सत्यमेव जयते

Demonstration of Bycatch Reduction and Juvenile Fish Excluder Devices (BRJED) in Sindhudurg District of Maharashtra.

Introducing the Concept of Bycatch reduction and Juvenile Fish Excluder Device

Introduction

The shrimp trawl is a non-selective gear that commonly has an associated catch of non-targeted organisms such as finfish and miscellaneous invertebrates generally known as bycatch. The classification of targets and bycatch is often misleading in literature and hence there are difficulties in the actual quantification of the bycatch in many fisheries. The most widely used classification is the one by Kelleher in which the 'Target catch' is denoted as the species or species assemblage primarily sought in a fishery for example shrimps. 'Incidental catch' is the retained catch of non-targeted species and 'discarded catch' is that portion of the catch returned to the sea because of economic, legal or personal considerations. Bycatch includes both discarded and incidental catch. In additional to the non- targeted finfish and invertebrates, bycatch also involves threatened and protected species like sea turtles, dolphins etc.

The Code of Conduct for Responsible Fisheries (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. A large number of studies are being carried out world over to reduce the incidence of bycatch in fishing systems and most of these works are concentrated to reduce incidence of bycatch during trawling.

Bycatch in Trawl Fisheries:

Globally, shrimp trawling contributes to the highest level of discards-to-catch ratios, ranging from about 3:1 to 15:1, and the amount of bycatch varies in relation to target species, season and areas (EJF,2003; Kelleher, 2005;). Trawl fisheries for shrimp and demersal finfish accounts for over 50% of the total global discards of 7.3 million t, during 1992-2001 Kelleher, 2005). Trawling industry in India tended to be shrimp-oriented due to its economic importance and export value and large quantities of finfish bycatch including significant amount of juveniles are landed during shrimp trawling. These are over 35,000 trawlers operating in small-scale mechanized sector of India (CMFRI, 2012). Bycatch in Indian trawl fisheries has been reviewed by Boopendranath (2007). Bycatch was estimated at 79.18% (3, 15,902 t) of the total shrimp trawl landings in India, during 1979 (George et al., 1982). The quantum of bycatch was maximum in Gujarat (92.58%), followed by Tamilnadu (91.04%) and

Pondicherry (86.52%) and was utilized either for human consumption or as fish meal and fish manure (George et. al., 1981).

Trawl bycatch in the tropics is known to be constituted by high proportion of juveniles and sub-adults, particularly of commercially important fishes, which needs serious attention in development and adoption of bycatch reduction technologies (Luther & Sastry, 1993). Najmudeen & Sathidhas (2008) have estimated that the annual economic loss due to juvenile fishing made by trawlers, along Indian coast at US$ 15,686million yr^{-1}. Pramod (2010) has estimated the bycatch discards of Indian trawlers as 1.2 million t. The bycatch, mostly comprising of sharks from tuna gillnets along the Indian Ocean is estimated to be around 80,000t/year and the average turtles caught was 0.24 per vessel per year.

Dinesh babu et al., 2013, studied the Low value bycatch (LVB) composition of catches along the east and west coasts of India and substantiate the growth overfishing happening in the Indian fisheries, by the way of landings of juveniles of major commercially important species. They show that the all India contribution of LVB increased from 14% in 2008 to 25% in 2011. The value realization from the LVB has also increased in the recent years which in some seasons may go up to INR 16 in some harbours. The increase in the LVB can be attributed to the increased landings of the discards that were otherwise thrown away during the fishing operations. The increased value realization for the LVB and no processing costs involved encourage the fishermen to land the catch which consists predominantly of the juveniles of commercially important species. The economics of operation of trawlers along Southeast coast during 1978-2008 reveal that the income from the target species has reduced drastically over the years and the main income is from the LVB that is landed for drying (Lobo et al, 2010). Though very seasonal in occurrence, the predominance of Squilla, crabs and shells are reported from all the major landing centres along the Indian coast (Dineshbabu et al., 2013).

The coast of Sindhudurg, 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 (LOA) 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).

What are Bycatch Reduction Devices (BRD)?

