ISSN 0254-380 X

Marine Fisheries Information Service

Technical and Extension Series

Number 198
October - December 2008

cadalmin™

Central Marine Fisheries Research Institute
(Indian Council of Agricultural Research)
Post Box No. 1603, Cochin - 682 018, Kerala, India
WWW.cmfri.org.in

Marine Fisheries Information Service T&E Ser., No. 198, 2008

Marine Fisheries Information Service

How environmental parameters influenced fluctuations in oil sardine and mackerel fishery during 1926-2005 along the south-west coast of India?

P. K. Krishnakumar, K. S. Mohamed, P. K. Asokan, T. V. Sathianandan, P. U. Zacharia, K. P. Abdurahiman, Veena Shettigar and R. N. Durgekar
Central Marine Fisheries Research Institute, Cochin

Introduction

The south-west coast of India is one of the major upwelling systems of the world (Malabar upwelling zone) and contributes to nearly 30-50% of the total marine fish catch from India. Generally, the coastal upwelling ecosystems are colonized by planktivorous small pelagic fishes such as anchovies, sardines and these fish populations are characterized by significant inter-annual fluctuations in their abundance. The striking feature of the marine fisheries of the Malabar upwelling area is the predominance of pelagic resources dominated by oil sardine (*Sardinella longiceps*) and Indian mackerel (*Rastrelliger kanagurta*), which support the western Indian Ocean's largest coastal pelagic fishery. These fishes have a central place in the Malabar upwelling ecosystem where they are important commercially exploited species and play a role as forage fish for numerous predators such as large pelagic fish, demersal fish, sea birds and mammals. The landing pattern of these two species along this coast can be compared to the alternating patterns of abundance between one species of sardine (or *Sardinella*) and one species of anchovy observed in other major upwelling areas of the world. Analysis of time series data on fish landing for 50 to 100 years together with environmental (ocean atmosphere) data is useful in understanding the influence of environmental parameters on the large scale fluctuations in the fisheries.

Time series data

The oil sardine and mackerel catch statistics for the south-west coast of India (Kerala and Karnataka) for the period 1926 to 2005 was taken from the publications of the erstwhile Madras Presidency and CMFRI database. The biological information on spawning season and larval abundance of these fishes were compiled from the UNDP/FAO Pelagic Fishery Project Reports and recent publications. Time series (1926-2005) data on annual rainfall for Kerala and coastal Karnataka, El Nino Southern Oscillation (ENSO) index and sunspot were used for the study. Upwelling along the south-west coast of India is reported both during March-April and during June-August. During intense upwelling season, very low sea surface temperature (SST) values were recorded from the inshore waters along the south-west coast of India. The coastal upwelling strength (CUS) for these periods were indirectly calculated based on common ocean data access system (CODAS) SST data. The catch data were related to environmental data using correlation analysis. The six point moving averages of the anomalies of fish catch, rainfall, ENSO and CUS were also plotted to determine the relationships.

Fishery trends

During the first 31 years starting from 1926 to 1956, the catches of mackerels were generally high when compared to oil sardine (Fig. 1). For the next 36 years covering 1957 - 1992, sardine catch was generally high when compared to other species. Later, during 1993-1998, again mackerel catches were higher than the oil sardine for another 6 years. The trend was again reversed during 1999-2005 and sardine was once again dominant for the recent 7 years.

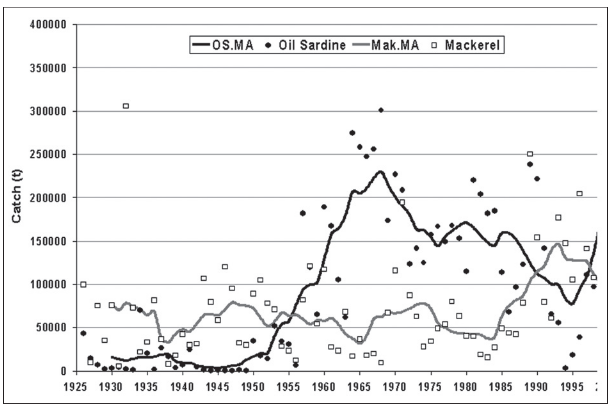

Fig. 1. Catches of oil sardine (OS) and Indian mackerel (Mak) along the south-west coast of India during 1926-2005. Moving average (MA) values plotted to show the trend

The landing patterns of the oil sardine and mackerel are compared in Table 1. The oil sardine fishery had totally collapsed during early 40s and its fishery was officially closed by the erstwhile British Government for 5 years (1943-'47). During the remaining 75 years, the catches of oil sardine were high and mackerel were low for 48% of the period and for 24% of the period, the catches of oil sardine were low and mackerel were high (Table 1). Catches of both the species were low during 15% of the period while for 3% of the period, catches of both were high. The remaining 10% of the period, a definite pattern or trend in the catches of both the species were not visible. In general, inter-annual fluctuations in oil sardine catches were very high when compared to mackerel (Fig. 1). Unlike oil sardine, catches of mackerel have shown only small fluctuations and its catches always remained around 50,000 t.

