Soft Bycatch Reduction Devices for Bottom Trawls :A Review

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Soft Bycatch Reduction Devices for Bottom Trawls : A Review

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Trawling, though an efficient and popular method of commercial fishing, is known to be one of the least selective methods of fish capture. FAO Code of Conduct for Responsible Fisheries has stressed the need for development and improvement of fishing technology that eliminates bycatch in order to promote sustainability and conservation of fishery resources. Devices that can be used to reduce bycatch are generally known as Bycatch Reduction Devices (BRDs). BRDs made of soft materials like netting and rope frames with minimum use of rigid parts are called Soft BRDs. Soft BRDs such as square mesh window, rope BRD, radial escapement device, extended funnel BRDs, monofilament BRD, Neil Olsen BRD, trawl flow regulative ecological friendly netting device (TREND), bigeye BRD, V-cut BRD, diamond BRD, Lake-Arthur BRD, Authement-Ledet excluder, separator panel BRD, Morrison soft TED, Parker soft TED, Andrews soft TED and sieve net have been deployed in commercial and experimental fishing operations in different fisheries. In this paper, an attempt is made to review the bycatch issues and BRDs, in general, and soft BRDs, in particular, in the world trawl fisheries.

Keywords: Bottom trawl, bycatch, BRDs, soft bycatch reduction devices

The bulk of the wild caught penaeid shrimps are caught by trawling. In addition to shrimps, the trawler fleet also catches considerable amount of non-shrimp resources. Bycatch and discards are serious problems leading to the depletion of the resources and have negative impacts on biodiversity (Harrington *et al*., 2005; Alverson & Hughes, 1996). The importance of reducing bycatch and minimizing ecological impacts of fishing operations have been emphasized by a number of authors (Andrew & Pepperell, 1992; Alverson *et al*., 1994; FAO, 1995; Kennelly, 1995; Mitchell *et al*., 1995; FAO, 1996; Hall, 1996; Clucas, 1997; Broadhurst, 2000; Hameed & Boopendranath, 2000; Kaiser & de Groot, 2000; Anon, 2002a; Broadhurst *et al*., 2002; Chockesanguan, 2002; Boopendranath *et al*., 2006; Boopendranath, 2007; AFMA, 2008; Boopendranath, 2009; Boopendranath & Pravin, 2009). FAO Code of Conduct for Responsible Fisheries has given priority status to the development and improvement of fishing technology that eliminates bycatch and selectively target fish in a way that promotes long-term sustainability and protection of biodiversity (FAO, 1995). The term bycatch means that portion of catch other than target species caught while fishing, which are either retained or discarded (Alverson *et al*., 1994). In order to minimize the problem of bycatch, trawling has to be made more selective (FAO, 1996; Hameed & Boopendranath, 2000; Eayrs, 2005). Devices used to exclude or reduce bycatch are known as Bycatch Reduction Devices (BRDs). The soft BRDs use soft structures made of netting and rope frames instead of rigid grids or structures, for separating and excluding the bycatch.

Bycatch in world fisheries

A preliminary assessment of bycatch in world fisheries was made by Saila (1983). According to Saila (1983), the discards were 6.72 million tonnes in shrimp fisheries. Later,

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Andrew & Pepperell (1992) estimated global bycatch in shrimp fisheries at 16.7 million tonnes. In the year 1994, Alverson *et al*. (1994) estimated the annual bycatch in the world fisheries as 28.7 million tonnes of which an estimated 27.0 million tonnes were discarded. Shrimp trawling accounted for 37.2% (9.5 million tonnes) of the total world bycatch. In 1998, FAO estimated a global discard level of 20 million tonnes (FAO, 1999). Average annual global discards, has been re-estimated to be 7.3 million tonnes by Kelleher (2004). Decline in discards, may be due to a number of reasons such as stock depletion, strict regulations in some fisheries in the form of improved fishing selectivity, anti-discard regulations and increased use of bycatch reduction devices. Globally, shrimp trawling contributes to the highest level of discard/catch ratios of any fisheries (EJF, 2003; Kelleher, 2004). Davies *et al.* (2009) recently 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.