Devices developed to reduce the capture of non-targeted species during trawling are collectively known as Bycatch Reduction Devices (BRD). These devices have been developed taking into consideration variation in the size and differential behaviour pattern of shrimp and other animals inside the net. Trawl fisheries in different parts of the world are now being required to use Bycatch Reduction Devices (BRDs) as result of pressure from conservation groups and legal regimes introduced by the government.

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.

A. **Soft BRDs** make use of soft materials like netting and rope frames for separating and excluding Bycatch.
B. **Hard BRDs** are those which use hard or semi-flexible grids and structures for separating and excluding Bycatch.
C. **Combination BRDs** use more than one BRD, usually hard BRD in combination with soft BRD, integrated into a single system.

A large number of technologies have been developed and field tested especially for shrimp trawling in India, which generates largest quantity of bycatch in India (Boopendranth et al, 2008, Boopendranath and Pravin, 2009). The adoption of these technologies hitherto has been poor among the fishermen. The loss of revenue associated with the reduction in bycatch is the main reason for lack of adoption. The failure to adopt regulations and unbridled expansion in the capacity, has invariably resulted in growth overfishing in the Indian fisheries (Bhathal and Pauly, (2008); Dineshbabu et al., 2013).

Advantages of using BRD:

1. Reduction in impact of trawling on non-targeted marine resources
2. Reduction in damage to shrimp due to absence of large animals in codend
3. Shorter sorting times
4. Longer tow times
5. Lower fuel costs due to
6. Greener catches which are acceptable in the export market

Objectives:

The main objectives of the project were as follows:

1. To introduce the concept by conduct of an inception workshop to discuss the relevance of the Bycatch reduction and juvenile fish excluder device (BRJED) in Sindhudurg coast.

2. Conduct of trials on the BRJED utilizing, local fishing vessels through involvement of the fishermen federation, fishermen societies and officials of the Fisheries Department.

3. Capacity building of the fishers communities in use of the devices, along with field visits to sites where such devices have been used and implemented.

4. Based on the outcome of trials, conduct demonstration of the device to all the 30 fishermen societies spread over the three talukas.

5. Facilitate fabrication of the device locally and its maintenance through capacity building of the fishermen societies and involvement of the Fisheries Department.

6. Sharing the results of the trials with the local fishermen societies and the Fisheries Department through conduct of a workshop.

7. Formation of a policy paper on introduction of the device towards sustainable development of marine fisheries in Maharashtra.

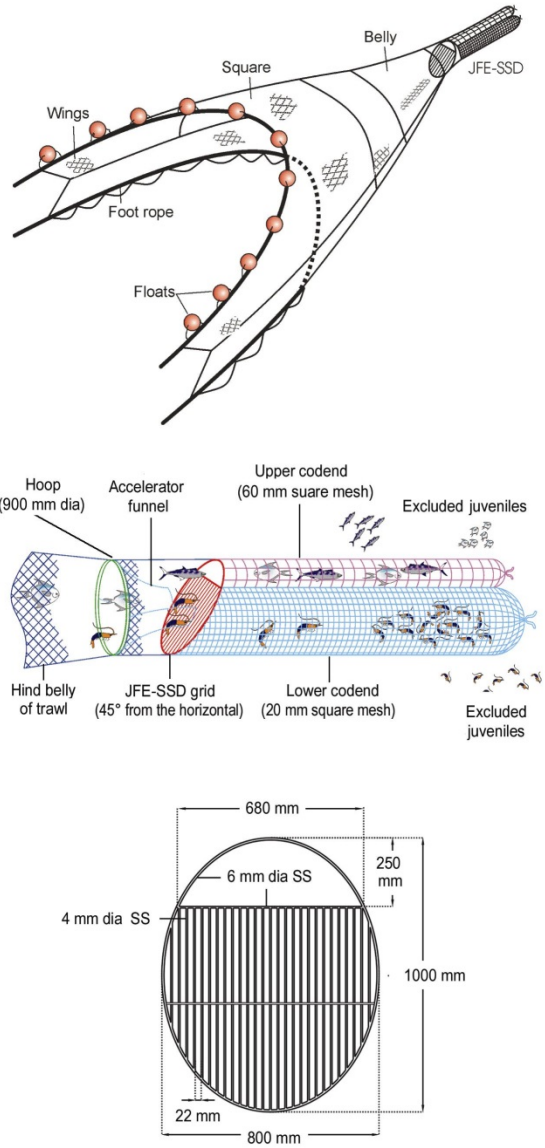
Study area:

The demonstration of the By-catch Reduction and Juvenile Excluder Device (BRJED) was carried out in the three Talukas of Sindhudurg *viz.,* Devgad, Malvan and Vengurla.

