Chapter 23

Implications of Extreme Climatic Events on Marine Fisheries Sector

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Introduction

Over the last two decades several studies have been carried out over the North Indian Ocean (NIO) by explaining the impact of extreme oceanographic events on the general hydrodynamic and thermodynamic characteristics of the Arabian Sea and Bay of Bengal (Tourre and White, 1995; Behera et al., 2000; Bakun et al., 2015). Some of these investigations are extended to the vulnerability studies of the major fishery along the Indian coastline with respect to the present scenario of enhanced frequency of occurrence of extreme climatic events such as El Niño Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) (Krishna Kumar et al 2008, Thara. 2012). These climatic fluctuations may be responsible for the inter-annual variability in abundance of fish populations. Highly mobile, plankton-based food chain and short life spans make the pelagic fishes predominantly sensitive to environmental forcing. Concerning the importance of marine fishery resources as a major source of income, so the influence of these extreme climatic events on the ecosystem productivity and fishery production should be studied well (Thara, 2012). Based on the above baseline information, the present tutorial is try to elucidate the influence of extreme events on Indian Oil Sardine fishery along the south-west coast of India. Rather than the detailed description of one to one relationship between the extreme oceanographic events and major fishery, this tutorial is mainly intended to provide some hints on the variability observed in the trend of Oil Sardine landings along the south-west coast of India during a decade with more number of extreme events. The period selected for this study is from 1990 to 2015, in which the two decades from 1990 to 2015 is characterized by the occurrence of more number of ENSO and IOD.

Data and Methods

Concerning the importance of temperature and primary productivity induced by upwelling in determining the annual pelagic fishery production along the shelf waters, an attempt has been made to understand the inter-annual variability of Coastal Upwelling Index (CUI) and Mixed layer Temperature (MLT) along the south-west coast of India. The study is also extended to understand the specific influence of extreme events on the profound variability observed in the MLT and CUI during the IOD and ENSO years. A correlation analysis between the CUI and Oil Sardine fishery is also included in this study. Ekman mass transport derived from the alongshore component of wind along the south-west coast of India is used as Coastal Upwelling Index (CUI) and the calculation of CUI is followed by Shah et al., 2015. ERS, QuickSCAT and ASCAT wind products were used for the calculation of coastal upwelling Index along the south-west coast of India. The fish landings data for Indian Oil sardine was collected from Central Marine Fisheries Research Institute. MLT is calculated from the potential temperature profile provided by Simple Ocean Data Assimilation (SODA).

Results and Discussion

Indian Ocean Dipole and El Niño Southern Oscillation (ENSO)

Table 1 represents the list of IOD, El Niño and La Niña years during 1990 to 2015. From the Table 1, it was evident that during the entire study period the first decade from 1991 to 2000 was experienced by more number of IOD events. During this decade, out of the five IOD events occurred, two of them are Strong positive IOD years (1994, 1997) and the rests are strong negative IOD years (1992, 1996 and 1998). Year 1997 was peculiar by the co-occurrence of strong IOD and strong El Nino. Another distinctiveness of the first decade is that all the years from 1991 to 2000 are chracterised by the occurrence of either an IOD (positive or negative) event or an ENSO (El Niño or La Niña) event.

Second decade (from 2001 to 2010) during the study period is the more occurrence of ENSO events and rarest occurrence of IOD events compared to the first decade from 1991 to 2000. After 2010. The years from 2014 to 2016 are strongest El Niño years and 2015 is a strong positive IOD year.

Table 1: List of IOD and ENSO events during 1990 to 2016

Positive IOD events	Negative IOD events	El Niño events	La Niña events
1994	1992	1991-1992	1995-1996
1997	1996	1992-1993	1998-1999**

2006	1998	1994-1995	1999-2000
2012	2010	1997-1998*	2000-2001
2015	2016	2002-2003	2007-2008**
		2004-2005	2010-2011
		2006-2007 2014-2016*	

* represents strong El- Niño year; **represents strong La Niña year.

Inter- annual variability of Mixed Layer Temperature (MLT)

Previous studies revealed the influence of temperature on fish spawning behavior and every fish stocks have a particular temperature choice with a temporal cycle and any change in this temperature pattern significantly influences the gonadal ripening of the fish. Since the influence of ENSO and IOD events are predominant on temperature during the winter season, a two month average of MLT during November and December is used to understand the inter-annual variability of temperature along the shelf waters of south-west coast of India.

Analysis of **Figure 1** revealed that the highest ever recorded mixed layer temperature along the south-west coast of India from 1990 to 2015 is during 1997 and it is a strong positive IOD year co-occurred with El Niño. The lowest temperature occurred along the south-west coast of India is during 1999. Analysis also revealed that the co-occurrence of El Niño and positive IOD events (1994, 1997, 2006 and 2015) significantly increases the winter temperature along the shelf waters of south-west coast of India compared to previous years. Positive IOD (2012) and strong La Nina (2010) alone decreases the temperature along the south-west coast of India.

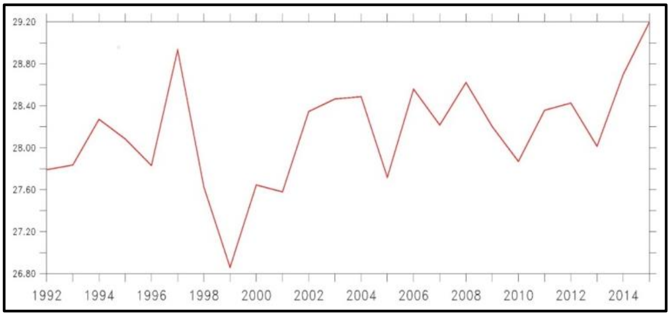

Figure 1: Inter-annual variability of Mixed Layer Temperature (°C) along the south-west coast of India from 1992 to 2015[November-December averaged].

