SUMMARY
Indian Ocean is one of the dynamic oceans. The northern Indian Ocean is divided into two large basins, the Arabian Sea (AS) on the west and Bay of Bengal (BoB) on the east. The biological productivity in coastal waters of the AS and the BoB are largely influenced by the physical forcings that these basins are being subjected to, but in contrasting ways. The BoB receives large volumes of freshwater due to the opening of several large rivers during the summer, reducing the surface salinity which creates a highly stable barrier layer or stratification which prevents vertical mixing and supply of nutrients from deeper waters. The excess of precipitation over evaporation is another source of freshwater to the bay. The barrier persists although the late summer and the entire post-monsoon season which has a profound impact on the biological productivity of the BoB. The winds prevailing over BoB is not strong enough to break the barrier. Also, the upwelling in the BoB is confined nearer to the coast and only along the southern boundary during the summer. The BoB is generally considered to be low in biological productivity compared to the AS. This is mainly due to the fact that the nutrients brought in by the rivers are being removed in the deeper layers because of the narrow shelf of the bay.

The AS, on the other hand, experiences strong coastal upwelling during the summer monsoon, enriching the upper water column and thereby enhancing the biological productivity. Nutrient rich upwelled waters from the Somalia and Arabia coasts are also being transported to the central Arabian Sea, further giving an impetus to the biological productivity. In the AS, in contrast with the BoB, the evaporation exceeds precipitation and runoff and this results in the high surface salinities. With the winter cooling experiencing in the north, it leads to formation of high saline water masses that sink and replenishes the upper sub-surface layers. Further, the shallow and wide shelf facilitates mixing and enrichment of
nutrients, keeping the biological productivity of the coastal waters, generally high throughout the year.

Zooplankton serve as the important trophic link in the marine food chain as it transfers energy from primary producers to tertiary producers. They mostly consume the primary producers (phytoplankton) and form the major food sources for tertiary producers. They, thus convert the plant organic matter into animal organic matter and supply to higher trophic level. Therefore, they play an important role in determining the fishery potential of any region. The mesozooplankton abundance, distribution and productivity in the Indian coastal waters are influenced by many factors, particularly the monsoons, upwelling, current reversals, oxygen depletion, salinity stratification, phytoplankton bloom etc.

The published work on mesozooplankton related to food web from the Indian waters are limited. There are no comparative studies on the mesozooplankton production between the coastal waters of the east and west coasts of India with respect to prevailing ecological conditions on seasonal basis. The present study is an attempt to understand the role of environmental factors on the distribution and abundance of mesozooplankton in the coastal ecosystem so as to identify the key parameters and also to understand the interactions between the different trophic levels. The study was carried out in the coastal region of the west coast (Goa and Mangalore coasts) and the east coast (Kakinada). The study area extends geographically from latitude 15°30’00” to 73°35’00” along the Goa coast, 13°00’00” to 74°38’11” along the Mangalore coast and 16°43’00” to 82°33’00” along the Kakinada coast. Along the Goa and Mangalore coasts, three stations along one transect each were sampled, representing 30, 50 and 100 m depth contours. Along the Kakinada coast, 6 stations were sampled two each representing, 30, 50 and 100 m depth contours. Sampling along the west coast was carried out in 2004 (January, April & September) and along the east coast in 2005.
(April, September & November), representing the pre-monsoon, monsoon and post-monsoon
seasons.

The study addresses the following three major objectives:

1) To study the spatial and temporal variation in the diversity of mesozooplankton in the
coastal waters.

2) To understand the ecobiological influence on the distribution, abundance and productivity
of mesozooplankton.

3) To evaluate the interactions between different trophic levels in relation to
mesozooplankton.

