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Spatio-temporal analysis and impact assessment of trawl bycatch of Karnataka to suggest operation based fishery management options

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ABSTRACT

The term 'trawl bycatch' is losing significance from commercial view point, since every fish landed is in demand. However, from the resource conservation and fishery sustainability point of view, the magnitude of resource damage caused by trawl bycatch is alarming. At Mangalore Fisheries Harbour, it was estimated that, in 2008-2009, single day operating trawlers (SDT) landed 3,515 t of fishes, out of which only 2,246 t (64%) were landed for edible purpose and the rest was rated as low value bycatch (LVB) used for miscellaneous purposes. Multiday trawlers (MDT) landed an estimated 2,20,678 t of fishes of which 1,83,145 t was retained for commercial purpose and 37,533 t (17%) was discarded. Of the retained fish, 1,67,810 t were marketed for edible use and 15,335 t (7% of the catch and 9% of the landings) was marketed as "low value bycatch" (LVB) mainly for fish meal production. Low value bycatch landed in Mangalore increased from 3% in 2008 to 17% in 2009, but the discards showed a reduction from 23 to 18%. From the discarded catch, 116 species of finfishes, 31 species of gastropods, 4 species of bivalves, 7 species of cephalopods, 13 species of shrimps, 3 species of stomatopods, 21 species of crabs, 3 species of lobsters and juveniles of unidentified sharks and rays were recorded. Juveniles of commercially important species formed 34% of the trawl discards by weight (44% by number). An estimated 2,733 t (464 million in number) of *Platycephalus* juveniles and 1341 t (333 million in number) of *Nemipterus randalli* were discarded by MDT operated from Mangalore during 2008-2009. Spatio-temporal analysis of bycatch data from fishing grounds off Karnataka revealed that the grounds trawled during the month of August 2009 had high discard rate in terms of quantity discarded (biomass loss) and operations during March 2008 had the highest loss of biota (biodiversity loss) in terms of number of species. The paper advocates bycatch management through effort reduction in areas and during months of high dominance of bycatch.

Keywords: Bycatch, Discards, Juvenile exploitation, Management, Resource mapping, Sustainability

Introduction

Trawling is one of the most efficient methods of catching fish world over and is also the most important human intervention causing physical disturbance to the world's continental shelves, and consequently, the physical destruction of ecosystems (Jennings and Kaiser, 1998). Trawling is targeted at specific groups of organisms, and trawl net being a non-selective gear, catches everything available in its towing path. In general non-targeted, non-commercial species in the bycatch will be thrown overboard, a practice called discarding (Van Beek, 1998). Intensity of trawl fishing has a vicious impact on benthic ecology and biodiversity (Dayton *et al.*, 1995) and the biological and economic loss due to discarding is one of the important issues fishery managers have to tackle (Kelleher, 2005). Discarded species not only include non-commercial species, but several other commercial species that are below minimum landing size (MLS) or are less profitable owing to market conditions and quota restrictions (Catchpole *et al*., 2005). Resource damage due to discarding the bycatch has been taken seriously by international bodies like FAO and in the past decade, a decline in global discards has been observed in the major world fisheries due to fall in catches, greater utilisation for human consumption and the progressive attitude by fisheries managers, user groups, and society towards the need to resolve the bycatch problem (FAO, 2004).

In Karnataka, bottom trawling was first introduced by the Japanese trawler *M.S. Kaiko Maru* in 1961. During 1963-67, vessels of Indo-Norwegian Project conducted systematic exploitation of fishing grounds. Initially trawlers operated 10-15 km offshore, but later shifted to shallow waters which promised good catch (Kurup *et al*., 1987). The target species of trawlers in Karnataka were high valued prawns, squids, cuttlefish, threadfin breams and ribbonfish. Most of the bycatch are brought to the landing centre by single-day trawlers (SDT) whereas onboard discarding is done by multiday trawlers (MDT) where the bycatch obtained in the first few days is thrown back into the sea (Zacharia *et al*., 2006). During 1980-81 and 1981-82, the annual bycatch in trawl fishery of Karnataka was estimated as 85% of the total trawl catch, stomatopods being the major constituent (Kurup *et al*., 1987). Reasons for discarding the fishes were studied by several workers (Saila, 1983; Northridge, 1991; Murawski, 1993; Jennings and Kaiser, 1998).

In the present fishing scenario, the term trawl bycatch has lost its original meaning and significance because the MDT carry different types of nets to target different resources during a single voyage. The same species is treated as target or bycatch according to its comparative economical significance during the course of fishing. In multiday operations, bycatch of the last two days are generally brought to the shore and those caught earlier are discarded. Boopendranath (2007) has discussed the terminologies used such as gross catch, bycatch, discarded bycatch and retained bycatch. Costa *et al*. (2008) also illustratively classified these terminologies to avoid further confusion. FAO (2010) has given the diagrammatic presentation of catch concept of global marine fisheries. From commercial point of view, trawl bycatch is losing significance since every fish landed is in demand and the fishermen are encouraged to utilise more catch, not for edible purposes alone. In many instances the value realised for LVB is more than that realised for low value edible catch and this is causing serious threat to food security. Discards during fishing operations represent a significant proportion of global marine catch which are generally considered to constitute a waste or suboptimal use of fishery resources (Chandrapal, 2005). From resource conservation and fishery sustainability point of view, the magnitude of resource damage happening by trawl bycatch is increasing in alarming proportions (Biju Kumar and Deepthi, 2006). In the present study, data on bycatch in trawl was analysed quantitatively and qualitatively, incorporating its spatial reference. The study also attempts the application of GIS software to provide a visual projection of spatio-temporal marine fishery resource distribution with special reference to bycatch, which will help to understand the extent of resource damage due to discards in different fishing grounds in different months of operation. The results can serve as a tool for suggesting operation based discard reduction options in trawl fisheries.

