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Co-occurrence of Species in Catches from Multi-day Trawlers along North-east Arabian Sea – Implications for Resource Predictions

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Abstract

Conventional approaches for prediction of fishery resource abundance use remote sensing data of chlorophyll concentration along with secondary parameters such as sea surface temperature, wind speed and direction. The knowledge of co-occurrence of species can help as an input for developing ecological models for species specific predictions. This study attempts to understand abundance and co-occurrence of species in fish catches from commercial multiday bottom-trawling operations carried out over the shelf off Gujarat, based on data collected during 2004-2008. We found that ribbonfish dominated the fishery in this region and was accompanied by lizard-fishes, cuttlefishes and perches; indicating a co-occurrence of species based on the prey preferences.

Keywords: Species co-occurrence, SIMPER, potential fishing zone, trawling, multivariate

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Introduction

Chlorophyll concentration and its variation form the basis of discontinuous productivity in the oceans. Identification of areas with higher chlorophyll content conducive for fish aggregation is one of the most important operational products from satellite oceanography.

Even though higher catch rates and profits are reported from the notified areas identified using satellite imagery (Nayak et al., 2003), the biological processes behind it, are poorly understood (Solanki et al., 2008). The development of a local ecosystem in the region by formation of food chain and prey-predator interactions, are often speculated for the higher production in areas with higher content of chlorophyll. Temporal increase in the chlorophyll concentration can attract fishes feeding on the primary and secondary producers and hence improved catches of fishes like sardines and mackerels are reported in these areas along the Indian coast (Srinivasa et al., 2008; Deshpande et al., 2011).

Gujarat is a coastal state of India with substantial contribution to marine fishery production and export. Fish-landing centre-wise data collected from State fishery department have shown that Veraval alone contributes to 20% of marine fish production of Gujarat. Mechanized fishing contributes about 80% of the total catches from Gujarat and trawlers form the mainstay of the mechanized fishing in the state. Increase in catches, with an accuracy of 50-60% from bottom trawlers operating in the notified areas along the coastal waters of Gujarat is reported by Dwivedi et al. (2005) and Das et al. (2010). This study is an approach to ascertain the fishes that co-occur in the trawl catches which indirectly indicate the ecological linkages that possibly exist in the fishery along Gujarat coast.

Materials and Methods

The data for the study were collected from commercial fishing fleet operating off Gujarat coast (18-24° N, 67-73° E) during 2004-2008, except during the monsoon fishing ban (June-July). Species-wise details of commercial catch were collected from the log books maintained by fishermen and also from sales slips from the landing centre. A representative sample was also collected from the incidental catches, often brought to the landing centre to identify and quantify the species. Species were identified with the help of Fish Base World Wide Web database (Froese & Pauly, 2013). Pre-tested questionnaire was used to collect information related to the fishing effort, location, bathymetry and overall sea-state.

A species and location wise matrix was created with the data collected and the association with other species/groups was indicated as present or absent in a particular trip. Year wise, month wise and seasonal variations were also analysed to determine changes in species abundance and co-existence.

The co-occurrence of species caught by trawlers along the Gujarat coast was calculated based on 1000 simulations upon a null model. The Ecosim software was used for the simulations. Multi-Dimensional Scaling (MDS), ANOSIM and Similarity Percentages (SIMPER) analysis were carried out to characterize the species assemblages that contributed to the change in the assemblage structure. The software PRIMER^{TM} Ver.5.2.8 was used for the MDS, ANOSIM and SIMPER analysis. Catch from different years and the respective months were used as factors for the MDS and ANOSIM and year was taken as factor for SIMPER analysis. The MDS ordination was carried out on similarity file derived using Bray-Curtis similarity index on the presence-absence data file.

Results and Discussion

The catch compositions recorded during different seasons is shown in Table 1. Ribbonfish (*Trichiurus lepturus*) was found to be the most important catch irrespective of the season of capture. Other important species include perches (*Nemipterus japonicus*), squid (*Loligo duvaceli*) and moontail bullseye (*Priacanthus hamrur*). The peak seasons for these fishes were found to be post-monsoon, spring and winter respectively.

