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Bycatch Fauna in the Landings of the Karaikal Fishing Harbour, South East Coast of India

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Abstract: This study examines the bycatch fauna in the trawl fishery landings of Karaikal Fishing Harbour in south east coast of India. A total of 295 species were identified in the bycatch, including 199 finfish species, 11 shrimp species, 4 lobster species, 2 stomatopod species, 14 crab species, 10 cephalopod species, 46 molluscan shell species, 7 echinoderm species and 2 jellyfish species. Trawl fisheries are known for their indiscriminate capture of non-target species and high discard rates, posing a concern for sustainability. Bycatch and discards significantly affect non-target species, biodiversity, ecosystem function and habitat. The high diversity of species in tropical waters like India results in high bycatch and discards. The use of small mesh sizes also contributes to bycatch. Various bycatch reduction devices have been developed to reduce bycatch. However, effective data collection and management measures are still needed. The study provides baseline species data of the trawl fishery landings which can inform conservation strategies like strict enforcement of mesh size regulations, bycatch reduction devices, and awareness programs for fishers on the impacts of bycatch.

Keywords: Karaikal, Trawl fishery, Landings, Bycatch, Non-target species

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Introduction

India is endowed with a wide diversity of water resources, which sustain a large fisheries sector in the country. India has a coastline of 8,118 km with an Exclusive Economic Zone (EEZ) stretching over 2.02 million sq. km, and a continental shelf covering 0.53 million sq.km. The Marine Fisheries potential in the Indian waters has been estimated

at 5.31 MMT constituting about 43.3% demersal, 49.5% pelagic and 4.3% oceanic groups. In India, increasing fishing effort, overfishing and overcapitalisation as well as unsustainable fishing practices over the years are pushing many fish stocks to the point of concern (Vivekanandan, 2022). It has been assessed that one-third of the

marine fish stocks has been overfished in the recent years (Sathianandan *et al.*, 2021).

Commercial fishing affects not only the species targeted, but also several other species that are caught incidentally. This is commonly referred to as bycatch. Bycatch taken by the trawl fishery is an important issue in the management of fisheries resources given the perceived high mortality of the different fish stocks other than targeted fish. Trawl fisheries, known for their indiscriminate capture of non-target species and high discard rates, are a pressing concern in today's fishing industry (Sokolova *et al.*, 2021; Tiralongo *et al.*, 2021). In general bycatch can be defined as anything that incidentally come into the fishing net such as non-targeted commercially important fishes, juvenile fishes, trash fishes and mammals, whereas discard is the part of bycatch that thrown back to the sea due to the poor market value and legal prohibition (Alverson *et al.*, 1994; Hall, 1996). Overfishing and fishery bycatch challenge our ability to develop sustainable management and conservation plans to maintain a healthy ecosystem, as it significantly affects the non-target resources, biodiversity, ecosystem function, and the habitat (Pauly *et al.*, 2001; Bijukumar and Deepthi, 2009; Dineshbabu *et al.*, 2016).

Bycatch and discard is a pressing issue in the world's fisheries and significantly affect the non-target species, biodiversity, ecosystem function and the habitat (Pauly *et al.*, 2001; Bijukumar and Deepthi, 2009; Bhagirathan *et al.*, 2014; Dineshbabu *et al.*, 2016). Bycatch particularly comprising of juveniles pose a serious ecological impact, affecting the long-term sustainability of the resources by growth overfishing, decrease the fish catch and reduced economic return to fishery (Dineshbabu and Radhakrishnan, 2009; Dineshbabu *et al.*, 2014; Mahesh *et al.*, 2019).

The trawl fishery contributes a relatively higher proportion of bycatch (Andrew and Pepperell, 1992; Tonks *et al.*, 2008; Samanta *et al.*, 2018) due to the sweeping capture of non-target fishery resources and it is estimated to be about 27% of global bycatch discards (Fennessy and

Groeneveld, 1997; Kelleher, 2004; Eayrs, 2007). In India several attempts have been carried out to study on trawl bycatch (Gordon, 1991; Sujatha, 1995, 1996, 2005; Pravin and Manoharadoss, 1996; Pillai, 1998; Rao, 1998; Kurup *et al.*, 2003, 2004; Dixitulu, 2004; Jagadis *et al.*, 2004; Bijukumar and Deepthi, 2006, 2009; Zacharia *et al.*, 2006; Boopendranath, 2007, 2009; Boopendranath *et al.*, 2008).

