Square Mesh Codends for Selective Trawling: A Case Study along Sindhudurg District, Maharashtra

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Square mesh codend covered with small mesh webbing (white) to retain escapees

Abstract

Tropical trawling fisheries are often implicated with the generation of large quantities of by-catch. The Sindhudurg coast of Maharashtra is an important trawl landing centre along the West coast and about 317 trawlers operate from three major landing centres of this region. Square mesh codends are widely tested and recommended as effective gear based on technical measure for the reduction of by-catch, often constituted by juveniles of commercially important species, and affecting the fishery.

This paper reports the results of a study conducted along the Sindhudurg coast using square and diamond mesh codends of 30 mm size and 1.25 mm thickness. A total of 38 hauls using diamond mesh and 44 using square mesh codends were used for the analysis. The mean CPUE – Catch Per Unit Effort, (kg.h.$^{-1}$) for diamond mesh (18.77) and square mesh codend (19.48) fitted trawls, were not significantly different (Kruskal-Wallis chi-squared = 0.058711, df = 1, p-value = 0.81). The increase in the mean length of 12 out of the 15 commercially important species studied increased by 7.85%. The rate of escape was 0.76 kg per hour, from the square mesh codends, which is 3.9% of the total catch (2,142.4 kg) retained and valued at INR 28.5 per haul. By-catch generated per haul, was significantly higher during the months of December (43.5±9.3 SD) and January (56.3±17.1 SD) and the by-catch during months of September, October and November were less than 20.0 kg/haul.

The study concludes that installation of square mesh codends did not affect the performance of the gear. The selection properties of the trawl net improved and no significant loss was incurred due to the use of square mesh codends. Though, mesh size optimization for

multiple species in the codend and the modelling for the future value of the escapees were not worked out, based on the analysis carried out, it is recommended that traditional diamond mesh codends can be replaced with square mesh codends, as an easy and inexpensive technical measure for management of trawl fisheries along the Sindhudurg coast.

Keywords: by-catch, Sindhudurg, trawling, square mesh, codend,

Introduction

Trawling generates significant quantities of by-catch (Pramod, 2010, Boopendranath, 2011) and also affects the integrity of the sea bottom (Collie, et al., 2000; Usha et al., 2010). The global discards have been estimated at 7.3 million tonnes by Kelleher, (2005) and trawling has the highest proportion of discards compared to any other fisheries. Davies et al., (2009), had re-estimated the global by-catch at 38.5 million tonnes, which was about 40.4% of the total global catch.

George et al. (1981) estimated by-catch in Indian shrimp trawl fisheries at 3,15,902 tonnes per annum which formed 79.18% of the total shrimp trawl landings in India. Najmudeen & Sathidhas (2008) have estimated the annual economic loss due to juvenile fishing by trawlers, along the Indian coast at US$ 15,686 million. Pramod (2010) has estimated the discards from the Indian trawl fisheries to be 56.3% of the total marine catch. Dineshbabu et al., 2014 have reported that the low value by-catch (LVB) from trawlers increased from 14% to 25% during the period 2008 -2011.

A large number of technical measures have been proposed and undertaken to reduce the incidence of by-catch (Broadhurst, 2000; Hall et al., 2000; Steele et al., 2002, Boopendranath et al., 2013). Among these, the use of square mesh codends is very popular, due to its conceptual simplicity and the ease of installation by the fishers (Ragonese & Bianchini, 2006). The mesh lumen (opening) of the diamond meshes tend to close during fishing due to various forces acting on the net, whereas the square meshes remain open and retain their shape, thus allowing non-targeted catch like small fish and juveniles to escape through the mesh openings. Studies using square mesh codends in India, have demonstrated the improvements in the selection properties (Kunjipalu, 1994; Madhu et al., 2010, Madhu et al., 2016).

The coast of Sindhudurg District, with a total fish production of 24,000 tonnes, is an important trawl fishing ground along the west coast of India (CMFRI, 2010). Sindhudurg District has a total of 317 trawlers and the Length overall (L_{OA}) of these vessels range from 12-15m. The majority of the vessels are fitted with 104 HP marine diesel engines and exclusively use codends of mesh size between 15-25 mm in the codend. There are no reports of by-catch generated by trawlers along the Sindhudurg coast, but the discards along the Maharashtra coast have been reported to vary between 68,807 – 1,11,268 tonnes forming 8%-15% of the total catches, and is constituted by juveniles of commercially exploited species (Pramod, 2010).

There are studies on the selection properties of trawlers along the North-west coast; however, reports regarding selection properties of trawlers along the Maharashtra coast are limited. The objective of this study is to conduct a comparative study using diamond and square mesh codends in the traditional trawling grounds off the Sindhudurg coast and evaluate the results in terms of ecological benefits.