Work plan

The following Bycatch Reduction Device (BRD's) were demonstrated during the project period

1. **Juvenile Fish Excluder cum Shrimp Sorting Device (JFE-SSD) -**
   Developed by CIFT, Cochin which brings down the bycatch of juveniles and small sized non targeted species that enables fishermen to harvest and retain large commercially valuable fin fishes and shrimps species.

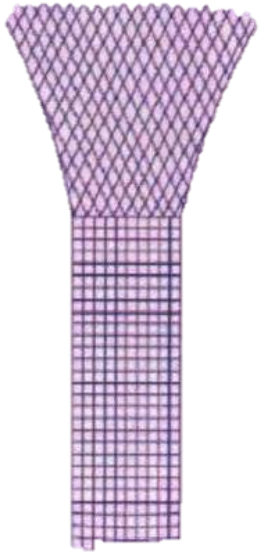


Juveniles Fish Excluder -Cum Shrimp Sorting Device (JFE-SSD)

JFE-SSD is an innovative BRD design to reduce bycatch of juveniles with an integrated system for in situ shrimp sorting. The device consists of an oval grid having bar spacing of 22 mm (or grid covered by a square mesh panel of 22 mm mesh size) kept at 45° angle to the horizontal. The grid is provided with a 250x680 mm top opening which leads to an upper codend with large square meshes (60 mm). Shrimps pass through the grid and are retained in the lower codend made up of 20 mm square mesh netting. Juveniles escape through the respective codend meshes.

2. Square mesh codend –

Square mesh codend has an advantage that the mesh opening is not distorted while under operation, unlike diamond meshes and thus allow escaping juveniles of commercially important species.



3. CIFT Semi-Pelagic Trawl System (CIFT-SPTS-I)

An alternative to shrimp trawling in the small scale mechanized trawler sector. It is capable of attaining catch rates beyond 200kg/hr in moderately productive grounds and can selectively harvest fast swimming demersal, semi-pelagic finfishes and cephalopods, which are beyond the speed limits of shrimp trawls. The net is operated above the sea bottom and hence the impact to the sea bottom is very minimum.

4. CIFT collapsible fish trap

Trap fishing is not practiced along the Sindhudurg coast. Due to the availability of large rocky areas, the site is an excellent ground for trap fishing. This gear was demonstrated along the Malvan coast. The trap is made of large square meshes (50 mm diameter) and the entrance of the trap was modified to allow the entry of big fishes and the juveniles entering the trap could escape out of the large meshes. The trap can be collapsed and hence stacking of the traps is very easy.

Conduct of trails

List of fisheries co-operative societies in Sindhudurg:

There are total 30 fisheries co-operative societies present in Sindhudurg which are involved in different activates related to fisheries such as traditional fishing, gillnet etc. but only the following fisheries co-operative societies which are involved in trawling related activities were involved to carry out awareness program and demonstration of BRJED and hands-on-training programs on square mesh codend to the local fishermen in Sindhudurg

Sr. no	Name of the Society	Place
1	Sindhudurg Dist. Machimar Fisheries Federation	Malvan
2	Rameshwar fisheries co-op society	Malvan
3	Sarjekot fisheries co-op. society	Malvan
4	Rajkot fisheries co-op. society	Malvan
5	Shree. Bhadrakali Devi Matsya- Vyavsaik, Sahakari saunstha maryadit.	Malvan
6	Jesus Machimar co-op society	Malvan
7	Rosary Machimar co-op society	Malvan
8	Malvan Fisheries co-op society	Malvan
9	Wagheshwar Machimar co-op society	Malvan
10	Taramumbri Machimar co-op society	Devgad
11	Devgad Fisherman co-op society	Devgad
12	Devdurg Machimar co-op society	Devgad
13	Dirba Yantriki Nauka Malak Sangha	Devgad
14	Vengurle Machimar co-op society	Vengurla

