Fishery Technology 54 (2017) : 162 - 169

Status of Bycatch from Commercial Trawlers Operated off Central Kerala

V. R. Madhu*, Leena Raphael, Jolsana Jeevan, V. T. Antony and Leela Edwin
ICAR-Central Institute of Fisheries technology, P.O. Matsyapuri, Cochin - 682 029, India

Abstract

Bycatch and discards in trawl fishing is a serious issue that requires prompt interventions. Different management measures are being followed to mitigate this issue among which gear based technical measures like BRDs are widely used. Characterization of bycatch with regard to the type and sizes are very important inputs for development and implementation of any management regulation in a fishery. The purpose of this study was to quantify the total bycatch and also the incidence of juveniles in the bycatch generated by commercial trawlers operating off Central Kerala During the study, 67 species from 25 families were identified in the trawl catch. The catch included 51 species of fishes, 7 species of shrimps, 5 species of crabs, 3 species of cephalopods and 1 species of stomatopod. The study also compared average length of commercially important species obtained during the pre-monsoon and post-monsoon period with that of the Minimal Legal Size (MLS). Minimum legal Size (MLS) is seen as a fisheries management tool with the ability to protect juvenile fish, maintain spawning stocks and control the sizes of fish caught. The MLS sets the smallest size at which a particular species can be legally retained if caught. About 84% of the bycatch was observed to be juveniles during the study. From the total catch observed from the 27 trawlers, 72% of the catch was targeted catch and 28% was bycatch.

Keywords: Bycatch, discards, minimal legal size (MLS), trawlers

Received 16 July 2016; Revised 05 September 2017; Accepted 06 September 2017

**E-mail: madhucift@gmail.com*

Introduction

Bycatch and discards impact marine ecosystems and can affect the sustainable management of fisheries resources. Bycatch includes all non-target animals and non-living materials (debris) which are caught while fishing (Eayrs, 2007). Discarding is the practice of returning an unwanted portion of the catch to the sea during fishing operations (Alverson et al., 1994). Other than the non-targeted finfishes and invertebrates, bycatch involves threatened and protected species like sea turtles, sea birds and cetaceans (Pitcher and Cheung, 2013). Bycatch quantity varies according to season, area of fishing operation, type of fishery and type of fishing gears. Different types of bycatch reduction technologies have been developed fishing industry around the world, in order to minimise the impact of fishing on non-target resources (Boopendranath, 2010).

Alverson et al., 1994 estimated the total discards during the period 1980-1990 as between 17.9-39.5 million tonnes. In 1998, FAO estimated a global discard level of 20 million tonnes (FAO, 1999). Globally, shrimp trawling contributes to the highest level of discard/catch ratios of any fisheries. In the year 1992 Andrew and Pepperell estimated total global discards of 16.7 million tonnes bycatch from shrimp fisheries alone. Average annual global discards, has been re-estimated to be 7.3 million tonnes by Kelleher (2004).

India has a catchable annual fisheries potential yield of 4.41 million tonnes (CMFRI 2013). Marine fish production of India which was only 0.5 million tonnes in 1950, increased to 3.59 million tonnes in 2014. The first estimation of the quantity of bycatch associated with shrimp trawling by the Central Marine Fisheries Research Institute (CMFRI), Cochin in 1979 showed that 79.18% (3 15 902 tonnes) of the total landings was represented as bycatch; the percentage of bycatch was maximum in Gujarat (92.58), followed by Tamil Nadu (91.04) and

Pondicherry (86.52). In India, the bycatch landed at fishing harbours are utilized mainly for the production of manure and animal feed (Biju Kumar & Deepthi, 2006). Kelleher (2004) estimated total bycatch discards in Indian fisheries at 58 000 tonnes, which formed about 2% of the total landings. In Indian scenario, it is estimated that about 56.3% of the total catch of shrimp trawlers is bycatch (Pramod, 2010).