Materials and methods

The study was carried out along the Sindhudurg coast of Maharashtra during September 2014 to January 2015. The three fish landing centres of the Sindhudurg District viz., Vengurla, Malvan and Devgad were selected for the study. A traditional trawlnet, locally called *Disco net,* was selected for installation, the square mesh codend with a mesh size of 30 mm and twine thickness of 1.25 mm thickness. Only the codend (the last portion of the trawl net, where the catches accumulates) was changed and the design and the operational parameters were not altered. A codend cover with a mesh size of 10 mm and the length and circumference of approximately1.5 times the codend size, was stitched to the square mesh codend to retain and quantify the escapees from the square mesh codend (Madhu et al., 2010). The catch data and length measurements were made by project staff by on-board participation.

The catch landed on the deck after each haul was quantified and a representative sample, not less than 20% of the catch, was retained for species identification and length-weight measurements. Length was measured to the nearest centimetre and weights to the nearest gram. The catches, in weight or number, was expressed as Catch Per Unit Effort (CPUE) which is the catch retained or escaped per hour of trawling.

Results and discussion

A total of 82 valid hauls (38 hauls using diamond mesh and 44 using square mesh codends) were used for the analysis. The total time spend during the trawling operations were 205 hours (110 hours using square and 95 hours for diamond mesh codend). The mean CPUE ($kg.h.^{-1}$) for the diamond mesh (18.77) and square mesh codend (19.48) fitted trawls, were not significantly different (Kruskal-Wallis chi-squared = 0.058711, df = 1, *p*-value = 0.81) Table 1. This shows that the installation of the square mesh codend did not affect the performance of the trawl system and is in accordance with studies that showed no change in the gear performance by using square mesh codend (Guijarro and Massuti, 2006; Lucchetti, 2008;Mohammed et al., 2011).

The length frequencies of 15 major species (Table 2), showed that 12 species retained in square mesh, had higher mean total length with an average increase of 7.85%. The largest positive difference in the length was observed for *T.lepturus* (39.4%) and the least for *Nemipterus* sp. (0.76%) (Fig. 1). The mean length of *Ariomma indicum* (-10%), *Megalaspis cordyla* (-11.3%) and *Caranx* sp. (-15.1%) captured in the square mesh codend was lower in square mesh codends. Studies have proved that the square meshes are more selective for carangids species along Kerala coast (Remesan et al., 2010; Leela et al., 2013). It is reported that only flat bodied fishes do not benefit from change in mesh shape (Fonteyne and M'Rabet, 1992). The catch rates of the above three species were small and may not be an actual representation of the catches, resulting in contrasting results.

The escapet from the square mesh codend was 0.76 $kg.h^{-1}$ and was constituted by juveniles of commercially important species (Table: 2). Escaped juveniles in the range of 1.8-4.6 kg per hour from 40 mm square mesh codend was reported from Gujarat coast (Mohamed et al., 2010). The slightly lower average recorded in this study, could be due to the result of 30 mm mesh used, instead of 40 mm. The list of the major species that escaped from the codend, with their escapement rates is given in Table: 3.

A total of 83.6 kg of juveniles, with a rate of 0.76 kg per hour, were released by the square mesh codend. This is about 3.9% of the total catch (2,142.4 kg) retained in the square mesh codend. The escapees, due to their small size cannot be commercially utilized and fall into the category of by-catch, with a value realization of INR 15 per kg. The value of the catch excluded was approximately INR 28.5 per haul. Results from commercial operations using square mesh codends along Gujarat coast by Mohamed et al., (2010), have reported an escapement between 1.8-4.6 kg/hour and valued between INR 4.1 – 18.0. The difference in the escapement could be due to the different codend mesh size used (Madhu et al., 2015) and also due to the spatial variation in the species profile of by-catch (Dineshbabu, et al., 2014).

The total by-catch generated by the trawlers during different months was also calculated for the period. The by-catch was low during the months from September (12.9±2.7SD kg/haul) to November (17.4±8.1 SD kg/haul). The quantity of by-catch generated was significantly higher during the months of December (43.5±9.3 SD) and January 56.3±17.1 ($p<0.01$). The variation in by-catch between other months was not significantly different ($p>.05$) Figure: 2. The total by-catch generated by other designs of trawls used for shrimp trawling (locally called *chalu* fishing) is much more than fish trawls (Personal Observations). This is the first report of the quantity of incidental by-catch generated by fish trawls operating along the Sindhudurg coast. Pramod, (2010) based on surveys along Maharashtra coast had reported the discards between 8-15% of the total catches. The catches from the present study showed incidental catches between 8.5 – 46.9% of the total catches during post-monsoon season. The difference could be due to the increased landings of incidental catches, for use in poultry industry as reported by Dineshbabu, et al. (2014).

