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Towards Ecosystem Based Management of Marine Fisheries – Building Mass Balance Trophic and Simulation Models

INFORMATION ONLY

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Technical Notes

IMPACT ASSESSMENT OF BOTTOM TRAWLING ON THE MARINE BIODIVERSITY ALONG KERALA

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Introduction

The introduction of mechanised trawlers to exploit the demersal resources beyond the traditional fishing grounds of Kerala in the early fifties was an important event in the marine fisheries of Kerala and due to its high returns it became widespread all along the trawlable coastal grounds. As it is found as the most efficient method for the exploitation of shrimps and therefore, its number has shown an exponential increase along the coastal waters of Kerala. Among the mechanised boats operating along Kerala coast more than 90% belong to bottom trawl specifically aimed for the exploitation of shrimp resources of the inshore waters (Ravindran and Baiju, 1998). Kurup and Radhika (2003) enumerated the number of bottom trawlers operated from 11 major and minor fisheries harbours of Kerala as 4960.Bottom trawling being a non selective fishing gear, it hauls up all the organisms dwelling at the sea bottom and therefore, its destructive effect to the non target organisms of the sea bottom is a matter of grave concern on a global basis (Jennings and Kaiser, 1998). Discards are bycatch organisms that are trapped in the trawl net during its path of tow and most of them are thrown back to the sea because of various reasons such as they are non-edible and poisonous nature of the species, not marketable, inferior quality and also due to lack of storage space on board (Clucas, 1997). Saila (1983) estimated that 6.72 million tonnes of biota were discarded back to the sea while Andrew and Pepperal (1992) estimated a total global discards of 16.7million tonnes from shrimp fisheries alone. Commercial bottom trawling globally has been estimated to produce 27 million tonnes of discards and this represent more than half of all fish produced annually from marine capture fisheries for direct human consumption (Alverson *et al.,* 1994). Quantification of discards have been made based on discards landed at the harbour (Rao, 1998; Bensam *et al.*, 1994) but no concerted attempts have been made to quantify the discards by collection data onboard the bottom trawlers operated along Kerala coast. Therefore in the present study a pioneer attempt was made to quantify the discards from the bottom trawlers of Kerala.

Materials and methods

The quantification of discard on board the trawlers were done on the basis of data generated from fishing operation of 375 bottom trawlers operated from 6 major fisheries harbours such as Sakthikulangara Neendakara, Cochin, Munambam, Beypore and Puthiyappa (Fig.1) during April 2000 to March 2002. Besides, the trawl catch composition were analysed from 100 boats beyond 100 m on the basis of samples collected from the last haul and preserved in tubs. The trawl catch composition was also examined by collecting samples from 120 boats during trawling operations carried out in the regular fishing grounds with the help of a hired boat during the study period. Data during second half of June and full month of July could not be collected due to the ban imposed for bottom trawling along Kerala coast. The units of bottom trawlers for monthly onboard participation from various

harbours were selected following Alagaraja (1984). The fishing endurance of the selected units varied from 1-3 days. The number of hauls in each voyage varied from 1-8 depending on the endurance and availability of fish. The catches from individual hauls were examined separately and the components were sorted in to target, non-target and discards following McCaughran (1992) and species /group level identification was done following FAO, (1984), Munro (2000) and Dance (1977). The marketable fraction of the catch was sorted out and packed in trays of 20kg and the number of boxes was counted to compute the total weight. The discards were also sorted group/species wise, weighed and 10% of the assorted sample was taken for detailed analysis in the laboratory. Details such as cruise time, facilities on board, OAL, cod end mesh size, fishing endurance and actual fishing hours together with the number of hauls, number of units operated in the vicinity and details of crew, duration and number of hauls performed, depth of fishing, fishing ground, etc. were also collected and entered on to proforma. The daily discarded fraction from the trawl catch was computed by multiplying the average catch arrived at from individual units multiplied by total units operated from the harbour on a daily basis. The monthly catch was estimated by multiplying the daily landings with actual fishing days of each month. The number of trawlers operated from different fisheries harbours agrees with that of Kurup and Radhika (2003). The discards were categorized under finfishes, Soles, Crabs, Gastropods, Shrimps, Cephalopods, Jellyfish, Stomatopods, eggs, juvenile shrimps and Snakes. The effort in terms of fishing hours was worked out on the basis on actual time spent for fishing following Kurup and Radhika (2003). The catch per hour and catch per unit of the discards were computed following Scariah *et al.* (1999). The data was processed with the help of Microsoft excel package at the School of Industrial Fisheries as part of the DOD-OSTC project.

