The fact that the quality and quantity of the plankton are an index of the fertility of the oceans and the fishery potential in oceanic waters hinges upon plankton has been well recognised in temperate and boreal waters, particularly in the Atlantic and Pacific oceans. The planktonology of Indian Ocean in this regard remained relatively neglected and did not make any major strides until 1960. The concerted exploratory work by no less than 14 nations which participated in the International Indian Ocean Expedition (IIOE) 1960-1965 stimulated and imparted tremendous impetus to the efforts made to inquire into plankton and its biomass in areas of Indian Ocean bordering the South-East Asian countries resulting in voluminous literature. Principal pertinent publications in this regard, are those of Bogorov and Vinogradov (1961), Vinogradov and Voronina (1961a, 1961b), Vinogradov et al (1961), Ponomareva and Naumov (1962), Vinogradov (1962), Voronina (1962), Naumov and Ponomareva (1964), Aravindakshan (1969), Daniel and Daniel (1969), Gopalakrishnan and Brinton (1969), Jacob (1969), Menon et al (1969), Nair (1969), Peter (1969), Prasad (1969) and Sakthivel (1969). Besides the above, there have been several scientific reports on various zooplanktonic taxa of Indian Ocean provided by a number of oceanic expeditions that have passed through Indian Ocean in the earlier and latter half of the present century (Investigator, 1884 to 1927; Valdivia, 1898-1899; Siboga, 1899-1900; Dana, 1901-1903; John Murray Expedition, 1933-1934; Galathea, 1952).
A survey of the published accounts dealing with the zooplankton of the Indian seas indicates that the various aspects like qualitative and quantitative composition; biomass, density, volume studies; diurnal/vertical migrations; nutrient-plankton relations including those of phyto- and zooplankton; biodiversities; temperature - salinity - plankton (T-S-P) relations; community stability; feeding biology, trophic significance; plankton culture involving experimental aquaculture studies; ecology of zooplankton in relation to pollution; karyotype and cytotaxonomical studies of Copepoda; reproductive biology and breeding cycles; respiratory physiology and metabolism; biochemical composition and systems analysis involving modelling of zooplanktonic communities have so far, been investigated and a great deal of literature has been built up particularly over the last three decades.


The trophic significance of zooplankton is emphasised and brought to light by several research works conducted on the food and feeding habits of various species of pelagic marine and estuarine fishes and prawns. The works of Chidambaram and Menon (1945), Bal and Joshi (1956), Venkataraman (1956, 1961), Subramanyan (1959), Dhulkhed (1964), Sudarsan (1964), Panikkar and Jayaraman (1966), Mukudan (1967), Prasad (1969), George (1970a, 1970b), Mohamed (1970), Rao (1973),

Several studies have been carried out on mass culturing of different filter feeding zooplanktonic taxa by phased fertilization techniques at the laboratory and field levels in an attempt to augment zooplankton production and thereby the yield of fish and prawns feeding on them. In this regard, the works of Shirgur (1971, 1984, 1985), Shirgur and Naik (1977), Naik and Shirgur (1980a, 1980b, 1980c), Shirgur and Gadge (1981a, 1981b, 1981c), Shirgur et al (1984, 1987) and Shirgur and Pandharikar (1987) are of importance.

Interesting accounts on the biology of pollution with special reference to the zooplanktonic communities and labeling of the planktonic indicator species have of late been published. The works of Gajbhiye et al (1981a), Nair et al (1981a) and Desai et al (1982, 1983) are of relevance in this context.

In the recent years, sincere attempts have been made to investigate the cytology of planktonic taxa (particularly calanoid copepods) with reference to their karyotype and cytotaxonomy (Harding, 1950; White, 1954; Goswami and Goswami, 1972, 1973, 1974, 1978, 1979). Reproductive biology and breeding cycles of the copepods and their relation to diatom cycle are researched by Prasad and Kartha (1959). A considerable amount
of literature is built up on the respiratory physiology and metabolism of the planktonic crustacea from temperate, boreal and tropical locations. The works of Marshall and Orr (1958), Rajgopal (1962), Lasker (1966), Gauld and Subbaraju (1975) merit mentioning here.