Kerala with a coastline of 590 km and a continental shelf area of 39 139 sq km is ranked third among the maritime states of India, with a total marine landings of 0.57 million tonnes during 2014 (CMFRI, 2015). Marine fishing fleet in Kerala consists of 4 722 (21.7%) mechanized, 11 175 (51.3%) motorized and 5 884 (27.0%) non-motorized fishing vessels (CMFRI, 2012). Trawling is the most widespread method of capturing marine fish and invertebrates in Kerala. About 3 678 trawlers operate from Kerala coast (CMFRI, 2012). According to Pillai et al. (2009) the deep-sea shrimp trawling operations often generate huge proportion of fish discards which ranges from 20-40% and sometimes exceed more than 80%. Kurup et al. (2003) reported that incessant trawling operations in the coastal habitats resulted in destruction of non-target groups along with the juveniles and sub adults of commercially important fishes, shell fishes and a wide spectrum of benthic organisms. Shanis et al. (2014) have reported that in deep sea fishery operations in Kerala coast, all the bycatch fish are dumped in to the sea except for the sharks and some finfishes. The positive effect of monsoon trawl ban had been reported by Kurup (2010).

The study on constituents of bycatch helps in improving the knowledge regarding the biodiversity of the region and is an important input for fisheries management. The present study was aimed to quantify the proportion of bycatch and to characterize the bycatch generated by commercial trawlers operating along Central Kerala.

Materials and Methods

Data on fish catch were collected from trawlers operating from three major fishing harbours in Central Kerala viz; Cochin fishing harbour, Kalamukku fish landing center and Munambam fishing harbors of Ernakulum district, according to a pre-fixed sampling schedule during the period from 2013 to 2015. Details regarding depth, fishing ground, type of gear used; total catch and total bycatch obtained in the vessel were collected from the vessel operators using structured questionnaires prepared for the purpose.

Samples were collected randomly from trawlers to quantify and characterize the bycatch. Sampling was not possible from 15th June to 31st July because of monsoon fishing ban during this period. A portion of bycatch was collected and stored in icebox and brought for analysis. The length and weight of different species were observed and recorded. The catch were identified upto species level with the help of Fish Base World Wide Web Database (Froese & Pauly, 2013), FAO Species Identification sheets for fishery purposes, Western Indian Ocean Fishing Area 51 and Smiths sea fishes (Margaret M. Smith and Philip C. Heemstra). Month wise and seasonal variations in the bycatch were analysed. Average length of each species in the bycatch were compared with the minimal legal size (MLS) to identify the percentage of juvenile incidence.

Results and Discussion

During the period of study, 67 species from 25 families were encountered in the trawl bycatch, along Central Kerala. The catch included 51 species of fishes, 7 species of shrimps, 5 species of crabs, 3 species of cephalopods. All other species of molluscan shells, gastropods, echinoderms, jelly fishes and stomatopods were categorised as miscellaneous. The species which occurred in the trawl bycatch are listed in Table 1.

Minimum legal Size (MLS) is seen as a fisheries management tool with the ability to protect juvenile fish, maintain spawning stocks and control the sizes of fish caught. The MLS sets the smallest size at which a particular species can be legally retained if caught. MLS could be used to protect immature fish ensuring that enough fish survive to grow and spawn, control the numbers and sizes of fish landed, maximize marketing and economic benefits and promote the aesthetic values of fish (CMFRI, 2014). The study in case of average length of commercially important species in the pre-monsoon and post monsoon during three consecutive years (2013-2015) was compared with that of the Minimal Legal Size (MLS).

Marine fish landing in Kerala during 2014 is estimated at 0.576 million tonnes registering a decline of 95 000 tonnes i.e., 15% compared to 0.671