Table 1: The catches recorded in the diamond, square and codend cover during the study

Codend type	Portion of trawlnet	CPUE ($kg.h.^{-1}$)
Diamond mesh	Codend	18.77
Square mesh	Codend	19.48
	Codend cover	0.76 (3.9%)

CPUE-Catch Per Unit Effort

Conclusion

The catches in trawls installed with square and diamond meshes showed no significant variation and hence it can be assumed that use of square mesh codend

did not alter the geometry of the net. The use of square mesh codends increase the mean length of fishes in the codend by an average of 7.85% indicating that smaller individuals escaped from the square mesh codend, thereby improving the selectivity. The rate of escape of the juveniles from square mesh codends was 0.76 kg per hour, with a value of INR 28.5, which worked out to about 0.12% of the value of catch in codend. Though not quantified scientifically, the fishers operating the trawlnet with square mesh had experienced lesser drag which translates to savings in fuel, which can significantly affect the adoption of the technology, since fuel contributes to more than 70% of the recurring cost during fishing.

This study concludes that square mesh codends can be used instead of traditional diamond mesh codends in the fishery, as an easy and inexpensive technical measure for management of trawl fisheries in the region. Targeted works to popularize this technology and awareness regarding the loss incurred by catching small fishes will help immensely in adoption of this technology.

Limitations

The present study has concentrated only on the value of the juvenile fishes that had escaped and the present value of the escapees. The value of the juveniles of commercially important species will be much higher

Table 2. The mean length (cm) of major species captured in the diamond and square mesh codends.

Species	Diamond #	Square #	Escape*
Caranx sp.	24.4	20.7	5.6 (3.5-6.6)
Pampus argenteus	21.7	22.4	-
Trichiurus lepturus	47.4	66.1	21.8 (7.6-27.4)
Rastrelliger kanagurta	16.7	17.9	6.6(4.5-9.0)
Sepiella inermis	10.7	12.1	3.2(2.5-4.2)
Parastromateus niger	14.3	15.6	3.2(2.7-3.9)
Epinephelus sp.	11.8	13.2	7.1(4-9.9)
Ariomma indicum	12.4	11.1	5.9(4.5-9)
Nemipterus sp.	13.3	13.4	4.1(2.9-6)
Thryssa sp.	14.2	14.9	7.8(6.2-10)
Megalaspis cordyla	22.1	19.6	8.2(7-9)
Atule mate	16.6	19.4	5.6(2.8-8.7)
Sciaenids	14.9	19.2	6.3(2.9-10)
Sardinella longiceps	14.1	15.9	8.9(5.4-17)
Uroteuthis (P) duvauceli	13.6	14.5	5.1 (2-9.2)

= Average length (cm), *=length range (cm)

Table 3: CPUE of juveniles that escaped from the square mesh codend

Species	CPUE (kg/h)	Nos./h
Sciaenids	0.140	4
Decapterus sp.	0.130	15
Thryssa sp.	0.108	9
Rastrelliger kanagurta	0.107	4
Stolephorus sp.	0.056	3
Uroteuthis (P) duvauceli	0.081	10
Sardinella longiceps	0.046	8
Ariomma indicum	0.042	1
Trichiurus lepturus	0.026	4
Epinephelus sp.	0.011	2

