an intermediate link between the primary producers, the phytoplankton (bacteria, naked flagellates, coccolithophores, peridinians and diatoms) and the macrozooplankton. Information on species diversity, richness, evenness and dominance evaluation on the biological components of the eco-system is essential to understand detrimental changes in environments or deterioration of water quality (Krishnamoorthy and Subramanian, 1999). Species diversity is a basic measure of community structure and organization and the most important parameter to understand the healthy status of the ecosystem. The diversity index gives a measure of how the individuals in a community are distributed. In the context of global loss of thousands of species as a result of pollution and habitat destruction, assessments of species diversity and richness are highly needed (May, 1986). Such studies assist the environment biologists to predict where and how many species go extinct so that certain effective measures may be taken to conserve them (Reise and Bartsch, 1990). While the information available on these aspects from the coast (Pillai *et al.*, 1973; Madhupratap, 1979; Goswami, 1982; Madhupratap, 1983; Goswami and Padmavathi, 1996 and Paulinose *et al.*, 1998) is fairly good, it is meager from the east coast of India (Srinivasan and Santhanam, 1991; Krishnamoorthy and Subramanian, 1999).

Monitoring of the environment is one of the vital essential steps in the process of management and it is not an end by itself. Therefore knowledge on the physico-chemical and biological features of the marine ecosystem for proper management is highly indispensable to utilize the marine environment in a better way for the welfare of the mankind. Moreover the hydrological study is pre-requisite for the assessment of potentialities and to understand the different trophic levels and food webs. In the marine environment, biotic and abiotic environmental factors have an effect on phytoplankton succession and abundance. In addition to the optimum light and nutrients which are very necessary for primary producers, some physical processes such as fronts and gyres are also very important in phyto- plankton dynamic due to their role in nutrient recycling. In entropic areas it determines the changes of water quality and makes a general evaluation of the area. Zooplankton, the secondary producers directly depend on the primary producers for their survival.

Based on a series of oceanographic investigations on the surface waters of the near-shore areas up to 18 metres off Visakhapatnam, a fairly accurate picture of their hydro-biological conditions is available (Ganapati and Sarma, 1958; Ganapati and Rao, 1958; Rao and Rao, (1962). Sivaswamy & Prasad (1990) indicated changes in water due to variation in different physico-chemical parameters and the phytoplankton population fluctuated at different seasons in the coastal waters. Ashok Prabu *et al.* (2005) studied the occurrence of heterophilic bacteria in the water and sediment samples collected from Chennai coast and found that limited fluctuation in heterotrophic bacteria occurred throughout the year on both water and sediments. It is well known that the seasonal climatic changes in the marine environment play a significant role in the ecological cycle of the Indian seas especially the Arabian Sea. Observations made over the year, point to the fact that the seasonal changes brought the premonsoon, monsoon and post-monsoon phenomena along with the resultant oceanographic changes influence the overall productivity of the region significantly. The biological productivity of the seas in this region is dependent on the complex physical, chemical and biological processes active in the medium and subsequently transferred to different trophic levels.

In India considerable works have been reported along south west coast of India (Shynamma and Balakrishnan, 1973; Sreetharan Manikoth and Mohammed Salih, 1974; Sarala Devi *et al.*, 1983; Nair *et al.*, 1984; Lakshmanan *et al.*, 1987; Balakrishnan Nair and Abdul Azis, 1987 and Nair *et al.*, 1988). In the south east coast of India the reports on dissolved nutrient are available from Burton (1970) Santhakumari (1970), Krishnamurthy (1970), Venugopalan (1971) Purusothaman and

Venugopalan (1972), Vijayalakshmi and Venugopalan (1973), Rajendran (1974), Ramanathan and Varadharajulu (1975), Thangaraj *et al.* (1979), Venugopalan *et al.*, (1981), Sivakumar (1982), Chandran and Ramamoorthy (1984b), Jegadeesan (1986), Prabhadevi (1986) Anbazhagan (1988), Upadhyay (1988), Patterson Edward (1988), and Sai Sastry and Chandramohan (1990).

Arabian Sea is one amongst the most productive regions in the world ocean and is characterized by one of the largest bodies of oxygen deficient waters on the Earth. A stable oxygen minimum zone (OMZ) exists in the northeastern Arabian Sea characterized by greater accumulation of organic matter. The organic matter is supplied to marine system from both terrestrial and marine resources. More recently, there has been considerable interest in carbon cycle in the ocean, which involves settling and burial fluxes of carbon and associated biogenic elements at discrete oceanic sites. Al. Saddi and Arndt (1973) and Al. Saddi *et al.* (1975) investigated the hydrographical condition of estuarine and marine region, Arabian Gulf. Haridas *et al.* (1973) studied the salinity, temperature, oxygen of the backwaters from Cochin to Alleppey. Bhargava *et al.* (1973) extensively studied the hydrobiology of surface waters along Panaji Bombay coast.

The hydrological parameters such as temperature, salinity, inorganic phosphate and dissolved oxygen content of sea water were studied during the year June 1977 to May 1978 at Canada India Reactor Jetty (CIRUS Jetty) in the Bombay Harbour Bay. Estimations of dissolved oxygen and inorganic phosphate were carried out by Gogate (1960) at two other locations i.e. in the Light ship and Light house. Seasonal variations in the physico – chemical and biological characteristics of the eastern Arabian Sea were studied by Pillai *et al.* (2000). Hydrographic parameters of Gulf of Mannar and Palk Bay were studied by Bindu Sulochanan and Muniyandi (2005).

Studies on the ecology of secondary producers from the east coast were made by Santhakumari 1970; Thankaraj *et al.*, 1979; Chandran, 1982; Prabha Devi, 1986; and Subramanian, 1987. The biological wealth of an aquatic system primarily depends upon the availability of plant nutrients, increased attention had been paid to study the nutrient flux in marine environment. Studies on sediment nutrient are important for understanding the extent of biological activity and fertility of overlying water column, and the status of pollution in coastal waters.

The observation on the diurnal variations in hydrographic conditions during different seasons in the Cochin harbour was made by Balakrishnan and Shynamma (1976). Rao *et al.* (1976) studied the hydrographic conditions of Cumbarjua canal, Goa. The present investigation has been made to study the distribution of nutrients such as nitrate, nitrite phosphorous and silicate at two

stations along the Palk Strait. Comprehensive accounts on the hydrographical parameters of the habitat qualitative and quantitative composition, assessment of species diversity, richness and evenness of zooplankton through seasons are not known from S.P.Pattinam and Manamelkudi along the Palk Strait of east coast of Tamil Nadu. Detailed ecological studies on zooplankton of Palk Strait are few and studies in S.P.Pattinam and Manamaelkudi coast are lacking.

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