Details of the trawlers that were engaged in the on-board trials of square mesh codend in Sindhudurg:

The below mentioned trawl owners were hired under BRJED project to carry out the on-board trials of square mesh codend with Disco (Fish) trawling from September to December and Chalu (Shrimp) trawling from January to April. The seasons were selected based on the interviews conducted before the trials and the design of the trawlnets used were of the same design that was used by the local fishermen. The required numbers of trawlnets were purchased from the trawl owners itself. Shri. Prafulla M. Dhuri discontinued the fishing operations (Personal reason) so another boat was hired in Malvan of Mr. Nilesh Avadhoot Chopdekar during the course of the demonstrations.

Sr. No.	Boat owner's name	Boat name	Registration No.	Engine Make and (hp)	L_{OA} (m)	Place
1	Mr. Harshal Babi Redkar	Ganapati Krupa	IND-MH-5-MM-2000	Ashok Leyland (99.27)	12.85	Vengurla
2	Mr. Prafulla Mahadev Dhuri	Rajashri	IND-MH-5-MM-2126	Ashok Leyland (99.27)	15.40	Malvan
3	Mr. Nilesh Avadhoot Chopdekar	Jesus Krupa	IND-MH-5-MM-225	Ashok Leyland (99.27)	15.00	Malvan
4	Mr. Sunil Mahadev Sawant	Mauli Mata	IND-MH-5-MM-2557	Ashok Leyland (98)	13.65	Devgad

The demonstration and on-board participation of observers of the square mesh codends trials were carried out in the three landing centres simultaneously from September 2014 to January 2015. The demonstration was carried out till the end of December, 2015 for the purpose of showcasing the results. 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.

On-board data collection of square mesh codend:

On-board data collection of traditional trawl net

Onboard trial of square mesh codend and data collection

Field trials using JFE-SSD at Devgad

Juveniles escaped to the cover of the codend

Total hauls of Square mesh codend and Traditional codend trials in Sindhudurg

Total number of hauls conducted		
Place	**Diamond mesh codend**	**Square mesh codend**
Malvan	50	45
Vengurla	60	60
Devgad	30	36
	140	**141**

RESULTS

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)

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. The escapement from the square mesh codend was 2.45 kg.h-1 and was constituted by juveniles of commercially important species (Table: 3). The escapement in terms of numbers was 18% and this formed 7.25% in terms of weight compared to the weight of targeted catch in the 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 60.0 per haul. The total loss estimated in a single day trip was INR 180. 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.

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

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

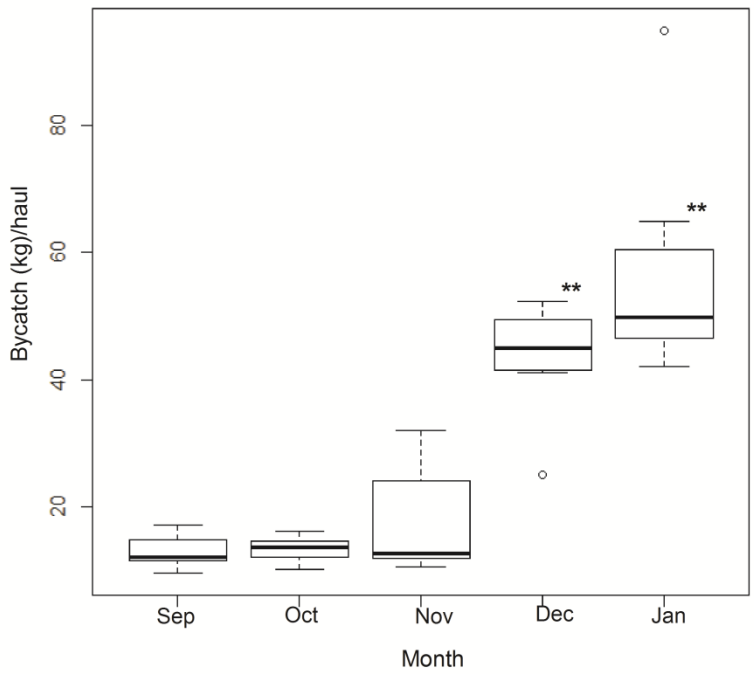


Fig. 2 Variation in the by-catch observed during the study period. The means which are significantly different are indicated as (**). The open circles are outliers and the box represents 25% and 75% quartiles. The thick line in the box is the mean.

