



Chapter 26

Role of Bycatch Reduction Devices in Fisheries Management

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1.0 Introduction

Dynamic developments in the harvest technologies and fish detection methods, uncontrolled expansion in fleet size, and ever increasing market demand for fish resulted in over fishing and negative impacts on ecosystem. This highlighted the need for scientific management of fishery resources in order to ensure their long term sustainability and availability for future generations. Bycatch is one of the most important issues affecting fisheries management today.

2.0 Bycatch

Number of definitions are available regarding the term, bycatch. Bycatch is often defined as "that part of the catch which is not the primary target of the fishing effort which includes fish which is retained, marketed (incidental catch) and that which is discarded or released".

Recent estimate by FAO, determine the discards at 7.3 million tons, based on a weighted discard rate of 8%, during 1992-2001 periods. 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, ranging from about 3:1 to 15:1, and the amount of bycatch varies in relation to target species, seasons and areas. Trawl fisheries for shrimp and demersal finfish account for over 50% of the total estimated global discards.

In India, the bycatch problem is more due to the multi-species nature of the tropical fisheries. During shrimp trawling large quantities of finfish bycatch including significant amount of juveniles are also landed. Estimate by CMFRI shows that 79.18% (3,15,000 t) of bycatch generates by shrimp trawling in India, maximum being in Gujarat (92.58%), followed by Tamil Nadu (91.04%) and Pondicherry (86.52%).

Bycatch reduction by modification of fishing gears, installing Bycatch Reduction Devices and Turtle Excluder Devices is considered as the main approach for shrimp trawling industry around the world.

Bycatch Reduction Device (BRD) is defined as any device that can be incorporated in a fishing gear in order to exclude or reduce non targeted and unwanted catch in a fishing system and there by making it more selective.

2.1 Advantages of using BRDS in Trawls

BRDs reduce the negative impacts of shrimp trawling on marine ecosystem, by taking advantage fishers could benefit economically from higher catch value due to improved catch quality, shorter sorting time, lower fuel costs, and longer tow duration. Recreational and non-shrimp commercial fisheries would also benefit due to a reduced impact on the species targeted.

2.2 Classification of Bycatch Reduction Devices

BRDs have been developed based on the differential behavior patterns such as differences in swimming speed, vertical distribution or size of shrimp and fish inside the net and size selectivity. The fish are active and capable of swimming against the water flow inside the net and may escape at any time when opportunity is provided. Shrimp is unable to swim against the water flow and carried away with the flow of water 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. Soft BRDs make use of soft materials like netting and rope frames for separating and excluding bycatch. Hard BRDs 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.

2.2.1 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.

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2.2.2 Hard Bycatch Reduction Devices TED

The important hard BRD TEDs like NMFS hooped TED, Fixed angle TED and Cameron TED, were developed under the category of hard TEDs for the conservation of Sea turtles.

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), NAFTAED; (iv) Flat grid BRDs such as Nordmore grid, Wicks TED, Kelly-Girourard grid, and EX-it grid.

Fisheye BRD (Fig.1) 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.

2.2.3 Semi-flexible BRDs

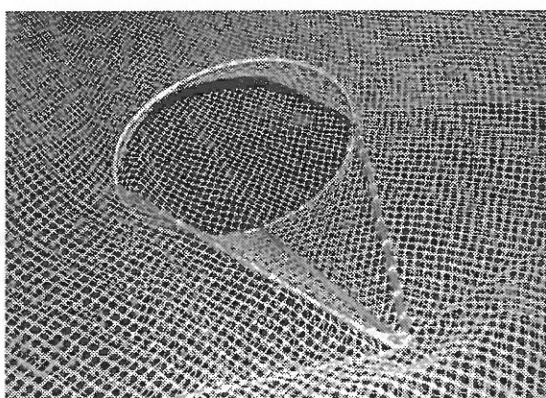


Fig.1 Fish eye BRD

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 facilitates 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.