Table 1. Constituents of bycatch

Sl.No.	Scientific Name	Common Name
	Clupeidae	
1.	*Sardinella gibbosa* (Bleeker, 1849)	Goldstripe sardinella
2.	*Sardinella longiceps* (Valenciennes, 1847)	Oil Sardine
3.	*Anodontostoma chacunda* (Hamilton, 1822)	Chacunda gizzard shad
4.	*Dussumieria acuta* (Valenciennes, 1847)	Rainbow sardine
5.	*Escualosa thoracata* (Valenciennes, 1847)	Whitesardine
6.	*Opisthopterus tardoore* (Cuvier, 1829)	Tardoore
	Engraulidae	
7.	*Stolephorus commersonnii* (Lacepede, 1803)	Commerson's anchovy
8.	*Stolephorus indicus* (Van Hasselt, 1823)	Indian anchovy
9.	*Stolephorus insularis* (Hardenberg, 1933)	Hardenberg's anchovy
10.	*Stolephorus waitei* (Jordan & Seale, 1926)	Spotty- face anchovy
11.	*Thryssa dussumieri* (Valenciennes, 1848)	Dussumier's thryssa
12.	*Thryssa malabarica* (Bloch, 1795)	Malabar thryssa
13.	*Thryssa mystax* (Bloch & Schneider, 1801)	Moustached thryssa
	Serranidae	
14.	*Epinephelus diacanthus* (Valenciennes, 1828)	Spinycheek grouper
	Nemipteridae	
15.	*Nemipterus japonicus* (Bloch, 1791)	Japanese threadfin bream
	Teraponidae	
16.	*Terapon jarbua* (Forsskal, 1775)	Tiger perch
	Platycephalidae	
17.	*Platycephalus scaber* (Linnaeus, 1758)	Thornscale flathead
	Synodontidae	
18.	*Saurida tumbil* (Bloch, 1795)	Greater lizard fish
	Scombridae	
19.	*Rastrelliger kanagurta* (Cuvier, 1816)	Indian mackerel
20.	*Scomberomorus commerson* (Lacepede, 1800)	Narrow-barred Spanish mackerel
21.	*Scomberomorus guttatus* (Bloch & Schneider, 1801)	Indo-Pacific king mackerel
22.	*Scomberomorus lineolatus* (Cuvier, 1829)	Streaked seerfish
	Menidae	
23.	*Mene maculata* (Bloch & Schneider, 1801)	Moon fish
	Hemiramphidae	
24.	*Hyporhamphus limbatus* (Valenciennes, 1847)	Congaturi halfbeak
	Ambassidae	
25.	*Ambassis gymnocephalus* (Lacepede, 1802)	Bald Glassy Perchlet
	Sciaenidae	
26.	*Johnius dussumieri* (Cuvier, 1830)	Sin croaker
27.	*Johnius belangerii* (Cuvier, 1830)	Belanger's croaker
28.	*Johnius carutta* (Bloch, 1794)	Karut croaker
29.	*Otolithes cuvieri* (Trewavas, 1974)	Lesser tigertooth croaker
30.	*Otolithes ruber* (Bloch & Schneider, 1801)	Tiger-toothed croaker
31.	*Kathala axillaris* (Cuvier, 1830)	Kathala croaker
	Cynoglossidae	
32.	*Cynoglossus bilineatus* (Lacepede, 1802)	Fourlined tongue sole
33.	*Cynoglossus macrostomus* (Norman, 1928)	Malabar tongue sole