Bycatch in Indian fisheries

Bycatch in Indian fisheries has been studied by George *et al.* (1981), Gordon (1991), Luther & Sastry (1993), Rao (1998), Pillai (1998), Kurup *et al.* (2003 ; 2004), Bhathal (2005), Zacharia *et al*. (2005), Kumar & Deepthi (2006), Boopendranath *et al.* (2008) and Gibinkumar (2008). George *et al*. (1981) estimated bycatch in Indian shrimp trawl fisheries at 3,15,902 tonnes per annum which formed 79.18% of total shrimp trawl landings in India. Gordon (1991) estimated bycatch landings in the east coast of India at 90,000 to 130,000 tonnes per annum. Rao (1998) re-assessed the bycatch discards by the fleet based at Visakhapatnam during 1988-89 between 18,930 tonnes and 32,421 tonnes, assuming 10-15% of shrimp catch.

A study conducted during 1985-90 estimated the quantity of bycatch landed by trawlers in Kerala, Karnataka and Tamil Nadu, as 43,000 tonnes (Menon, 1996). Pillai (1998) estimated that bycatch landings along Cochin, Visakhapatnam and Saurashtra (Gujarat), was about 70 to 90% and average discards was 15 to 20% of the shrimp trawl catch. Bycatch landings was maximum in Gujarat (90-95%), followed by Tamil Nadu (80-90%), Andhra Pradhesh and Karnataka (80-85%), Orissa (75-80%), Maharashtra (70-75%) and Kerala (65-70%). In Karnataka state, bycatch from trawlers was 56,083 tonnes in 2001 and 52,380 tonnes in 2002, which formed 54.4% and 47.9% of total trawl catch, respectively (Zacharia *et al*., 2005). The quantity of discards was 34,958 tonnes (33.9% of total catch) in 2001 and 38,318 tonnes (35.1%) in 2002. Discards were more in post-monsoon months. The characterization and quantification of bycatch and discards along Kerala coast, during 2000-2002, was done by Kurup *et al.* (2003). The discarded quantity estimated during 2000-2001 was 262,000 tonnes and during 2001-2002 it was 225,000 tonnes. The dominant varieties among the discards were finfishes, crabs and stomatopods (Kurup *et al*., 2003; 2004).

Based on their study of marine fisheries in the early 1990s, Luther & Sastry (1993) reported that the bulk of marine landings in all the maritime states consisted of juvenile fish. Gordon (1991) estimated that juvenile discards from trawling operations, off Visakhapatnam was 25 to 30% of total catch. Pillai (1998) reported that among the bycatch, about 40% consisted of juveniles. Juveniles contributed 36% of the discards (15.9% of total catch) in single day fishing and 78% (23.5% of total catch) in multi-day fishing conducted during 2001-02 in Karnataka (Zacharia *et al*., 2005).

Bycatch Reduction Devices

Several approaches have been proposed and undertaken for bycatch reduction in trawling (Sainsbury, 1971; Mitchell *et al*., 1995; Hall, 1996; Broadhurst, 2000; Hall *et al*., 2000; Ramirez, 2001; Steele *et al*., 2002; EJF, 2003). BRDs are also known as trawl efficiency devices or trash excluder devices (Robins-Toeger, 1994; Mounsey *et al.* 1995; McGilvray *et al.*, 1999). Turtle Excluder Device (TED) is a specific type of BRD designed to exclude large animals such as sea turtles. There is a widespread and increasing requirement for using bycatch reduction devices in trawl fisheries throughout the world. There are several advantages in using BRDs in shrimp trawling (Brewer *et al.*, 1998; Boopendranath *et al.*, 2008; Boopendranath and Pravin, 2009; Gibinkumar, 2008; Sabu, 2008). BRDs reduce the negative impacts of shrimp trawling on marine resources. Fishers could benefit economically from higher catch value due to improved catch quality, shorter sorting time, lower fuel costs, and longer tow duration. Adoption of BRDs by fishers would forestall any criticism by conservation groups against trawling. BRDs have been developed based on the differential behavior patterns such as differences in swimming speed and size selectivity of fish and shrimp (Broadhurst & Kennelly, 1994; 1996; Brewer *et al.*, 1998; Pillai, 1998; Broadhurst, 2000; Hameed & Boopendranath, 2000; Eayrs, 2004; 2005; Boopendranath *et al.*, 2008). The fish are active and capable of swimming against the water flow inside the net and can escape when the required facilities are provided. Shrimp have poor swimming ability and are carried away with the flow of water up to the codend.