Biochemical composition of zooplanktonic taxa to understand their metabolism, nutritive value and role in aquatic food chains have also been investigated by several authors (Raymont et al, 1966, 1967, 1968, 1969; Omori, 1969; Raymont, 1972; Gupta, 1977; Stephen et al, 1979; Goswami et al, 1981a, 1981b).

Studies on modelling and systems analysis of the zooplankton communities are of a relatively recent origin. These works are aimed at to simulate and mimic the real field situations to understand the process of change of material, mass and energy at physical, chemical and biological levels so that an efficient manipulation of the forcing functions, factorial interactions and output is possible to step up the productivity of a system and predict its behavioural patterns in the wake of ecological perturbations like pollution and over exploitation of the living and non-living resources by the humans. The works of Prasad et al (1970), Cushing (1971, 1973); Wyrtki (1971); Iyer and Devi (1977); Madhupratap (1977a) and Qasim (1977) are worth mentioning in this regard.

In spite of these highly accredited meticulous in depth researches dealing with several aspects of zooplanktonic
communities, there are vast areas of estuaries, backwaters and lagoons along the east and west coast of India still awaiting initiation of comprehensive scientific investigations to generate baseline data on the qualitative and quantitative aspects of plankton for a rational and judicious development and conservation of these highly productive and dynamic but critical and fragile ecosystems.

The results of IIOE revealed that the shallow coastal regions of India embodying abundant brackish water environs are among the richest and most productive marine areas of the world. Along the 7000 km long Indian Coast, are the estuaries and lagoons covering nearly 5,73,950 hectares (Bhimachar, 1959). The major estuarine systems are situated in the east coast at the mouths of great rivers like Brahmaputra, Ganga, Mahanadi, Godavari, Krishna and Cauveri. On the west coast of the peninsula, there are extensive systems like backwaters of Kerala, Mandovi-Zuari estuarine complex of Goa etc. Estuarine lagoons of considerable importance on the west coast include Vembanad lake in Kerala. On the east coast besides the major estuaries, the two large coastal estuarine lagoons of importance are Chilka lake (Orissa) and Pulicat lake (Andhra Pradesh – Tamilnadu).

Lagoonal environment and its biota are hydrochemically complex and ecologically unique since they are influenced by interactions between marine and terrestrial factors (Clark, 1977; Ohtake et al, 1982). They are the areas of transition
(ecotones) between fresh water and marine habitats (Clark, 1977). Brackish water lagoons subserve as the feeding and breeding grounds for a variety of commercially important fishes, molluscs, prawns, crabs etc. (Remane, 1933; Jhingran, 1963, 1982; Green, 1968; Ganapati, 1969). The significance of planktonological investigations in assessing the productive propensities of the lagoons in general, and the fish wealth in particular, are well recognised and documented (Jhingran, 1963, 1982; Odum, 1971; Wickstead, 1976).

Chilka lagoon (latitudes 19°28' and 19°54'N and longitudes 85°67'E and 85°35'E) - the largest brackish water ecosystem (1165 km² area) of the peninsular India known for supporting a rich and viable pelagic and demersal fisheries has been little investigated for its planktonology excepting for the pioneering systematic researches conducted by Sewell (1913, 1919, 1924) on the carcinological component of the zooplankton. The natural history of the lake flora and fauna was given by Annandale (1915). Tattersall (1915) carried out the systematic studies of the Mysidacea of the lagoon. Kowtal (1969) reported on the occurrence and distribution of fish eggs and larvae of Chilka lagoon. Of late, Patnaik (1988) investigated the ecology of mysids. The phytoplankton quality and quantity were researched by Patnaik and Sarkar (1976), Panigrahy (1985) and Rout (1990). Comprehensive ecologic works dealing with the qualitative and quantitative composition of zooplankton are not known from Chilka excepting for the cursory and preliminary observations made by Devasundaram and Roy (1954),
Roy (1954) and Patnaik (1973, 1986). A survey of the above papers dealing with the planktonology of Chilka reveals that the studies conducted so far are either of pure systematic nature or natural history type including preliminary observations on the qualitative and quantitative composition of plankton without any special emphasis on the species composition, species diversity; affinity or coexistence of the species; phyto- and zooplankton interrelations; temperature-salinity-plankton relations; determination of coefficients of physico-chemical and biological components and their patterns in different sectors of the lake and the composition and abundance of holo-, mero-, and ichthyoplankters in relation to fisheries of the lagoon. As such, the planktonological studies of Chilka in general, are still in their infancy leaving many lacunae in our knowledge and understanding of the planktonology of Chilka lagoon.