The higher diversity of species is the main cause of the higher magnitude of discards found in tropical waters (Gibinkumar *et al.*, 2012). With the decline of the certain target species catch, the bycatch began to contribute significantly to the overall income of the trawlers. It is important to note that among the bycatch, about 40% consisted of juveniles and those in the early stages of development which are invariably discarded leading to the depletion of the resources (Pillai, 1998). Along the east coast of India, especially in Karaikal - a region in the Puducherry Union Territory, most of the bycatch caught is landed and utilized for fish oil, fish meal and manure production.

However, species-specific data is not available for the species in the bycatch in many parts of the world. The lack of species-specific data of these by caught fishes hinders fisheries management initiatives (Bornatowski *et al.*, 2013). Further, the poor management of bycatch results in large undocumented biomass removal (Davies *et al.*, 2009), and may lead to the depletion of the resources and have destructive effects on biodiversity (Alverson and Hughes, 1996). In this investigation, an attempt was made to study the various fauna in the trawl fishery landings of Karaikal fishing harbour, southeast coast of India, which will form the base line data to formulate conservation strategies in and around that area.

Materials and Methods

The present study was conducted in the Karaikal Fishing Harbour, situated on the south east coast of India (Latitude 10° 16'N and Longitude 79° 51'E) in Karaikal District of Puducherry Union

Territory, India. In Karaikal Fishing harbour 260 Mechanised Fishing Boats are operating and these boats carry out trawl operations operate from Krishna district of Andhra Pradesh to Ramnad district of Tamil Nadu. The bycatch in the landings were studied from April 2022 to March 2023. The fish catch data was collected from 10% of the total number of trawl boats for 16 days in a month by adopting the random sampling design developed by ICAR-CMFRI (2016). The collected fishes were preserved in 10% neutralized formalin and the specimens were examined for the various morphological characters for identification. Standard manuals were followed for identification of fin fishes, shell fishes and molluscs (Fischer and Bianchi, 1984; Nelson, 1994; De Bruin *et al.*, 1995; Froese and Pauly, 2023; WoRMS, 2023).

Results and Discussion

During the period of study, 295 species were identified in the trawl catch, in the landings of Karaikal fishing harbour (Table 1). The catch included 199 species of finfishes, 11 species of shrimps, 4 species of lobsters, 2 species of stomatopods, 14 species of crabs, 10 species of cephalopods, 46 species of molluscan shells, 7 species of echinoderms and 2 species of jelly fishes.

Among the bycatch the details of number of order, family genus and species is presented in Table 2. 199 species of fishes belonging to 12 orders and 55 families and 114 genera were identified. 11 shrimp species belonging to single order 3 families and 7 genus and 13 crab species belonging to 5 families have been identified. Two stomatopod species belonging to single order and single family and ten cephalopod species belonging to 3 orders and 3 families were identified. Other molluscan species belonged to 22 families and jellyfishes belonged to 2 families were also recorded in the study.

The marine fisheries sector of India has witnessed remarkable changes during the last five decades in terms of a remarkable growth in fish landings, principally, owing to the introduction of

mechanized fishing vessels such as trawler (Dineshbabu, 2012; Dineshbabu *et al.*, 2016; Vivekanandan, 2022). The widespread adoption of trawling has resulted in increased marine fish production and in India, trawlers have contributed major portion of the total marine fish production (Srinath, 2003). In recent years due to its irrational operation, trawl fishery became a major human caused physical and ecological disturbance of the continental shelves of this entire world leading to physical destruction of marine ecosystems (Jennings and Kaiser, 1998). The widespread combing operation of the trawling in the sea bottom is causing widespread damage to marine resources and it warrants a serious regulation in fishing so that fish production can be made sustainable. Bycatch and discarding from trawlers is of serious concern throughout the world and widespread studies are carried out to understand its impact on the structure of marine communities and/or ecosystems (Alverson *et al.*, 1994).