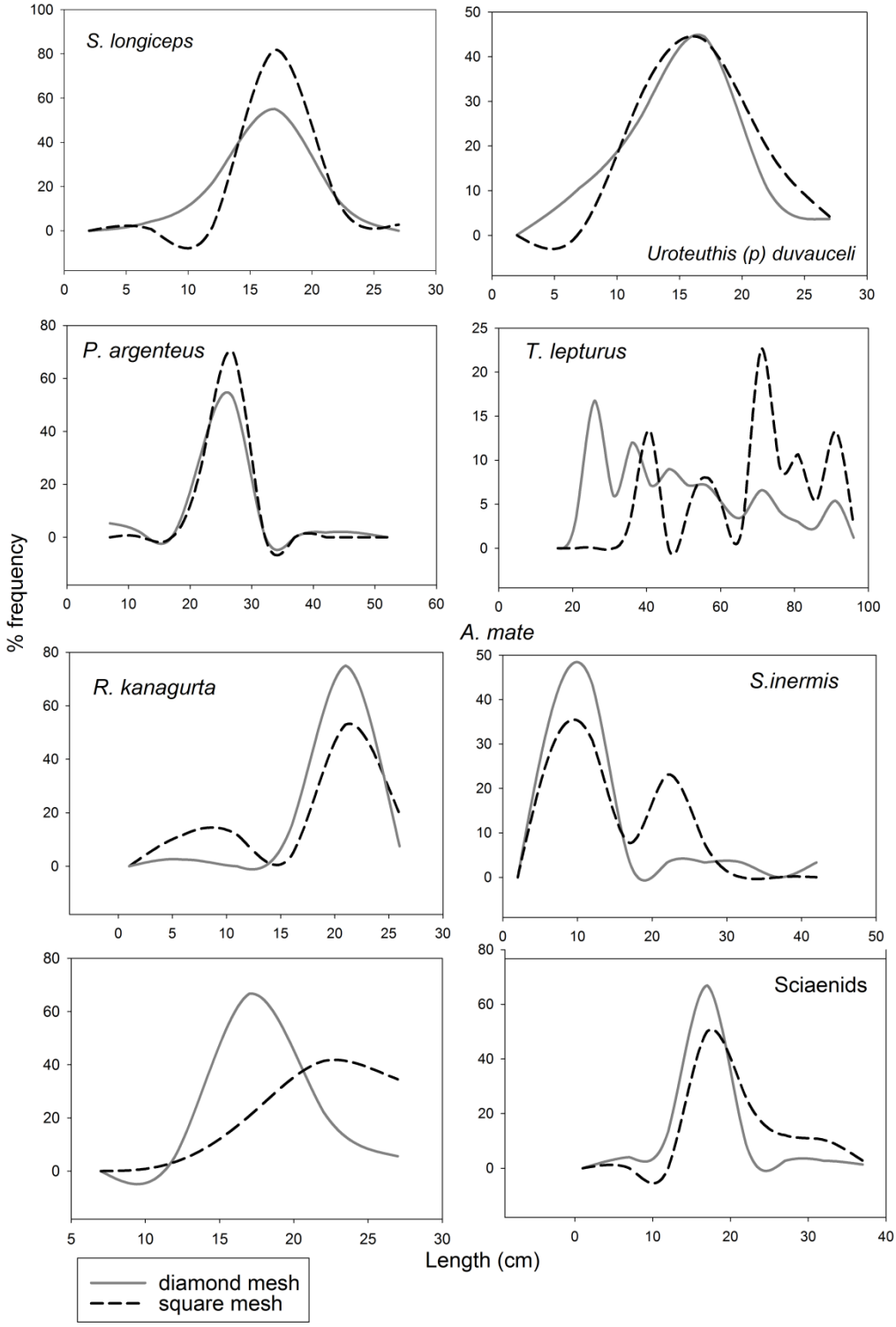


Fig: 1. Size- frequency distribution of major species reatined in the diamond and square mesh codends.