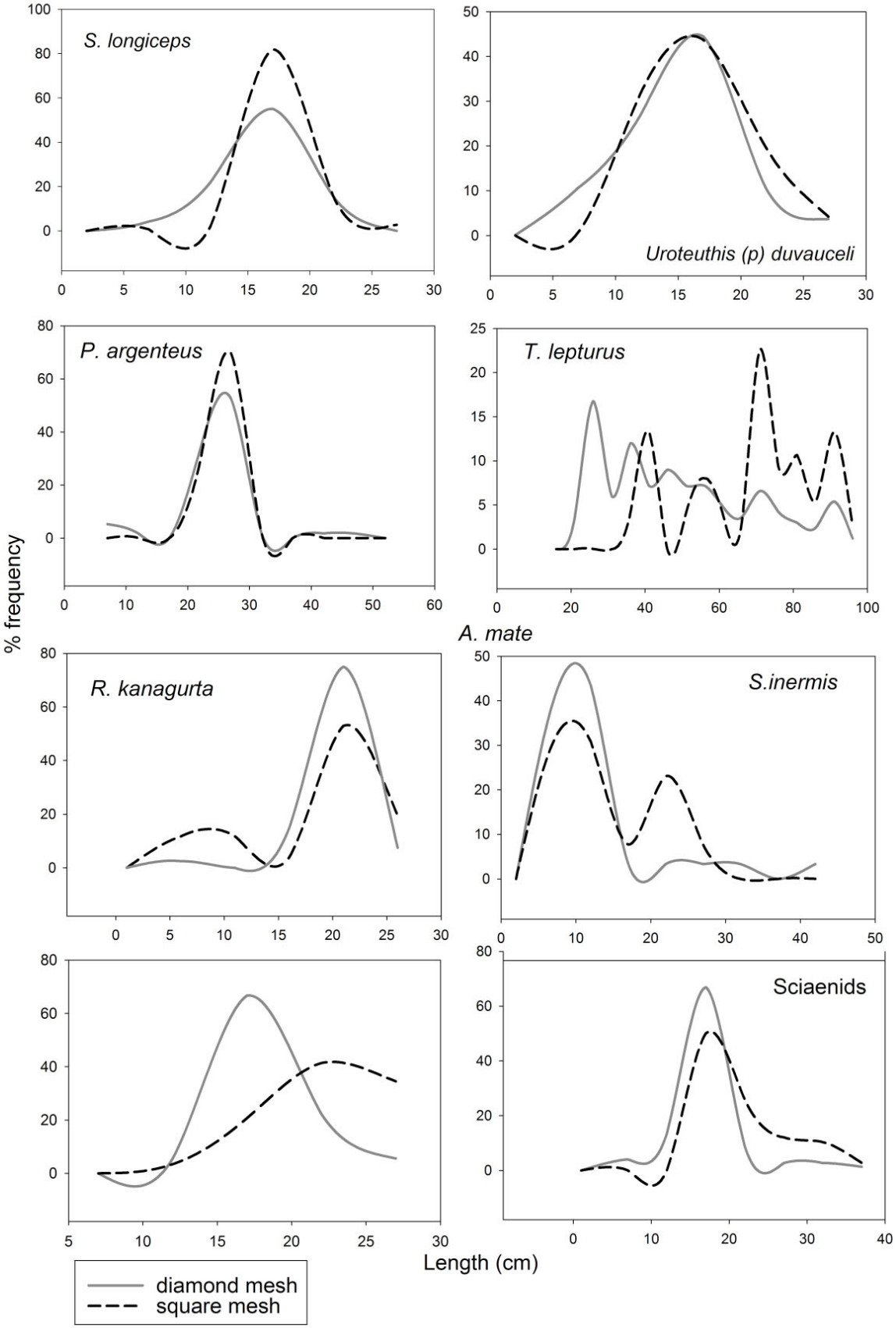

Fig: 1. Size- frequency distribution of major species reatined in the diamond and square mesh codends.

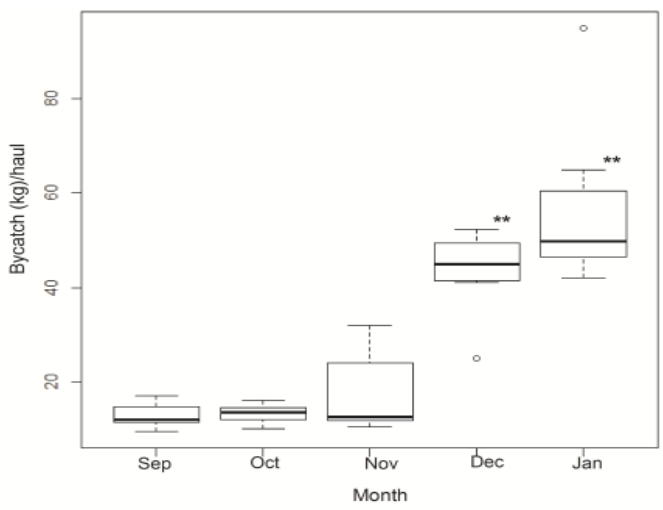

Fig. 2 Variation in the by-catch observed during the study period. The means which are significantly different are indicated as (**). The open circles are outliers and the box represents 25% and 75% quartiles. The thick line in the box is the mean.

if they are allowed to grow. Modelling techniques like Virtual Population Analysis (VPA) to estimate the future weight and value were not carried out in this study. The selectivity of individual species was also not evaluated. Since the fishery industry is of multi-species nature, the selection of an optimum mesh size would require considerations both in terms of value and the assessment of stock of the targeted species.

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Juveniles of Fish and Squid that were caught in the outer net