However, the fish and fisheries of the lagoon were well investigated and documented (Jhingran, 1958, 1963, 1982; Jhingran and Natarajan, 1965, 1966; Directorate of Fisheries, Government of Orissa, India, 1970; Kowtal, 1970; Natarajan and Patnaik, 1971). As many as 158 species of fishes and prawns have so far been recorded from Chilka.

The dominant fishes of the lake include Mullets (e.g. *Mugil cephalus*, *M. tade*, *M. subvirdis*, *M. speigleri*, *Liza troschelli*, etc.), Clupeoids (e.g. *Chanos chanos*, *Nematolosa nasus*, *Hilsa ilisa*, *Megalops cyprinoids*, *Elops saurus*,


The limnology of the lagoon dealing with the physico-chemical parameters was dealt by Sewell and Annandale (1922), Reddy (1962), Rajan (1964, 1971), Ramanadham et al (1964),

The foregoing account sufficiently demonstrates, the biocoenoses of the zooplankton, surprisingly received little or passing attention of the researchers whilst the fish and fisheries of the lagoon were elegantly researched. As such, there exists wide gaps and deficiencies in our knowledge and understanding of the zooplankton of Chilka. Of late, Chilka became a national concern as a premier wetland ecosystem in the country needing immediate ecologic conservation and protection lest the system ages and falls a victim of senescence leading to permanent closure affecting the economy and sustenance of the weaker section of the society. The Chilka fishery forms livelihood for 60,000 fishermen belonging to 114 villages in and around Chilka lake. As many as 3,000 boats are engaged in fish catching here. To start with, there were 309 fishing areas inside the lake and have been reduced to 275 now because of shrinkage and heavy siltation. Chilka is also an abode of migrating birds coming from far off places like the Himalayan ranges and Siberia. Around 93 species and 160 varieties of birds have been identified in Chilka lake. The problems of increasing shrinkage, shallowness and widespread coverage of macrophytes jointly appear to have been
causing the decline in the production of fish and prawns (i.e. 8872 tonnes of fish and prawn catch in 1986-1987 is reduced to 4273 tonnes in 1990-1991) and arrival of migratory birds (Wildlife Organisation of Forest Department, Government of Orissa, 1990; Forest and Environment Department, Government of Orissa, 1991).

The problems of siltation (thirteen million tonnes of silt per annum discharged by the rivers), spurious macrophyte growth (covering 244 km\(^2\) of the surface area) are posing a major threat to the lagoon augmenting the rate of shrinkage at the rate of 1.5 km\(^2\) per annum. According to the data available the average depth of the lake was 2.4 meters in 1921 and has been reduced to 0.51 meter - 1.6 meter in 1991 due to siltation and macrophyte growth. Further, it is being increasingly realised that the weeds are detrimental to the lake ecosystem and act as sinks of the nutrients. In the wake of these problems, at the convention of IUCN (International Union of Conservation of Nature) in 1971 under the auspices of UN organisation, Chilka lake of Orissa along with Keoladeo National Park, Bharatpur (Rajasthan) was identified and selected for conservation and management. India formally accepted this in 1981. In 1989 the State Government of Orissa submitted a project profile on Conservation and Development of Chilka lake to Canadian International Development Agency (CIDA) for international assistance and has got a clearance for such assistance in 1990. The main emphasis of the project is to
understand the ecological relationship between salinity, silt deposition, entry of sea water, growth of weeds and production of fish and other organisms in the lake. In the management of the fisheries of the lake, researches on the food chains are identified as prerequisite and mandatory. Further, the CIDA Project also highlighted the need for researches on the trophic status of varying organisms so that removal or encouragement to a given species can be resorted to in the interest of the biology of the lake. In the wake of the proposed dredging (to deepen Chilka mouth area and maintain a constant replenishment of seawater into the lake) aimed at conservation and development of Chilka, studies on the dynamic planktonic communities are heavily warranted.