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 (Mitchell *et al.*, 1995; Talavera, 1997; Broadhurst, 2000; Boopendranath *et al.*, 2008; Gibinkumar, 2008; Sabu, 2008). 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 to a single system.

Soft Bycatch Reduction Devices

The soft BRDs 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 (Sabu *et al.*, 2005; Sabu, 2008). Soft BRDs have advantages such as ease of handling, low weight, simplicity in construction and low cost, compared to hard BRDs.

Escape windows

Escape windows function based on the differential behaviour of fishes and shrimps. Fishes that have entered the codend tend to swim back and escape when suitable escape windows are provided, at the top in the front section of the codend. Square mesh window (Fig. 1), and rope BRD (Fig. 2) are the examples of this category (Broadhurst & Kennely, 1994; 1996; Brewer *et al.*, 1998; Eayrs & Prado, 1998a; 1998b; Pillai, 1998; Pillai *et al.*, 2004). Studies carried out using square mesh windows have indicated their effectiveness in reducing bycatch by 30 to 40% in Northern prawn trawl fisheries, Australia (Broadhurst & Kennely, 1994; 1996; Brewer *et al.*, 1998). Square mesh has the advantage that the mesh opening is not distorted while under operation, unlike diamond meshes (Broadhurst & Kennelly, 1994; 1996; FAO, 1997; Kunjipalu *et al.*, 1994a; Brewer *et al.*, 1998; Robins *et al.*, 1999; Kunjipalu *et al.*,

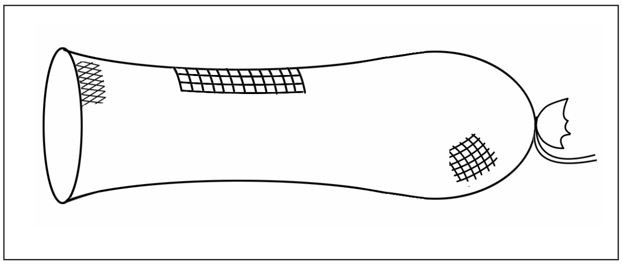

Fig. 1. Square Mesh Window

2001). Experiments conducted in Persian Gulf waters have shown that rope BRD is effective in excluding 25% of the bycatch with no loss of shrimp or commercial fish species (Eayrs & Prado, 1998a). Use of square mesh panels has been found to reduce the bycatch, particularly juveniles and young ones, by about 20% in Indian waters (Kunjipalu *et al*., 1994b; 1998; Pillai, 1998; Pillai *et al*., 2004).

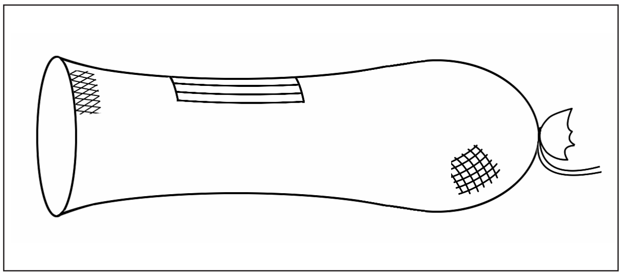

Fig. 2. Rope BRD

Radial Escapement Section without Funnel

In radial escapement section without funnel, a radial section of netting with large meshes is provided between hind belly and codend. Small sized fishes, jellyfish and other bycatch components, which have low swimming ability, are expelled due to enhanced water flow through large mesh section. Based on this principle, Fuwa *et al*. (2003) described a Trawl Flow Regulative Ecological Friendly Netting Device (TREND) (Fig. 3). Experiments in Japanese waters, using TREND were found to give safe escapement to juvenile fish, with better opportunity for survival.