Results

1. Species composition of discards

From the discards, during the study period, a total of 120 species of finfishes, 65 species of gastropods, 12 species of bivalves, 12 species of crabs among them 3 are only commercially important, 8 species of shrimps in the form of advanced post larvae and juveniles, 3 species of echinoderms, 2 species of Stomatopods, and 5 species of cephalopods were identified . During the first year (2000-01) the Finfishes (37.13%) were the dominant groups in the discards followed by Crabs (28.46%), Stomatopods (8.13%) and Gastropods (9.94%). Shrimps formed 1.96%, Jellyfish accounted for 0.85% while cephalopods and Soles contributed to 1.50 and 1.17% of the discards respectively (Fig.2). The contribution of eggs and echinoderms were to the tune of was 0.40 and 0.51% respectively. The year 2001-02 also showed a similar trend with Finfishes dominating the discards (42.08%) followed by Crabs (27.31%), Stomatopods (15.08%) and Gastropods (7.79%). The share of Shrimps, Cephalopods, Soles and Echinoderms were to the tune of 2.51, 1.61, 1.32 and 1.01% respectively.

2. Quantification of onboard discards

The annual discarded quantity during 2000-01 was computed at 2.62 lakh tonnes and that of the second year (2001-02) was 2.25 lakh tonnes. During the first year 0.97 lakh tonnes of finfishes of both edible and non-edible categories were found to be discarded back to the sea. Crabs discarded were mostly of non-edible species which accounted for 0.74 lakh tonnes, where as stomatopods were more or less dominated by *Oratosquilla nepa*, (0.47lakh tonnes). The quantity of gastropods was around 0.25 lakh tonnes while other major groups of discards were Soles (0.03 lakh tonnes), juvenile cephalopods (0.02 lakh tonnes) , juvenile shrimps (0.051 lakh tonnes) and jelly fishes (0.039 lakh tonnes).

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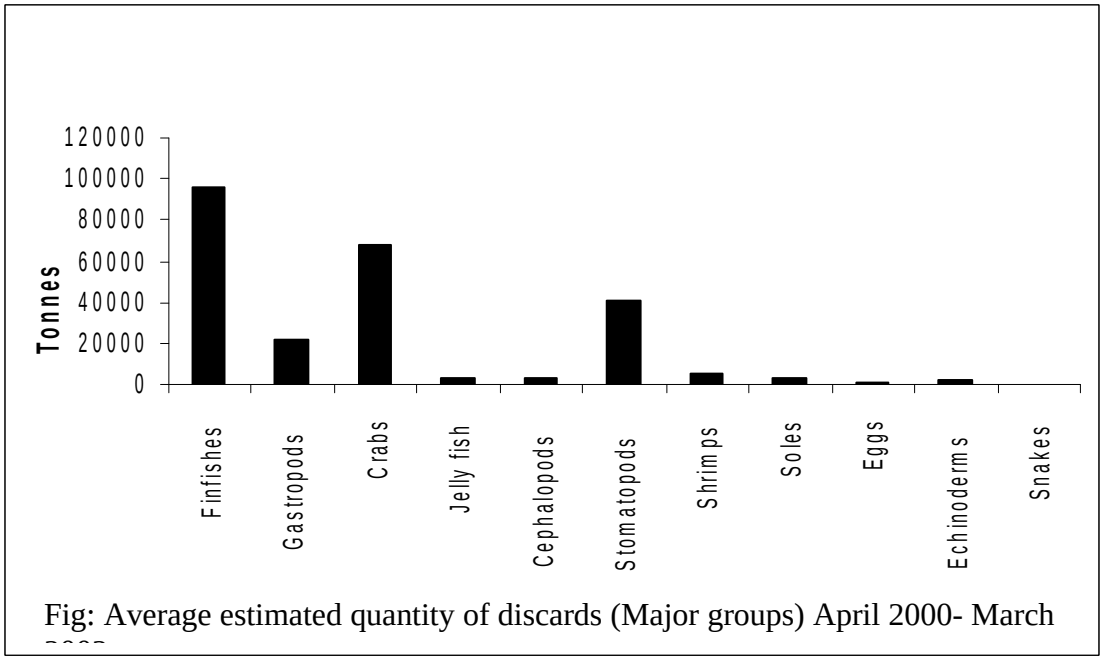

