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GIS for Assessing Spatio-temporal Variations in Trawl Bycatch off Mangalore Coast

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Abstract

In India, trawl is the major gear contributing more than 50% of the marine fish landing and during 2008-2011, the average landing along the Indian coast was estimated at 1.7 million t. In India, fish brought from trawl fishery for human consumption in fresh or processed form is termed as commercial landing and the rest is called low valued bycatch (LVB). The increased demand for LVB from fish meal plants is an emerging threat for marine fish production in the future, since LVB was constituted mainly by juveniles of commercial fishes. The study showed that the percentage of LVB from the trawlers in India increased from 21% in 2008 to 23% in 2011. The results of the study identify some of the fishing grounds and seasons, in which the percentage of juvenile bycatch of the commercial species is very high. Implementing operational restrictions in the fishery in such areas will help in reviving the stock. The paper illustrates the utility of the spatio-temporal data in suggesting seasonal and spatial restrictions in fishing operations in tropical multispecies scenario.

Keywords: Trawl fishery, bycatch reduction, juvenile exploitation, GIS, operational restriction

Introduction

About 27 million t of the total global catch is discarded annually (Alverson et al., 1994). There are various bycatch reduction devices employed in different countries for different gears and Eayrs (2005), Boopendranath (2007) and Pravin et al. (2011) have reviewed the development and utility of design based bycatch reduction devices (BRD). The use of selection technology in reducing the incidental catch of non-target species from fishing grounds in tropical waters was found to be less effective due to various reasons (Dineshbabu et al., 2014). In tropical fishery scenario, where various species at different phases of their life cycle co-exist, mesh size regulation and similar design based restrictions have lot of practical difficulties. It is suggested that the BRDs in association with spatial and temporal closures of trawling will be the best option for the bycatch reduction in tropical waters. Expert Consultation on International Guidelines for Bycatch Management of Discards (FAO, 2010) suggested that closure of nursery/spawning grounds or areas of special biological significance can reduce bycatch and such spatially based measures help in the creation of marine protected areas, marine parks and zones reserved for traditional fishing activities.

Geographic information systems (GIS) is a powerful tool which integrates the spatial component with the present temporal studies, but GIS rarely appears within the institutionalized system of science in many countries (St. Martin, 2004). GIS mapping of spatio-temporal distribution of all fishes and the different life stages and sizes of the fish distributed in a specific area can form a background information for spatial restriction of fishery to reduce bycatch. This multilayered information on different species, different size groups and different maturity stages, will enable researchers and policy makers to assess the fishing ground under their jurisdiction in terms of resource conservation and exploitation. GIS based mapping was used for spatial allocation of fishing intensity successfully implemented in inshore waters of bay of Fundy in Canada (Caddy & Carocci, 1999). Operational restrictions in fisheries management will help in curtailing fishing operations in

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certain areas of biological significance, designated as marine protected areas (MPA). MPA managers and scientists are increasingly using GIS to manage, map and analyze resources under their jurisdiction (Manson & Die, 2001). Objective of the study was to understand the spatial and temporal distribution of juvenile fishes to suggest approaches for conservation of resources.

Material and Methods

Data on total catch, bycatch and discards were collected from a pre-identified commercial trawler. The L_{OA} of trawler was 15.85 m with 160 hp engine which was engaged in multi-day trawling ranging from 8 to 13 days. Crew in the sampling vessel were trained for onboard data collection using a log sheet. Along with fishing information, an unsorted portion of discarded catch was collected as sample for analysis. The samples were preserved in ice and stored in fish-hold and were identified up to species level. The spatial data collected were used as an input for the GIS study. For spatio-temporal distribution mapping and smooth handling of data, two softwares were used, *viz.*, ArcGIS and Visual Basic 6. Visual Basic was populated with data of commercial catch and discards, geographic coordinates, water depths and net types. Thematic shape files/feature classes were prepared by sending queries to this database. Data collection was done during 2008-2009 and data from 483 trawling days were used for the analysis.

To get an overall picture of catch-bycatch situation in trawl fishery of India, trawl fishery data were collected from all the major fishing harbours of India, namely Veraval (Gujarat), Mumbai (Maharashtra), Karwar and Mangalore (Karnataka), Calicut, Cochin and Sakthikulangara (Kerala), Chennai (Tamil Nadu) and Visakhapatnam (Andhra Pradesh) during 2007-2012.

