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Performance of Separator Trawl off Cochin, Southwest Coast of India

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Abstract

Shrimp trawling generates large quantities of bycatch due to the non-selective nature of the gear. Behavioural differences and vertical distribution of the targeted species are among the main factors considered for designing trawls for selective trawling. This study attempts vertical separation of species in a trawl by inserting a horizontal panel, leading the upper and lower compartments to two separate codends. A total of 27 hauls were carried out and the species assemblage in the upper and lower codends were studied. Multivariate analysis was carried out to find the differences in the species assemblage structure between the two codends. Comparative analysis of the catches in the two codends has shown that the catch rate was about 25 times higher in the lower codend than in the upper codend. The catch rate of *Parapenaeopsis stylifera* and *Metapenaeus dobsoni* alone formed around 77% of the total CPUE in the lower codend. The contribution of shrimps in the upper codend was only about 15% of the total CPUE, which confirmed the importance of vertical height of the trawl mouth in the selective capture of fishes and for reducing bycatch, which comprised mostly of juveniles of commercially important fishes, in targeted shrimp trawling. Although the diversity indices did not show any significant difference between the codends, the difference in the species were very significant in the ANOSIM test ($p<0.01$) and the major species that were responsible for the difference in the species assemblages were found to be *P. stylifera* and *Sardinella longiceps*. As the catch of jellyfish were significantly lower in the lower codend, their catch in shrimp trawls can be considerably reduced by using nets with low vertical height.

Keywords: Separator trawl, shrimp trawling, bycatch, southwest coast of India

Introduction

Shrimp trawling is the largest contributor of bycatch in the world (Andrew & Pepperell, 1992; Kelleher, 2005). Shrimp trawling is an important fishing method in India and it contributed about 0.2 million t of penaeid shrimps, during 2013-14 (CMFRI, 2014). Trawling for shrimp is carried out in India by small and medium sized mechanized trawlers in the size range of 9.5-16 m using trawl nets with codend mesh sizes in the range of 10-20 mm (Edwin et al., 2014a), which leads to generation of large quantities of bycatch (Boopendranath et al., 2008). The quantity of bycatch generated annually by the trawlers in India was reported by George et al. (1981), Gordon (1991) and Pramod (2010).

Shrimps contribute a sizeable portion of the landings by trawlers in Kerala and value-wise the exports are to the tune of Rs. 14491.4 Million (Anon, 2013). There are about 3 678 mechanized trawlers operating along the Kerala coast (CMFRI, 2012). Size of the shrimp trawls in the State ranges from 23 to 58 m (head rope length) with 18-25 mm codend mesh size (Edwin et al., 2014b). Quantification and characterization of trawl discards along Kerala coast was reported by Kurup et al. (2003; 2004) and Gibinkumar et al. (2012). Boopendranath et al. (2008) have reported that the average catch of shrimps in terms of weight as 13.7% of the total landings and the rest is constituted by juveniles of commercially important fish species, low value fishes, cephalopods, crustaceans and others. Further, a total of 64 species were reported in the

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discard component during experimental trawling operations, which shows large scale impact of trawling on aquatic resources.

Studies to reduce bycatch are being attempted world over and for this, introduction of BRDs and changes in the designs of trawls are often attempted (Rogers et al., 1997; Brewer et al., 1998; Courtney et al., 2006; Hannah & Jones, 2007; Tosunoglu et al., 2009). In the Indian scenario, studies using BRDs were conducted along the Cochin coast (Boopendranath et al., 2008). Studies were carried out using square mesh codend and windows, mostly along the Kerala and Gujarat coasts (Varghese et al., 1996; Kunjipalu et al., 2001).

Size and behavioural responses of different species are used for selective exclusion of non-target species from trawls (Main & Sangster, 1985; Ashok & Sheshappa, 1991). The slow swimming speed and the bottom dwelling habit of shrimps can be used for their selective capture and exclusion of bycatch. Hence the knowledge on the composition and the vertical separation profile of the species during trawling will aid in the development of resource specific trawl designs and developing novel bycatch reduction devices for the fishery. The aim of the present study is (i) to determine the vertical separation of different trawl resources by using a trawl with horizontal separator panel that leads to two separate codends; and (ii) to study the species assemblages encountered in the upper and lower codends.

