Indian J. Fish., 61(3) : 111-115, 2014

Note

Correlation between changes in sea surface temperature and fish catch along Tamil Nadu coast of India - an indication of impact of climate change on fisheries?

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ABSTRACT

Increase in mean sea surface temperature (SST) over the years is the primary indicator of ocean warming; which is likely to impact fish growth, reproduction and migration in the ocean. As a prelude to understanding changes in biotic communities along the Tamil Nadu coast of India, the trend in SST along the Tamil Nadu coast was assessed over a period of 105 years (1906-2010). The annual catch data of two major pelagic resources, the Indian oilsardine and Indian mackerel, and the annual catch (1979-2010) by the trawlers operating from Madras Fisheries Harbour, Chennai, were correlated with SST. There was an increase in minimum and maximum SST in all the seasons off Nagapattinam and Kanyakumari while at Chennai, the minimum SST in south-west monsoon season and maximum SST in summer season has decreased. The catches of oilsardine and mackerel showed an increasing trend over the last 25 years. Seasonal analysis showed positive correlation of the catches with SST. The catch of oilsardine during the summer months in particular showed an increasing trend over the period. Among the 17 dominant resource groups assessed, the catch of whitebaits showed significant positive correlation with increasing SST (at 5% level). Ribbonfish, perches and crabs also showed high 'r' values but the correlation was not statistically significant.

Keywords: Climate change, Mackerel, Marine fisheries, Oilsardine, Sea surface temperature

Increase in mean sea surface temperature (SST) over the years is one of the primary indicators of global warming. Climate change is undoubtedly complicating the patterns in global fisheries. The evidence of global warming is a 0.6°C increase in mean annual SST over the past 100 years (Karl and Trenberth, 2003). Temperature affects other ocean parameters such as salinity, pH and dissolved oxygen. All these factors have a synergistic effect on the biota ranging from microscopic plankton to large fishes and marine mammals. Physiological functions like growth, reproduction, spawning, and recruitment are directly influenced by change of temperature (Chowdhury *et al*., 2010). Primary production, secondary production, fish distribution (through permanent movement or changes in migration patterns), fish abundance (primarily due to changes in primary and secondary production) and phenology, *i.e.*, timing of life-cycle events such as spawning are also affected by change of temperature (Harvell *et al*., 1999; Beaugrand *et al*., 2002; Edwards and Richardson, 2004; Perry *et al*., 2005; Edwards *et al*., 2006; Lehodey *et al*., 2006; Bruno *et al*., 2007; Reid *et al*., 2007). Studies from the Indian sub-continent on the impact of changes in SST on fish production are minimal and mainly focused on extension of distribution range of the oilsardine (Vivekanandan *et al*., 2009; Vivekanandan and Krishnakumar, 2010) and Indian mackerel (Asokan *et al*., 2009), shift in spawning peaks in the threadfin bream, *Nemipterus japonicus* (Vivekanandan and Rajagopalan, 2009), coral bleaching (Vivekanandan and Jeyabaskaran, 2010) and vulnerability of marine ecosystems and fisheries (Vivekanandan, 2009; 2010; 2011). In the present study, as a prelude to understanding changes in biotic communities along the Tamil Nadu coast of India induced by alterations in climatic conditions, annual catch data of major fishery resources were correlated with SST.

Data on SST (9 km resolution) were downloaded from the website of International Comprehensive Ocean-Atmosphere Data Set (ICOADS), NOAA/NASA (BSRL PSD www.cdc.noaa.gov) following standard protocol. Three regions, Chennai, Nagapattinam and Kanyakumari, were selected for retrieving the SST data over the last 105 years (1906-2010). Months were grouped into four seasons, based on the climate conditions in Tamil Nadu: post-monsoon (January-March), summer (April-June), south-west (SW) (July-September) and north-east (NE) monsoon (October-December). The data were sorted season-wise for four seasons: and mean value and anomaly for each season of every 20 years were calculated for all the three regions. Pooled data were used to arrive at a profile of the SST along Tamil Nadu coast. Available fish catch data with the Fisheries Resources Assessment Division of the Central Marine Fsiheries Research Institute (CMFRI), Kochi were tabulated along with the SST and correlations were made. Annual catch data (all gears, for the period 1985-2010) of two major pelagic resources, Indian oilsardine and Indian mackerel, were correlated (Pearson correlation) with SST. Trawl catch from north Tamil Nadu coast by trawlers operating from Madras Fisheries Harbour, Chennai, was also related to the average annual SST over a period of 32 years (1979-2010). The analysis was done for the total trawl catch as a whole and for the catch of oilsardine, Indian mackerel, threadfin breams, lizardfishes and croakers, and the Pearson correlation coefficient 'r' was estimated. The exercise was repeated with a recent set of data (1998-2010) for total catch of major fishery resources landed by all gears and the average SST along Tamil Nadu coast.