Thus, the thesis presents and compares the data on the quantitative and qualitative aspects of
mesozooplankton, including group diversity, seasonal distribution and relation with respect to
physical, chemical and biological parameters in the coastal waters along the west and east
coasts of India. The highlights of the study are listed below:

- Water Temperature ranged from 19.02 to 29.6 °C along the Goa transect and 20.6 to
30.9 °C along the Mangalore transect during the study period. Vertical distribution of
temperature was relatively stable at both the transects during the pre-monsoon and
post-monsoon seasons, but during the monsoon season, a sharp decrease was
observed with depth at some stations. The lowest temperatures at both the transects
were recorded during this season which was 19.02 °C at Stn. 3 (90 m) (off Goa) and
20.6 °C at Stn. 6 (90 m) (off Mangalore).

- Water temperature along the Kakinada coast ranged from 24 to 32 °C during the study
period. A reduction with depth was observed during all the seasons, but the decrease
with depth was sharp during the pre-monsoon season. Generally, the temperature
recorded along the east coast was higher than that of the west coast, particularly during the monsoon season. The Canonical Correspondence Analysis also clearly reflected the high temperature prevailing along this coast.

- Salinity ranged from 33.4 to 36.6 psu at Goa transect and 32.9 to 36.1 psu at the Mangalore transect during the study period. Salinity was more or less stable at both the transects during the pre-monsoon season while it was low at the off Goa transect during the monsoon and the post-monsoon seasons. The overall salinity was high during the pre-monsoon season and an increase with depth was noticed during all the three seasons. Along the Mangalore transect also, the pre-monsoon and monsoon values were closely similar to that of Goa transect, but during the post-monsoon season the values recorded were relatively low compared to that of the Goa transect. This could be attributed to the influence of north-east monsoon prevailing along the east coast. Increase in salinity with depth though marginal was observed at most of the stations during all the stations.

- Salinity along the east coast was relatively lower during all the seasons compared to that of the west coast. It ranged from 22.31 to 36.1 psu during the period of study. The near-surface values were generally lower compared to the near-bottom values and during the monsoon and the post-monsoon seasons it was 3-6 psu lower than the near-bottom values. No clear seasonality in salinity distribution was observed along the coasts unlike that of the west coast.

- DO ranged from 0.23 to 5.64 ml.l\(^{-1}\) along the Goa transect and 0.17 to 4.79 ml.l\(^{-1}\) along the Mangalore transect. Seasonal variations were observed in DO concentration at both the transects. Generally well oxygenated condition was prevailing during the pre-monsoon season at both transects. However low values were observed at a few near-bottom stations. During the monsoon season although, the DO was slightly
higher at the Goa transect, most of the sub-surface and near-bottom values showed sub-oxic levels along both the transects.

- Along the Kakinada coast, DO was generally high during the pre-monsoon followed by monsoon and post-monsoon seasons. Overall, there was a decrease in DO content with increasing depth, but the sub-oxic situation prevailing along the west coast during the monsoon season was not visible here.

- Nitrate content during the study period ranged from 0.01 to 4.97 μM at the off Goa transect and 0.003 to 5.16 μM, both high values were recorded during the monsoon season. Generally, NO₃ maxima was seen in sub-surface or near-bottom layers (shallow stations). Very low values were recorded at near-surface and mid-depths. Nitrate values were relatively higher off Mangalore transect compared to off Goa transect for the respective seasons.

- Along the Kakinada coast, generally low nitrate content was recorded at the near-surface which increased with depth during all the seasons. The NO₃ content recorded during the post-monsoon season was lower compared to other seasons. No subsurface maxima was observed during any season.

- Phosphate content ranged from 0.01 to 3.41 μM at the off Goa transect and 0.01 to 3.83 μM at the off Mangalore transect. The ranges observed at both the transects were closely similar for the respective season, except that the highest recorded value during the monsoon season at the Goa transect was almost 3 times higher than that of Mangalore transect.

- Phosphate ranged from 0.07 μM to 5.23 μM along the Kakinada coast. No particular trend was observed in the seasonal distribution. The vertical profile however, showed
that at most of the stations, PO₄ content was relatively higher in the near-bottom layers.