Materials and Methods

The study was carried out along the coastal waters off Cochin in the depth zone of 18-35 m. All the trawling operations were carried out during day time in the commercial shrimp trawling grounds off Cochin (Fig. 1).

Departmental fishing vessel MFV Sagarsakthi (15.5 m $L_{OA;}$ 220 hp) was used for the studies. A 30 m shrimp trawl that was re-rigged with a horizontal separator panel starting from the mouth of the trawl and leading to two separate codends was used for the experiments. The gear was rigged with a pair of V-form steel otterboards weighing 87 kg each. Scope ratio (ratio of length of warp released to depth of water) was maintained at 5:1 and the speed of each tow was maintained between 2.0 and 2.1 knots during the experiments. The design of the experimental trawl net is given in Fig. 2.

Experimental trawling was carried out for the stipulated time, ranging from 1 to 1.5 h. Catches in the codends were emptied to the deck and kept separately and sorted for length and weight measurements. When the catch volume was more than 10 kg, a sub-sample weighing around 20% of the total, was sampled and scaled-up for the analysis. Weight and length of the species was measured to the nearest gram and to the nearest millimetre respectively.

Catches were segregated based on the distribution behaviour of the species and the different species groups made for the analysis was shrimp, benthic fishes and off-bottom fishes. The catches other than shrimp, collected in the lower codend were considered as bycatch, whereas the shrimp, caught in the upper codend were considered as bycatch for analysis.

Data for all the variables were analysed using Cochran's test for homogeneity of variances and transformed if necessary and used for the analysis. Diversity indices that depict the species assemblages in the upper and the lower codend of the net were worked out (Mérigot et al., 2007). Non-metric Multidimensional Scaling (nMDS), Analysis of Similairity and Similarities Percentage (SIMPER) test was used to ascertain the difference in the species assemblages captured in the two codends of the trawl net (Selleslagh & Amara, 2008).

All the statistical analysis were carried out using PRIMER© and R routines (Ihaka & Gentleman, 1996; Clarke & Gorley, 2001; R Core Development Team, 2009).

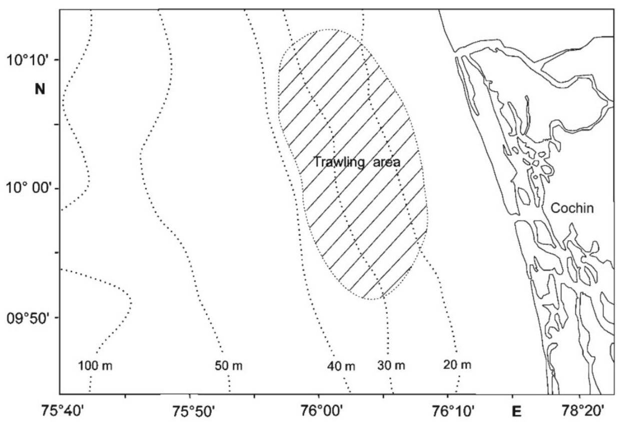

Fig. 1. The location of trawling experiments

Results and Discussion

Comparative analysis was made based on the occurrence of the species in the lower and upper codends of the separator trawl. A total of 27 hauls were carried out using the trawl and the mean CPUE for the catches in the upper codend was 1.29±0.23 kg h^{-1} and the lower codend had significantly higher CPUE ($p<0.05$), with the mean value of 6.38±1.59 kg h^{-1}.

Since the homogeneity of variance test failed, Kruskal-Wallis rank sum test was used to test whether there was significant difference in the weight of shrimp, benthic fish and off-bottom fish captured in the upper and lower codends of the separator trawl. The CPUE of shrimps were significantly higher in the lower codend (lower (mean) = 1.20 kg h^{-1}; upper (mean) = 0.05 kg h^{-1}; Kruskal-Wallis chi-squared=13.15, df=1, $p<0.001$). Catch rate of benthic fish were also significantly higher in the lower codend (lower (mean) = 0.10 kg h^{-1}; upper (mean) = 0.02 kg h^{-1}; Kruskal-Wallis chi-squared=4.63, df=1, $p<0.03$). Catch rates of other fish were not significantly different (lower (mean) = 0.37 kg h^{-1}; upper (mean) = 0.51 kg h^{-1}; Kruskal-Wallis chi-squared=0.68, df=1, $p<0.41$). The results are shown in Fig. 3.