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. The estimated savings in terms of fuel for 12 hours of operation was about 2-3 litres, which can save between INR 110-165 in a day. The long term benefits of releasing the juveniles of the commercially important species would be around INR 4800* in one haul. (*Based on an empirical study assuming steady state of environmental conditions, fishing effort and capacity).

The highlight of the study and the point which was transferred to the fishermen was that the loss due to escapement of juveniles from the net is compensated by the gain in conservation of fuel. This has a major impact on the adoption of the technology since the attempt to study the fuel savings was made by the fishers themselves.

Empirical estimates of the fuel saving show that with 317 trawlers in operation along Sindhudurg coast, with an estimated 0.75 million hours of trawling in an year, the total fuel savings could be 1.3 lakh litres, with a reduction in CO_2 emissions by 330 tonnes/year.

The above estimates are based on the assumption that all trawlers use square mesh codends and a steady state of the fishery.

Capacity building

A. Awareness programs:

Different awareness programs were conducted at Malvan, Devgad and Vengurla so as to aware the local fishermen community and net makers regarding the concept of BRD, its different types, applications and subsequent advantages. A Marathi questionnaire was also circulated among the participants at all the places mentioned above. And it was observed that all the participants were unaware about the BRDs but were aware of diminishing catches and need to conserve the same.

Awareness program on BRD

Lecture on BRD in progress

Participants during the program

Hands on training for square mesh codend - Hands on Training program on 'conversion of diamond mesh codend into square mesh codend' were conducted in Malvan, Devgad and Vengurla under the guidance from Mr. Arvind Kalangutkar (Tech. officer) CIFT, Cochin. A total of 59 persons participated in the training program mostly the trawl boat owner's, net makers and society members etc.

Mr. Kalangutkar giving Hands on training of square mesh codend at Malvan, Devagd and Vengurla

Onboard trials of Square mesh codend with codend cover:

Square mesh codendswere made with the help from the trained local net makers at Malvan,Devgad and Vengurla and were fixed with codend cover. so as to collect the data of the escaped juveniles and small fishes from the square mesh codend.

The ready square mesh codend with codend covers were then fixed to trawl net for on-board trials. The training for the same was given byMr. Pungera (Tech.officer) CIFT, Veraval.



Mr. Pungera giving the training to the local trawl net makers for square mesh codend at Vengurla and Devgad



Catch in square mesh codend with cover and escaped juveniles which were caught in codend cover

Display of square mesh cod end and Juvenile fish excluder cum shrimp sorting device (JFE-SSD):



Participants observing JFESSD & Square mesh codend and also watching videos of the same

List of awareness and training programs conducted in Sindhudurg

Following different programs were conducted to aware and educate the fishermen community, society members and officials of fisheries department related to BRD.

Sr. No.	Date	Name of the Program
1	21.06.14	Awareness Program regarding Bycatch Reduction Devices, it's different types and uses to the local fishermen community in **Malvan**
2	23.06.14	Awareness Program regarding Bycatch Reduction Devices, it's different types and uses to the local fishermen community in **Devgad**
3	08.07.14	Awareness Program regarding Bycatch Reduction Devices, it's different types and uses to the local fishermen community in **Vengurla**
4	26.08.14	JFE-SSD and Square mesh codend display program in (**Rajkot**)**Malvan**
5	27.08.14	JFE-SSD and Square mesh codend display program in (**Sarjekot**) Malvan
6	30.08.14	JFE-SSD and Square mesh codend display program in **Devgad**
7	01.09.14	JFE-SSD and Square mesh codend display program in **Vengurla**
8	17.07.14	Hands on Training of ***'conversion of diamond mesh codend into square mesh codend'***was conducted in **Malvan**
9	18.07.14	Hands on Training of ***'conversion of diamond mesh codend into square mesh codend'***was conducted in, **Devgad**
10	19.07.14	Hands on Training of ***'conversion of diamond mesh codend into square mesh codend'***was conducted in **Vengurla**
11	13.10.14	On-board trials of Square mesh Codend at **Vengurla**
12	18.10.14	On-board trials of Square mesh Codend at **Malvan**
13	11.01.15	JFE-SSD, SPTS and Square Mesh Codend Display at **Malvan**
14	21.02.15	JFE-SSD, SPTS and Square Mesh Codend Display at **Devgad**
15	2016	Total of 3 programs on square mesh fabrication
16	2017	One training program on fabrication of square mesh codend