There is a rise in SST along the Tamil Nadu coast over a period of 105 years (Fig. 1). The increase is more perceptible for the past 20 years in all the three regions selected (Table 1). Except in the case of Chennai in summer and SW monsoon seasons, the mean temperature is seen to be highest in 1986-2010 in all regions. The temperature range remained on the lower side off Kanyakumari (26ºC-29ºC) and on the higher side off Nagapattinam (27ºC-30ºC), while the lowest minimum (25.5ºC) and highest maximum (30.56ºC) temperatures were recorded off Chennai. The difference between the mean temperature

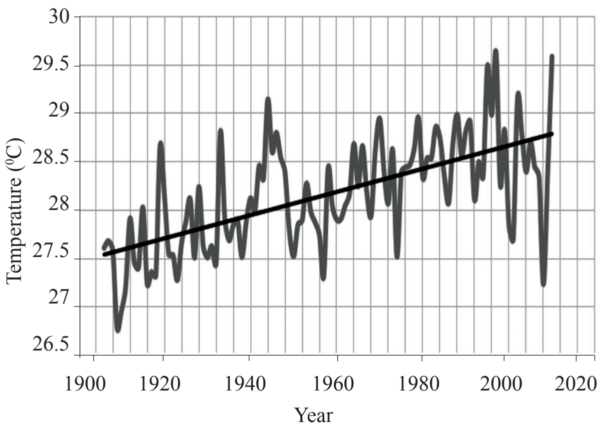

Fig. 1. Annual average SST in Tamil Nadu (1906-2010)

Table 1. Season-wise mean and range of SST in three regions of Tamil Nadu for every 20 years from 1906 to 2010

Post-monsoon	Chennai				Nagapattinam				Kanyakumari			
	Mean	S.D	Min	Max	Mean	S.D	Min	Max	Mean	S.D	Min	Max
1906-1925	26.21	0.43	25.63	27.10	26.77	0.60	26.14	28.04	27.47	1.00	26.23	28.90
1926-1945	26.78	0.72	25.68	28.38	27.20	0.97	26.14	29.25	27.68	0.76	26.50	29.40
1946-1965	26.77	0.48	25.97	27.84	27.15	0.28	26.71	27.76	28.04	0.84	26.70	29.70
1966-1985	27.36	0.99	25.50	29.00	27.71	0.50	26.72	28.47	28.04	1.13	26.10	30.25
1986-2010	27.56	0.88	26.33	29.50	28.07	1.08	26.34	30.00	28.07	1.09	26.24	29.55
Summer												
1906-1925	28.71	1.14	25.76	31.10	28.74	0.33	28.09	29.45	28.12	0.71	26.15	28.90
1926-1945	29.11	0.54	28.35	30.60	28.96	0.28	28.45	29.61	28.42	0.96	26.00	30.14
1946-1965	29.19	0.51	27.75	30.13	29.27	0.35	28.60	29.68	29.05	1.16	27.20	31.10
1966-1985	29.77	0.67	28.57	31.56	29.62	0.52	28.69	30.80	29.13	1.33	26.33	31.10
1986-2010	29.61	1.25	26.52	31.02	30.03	0.61	28.87	31.09	29.32	0.92	27.00	30.37
SW Monsoon												
1906-1925	28.19	0.42	27.53	29.00	27.89	0.34	27.26	28.81	26.44	0.91	25.00	28.20
1926-1945	28.31	0.39	27.56	29.07	28.15	0.37	27.67	29.29	27.13	1.25	25.00	30.00
1946-1965	28.49	0.37	27.80	29.14	28.29	0.24	27.77	28.55	27.30	0.84	25.94	28.85
1966-1985	28.88	0.79	27.65	30.51	28.63	0.43	27.96	29.61	27.68	1.42	25.00	31.00
1986-2010	28.87	1.07	26.10	30.00	28.80	0.47	27.69	29.61	27.73	1.28	25.65	31.00
NE Monsoon												
1906-1925	26.85	0.41	26.08	27.47	27.09	0.35	26.52	27.65	27.32	0.79	25.90	28.59
1926-1945	27.06	0.76	25.90	28.75	27.67	0.48	26.88	29.00	27.43	0.60	26.62	28.80
1946-1965	27.40	0.47	26.63	28.28	27.87	0.26	27.53	28.46	27.48	1.06	25.00	28.90
1966-1985	27.91	1.19	25.50	30.00	28.26	0.30	27.43	28.66	27.69	2.65	17.80	29.40
1986-2010	28.54	0.74	27.27	30.00	28.47	0.72	27.14	29.85	28.07	0.58	27.10	28.93