The major species that occurred in the upper and lower codends of the net is shown in Table 1. *S. longiceps* was the most abundant species in the upper codend, with an average CPUE of 0.428 kg h^{-1}. *P. stylifera* dominated the catches in the lower codend with an average CPUE of 4.79 kg h^{-1}. Separation of major species in the upper and lower codend of the separator trawl expressed as percentage of the total weight is shown in Fig. 4.

Diversity of the species assemblages encountered in the upper and lower codends were worked out to quantify the biodiversity level impacts. Diversity indices were derived based on the weight of each species, to avoid the selective properties of the trawl net (Xu & Jin, 2005).

Diversity indices derived for two codends are shown in Table 2. There was no significant difference in the values of the diversity indices worked out for the two codends in the trawl ($p>0.05$).

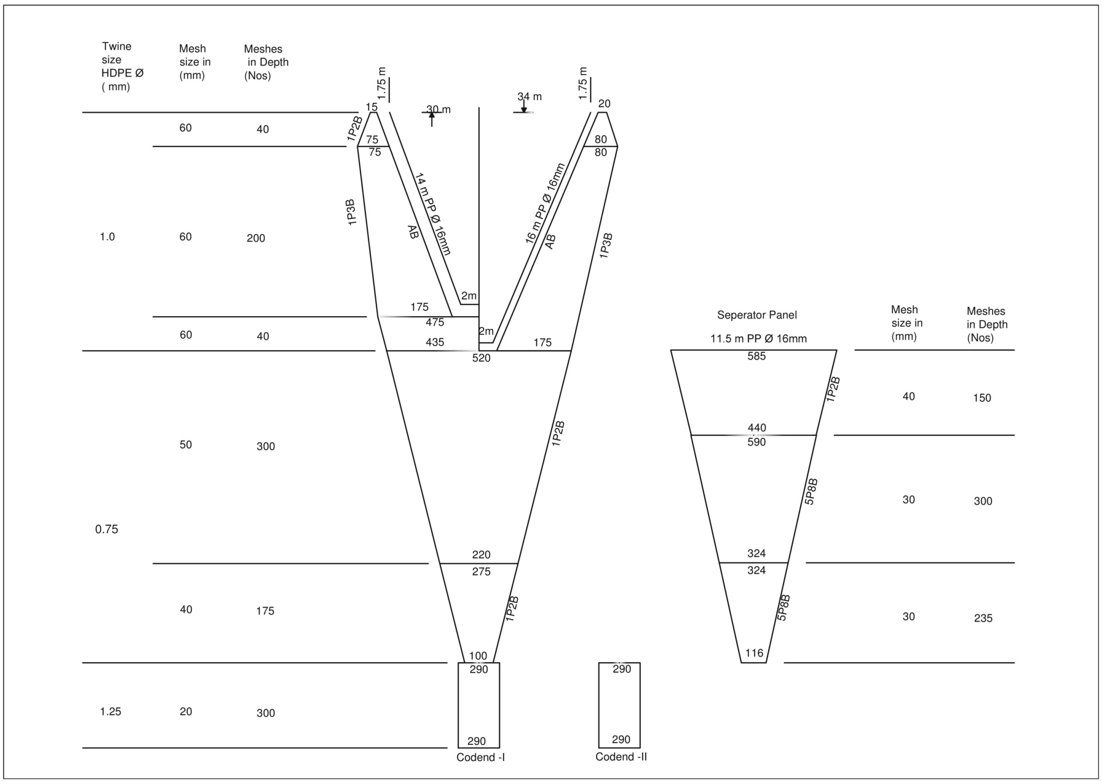

Fig. 2. Design of the trawl net used for the experiment

Table 1. Segregation of species in the upper and lower codends

Upper codend	Average CPUE (kg h^{-1})	Lower codend	Average CPUE (kg h^{-1})
Sardinella longiceps	0.428*	*P. stylifera*	4.794*
Parapenaeopsis stylifera	0.138*	*S. longiceps*	0.252*
Jellyfish	0.126*	*M. dobsoni*	0.133*
Carangids	0.092*	*Oratosquilla nepa*	0.099
Metapenaeus dobsoni	0.060*	*Cynoglossus macrostomus*	0.096*
Secutor insidiator	0.043*	*Turitella attenuata*	0.061
Rastrelliger kanagurta	0.042*	*Dussumieria acuta*	0.044
Megalaspis cordyla	0.039*	*Johnius* spp.	0.039*
Scomberomorus guttatus	0.027	*Otolithes ruber*	0.031
Leiognathus spp.	0.026	*Rastrelliger kanagurta*	0.030*
Pampus argenteus	0.020	Jellyfish	0.030*