Trichiurus lepturus, which is higher in the trophic level and occurs in all the seasons, was considered as a base species and the association of other commercially important species along with this species was considered for co-occurrence analysis. Indian mackerel (*Rastrelliger kanagurta*), the species lower in the trophic level and that occurred regularly in the catches was taken as another base species for deriving co-occurrence pattern. The scores obtained after the iteration analysis for ribbon fish and Indian mackerel are shown in Table 2. Five species groups were found to co-occur the most with the catches of ribbonfish while other four

Table 1. Average CPUE (kg h^{-1}) of resources recorded during different seasons

	Post-Monsoon (Aug-Nov)	Winter (Dec-Jan)	Spring (Feb-March)	Pre-monsoon (Apr-May)
Perches	19.14	9.36	15.52	15.53
Cuttlefishes	11.14	3.35	3.26	4.13
Squids	3.10	5.73	10.86	7.76
Lizardfishes	5.40	3.98	6.06	5.43
Ribbonfish	25.57	17.21	8.58	15.51
Croakers	4.26	6.59	3.96	6.71
Catfish	2.64	4.54	3.84	5.33
Groupers	3.14	3.74	3.36	0.00
Bullseye	5.75	17.19	16.84	6.56
Crabs	1.47	1.19	11.43	3.17
Indian mackerel	2.38	2.54	1.82	1.26
Seerfish	5.30	1.92	0.56	1.59
Octopus	1.62	6.35	3.97	2.40

species groups had lower co-occurrence. Lizard fishes were the only species group that regularly co-occurred with Indian mackerel. Other groups with lower associations in the catches were bullseye, octopus, cuttlefishes and groupers.

Table 2. Association of fish-groups with ribbonfish and Indian mackerel (1000 iterations using a null model)

Species groups	Ribbonfish	Indian Mackerel
Bulleye	13790	5452
Lizard fishes	18340	10829
Perches	18088	
Cuttlefishes	18952	8142
Groupers	13578	5616
Catfish	5605	
Octopus	8034	5472
Squids	9130	
Crabs	8159	

The species that co-occur with ribbonfish are all higher or mid-trophic level carnivores which mainly feed on small crustaceans, crabs, shrimps and other benthic fauna (Froese & Pauly, 2013). Abundance and repeated co-occurrence of these fishes in the catch could indicate that bottom ecology is linked with near-surface productivity and major groups of fishes depend upon these crustaceans. Such vertical linkage in food chain is sustained due to shallow and well-mixed water in bottom-trawling fishing grounds over wide continental shelf off Gujarat. The importance of small crustaceans especially the *Acetes* sp. in the diet of commercially important demersal fishes found in the study area is reported by Thangavelu et al. (2012). The association of jellyfishes with fishes higher in the trophic level was reported by Panda & Madhu (2009).

In case of Indian mackerel, very low score was observed with the groups such as bullseye, cuttlefishes and groupers, which in turn showed strong co-occurrence pattern with ribbonfishes. The comparatively higher co-occurrence pattern of Indian mackerel with lizardfish (*Saurida tumbil*), which is reported to be an opportunistic predator of zooplankton and small crabs, indicates the importance of prey items in structuring the trawl catches, which could be taken as an input for predicting availability of these fishes in the fishing ground.

The years and months with significant differences in the multivariate structure derived using ANOSIM analysis revealed that the species assemblages differed significantly between all the months except between September and October. The average dissimilarity between years and the similarity within each year derived using SIMPER is shown in Table 3. The largest difference in the species assemblages was observed between April and August, which can be attributed to difference between pre-monsoon stratified upper layer conditions to that of the post-monsoon well-mixed water column, resulting in homogenous nutrient availability. The nutrient availability will affect the prey production and hence changes in the fish assemblages feeding on them. Another significant non-coherence that was observed was between September and October. This suggests that better availability of Photosynthetically Available (/Active) Radiation (PAR) could be playing an important role in October when cloud cover is less compared to that in September. The fishermen often refer to 'a lull' in fishing season in winter starting from October.

Table 3. Results of the similarities percentage test showing average dissimilarity of species assemblages between years (A) and (B) between months

A. Between two years	
Groups	Avg. Dissimilarity
2004 & 2005	64.55
2004 & 2006	67.15
2005 & 2006	62.36
2004 & 2007	65.70
2005 & 2007	63.92
2006 & 2007	62.77
2004 & 2008	74.05
2005 & 2008	72.22
2006 & 2008	70.83
2007 & 2008	67.68
B. Individual Years	
Year	Similarity (%)
2004	40.15
2005	41.89
2006	36.93
2007	41.49
2008	37.50

The result of winter "lull" in fishing was more obvious with respect to December and April, with highly varied species assemblages. This is believed to be due to cooling and sinking of upper layer waters in the absence of strong winds during month of December, resulting in a drop of productivity (Madhupratap et al., 1996).