2.3 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 provided, at the top in the front section of the codend. (Fig.2) Square mesh window, square mesh panels and rope BRD are the examples of this category. Studies carried out using square mesh windows have indicated their effectiveness in reducing bycatch by 30 to 40% in Northern prawn trawl fisheries. Square mesh has the advantage that the mesh opening is not distorted while under operation, unlike diamond meshes. Experiments conducted in Persian Gulf waters has shown that Rope BRD is effective in excluding 25% of the bycatch with no loss of shrimp or commercial fish species. Use of square mesh panels has been found to reduce the bycatch, particularly juveniles and young ones, by about 20% in Indian waters.

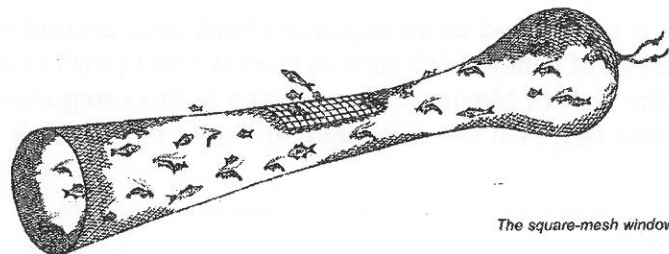


Fig.2. Square mesh window

2.4 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 Trawl flow Regulative Ecological Friendly Netting Device (TREND). Experiments in Japanese waters, using TREND has been shown to give safe escapement to juvenile fish, with better opportunity for survival, Fig.3.

2.5 Radial Escapement Section with Funnel

Radial Escapement Devices with funnel positioned between hind belly and codend of the trawl. 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. Studies in India have indicated of 18% reduction in fish bycatch by using a variation of Radial Escapement Device with 80 mm square meshes, surrounding the funnel.

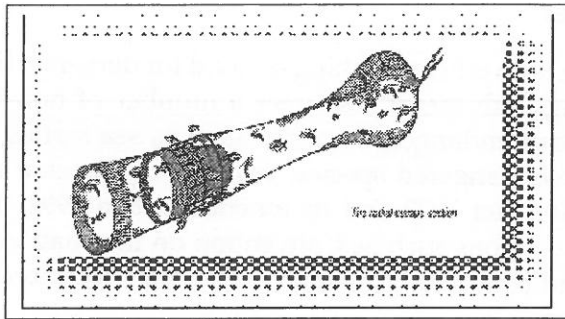


Fig.3. Trend

2.6 BRDs with differently shaped slits

BRDs with differently shaped slits utilise 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. Average bycatch reduction from V-cut BRD, operated in Queensland east coast trawl fishery has been reported to be 16%, with very low or no shrimp loss. Big eye BRD reduce bycatch by 30 to 40%, in tropical coastal waters, commercially used by shrimp fleet in Queensland east coast waters. 30% of the Queensland east coast trawl fleet use Big eye BRD in their penaeid fishery.

2.7 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.4

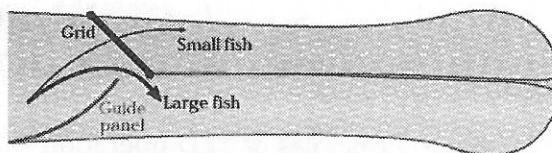


Fig.4. BRD with guiding panel

3.0 Development of Combination BRDs

Researchers proposed different combinations of sorting grids, slotted BRDs such as fisheye and soft BRDs such a square mesh window and bigeye BRD in order to obtain higher bycatch

exclusion efficiencies a combination of square mesh panel with Nordmore grid is designed for commercial operations in Antarctic.

3.1 Turtle Excluder Devices

Though bottom trawling is an efficient fishing method for demersal fishes, it is a less selective fishing technique. Along with target resources a number of non-target resources, which may include protected and endangered species such as sea turtles, are also caught during trawling. Sea turtles are endangered species, which are protected under Schedule I of the Indian Wildlife Protection Act 1972 and its amendment in 1991. They are also protected under international conventions such as Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)¹¹ and the Bonn Convention on Migratory Species to which India is a signatory.

