Bycatch Reduction Devices for Trawls

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Introduction

The global fish production reached the all-time high in 2016, estimated at 171 million tonnes, with the capture fishery contributing 90.9 million tonnes and the rest from aquaculture. With this high recorded production, the world fish supply reached a record high of 20.3 kg per capita in 2016. The record growth has been due to the increase in aquaculture production, whereas the global marine fisheries production has reached a plateau during the last decade and is now hovering around 80 million tonnes. It is estimated that about 33.1% of assessed fish stocks are overfished and the stocks which were fished at biologically sustainable levels decreased from 90 percent in 1974 to 66.9 percent in 2015 (SOFIA, 2018), and the percentage of assessed stocks that are underfished is estimated now as only 7%. The trends are really ominous and unless measures to ensure sustainability are not considered, there is no further potential for increase in marine capture.

Though there are different dimensions to the problem of stagnation in marine fish capture, growth overfishing and recruitment overfishing, illegal methods and gears used for fishing is a big issue. The non-legal gears used are often with smaller mesh sizes and are not regionally appropriate, which results in the capture of large amounts of non-targeted catch. Among the different fishing methods, however, trawling is implicated the most, due to generation of large quantities of bycatch and collateral damage to the ecosystem structure and function. Adding to the complexity is the exponential increase in the number of trawlers in the tropics over the years.

The importance of reducing bycatch and minimizing ecological impacts of fishing operations has been emphasized by scientists and fishery managers and recognized by fishermen. Trawl fisheries in different parts of the world are now required to use bycatch reduction devices as result of legal regimes introduced by the governments. The Code of Conduct for Responsible Fisheries (CCRF) (FAO, 1995), which gives guidelines for sustainable development of fisheries, stresses the need for developing selective fishing gears in order to conserve resources, protect non-targeted resources and endangered species.

Bycatch from harvesting systems

The term bycatch refers to the non-targeted species retained, sold or discarded for any reason. Target catch is the species that is primarily sought after in the fishery and incidental catches is the retained catch of non-targeted species and the discarded catch is that portion of the catch that is returned to the sea due to economic, legal or personal considerations. Global bycatch by the world's marine fishing fleets was estimated at 28.7 million t in 1994, of which 27.0 million t (range: 17.9-39.5 million t) were discarded annually and shrimp trawling alone accounted for 9.5 million t (35%) of discards annually. In 1998, FAO estimated a global discard level of 20 million t. Average annual global discards, has been re-estimated to be 7.3 million t, based on a weighted discard rate of 8%, during 1992-2001 period (Kelleher, 2004). Davies et al. (2009) redefined bycatch as the catch that is either unused or unmanaged and re-estimated it at 38.5

million tonnes, forming 40.4% of global marine catches. The recent global estimates of bycatch are 9.1 million tonnes, with highest contribution from bottom trawls of about 4.2 million tonnes, in which tropical shrimp trawl fisheries contributes the most. Based on confidential interviews, grey literature reports and direct field observations, during 2008-09, Pramod (2010) estimated the bycatch discards from mechanised trawlers operating in Indian EEZ at 1.2 million tonnes.

The reduction in bycatch discards globally, in recent years could be attributed to (i) increased use of bycatch reduction technologies, (ii) anti-discard regulations and improved enforcement of regulatory measures, and (iii) increased bycatch utilization for human consumption or as animal feed, due to improved processing technologies and expanding market opportunities.

Also equally important as the issue of bycatch is the un-quantified impacts of different fishing systems on the ecosystem, with active fishing gears like trawls causing the most damage.

FAO has brought out International guidelines on bycatch management and reduction of discards, in view of its importance in responsible fisheries (FAO, 2011). Life under water (14th Goal) among the Sustainable Development Goal (SDG) has different targets for sustainable use of fisheries resources.

A typical trawl catch from the tropics typically consists of more than 25-35 species of different sizes and shapes, behavioural differences, different maturity sizes and longevities. The mesh size of the trawl codend used in shrimp trawls operating along the Indian coast varies from 10-20 mm, which makes it impossible for juveniles of other species to escape. for moreTrawl bycatch, in the tropics is constituted by high proportion of juveniles and sub-adults, particularly of commercially important fishes, which needs serious attention in development, optimization and adoption of Bycatch Reduction Technologies (BRD).

