Recent Trends in Sea Surface Temperature and its Impact on Oil Sardine

E. Vivekanandan[1], M. Rajagopalan[2] and N.G.K. Pillai[3]

THE surface temperature of the Indian seas has increased by 0.03° to 0.18° C per decade during 1950-2005 (http://podaac.jpl.nasa.gov). The UKMO HadCM3 model has predicted that the sea surface temperature in the Indian Seas may increase by about 3.0°C during 2000 to 2099. A rise in temperature as small as 1° C could have important and rapid effects on the geographical distributions and mortality of some organisms. The more mobile species should be able to adjust their ranges over time, but less mobile and sedentary species may not. Depending on the species, the area it occupies may expand, shrink or be relocated with changes in oceanic conditions. For fishes, climate change may strongly influence distribution and abundance (Wood and McDonald, 1997). These changes may have impacts on the nature and value of commercial fisheries. Fish species with more rapid turnover of generations may show the most rapid demographic responses to temperature changes (Perry *et al.*, 2005). The distribution of the oil sardine, *Sardinella longiceps* along the Indian coast to find out how responsive is the fish to temperature changes.

The oil sardine is a coastal, pelagic schooling fish, forming massive fisheries in India. It has high population to doubling time of less than 15 months and is probably the largest stock in the Indian Ocean (www.fishbase.org). Like many other small pelagics, the oil sardine also has shown population crashes and sudden recoveries in the past. It is a tropical fish, governed by the vagaries of ocean climatic conditions. It is known for its restricted distribution in the Malabar upwelling region along the southwest coast. It attains a maximum total length of about 22 cm and plays a crucial role in the ecosystem as a plankton feeder and as food for large predators. The annual average production is 3.8 lakh tones (15% of all India total catch) valued at about Rs 350 crores. It is a cheap source of protein and forms a staple, sustenance and nutritional food for millions of coastal people.

The objectives of this study are to quantify the increase in sea surface temperature along the Indian coast, and to find out the changes in the distribution of the oil sardine *Sardinella longiceps* as a consequence of warming.

METHODOLOGY

For examining the response in the distribution of the oil sardine to temperature changes, two sets of data were used. The first data set was on sea surface temperature obtained from International Comprehensive Ocean – Atmosphere Data Set (ICOADS) (ESRL

[1-3]Central Marine Fisheries Research Institute, Cochin, Kerala 682 018

PSD www.cdc.noaa.gov) and 9-km resolution monthly sea surface temperature obtained from AVHRR satellite data (provided by the NOAA/NASA at http://podaac.jpl.nasa.gov/). The annual average sea surface temperature data were computed for 45 years i.e. from 1961 to 2005, further averaged into four time periods, *viz.*, 1961-1976, 1977-1986, 1987-1996 and 1997-2005, and plotted in Surfer. The second data set was on annual oil sardine catch along each maritime state for 45 years i.e. 1961 to 2005 obtained from CMFRI, Kochi. The data were collected by qualified and well-trained technical staff of CMFRI by following stratified multi-stage random sampling technique in which the oil sardine landings was recorded by covering landing centres along the Indian coast at pre-determined frequencies. The catch data were weighted to arrive at annual catch for each maritime state and the per cent contribution of each maritime state to the All India Oil Sardine Catch during the four time periods was estimated. For plotting in Surfer, the percentage contribution by each maritime state was converted into corresponding 2° latitude-longitude grid. Here, the catch is considered as the surrogate of distribution.

RESEARCH ACCOMPLISHMENT

The sea surface temperature plot showed warming of sea surface along the entire Indian coast (Fig.20.1). For instance, the annual average sea surface temperature, which ranged between 27.7° C and 28.0° C from 1961 to 1976 increased to 28.7° C to 29.0° C during 1997-2005 between 9°N, 76°E and 11°N, 77°E (south-west coast). The warmer surface waters (29.0° to 29.2° C) expanded to a very large coastal area (between 8°N, 72°E and 14°N, 75.5°E) in 45 years. The cooler waters (25.2° C to 25.5° C) in 23°N,

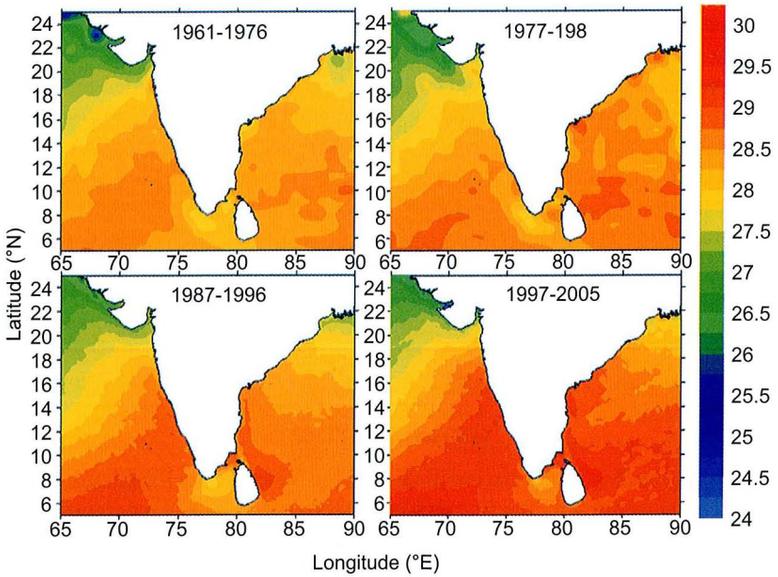

Fig. 20.1. Sea Surface Temperature profile prior to, during and after the "high" coral bleaching event of 1998 in the Gulf of Mannar (source: AVHRR data)