Materials and methods

Fish landing data were collected from trawl landings at Mangalore Fisheries Harbour during 2008-2009. Collection schedule was twice a week with 8 observations per month. The catch was recorded as those landed for "edible use" and the rest landed as low value bycatch or "trash". Monthly estimates of catch, effort and species composition of commercial catch and trash was prepared based on these data (Srinath *et al*., 2005). For understanding the overall trend in trawl fishery of Karnataka, catch and effort data from the database of the Central Marine Fisheries Research Institute (CMFRI) for the period 1996-2009 was also used. Data on onboard catch, bycatch and discard were collected from a commercial trawler which operated from Mangalore during 2008-2009 on daily basis for 483 trawling days. The wooden trawler (15.8 m in LOA; 160 hp) was engaged in multiday trawling with a trip duration of 8 to 13 days. Generally the trawler took one day break for unloading and ice filling between the cruises. The trawler generally carried three types of trawl nets, with about 10 different codend pieces to change the codend of the trawl net according to the availability of resources. Except during the trawl ban period (June-July), continuous data were collected. Onboard information collected and recorded were: cruise no., date, depth of shooting, time of shooting, shooting longitude, shooting latitude, hauling depth, hauling time, hauling latitude, hauling longitude, net type, mesh size, total catch (kg), total discard (kg) and number of hauls per day. Along with fishing information, an unsorted portion of discarded catch was collected as sample with token number representing each haul. The spatial data thus collected were used as inputs for the GIS study as described by Graham *et al.* (2002). The discard samples were preserved in ice and stored in fish-hold and brought to the laboratory in as fresh condition as possible to identify the fishes to species level. Qualitative and quantitative analysis of the samples were carried out in the laboratory. Weight of the sample was recorded and the species present in the sample were sorted out. The number, length and weight of individual fishes in each group were recorded. The number was raised to number of fishes in each haul and then raised to the day's catch. Similar raising was also done in the case of commercial fishes also. These data were fed to MS Access files. Number, size and individual weight of the species in the sample were recorded to get a picture of life stages of the species, especially juvenile, sub-adult and adult stages. For spatio-temporal distribution mapping and smooth handling of data, two softwares *viz*., the ArcGIS and Visual Basic 6 were used. Visual Basic is populated with data of commercial catch and discards, which comprises geographic coordinates, water depths, net types, commercial fish, discard species *etc*. Thematic shape files/feature classes were prepared by sending queries into these tables.

In this paper, we have used the following terms and definitions, after Costa *et al*. (2008): *total catch* is the quantity of all species brought onboard, *landed catch* is the part of the total catch that has economic value (*i.e*., the quantity of commercial fish for edible use and low values species for non-edible purpose), *total bycatch* is the portion of the total catch which includes all the species caught accidentally and landed as trash as well as discarded (non-target species). Total bycatch may be retained if it has commercial value (LVB) and/or discarded at sea if it is not used for any purpose (discarded bycatch). In order to simplify, the term "*discarded bycatch*" will be referred to as "*discard(s)*" throughout this paper.

Results

Trawl fishery of Karnataka

Along the Mangalore coast, two categories of bottom trawl units are in operation. The first category consists of small boats (<9.75 m OAL) conducting daily trips. The catch generally consists of prawns, flatfishes and other finfishes. The trawl net has a codend mesh size of 10-20 mm. The second category comprises medium sized boats (9.75-15.0 m OAL) making multiday fishing cruises. They carry various types of nets including 'fish-nets' with relatively larger codend meshes for targeting finfishes, and 'shrimp-nets' with codend mesh sizes of 15-18 mm targeting shrimps. The MDT have evolved into highly sophisticated vessels with an endurance of 15- 20 days and possess the latest electronic equipments like fish finders, sonars, GPS and radiotelephone. The fish hold capacity of MDT ranges from 5 to 40 t.

In Karnataka, during 1996-2009, on an average 1,20,000 single day trawler units operated annually with the effort ranging from 96,012 (2005) to 1,37,240 (2003). The number of fishing units and fishing hours operated showed a decreasing trend (Fig.1). The quantity of fish landed decreased from 26,708 t (1997) to 24,882 t (2004), with an average of 32,405 t. In the case of MDT, units operated remained more or less same throughout the period of observation (Fig. 2). The fishing units operated ranged from 22,836 (1998) to 31,795 (2008) with an average of 27, 678. But there was phenomenal increase in hours operated and the landings by MDT. The fishing duration was below 13 lakh hours in 1998 which has increased to more than 33 lakh hours in 2008. The catch increased from

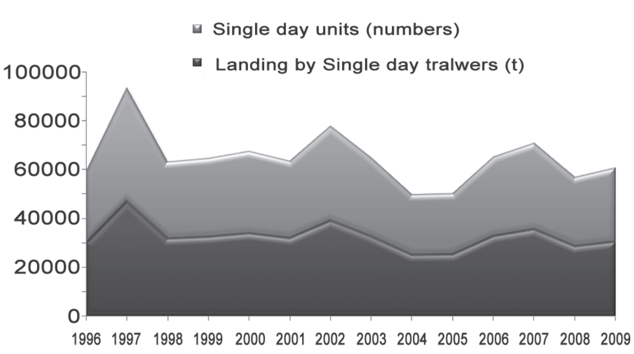

Fig. 1. Trends in trawl fishery from SDT operated in Karnataka during 1996-2009

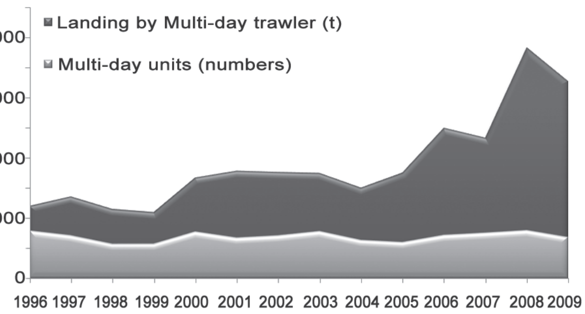

Fig. 2. Trawl fishery trends from MDT operated from Karnataka during 1996-2009

47,897 t (1996) to 1,53,117 t (2008). Even though there was a substantial increase in landing, similar increase was not reflected in the value realised from the fishery.