Fig: Average estimated quantity of discards (Major groups) April 2000- March

During the year 2001-02, Finfishes accounted for 0.95 lakh tonnes followed by Crabs (0.61 lakh tonnes), Stomatopods (0.34 lakh tonnes), Gastropods (0.17 lakh tonnes) and Shrimps (0.56 lakh tonnes). The share of Cephalopods, Soles and Echinoderms were to the tune of 0.036, 0.03 and 0.02 tonnes respectively. The contributions from Eggs (0.007 lakh tonnes) and Jellyfish (0.02 lakh tonnes) were relatively low when compared to preceeding year (Fig. 3).

3. Major groups

The percentage compositions of edible and non-edible biota in the onboard discards during first year is shown in Fig. 4. During 2000-01 edible biota was worked out to be 0.87 lakh tonnes which accounted for 33.33% of the discards while the non-edible fraction formed 66.67 % with 1.74 lakh tonnes .

Even though the trend during the second year was similar, a slight increase in the edible quantity was observed which contributed to 35.54 % (0.80 lakh tonnes) while the non-edible one formed 64.45% with 1.45 lakh tonnes.

3.1 Edible Finfishes

Edible finfish component during 2000-01 accounted for 28.45% of the total discards. Highest quantity of discards were registered in the month of September 2000 (19600 tonnes), which was predominated by juveniles of *Nemipterus japonicus* and *Decapterus russelli*, contributing to 37.04% and 36.52 % respectively of the total edible finfishes discarded in this month. An increase in the discarded quantity in this month can be attributed to the hectic fishery of Nemipterids during the post monsoon periods. Nempterids having length below 12cm lengths were found discarded onboard itself since it do not fetch a good price in the market. The edible fishes were found lowest in December 2000 (1273.02 tonnes) in the discarded fraction. In 2001-02 too similar trend was observed, with highest contribution in September 2001(10369 tonnes), where both the Nemipterids and Decapterids contributed to 37.08 and 25.14 % respectively Fig. 5. Decapterids were found discarded along Cochin and Sakthikulangara regions, mostly due to their vulnerability to easy spoilage within very short time, which would in turn deteriorate the

quality of other commercially important fishes stored along with it. It appears that edible finfishes were discarded more during the pre monsoon and monsoon periods while these contribution in the discarded fraction was insignificant during post-monsoon periods.

During the second year Nemipterids contributed to 23.28% among the discarded edible finfishes followed by silver bellies and Carangids registering 19.4 and 17.9% respectively. The share of the perches (e.g. *Epinephelus tauvina* and *E. diacanthus)* and sciaenids (e.g. *Johnius* and *Otolithes spp)* were 15.28 and 15.21% respectively while ribbonfishes, Priacanthids, other clupeids and anchovies accounted for 3.31, 1.91, 1.47 and 1.41% respectively of the edible finfish discards.