Though, India has a large fleet of trawlers operating in its coastal waters with a significant proportion targeting the commercial fishes (CMFRI, 2019), information on the rates of bycatch and discards with fine details of its spatial and seasonal variability which is very essential for judicious exploitation is scanty from the region (Azeez *et al.*, 2021). Bycatch and discarding from trawlers is of serious concern throughout the world and widespread studies are carried out to understand its effect on the structure of marine communities and ecosystems (Alverson *et al.*, 1994). There were many researches to estimate the bycatch from trawlers in different parts of the country at different occasions.

Due to the high species diversity coexisting in the same habitat, tropical countries like India face an acute problem of bycatch and consequent discards in the fishery (George *et al.*, 1981; Eayrs, 2007; Dineshbabu and Radhakrishnan, 2009; Dineshbabu *et al.*, 2010; Brown, 2014). Bycatch and discards are known to have a strong implication on the stock dynamics of the non-

Table 1: List of species noted in trawl bycatch in the landings of Karaikal Fishing Harbour

S. No.	Species	Order	Family	
FINFISHES				
1	<i>Dasyatis kuhlii</i> (Muller & Henle, 1841)	Rajiformes	Dasyatidae	
2	<i>Dasyatis zugei</i> (Müller & Henle, 1841)			
3	<i>Himantura bleekeri</i> (Blyth, 1860)			
4	<i>Himantura gerrardi</i> (Gray, 1851)			
5	<i>Himantura uarnak</i> (Forsskal, 1775)		Myliobatidae	
6	<i>Aetobatus flagellum</i> (Bloch & Schneider, 1801)			
7	<i>Aetobatus narinari</i> (Euphrasen, 1790)			
8	<i>Aetomylaeus nichofii</i> (Bloch & Schneider, 1801)			
9	<i>Carcharhinus hemiodon</i> (Müller & Henle, 1839)	Carcharhiniformes	Carcharhinidae	
10	<i>Carcharhinus limbatus</i> (Müller & Henle, 1839)			
11	<i>Rhizoprionodon acutus</i> (Ruppell, 1837)			
12	<i>Scoliodon laticaudus</i> Muller & Henle, 1838		Sphyrnidae	
13	<i>Eusphyrna blochii</i> (Cuvier, 1816)			
14	<i>Sphyrna zygaena</i> (Linnaeus, 1758)			
15	<i>Uroconger lepturus</i> (Richardson, 1845)	Anguilliformes	Congridae	
16	<i>Congresox talabonoides</i> (Bleeker, 1853)		Muraenesocidae	
17	<i>Chirocentrus dorab</i> (Forsskal, 1775)	Clupeiformes	Chirocentridae	
18	<i>Chirocentrus nudus</i> (Swainson, 1839)			
19	<i>Anodontostoma chacunda</i> (Hamilton, 1822)		Clupeidae	
20	<i>Dussumieria acuta</i> Valenciennes, 1847			
21	<i>Escualosa thoracata</i> (Valenciennes, 1847)			
22	<i>Opisthopterus tardoore</i> (Cuvier, 1829)			
23	<i>Sardinella albella</i> (Valenciennes, 1847)			
24	<i>Sardinella fimbriata</i> (Valenciennes, 1847)			
25	<i>Sardinella gibbosa</i> (Bleeker, 1849)			
26	<i>Sardinella longiceps</i> Valenciennes, 1847			
27	<i>Ilisha elongate</i> (Anonymous [Bennett], 1830)			Pristigasteridae
28	<i>Ilisha filigera</i> (Valenciennes, 1847)			
29	<i>Opisthopterus tardoore</i> (Cuvier, 1829)			
30	<i>Pellona ditchella</i> Valenciennes, 1847			
31	<i>Raconda russeliana</i> Gray, 1831			
32	<i>Encrasicholina devisi</i> (Whitley, 1940)			
33	<i>Encrasicholina heteroloba</i> (Ruppell, 1837)			
34	<i>Encrasicholina punctifer</i> Fowler, 1938			
35	<i>Setipinna taty</i> (Valenciennes, 1848)			
36	<i>Stolephorus commersonii</i> Lacepede, 1803		Engraulidae	
37	<i>Stolephorus indicus</i> (van Hasselt, 1823)			
38	<i>Stolephorus insularis</i> Hardenberg, 1933			