Extent of fishing operations by trawlers operated from Mangalore

Mangalore is the most important trawl landing centre in Karnataka and one of the most progressive fisheries harbour in the country. During 2008-2009 trawlers from Mangalore operated from seas off Calicut in the south (75° E, 11°N) to off Ratnagiri in the north (73.5° E to 17° N). The depth of operation was between 5 to 167 m (Fig. 3). During 2008-2009 period, most intensive trawling operations were conducted in fishing grounds at 30 m depth off Mangalore to Panaji, followed by fishing grounds at 100 m depth off Malpe to Karwar. Fishing grounds at 30 m depth off Ratnagiri were found to be fished with moderate

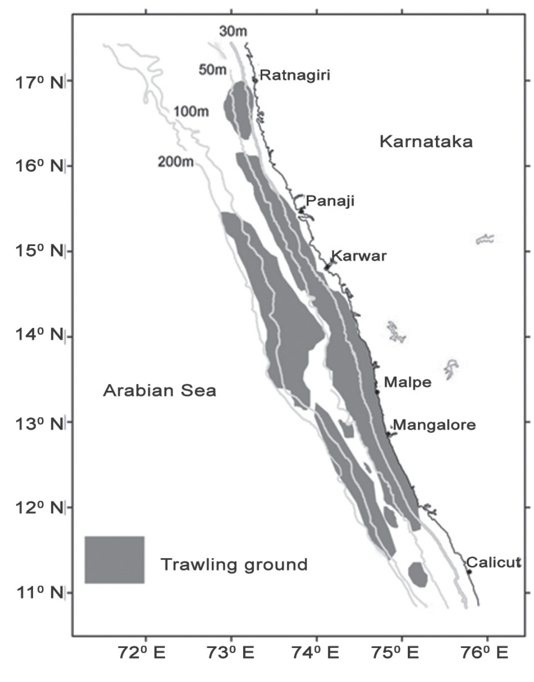

Fig. 3. Extent of fishing grounds covered by trawlers from Mangalore during 2008-2009

intensity. The present study reveals that most of the fishing operations are concentrated within the 150 m depth zone and extension was mainly parallel to the shore, towards south or north.

Landings of commercial fishes and low value bycatch (trash) by single day trawlers (SDT)

Single day trawlers (SDT) generally operate in waters up to 30 m depth and the entire catch is brought to shore, which is separated as commercial catch and the rest as low valued bycatch termed as trash . The landing of SDT at Mangalore in 2008 was 1,946 t, of which 74% was of edible grade and 26% was LVB. In 2009, out of 1,568 t landed, the composition was 53% and 47% respectively (Fig. 4). A total of 123 species were identified from trash landing of SDT. Stomatopods were the major components of the trash forming 63% in 2008 and 43% in 2009. List of major species landed as trash is given in Table 1. Seasonal trends in landing of trash by single day operating trawlers showed that highest percentage of trash landing was observed in March (46%) in 2008 and in February (63%) in 2009.

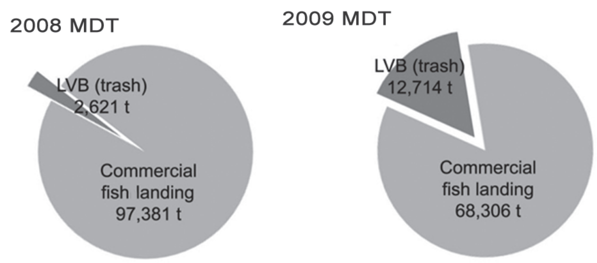

Fig. 4. Landings of commercial fishes and low valued bycatch (trash) by SDT

Table 1. List of major species and their percentage composition landed as trash by SDT

Species/Year	Percentage composition	
	2008	2009
Stomatopods	63.1	42.7
Gastropods	16.9	6.2
Crabs	5.3	15.5
Eel	3.7	2.7
Echinoderms	3.6	6.8
Sciaenids	2.3	1.4
Ribbonfish	0.9	1.9
Cephalopod juveniles	0.8	0.6
Anchovies	0.8	2.4
Leiognathus sp.	0.6	1.8
Prawns	0.5	2.2
Pufferfish	0.5	8
Bivalves	0.4	1
Flatfish	0.2	3.4
Thryssa sp.	0.1	3.3

Catch and bycatch in multiday trawlers (MDT)

In 2008, a total of 1,00,002 t of fishes were landed by MDT out of which 97,381 t (98%) were landed for edible purpose and rest was landed as trash. In 2009, landing reduced to 83,148 t out of which only 70,429 t (83%) were landed for edible purpose and the rest were landed as LVB (trash) (Fig. 5). Presently boats with high fish hold capacity bring the bycatch of all days for fish meal preparation. More than 300 species of fishes and shell fishes were identified from trawl landings of Mangalore and most life stages of many of the species were represented in LVB. Lizard fishes, pufferfishes, threadfin breams and flatheads are the major contributors to trash. In recent years, the percentage of oilsardine in the trash showed an increasing trend. The composition of major species of LVB from Mangalore Fisheries Harbour for 2008 and 2009 is given in Table 2.