Inter-annual variability of Coastal Upwelling Index (CUI)

Since the south-west coast of India was characterized by upwelling during the summer monsoon, CUI averaged over June to September is used in this study to understand the inter-annual variability of upwelling along the south-west coast of India. Figure 2 represents the CUI variability along the shelf waters during the study period from 1990 to 2015. From Figure it was evident, upwelling along the south-west coast of India is considerably lower during 1992 to 1999 compared to the rest of the study period and this was a decade with more number of extreme oceanographic events. During the entire study period stronger upwelling due to the Ekman mass transport was observed during 2000 to 2008. During the strong positive IOD years 1994 and 1997 upwelling along the south-west coast of India considerably diminishes compared to the previous years. Analysis of Figure 2 also revealed that during the entire study period the highest recorded upwelling is during 2000 and minimum value of CUI was observed during 1998 and it was a strong La Niña year.

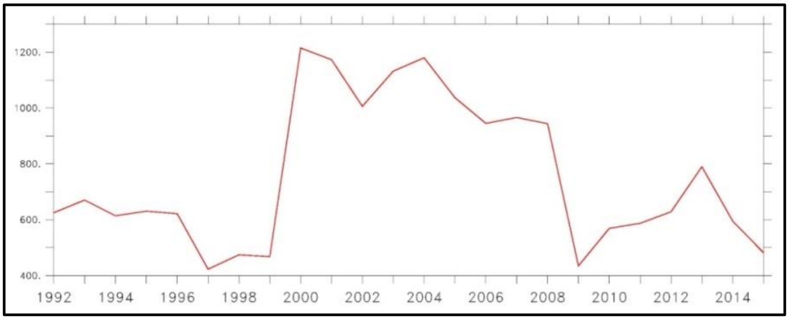

Figure 2: Inter-annual variability of Coastal Upwelling Index along the south-west coast of India from 1992 to 2015 [June-September averaged]. Ekman mass transport (kg/m/s) is used as Coastal Upwelling Index.

Inter-annual variability of trend in Indian Oil Sardine landings along the south-west coast of India

Figure 3 represents annual average Indian Oil Sardine landings along the south-west coast of India from 1985 to 2016. Considerable decrease in Oil Sardine landing was observed along the south-west coast of India during 1991 to 1999 and this was a decade with more number of climatic events. Also this decade was characterized with more number of Indian Dipole events compared with the other decade.

Analysis of Coastal Upwelling Index (CUI) also showed the declining trend in upwelling along the south-west coast of India during this decade. During the entire study period lowest catch was recorded in 1994 and it was a positive IOD year. From 1995 onwards an increase in trend in Oil sardine landings was observed along the south-west coast of India and a maximum catch was observed during 2012. After 2014 a decline in Oil Sardine landing was initiated along the south-west coast. The decade from 1991 to 2000 was a strong IOD era and the years from 2001 to 2010 characterizes more number of ENSO events.

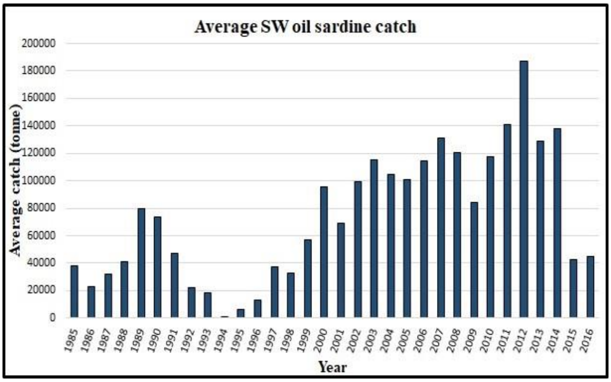

Figure 3: inter-annual variability of Oil Sardine landings along the south-west coast of India from 1985 to 2016.

Hence the overall analysis of trend observed in Oil Sardine catch hints the adverse influence of IOD events on Oil Sardine fishery along the south-west coast of India.

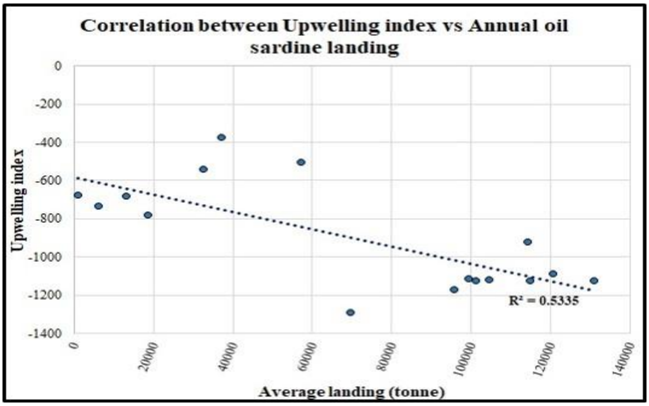

Figure 4: Correlation analysis between CUI and Annual Oil sardine landings along the south-west coast of India.

Simple Correlation analysis between CUI and Oil Sardine catch also showed a significant positive correlation along the south-west coast of India (Figure 4).

Conclusion

The objective of the present tutorial is intended to provide some hints on the interaction of extreme climatic events and coastal dynamics on Indian Oil Sardine fishery along the south-west coast of India. The results of the analyses of Coastal Upwelling Index and Mixed Layer Temperature revealed that upwelling significantly diminishes and a corresponding increase in Mixed Layer Temperature was observed along the south-west coast of India during the positive IOD years. The study also showed some insights on the adverse effects of IOD events on the Oil Sardine fishery along the south-west coast of India.

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