Nemipterids showed the dominance in the discarded finfish group during 2001-02 also as in the preceding year, registering 25.33%, followed by perches (19.86%) and Carangids (18%). However, the contribution of silver bellies and sciaenids showed a reduction to 9.41 and 10.80% respectively. Interestingly when compared to the first year, the percentage contribution of the Ribbonfishes, Anchovies and Sardines increased to 6.39, 4.66 and 2.99% respectively when compared to the previous year Fig. 6.

3. Non-edible fin fishes

The percentage contribution of the non- edible fishes to the total discards during 2000-01 and 2001-02 was arrived at 8.69 and 12.83 % respectively. Discards of this category during 2000-01 was found to be very high in September (5319 tonnes) during when *Rogadis asper* (2713 tonnes) emerged as the dominant species which accounted for 51% while it was least in December (357 tonnes). However, in 2001-02 maximum quantities of discards was observed in May (5472 tonnes), which was dominated by *Lagocephalus inermis* 45.51% followed by *Apogonychthys* spp. 41.34%. while the former species is discarded due to its poisonous nature, ,latter is thrown due to its smaller (5-8 cm) size. Quantities of discards were lowest in December 2001(186.16 tonnes) during when *Lagocephalus* dominated the non-edible finfish catch (91.45%). Species composition of the non-edible fin fishes in the total discards category is given in Fig 7. *Lagocephalus inermis* (30.85%) was the dominant species followed by *Diodon spp* (21.61%) and *Rogadius asper* (19.57%). The contribution from *Apagonychthys molutrix, Platycephalus niger* and *Synodus indicus* were to the tune of 5.57, 3.77 and 3.55% respectively.

The trend in discarded fraction during the second year was same with the dominance of *Lagocephalus inermis* (26.31%) followed by *Diodon spp* (24.95%), *and Rogadis asper* (13.96%). *Apagonychthys molutrix* (5.57%), *Platycephalus niger* (3.77%) and *Synodus indicus* (3.55%) were also contributed insignificantly.

5. 5.3 Edible crabs

The contribution of crabs having edible value in the total discards during 2000-01 and 2001-02 was 0.54 and 0.42 % respectively. During the first year, April recorded highest quantity (1052 tonnes) during when *P.sanguinolentus* was the dominant species (858 tonnes). It was lowest during October (21.24 tonnes), however during August this group was not represented. On the contrary, during the second year, highest quantity was recorded in May 2001 (1331 tonnes) while during October it was least registering the lowest catch (35.74 tonnes). Interestingly, during August, December, January, February and March this group was totally absent. Of the total edible crabs discarded, *C.cruciata (*57.26%) appeared as the dominant species followed by *P. sanguinolentus (39.89*%) while *P. pelagicus* contributed insignificantly. However, during 2001-02, *P. sanguinolentus (*62.15%*)* emerged as the dominant species followed by *C.cruciata (*37.56%). The share of *P. pelagicus (*0.29%) was more or less negligible Fig. 8.

4.Non-edible crabs.

Of the total onboard discards, non-edible crabs contributed to 26.96 % with apportioning of the first and second years were 14.75 and 12.21% respectively. During the first year (2000-01), highest quantity of non-edible crabs were discarded in August (28098 tonnes) followed by September (18239 tonnes). During these months the most predominant species was the swarming crab *Charybdis smithii* that accounted for 54.67 % of the total discarded non-edible crabs. *C.smithii* was found all along the coast with highest abundance off Cochin region at the depths 70-180 m. The peak abundance of this species recorded during August and September corroborated with the findings of Joice and Kurup (2000), who reported this species in the inshore waters of Kerala during August with a CPUE in the range 120-200kg. Least quantity of non-edible crabs discarded was found during May (722 tonnes). Of the total non-edible crabs *Charybdis smithii* (54.68%) dominated the discards followed by *Charybdis granula* (34.77%). The contributions from *Callapa lophosa*, *Doclea gracelepis* and *Phyllyra coralicola* were 2.95, 2.49and 1.96% respectively. Even though similar trends of high discards were observed during the second year in August (17343 tonnes) and September (15711 tonnes), the discarded quantity during these months was lower when compared to 2000-01. Availability of non-edible crabs was lowest in May 02 (405 tonnes). The species composition of non-edible crabs is shown in Fig.9. *Charybdis smithii* contributed to 45.81 % while that of C.granula was 36.11 %, whereas *Calapa lophosa* formed only 11.07 % of the total discarded non-edible crabs.

