Bycatch from tuna fishery and trawl operations along the southern peninsular India

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Introduction

India, a tropical country has multispecies fishery, exploiting species that differ in their biological characteristics and habitats. Trawl is the major gear that contributes to the marine fish production of the country. We have the fish trawls and the shrimp trawls, the former hauls slightly off bottom with more floats and the shrimp trawl scrapes through the bottom with more sinkers. Over the years the fisheries sector in India witnessed progressive expansion of trawling to greater depths resulting in phenomenal growth in marine fish production from a subsistence fisheries in the 50's to 3.78 million t in 2014 (CMFRI, 2014).The highest rate of incidental catch of non-target species as identified by Alverson*et al* (1994) and other worker's is associated with shrimp trawling. Tunas and tuna like fishes are generally exploited by lines (hooks and line, long lines, pole and line) and to a certain extent by gillnets. The bycatch from hooks and line consists of dolphinfish, billfishes and sharks. Gillnets operated mostly target the coastal tunas and the bycatch consists of carangids and seerfish. However, bycatch from any gear is cause for concern and in the Indian context, trawl being the major gear the bycatch from this gear is of greater worry as sieving the seas with fine mesh nets removes species that are important link in the trophic food chain, affecting the predator-prey relation and thus the ecosystem.

Background information

India has a coastline of 8,118 Km (including Lakshadweep Islands in Arabian Sea and Andaman & Nicobar Islands in the Bay of Bengal). The length of the coastline of Indian mainland is 6100 Km and its territorial waters extend into the sea to a distance of 12 nautical miles (22.2 Km) from the coast baseline. India has a wide EEZ of about 2.172 million Km^2 in the sea all along the 7500 Km long coastline around her. There are nine maritime states in India involved in marine capture fishing activities (Table 1).

Table 1 Maritime states of India

S.No.	Maritime States	Length of coastline (Km)
1	Gujarat	1915.29
2	Maharashtra	510.31
3	Goa	113.03
4	Karnataka	258.15
5	Kerala	560
6	Tamil Nadu	864.73
7	Andhra Pradesh	1037
8	Odisha	457.2
9	West Bengal	374

The monsoonal currents seasonally reverse in the two wings of the Indian Ocean – the Arabian Sea and Bay of Bengal. Though the southwest Bay of Bengal has a narrow shelf there is large subsistence fishery as well as industrialized fishery supported by around 50-60 species of commercially important fishes, crustaceans and molluscs (CMFRI, 2012). Compared to the east coast the continental shelf is wider that provides more area for trawling in the west coast.