	Chlorophthalmidae	
34.	*Chlorophthalmus punctatus* (Gilchrist, 1904)	Spotted green eye
	Leiognathidae	
35.	*Secutor insidiator* (Bloch, 1787)	Pugnose ponyfish
36.	*Secutor ruconius* (Hamilton, 1822)	Deep Pugnose ponyfish
37.	*Leiognathus splendens* (Cuvier, 1829)	Splendid ponyfish
38.	*Leiognathus bindus* (Valenciennes,1835)	Orangefin ponyfish
39.	*Leiognathus dussumieri* (Valenciennes, 1835)	Dussumier's ponyfish
	Stromateidae	
40.	*Pampus argenteus* (Euphrasen, 1788)	Silver pomfret
	Carangidae	
41.	*Alepes djedaba* (Forsskal, 1775)	Shrimp scad
42.	*Scomberoides lysan* (Forsskal, 1775)	Doublespotted queenfish
43.	*Parastromateus niger* (Bloch, 1795)	Black pomfret
44.	*Megalaspis cordyla* (Linnaeus, 1758)	Torpedo scad
45.	*Decapterus russelli* (Ruppell, 1830)	Indian scad
46.	*Atule mate* (Cuvier, 1833)	Yellowtail scad
47.	*Caranx ignobilis* (Forsskal, 1775)	Giant trevally
48.	*Alepes kleinii* (Bloch, 1793)	Razorbelly scad
	Trichiuridae	
49.	*Trichiurus lepturus* (Linnaeus, 1758)	Largehead hairtail
	Squillidae	
50.	*Squilla* sp.	Squilla
	Tetraodontidae	
51.	*Lagocephalus spadiceus* (Richardson, 1845)	Brown backed toadfish
52.	*Lagocephalus inermis* (Temminck& Schlegel, 1850)	Smooth blaasop
	Penaeidae	
53.	*Fenneropenaeus indicus* (H. Milne Edwards, 1837)	Indian white shrimp
54.	*Penaeus monodon* (Fabricus, 1798)	Giant tiger prawn
55.	*Metapenaeus affinis* (H. Milne Edwards, 1837)	Jinga shrimp
56.	*Metapenaeus dobsoni* (Miers, 1878)	Kadal shrimp
57.	*Metapenaeus monoceros* (Fabricius, 1798)	Speckled shrimp
58.	*Parapenaeopsis stylifera* (H Milne Edwards, 1837)	Kiddi shrimp
59.	*Parapenaeopsis coromandelica* (Alcock, 1906)	Coramandel shrimp
	Portunidae	
60.	*Charybdis feriatus* (Linnaeus, 1758)	Cross crab
61.	*Charybdis lucifeara* (Fabricius, 1798)	Swimming brachyuran
62.	*Portunus pelagicus* (Linnaeus, 1766)	Bluegreen crab
63.	*Portunus sanguinolentus* (Herbst, 1783)	Three spot crab
64.	*Scylla serrata* (Forskal, 1775)	Mud crab
	Sepidae	
65.	*Sepia pharaonis* (Ehrenberg, 1831)	Pharaoh cuttlefish
	Loliginidae	
66.	*Uroteuthis duvaucelli* (d'Orbigny, 1835)	Indian squid
	Octopodidae	
67.	*Octopus vulgaris* (Cuvier, 1797)	Common octopus

The study in case of average length of commercially important species in the pre-monsoon and post monsoon during the three consecutive years (2013-2015) were been compared with that of the Minimal Legal Size (MLS) stipulated by Government of Kerala (CMFRI, 2014).

million tonnes landed during 2013. Pelagic finfish production in the region decreased to 3.91 lakh tonnes from 0.49 million tonnes in 2013 because of the reduction in oil sardine landings compared to 2013 (CMFRI, 2015). The MLS recommended for oil sardine (*Sardinella longiceps*) is 10 cm total length (TL) and during the study, the mean length obtained in pre and post monsoon was 14.3 and 16 cm respectively and the species was above the prescribed MLS. The mean total lengths observed for *Nemipterus japonicus* were 10.2 and 10 cm during pre and post monsoon respectively and the prescribed MLS is 17 cm. Indian mackerel (*Rastrelliger kanangurta*) showed mean total lengths of 12.5 and 18.2 cm for the pre monsoon and post monsoon and the MLS is 14 cm. *Epinephelus diacanthus* was not observed during pre-monsoon but the mean total length observed during post monsoon was about 10.3 cm which is below the prescribed MLS (18 cm).

Scomberomorus commerson, during the pre-monsoon had an average fork length of 10 cm and the MLS recommended is a fork length of 50 cm. *Scomberomorus guttatus* showed a mean fork length of 12.1 cm during the post-monsoon season and the legal size was 37 cm. The mean total length obtained for *Johnius carutta* during pre and post monsoon periods were 10.1 and 5.4 respectively and the MLS for this species is 15 cm. *Johnius belanerii* caught during the pre-monsoon period reported a mean