List of workshop and training program conducted and total no. of participants participated during training program in Sindhudurg under BRJED project

Activity	Total programs	Male	Female	Total participants
Capacity building programs	11	229	16	245
Awareness programs	12	272	2	279

Results and outcome of the study

Square mesh codend distribution

Realising the benefits of using square mesh technology, all the trawl societies operating along Sindhudurg had requested for square mesh codends. As part of the project, square mesh codends were fabricated with specifications based on local dimensions and distributed to all the fishermen societies. A function was organized for the distribution of the codends in which Ms. Leena Nair, IAS, Chair Person MPEDA was the chief guest.

Distribution of square mesh codends to fishermen

Publicity

Local newspaper coverage:

Various awareness program of Bycatch Reduction Devices (BRD's) conducted and covered by the various local newspaper such as Tarun Bharat, Sakal, Prahar etc.


ट्रॉलिंग मासेमारीसाठी आता 'बीआरडी' पद्धत


मच्छीमारांना निरुपयोगी मासळी मारणे टाळावे

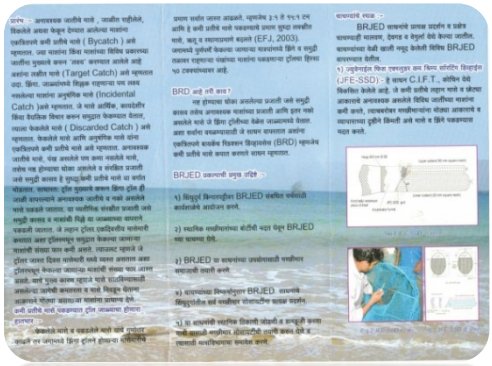
डॉ. व्ही. आर. मधू : बचाव नियमावलीचा वापर करावा


मासेमारीसाठी आधुनिक जाळ्यांचा वापर झाल्यास अधिक फायदा : खानोलकर

वेंगुर्लेत बी. आर. जे. ई. डी. प्रदर्शन व चाचणी प्रयोगाला प्रतिसाद

Awareness Programme Vengurla. BRJED

Leaflets:
Following leaflet was designed in local language (Marathi) and distributed to participants during the various awareness programs.



Way Forward

1. Awareness program for the local fishermen and trawl boat owners along Maharashtra coast was carried out. As per the mandate of the institute, sharing the results of the trials conducted at Sindhudurg is highlighted and in collaboration with other agencies, three training programmes were conducted at Mumbai and two programmes at Malpe, Karnataka.

2. The results of the field trials along Sindhudurg coast, was taken as an input for the recent inclusion of the mandatory use of square mesh codends in the Marine Fisheries Regulation Act of Kerala.

3. The accurate savings of fuel when using square mesh codends is being studied in controlled conditions on-board Dept. Fishing vessels of ICAR-CIFT at Kochi.

4. Trials using new generation synthetic materials for trawlnet fabrication for fuel savings are also developed and the technology will be released to the fishermen.

Annexure 1

Project personnel involved in the BRJED - project

Sr. No.	Name	Designation	Work Station
1	Dr. Madhu V.R.	Sr. Scientist, Principal Investigator (PI)	CIFT, Kochi, Kerala
2	Mr. Paresh S. Khanolkar	Senior Research Fellow (SRF)	CIFT, Malvan
3	Mr. Prashant S. Dudwadkar	Technical Assistant (TA)	CIFT, Malvan
4	Mr. Harshal B. Redkar	Technical Assistant (TA)	CIFT, Vengurla
5	Mr. Harehwar B. Khavale	Technical Assistant (TA)	CIFT, Devgad
6	Ms. Priyanka B. Satam	Office Assistant	CIFT, Malvan

References

Alverson, D. L., M. H. Freeberg, J. G. Pope and S. A. Murawski. 1994. A global assessment of fisheries bycatch and discard. FAO Fish. Tech. Pap. 339, 233 pp.