5. Cephalopods

During 2000-01, Cephalopods formed 0.85% of the total discards, while during 20001-02, it formed 1.61%. The highest discards during 2000-01 were recorded in March (929 tonnes) where the juveniles of Octopus *dolfusi* (477 tonnes) showed the dominance while lowest was in December (5.91 tonnes). May (1319 tonnes) accounted for the highest quantity of discards in 2001-02 due to the glaring dominance of *S. pharoanis* (1172 tonnes). The high occurrence of cephalopod in the discards during May is due to the intensification of fishing for cephalopods along the shelf waters of Kerala. Majority of the discarded cephalopods fall in 5-7cm average mantle length. It appeared only in very stray numbers in November (26.65 tonnes) where as in December virtually no specimens of cephalopods were found in the discarded category. The percentage composition of cephalopod species in discards for the year 2000-01 is shown in Fig 10. *Loligo duvaceli* formed the dominant species with 52.10% followed by *Sepia pharoanis* with 30.96 % while *S.brevimana* formed only 13.22 % whereas the contributions from *Octopus dolfusi* was least with 3.72 % of the total discarded quantity of cephalopods. Although a similar trend was observed in the second year the percentage contribution of Sepia *pharoanis* (42.80%) showed an increase, in contrast *S.brevimana* (*4.98*%) and *Octopus dolfusi* (0.59%) showing an inversing trend .

6. Shrimps

Discarding of juvenile shrimps is another matter of grave concern. It was observed that a total of 5110 (2000-01) and 5662.06 tonnes (2001-02) of juvenile shrimps were discarded during the study period accounting for 1.95 and 2.51% of the total discards respectively of the two years. During the first year, the highest discarded quantity was observed in March (1248 tonnes) where *P.stylifera* (871 tonnes) was the dominant species. The contribution of shrimp species to the total discards (2000-01) is shown in Fig.11, where the dominance of P.stylifera (66.34 %)is clearly discernible followed by *M. dobsonii* (33.02%). Interestingly ,during the second year, discarding of shrimps were nil

during March, however a maximum of 2813 tonnes was recorded in May mainly comprised *P.stylifera* (2238 tonnes) and *M.dobsonii* (575 tonnes). During this period, *P.stylifera* accounted for 64.22 % while *M.dobsonii* formed 33.68 % whereas the share of *Plesionika spp*. was 2.10 % of the total shrimps being discarded onboard .

7. Gastropods

Gastropods are mostly inedible or accommodate hermit crabs in them and hence are being discarded.During 2000-01, Gastropods contributed to 9.91 % of the total discards. During this period highest quantity of gastropods discard were recorded in September (12122 tonnes) whereas it was very low in October (499 tonnes). However unlike the first year, the discards in August were very low during the second year. The contribution of Gastropods (2001-02) to the total discards were 7.67%. Highest quantity was (3471 tonnes) recorded during February. In 2001-02 *Turritella maculata* (16.73%) dominated the discards, followed by *Tibia maculata* (13.47%), and *Babylonia zeylandica* (10.59%) with significant contributions from *Turritella spp* (10.29%), *Tibia fucus* (10.10%), *Babylonia spirata* (9.70%), *Harpa spp* (8.77%) *and Murex spp* (7.25%). On the other hand, in 2001-02, *Murex* spp. dominated with 26.65 % followed by *Babylonia spirata (16.89%)* and *Tibia fucus* (14.54 %). The share of *Murex retrirostris , Harpa spp,* and *Turritella maculata* were found to the tune of 6.51, 5.16 and 4.82% respectively (Fig.12).

8 .Jellyfish.