Table 2. Comparison of average length of species with that of MLS

Sl.No.	Species	Average Length (cm)		MLS (cm)
		Pre Monsoon	Post Monsoon	
1.	*Sardinella longiceps*	12.0	14.5	10 TL
2.	*Epinephelus diacanthus*	-	10.3	18 TL
3.	*Nemipterus japonicus*	10.2	10	12 TL
4.	*Saurida tumbil*	9.7	-	17 TL
5.	*Rastrelliger kanagurta*	12.5	18.2	14 TL
6.	*Scomberomorus commerson*	10	-	50 FL
7.	*Scomberomorus guttatus*	-	12.1	37 FL
8.	*Johnius carutta*	10.1	5.4	15 TL
9.	*Johnius belangerii*	8.1	-	14 TL
10.	*Otolithes cuvieri*	6.5	10.5	16 TL
11.	*Otolithes ruber*	13.9	5.4	17 TL
12.	*Cynoglossus macrostomus*	7.3	5.1	9 TL
13.	*Pampus argenteus*	9.1	-	13 TL
14.	*Megalaspis cordyla*	14.7	17.5	19 TL
15.	*Decapterus russelli*	11.6	9	11 TL
16.	*Trichiurus lepturus*	23.2	35	46 TL
17.	*Metapenaeus affinis*	9	-	9 TL
18.	*Metapenaeus dobsoni*	6.5	8	6 TL
19.	*Metapenaeus monoceros*	-	6.9	11 TL
20.	*Parapenaeopsis stylifera*	4.9	8.5	7 TL
21.	*Charybdis feriatus*	3.4	4.3	5 CW
22.	*Portunus pelagicus*	4.3	4.4	9 CW
23.	*Portunus sanguinolentus*	6.6	11.5	7 CW
24.	*Sepia pharaonis*	4.6	5.5	11 DML
25.	*Uroteuthis duvaucelli*	8.5	3.5	8 DML

TL = Total Length, FL = Fork Length, CW = Carapace Width of crabs, DML = Dorsal Mantle Length in the case of cephalopods

total length of 8.1 cm and the recommended legal size is 14 cm. *Otolithus ruber* had mean total length of 13.9 and 5.4 during the pre and post monsoon season respectively and prescribed MLS is 17 cm. *Cynoglossus macrostomus* had a mean total length of 7.3 and 5.1 cm during the pre and post monsoon period respectively and the MLS for this species is 9 cm. *Pampus argenteus* was seen during the pre-monsoon period with a mean total length of 9.1 cm which did not meet the recommended size of 13 cm. The mean total length of *Megalaspis cordyla* during the pre and post monsoon period were 14.7 and 17.5 respectively and the recommended size is 19 cm. *Decapterus russelli* showed mean total length of 11.6 and 9 cm for pre and post monsoon and MLS is 11 cm. *Trichiurus lepturus* showed mean total length of 23.2 and 35 cm for the pre and post monsoon seasons and the MLS is about 46 cm.

The prawn species *Metapenaeus affinis* showed a mean total length of 9 cm and the recommended legal size is about 9 cm which was satisfactory. *Metapenaeus dobsoni* showed mean total length of 6.5 and 8 cm during the pre and the post-monsoon period respectively and the MLS is 6 cm. *Metapenaeus monoceros* during the post monsoon period was having a mean total length of 6.9 cm and the MLS is 11 cm. *Parapeneopsis stylifera* had mean total length of 4.9 and 8.5 for the pre and post monsoon period respectively and the recommended size is 7 cm. The crab species *Charybdis feriatus* had a mean carapace width of 3.4 and 4.3 cm respectively and the MLS was 5 cm. *Portunus pelagicus* showed a mean carapace width of 4.3 and 4.4 cm for the pre and post monsoon period and the MLS is 9 cm. *Portunus sanguinolentus* showed mean carapace widths of 6.6 and 11.5 for the pre and post monsoon period and the MLS is 7 cm. Mean dorsal mantle lengths showed by *Sepia pharaonis* were 4.6 and 5.5 for the pre and post monsoon respectively and the MLS is 11 cm. *Photololigo duvacelli* showed mean dorsal mantle lengths of 8.5 and 3.5 for the pre and post monsoon period and the MLS is 8 cm. The comparison of the mean length of commercially important species during the pre-monsoon and post monsoon with that of the Minimal Legal Size is shown in Fig. 1. Gibinkumar et al (2012) has identified 281 species including juveniles of commercially important fishes and shellfishes from the shrimp trawl bycatch along the Cochin region.