in each season in 2010 and the lowest mean temperature recorded in each season during the period from 1906 to 2010 was +1.66°C in the NE monsoon season, +1.75°C in the post-monsoon season, +1.97°C in the SW monsoon season and +3.02°C in the summer season. The rate of change in SST calculated from the period 1906-'25 to 1986-2010 showed that the rate of increase in minimum SST is pronounced off Kanyakumari coast. Off Chennai cost, the minimum SST in SW Monsoon season and the maximum SST in summer season has decreased over the years. With this exception, the seasonal trend shows increase in minimum and maximum SST in the three centres. The anomaly in SST for every twenty years is more pronounced towards the recent period and the sum of anomalies remained higher in Chennai and Nagapattinam in all the seasons during 1969-1989 and 1990-2010 and in all three regions in post-monsoon season during 1948-1968 (Fig. 2).

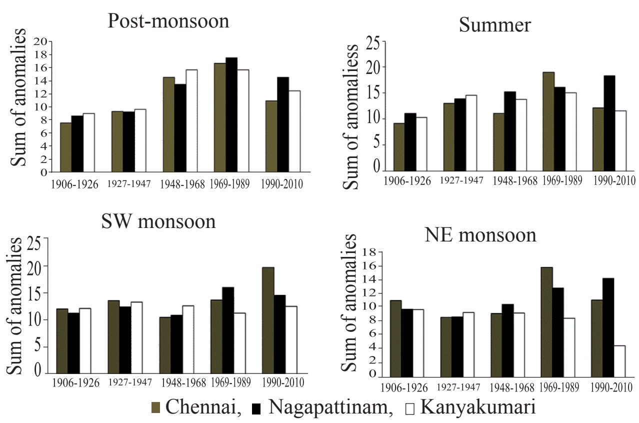

Fig. 2. Season-wise anomaly in SST in three regions of Tamil Nadu

The catches of oilsardine (Fig. 3) and mackerel (Fig. 4) showed increasing trend over the past 25 years. Seasonal analysis showed positive correlation of the catches with SST. The catch of oilsardine during the summer months in particular showed an increasing trend over the period, indicating a link between SST and resource abundance.

Total trawl catch, catch of oilsardine, mackerel, threadfin breams, lizardfishes and croakers and SST along the north Tamil Nadu coast for 1979-2010 showed positive correlation in all the cases except croakers (Table 2).

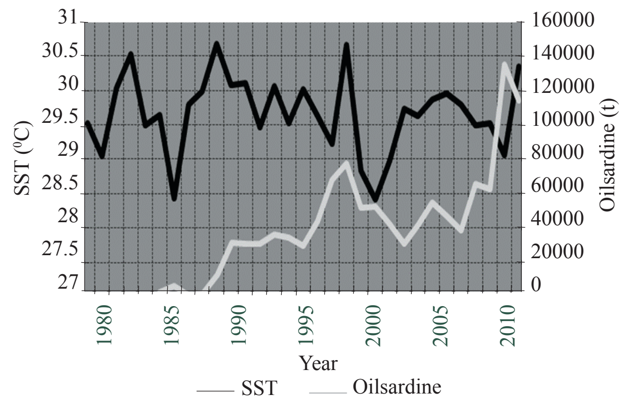

Fig. 3. Catch of Indian oilsardine *vs.* SST along Tamil Nadu coast (1985-2010)