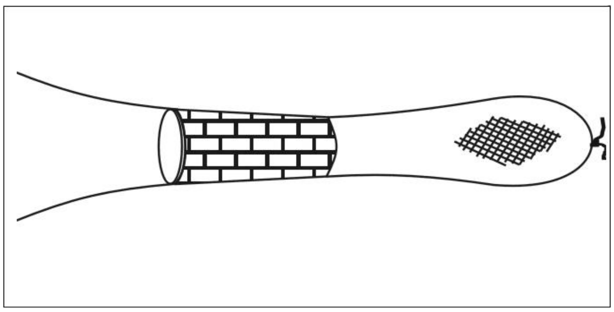

Fig. 3. TREND

Radial Escapement Section with Funnel

Radial escapement devices with funnel (Watson & Taylor, 1988, Valdemarsen, 1986) are positioned between hind belly and codend of the trawl (Fig. 4). A small meshed funnel accelerates the water flow inside the trawl and carries the catch towards the codend. Actively swimming fishes swim back and escape through the large mesh netting section surrounding the funnel, where the water flow rate is weak, while the shrimps are retained in the codend. Studies using radial escapement device have shown 20-40% reduction in the fish bycatch in Australia's Northern Prawn Fishery (Brewer *et al*., 1998). Studies in India have indicated a 14-21% reduction in fish bycatch by using designs of radial escapement device with 80 mm, 100 mm and 150 mm square meshes, surrounding the funnel (Pillai *et al*., 2004; Boopendranath *et al*., 2008; Sabu, 2008).

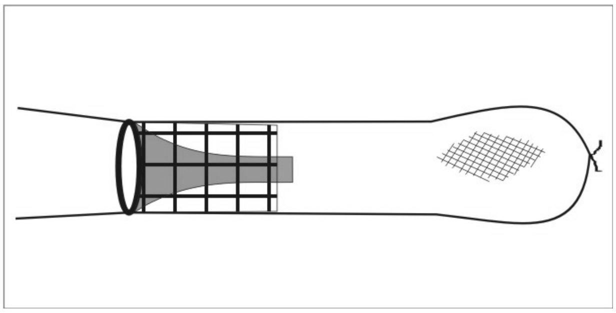

Fig. 4. Radial Escapement Device

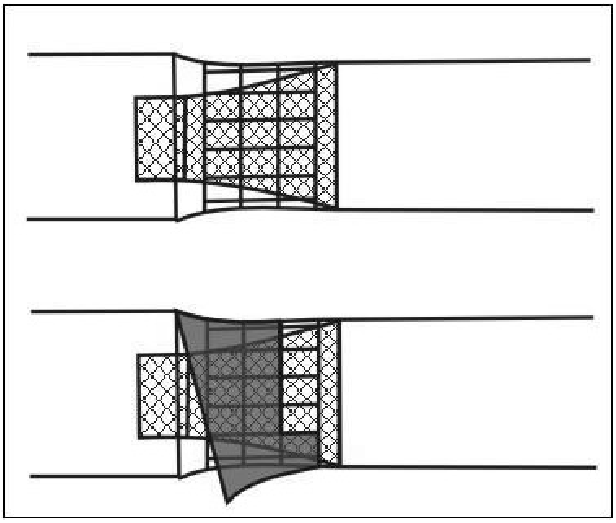

Fig. 5. Extended Funnel BRD

Experiments in Louisiana have shown that nets fitted with extended funnel BRD (Fig. 5) and skirted extended funnel BRD caught lesser bycatch than the control nets (Rogers *et al.*, 1997). The extended funnel BRD provided 44% fish reduction with 5% shrimp loss (Rogers *et al.*, 1997). The monofilament BRD (Fig. 6), used in commercial trawling, has been reported to give 25-51% reduction in bycatch, without problems of clogging. Bycatch reduction by Neil-Olsen BRD (Fig. 7) has been reported as 27-45%, in tropical coastal waters (Robins *et al.*, 1999).