*Significant difference between the two codends (p<0.05)

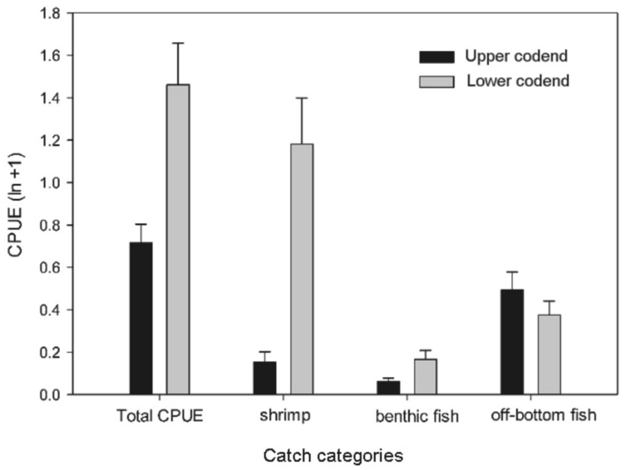

Fig. 3. CPUE obtained for different species in the upper and lower codends of the separator trawl

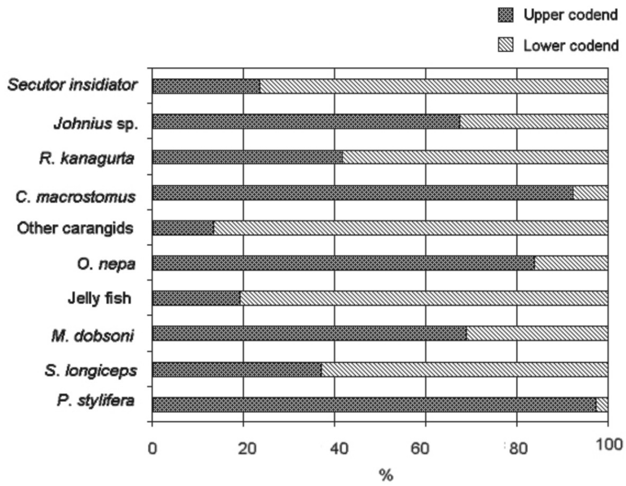

Fig. 4. Distribution of the major species in the lower and the upper codend

Non-Metric Multidimensional Analysis (nMDS)

The biomass data of species were log (x+1), transformed and Bray-Curtis dissimilarity was used for creating the similarity file and to carry out the non-metric multidimensional analysis. The stress value observed was 0.19, indicating a good separation of species in the multidimensional space (Fig. 5).

ANOSIM test

One-way ANOSIM analysis showed that the separation of species was significantly different at p<0.01 with a global R value of 0.129 with 999 random permutations. The main species that were responsible for the dissimilarity between the two groups were identified using SIMPER analysis. The average similarity of species caught in the upper codend was 13.83 and for the lower codend the value was 22.58. The average dissimilarity of the assemblages in the upper and the lower codends were 87.50 and the major species responsible for the dissimilarity between the two codends of the trawl is shown in Table 3.

Table 2. Diversity indices for species assemblages in the upper and lower codends of the separator trawl

Diversity Index	Upper codend	Lower codend
Species (S)	7±1	9±1
Margalef index (d)	11.21±3.26	10.66±2.58
Pielou'seveness (J')	0.61±0.04	0.51±0.05
Shannon eveness (H')	1.12±0.11	1.02±0.02
Simpson index (λ)	0.48±0.11	0.54±0.05
Berger Parker index (BP)	0.61±0.11	0.65±0.05