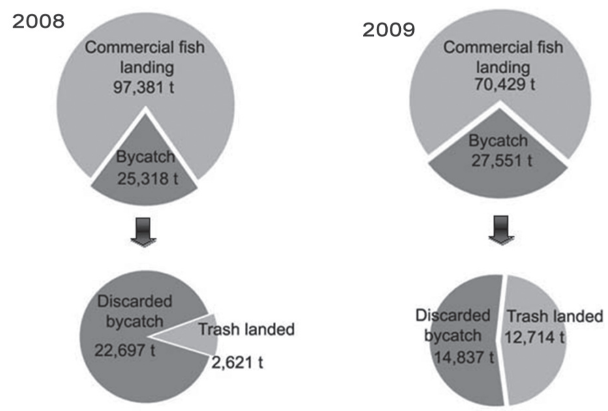

Fig. 5. Composition of commercial catch, low valued bycatch and discards from MDT at Mangalore Fisheries harbour during 2008-2009

In MDT, the catch was formed of high value fishes, LVB (trash) and a part of bycatch was discarded overboard (discards). In 2008, an average 23% of the MDT catch was discarded which means the catch from the fishing ground was 23% more than the landing and the total catch is thus estimated to be 1,22,699 t. In 2009, the estimated discard percentage was 19%. It was observed that while the percentage of discard was reduced, the landing of LVB increased substantially (Fig. 6).

Spatio-temporal studies on discards

The highest discard percentage was observed in June (46%) and August (44%) in 2008 and August (52%) and September (44%) in 2009. Lowest discard percentage of 9% and 1% was observed in March 2008 and April 2009 respectively. Average catch per haul was 271 kg in 2008 and average discard per haul was 80 kg. In 2009, average catch per haul was 183 kg and average discard per haul

Table 2. List of major species, quantity landed and their percentage composition landed as LVB (trash) by MDT at Mangalore Fisheries Harbor during 2008-2009.

Specie name/Year	2008		2009	
	Landing as LVB (t)	Percentage	Landing as LVB (t)	Percentage
Saurida spp.	330	12.6	1195	9.6
Lagocephalus inermis	294	11.2	1694	13.6
Nemipterus spp.	276	10.5	1414	11.4
Platycephalus spp.	215	8.2	390	3.1
Leiognathus spp.	194	7.4	921	7.4
Sardinella longiceps	173	6.6	959	7.7
Decapterus spp.	173	6.6	381	3.1
Dussumeria acuta	128	4.9	609	4.9
Trichiurus lepturus	84	3.2	578	4.6
Priacanthus spp.	81	3.1	265	2.1
Cynoglossus spp.	81	3.1	109	0.9
Lesser sardine	78	3.0	372	3.0
Anchovies spp.	60	2.3	160	1.3
Charybdis spp.	30	1.1	142	1.1
Epinephelus spp.	28	1.1	133	1.1
Prawns	5	0.2	237	1.9
Sepia spp.	5	0.2	181	1.5
Eel	3	0.1	200	1.6
Total trash landing	2,621		12,713	
Total fish landing (t)	1,00,002		83,142	

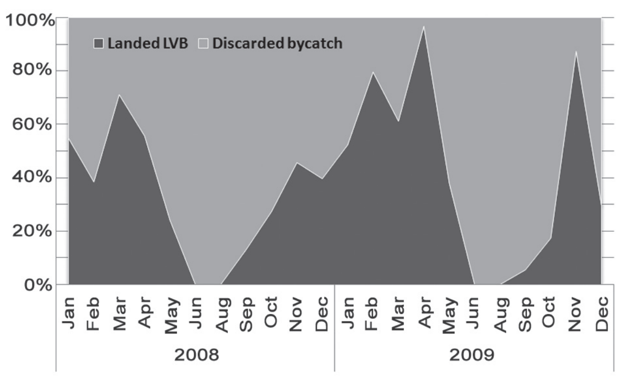

Fig. 6. Monthly trend of LVB (trash) discard ratio from MDT in Mangalore

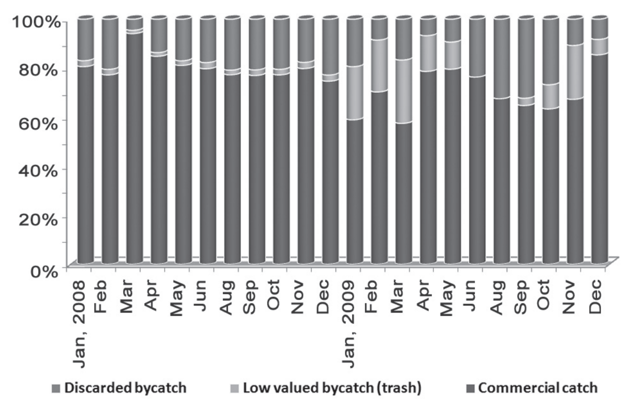

Fig. 7. Monthly variation in the contribution of commercial catch, low valued bycatch and discards from MDT at Mangalore Fisheries harbor during 2008-2009

was 44 kg (Table 3). Total estimated bycatch during 2008 and 2009 were 1,139 t and 741 t respectively and highest bycatch was recorded during September, 2008 (195 t). There was an inverse relation between trash and discards, *i.e.,* in the months of heavy discards the trash landing was negligible. In monsoon and post-monsoon months, due to the prevailing rainy condition, the demand of trash is less, which has resulted in high percentage of discards (Fig. 6). Annual composition of MDT catch during 2008-2009 in terms of commercial catch, LVB and discards is given in Fig. 7.