Statistical analysis of the 80 year data has not shown any significant negative correlations between

Table 1. Comparison of oil sardine and Indian mackerel catch patterns along the south-west coast of India for the last 80 years (1926- 2005)

Oil Sardine and Mackerel catch	Years	Years of occurrence	%
High oil sardine and low mackerel	1934, 1957, 1960-1985, 1987-88, 1991, 1999-2005.	36	48
Low oil sardine and high mackerel	1926, 1928-30, 1932-33, 1936, 1940, 1942, 1948-52, 1993-1996.	18	24
Low oil sardine and low mackerel	1927, 1931, 1935, 1937-39, 1954-59,1986	11	15
High oil sardine and high mackerel	1989-90.	2	3
No definite pattern or trend	1941, 1953, 1958, 1963, 1971, 1992, 1997-98.	8	10
Oil sardine fishing ban	1943-47.	5	-
	Total	80	100

Table 2. Pearson correlation between catches and environmental parameters from the study area.

	Sunspot	Rainfall	ENSO	March CUS	August CUS	Oil Sardine	Mackerel
Sunspot	1						
Rainfall	0.074	1					
ENSO	0.005	-0.317**	1				
March CUS	-0.069	0.033	-0.102	1			
August CUS	0.116	0.129	0.089	0.357**	1		
Oil Sardine	0.185	-0.088	0.047	-0.269*	-0.323**	1	
Mackerel	0.02	0.029	0.017	-0.157	0.05	-0.026	1

** indicates highly significant relationships and * indicates significant relationship.

oil sardine and mackerel (Table 2). Many of the earlier studies have shown that oil sardine and mackerel have an inverse relationship and shown some cyclic pattern (10 year cycle) in their abundance. However, the present analysis has ruled out the existence of any such inverse relationships or patterns. Both these species were exploited by the same gears all along the south-west coast of India. After analysing eighty years data, it can be stated that over-exploitation may not be the reason for the fluctuations of either oil sardine or mackerel fishery from the study area. If decadal fluctuations in the catches of sardine from the west coast of India have been caused by over-exploitation, then the catches of the other major target species (mackerel) should also be similarly affected. In fact, the catches of both the species were simultaneously very low only for 15% of the period (Table 1) and except for 1986; all such events occurred prior to 1959, even before the introduction of the mechanized purse seine and ring seine gears along the south-west coast. Therefore, the collapse of either the oil sardine or mackerel fishery has happened not due to over-exploitation but due to some other fishery independent factors. Interestingly, collapses and recoveries of both these species have occurred during different years (Table 1).

Environmental parameters

Correlations between environmental parameters and catches of oil sardine and mackerel are shown in Table 2. The rainfall has shown negative correlations with ENSO as reported earlier by several workers. Oil sardine catches show significant negative correlations with the CUS, indicating that intense upwelling is not favourable for its successful fishery. However, such relationships were not observed between mackerel and CUS values (Table 2). Rainfall, sunspot activity or ENSO index did not have any significant relations with catches of both species.

Positive anomalies of CUS (indicating intense upwelling) were found to result in poor landing of oil sardine during 1926 - 1956 (A) and during 1993-1998

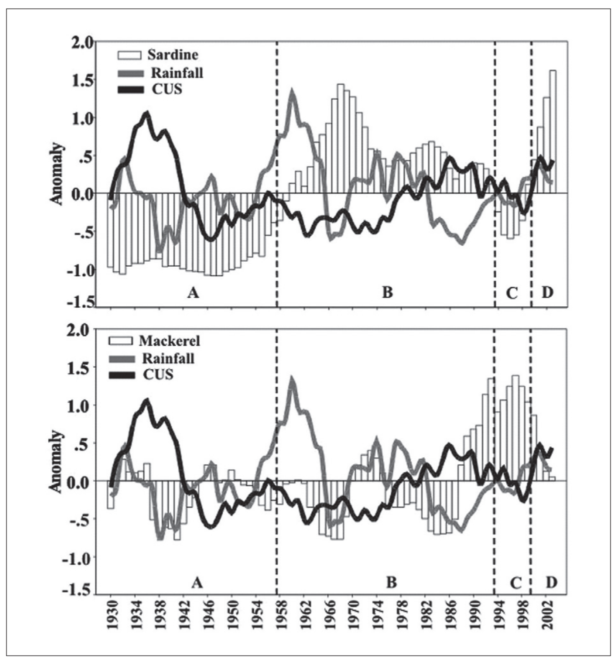

Fig. 2. Six point moving average of anomalies of CUS and rainfall against anomalies of oil sardine landing (top panel) and Indian mackerel landing (bottom panel) along the west coast of India during 1926-2005.