Bhathal, B. and Pauly, D. (2008). Fishing down the marine food webs and spatial expansion of coastal fisheries in India 1950-2000. Fisheries Research, 91: 26-34.

Boopendranath, M.R. (2012) Waste minimization in Fishing Operations, Fishery Technology, 49, 109-112.

Boopendranath, M.R. and Pravin, P. (2009) Technologies for responsible fishing - Bycatch Reduction Devicesand Turtle Excluder Devices. Paper presented in the International Symposium on Marine Ecosystems- Challenges and Strategies (MECOS 2009), 9-12 February 2009, Marine Biological Association of India,Cochin.

Boopendranath, M.R., Pravin, P., Gibinkumar, T.R. and Sabu, S. (2008) Bycatch Reduction Devices for Selective Shrimp Trawling, Final Report on ICAR Ad-hoc Project, Central Institute of Fisheries Technology, Cochin.

Davies R. W. D., Cripps, S. J. Nicksona, A. Porter, G. (2009) Defining and estimating global marine fisheries bycatch, Marine Policy 33 (4), 661-672

Dineshbabu, A.P., Radhakrishnan, E.V., Thomas, S., Maheswarudu, G., Manojkumar, P.P., Kizhakudan, S.J., Pillai, S.L., Chakraborty, R., Jose, J., Sarada, P.T., Sawant, P.B., Philipose, K.K., Deshmukh, V.D., Jayasankar, J., Ghosh, S., Koya, M., Purushottama, G.B. and Dash, G. (2013) An appraisal of trawl fisheries of India with special reference on the changing trends in bycatch utilization. Journal of the Marine Biological Association of India, 55(2), 69-78, July-December, 2013.

George, M. J., Suseelan, C. and Balan, K. (1981) Bycatch of shrimp fisheries in India, Mar. Fish. Inf. Ser. T&E. Ser, 28, pp 3-13.

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, 29 p.

Kelleher, K. (2004) discards in the World's Marine Fisheries - An Update. FAO Fisheries Technical Paper 470, Food and Agriculture Organization of the United Nations, Rome

Lobo, A.S., Balmford, A., Arthur, E. and Manica, A. (2010). Commercializing bycatch can push a fishery beyond economic extinction. Conservation Letters, 3: (4), 277-285.

Luther, G. and Sastry Y. A. (1993) Occurrence of spawners, juveniles and young fish in relation to the fishery seasons of some major fishery resources of India—a preliminary study, Marine Fisheries Information Service, T & E. Series. 122, pp 1-8.

Menon, N. G. (1996) Impact of bottom trawling on exploited resources, In: Marine Biodiversity, Conservation and Management (Menon, N. G. and Pillai, C. S. S., Eds), pp 97–102, Central Marine Fisheries Research Institute, Cochin.

Najmudeen, T.M. and Sathiadhas, R. (2008) Economic impact of juvenile fishing in a tropical multi- gear multi-species fishery, Fisheries Research, 92: 322-332

Pillai, N. S. (1998) Bycatch Reduction Devices in shrimp trawling, Fishing Chimes. 18(7), pp 45–47.

Pramod, G. (2010) Illegal, Unreported and Unregulated Marine Fish Catches in the Indian Exclusive Economic Zone, Field Report (Pitcher, T.J., Ed.), Policy and Ecosystem Restoration in Fisheries. 29p, Fisheries Centre, University of British Columbia, BC, Vancouver, Canada.

Rao, G.S. 1998. Bycatch discards of trawlers of Visakhapatnam In: Advances and priorities in fisheries Technology, Society of fisheries technologists, India Cochin, 501-505.

Zacharia, P. U., Krishnakumar, P. K., Muthiah, C., Krishnan, A. A. and Durgekar, R. N. (2005) Quantitative and qualitative assessment of bycatch and discards associated with bottom trawling along Karnataka during 2001-2002, Paper presented at the International Symposium on Improved Sustainability of Fish Production Systems and Appropriate Technologies for Utilization, CUSAT, Cochin.