Composition of discarded bycatch

Analysis of *in situ* discard samples of 483 trawling days were carried out during 2008-2009 and 198 species were identified from discard samples. One hundred sixteen species of finfishes, 31 species of gastropods, 4 species of bivalves, 7 species of cephalopods, 13 species of shrimps, 3 species of stomatopods, 21 species of crabs, 3 species of lobsters and juveniles of unidentified sharks and rays were recorded.

Table 3. Monthly average catch rate, discard rate and retained catch (commercial catch +LVB) rate from MDT during 2008-2009

Month	Avg. catch per haul (kg)	Avg. discard per haul (kg)	Av. retained catch per haul (kg)
Jan, 2008	259	44	215.68
Feb	188	53	134.31
Mar	264	15	248.42
Apr	274	63	210.50
May	259	99	159.84
Jun	209	121	87.14
Jul	0	0	0
Aug	390	130	260.40
Sep	354	132	221.88
Oct	343	90	252.50
Nov	221	58	162.77
Dec	223	77	145.60
Average	271	80	191
Jan, 2009	165	37	128.15
Feb	154	8	146.34
Mar	196	40	156.22
Apr	148	1	147.28
May	287	34	253.80
Jun	205	64	141.00
Jul	0	0	0
Aug	223	107	116.61
Sep	191	96	94.89
Oct	172	86	86.08
Nov	157	3	154.34
Dec	116	11	105.04
Average	183	44	139

Utility of resource mapping in policy decisions on fishery

Resource exploitation maps for all the months were prepared and from these maps, highest discarding of fishery resources was observed during August 2009. During this month, area of operation was south of Mangalore between a depth of 56-150 m (Fig. 8). Major commercial catch from these grounds were squids, cuttlefishes and shrimps dominated by *Solenocera choprai*, threadfin breams, flatfishes, lizardfishes and whitefish. By temporal analysis (Table 3) it was observed that average retained catch per haul during the month was 117 kg. During the process of retaining these commercial resources, 69 species of fishes were discarded and the discarded bycatch per haul was 107 kg. Major species discarded (by number) were *Metapenaeus andamanensis* (10%) followed by *S. choprai* (9%). In terms of weight *Pterois russelii* (5%), *Pomacentrus* sp. (5%), *Parapercis* sp. (4%) and *Uranoscopus* sp. (4%) were dominant. Table 4 shows the details of species recorded, depth of occurrence, length range, percentage by weight and percentage by number of each species. By this analysis, the fishing grounds could be evaluated in terms of value realised for the retained catch and in terms of the resource damage due to discarding of juveniles of commercial fishes, and also by the destruction of non-commercial species of high ecological significance. For example, in case of shrimps, in August 2009 *M. andamanensis*, formed only 3% of the discards by weight but in terms of numbers it formed 10% of the discarded catch. In the case of *M. andamanensis,* the weight discarded per haul was about 3.32 kg, and with an average weight of 1.2 g, the number discarded was estimated to be more than 2,500 per haul. From sustainability point of view, loss in terms of number is more important than the weight, since discarded fishes were usually juveniles which form the backbone of the fishery for the future. Similar projections can be made for each discarded species. Such projections are essential to understand the impact of current fishing on the future fishery and also to take appropriate decisions on the effort reduction for sustainability.

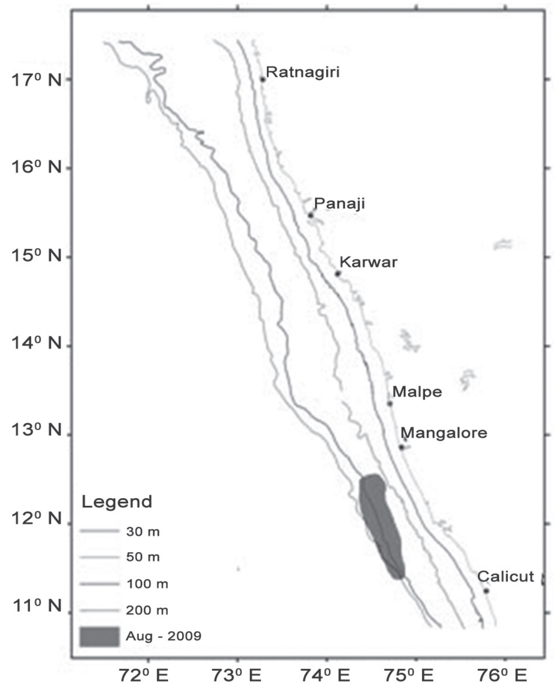

Fig. 8. Fishing ground and month from which highest quantity of discarded fishes from MDT was observed

In terms of biodiversity loss, the highest number of species were caught and discarded during March, 2008. Trawling was carried out in the depth range of 30 to 150 m and the fishing grounds covered were off Mangalore to off Goa (Fig. 9). During this month, resources landed were crabs, squids, pufferfishes, threadfin breams, lizardfishes, bullseye, shrimps, Indian mackerel, scads, ribbonfishes and anchovies with catch per haul of 248 kg. It is observed that 84 species were discarded during the month. Discard per

Table 4. The depth range of occurrence, size range, percentage composition in number and weight of discarded species during August, 2009