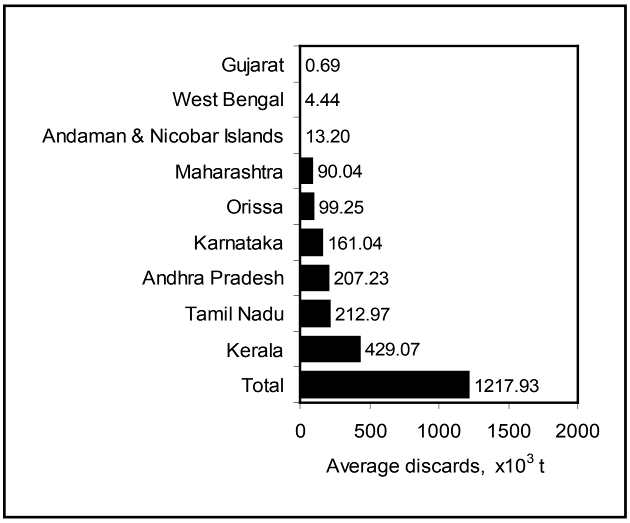

Fig. 1. Estimates of average bycatch discards from mechanized trawlers (Pramod, 2010)

Bycatch Reduction Devices

Devices developed to reduce the capture of non-targeted species during trawling are collectively known as Bycatch Reduction Devices (BRDs). These devices have been developed taking into consideration variation in the size, and differential behaviour pattern of shrimp and other animals inside the net. Different types of bycatch reduction technologies have been developed in the fishing industry around the world (Prado, 1993; Brewer et al., 1998; 2006; Eayrs et al., 1997; Broadhurst, 2000; CIFT, 2007; Eayrs, 2007; Boopendranath, 2007; 2009; 2012; Boopendranath et al., 2008; 2010a; 2010b; Kennelly, 2007; Broeg, 2008; Boopendranath & Pravin, 2009; Pravin et al., 2011; Suuronen et al., 2012).

BRDs can be broadly classified into three categories based on the type of materials used for their construction, *viz*., Soft BRDs, Hard BRDs, and Combination BRDs. Soft BRDs make use of soft materials like netting and rope frames for separating and excluding bycatch. Hard BRDs are those, which use hard or semi-flexible grids and structures for separating and excluding bycatch. Combination BRDs use more than one BRD, usually hard BRD in combination with soft BRD, integrated into a single system. Designs that reduce the non-targeted catch either by taking into account the behavioural difference of the species or by excluding the catch entered also can be considered as BRDs, though the term is commonly used for devices that are attached to trawls to reduce non-targeted catch.

Use of BRDs is one of the widely used approaches to reduce bycatch in shrimp trawls. Some of the advantages in reducing the amount of unwanted bycatch caught in shrimp trawls by using BRDs are (i) Reduction in impact of trawling on non-targeted marine resources, (ii) Reduction in damage to shrimps due to absence of large animals in codend, (iii) Shorter sorting times, (iv) Longer tow times, and (v) Lower fuel costs due to reduced net drag (Boopendranath et al., 2008; Boopendranath & Pravin, 2009). The effects of BRD installation on total drag of the trawl system and hence on fuel consumption has been reported to be negligible (Boopendranath et al., 2008).

Soft Bycatch Reduction Devices

The soft Bycatch Reduction Devices use soft structures made of netting and rope frames instead of rigid grids, prevalent in hard BRDs, for separating and excluding bycatch. Based on the structure and principles of operation they are classified into five categories viz., (i) Escape windows, (ii) Radial Escapement Section without Funnel, (iii) Radial Escapement Section with Funnel, (iv) BRDs with differently shaped slits and (v) BRDs with guiding/separator panel. Soft BRDs have advantages such as ease of handling, low weight, simplicity in construction and low cost, compared to hard BRDs.

Hard Bycatch Reduction Devices

Various designs of hard BRDs are in operation around the world which includes (i) Oval grids, oval shaped metallic grid with exit opening like Georgia-Jumper, Saunders grid , Thai Turtle Free Device (TTFD),Oregon grate, CIFT-TED ,Seal Excluder Device and Halibut Excluder Grate; (ii) Slotted grid BRDs which provide slots for the passage of non-targeted organisms such as Hinged grid and Anthony Weedless; (iii) Bent grids in which grid bars and grid frame are bent at one end near the opening such as Juvenile and Trash Excluder Device (JTED), NAFTED; (iv) Flat grid BRDs such as Nordmore grid, Wicks TED, Kelly-Girourard grid, and EX-it grid.

Fisheye BRD is considered as an important hard BRD around the world. There are several design variations of fisheye BRD such as Florida Fish Eye (FFE) used in the Southeast US Atlantic and in the Gulf of Mexico. Other designs in this categories are Snake-eye BRD used in North Carolina Bay, Fish slot, Sea eagle BRD and Popeye Fish excluder or Fishbox BRD.

