Impact of Climate Change on Indian Marine Fisheries and Options for Adaptation

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INTRODUCTION

Marine capture fisheries have very important roles for food supply, food security and income generation in India. About one million people work directly in this sector, producing 3 million tonnes annually. The value of fish catch at production level is about US $ 2.8 billion and India earns US $ 1.8 billion by exporting fish and fishery products. Being open access to a large extent, there is intense competition among the stakeholders with varied interests to share the limited resources in the coastal waters, which has resulted in overfishing and decline in stocks of a few species. Climate change is projected to exacerbate this situation and act as a depensatory factor on fish populations. Climate change will have strong impact on fisheries with far-reaching consequences for food and livelihood security of a sizeable section of the population.

Concerns about global warming have been with us now for more than 10 years. The global warming that is widely expected to occur over this century will not be confined to the atmosphere; the oceans would also get warmer. Over the next 50 years, temperature in the Indian seas are expected to rise by 1 to 3°. The oceans are predicted to acidify, become more saline, and the sea level will rise, and currents may change. It has been recognized that it will have consequences, both benign and disadvantageous, on fisheries. Fisheries, which essentially are an advanced form of hunting, are totally dependent on what nature will or will not provide. The effects of climate change on fisheries are likely, therefore, to be severe. Such changes are likely to affect fish migrations and habitat, augmenting fish stocks in some places and decreasing them in others, perhaps causing stocks to be displaced permanently to new habitats. Researches are underway to find out the possible consequences of climate change for fisheries. Nevertheless, the effects of global warming on fish stocks and their migrations are extremely difficult to predict.

IMPACT ON OCEANOGRAPHIC FEATURES OF INDIAN SEAS

There is now ample evidence of the impacts of global climate change on marine environments. Analysis of the data set on sea surface temperature (SST) obtained from International Comprehensive Ocean – Atmosphere Data Set (ICOADS) (ESRL PSD www.cdc.noaa.gov) and 9-km resolution monthly SST obtained from AVHRR satellite data (provided by the NOAA/NASA) showed warming of sea surface along the entire Indian coast. The SST increased by 0.2°C along the northwest (NW), southwest (SW) and northeast (NE) coasts, and by 0.3°C along the southeast (SE) coast during the 45 year period from 1961 to 2005. For instance, the annual average SST, which ranged between 27.7° C and 28.0° C during 1961-1976 increased to 28.7° C-29.0° C during 1997-2005 between 9°N, 76°E and 11°N, 77°E (southwest coast). The warmer surface waters (29.0° C-29.2° C) expanded to a very large coastal area (between 8°N, 72°E and 14°N, 75.5°E) in the 45 year period. The cooler waters (25.2° C-25.5° C) in 23°N, 68°E (off Saurashtra in the northwest coast) during 1961-1976 disappeared completely in the later years. Similar pattern of warming was evident in the Bay of Bengal too.

Based on the trajectory suggested by HadCM3 for SRES A2 scenario, it is predicted that the annual average sea surface temperature in the Indian seas would increase by 2°C to 3°C by 2099. The predicted trend showed that the annual average temperature is likely to increase from 28.5°C during 2000-09 to 31.5°C during 2089-99 in the Andaman, Nicobar, Lakshadweep and Gulf of Mannar; and from 27.5°C to 30.5°C in Gulf of Kutch.

TREND IN OCEANOGRAPHIC PARAMETERS OFF KERALA

Data on climatic and oceanographic variables such as monthly average Sea Surface Temperature (SST), Relative Humidity (RH), Total Cloudiness (TC), Zonal Wind (U), Meridional Wind (V), Scalar Wind (W), Multivariate El-Nino Southern Oscillation Index (MEI), Southern Oscillation Index (SOI), Coastal Upwelling Index (CUI) and Chlorophyll *a* Concentration (chl) showed that the SST peaked at an interval of about ten years (1969-70, 1980, 1987-88, 1997-98, 2007) during 1961-2007, and the decadal number of SST anomalous (+ 1 or – 1 deviation from the 47-year mean) months increased off Kerala. For example, only 16% of the months were SST anomalous during 1961-1970, but 44% during 2001-2007. The meridional wind speed (V) increased in the last ten years. The following conclusions on the climatic and oceanographic parameters are discernible off Kerala: (i) For some parameters, the anomalies of some of the variables are increasing, and for others, the annual trend is changing. (ii) The annual CUI and chl *a* concentration increased during 1999-2008. (iii) If the changing annual trend and anomalies affect the well-defined seasonal oceanographic settings, it is possible that the biological processes may be affected in future.