Turtle excluder device is a simple device attached to the trawl nets which facilitates the escapement of sea turtles. It consists of panel of large mesh netting (soft TED) or a frame consisting of grid of deflector bars (Hard TED) installed before the cod end of the trawl net at an angle leading upwards or downwards to an escape opening. Small animals such as shrimp, slip through the mesh lumen of the escape opening. Small animals such as shrimp, slip through the mesh lumen of the netting panel or gap between the deflector bars and are retained in the cod end while large animals like sea turtles, large fishes and large elasmobranchs are stopped by the netting panel or the grid of deflector bars and can escape through the opening. The sea turtles which breath air are prevented from incidental capture and death due to prolonged entrapment in the trawl (Fig.4).

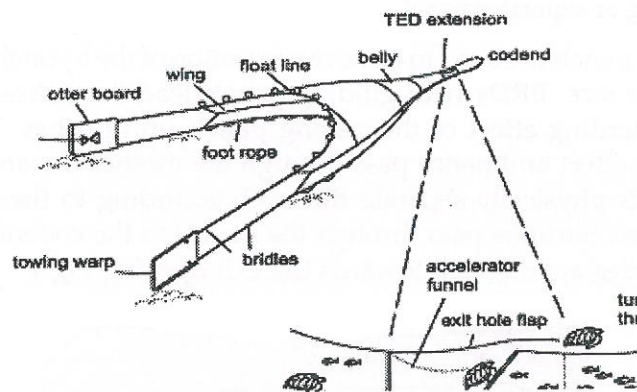


Fig.4. Principles of TED operation

Different designs of TED are available today and they vary with regard to their construction, principle of operation and materials for construction depending on the target groups and fishing conditions. Soft TED and Hard TEDs are the two types that are used worldwide. The hard TED is rigid frame device installed ahead of the cod end to separately and exclude turtles from the trawl catch. Designs of hard TED include Gorgia Jumper, NMFS hooped

TED, Fixed angle TED, Antony Weedless, Flounder TED, Super Shooter, Cameron TED, Jones TED, Thai turtle free device (Fig.5).

Modifications of the basic TED design have been carried out by different nations. Thai Turtle free device was developed by Kasetsart University and SEAFDEC/TD, in Thailand. The AusTED (Australlian trawling efficiency device) was developed in Australia and CIFT - TED in India.

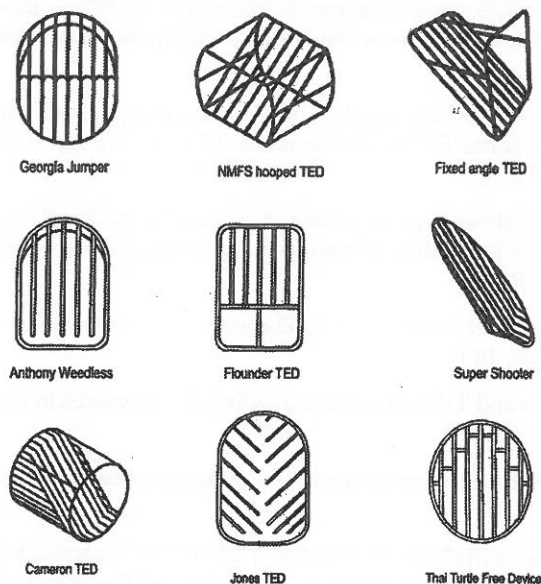


Fig.5. Single grid hard TED designs

4.0 Further reading

Alverson, D.L. and Hughes, S., (1996) Bycatch: from emotion to effective natural resource management. *Reviews in Fish Biology and Fisheries* 6, 443-462.

Alverson, D.L., Freeberg, M. H., Murawski, S. A. and Pope, J.G., (1994) A Global assessment of fisheries bycatch and discards. *FAO Fish. Tech. Pap. No 339*. Rome, FAO, 233 p.

Andrew, N.L and Pepperell, J.G., (1992) The bycatch of shrimp trawl fisheries. In: Barnes, M., Ansell A.D and Gibson, R. N., (Eds.). *Oceanography and Marine Biology Annual Review*, Vol. 30, 527-565.

Andrew, N.L., Kennelly, S.J. and Broadhurst, M.K. (1993) An application of the Morrison soft TED to the offshore prawn fishery in New South Wales, Australia. *Fish. Res.* 16: pp 101-111.

Anon., (2002a) Flexi grid beats problems, Tough grid fold on to net drum. *Fish. News Int.* 41(12), 1-12.