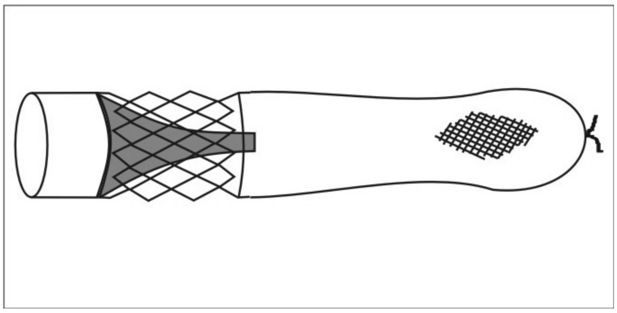

Fig. 6. Monofilament BRD

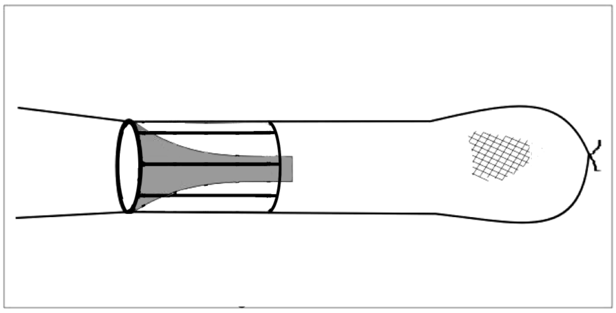

Fig. 7. Neil Olsen BRD

BRDs with differently shaped slits

BRDs with differently shaped slits utilize the difference in the behaviour of fish and shrimp. Fishes that enter the codend are given opportunity to swim back and escape by providing slits in the netting on the topside of the codend or hind belly, while shrimps are retained in the codend (Robins *et al.*, 1999; Morris, 2001). In diamond BRD (Fig. 8), a diamond shaped hole is provided on top of the codend (Anon, 2004). Average bycatch reduction from V-cut BRD (Fig. 9), operated in Queensland east coast trawl fishery has been reported to be 16%, with very low or no shrimp loss (DPI-QLD, 2004). The lake arthur BRD (Fig. 10), widely used in shrimp trawling in Lake Arthur area of Western Louisiana, is one of the earliest BRDs. Lake arthur BRD is reported to reduce the bycatch up to 34% (Morris, 2001). Bigeye BRD (Fig. 11) reduces bycatch by 30 to 40%, in tropical coastal waters and are commercially used by shrimp fleet in Queensland east coast waters (Robins *et al.*, 1999). During 1998, 30% of the Queensland east coast trawl fleet used bigeye BRD in their penaeid fishery (Robins *et al.*, 1999). Investigations in