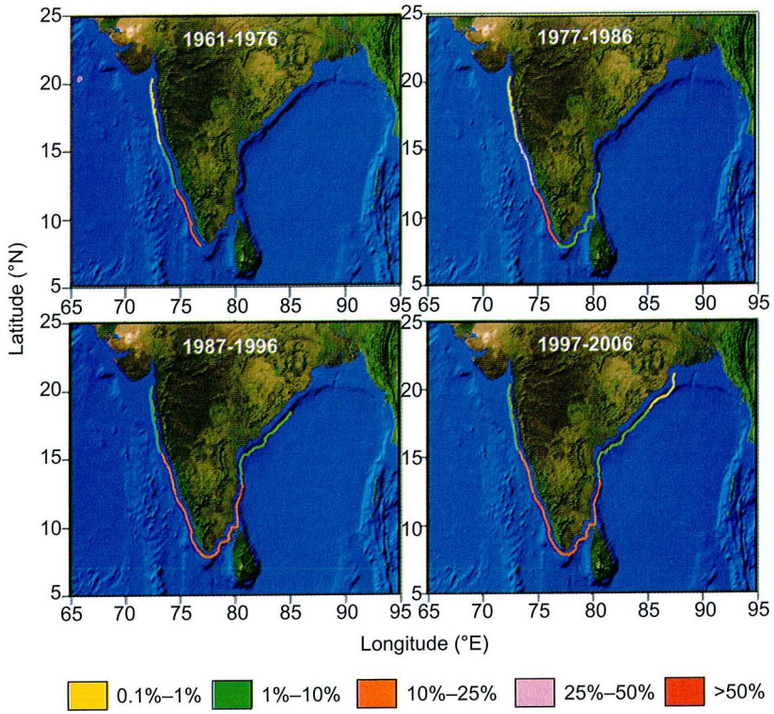

Fig. 20.2. Shifts in oil saradine catch along Indian coast during four time periods

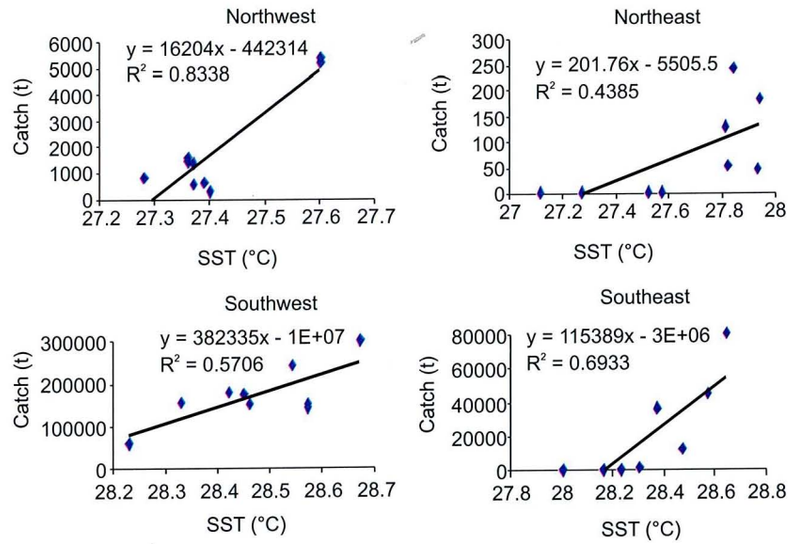

Fig. 20.3 Relationship between sea surface temperature and oil sardine landings during 1961-2005 for different zones

68°E (off Saurashtra coast) from 1961 to 1976 disappeared completely in the later years. Similar pattern of warming was evident in the Bay of Bengal too.

The oil sardine is a tropical fish preferring temperature range of 27° to 29°C (Chidambaram, 1950; www.fishbase.org). During 1961-1976, the catch was predominantly (nearly 90% of all India catch) between 8°–12°N and 75°–77°E (south-west coast) (Fig. 20.2) where the sea surface temperature ranged between 27.7° C and 28.0° C. The catch was very negligible (< 1.0%) from latitudes north of 15° N along the west coast (Maharashtra and Gujarat) where the sea surface temperature ranged between 25° C and 28° C during those years. There was no catch along the entire east coast. During 1997-2005, the oil sardine catch was recorded almost along the entire Indian coast (except off Gujarat and West Bengal coasts). The percentage of catch from latitudes north of 15° N along the west as well as east coasts increased, although the catch from latitude north of 15° N (off West Bengal) was still negligible. A good correlation was found to exist between the sea surface temperature and landings of oil sardine along the four coastal zones from 1961 to 2005 (Fig. 20.3).

CONCLUSIONS

Considering the catch as a surrogate of distribution, it is found that the oil sardine has extended its northern and eastern boundaries of distribution. Oil sardine fishery did not exist before 1976 in the northern latitudes and along the east coast as the resource was not available. With warming of sea surface, the oil sardine is able to find temperature of its preference especially in the northern latitudes and eastern longitudes, thereby extending the distributional boundaries and establishing fisheries in larger coastal areas. It is expected that the distribution may extend further to Gujarat and West Bengal coasts in forthcoming time assuming that other fishery related physical and biological parameters will not vary considerably. However, if the sea surface temperature in the southern latitudes increases beyond the physiological optimum of the fish, it is possible that the population may be driven away from the southern latitudes, which will reduce the catches along the south-west and south-east coasts in the future.

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