Results and Discussion

Even though trawl is a non-selective gear, there is a targeted fishery in each season. Major targets are shrimps, cephalopods and high value demersal fishes. Fish trawls are dragged with high speed to catch bottom and off bottom resources. The estimated all India trawl landing showed an increasing trend during the period of study. Average all India trawl landing for the period 2008-2011 was 17 lakh t. with a maximum of 20 lakh t in 2011. Trawl landings formed 51% of the total marine fish landing in the country. It was observed that even though the total landing by trawlers showed steady increase during 2008-2011, corresponding increase was not recorded in the edible portion of the landing, which fluctuated around 3 lakh t during the period. The non-edible portion of the landing steadily increased from 50,000 t in 2008 to 1 lakh t in 2011. Overall analysis of the trawl centres of Indian coast showed that the LVB percentage in the total landed fish was 16% in 2008, which increased to 27% in 2011. Though trash landing was on the increase in all the centres the quantity discarded was less. Alverson et al. (1994) observed that the Chinese shrimp trawl fleet discards very little of the non-shrimp catch and all the bycatch was used as feed for Chinese aquaculture industry. In Asia, there has been considerable growth in aquaculture in recent years and the demand for trash in fish meal plants in India has also increased to a large extent. In food deficit countries, bycatch is used for feeding people and better utilization of the bycatch has reduced the discards substantially (Clucas, 1996). In many instances the value realized for trash is more than that is available for low value edible variety and this is causing serious threat to food security (Chandrapal, 2005).

Karnataka accounted for 11% of the country's trawl landing during 2008-2011. Over the years trawling in Karnataka have undergone considerable changes. Shrimp trawling became a minor activity and the target is shifted towards finfishes and cephalopods. About 90% of the trawl landing of Mangalore in 2012 was formed by fin fishes and the contribution of shrimps was reduced to mere 2%. There was considerable reduction in discarded bycatch in Mangalore during 2008-2011. In 2008, the estimated discard percentage of multi day trawlers was 22%, which came down to 6% in 2011. Bycatch from single-day trawlers formed 30 to 40 % of total catch. There was a considerable increase in landed bycatch (trash) in Mangalore. The trash landing which formed only 3% (3,000 t) of the trawl landing in 2008 increased to 26% of the total fish landed (12,000t) in 2011. Detailed study of the composition of catch, LVB and discards from trawlers operated from Mangalore during 2008 and 2009 is shown in Fig. 1.

This kind of increase in LVB landing was the result of increased demand from the fish meal plants operating all along the Karnataka coast. Juveniles of 95 species of finfishes, 27 species of crustaceans and

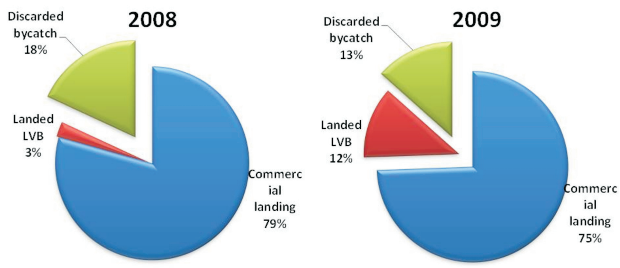

Fig. 1. Catch composition of trawlers during 2008 and 2009

20 species of molluscs were identified from LVB landing from Mangalore.

GIS mapping of the trawling grounds covered by trawlers from Mangalore in 2008-2009 showed that, they operated from seas off Malabar and Konkan coast, Calicut in the south (75º E, 11ºN) and to off Ratnagiri in the north (73.5 º E to 17 º N) (Fig. 2). The depth of operation was between 5m and 167m. While analyzing the fishing operation for 2008-2009, most intensive trawling operations were observed in fishing grounds at 30m depth off Mangalore to Panaji, followed by fishing ground at 100 m depth off Malpe to Karwar. Fishing ground at 30m depth off Ratnagiri also has found to be fished with moderate intensity. The present study reveals that most of the fishing operations are concentrated within the 150 m depth zone and extension was mainly parallel to the shore, towards south or north.