Hard BRDs also include TEDs like NMFS hooped TED, Fixed angle TED and Cameron TED (Oravetz and Grant, 1986; Prado, 1993; Mitchell *et al.*, 1995; Talavera, 1997, Rogers *et al.*, 1997), Matagorda TED, Georgia-Jumper, Super Shooter, Anthony Weedless, Jones TED and Flounder TED (Talavera, 1997; Mitchell *et al.*, 1995; Dawson, 2000; Belcher *et al.*, 2001; CIFT, 2003) that are devices used for the conservation of Sea turtles.

Semi-flexible BRDs

Semi-flexible BRDs made of semi-flexible or flexible materials such as polyethylene, polyamide and FRP are used in the North Sea brown shrimp fishery, Polyamide grid devices provided with hinges to facilitate operation from net drums have been used in the Danish experiments in the North Sea shrimp fishery and Polyamide-rubber grid design are used in Denmark.

BRDs with guiding or separator panel

Guiding or separator panels are used to achieve separation of the bycatch by using differences in their behaviour or size. BRDs with guiding panels lead the fishes to escape openings, making use of the herding effect of the netting panels on finfishes. The shrimps are not subjected to herding effect and hence pass through the meshes towards the codend. BRDs with separator panels physically separate the catch according to the size, with the use of appropriate mesh size. Shrimps pass through the panels to the codend while bycatch such as fishes and sea turtles are directed towards the exit opening Fig. (2).

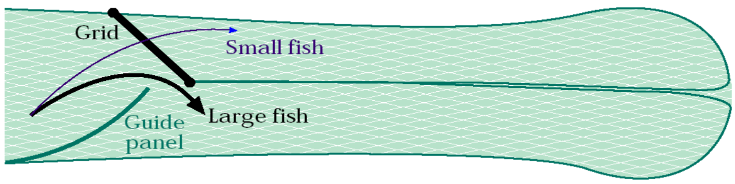

Fig. 2 Separator panel BRDs

BRDs in India

A number of BRDs have been developed and field tested in India. The BRDs evaluated include hard BRDs *viz.*, Rectangular Grid BRD, Oval Grid BRD, Fisheye BRD and Juvenile Bycatch Excluder cum Shrimp Sorting Device (JFE-SSD) and soft BRDs *viz.*, Radial Escapement Device (RED), Sieve net BRD, Separator Panel BRD and Bigeye BRD (Boopendranath et al., 2008). The square mesh codend and JFE-SSD are the designs that were tested commercially along Indian waters. The efficacy of square mesh codends for selective fishing is widely reported in India and the selection parameters for a large number of fishes are derived (Madhu, 2018). The mesh lumen (opening) of the traditional diamond meshes used in codends, 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. Square mesh codends are prepared from diamond mesh webbing by barcuts, rejoining and then strengthening by marling to prevent the unravelling of the meshes. The conceptual simplicity and the ease of installation of square mesh codends made its adoption much easier in the trawl sector of India.

Table 1. Bycatch exclusion and shrimp loss in different BRDs, during shrimp trawling operations off southwest coast of India (Boopendranath, et al., 2012)

BRDs	Bycatch exclusion, %	Shrimp loss, %
Bigeye BRD	11.4-37.3	2.3-4.1
Fisheye BRD	46.6-62.7	0.8-3.8
Oval grid BRD	57.8-58.7	6.1-8.0
Sieve net BRD	14.7	4.5
JFE-SSD	42.9	5.2

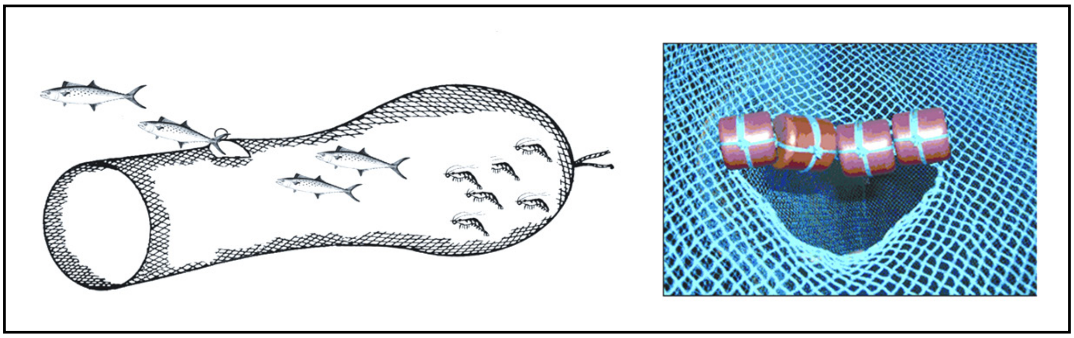

Fig. 3. View of the Bigeye BRD attached to the trawl codend. The opening of the BRD is kept open using floats.