In the absence of a detailed comprehensive ecologic account of the zooplanktonic communities of the lagoon, in terms of biomass production, turnover rates, biodiversities, spatial and temporal distribution patterns, correlation coefficient patterns among the biotic and abiotic factors and trophic status in relation to fisheries, essentially needed for a meaningful and purposeful monitoring and development of the living resources of Chilka, an attempt is made in the present thesis to generate a baseline data on the diverse aspects of the qualitative and quantitative composition of zooplankton of the Chilka.

The thesis begins with an introduction surveying the general marine zooplanktonological researches in Indian Ocean
in general and Indian seas, in particular, portraying the different trends of researches so far conducted. The significance and importance of the estuarine, brackishwater and backwater system and their excellence as world's most richest and productive regions are also dealt with. Special attention is paid to the varied works dealing with the pelagial planktonic communities, the benthic biocoenosis and phytal coenosis of Chilka besides the rich literature on the fish and fisheries of the lagoon. The rationale and justification for undertaking the present research and its utility in the overall management and development of Chilka is given in the introduction. Following the introduction is a detailed chapter dealing with the environmental topography and physiography describing the varied sampling sites. The prevailing atmospheric and aquatic climates are also dealt with. The methods of collection, tools used in the collection of hydrobiological samples, methods of analysis for species diversity, degree of similarity and correlation coefficient values between the biotic and abiotic parameters are described under the material and methods. Results are presented chiefly under three heads viz. (i) surface water analysis, (ii) qualitative composition and (iii) quantitative composition of zooplankton. The data obtained through seasons at different stations regarding the physico-chemical parameters, qualitative composition of zooplankton with special reference to the copepod (calanoid) species and their patterns of diversity and distribution, consistency of the species composition among the resident species of zooplanktonic copepods, biotic
similarity amongst the sampling sites and temperature - salinity - copepod (T-S-P) associations are presented under the results. The results on the quantitative composition include seasonality of the total zooplankton density, volume and biomass; holo-, mero- and ichthyoplankters; density and abundance fluctuations of varied zooplanktonic taxa with special reference to copepod (calanoid) species and the correlation coefficient ('r' values) values among the biotic and abiotic factors. The above results dealing with the community structure and fluctuations in the qualitative and quantitative composition of the zooplankton coenosis, formed the subject of discussion chapter. The discussion devoted to the qualitative composition dealt with the total zooplankton composition with special reference to the Copepoda, ecological classification and distribution of Copepoda, copepod species diversity, consistency of copepod species composition, copepod species coexistence and temperature - salinity - copepod (T-S-P) relationships at different sampling sites. Consequent to the qualitative composition the physico-chemical parameters are discussed for their correlation coefficient ('r' values) besides considering their coefficients determined in relation to total zooplankton density/total zooplankton volume/total zooplankton biomass/total copepod density and selected common copepod species. The coefficients of coexistence of copepod species found at different sampling sites of the lagoon are also discussed to further substantiate the affinities and similarities found in the qualitative composition. The quantitative ecological aspects discussed
include seasonal changes in the total zooplankton standing stocks viz. density, volume and biomass; holo-, mero- and ichthyoplankters and seasonal changes in the zooplanktonic taxa in general and Copepoda in particular. At the end of the discussion, a comparison of the standing stock values (density, volume and biomass) of zooplankton communities of the Chilka with certain selected marine, brackish and estuarine stations from other locales is attempted. It is hoped that the present research would fill up the gaps in our knowledge and understanding of qualitative and quantitative aspects of zooplankton of Chilka and pave way for sophisticated future researches dealing with systems analysis and modelling studies to help, develop and conserve the biodiversities and production of the Chilka in general and fisheries management in particular in the context of phenomenal changes ushering in as a sequel to the implementation of Chilka development Project aimed at desiltation, deweeding, dredging, deepening the entrance channel and stabilisation of the lake mouth connected with the Bay of Bengal.