- Silicate ranged from 0.01 to 20.27 μM and 0.17 to 8.27 μM along the Goa and Mangalore transects during the study period. The silicate content was higher at off Mangalore transect during all the seasons compared to off Goa transect and the higher values were recorded at near-bottom waters.

- Silicate values ranged from 0.16 μM to 26.6 μM during the study period along the Kakinada coast. The overall trend observed was an increased content at the near-bottom layers.

- Chlorophyll a was estimated as a measure of phytoplankton biomass. It ranged from 0.05 to 8.56 mgm⁻³ at the off Goa transect and 0.04 to 5.24 mgm⁻³ at the off Mangalore transect during the period of study. The highest values at both transects were observed during the monsoon season. Generally, at all the stations and during all the seasons, a sub-surface maxima was observed, mostly at 30 m depth and at some deeper stations, at 50 m depth. The overall trend showed that chl a content was higher at the off Goa stations compared to off Mangalore stations. CCA analysis also indicated high chl a biomass along the west coast.

- Chlorophyll a ranged from 0.04 to 0.82 mg.m⁻³ along the off Kakinada coast during the study period. It ranged from 0.06 to 0.82 mg.m⁻³ during the pre-monsoon, 0.05 to 0.67 mg.m⁻³ during monsoon and 0.11 to 0.78 mg.m⁻³ during the post-monsoon. The range in variation between seasons was marginal, but the values were generally lower compared to those recorded along the west coast transects. One of the striking differences noticed was that the sub-surface maxima seen along the west coast transects were not visible here. Generally, the chl a content was relatively higher at near-surface layers.
Mesozooplankton biomass along the Goa transect was high at 30 m stations during all the seasons and a decrease was observed with increasing depth. The highest values for all depth contours were observed during the pre-monsoon season (4.6, 4.1 & 2.1 ml.m\(^{-3}\), at Stn.1 (30 m), Stn. 2 (50 m) and Stn. 3 (100 m), respectively). An overall reduction in biomass was observed during the monsoon season, the highest being at Stn. 1. (3.7 ml.m\(^{-3}\)). The lowest biomass for the study period was recorded at Stn.3 (0.4 ml.m\(^{-3}\)) during the post-monsoon season.

The highest biomass for the entire study period along the Mangalore transect, was recorded at Stn. 4 (7.1 ml.m\(^{-3}\)) during the monsoon season. At 100 m stations, biomass values were low during all the seasons. During the post-monsoon season, all the depth contours along this transect recorded low biomass values (0.5, 1.3 and 0.7 ml.m\(^{-3}\), respectively at Stns. 4, 5 & 6).

Biomass along the Kakinada coast ranged from 0.17 to 0.78 ml.m\(^{-3}\) during the pre-monsoon season, 0.5 to 5.5 ml.m\(^{-3}\) during the monsoon season and 0.28 to 0.98 ml.m\(^{-3}\) during the post-monsoon season. Compared to the west coast transects, biomass recorded were very low during all the seasons.

The faunal density was low during the post-monsoon season along the Goa transect compared to other two seasons. Total faunal density encountered were 13192, 8630 and 3717 ind.m\(^{-3}\), respectively at Stns. 1, 2 & 3.

Total faunal density were 99547, 39572 and 14122 ind.m\(^{-3}\), respectively at the Stns. 4, 5 & 6 during the monsoon season along the Mangalore transect. All these values were higher compared to the same seasons for the respective depth contour of Goa transect.

Faunal density recorded at all the stations along the Kakinada coast was considerably lower than that of Goa and Mangalore coasts. Relatively higher diversity was observed during the monsoon season.
• General composition of various taxa/groups remained more or less similar along both the costs during all the seasons. However, Copepod was the single largest group, constituted >60% of the total faunal density at all the stations during all the seasons. At some stations its contribution was 80-90%. Ostracods, cladocerans and oikopleura were other groups which contributed significantly to the population.

