CMFRI

Winter School on
Impact of Climate Change on Indian Marine Fisheries

Lecture Notes

Part 2

Compiled and Edited by

E. Vivekanandan and J. Jayasankar

Central Marine Fisheries Research Institute (CMFRI),
(*Indian Council of Agricultural Research*)
P.B. No. 1603, Cochin - 682 018, Kerala

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ZOOPLANKTON REFLECTING GLOBAL WARMING

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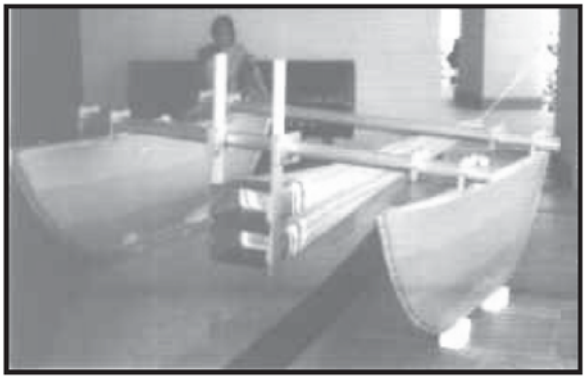
Rosamma Stephen
Scientist (Rtd.) , NIO, RC Kochi

The myriads and myriads of microscopic organisms that float with the currents are collectively called as zooplankton. They are the main grazers of the ocean and play intermediate link in transforming plant material to animal protein. These subtle organisms form the food for all higher animals including the whales. Most zooplankton organisms are very beautiful when alive. The zooplankton community is composed of nearly 80 different taxa including fish eggs and larvae. But the most abundant components are copepods, chaetognaths, euphausiids and ostracods. Copepods and euphausiids are the main herbivore and chaetognaths are strictly carnivores. Marine zooplankton function at many levels in ocean food webs, as consumers, producers and prey. Ranging in size from microns (protozooplankton) to centimeters and meters (metazooplankton, including chains of Thaliacea), they are also major contributors to elemental cycling and vertical fluxes. Ever since the work of Sir Alister Hardy on the Calanus - code relation fishery scientists are aware of the close relation between zooplankton and pelagic fish. There are special nets for collecting zooplankton. Continuous plankton collections like the CPR and CalCofi presents the variations in zooplankton community over the years.

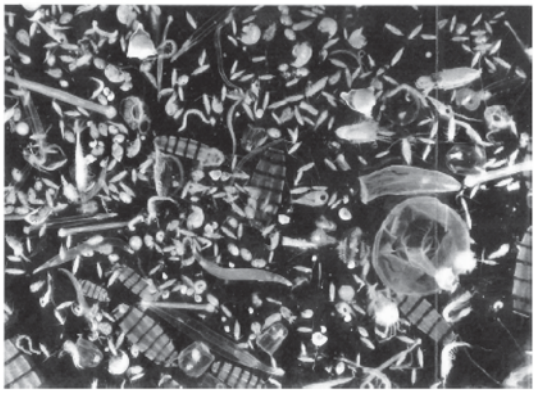
Bongo Net

Vertical Net

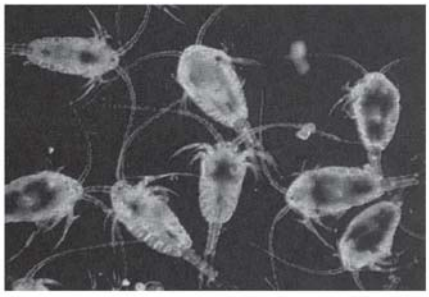
Neuston Net

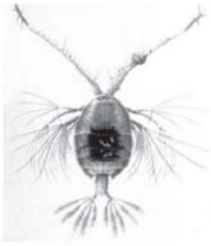


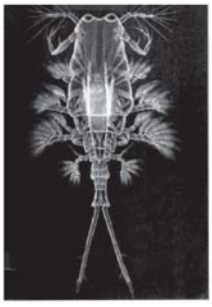
Zooplankton assemblages

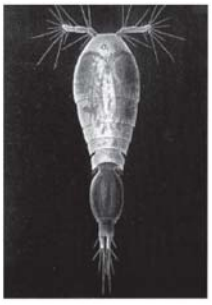


Copepods

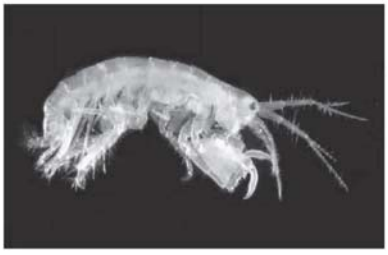








Amphipod



Chaetognath

Fish eggs and larvae

Zooplankton especially copepod species can act as sentinels to the marine biogeochemical cycles. Interannual changes in species assemblages often reflect an integrated response of the ecosystem to hydrometerological forcing. They are considered suitable to show the impact of the climate change because

(1) they are not commercially exploited.