Jellyfish accounted for 1.49% of the total discards during 2000-01 whereas the corresponding figures for the second year was 0.96%. The highest quantity of jellyfish discarded in the first year (1006 tonnes) and second year (712 tonnes) was found in August. Their abundance was registered during monsoon season, which can be correlated with heavy fresh water influx from the rivers. They showed a decreasing trend after monsoon,however increased during premonsoon period of 2000-01. In contrast this trend was not observed in 2001-02. They clog the gear thus increasing the resistance of tow.

9. Echinoderms

During 2000-01 and 2001-02, the respective quantity of echinoderms under discarded fraction were 1338 and 2284 tonnes. The highest discards of echinoderms was registerd during September (510 tonnes) during 2000-01 while during 2001-02 it was in April (1388 tonnes). These groups were found absent during August 2000, January 2001, February 2001, August 2001 and December 2001. While the lowest quantity discarded was in January 2002(11.04 tonnes) interestingly , there was practically no echinoderm discards during August 00, 01and December 01.

10. Stomatopods

Stomatopod discards, depicted were represented by one species, *Oratosquilla nepa* that was found abundant along the entire coast with predominance along northern zone, when compared to the other two zones. The quantity of this group even reached up to 300-400kg/haul with a cpue of 88.5 kg/ hr. During 2000-01 they accounted for 18.08% of the total discards, however its share in the year 2001-02 declined to 15.07%. Its hare among the discards during the first year was highest in March (11870 tonnes) while during the second year April registered the maximum discards of stomatopods (10939 tonnes) and thenceforth a decreasing trend was observed till March 02. However, this species was not found in September. The lowest was recorded in March 2002 with 418.87 tonnes.

11 Eggs

The quantity of Squid eggs discarded during 2000-01 and 2001-02 was 1041 and 735 tonnes respectively. Squid eggs were encountered in the trawl catches especially during August and September. The highest quantities of both the years was registered in September with 428 and 285 tonnes respectively. Eggs were totally absent in the trawl catches of late pre- monsoon and early monsoon months.

Temporal variations of Discards

During 2000-01, the discards were found highest in September (0.57 lakh tonnes) followed by March (0.45 lakh tonnes) and August (0.44 lakh tonnes). During this period least quantities discarded were registered during November (0.072 lakh tonnes). In 2001-02 maximum discards were recorded in September (0.32 lakh tonnes) followed by May (0.31 lakh tonnes). An increase in discards during May can be attributed to high fishing effort exerted for *M.dobson*ii before the introduction of fishing holidays. Quantity of discards during this period was least during December with 0.058 lakh tonnes. High quantity of discards recorded in April and May were due to the emergence of a non-edible crab *Charybdis granula* and *Oratosquilla nepa*. Discards in August was dominated by yet another non-edible swarming crab, *Charybdis smithii* which showed dominance in the catches during the monsoon periods and contributed to 63.03% of the total discards in these months. A highest of 1200 kg /haul was recorded off Cochin, while Sakthikulangara recorded 600kg/haul, in contrast this species was not recorded from Ponanni and Puthiyappa in such huge quantities. Among the finfishes, scianeids and Nemipterids were the major groups in discards. The scianeids fishery co-existed with that of *P.stylifera* since juvenile scianeids feed on them, as reported by Bhaskari (1977). During the last weeks of October, November and December, discards were found very less when compared to the preceding months and the reason can be attributed to the semi pelagic type of trawling operations being carried out aiming at resources like *Trichurus savala* and *Stolephorus spp.* With the help of bottom trawl, which was rigged with more floats so enabling the gear not to touch the sea bottom unlike shrimp trawling and as result there were very fewer discards. The trawl nets used for fishing of *Trichurus* spp. is characterized by big mesh size so as to reduce the resistance imparted by the water flow and thus retaining the trawling speed at 4-4.5 knots. In contrast, in shrimp trawling the trawling speed cannot be maintained more than 3.5 knots. The bigger mesh size also facilitated faster towing thus enabling catching of ribbonfishes, which are generally characterized by its fast moving. Hauls with practically no discards were also encountered in November. In January ,the discards were comprised mainly of Silver bellies, represented by 5 species, accounting for 11.51 (2000-01) and 8.75 %(2001-02) of the total edible finfish discards respectively.