• Bray-Curtis analysis was performed to identify the cluster of stations having similarity with respect to the group composition. Distinct groups were recognised for different seasons. MDS also brought out the similar type of grouping, thereby confirming the existence of the various clusters. Simper analysis could distinguish those groups which were associated with the dissimilarity between the clusters. Copepods, ostracods, oikopleura, polychaetes etc. were the major groups identified for the dissimilarity.

• The systematic status of the 33 identified zooplankton taxa/groups was examined and a list was provided.

• In order to understand the energy available at the primary trophic level (phytoplankton) and the energy requirement at the secondary trophic level (zooplankton) in the study area along the east and west coasts, the phytoplankton biomass (Chl a) and the zooplankton biomass were converted to respective carbon equivalent for each study area, separately for each season. The phytoplankton biomass calculated for the study area along the west coast for different seasons were, 2.42 and 2.7 KgC.m\(^{-3}\) for the pre-monsoon and post-monsoon seasons respectively, while the same for the monsoon season was 121.5 KgC.m\(^{-3}\) which is >50 times the other two seasons. The annual biomass sustained was estimated to be 42.2 KgC.m\(^{-3}\).

• A more uniform pattern of phytoplankton carbon availability was noticed for the east coast during different seasons. It was 3.9 KgC.m\(^{-3}\) for pre-monsoon, 3.8 KgC.m\(^{-3}\) for...
monsoon and 4.3 $\text{KgC.m}^{-3}$ for post-monsoon seasons. The annual biomass available was 4.04 $\text{KgC.m}^{-3}$.

- The zooplankton biomass estimated for the seasons along the west coast were, 98.6 $\text{KgC.m}^{-3}$ for the pre-monsoon season, 70.9 $\text{KgC.m}^{-3}$ for the monsoon season and 41.3 $\text{KgC.m}^{-3}$ for the post-monsoon season. The annual contribution of zooplankton carbon for the 50 m water column of the study area was estimated to be 70.3 $\text{KgC.m}^{-3}$.

- The zooplankton carbon estimated for the water column for the three seasons were 4.7, 102.8 and 7.2 $\text{KgC.m}^{-3}$, respectively for pre-monsoon, monsoon and post-monsoon. The biomass sustained on an annual basis was 38.2 $\text{KgC.m}^{-3}$ which was almost half that of the west coast.

- The phytoplankton and zooplankton biomass for the different seasons indicated that only during the monsoon season autotrophy was prevalent along the west coast when mesozooplankton could sustain the energy requirement through phytoplankton biomass since phytoplankton biomass available exceeded the energy requirement of zooplankton. However, during pre- and post-monsoon seasons, the available zooplankton carbon (98.6 and 41.3 $\text{KgC.m}^{-3}$) far exceeded the availability of phytoplankton biomass and therefore mesozooplankton may have to feed on available alternative food sources such as microzooplankton, since the phytoplankton biomass prevailing was not sufficient to sustain the zooplankton biomass. The results thus indicate that the autotrophy was prevailing only during the monsoon, while during the pre- and post-monsoon seasons, heterotrophy was more common. In other words, it was only during the monsoon season that phytoplankton biomass was available in excess to support the requirement of zooplankton standing stock. During the other two seasons, the phytoplankton biomass was insufficient to sustain the zooplankton biomass and therefore, the latter had to feed on other sources such as attached
bacterioplankton, microzooplankton or suspended organic matter etc. whichever was available.

- A contrasting trophic relationship was observed along the east coast. Here, autotrophic relationship was not observed during any season, but heterotrophic relationship was prevailing during all the seasons. Although the extent was low during the pre- and post-monsoon, it was conspicuously high during the monsoon season. It therefore, suggests that the zooplankton biomass along the east coast is not wholly supported by the availability of phytoplankton biomass, but these organisms sustain on alternate sources of energy during all the seasons and more so during the monsoon season.