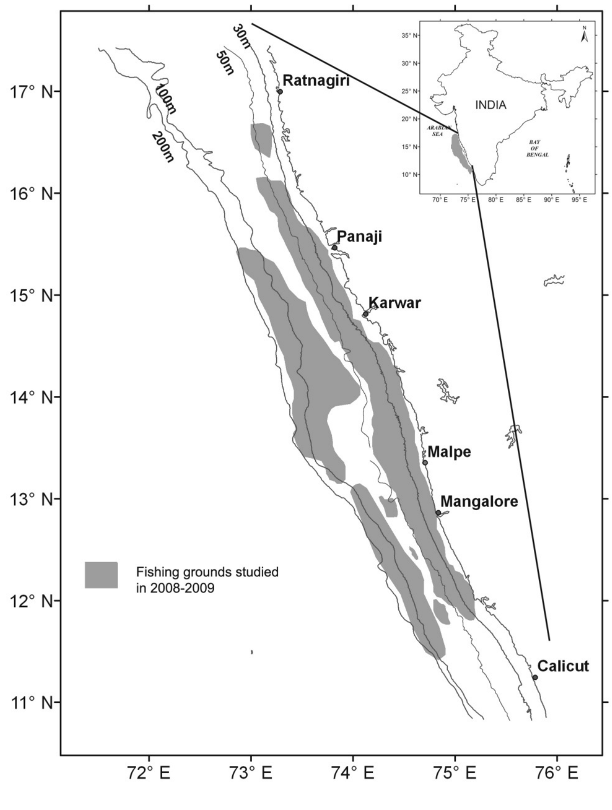

Fig. 2. Study area

Month wise analysis of catch and bycatch from the trawling grounds operated by the commercial fishing boats showed that discard percentage was maximum immediately after monsoon which is a clear justification for the trawl ban during monsoon. During the study, discards was found to be maximum during the beginning of the post monsoon season. In August, September and October the catch rate of discarded bycatch was at the rate of 36.8, 31.5 and 25.0 kgh^{-1} respectively (Fig. 3). The juvenile percentages in the discarded bycatch during these months were 74, 76 and 74% respectively.

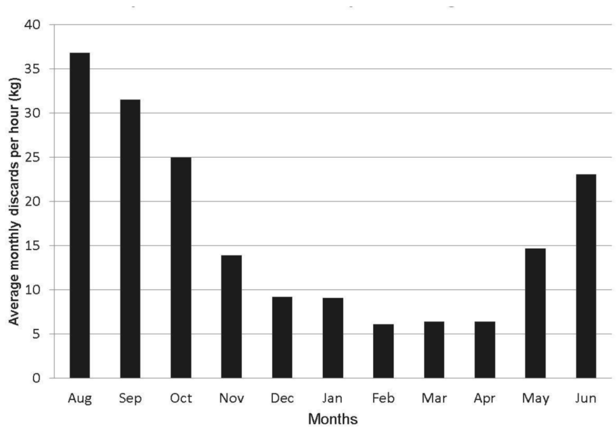

Fig. 3. Monthly variation of discarded bycatch from trawlers operated from Mangalore

Seasonal analysis reveal that rationalization of trawling operations is required during August-October to avoid high level of juvenile exploitation. To pinpoint the fishing grounds of critical nature, the abundance map of discarded juveniles of these months were prepared with the help of GIS and upon queries the data base for average month-wise juvenile discard rate, (Fig. 4) it was observed that the quantiy discarded is not uniform in different fishing grounds. Highest exploitation of juvenile was found mainly from the grounds with 50 m depth, where number of discarded juveniles formed 70 to 80% of the total catch. Spatial restrictions on trawling in the areas of high incidence of juveniles can reduce the juvenile bycatch considerably. Such inferences can help in deriving spatial restriction in trawl operations to reduce the resource damage due to trawling. Morphin et al. (2012), analysed the temporal variability/stability of the spatial distributions of key exploited species in the Gulf of Lions (Northwestern Mediterranean Sea). The spatial structure of the distribution of the 12 key species studied remained same during the time period sampled and with varying abundance in adult and juvenile phase. These maps were used to understand the repeatability of their assemblage and also to know the fishing pressure on the key species. Such repeatability of abundance of adult and juveniles will help the policy makers to develop management strategies based on prediction.

The utility of the layer character of GIS in bycatch reduction is that, effort restrictions can be imposed in those fishing ground in a particular season when the exploitation of juveniles is maximum. In Karnataka, *Nemipterus randalli* is a commercially important demersal species and exploitation of juveniles of this species is found to be very high. By mapping the abundance of *N. randalli*, it was found that there are grounds off 50 m depth, where the catch rate of juvenile *N. randalli* is more than 20 kg h^{-1} and all these are discarded (Fig. 5). When compared to Fig. 4, the present map is giving an additional layer of information to pin point on species of special concern. Similar mapping can be carried out in different species which need