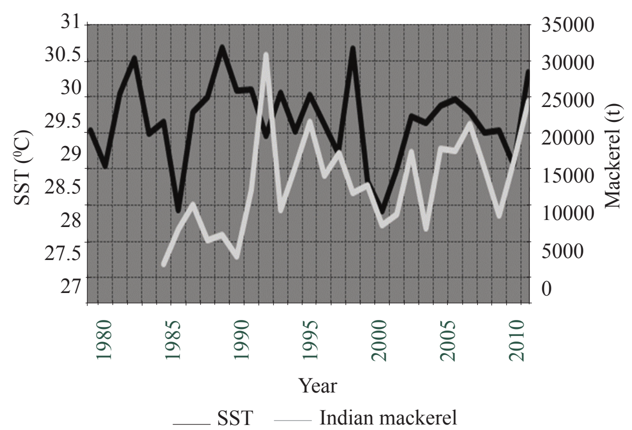

Fig. 4. Catch of Indian mackerel *vs.* SST along Tamil Nadu coast (1985-2010)

The Pearson correlation coefficient 'r' between total catch of major resources (all gears) and average SST along Tamil Nadu coast for the period 1998-2010 was found to vary between -0.239 and 0.683 (Fig. 5). Among the 17 dominant resource groups, the catch of whitebaits showed significant positive correlation with SST ($p<0.05$). Ribbonfish, perches and crabs also returned high 'r' values but correlation was not significant.

Although climate change is likely to have negative impacts on most of the earth's living ecosystems,

Table 2. Correlation between trawl catch and SST along north Tamil Nadu coast

Resource	Pearson correlation	N = n-2	t	t (table value)	
				0.05	0.01
Total trawl catch	0.389	30	2.316	2.042	2.750
Oilsardine	0.450	30	2.763	2.042	2.750
Mackerel	0.032	28	0.172	2.048	2.763
Threadfin breams	0.309	30	1.781	2.042	2.750
Lizardfish	0.029	22	0.135	2.074	2.819
Croakers	-0.176	10	-0.564	2.228	3.169

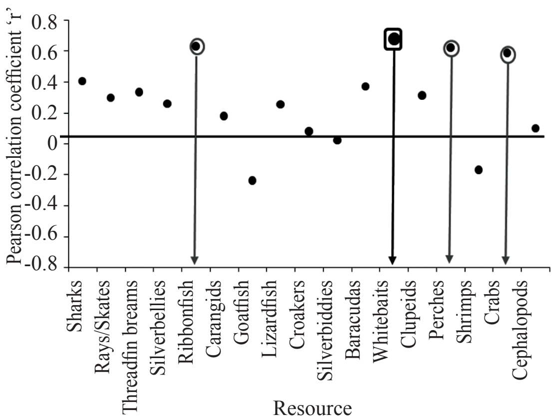

Fig. 5. Dispersion of Pearson correlation coefficient for catch of major fishery resources *vs.* SST along north Tamil Nadu coast (1998-2010)

the positive impact of climate change has also been highlighted in some studies, for *e.g.,* ocean warming has been predicted to create new opportunity for higher catch of warmer water species such as seabass, *Dicentrarchus labrax*, and red mullet, *Mullus surmuletus* (Davies, 2010). Similar observations have been made in tunas, billfishes, sharks and mackerel, with their distribution, migration and aggregation reported to respond to changes in surface temperature (Martinez Arroyo *et al.*, 2011). Changes in environmental conditions also strongly influence the spatial distributions of marine fishes (Pörtner, 2010) and shifts in distributions will result in species gains and losses and changes in fish capture. Ocean warming may also be linked to the increase in abundance of legal-sized lobsters in deep waters compared to shallow waters in Western Australia (Sumaila *et al.*, 2011).

In the present study, the fish catch *per se* has been directly related to the SST. In the context of India's multigear, multispecies and by-and-large, non-targeted fishery, the catch per unit effort or catch per hour will give a better estimate of resource abundance. The preliminary findings reported here have to be validated further by relating the gear-wise unit production of each resource with the SST over a range of time.

Acknowledgements

The authors thank the Director, Central Marine Fisheries Research Institute (CMFRI) for encouragement and permission given to present this paper at the 9th Indian Fisheries Forum (Chennai, 19-23 December, 2011). The authors also thank the Indian Council of Agricultural Research (ICAR) for funding the project on 'National Initiative on Climate Resilient Agriculture (NICRA), under which this study was carried out.

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Date of Receipt : 17.04.2013
Date of Acceptance : 14.02.2014