Seasonal Variations in Discards

The discards of the pre-monsoon period was predominated by *Charybdis granula* which was found distributed all along the coast up to 75 m followed by *Oratosquilla nepa* which also was found all along the coast with highest abundance in northern area, with highest of 400kg/haul recorded off puthiyappa during March 2001. On the contrary, the discards in the monsoon were dominated by *Charybdis smithii* with a catch up to 1200kg/haul off Cochin (August 2000). The cpue of discards during the monsoon period was much higher during both 2000-01 and 2001-02 where the average cpue were 75.33 and 83.39 kg/hr respectively, when compared to that of pre and post monsoon seasons (Fig. 13). Post monsoon periods registered the lowest cpue both in 2000-01(26.64 kg/hr) and 2001-02 (36.48 kg/hr).

Depth wise variation of discards

The total area was divided into 5 zones viz 0-20, 21-40,41-60, 61-80 and 81-100 m for the purpose of assessing the quantity of discards fro various depths, their species composition etc. Discards were encountered from all the depth zones surveyed. Highest discards were observed in the 21-40 m depth zone during the first and second years of study, contributing to 53.37 and 48.87% respectively of the total discarded fraction for 0-100 m depth(Fig.14). Depth zone 0-20 m was the next highest contributor with 15.475 in the former year and 17.35 during the latter year while 81-100m accounted for13.93 and 13.34% respectively during the first and second years respectively.

Recommendations:

1. On an annual basis, around 2.4 lakh tones of discards are thrown back in to the sea from bottom trawlers operated along Kerala waters due to their non edible nature, wrong species and size, lack of storage facilities onboard, low market value, etc. It is found imperative to initiate urgent steps for their effective utlisation for the preparation of protein rich fishery products, byproducts and value added products for local and export markets. With back up of these materials, Govt.of Kerala can plan for the setting up of high quality fishmeal manufacturing plant either under Govt. or public sectors.
2. The edible portion of the discards is worked out to be around 0.85 lakhs tones per annum and therefore, steps may be taken to make available this fraction of the discarded catch for consumption. This may be possible by improving the storage facilities in the bottom trawlers. The discarding of edible finfishes are mostly due to relative market price prevailing during different months.
3. The magnitude of destruction of eggs and juveniles of commercially important fin and shellfishes along Kerala waters due to bottom trawling is a matter of grave concern. The results of the present study revealed that, on an average annually around 2500 tonnes of cephalopods, 5000 tonnes of shrimp juveniles and 700 tonnes of squid eggs were destroyed due to bottom trawling. This may incur a loss to the marine fisheries wealth of Kerala by at least to the tune of one lakh tones per annum. It is recommended that this situation can only be ameliorated by a reduction of trawl fishing pressure during February to May and a definite improvement in the cod end mesh size used in the bottom trawlers.
4. The exploited marine fishery of Kerala need to be revalidated on the basis of the pioneer data generated on discards. This data base shall be given adequate attention while framing any policies and legislation on conservation and management of marine fisheries of Kerala.
5. The present study revealed that 94% of the bottom trawlers operated along Kerala coast are having a cod end mesh size of 18 mm and below against the statutory mesh size of 35 mm imposed by the Govt, of Kerala vide KMFRA (!980). This situation calls for an effective implementation of KMFRA regulation.
6. 232 organisms were found killed and discarded in to sea in varying proportions from the bottom trawlers. This disproportionate destruction of non-target organisms would brought about serious biodiversity degradation in the coastal waters of Kerala. The wanton killing of some of the uneconomic but key occupants in the

marine food chain may affect the life supporting system in the long run. The trawl net and accessories presently used cause heavy damage to the seabed by penetrating into it and dispersing off the top layer of sediments. So it is found essential to make necessary technical modification in the design and operation of trawl gears such as rigging with separate panels, sorting grids, square mesh cod ends, square mesh panels or windows, bycatch excluder devices, provision for electrical stimulation device at the footrope and release holes at the cod ends, rigging with more floats, dispensing with the tickler chain, etc. to make bottom trawling more ecofriendly in order to minimize mortality and devastation of benthic organisms.