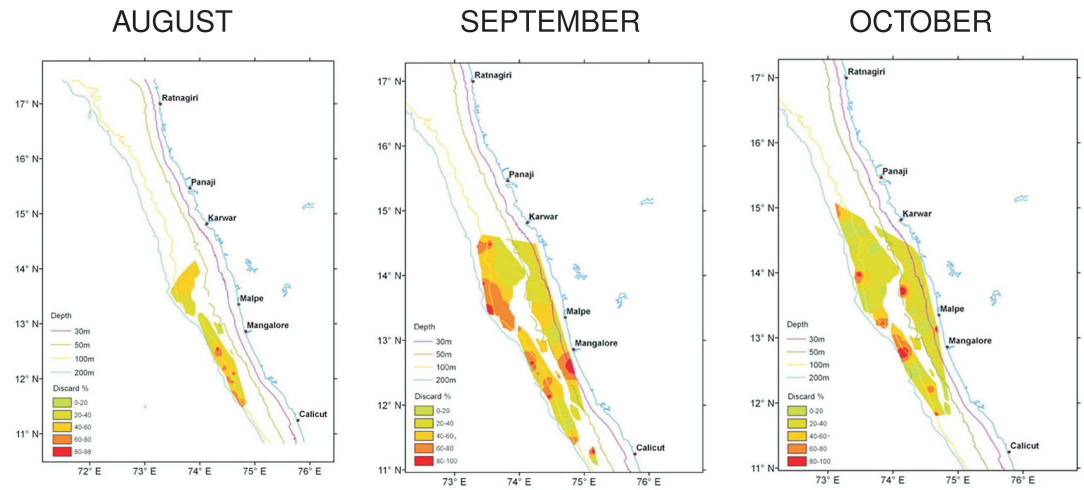

Fig. 4. Spatial abundance of juvenile fishes off Mangalore coast

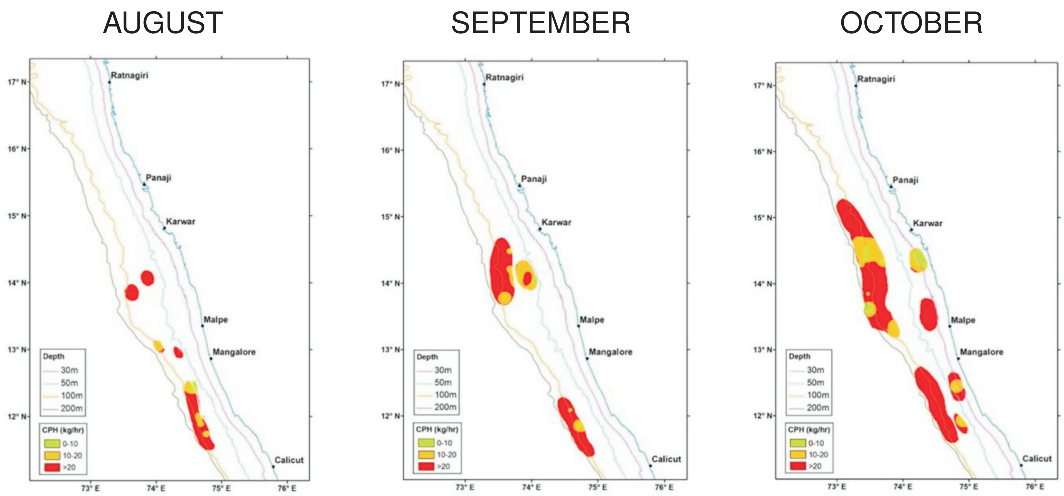

Fig. 5. Spatial abundance of threadfin bream juveniles caught off Mangalore coast during August-September

management intervention to sustain and improve their production. Using fishery stock assessment projection model (Thomson & Bell, 1934), and with less exploitation of juveniles better production in upcoming years was projected leading to better economic return, (Dineshbabu & Radhakrishnan, 2009, Dineshbabu et al., 2012). Further studies on the juvenile abundance in these particular fishing grounds will help in identification of critical fishing ground where seasonal and spatial closure of trawl fishery can be implemented to improve fishery production in the long run. Similarly spatio-temporal management of fisheries was suggested by Dunn et al. (2011) in USA to reduce bycatch of finfish or protected species. They also found that such measures are helpful in ecosystem-based management approaches. More fisheries can be managed through multispecies, multi-objective models with spatial component.

The resource maps can be used as an excellent tool for the policy makers to weigh each fishing ground in terms of commercial value and juvenile abundance so that the policy decisions match ground reality. Illustrated maps with seasonal and fishing ground wise distribution of juveniles and commercial fishes will help as a useful tool in awareness programs to extend the research findings to the stake holders.

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