Species	Depth range (m)	Size range (mm)	Percentage by number	Percentage by weight
Metapenaeus andamanensis	60-90	23-89	10.3	3.1
Solenocera choprai	83-108	40-102	9.0	1.7
Pomacentrus sp.	65-86	38-75	7.7	4.5
Parapenaeus fissuroides	78-116	41-75	7.5	2.0
Trachypenaeus sp.	56-86	40-82	6.6	2.2
Parapercis sp.	56-135	45-150	6.4	4.3
Polynemus sp.	60-85	42-70	6.0	1.3
Charybdis riversandersoni	74-108	5-35	4.2	0.9
Nemipterus randalli	65-90	35-100	3.8	1.8
Pterois russelii	74-150	105-160	3.8	4.5
Apogon sp.	65-86	40-105	3.6	2.4
Saurida sp.	56-150	35-172	2.8	1.5
Pristipomoides sp.	135	95-132	2.6	2.6
Epinephelus diacanthus	65-58	52-155	1.7	2.8
Scarus sp.	150	170-190	1.7	3.1
Platycephalus sp.	60-150	25-92	1.4	1.1
Saurida tumbil	84	42-145	1.4	1.4
Psenopsis intermedia	65-120	48-120	1.3	2.2
Trachinocephalus myops	84-86	100-195	1.0	1.4
Charybdis smithii	80	40-60	0.9	2.9
Squid juveniles	78-90	15-80	0.9	1.3
Charybdis hoplites	90	15-30	0.9	0.1
Zebrias sp.	85	120-155	0.8	2.5
Psettodes erumei	81-108	68-120	0.7	1.0
Scorpaenodes sp.	78-150	14-129	0.7	0.8
Saurida undosquamis	85-108	95-175	0.7	1.3
Muraenesox sp.	65-108	154-405	0.6	1.3
Acanthocepola indica	85	146-291	0.6	1.8
Bothus sp.	83-150	115-180	0.6	1.3
Parascolopsis aspinosa	60-150	21-145	0.6	0.5
Conus	150	90	0.6	0.5
Muraenesox cinereus	150	310	0.6	0.7
Sepia trigonina	56-108	18-86	0.5	1.2
Fistularia petimba	78	280-290	0.4	1.5
Gobius sp.	65	63-87	0.4	0.4
Sepiella inermis	60	33-98	0.4	1.4
Doclea ovis	83-85	38-75	0.4	1.1
Lophiomus sp.	60-150	63-240	0.3	1.6
Strombus listeri	85-150	118-140	0.3	0.9
Osteogeneiosus militaris	85	120-135	0.3	1.9
Dactyloptena sp.	78-150	155-245	0.3	2.1
Apogon sp.	65-86	40-105	0.3	0.3
Cynoglossus sp.	56-108	43-108	0.3	0.2
Oratosquilla nepa	84-85	65-185	0.3	0.7
Uranoscopus sp.	56-108	39-194	0.3	4.2
Pseudorhombus sp.	56-85	72-129	0.2	0.3
Octopus membraneous	56-86	40-68	0.2	1.3
Calappa granulata	60-85	60-80	0.2	1.5
Gymnothorax sp.	78-90	240-300	0.2	0.7
Charybdis feriatus	86-	31	0.2	1.0
Drupa sp.	86	210	0.2	3.2
Balistes sp.	78-83	185-195	0.2	2.6
Glyphocrangon sp.	78-83	32-50	0.2	0.0
Antennarius sp.	78-90	80-190	0.2	1.8
Ficus gracillis	84	85	0.2	1.0
Murex sp.	84	80	0.2	0.6
Xenophora solaris	84	71	0.2	0.7
Priacanthus hamrur	60-108	85-142	0.1	0.6
Decapterus russelli	78	125	0.1	0.3
Aploactinidae	80	150	0.1	1.2
Sargocentron rubrum	80	105	0.1	0.8
Shark juveniles	60	87	0.1	1.3
Pterois volitans	78-85	78-135	0.1	0.3
Cynoglossus macrostomus	85	125	0.1	0.1
Johnius sp.	85	97	0.1	0.2
Epinephelus chlorostigma	65	128	0.1	0.5
Lutjanus sp.	65	145	0.1	0.9
Rastrelliger kanagurta	81	68	0.1	0.1
Trichiurus lepturus	81	340	0.1	0.4

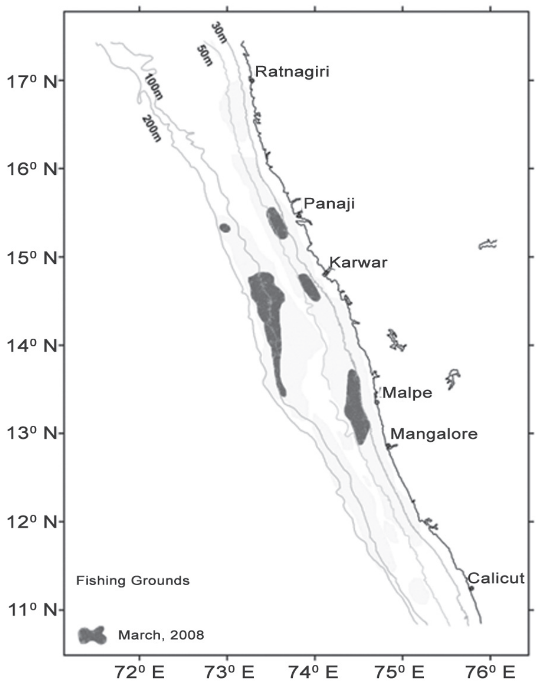

Fig. 9. Fishing ground and month during which most number of species was recorded from MDT discards

haul for the month was only 15 kg, however, during pre-monsoon months, considerable portion of the retained catch were landed as LVB for fishmeal preparation. In this case, the fishing ground should be evaluated in terms of economy and biodiversity loss before coming to any conclusion with regard to effort reduction.