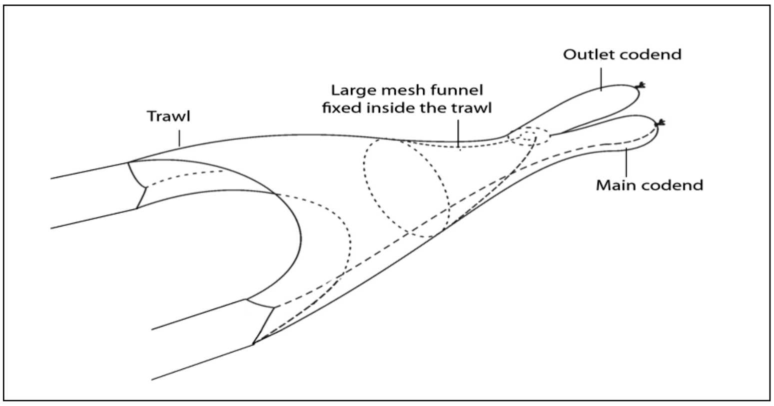

Fig. 4. Perspective view of Sieve net BRD installed in trawlnet

A large number of studies using square mesh codends in India, have demonstrated the improvements in the selection properties (Boopendranath and Pravin, 2005; Madhu, 2018) and use of square mesh codends significantly reduces the bycatch often comprising of the juveniles of commercially important species. Studies carried out by ICAR-CIFT along the Indian coast have recorded an increase of 12-25% in the mean selection length of different targeted species. Good filtration and reduction in the drag are other benefits of the technology. It has also been demonstrated along Gujarat and Maharashtra using commercial operations that no significant economic losses are incurred if traditional meshes are replaced, since the escapees are the juveniles
that fetch a low price in the market. This loss, though very meager is compensated with the fuel saved because of reduced drag of the trawl and improved quality of catch in the codend. The conversion of the traditionally used diamond meshes to square meshes is easy without involving additional cost.

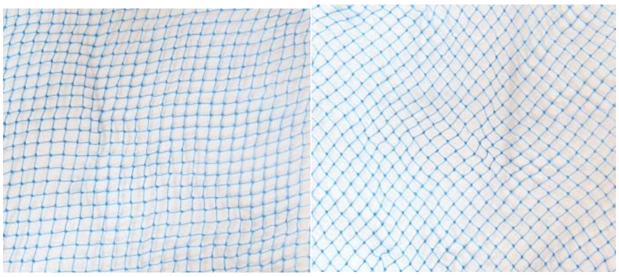

Fig. 5. Square and diamond shaped HDPE webbing

Insertion of square mesh panels in the traditional codends are also found to improve the selection properties in addition to reducing bycatch in trawls. An increase in the L_{50} values by 5-10% and a reduction in the bycatch by 4-5% were observed in case of square mesh panels field tested along Cochin coast. The advantage of the technology is the minimal amount of change required to the existing codend and minimal investment required for the installation.

Juvenile Fish Excluder Cum shrimp sorting Device (JFE-SSD) is another BRD that has undergone several commercial trials along Kerala, Gujarat and Maharashtra coast. JFE-SSD is a Smart Gear (WWF) award winning design developed by Central Institute of Fisheries Technology (CIFT) which reduces bycatch of juveniles and small sized non-targeted species in shrimp trawl and at the same time enables fishers to harvest and retain large commercially valuable finfishes and shrimp species. JFE-SSD operations off southwest coast of India have realized bycatch reduction up to 42.9% with shrimp retention of about 95%. Non-shrimp resources are largely guided to the top codend, with about 70% caught in the upper codend of the BRD. This BRD can be used as an alternate codend replacing the existing codends of trawlers for effective segregation of shrimp and fish and concomitant savings in terms of fuel and good catch quality.