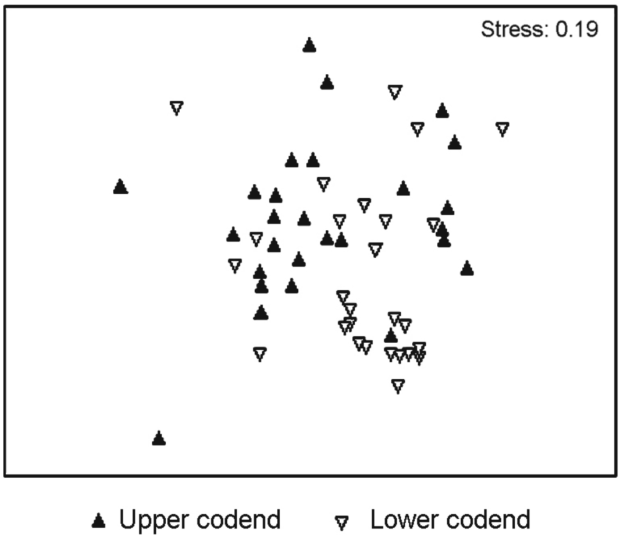

Fig. 5. nMDS ordination plot showing the separation of species in the upper and lower codends of the separator trawl

The two major species that contributed to the dissimilarity of the species assemblages of the upper and the lower codends was *P. stylifera* with a contribution of 33.85%, followed by *S. longiceps* with a percentage contribution of 14.28%.

Comparative analysis of the catches in the two codends has shown that the catch rate expressed as CPUE was about 24.8 times higher in the lower codend than in the upper codend. Catch rate of *P. stylifera* and *M. dobsoni* alone formed around 77% of the total CPUE in the lower codend. Contribution of shrimps in the upper codend was only 15.34% of the total CPUE. Although the actual vertical opening of the two codends could not be determined, it can be assumed that both the codends behaved like two trawl nets operating at different depths during the operation. The results confirmed the importance of vertical height in the selective capture of fish, since to capture an additional 15.34% in CPUE, large quantity of bycatch is generated, which comprised mostly of juveniles of commercially important fishes.

Although the diversity indices calculated from the biomass data did not show any significant difference between the codends, the difference in the species were very significant in the ANOSIM test ($p<0.01$)

Table 3. Major species in the upper and the lower codend codends identified using SIMPER analysis

Species	Upper codend Avg. abundance	Lower codend Avg. abundance	Avg. dissimilarity	Dissimilarity SD	Contribution %
Parapenaeopsis stylifera	0.14	4.97	29.62	1.21	33.85
Sardinella longiceps	0.44	0.26	12.49	0.86	14.28
Metapenaeus dobsoni	0.06	0.14	4.45	0.64	5.08
Rastrelliger kanagurta	0.04	0.03	2.83	0.45	3.24
Cynoglossus macrostomus	0.01	0.10	2.74	0.32	3.13
Jellyfish	0.13	0.05	2.53	0.28	2.89
Carangids	0.10	0.01	2.21	0.27	2.53
Dussumieria acuta	0.01	0.05	2.06	0.26	2.35
Leiognathus spp.	0.03	0.03	2.01	0.35	2.29
Secutor insidiator	0.04	0.01	1.83	0.38	2.10

and the major species that were responsible for the difference in the species assemblages were found to be *P. stylifera* and *S. longiceps* which is in agreement with the biomass level results showed in Table 1. Another important observation was the significantly lower catches of jellyfishes in the lower codend. Increased biomass of jellyfish was reported along the coastal waters (Panda & Madhu, 2009) and the catches of jellyfish make sorting difficult and at times damage the trawl nets. The catch of jellyfish can be considerably lowered by using nets with low vertical height.

The results of this study also indicate the ineffectiveness of using high opening bottom trawls for targeting shrimps, since the catches of shrimps taken together is more than 24 times in the lower codend, when compared to the upper codend. In tropical multispecies fishery, use of separator trawl can facilitate in-situ sorting and help in reducing labour and sorting time. Use of low vertical height trawl selectively catches shrimp resources, causing significant reduction in the quantity of fish bycatch in shrimp trawling. Use of gear designs like semi-pelagic trawl systems which fish at certain distance above the bottom and use of selection grids with appropriate opening, will help in selective capture of fishes (Ramm et al., 1993; Brewer et al., 1996; Hannah & Jones, 2003; CIFT, 2011).

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