Figure 1 Indian coastal characteristics

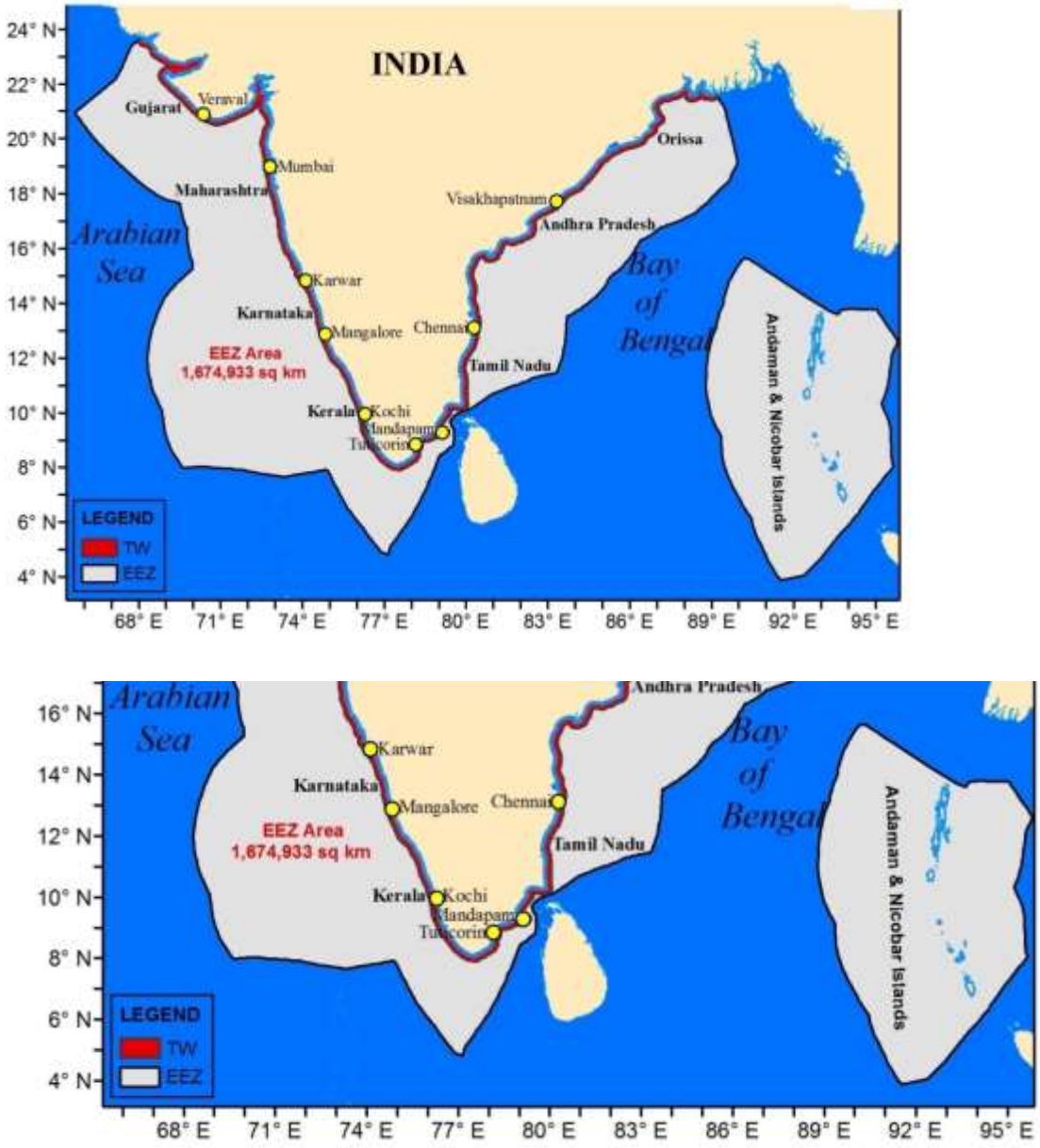

Figure 2 Peninsular India

Trawler fleet, catch trend and composition

Commercial trawling was initiated in Indian waters during the 50's partly on an exploratory and partly on a commercial basis. The 80's saw the introduction of multiday trawlers exploiting mid-shelf grounds, combining both day and night fishing leading to the introduction of non-conventional species in the catch. Fishery operation is usually restricted to within 100 m depth but during the 90's

commercial boats with high engine power and modified winches started operation in deep sea grounds at a depth of 175-400 m. Based on the 2010 Fisheries Census, the total number of trawlers operating in India are 35,228.

Trawl landings in India increased over the years, the annual average landings for the period 2008-2012 being 1.8 million t. During 2013, the total annual trawl landing of the country was around 3.78 million t, Tamil Nadu on the southeast coast registering the second position with 6.88 lakh t followed by Kerala 6.71 lakh t and Karnataka with 4.37 lakh t. The states of Kerala and Karnataka (southwest coast) contributed 12.1 lakh t accounting for 32.1% of all India landings. Tamil Nadu (east coast) contributed 67% to the total trawl landings of the south east coast of India. Kerala and Karnataka saw the dominance of Oil Sardine, Indian Mackerel, Threadfin breams and Cephalopods and in Tamil Nadu, Oil Sardine, Croakers, Silverbellies and penaeid prawns were the dominant resources. In all 670 species were landed during 2013 along the Indian coast, the highest number were landed in Tamil Nadu (373) followed by Kerala- 370 species and Karnataka-173 species (CMFRI, 2014). Fishery along the southwestern Bay of Bengal consists of around 750 species of finfishes, crustaceans and molluscs (Sathianandan *et al*., 2012). On an average 40 to 50 species are landed in each trawl haul. Analysis of data revealed that the monthly variation of species to be 106 to 154 in trawl fisheries of southwest coast of India. The major species contributing to the trawl catch are *Nemipterus* spp., *Lagocephalus* sp., *Trichurus lepturus*, *Saurida* sp., *Priacanthus spp.* and stomatopods.