(2) Since short lived do not contain persistent forms of previous years and exhibits imminent coupling between environmental changes and plankton dynamics.

(3) As they are free drifters can expand and contract geographical distribution according to their affinity to the environmental properties.

(4) Synchrony between the peak in plankton abundance and arrival of fish larvae – "match – mismatch hypothesis" – the abundance and timing of mesozooplankton affect the larval recruitment as well as the abundance of some adult fishes like mackerel.

A northward shift and re-orientation in tropical copepods due to climate change and global warming (regime shit) are reported from Atlantic and Pacific for the past 45 years. The important North Atlantic copepod *Calanus finmarchicus* peaked in abundance 11 days earlier. This is associated with the 'gadoid outburst'. Data from 40 published studies of the diet composition of larval and juvenile cod (*Gadus morhua*) from around the Northern Atlantic were summarized to assess generic patterns in ontogenetic and regional variability in the key prey. The results showed that larvae at the northern edge of the latitudinal range of cod depend primarily on development stages of the copepod *Calanus finmarchicus*, whilst those at the southern edge depend on *Para* – and *Pseudocalanus* species. Juvenile cod preyed on a wider range of taxa than larvae, but euphausiids were the main target prey. Analysis of regional variations in the relative abundances of *C. finmarchicus* and *Para/ Pseudocalanus spp*. in the plankton, as estimated by the continuous plankton recorder (CPR) surveys, showed a similar geographical pattern to the larval cod stomach contents. Comparison of CPR data from the 1960s and 70s with data from the 1990s showed that the boundary between *C. finmarchicus* and *Para/ Pseudocalanus* spp. dominance has shifted northwards on both sides of the Atlantic whilst the abundance of euphausiids in the southern cod stock regions has declined.

The results are discussed in relation to regional differences in the response of cod stocks to climate variability.

Long experience with copepods of Indian Ocean shows significant changes in the community structure of copepods in active upwelling coastal waters. The herbivorous *Temora* spp. has been recognized as an opportunistic species following pulses of diatom blooms. Swarms are observed in recently upwelled waters. This is followed by abundance of carnivores mainly *Euchaeta* spp. and *Candacia* spp. In the fading phase small carnivores – *Oithona* and *Oncaea* dominate. Smaller herbivores – Paracalanidae, and larger Eucalanidae supplement.

The study of copepods during 1998 to 2005 showed a drastic decrease in the abundance of the species during SW monsoon. This sweeping change persisted throughout the period of study. This can be a milestone in realizing the alteration of calanoid community in coastal environments. Since these samples are from different strata (0-500m) existence of diapause in the species is ruled out unlike *Calanoides carinatus* which sink to deeper layers after upwelling off Oman. Whether there is lateral movement into inshore waters is yet to be proved. A "regime shift" in geographical distribution cannot be ruled out. It is well known that mackerel fishery is associated with zooplankton abundance. The CMFRI report (2006) on recent trends in marine fish landings in India indicate a drastic drop in mackerels in recent years. In the light of copepod study a drop in herbivorous upwelling copepods was evident. Is this influence scaling down of the mackerel population - remains to be investigated.

The Northern Indian Ocean is a semi enclosed basin, the Asian land mass limiting northward extension into the subtropical and arctic regions. This is unique physical property distinct from Atlantic and Pacific

where natural forcings are different. Peninsular India divides the Northern Indian Ocean into 2 basins the Arabian Sea and Bay of Bengal with significant biological properties. The Northern Indian Ocean encompasses in the western side the Arabian Somali coast and on the eastern side Myanmar and Malayan archipelago. This is the only ocean where semiannual reversal of monsoons takes place. The Arabian Sea exhibits one of the most energetic current systems in the world causing strong coastal upwelling along Somalia, Yemen and Oman to a lesser extend along coasts of Pakistan and India making this one of the most productive marine environments of the world. Arabian Sea is one of the most productive seas. More recently Indian Ocean is experiencing global warming faster than the Atlantic and Pacific. Another important physical feature is the presence of the extensive area of O2 minimum zone or the "Dead zones". The SST has shown consistent increasing trends in all the seasons in the coastal belts of Pakistan and the northwestern India upto Bombay (Mumbai). In the coastal regions of the islands the increasing trend is confined to the summer only. The zooplankton population cannot respond to SST increase by expanding to northern latitudes, which may also contribute to the decline of the abundant zooplankton.

Species is the key stone of an ecosystem. The influence of physical process on plankton must be studied at individual species level. The scenario of global warming implies changes in biological systems which calls for sharper and intensive monitoring to track major species – through future multidisciplinary survey. Any alteration in the natural population may have far reaching destruction on the ecosystem. The re-orientation of zooplankton species due to climate change would result in an altered biological sequence in the coastal waters of India. In summary there is now compelling evidence that major changes have occurred in the biota of the oceans and a range of studies have highlighted how zooplankton might be important harbingers of change in marine systems. The reorganization of plankton communities has far reaching socioeconomic impacts through effects on commercial fisheries.