Annual trend in variables: The annual trend of the variables showed the following: (a) The trendline of annual values of SST, V, TC and chl did not change over the timescale. However, the SST showed peaks at an interval of about ten years (1969-70, 1980, 1987-88, 1997-98, 2007). The value of V increased in the last ten years. The annual average chl concentration remained at around 1.3 mg/m^3. (b) The trendline of W and MEI substantially increased from 4 m/s in 1961 to 5 m/s in 2007, and from – 0.75 in 1961 to 0.5 in 2007, respectively. (c) The trendline of U, RH, SOI and CUI substantially decreased during 1961 - 2007; U from 2.0 m/s to 1.6 m/s, RH from 38% to 21%, SOI from 0 to – 1, and CUI from 420 to 300. The annual CUI, which sharply decreased from 1988 to 1999, however, increased thereafter until 2008.

The number of anomalous months was identified from the monthly deviations from the respective mean values of SST, U, V, W and MEI over the 48-year period. A month was identified as anomalous if the anomaly was – 1 and below; or + 1 and above the mean value. The decadal number of anomalous months increased with regard to SST, U and SOI. For example, only 16% of the months were SST anomalous during 1961-1970, but 44% during 2001-2007. During the 48 years, the anomalies of SOI (189 anomalous months) and MEI (179 months) were very high, indicating the anomalies of the MEI components, *viz*., SST, surface air temperature, U, V and TC.

Monthly pattern: In spite of the changes in the annual trend and increase in anomalies, monthly patterns were discernible for all the parameters. As expected, two distinct peaks in SST, one during the summer (February – May) and the other during the southwest monsoon (June – September) were evident. Except SST, the peaks of all the forcing were during monsoon months and low values during summer months.

The analysis indicates the following temporal changes in the climatic and oceanographic variables off Kerala: (i) In spite of the changes in the variables over the years, the chlorophyll concentration has not shown conspicuous changes. (ii) The anomalies of some of the variables are increasing. (iii) If the changing annual trend and anomalies affect the well-defined seasonal oceanographic settings, it is possible that the biological processes may be affected in the future.

INDICATORS OF IMPACT ON FISHERIES

Catch is believed to be a crude measure of fish abundance. The changes in catches of main commercial species are so marked that it is possible that they reflect real changes in population size. Some indication whether the expected temperature change of 1–3° over the next 50 years will be associated with changes in fish migrations and abundance might, therefore, be gleaned from studying the changes in catches over the period covered by the time series. The oil sardine (*Sardinella longiceps*) annual catch fluctuated between a mere 3,187 tonnes (1994) to 342,789 t (2006) during 1961-2006 (Fig. 1).

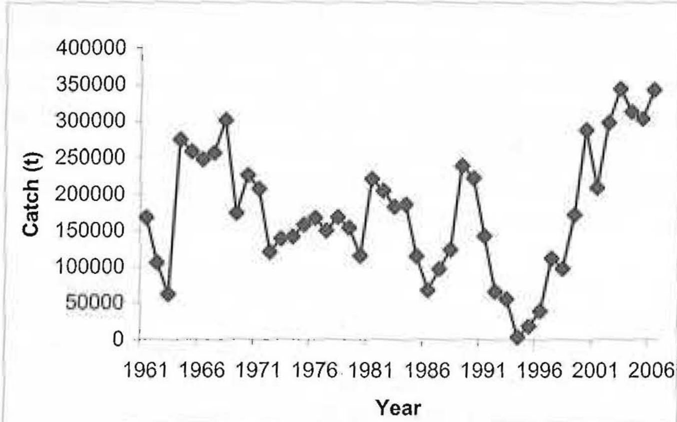

Fig. 1. Oil sardine landings along southwest coast of India during 1961-2006

At the outset, however, it is necessary to caution against two possible reasons why this approach might not be precise. First, there have been major changes in fishing technology and demand for fish over this period. The fact that the catches of certain types of fish were low 50 years ago, say, need have nothing to do with climate change but everything to do with improved technology or a rising demand. The precipitous decline in whitefish (*Lactarius lactarius*) catches was most likely caused by overfishing due to increase in trawl effort. The substantial increase in the catches of squids, cuttlefish and threadfin breams is also due to increase in trawl effort, and the increase in ribbonfish catch in the last ten years is due to rise in overseas market demand. Perhaps the catch trend over the time series may be considered as the impact of fishing effort/technologies, and the deviations from the trend as the impact of climate variables.