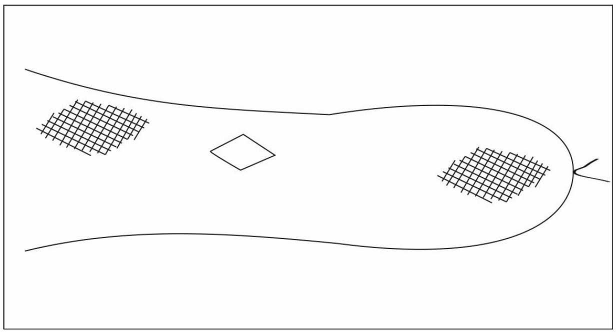

Fig. 8. Diamond BRD

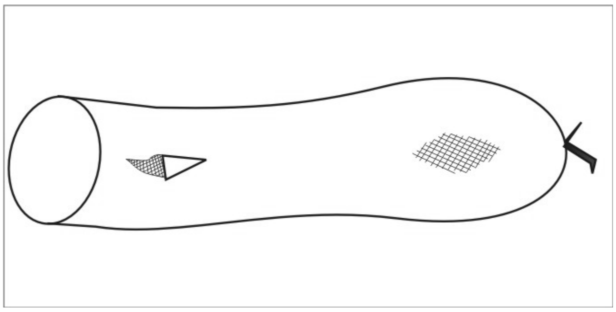

Fig. 9. V-cut BRD

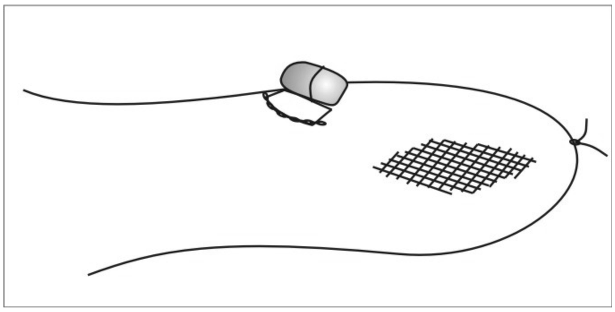

Fig. 10. Lake-Arthur BRD

India with bigeye BRD have shown bycatch exclusion in the range of 8-11% (Boopendranath *et al.*, 2008; Sabu, 2008)

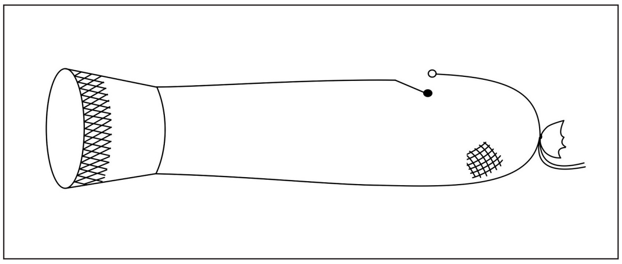

Fig. 11. Big eye BRD

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 (Christian *et al.*, 1988; Rogers *et al.*, 1997; Polet *et al.*, 2004). Separator panel BRD (Fig. 12) operations in New South Wales shrimp trawl fisheries have indicated a shrimp loss of 2-30% and fish exclusion of 30-80% (Anon, 2004). Studies in India using separator panel BRD installed in shrimp trawl have shown a target catch loss of 44-53% due to vulnerability of the device to clogging leading to ineffectual sorting (Boopendranath *et al.*, 2008; Sabu, 2008). Authement-ledet BRD (Fig. 13) with bottom opening has been reported to give better exclusion of fishes, while top opening BRD entailed in minimum shrimp loss (Rogers *et al.*, 1997).

The Morrison TED (Fig. 14), Parker TED (Fig. 15) and Andrews TED (Fig. 16) are efficient soft TEDs, which are used to exclude sea turtles and large marine animals in many countries. Proper installation of the soft TEDs are essential in order to ensure their efficient performance. Morrison soft TED has been used successfully to exclude sea turtles in Gulf of Mexico. In addition to sea turtles, it reduced other bycatch species, particularly fish (Christian *et al.*, 1988). The biggest drawback regarding this category of BRDs is the possibility of clogging with debris (Christian *et al.*, 1988; Kendall, 1990). Studies in Moreton Bay, Queensland, Australia using Morrison soft TED have shown reduction in bycatch by an average of 32% (Andrew *et al.*, 1993; Robins-Troeger, 1994). Studies conducted in the Gulf of Mexico and South Atlantic shrimp fisheries have shown that Andrews soft TED is very effective in excluding the red snapper bycatch up to 77% with a shrimp loss of 16% and Morrison soft TED excluded 20 to 40% of fish bycatch with a shrimp loss of 13%. Andrews soft TED was successfully used in West Florida shelf area without excessive clogging (Anon, 2002b). Turtle exclusion rate from Parker soft TED, approved for use in US waters, has been reported to be 97% (Anon, 1998). Experiments using sieve net in Belgium fishery had bycatch exclusion rates of 29-50% in different seasons, with less than