Resource damage due to discarding juveniles of commercial species

During the study it is seen that species discarded were both non-commercial and commercial species. Among commercial species, the criteria for discarding was smaller size. In 2008-2009 it was observed that 34% of the discards were formed by juveniles of commercial species and in terms of number they formed 44%. A list of 40 commercially important species that were discarded in 2008 and 2009 and their depth of distribution is given in Table 5. The discard list formed almost all the commercial species ranging from, shrimps, cephalopods, demersal fishes and also juveniles of pelagic fishes. The quantity of discards estimated for Mangalore Fisheries Harbour for 2008-2009 was 37,533 t. About 2,733 t of *Platycephalus* juveniles were discarded during this period and the discarded number estimated was 464 million. In the case of *N. randalli,* which is one of the highest contributor to trawl landings at Mangalore, the quantity discarded in weight and numbers were 1341t and 333 million respectively. Juveniles of high value resources like, seerfishes, cobia, cephalopods, shrimps, groupers and snappers also were seen in considerable quantity and numbers in discards (Table 6).

Discussion

The trawl fishery of Mangalore has undergone a sea change since its introduction, and study of bycatch has been the focus of research during the last two decades. The studies conducted in Karnataka during 1985-90 (Menon, 1996) showed that the maximum discards were stomatopods in SDT and finfishes in MDT. Squilla, though not of economical value, has significant ecological importance as it forms one of the food item of a large number of demersal organisms (Mohamed, 2004). High demand in poultry feed ingredient has led to indiscriminate exploitation of stomatopods from the coast and in view of these observations, assessment of stomatopod distribution and population dynamics is becoming a necessity from an ecological point of view. In the present study, the SDT bycatch was found to be dominated by Squilla and the bycatch rate was comparable with those reported by Zacharia *et al.* (2006) in which the percentage of SDT bycatch during 2001 and 2002 were 33.9% and 35.1% respectively

From a resource conservation point of view, discards and LVB are causing immense damage to the future of the fishery and food security. Since the demand for fish meal is on the rise, more advanced technologies in fishing and vessel infrastructure are being introduced and practised in Mangalore. These developments have resulted in heavy exploitation of juveniles of commercially important fishes and ecologically important biota. Bhathal (2005) observed that discards from Indian fisheries is having a heavy impact on marine trophic structure and the estimation of discard poses great problem since there is variation in discard rates among hauls within trips and within vessels. Economic considerations play a major role in the quantity of the bycatch landed and discarded. In Mangalore, it has been observed that highest landing of trash was observed during pre-monsoon months when the landing centre is favourable for fish drying and the demand for trash was maximum. During these months it is seen that the discard percentage was lowest and during rainy and post-monsoon months, the discard percentage was more than those landed as trash. It is disturbing, in terms of food security, to note that auction price for the trash also determines which fish is sold as trash and which goes for human consumption. When the trash auction price crossed Rs.10 per kg, the lesser sardines and oilsardine are also put along with trash storage since in fresh form these species fetch less than Rs. 10 per kg. The increase in oilsardine percentage in trash as seen in the present study clearly indicates this alarming trend.

Table 5. The percentage of juveniles of commercially important species in number and weight recorded from trawl discard samples during 2008 and 2009 with their bathymetric reference

Species name	Depth of occurrence (m)		Discarded percentage (by number)			Discarded percentage (by weight)		
	Minimum	Maximum	2008	2009	2008-2009	2008	2009	2008-2009
Platycephalus sp.	20	150	10.25	2.34	8.23	9.92	2.76	7.28
Nemipterus randalli	30	150	6.39	4.48	5.90	3.77	3.24	3.57
Parapenaeus fissuroides	36	111	6.15	2.31	5.17	2.53	0.44	1.76
Trachypenaeus sp.	35	92	3.51	4.18	3.68	1.12	0.98	1.07
Loligo duvaucelli	20	111	3.33	2.35	3.08	2.54	1.74	2.24
Encrasicholina devisi	30	55	2.05	4.49	2.68	1.62	1.09	1.42
Secutor insidiator	10	55	3.19	1.06	2.64	0.75	0.12	0.52
Leiognathus bindus	10	55	2.71	1.74	2.46	0.36	0.59	0.45
Saurida tumbil	30	132	0.86	4.21	1.71	1.00	5.23	2.56
Rastrelliger kanagurta	20	60	1.34	1.38	1.35	1.62	2.41	1.91
Solenocera choprai	30	126	1.39	0.71	1.21	0.32	0.32	0.32
Psettodes erumei	37	150	0.28	1.59	0.62	0.34	0.88	0.54
Muraenesox cinereus	31	109	0.49	0.79	0.57	1.61	1.27	1.48
Epinephelus diacanthus	25	85	0.54	0.22	0.46	1.20	0.44	0.92
Lactarius lactarius	12	53	0.55	0.05	0.42	0.26	0.02	0.18
Nemipterus japonicus	29	73	0.51	0.00	0.38	0.32	0.00	0.20
Lutjanus sp.	29	127	0.20	0.79	0.35	0.21	1.36	0.63
Cynoglossus bilineatus	85	132	0.28	0.48	0.33	0.37	0.26	0.33
Dussumieria acuta	10	55	0.30	0.32	0.30	1.78	0.85	1.44
Trachinocephalus myops	29	130	0.27	0.38	0.30	0.47	0.64	0.53
Cynoglossus macrostomus	10	87	0.07	0.95	0.29	0.06	0.34	0.16
Pseudorhombus sp.	36	132	0.39	0.00	0.29	0.35	0.00	0.22
Mene maculata	16	47	0.14	0.32	0.19	0.98	0.87	0.94
Megalaspis cordyla	51	121	0.08	0.43	0.17	0.09	0.15	0.11
Priacanthus hamrur	43	150	0.14	0.26	0.17	0.50	1.22	0.76
Sepia elliptica	46	48	0.04	0.53	0.17	0.07	1.01	0.42
Stolephorus waitei	32	42	0.17	0.13	0.16	0.07	0.07	0.07
Trichiurus lepturus	12	53	0.12	0.16	0.13	0.47	0.50	0.48
Saurida undosquamis	29	85	0.16	0.06	0.13	0.35	0.20	0.29
Sphyraena sp.	12	40	0.14	0.09	0.12	0.16	0.07	0.13
Gymnothorax sp.	92	150	0.09	0.18	0.11	0.43	0.82	0.58
Decapterus russelli	16	55	0.01	0.32	0.08	0.02	0.31	0.13
Sardinella longiceps	10	53	0.06	0.00	0.04	0.01	0.00	0.01
Alectis indicus	12	53	0.01	0.08	0.03	0.23	0.07	0.17
Thenus orientalis	12	92	0.03	0.01	0.02	0.26	0.07	0.19
Johnius sp.	10	52	0.02	0.00	0.02	0.02	0.00	0.01
Upeneus sp.	36	132	0.01	0.03	0.02	0.03	0.11	0.06
Scomberomorus commerson	38	90	0.01	0.02	0.01	0.01	0.04	0.02
Rachycentron canadum	40	47	0.00	0.00	0.00	0.03	0.00	0.02
Portunus sanguinolentus	25	140	0.00	0.00	0.00	0.00	0.00	0.00
			46.30	37.46	44.04	36.22	30.52	34.12