A) mackerel dominated period during 1926-1956, B) sardine dominated period during 1957-1992, C) mackerel dominated period during 1993-1998 and D) sardine dominated period during 1999-2005.

(C) as shown in Fig. 2. Negative anomalies of CUS (indicating mild upwelling) were found to result in good landing of oil sardine during 1957-1992 (B) and during 1999-2005 (D) as shown in Fig. 2. During early 1940s, intense upwelling were reported from the south-west coast of India resulting in the total collapse of oil sardine fishery (Fig. 1). Intense upwelling was found to be not affecting the mackerel fishery (Fig. 2). The oil sardine fishery was also generally low when the rainfall was below average during 1926 - 1956 and 1993-1998 (Fig. 2). It is interesting to note that the revival of oil sardine fishery in mid 50s and late 90s coincided with heavy rainfall.

Optimal Environmental Window (OEW)

The spawning and recruitment strategies of clupeoids from the upwelling areas were found to be adapted with the spatial and temporal pattern in the upwelling of the region. Wind driven upwelling takes place during March to April along the south-west coast of India. Again with the onset of south-west monsoon, the current driven upwelling occurs during June-September. The duration and intensity of upwelling varies from year to year. The spawning and recruitment period of oil sardine was found to overlap with the major upwelling season of June to September along the Malabar coast (Table 3). During or immediately after the upwelling from August to September, large scale phytoplankton blooms are seen along this coast, making it an ideal condition for the feeding and survival of the newly hatched sardine larvae and juveniles depending up on other environmental conditions. The heavy river discharge associated with monsoon rains also brings nutrients such as silicate required for the algal growth in the inshore waters.

Optimum environmental conditions or Optimal Environmental Window (OEW) such as nutrient enrichment (upwelling or mixing), concentration processes (convergence, stratification) and retention processes that maintain eggs and larvae in the suitable habitat were found to be crucial for the successful recruitment of clupeoids in the upwelling areas. Despite their high rate of production, the adverse environmental conditions during the upwelling season can create havoc for their larval survival and subsequent recruitment success. Therefore, the recruitment success of clupeoids such as oil sardine whose spawning and recruitment cycle is overlapping with the upwelling season is depending upon several environmental parameters (or OEW) such as wind speed, turbulent sea conditions, upwelling intensity, SST and dissolved oxygen (DO) content in upwelled water *etc*. Very low DO values in inshore waters due to intense upwelling can also prevent the spawners from even entering the shelf area for spawning and high wind speed (>5-6 m/s) or turbulent sea conditions can destroy or result in offshore drifting of the larvae away from their feeding ground. Unlike mackerel, the successful recruitment of oil sardine in the Malabar upwelling region in a particular year is very much at the mercy of environmental conditions prevailing in the area during June to September.

Mackerel reproductive strategy appears to be quite distinct from that of oil sardine since it was found to have an extended spawning and recruitment season starting from March to August and even extending to October (Table 3). Therefore, the unfavourable environmental conditions associated with intense upwelling may not be affecting the spawning and recruitment of mackerel due to its reproductive strategy which ensures that successful recruitment elsewhere can make for lost potential during the early part of the upwelling season. Longhurst and Wooster (1990) also have reported that the success in recruitment of oil sardine fishery is very much dependent on the intensity of upwelling (derived from sea level) along the south-west coast of India (Can. J. Fish. Aquat. Sci., 47: 2407-2419).

Table 3. Comparison of the reproductive biology of oil sardine and Indian mackerel from the south-west coast of India.

Biology	Oil sardine	Indian mackerel
Spawning season	June - August	March - August (often extended up to October)
Spawning ground	Shallow inshore waters	20-30 m depth zone within the shelf region
Length at first maturity	15 cm	18-19 cm
Fecundity	30×10^3 - 45×10^3	90×10^3 - 95×10^3
Season of larval abundance	June - August	April - October

Conclusion

Inter-annual fluctuations in oil sardine catches were very high when compared to mackerel. Significant inverse relationships were not observed between the catches of oil sardine and mackerel. Catches of both species were not having any significant relationships with sunspot activity, ENSO or rainfall. Both the species were exploited by the same gear from the same area and almost during the same period and hence, over-exploitation may not be the reason for the collapse of oil sardine fishery during early 40s and in 1994. The spawning and recruitment period of oil sardine was overlapping with the major upwelling season of June to September along the Malabar coast, while mackerel was having relatively extended spawning and recruitment period. Therefore, during certain years, the unfavorable environmental conditions associated with intense upwelling might have affected the successful spawning and recruitment of oil sardine. The revival of oil sardine fishery in mid 50s and late 90s coincided with heavy rainfall.

This work was carried out under an AP Cess Fund project on “Assessing the impact of fisheries on biodiversity of marine fish resources of south-west coast of India”.