Tuna fisheries and bycatch

Tuna is an important pelagic fishery resource of the country but it forms a mere 2.26% of the total catch. They are mostly exploited by hook and line, troll lines and gill nets. However it is important to note that the fishery is dominated by small scale fishermen who operate mostly the hand lines and the long lines. The operation is mostly carried out by the traditional sector using the lines and small gill nets in the near shore areas. The long lines are operated by the modified/converted trawl vessels.

Tuna catch is represented by several species. The neritic tunas include *Euthynnus affinis* (46.3%) followed by *Thunnus tongol* (14.6%), *Auxis thazard* (4.51%) and *A. rochei* (3.52%). Among the oceanic tunas, the yellowfin tuna *Thunnus albacares* (15.72%) and the skipjack tuna *Katsuwonus pelamis* (8.6%) are the dominant species.

The tuna fishery is mostly seasonal along the Indian coast, restricted to the cooler months (October to March). The oceanic tuna especially the yellowfin tuna come to the surface above the thermocline and is

generally caught by the troll lines and the long lines operated above the thermocline. These gear mostly land yellowfin tuna (>80%) and the bycatch consists of the dolphinfish-*Coryphaena hippurus*, Wahoo-*Acanthocybium solandri*, narrow barred Spanish mackerel-*Scomberomorus commerson*, billfishes, *Makaira indica* and *Xiphias gladius*, Sailfish-*Istiophorus platypterus* and sharks-*Carcharhinus limbatus*, *C. macloti*, *C. melanpterus, C. brevipinna* and *Scoliodon* spp.

The fishery for skipjack tunas is mostly around the islands (Lakshadwep and Andaman & Nicobar) and are exploited using the pole and line. The bycatch here is negligible (<2%) and consists of the Wahoo, fullbeaks- *Strongylura* spp. The gill nets are used to mostly exploit the coastal tunas-*E. affinis* and the *Auxis* spp. The bycatch here include the carangids, seerfish and barracudas. As the gear does not target the tunas the catch is mixed and the fishes other than tunas comprise 30-40% by weight depending on the season.

Table 2 Catch (in tonnes) of tuna bycatch during 2012

Gear	*Acanthocybium*	Barracuda	Big jawed jumper	Bill fishes	Half & full beak	*S.commerson*	*S.guttatus*	Sharks	Flying fish
MGN	55	890	4	1115	348	3570	3054	5528	
MHL	0.28	36		120	8	265	45	582	
OBHL	0.24	1011	43	886	830	3390	451	829	153

MGN: Mechanised Gill Net; MHL: Mechanised Hook & Line; OBHL: Out Board Hook & Line

Low value bycatch

Trawling pattern has undergone change over the years in response to consumer demand in the domestic and international markets. The cod end of the trawl net in most of the maritime states has mesh size of 18-20 mm. Though this selective gear targets a particular resource, trawling brings in enormous quantity of non - target groups: 1. Bycatch which occur regularly in trawl landings 2. Low value bycatch comprise fishes in an advanced state of spoilage and non-marketable resources like stomatopods and certain species of crabs and molluscs which are usually used in fish meal preparation 3. Low value bycatch sorted cleaned for drying and sold in local markets for human consumption like silverbellies,*Priacanthus* spp., anchovies, nonpenaeid prawns 4. Juveniles of major fish groups, removal

of which lead to recruitment overfishing (Kizhakudan *et al*., 2013). Though they are termed low value bycatch, they form a very essential component in the trophic food chain as they are fed upon by several high value fishes/targeted fishes, crustaceans and endangered species.

The LVB increased substantially from 3144t in 2008 to 30,737 t in 2011 and the discards reduced from 22696 t to 7359 t during the same period. During seasons of abundance of the small pelagic fishes, there is a glut in the market of such fish, driving the fishermen to divert a part of their catches as LVB, which otherwise would have been used for human consumption (Dineshbabu *et al*., in press). As aquaculture is gaining importance, fishes earlier discarded are landed as LVB.