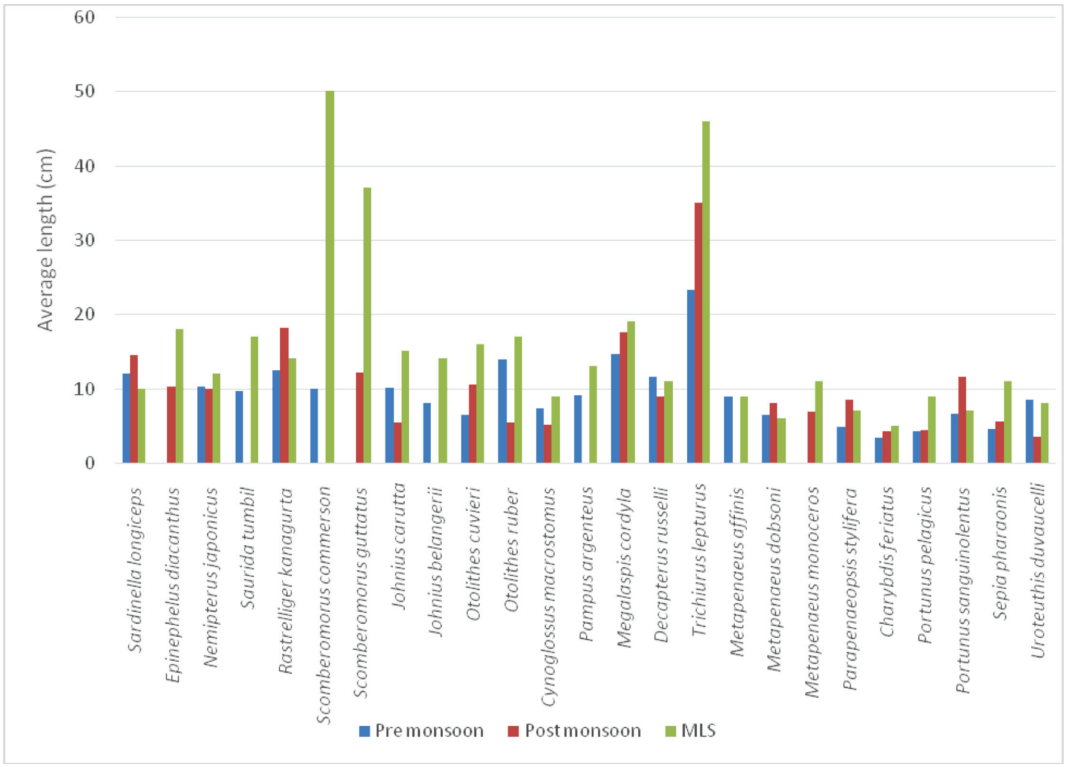

Fig. 1. Comparison of average length of commercially important species in the bycatch with that of MLS

Out of 16 440 kg was observed from 27 trawlers in which 72% (11 810 kg) was targeted catch and 28% (4 630 kg) was bycatch. The mean weights of the bycatch obtained for the pre-monsoon period (Jan-May) during 2013, 2014 and 2015 were 22.5, 95 and 130 kg respectively. The mean weight obtained during 2014 and 2015 in the post monsoon period (June-Dec) were 232 and 460 kg respectively.

The monthly variation of the bycatch during two consecutive years from 2014 to 2015 were compared. During 2014 period, the highest catches was observed during September (2200 kg) in which the bycatch constituted 490 kg. The lowest catch observed during the same year was during the month of January which was a lean season with a total catch of about 230 kg and bycatch of 50kg of fishes. During 2015 the, the highest catch was observed during December (2100 kg) and the bycatch recorded was 600 kg. The lowest catch was observed during the month of February in which the total catch observed was about 200 kg and the bycatch was about 100 kg.