39	<i>Stolephorus waitei</i> Jordan & Seale, 1926			
40	<i>Thryssa dussumieri</i> (Valenciennes, 1848)			
41	<i>Thryssa malabarica</i> (Bloch, 1795)			
42	<i>Thryssa mystax</i> (Bloch & Schneider, 1801)			
43	<i>Thryssa purava</i> (Hamilton, 1822)			
44	<i>Thryssa setirostris</i> (Broussonet, 1782)			
45	<i>Arius arius</i> (Hamilton, 1822)	Siluriformes	Ariidae	
46	<i>Arius dussumieri</i> Valenciennes, 1840			
47	<i>Arius jella</i> Day, 1877			
48	<i>Arius maculatus</i> (Thunberg, 1792)			
49	<i>Arius sona</i> (Hamilton, 1822)			
50	<i>Arius thalasinus</i> (Ruppell, 1837)		Plotosidae	
51	<i>Plotosus canius</i> Hamilton, 1822			
52	<i>Plotosus lineatus</i> (Thunberg, 1787)			
53	<i>Saurida tumbil</i> (Bloch, 1795)		Synodontidae	
54	<i>Saurida undosquamis</i> (Richardson, 1848)			
55	<i>Fistularia petimba</i> Lacepede, 1803	Syngnathiformes	Fistularidae	
56	<i>Pterois russelii</i> (Bennett, 1831)	Scorpaeniformes	Scorpaenidae	
57	<i>Pterois volitans</i> (Linnaeus, 1758)			
58	<i>Cociella crocodilus</i> (Tilesius, 1812)		Platycephalidae	
59	<i>Grammoplites scaber</i> (Linnaeus, 1758)			
60	<i>Platycephalus indicus</i> (Linnaeus, 1758)			
61	<i>Dactyloptena macracantha</i> (Bleeker, 1854)		Dactylopteridae	
62	<i>Myripristis melanostictus</i> Bleeker, 1863	Beryciformes	Holocentridae	
63	<i>Sargocentron rubrum</i> (Forsskål, 1775)			
64	<i>Pelates quadrilineatus</i> (Bloch, 1790)		Teraponidae	
65	<i>Terapon jarbua</i> (Forsskal, 1775)			
66	<i>Terapon puta</i> Cuvier, 1829			
67	<i>Terapon theraps</i> Cuvier, 1829		Serranidae	
68	<i>Cephalopholis formosa</i> (Shaw, 1812)			
69	<i>Cephalopholis sonnerati</i> (Valenciennes, 1828)			
70	<i>Epinephelus areolatus</i> (Forsskal, 1775)			
71	<i>Epinephelus diacanthus</i> (Valenciennes, 1828)			
72	<i>Epinephelus latifasciatus</i> (Temminck & Schlegel, 1842)			
73	<i>Epinephelus merra</i> Bloch, 1793			
74	<i>Epinephelus tauvina</i> (Forsskal, 1775)			
75	<i>Priacanthus hamrur</i> (Forsskal, 1775)			Priacanthidae
76	<i>Apogon aureus</i> (Lacepede, 1802)			Apogonidae
77	<i>Apogon fasciatus</i> (White, 1790)			
78	<i>Diagramma pictum</i> (Thunberg, 1792)		Haemulidae	
79	<i>Plectorhinchus lineatus</i> (Linnaeus, 1758)			
80	<i>Pomadasys kaakan</i> (Cuvier, 1830)			