The average dissimilarity and similarity between years in terms of species assemblages is shown in Table 3. The results show that consecutive years were similar to each other in terms of years 2004 & 2005 and 2006 & 2007 were found to be similar in terms of species assemblages. The year 2008 was significantly different from the other years and this could be related to the teleconnection of North-East Arabian Sea ocean-atmosphere coupled processes to ENSO variations in equatorial eastern Pacific Ocean (Nimit et al., 2013).

The MDS plot generated using months and years as factors are shown in Fig. 1 and 2 respectively. The stress value obtained for the MDS test was 0.18, which is a fair representation of the species assemblages in two dimensional space (Borg & Groenen, 1997). The MDS analysis also indicates the

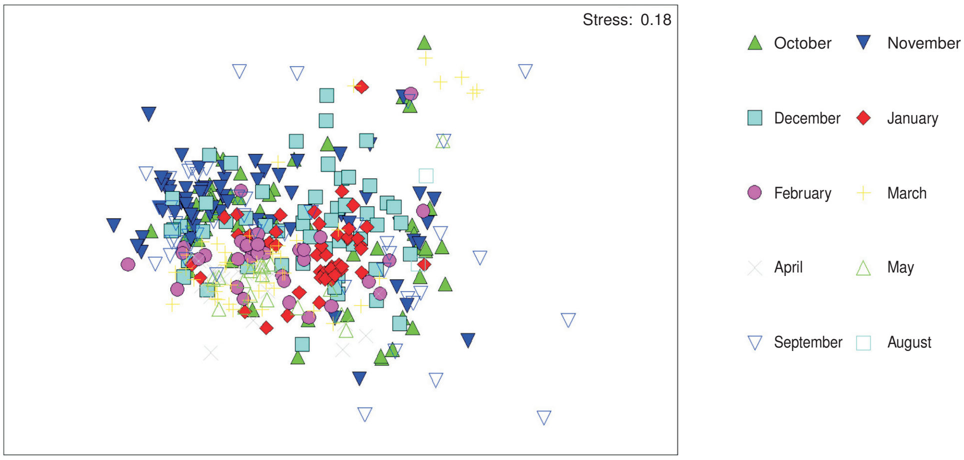

Fig. 1. Multidimensional Scaling (MDS) ordination diagram of species assemblages of different months during 2004-2008

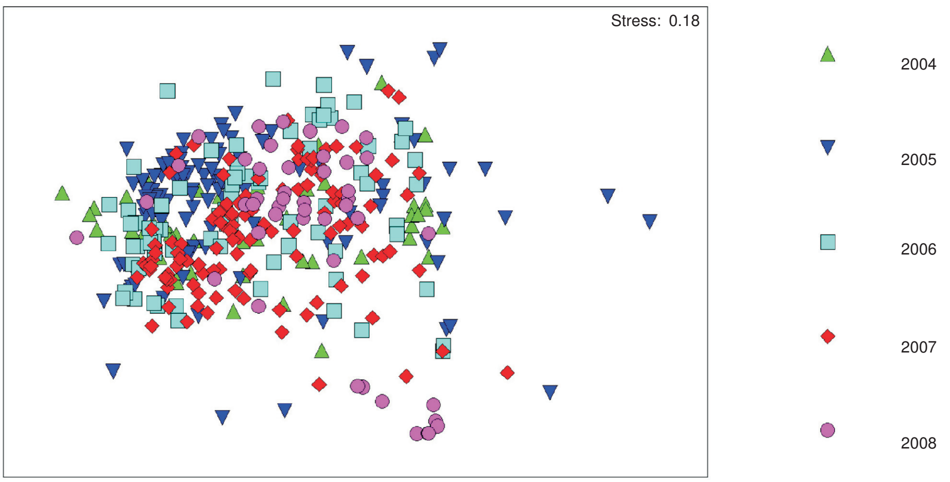

Fig. 2. Multidimensional Scaling (MDS) ordination diagram of species assemblages of different years for the period 2004-2008

difference in the assemblages caught during the months of September-October, which are the months immediately following the monsoon ban along the coast. The assemblages during 2008 stand out separately indicating difference in the multidimensional space, which is in concurrence with results of ANOSIM and SIMPER.

This study is a preliminary attempt to determine the species that co-occur with major commercially targeted fishes by trawlers, along the waters off Gujarat. The results indicated that ribbonfish was the most important species in the fishery and was almost always accompanied by lizard-fishes, cuttle-fishes and perches in multiday fishing operations carried out in the depth zone of 35-60 m. The results of the analysis also indicate a co-occurrence of species which is mostly related to the preference of prey found in the fishing ground. The results of the study can be an input for models, which could be used for developing species-specific, PFZ advisories for Gujarat.

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