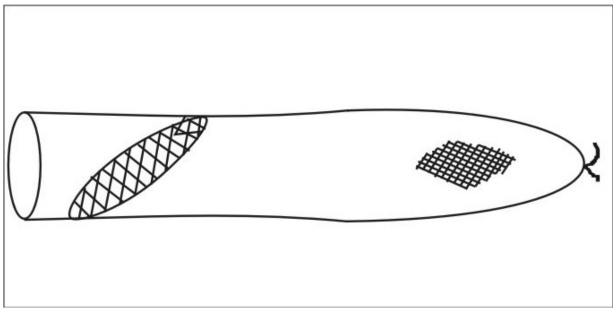

Fig. 12. Separator panel BRD

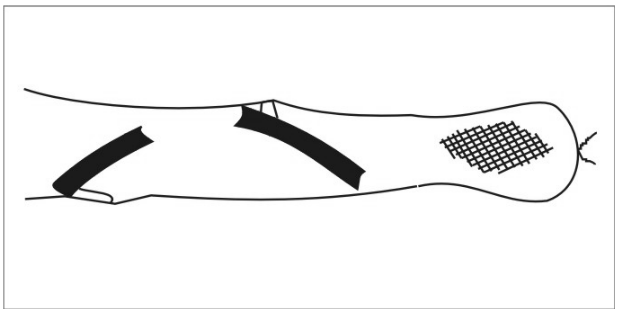

Fig. 13. Authement-Ledet Excluder

15% shrimp loss (Polet *et al.*, 2004). Investigations in Indian waters with sieve net (Fig. 17) have given 33-37% exclusion in bycatch with minimum shrimp loss (Boopendranath *et al.*, 2008; Sabu, 2008).