It was observed from the study that more than 76% of the fish caught were below the stipulated MLS. Among the 25 species studied, 19 had lengths lower than MLS. Increasing the size at capture can be

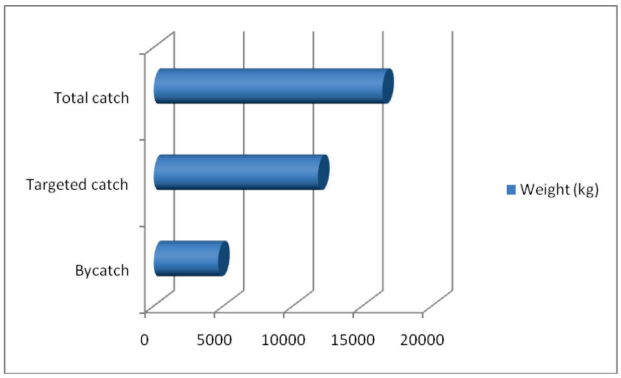

Fig. 2. Total weight of fishes observed in the selected trawlers during 2013-2015

attained by using different gear based technical measures. A large number of studies involving square mesh codend and grids have been carried out along the Indian coast. All these studies show significant improvements in the L50 values. So effective implementation of gear based measures in addition to other provisions in the fisheries regulation act will help in sustaining the trawl resources.

Acknowledgements

The authors would like to express their sincere thanks to NASF for providing financial assistance to

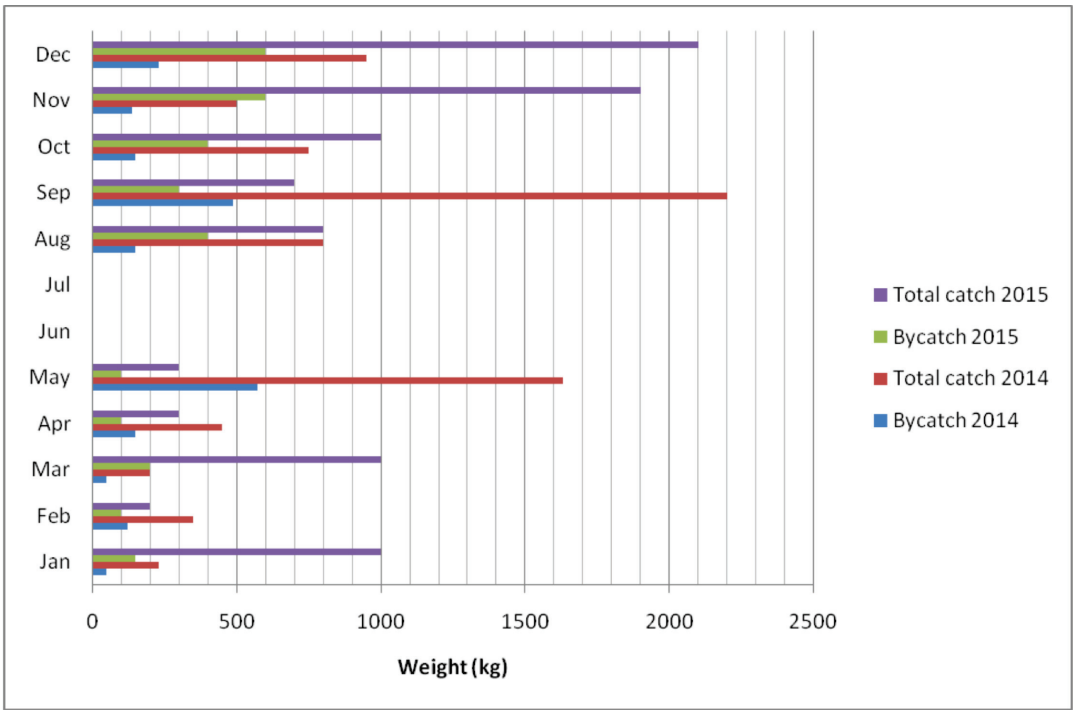

Fig. 3. Monthly variation in the trawl bycatch of selected trawlers during 2014 and 2015

the GFSTS project. Acknowledgements are also due to the Director, ICAR-Central Institute of Fisheries Technology, Cochin, for providing facilities to carry out this study.