Higher temperatures may have positive effects also. Some commercially valuable species in lower latitudes have higher growth rates and larger annual harvests. For example, the oil sardine (*S. longiceps*) and Indian mackerel (*Rastrelliger kanagurta*) catches are generally highest along the southwest coast of India and declines northward. Increase in temperatures has increased the annual yield of oil sardine and Indian mackerel along the northwest coast and east coast of India in the last two decades.

IMPACT ON MARINE ECOSYSTEMS

These changes may have a significant effect on coastal ecosystems, especially estuaries and coral reefs, which are relatively shallow and currently under stress because of human population growth and coastal developments.

Changes in distribution patterns would change the mix of predators, prey, parasites, and competitors in an ecosystem that could alter the functions of the ecosystem and the productivity of selected fisheries. Predation pressure in marine ecosystems generally increases from poles to the tropics. Hence warming due to climate change could cause an ecological shift to increased predation if it led to greater diversity and numbers among predators.

There is evidence that marine organisms and ecosystems are resilient to environmental change. The biological components of marine systems are tightly coupled to physical factors, allowing them to respond quickly to rapid environmental change and thus rendering them ecologically adaptable. Some species also have wide genetic variability throughout their range, which may allow for adaptation to climate change.

Some believe that marine systems experience fewer extinctions of species compared to terrestrial systems because large numbers of marine species have wide geographic temperature ranges as well as greater capacity to migrate to new habitats through their larvae that drift in the water column. Others counter that not all marine species have drifting larvae, and that many larvae are short-lived or remain relatively close to the parental population before becoming juveniles.

OPTIONS FOR FISHERIES SECTOR FOR ADAPTATION

Options for adaptation are limited, but they do exist. The impact of climate change depends on the magnitude of change, and on the sensitivity of particular species or ecosystems.

Develop knowledge base for climate change and marine fisheries

As the ability to sustain fisheries will rest on a mechanistic understanding of interactions between global change events and localized disturbances, it is important to recognize the regional responses to climate change. It is also important to recognize the importance of the changes in these parameters as drivers of change in marine organisms including fish. Initiating a commitment on long-term environmental and ecological monitoring programmes is important as such data cannot be collected retrospectively. Projections on climate change impact on fish populations need to be developed as the first step for future analytical and empirical models, and for planning better management adaptations.

Adopt Code of Conduct for Responsible Fisheries

Fishing and climate change are strongly interrelated pressures on fish production and must be addressed jointly. Reducing fishing mortality in the majority of fisheries, which are currently fully exploited or overexploited, is the principal means of reducing the impacts of climate change. Reduction of fishing effort (i) maximizes sustainable yields, (ii) helps adaptation of fish stocks and marine ecosystems to climate impacts, and (iii) reduces greenhouse gas emission by fishing boats. Hence, some of the most effective actions which we can take to tackle climate impacts are to deal with the old familiar problems such as overfishing, and adapt Code of Conduct for Responsible Fisheries and Integrated Ecosystem-based Fisheries Management. The challenge becomes severe considering the high level of poverty prevalent in the coastal communities involved in traditional fishing methods, and the lack of suitable alternate income generating options for them. These factors make these communities highly vulnerable to future changes, as their capacity to accommodate change is very much limited. Effort to reduce dependence on fishing by these vulnerable communities is essential.

Increase awareness on the impacts of climate change

Specific policy document with reference to the implications of climate change for fisheries needs to be developed. This document should take into account all relevant social, economic and environmental policies and actions including education, training and public awareness related to climate change. Effort is also required in respect of raising awareness of the impact, vulnerability, adaptation and mitigation related to climate change among the decision makers, managers, fishermen and other stakeholders in the fishing sector.

Strategies for evolving adaptive mechanisms

In the context of climate change, the primary challenge to the fisheries and aquaculture sector will be to ensure food supply, enhance nutritional security, improve livelihood and economic output, and ensure ecosystem safety. These objectives call for identifying and addressing the concerns arising out of climate change; evolve adaptive mechanisms and implement action across all stakeholders at national, regional and international levels. In response to shifting fish population and species, the industry may have to respond with the right types of craft and gear combinations, on-board processing equipments etc. Governments should consider establishing Weather Watch Groups and decision support systems on a regional basis. Allocating research funds to analyze the impacts and establishing institutional mechanisms to enable the sector are also for future analytical and empirical models, and for planning better management adaptations.

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For the fisheries sector, climate change notwithstanding, there are several issues to be addressed. Strategies to promote sustainability and improve the supplies should be in place before the threat of climate change assumes greater proportion. While the fisheries sector contributes little to greenhouse gas emission, it could contribute to reduce the impact by following effective adaptation measures.