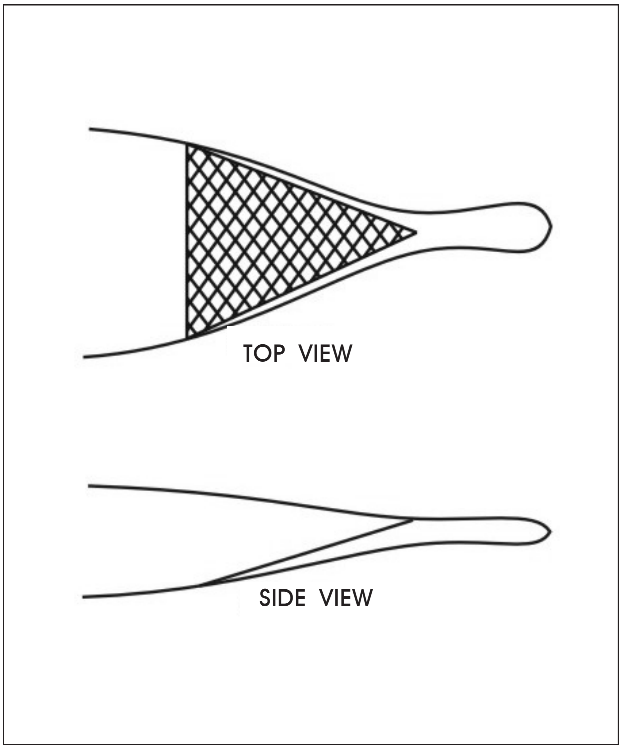

Fig. 14. Morrison soft TED

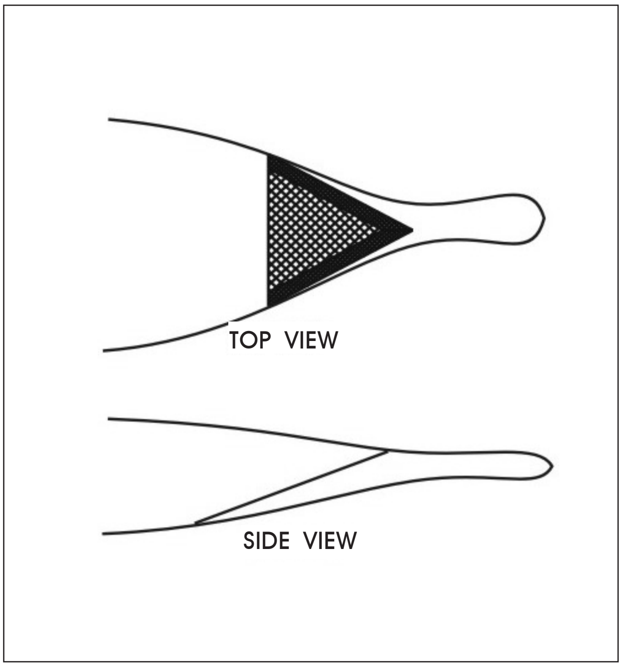

Fig. 15. Parker soft TED

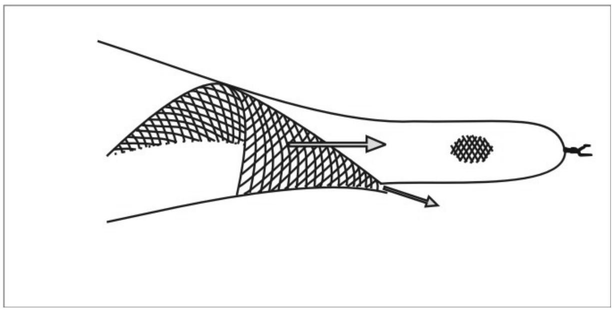

Fig.16. Andrews soft TED

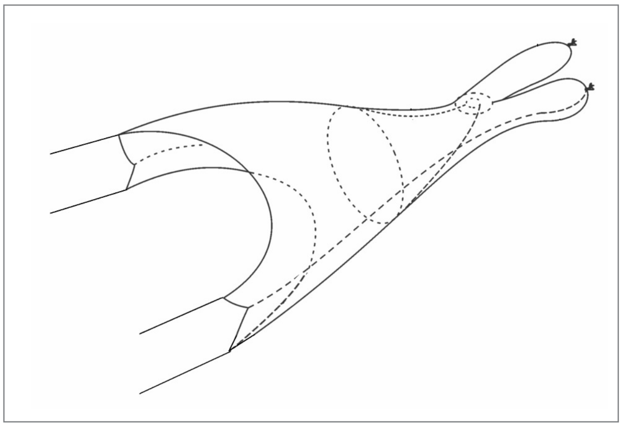

Fig. 17. Sieve net

Bycatch reduction has been taken as a serious issue in almost all the fishing nations. However, implementation of BRDs in different fishing areas has been disparate, partly due to high catch loss and the difficulties in adapting the device to local conditions. Soft BRDs have been developed and tested in many countries like Australia, USA, Mexico, Belgium, Denmark, France and India. BRDs differ in their construction and performance based on the type of fishery and geographic peculiarities of the fishing ground.

Soft BRDs have advantages such as ease of handling, low weight, simplicity in construction and low cost, compared to hard BRDs. Many of them such as square mesh window, square mesh codend, sieve net, radial escapement devices and their design variations and bigeye BRD are popular among commercial shrimp fishermen in different fishing areas. An important drawback of soft BRDs is the vulnerability to clogging of the netting panels used in its construction due to gilling and tangling by fish or marine debris. The use of soft BRDs such as bigeye and sieve net appropriate for Indian fishing conditions need to be promoted in order to support long-term sustainability of fishery resources and protection of biodiversity.

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