81	<i>Pomadasys maculatum</i> (Bloch, 1793)	
82	<i>Lutjanus malabaricus</i> (Bloch & Schneider, 1801)	Lutjanidae
83	<i>Lutjanus argentimaculatus</i> (Forsskal, 1775)	
84	<i>Lutjanus fulviflamma</i> (Forsskål, 1775)	
85	<i>Lutjanus kasmira</i> (Forsskål, 1775)	
86	<i>Lutjanus lutjanus</i> Bloch, 1790	
87	<i>Lutjanus rivulatus</i> (Cuvier, 1828)	
88	<i>Pinjalo pinjalo</i> (Bleeker, 1850)	
89	<i>Gymnocranius elongates</i> Senta, 1973	Lethrinidae
90	<i>Lethrinus nebulosus</i> (Forsskal, 1775)	
91	<i>Lethrinus elongatus</i> Valenciennes, 1830	
92	<i>Lethrinus lentjan</i> (Lacepède, 1802)	
93	<i>Lethrinus mahsena</i> (Forsskål, 1775)	Nemipteridae
94	<i>Nemipterus japonicus</i> (Bloch, 1791)	
95	<i>Parascolopsis inermis</i> (Temminck & Schlegel, 1843)	
96	<i>Scolopsis bimaculata</i> Rüppell, 1828	Gerreidae
97	<i>Gerres abbreviatus</i> Bleeker, 1850	
98	<i>Gerres filamentosus</i> (Cuvier, 1829)	
99	<i>Gerres oblongus</i> Cuvier, 1830	
100	<i>Gerres oyena</i> (Forsskal, 1775)	
101	<i>Pentaprion longimanus</i> (Cantor, 1849)	Mullidae
102	<i>Upeneus sulphureus</i> (Cuvier, 1829)	
103	<i>Upeneus tragula</i> (Richardson, 1846)	
104	<i>Upeneus vittatus</i> (Forsskal, 1775)	Sillaginidae
105	<i>Sillago sihama</i> (Forsskal, 1775)	Lactariidae
106	<i>Lactarius lactarius</i> [Bloch & Schneider, 1801]	Sciaenidae
107	<i>Johnius amblycephalus</i> (Bleeker, 1855)	
108	<i>Johnius carouna</i> (Cuvier, 1830)	
109	<i>Johnius carutta</i> Bloch, 1793	
110	<i>Johnius dussumieri</i> (Cuvier, 1830)	
111	<i>Johnius elongatus</i> (Bowdich, 1825)	
112	<i>Kathala axillaris</i> (Cuvier, 1830)	
113	<i>Nibea maculata</i> (Bloch & Schneider, 1801)	
114	<i>Otolithes cuvieri</i> Trewavas, 1974	
115	<i>Otolithes ruber</i> (Bloch & Schneider, 1801)	
116	<i>Otolithoides biauritus</i> (Cantor, 1849)	
117	<i>Protonibea diacanthus</i> (Lacepede, 1802)	
118	<i>Gazza minuta</i> (Bloch, 1795)	
119	<i>Leiognathus bindus</i> (Valenciennes, 1835)	
120	<i>Leiognathus brevirostris</i> (Valenciennes, 1835)	
121	<i>Leiognathus daura</i> (Cuvier, 1829)	
122	<i>Leiognathus dussumieri</i> (Valenciennes, 1835)	