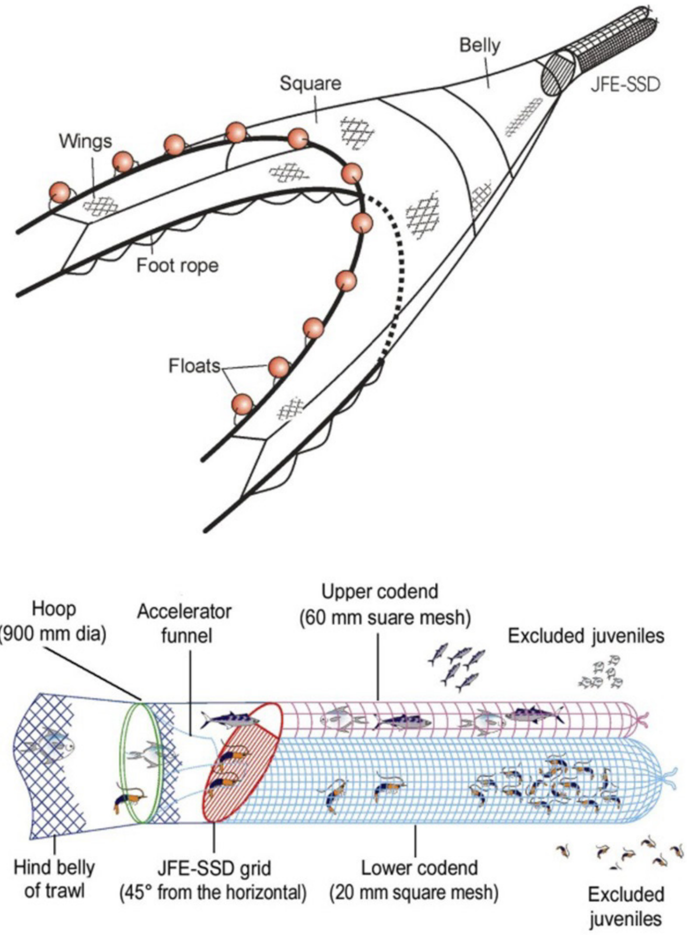

Fig. 6. Design of the JFE-SSD

Improved trawl designs like the CIFT-Off Bottom Trawls System (CIFT-OBTS), short body shrimp trawl, Cut-away Trawl belly and separator trawls are found to significantly reduce non-targeted catches due to its design features, though no BRDs as such are attached to the designs.

CIFT-Off Bottom Trawls System (CIFT-OBTS) consists of an 18 m four-panel semi-pelagic trawl with double bridles, front weights and vertically cambered high aspect ratio otterboards as was developed as an alternative to traditional shrimp trawling in the Indian waters. Due to the design features, the net operates a few centimeters above the sea bottom and hence the bottom impact of the net decreased substantially. This is an ideal gear to operate during non-shrimping season, where fishers predominantly target the off-bottom species.

Short body shrimp trawl is a design variation with a relatively short body and large horizontal spread for selective retention of shrimp. The length of the trawl body is reduced by increasing the taper ratio. The large horizontal spread of the trawl mouth increases the effective sweep area and the low vertical opening of the trawl and the short belly reduces the fish catch making the gear more selective for shrimps. The net has been designed considering the difference in relative swimming speed and vertical distribution of the shrimp and fish species occurring in the Indian waters.

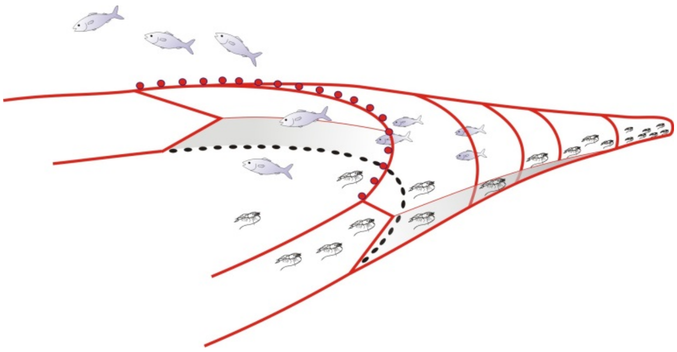

Fig. 7. Finfishes escaping from the short body shrimp trawl due to better swimming speed (*Artist perspective*)

Conclusion

Studies using bycatch reduction devices have shown to reduce the incidence of bycatch in trawling considerably. Different BRD designs have been tried and the efficacy of a particular design depends on the composition of bycatch in the area. Experimental trials for optimization are needed before the designs are released for field trials among the fishers for adoption. A small loss in revenue, as a result of reduced bycatch is often negated when the overall future gain is considered in the fishery as a result of increase in the yield per recruit from the stock. Benefits like subsidies in the fishery can also be linked with the adoption of good practices in the trawl fishery. Use of BRDs for resource conservation is one of the many strategies for sustainable harvest of the fishery resources. Adherence to the norms in the marine fisheries regulations acts (MFRA), reduction of fishing effort (in terms of capacity and size of the vessels and gear), spatial and temporal fishing area restrictions and strict monitoring, control and surveillance are required for the gear based technical measures like BRDs to be effective.

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