Anon., (2004c) Popeye fish excluder. Queensland Government Department of Primary Industries and Fisheries. *Trawl fishery newsletter*. July 2004. No. 5.

Brewer, D., Rawlinson, N., Eayrs, S and Burridge, C. (1998) An assessment of bycatch reduction devices in tropical Australian prawn trawl fishery. *Fish. Res.* 36, 196-215.

- Broadhurst, M. K. and Kennelly, S.J., (1996) Effects of the circumference of codends and a new design of square mesh panel in reducing unwanted bycatch in the New South Wales oceanic prawn trawl fishery, Australia. *Fish. Res.* 27, 203-214.
- Broadhurst, M. K., (2000) Modifications to reduce bycatch in prawn trawls: A review and frame work for development. *Reviews in Fish Biology and Fisheries.* 10(1), 27-60.
- Burrage, D.D., (2004) Evaluation of the "Gulf Fisheye" Bycatch Reduction Device in the Northern Gulf Inshore Shrimp Fishery. *Gulf. Mex. Sci.* 22(1), 85-95.
- Chokesanguan, B., Ananpongsuk, S., Siriraksophon, S., Podapol, L. (2000) Study on Juvenile and Trash Excluder Devices (JTEDs) in Thailand, South East Asian Fisheries Development Center Training Department (SEAFDEC), Thailand, TD/RES/47, 8 p
- Chokesanguan, B., Theparoonrat, Y., Ananpongsuk, S., Siriraksophon, S., Podapol, L., Aksomboon, P. and Ahmad, A., (1996) The experiment on Turtle Excluders Devices (TEDs) for shrimp trawl nets in Thailand, SEAFDEC Technical Report TD/SP/19, 43 p.
- Clucas, I.J., (1997) Reduction of fish wastage-an introduction, In: Clucas, I.J and James, D.G., (Eds). Paper presented at the Technical Consultation on Reduction of Wastage in Fisheries, Tokyo, Japan, 28 October-1 November 1996. *FAO Fish. Rep. No. 547*, FAO, Rome.
- Dawson, P. and Boopendranath, M.R., (2001) CIFT-TED-construction, installation and operation, CIFT Technology Advisory series-5, CIFT, Cochin, 16 p.
- Dawson, P., (2000) Use of BRDs and TEDs in shrimp trawling. In: *Advances in Harvest Technology. ICAR Winter School Manual*, CIFT, Cochin, 424-433.
- Eayrs and Prado., (1998) Bycatch reduction devices show promise in the Persian Gulf. *INFO FISH*, Number 3/98, May/June, 62-66.
- Eayrs, S., (2004) Reducing turtle mortality in shrimp-trawl fisheries in Australia, Kuwait and Iran. Papers presented at the Expert Consultation on interactions between Sea turtles and Fisheries within an Ecosystem context, 9-12 March, 2004. *FAO Fisheries Report no. 728*, FAO, Rome, 238 p.
- FAO, (1995) Code of Conduct for Responsible Fisheries, FAO, Rome, 41p.
- FAO, (1996) Fishing operations, *FAO Technical Guidelines for Responsible Fisheries 1*, 26 p.
- Fuwa, S., Nakamura, J., Ebata, K., Kumazawa, T. and Hirayama., (2003) Flow distribution on a simple separator device for trawling, *TREND. Fish. Sci.* 69, 1169-1175.
- Gordon, A., (1991) The bycatch from Indian shrimp trawlers in the Bay of Bengal-Programme for its improved utilization. Working paper No. 68 Bay of Bengal Programme, Chennai.
- Hall, M. A., (1996) On bycatches. *Rev. Fish. Biol. Fish* 6, 319-352.
- Hall, M. A., Alverson, D.L. and Metzals, K.I., (2000) Bycatch: Problems and Solutions, *Marine Pollution Bulletin* 41(1-6), 204-219
- Hameed, M. S. and Boopendranath, M. R., (2000) *Modern Fishing Gear Technology*, Daya Publishing House, Delhi, 186 p.
- Isaksen, B., Valdemarsen, J.W., Larson, R.B., Karlsen, L., (1992) Reduction of fish bycatch in shrimp trawl using a rigid separator grid in the aft belly. *Fish. Res.* 13, 335-352.
- Kelleher, K., (2004) Discards in the World's Marine Fisheries: An Update, *FAO Fisheries Technical Paper. No. 470*, FAO, Rome.