Reference

Alverson, D. L., Freebag, M. H., Murawski, S. A. and Pope, J. G. (1994) A global assessment of fisheries by-catch and discards. FAO Fish. Tech. Pap. No. 339, 233 p

Andrew, N. L. and Pepperell, J. G. (1992) The by-catch of shrimp trawl fisheries. Oceanogr. Mar. Biol. Annu. Rev. 30: 527-565

Biju Kumar, A. and Deepthi, G. R. (2006) Trawling and by-catch: Implications on marine ecosystem. Curr. Sci. 90(7)

Boopendranath, M. R. (2013) Biodiversity conservation technologies in fisheries, J. Aquat. Biol. Fish. 1 (1 & 2): 10-22

Boopendranath, M. R. (2010) Bycatch Reduction Technologies, Coastal Fishery Resources of India Conservation and Sustainable Utilisation, Society of Fisheries Technologists (India), Cochin, pp 269-295

CMFRI (2012) Marine fisheries census 2010 Part-I India, Department of Animal Husbandry, Dairying & Fisheries and Central Marine Fisheries Research Institute, Cochin, 98 p

CMFRI (2013a) Annual Report 2012-2013. Central Marine Fisheries Research Institute, Cochin, 200 p

CMFRI (2013b) Estimated Marine Fish Landings in India. Central Marine Fisheries Research Institute, Cochin. http://www.cmfri.org.in/annualdata.html

CMFRI (2015) Annual Report 2014-2015. Central Marine Fisheries Research Institute, Cochin

Eayrs, S. (2005) A Guide to Bycatch Reduction in Tropical Shrimp-Trawl Fisheries, FAO, Rome, 110 p

Froese, R. and Pauly, D. (2007) Fish Base. World Wide Web electronic publication. www.fishbase.org. version (09/2007)

Gibinkumar, T. R., Sabu, S., Pravin P. and Boopendranath M. R. (2012) Bycatch characterization of shrimp trawl landings off South west coast of India. Fish. Tech. 49(2012): 132-140

Kelleher, K. (2004) Discards In The World's Fisheries Marine - An Update. FAO Fisheries Technical Paper 470. FAO, Rome, 131 p

Kurup, B. M., Premlal, P., Thomas, J. V. and Anand, V. (2003) Bottom trawl discards along Kerala coast : A case study, J. Mar. Biol. Ass. India. 45(1): 99-107

Kurup, B. M. (2010) Monsoon Trawl Ban and Conservation of Coastal fisheries of Kerala, Coastal Fishery Resources of India Conservation and Sustainable Utilisation, pp 246-268

Pillai, N. G. K., Bineesh, K. K., Manju, S., Akhilesh, K. V. (2009) Lantern fishes (Myctophids): by-catch of deep-sea shrimp trawlers operated off Kollam, south-west coast of India. Mar. Fish. Infor. Serv. T&E Ser. 202: 1-4

Shanis, R. C. P., Shyam S. Salim, Hashim, M. U., Ganga, Manjusha, U. and Pillai, N. G. K. (2014) Deep-sea shrimp fishery operations in Kerala coast: Problems and Prospects. Int. J. Fish. Aquat. Stud. 1(6): 237-242

Sunil Mohamed, K., Zacharia, P. U., Maheswarudu, G., Sathianandan, T. V., Abdussamad, E. M., Ganga, U., Lakshmi Pillai, S., Sobhana, K. S., Rekha J. Nair, Josileen Jose, Rekha, D. Chakraborty, Kizhakudan, S. and Najmudeen, T. M. (2014) Minimum Legal Size (MLS) of capture to avoid growth overfishing of commercially exploited fish and shell fish species of Kerala. Mar. Fish. Infor. Serv. T & E Ser., No.220

Pitcher, T. J. and William, W. L. C. (2013) Fisheries: Hope or despair? Mar. Poll. Bull. (Article in Press)