7. It has been observed that the survival of crabs, stomatopods ,echinoderms, gastropods, sea snakes, etc are quite long among the discards while the post fishery survival of fishes and shrimps are almost negligible. This may lead in to the proliferation of the former group of organisms in the fishing ground. This amounts to the transformation of the mature ecosystem in to an immature and inefficient ecosystem over a period of time and would ultimately leads in to the ecosystem over fishing as defined by Pauly (1983). The increase of gastropods and crabs observed during the second year in the present study also corroborate with this view. So it is recommended that the invasion of the above unwanted species in the fertile fishing grounds shall be prevented either by killing them onboard itself or bringing them to the shore for their effective utilization.
8. Vide Kerala marine Fisheries Regulation Act(KMFRA), up to 30 m between Kollemoode to Paravoor and upto 20 m from Paravoor to Manjeswar along Kerala coast are earmarked exclusively for the artisanal fishermen. The present study revealed that there is infringement by the trawlers in to these areas as this depth zone contribute to 17% of the total discards from the bottom trawls .

9. Establish “no trawling zones” in selective region of continental shelf and slope ecosystems along Kerala coast as a measure to recoup the benthic communities for the sustenance of demersal fishery. Marine Protection Areas (MPAs) may also be established for the protection of benthic habitats and conservation of marine fishery.

10. Since the ban imposed on bottom trawling during June -July for a period of 45 days was found very effective for the regeneration and recoupement of benthic communities, it is recommended that the fishing holidays may be increased to 65 days in consonance with the uniform ban being proposed for the west coast states by the Govt. of India. Furthermore, the high CPUE of discards were also observed during the monsoon periods and therefore, the quantity of discards can be reduced by regulating the fishing effort during these months

11. It is recommended that research need to be pursued on post fishery survival of discards in general and juveniles of fin and shell fishes in particular. Based on the results so compiled, the survival rate of discards can be improved by keeping them in short term rearing facilities to be equipped in the trawlers and their subsequent release in to the sea. This facility shall be made mandatory for the bottom trawlers operated along Kerala coast vide Kerala Marine Fisheries Regulation Act(KMFRA).

12. Minimum landing size (MLS) system should be fixed and implemented to curb landings of juveniles and young ones. Holding, selling, processing and exporting of

under sized shrimps, crabs, squids, cuttle fishes and other commercially important fin and shellfishes shall be fully banned. This will be most useful as a conservation measure and minimizing the magnitude of juvenile fishery.

13. The fishing pressures from bottom trawlers along coastal waters of Kerala is very high when compared to any other maritime states of the country and therefore, it is recommended that there is an urgent need for the regulation of fishing effort. At present around 4900 bottom trawling units are operated from the nine coastal districts of Kerala. The number of bottom trawlers may be regulated to 3000.The mesh size regulation may be limited to 30 mm for making it much more practical.

14. The present study revealed that the discards from multi day fishing trawlers are higher when compared to single day fishing trawlers. It is recommended that cold storage facilities in the former category of vessels shall be proportionately increased in consonance with their endurance.

15. Mass awareness programmes shall be conducted among fishermen engaged in bottom trawling, boat owners, auctioneers, and middlemen, workers engaged in peeling sheds, processing factories etc. about the impact of bottom trawling on sea bottom and its living communities. Definite programmes for the conservation and management of discards and for the protection and preservation of marine habitats shall be formulated by giving due participation to the fishermen who are actively involved in trawl fishing. Effective conservation and utilization of discards can be undertaken under the aegis of local bodies. Strengthen the co management activities with the participation fishermen for mitigating the wanton killing and discarding of the non target organisms in to the sea.