123	<i>Leiognathus elongatus</i> (Gunther, 1874)	Perciformes	Leiognathidae
124	<i>Leiognathus equulus</i> (Forsskal, 1775)		
125	<i>Leiognathus splendens</i> (Cuvier, 1829)		
126	<i>Secutor insidiator</i> (Bloch, 1787)		
127	<i>Secutor ruconius</i> (Hamilton, 1822)		
128	<i>Alectis ciliaris</i> (Bloch, 1787)		
129	<i>Alectis indicus</i> (Ruppell, 1830)		
130	<i>Alepes djedaba</i> (Forsskal, 1775)		
131	<i>Alepes kleinii</i> (Bloch, 1793)		
132	<i>Atropus atropus</i> (Bloch & Schneider, 1801)		
133	<i>Atule mate</i> (Cuvier, 1833)		
134	<i>Carangoides armatus</i> (Ruppell, 1830)		
135	<i>Carangoides malabaricus</i> (Bloch & Schneider, 1801)		
136	<i>Carangoides oblongus</i> (Cuvier, 1833)		
137	<i>Caranx ignobilis</i> (Forsskal, 1775)		
138	<i>Caranx sexfasciatus</i> Quoy & Gaimard, 1825		
139	<i>Decapterus russelli</i> (Ruppell, 1830)	Carangidae	
140	<i>Gnathanodon speciosus</i> (Forsskal, 1775)		
141	<i>Megalaspis cordyla</i> (Linnaeus, 1758)		
142	<i>Parastromateus niger</i> (Bloch, 1795)		
143	<i>Scomberoides lysan</i> (Forsskal, 1775)		
144	<i>Scomberoides tala</i> (Cuvier, 1832)		
145	<i>Scomberoides tol</i> (Cuvier, 1832)		
146	<i>Selar crumenophthalmus</i> (Bloch, 1793)		
147	<i>Trachinotus blochii</i> (Lacepede, 1801)		
148	<i>Uraspis uraspis</i> (Gunther, 1860)		
149	<i>Eleutheronema tetradactylum</i> (Shaw, 1804)	Polynemidae	
150	<i>Filimanus similis</i> Feltes, 1991		
151	<i>Polynemus indicus</i> Shaw, 1804		
152	<i>Polydactylus sexfilis</i> (Valenciennes, 1831)	Sphyraenidae	
153	<i>Sphyraena barracuda</i> (Walbaum, 1792)		
154	<i>Sphyraena forsteri</i> Cuvier, 1829		
155	<i>Sphyraena jella</i> Cuvier, 1829		
156	<i>Sphyraena obtusata</i> Cuvier, 1829	Gobiidae	
157	<i>Trypauchen vagina</i> (Bloch & Schneider, 1801)		
158	<i>Lepturacanthus savala</i> (Cuvier, 1829)	Trichiuridae	
159	<i>Trichiurus lepturus</i> Linnaeus, 1758		
160	<i>Pampus argenteus</i> (Euphrasen, 1788)	Stromateidae	
161	<i>Pampus chinensis</i> (Euphrasen, 1788)		
162	<i>Ambassis ambassis</i> (Lacepede, 1802)	Ambassidae	
163	<i>Ambassis commersonii</i> Cuvier, 1828		
164	<i>Ambassis gymnocephalus</i> (Lacepede, 1802)		

165	<i>Liza parsia</i> (Hamilton, 1822)		
166	<i>Liza tade</i> (Forsskal, 1775)		Mugilidae
167	<i>Mugil cephalus</i> Linnaeus, 1758		
168	<i>Valamugil speigleri</i> (Bleeker, 1858)		
169	<i>Mene maculata</i> (Bloch & Schneider, 1801)		Menidae
170	<i>Scatophagus argus</i> (Linnaeus, 1766)		Scatophagidae
171	<i>Acanthocybium solandri</i> (Cuvier, 1832)		
172	<i>Euthynnus affinis</i> (Cantor, 1849)		
173	<i>Rastrelliger kanagurta</i> (Cuvier, 1816)		
174	<i>Scomberomorus commerson</i> (Lacepede, 1800)		Scombridae
175	<i>Scomberomorus guttatus</i> (Bloch & Schneider, 1801)		
176	<i>Scomberomorus lineolatus</i> (Cuvier, 1829)		
177	<i>Siganus canaliculatus</i> (Park, 1797)		
178	<i>Siganus javus</i> (Linnaeus, 1766)		Siganidae
179	<i>Acanthurus mata</i> (Cuvier, 1829)		Acanthuridae
180	<i>Uranoscopus marmoratus</i> Cuvier, 1829		Uranoscopidae
181	<i>Drepane punctata</i> (Linnaeus, 1758)		Drepaneidae
182	<i>Pempheris mangula</i> Cuvier, 1829		
183	<i>Pempheris oualensis</i> Cuvier, 1831		Pempheridae
184	<i>Hyporhamphus dussumieri</i> (Valenciennes, 1847)	Beloniformes	Hemirhamphidae
185	<i>Rhynchorhamphus georgii</i> (Valenciennes, 1847)		
186	<i>Cynoglossus arel</i> (Schneider, 1801)		
187	<i>Cynoglossus bilineatus</i> (Lacepede, 1802)		
188	<i>Cynoglossus puncticeps</i> (Richardson, 1846)		Cynoglossidae
189	<i>Cynoglossus lingua</i> Hamilton, 1822	Pleuronectiformes	
190	<i>Zebrias quagga</i> (Kaup, 1858)		Soleidae
191	<i>Pseudorhombus arsius</i> (Hamilton, 1822)		Paralichthyidae
192	<i>Triacanthus biaculeatus</i> (Bloch, 1786)		
193	<i>Triacanthus nieuhofii</i> Bleeker, 1852		Triacanthidae
194	<i>Pseudotriacanthus strigilifer</i> (Cantor, 1849)		
195	<i>Cylichthys orbicularis</i> (Boch, 1785)		
196	<i>Diodon hystrix</i> Linnaeus, 1758	Tetraodontiformes	Diodontidae
197	<i>Lagocephalus inermis</i> (Temminck & Schlegel, 1850)		
198	<i>Lagocephalus spadiceus</i> (Richardson, 1845)		
199	<i>Chelonodon patoca</i> (Hamilton, 1822)		Tetraodontidae
SHRIMPS			
200	<i>Fenneropenaeus indicus</i> (H. Milne Edwards, 1837)		
201	<i>Metapenaeus monoceros</i> (Fabricius, 1798)		
202	<i>Metapenaeus affinis</i> (H. Milne Edwards, 1837)		
203	<i>Metapenaeus dobsoni</i> (Miers, 1878)		
204	<i>Parapenaeopsis stylifera</i> (H. Milne Edwards, 1837)		
205	<i>Penaeus indicus</i> (H. Milne Edwards, 1837)		Penaeidae