Along the northern Tamil Nadu coast (southwest Bay of Bengal), the low value bycatch formed 60.04% of fishes, 34.15% of crustaceans, 4.6% of molluscs and 1.21% of miscellaneous groups like the starfish, sea urchin etc. The LVB fluctuated from 1.9% to 21.2% between months. Silverbellies, Cardinalfishes and flatheads were dominant among the fishes. The major chunk of the crustaceans in the LVB were constituted by brachyuran crabs like *Calappa lophos*, *Calappa* spp., *Dorippe quadrigens*, *Arcania elongata*, *Leucasia* spp. etc and the juveniles of the commercially important *Portunus sanguinolentus*, *Portunus argentatus*, *Portunus gladiator*, *Charybdis lucifera* and *Charybdis hoplites*. Shrimps comprised the juveniles and damaged adults of *Metapenaeopsis stridulans* and *Parapenaeus longipes*. Stomatopods were an important constituent in the LVB consisting of 8 species – *Oratosquilla nepa*, *O. woodmasoni*, *O*. *gonyptes*, *Harpiosquilla harpax*, *H. annandeli* and *H. raphideae*. Lobsters were mostly the scyllarid species – *Petractus rugosus* and *Thenus unimaculatus*. The monthly Shannon-Weiner species diversity index here ranged from 3.13 to 5.53 and season wise the index ranged from 4.76 to 5.59. The index was highest during the south-west monsoon season.

Table 3. Composition of LVB (%)

Group	Composition of LVB (%)
Fish	
Crossorhombus azureus	4.56
Upeneus taeniopterus	3.3
Upneus sundaicus	2.82
Thryssa mystax	2.57

Sardinella gibbosa	2.46
Eubleekeria splendens	2.1
Secutor insidiator	2.0
Lagocephalus inermis	12.80
Saurida spp.	11.70
Decapterus sp.	10.63
Sardinella longiceps	8.59
Nemipterus spp.	8.56
Lesser sardines	5.93
Platycephalus sp	4.06
Alepes sp	3.88
Rastrellige kanagurta	3.64
Dussumieria acuta	3.49
Trichiurus lepturus	3.41
Thryssa spp	3.25
Eel	2.46
Leiognathus spp.	2.8
Johnius spp.	2.1
Arius sp.	1.8
Otolithus spp.	1.3
Saurida tumbil	8.2
Cynoglosssus spp.	3.2
Sciaenids	4.1
Crustaceans	
Metapenaeopsis stridulans	17.1
Parapenaeopsis maxillipedo	12.6
Oratosquilla nepa	25.2
Harpiosquilla harpax	5.2
Charybdis lucifera	6
Doclea spp.	6.6
Dorippe sp.	4.8

Leucasia spp.	3.4
Lauridromia dehaani	2.0
Chraybdis hoplites	3.2
Calappa lophos	2.8
Calappa calappa	1.0
Matuta planipes	1.4
Ashtoret lunaris	1.2
Demania spp.	0.8
Molluscs	
Babylonia sp.	11
Bursa sp.	6
Dentalium	2.3
Conus sp.	1.2
Trochus sp.	2
Others (starfish, bivalve shells, jellyfish)	0.4

Table 4.**Size range of LVB species**

Fishes

Sardinella longiceps	95-138
Cyanoglossus sp.	67-105
Leiognathus dussumieri	60-75
Catfish	78-180
Trichurus lepturus	118-250
Sciaenids	80-92
Coila dussumieri	77-110
Leignathus bindus	35-80
Otolithes cuvieri	56-112
Psettodes erumie	67-80
Megalaspis cordyla	81-115
Stolephorus sp.	40-80
Lactarius lactarius	48-115
Therapon jarbua	40-50
Epinephelus diacanthus	51-80
Sardinella guttatus	80-90
Penaeidae	
Solenocera crassicornis	28-56

Sycionia lancifera	30-48
Trachypenaeus asper	39-66
Trachypenaeus sedili	48-93
Trachypenaeus curvirostris	45-90
Sergestidae	
Atypopenaeus stenodactylus	50-95
Acetes sp.	18-28
Exhyppolysmata stylirostris	60-90
Nematopalaemon tenuipes	28-35
Alphid sp.	53-130
Portunidae	
Portunus sanguinolentus	30-50
Portunus argentatus	18-55
Portunus granulata	43-64
Portunus gladiator	28-55
Portunus pelagicus	51-58
Thalamita integra	31-60
Charybdis natator	43-98
Charybdis lucifera	35-93
Charybdis feriata	45-55
Charybdis smithii	22-60
Charybdis truncata	46-78
Charybdis hoplites	20-48
Calappidae	
Calappa calappa	53-73
Calappa lophos	58-109
Calappa clypeata	55-62
Calappa capellonis	72-78
Calappa japonica	50-55
Xanthidae	
Liagore rubromaculata	32-63
Demania armadilius	27
Demania baccalipes	38-43
Halimedia ochtodes	42-95
Matutinae	
Ashtoret lunaris	28-56
Matuta planipes	
Dorippidae	
Dorippe frascone	50-73
Dromiidae	
Lauridromia dehaani	80-98
Conchoecetes artificisus	21-45