- Kunjipalu, K.K., Varghese, M.D., Nair, A.K.K., (1994b) Studies on square mesh codend in trawls-I studies with 30mm mesh size, *Fish.technol.*31(2): pp 112-117.
- Maartens, L., Gamst, K.A., Schneider, P.M., (2002) Size selection and release of juvenile monk fish *Lophius vomerinus* using rigid sorting grids. *Fish. Res.* 57, 75-88.
- Martin A. Halla, Dayton L. Alversonb, Kaija I. Metzalsc (2000) By-Catch: Problems and Solutions *Marine Pollution Bulletin* Volume 41, Issues 1-6, , Pages 204-219.
- Mitchell, J.F., Watson, J.W., Daniel G. Foster, D.G., Taylor, R.E., (1995) The Turtle Excluder Device (TED): A Guide to better performance. NOAA Technical Memorandum NMFS-SEFSC-3-6, 35 p.
- Morris, B., (2001) Certification of bycatch reduction devices in North Carolina. Report to North Carolina Sea Grant, November 2001, Grant 99-FEG-33.
- Mounsey, R. P., Baulch, G.A. and Buckworth, R.C., (1995^d) Development of a trawl efficiency device (TED) for Australia's Northern Prawn Fisheries I, The AusTED Design. *Fish. Res.* 22, 99-105.
- NCDMF, (1997) Bycatch reduction device specifications, Proclamation SH-9-97. Department of Marine Fisheries, North Carolina (www.ncfisheries.net/content/index.html; accessed on 1.5.2008).
- Pillai, N. S., (1998) Bycatch Reduction Devices in shrimp trawling, *Fishing Chimes.* 18 (7), 45-47
- Polet, H., Coenjaerts, J. and Verschoore, R., (2004) Evaluation of the sieve net as a selectivity-improving device in the Belgian brown shrimp (*Crangon crangon*) fishery. *Fish. Res.* 69, 35-48.
- Ramirez, D.A., (2001) Modified trawl net for selective capture of shrimp using small boats in Baja California Sur, Mexico, *INFOFISH Intl.* no. 6/2001: pp 60-62.
- Rao, G. S., (1998) Bycatch and discards of shrimp trawlers in Visakhapatnam. In: Balachandran, K.K., Iyer, T. S. G., Madhavan, P., Joseph, J., Perigreen, P. A.,
- Robins, J.B. and McGilvray, J.G., (1999) The Aus TED-II, an improved trawl efficiency device II Commercial Performance. *Fish. Res.* 40, 29-41.
- Robins-Troeger, J.B., (1994) Evaluation of the Morrison soft turtle excluder device: prawn and bycatch variation in Moreton Bay, Queensland. *Fish. Res.* 19, 205-217.
- Rogers, D.R., Rogers, B.D., Desilva, J.A., Wright, V.L., and Watson, J.W., (1997) Evaluation of shrimp trawls equipped with bycatch reduction devices in inshore waters of Louisiana. *Fish. Res.* 33, 55-72.
- Steele, P., Bert, T.M., Johnston, K.H., Levett, S., (2002) Efficiency of bycatch reduction devices in small otter trawls used in the Florida shrimp fishery. *Fish. Bull.* 100, 338-350.
- Sukumaran, K.K., Telang, K.Y. and Thippeswamy, O., (1982) Trawl fishery of South Kanara with special reference to prawns and bycatches. *Mar. Fish. Inf. Ser. T& E. Ser.*, 1982, 44, 8-14.
- Talavera, R.V., (1997) Dispositivos excluidores de tortugas marinas, *FAO Documento Technico de Pesca*, No. 372, Roma, FAO, 116 p
- Watson, J.V. and Tailor, C.W., (1988) Research on selective shrimp trawl design for penaeid shrimp in the United States, *FAO Expert Consultation on Selective Shrimp Trawl Development*, 24-28, November, 1986, Georgetown, Guyana