Stock assessments are generally based on landing data and ignoring discards in the population analysis may lead to serious bias in the perceived dynamics of the population. In particular, the estimates of zero year class strength will be underestimated (Casey, 1993; Dingsor, 2001). Luther and Sastry (1993) and Shivasubramaniam (1990) found that bulk of the landings in different maritime states in different fishery comprised of juveniles of zero year class. Menon (1996) has estimated that 6,200 t of juvenile fish and prawns were discarded back into the sea during 1980-84 along the

Table 6. Estimated resource damage to commercially important resources of Mangalore Fisheries Harbour during 2008-2009 due to discarding

Species	Average weight (g)	Discarded weight (t)	Discarded number (million)
Platycephalus sp.	5.9	2733.0	464.1
Nemipterus randalli	4.0	1340.8	332.7
Saurida tumbil	9.9	960.3	96.7
Loligo duvaucelli	4.8	841.7	173.9
Rastrelliger kanagurta	9.4	716.5	76.4
Parapenaeus fissuroides	2.3	659.8	291.6
Trachypenaeus sp.	1.9	402.6	207.4
Epinephelus diacanthus	13.3	345.1	25.9
Priacanthus hamrur	30.1	286.8	9.5
Lutjanus sp.	11.9	236.5	19.8
Trichiurus lepturus	24.2	181.3	7.5
Leiognathus bindus	1.2	168.0	139.0
Sepia elliptica	16.5	156.6	9.5
Cynoglossus bilineatus	6.5	122.3	18.8
Solenocera choprai	1.7	119.0	68.5
Saurida undosquamis	14.8	109.4	7.4
Nemipterus japonicus	3.5	75.6	21.6
Lactarius lactarius	2.8	65.9	24.0
Cynoglossus macrostomus	3.7	61.4	16.5
Decapterus russelli	10.0	47.8	4.8
Sphyraena sp.	6.7	47.2	7.0
Megalaspis cordyla	4.3	41.1	9.5
Scomberomorus commerson	13.7	7.7	0.6
Rachycentron canadum	28.5	6.8	0.2

south-west coast of India. Recent studies on trawl fishery of Karnataka (2007-2008) revealed that an estimated 63.7% (by numbers) of discards were constituted by juveniles of commercially important fishes causing significant damage to valuable species. In terms of weight, commercial species constituted 37.4% of total bycatch (Dineshbabu *et al.*, 2010). Results of the present study indicate that sustainability of marine fisheries will be affected if the present trend continues. The projections made on trawl exploitation of threadfin breams by trawlers of Mangalore showed that the fishery loss due to juvenile catch of the species in Mangalore is 7% by weight and 22% by value, and the economic loss is estimated at Rs. 286 lakhs annually (Dineshbabu and Radhakrishnan, 2009).

The use of GIS by fishery managers and policy makers as an active aid in decision making, scenario testing or socio-economic analysis have yet to be established in marine fisheries (St.Martin, 2004). Based on monthly and annual resource mapping, effort restrictions in particular fishing grounds can be suggested to reduce the resource damage. Maps of retained catch and discarded catch in different months give an opportunity to evaluate the fishing ground month-wise or season-wise in order to come to a conclusion about the extent of fishing pressure required in different fishing grounds for exploitation of the resources in a most sustainable manner. The database created in GIS platform with illustrations in the form of maps will work as a tool for the policy makers to find mutually agreeable solution to tackle problems in conserving and managing the fishery with the active participation of fishermen. “No fishing zones” and “marine sanctuaries” can be marked on the basis of spatio-temporal data of fish distribution (Manson and Die, 2001).

Present day mechanised fishing fleets are equipped with GPS and other modern gadgets and the need of the hour is creation of awareness with regard to the utility of the participatory programme. The present study was made based on daily data collection from a single trawler employed for sampling. More involvement from fishermen, will fill the lacunae in the collected data as faced in the present study, by which multiple spatial data from different fishing grounds for a single day would be possible and the results will be comprehensive. Participatory decision making could also create awareness, to avoid capturing juveniles without causing much difference in their income. Spatio-temporal resource mapping on long term basis will also help in reducing man hours and fuel spent on search operations.

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