Majidae	
Doclea ovalis	23-48
Doclea canalifera	43-65
Galenidae	
Galene bispinosa	36-135
Parthenopidae	
Parthenope longimanus	32-48
Enoplolambrus echinatus	21-38
Arcania elongata	15-18
Lyphira preplexa	15-16
Cryptopodia fornicata	30-45
Corystidae	
Jonas indica	35-45
Hermit crab	
Clibanarius sp	20-22
Lobsters	
Thenus unimaculatus	65-120
Petractus rugosus	30-55
Stomatopods	
Oratosquilla nepa	48-115
Oratosquilla woodmasoni	32-110
Oratosquilla holochista	36-123
Oratosquilla gonyptes	62-105
Oratosquilla quinquindata	95-135
Harpiosquilla harpax	53-198
Harpiosquilla annandeli	42-118
Harpiosquilla raphidae	110-150

Molluscs

Babylonia spirata	35-52
Bursa spinosa	53-80
Donax sp.	20-25
Turitella sp.	36-100
Ficus sp.	16-62
Trochus sp.	4-28
Babylonia zeylanica	17-60
Loligo sp.	36-60
Sepia sp.	31-60

Utilisation and price structure of LVB

In the maritime states along the southern peninsular India,the juveniles of certain fishes – *Johnius* sp., *Epinephelus diacanthus* etc and shrimps like *P.stylifera, M. dobsoni,* crabs – *P. sanguinolentus* are sold in the landing centre @ 15-20 INR. Stomatopods and non-commercial crabs find market as raw material for fish meal preparation. The gastropods and bivalve shells are used in lime industry. Non edible LVB landed are used in the fish meal plants. The edible fishes, crustaceans and molluscs are sorted by fisherwomen and sold in the local markets at nominal rates (depending on the species the price vary from 20-50 INR).

Over the years the demand for LVB has increased with strong demand in the domestic market as raw material for fish meal plants, for aquaculture feed preparation. Though the aim and the desire are to reduce the LVB, the panoply of LVB presently landed can have a better fate if judicious methods are adopted to establish a value chain. Most of the small fishes can be breaded, baked/grilled/barbecued and sold through local kiosks. The non-commercial crabs can be utilized in the invertebrate aquarium trade. Stomatopods which have yet to take up in India as human food can be popularized and acceptance generated.

Mitigation and the future

Livelihood of the coastal population is depended on fishing and related activities (net making, fish drying, processing/post-harvest technology, marketing etc.) and fish is the staple diet of several communities in India. Catching a bounty of high value fish is the aspiration of every fisherman when he ventures out into the sea. Hence any mitigation measure requires to be evolved on a holistic approach involving fishermen, planners, stakeholders, traders and the government representatives. In India, fishing in territorial waters (up to 12 nautical miles from the shore) is a state subject, the different maritime states have their own decision making system. Trawl ban is presently followed in India as a step to sustain the fishery of commercial species, ban being exercised during fixed period that differ along the east and the west coast. Along the southwest coast the ban is for 45 days beginning on 15th June and ending on 31stJuly every year and along the southeast coast the ban period extends from 15th April to 31stMay annually.

Regulation of mesh size of trawl net is another step that is often suggested and contemplated. Mesh size regulation in tropical multispecies fishery is a tricky affair as the minimum legal size differs from species to species and so the decision should explicitly balance the fate of the ecosystem on one side and the fishermen on the other.

A mid-way approach would be practical which takes into consideration both the ecosystem services and the fishermen aspirations. Geographic Information System (GIS) and Remote Sensing are considered the modern panacea to tackle the problems of juvenile fishing and LVB/discard. The CMFRI has taken up a major project on GIS based studies to suggest fisheries management options, all along the maritime states of India. The project encompasses collection of data pertaining to all the gears (not only trawls) from all the maritime states of the country, the analysis of which can lead to advisories appropriating optimistic management steps to control the juvenile and LVB problem. Fisheries management is just not about fish anymore for that matter the target groups alone but has the wider interests of society, healthy ecosystems and biological diversity.

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