206	<i>Penaeus monodon</i> (Fabricius, 1798)	Decapoda		
207	<i>Penaeus semisulcatus</i> (De Hann, 1844)			
208	<i>Trachypenaeus curvirostris</i> (Stimpson, 1860)			
209	<i>Acetes indicus</i> H. Milne Edwards, 1830			Sergestidae
210	<i>Alpheus malabaricus</i> (Fabricius, 1775)			Alphidae
LOBSTERS				
211	<i>Palinurus homarus</i> (Linnaeus, 1758)	Decapoda	Palinuridae	
212	<i>Palinurus ornatus</i> Fabricius, 1798			
213	<i>Puerulus sewelli</i> Ramadan, 1938			
214	<i>Thenus orientalis</i> (Lund, 1793)			Scyllaridae
CRABS				
215	<i>Philyra scabriuscula</i> (Fabricius, 1798)	Decapoda	Lucosidae	
216	<i>Calappa lophos</i> (Herbst, 1782)		Calappidae	
217	<i>Charybdis feriatus</i> (Linnaeus, 1758)		Portunidae	
218	<i>Charybdis lucifera</i> (Fabricius, 1798)			
219	<i>Charybdis natator</i> (Herbst, 1789)			
220	<i>Podophthalmus vigil</i> (Fabricius, 1798)			
221	<i>Portunus pelagicus</i> (Linnaeus, 1766)			
222	<i>Portunus sanguinolentus</i> (Herbst, 1783)			
223	<i>Scylla serrata</i> (Forskål, 1775)			
224	<i>Scylla tranquebarica</i> (Fabricius, 1798)			
225	<i>Ashtoret lunaris</i> (Forskål, 1775)			Matutidae
226	<i>Matuta planipes</i> Fabricius, 1798			Epiplatidae
227	<i>Doclea ovis</i> (Fabricius, 1787)			
228	<i>Doclea rissoni</i> Leach, 1815			
STOMATOPODS				
229	<i>Oratosquilla nepa</i> (Latreille, 1828)	Stomatopoda	Squillidae	
230	<i>Squilla maculata</i> Fabricius, 1793			
CEPHALOPODS				
231	<i>Sepia aculeata</i> Van Hasselt, 1835	Sepiida	Sepiidae	
232	<i>Sepia pharaonis</i> Ehrenberg, 1831			
233	<i>Sepiella inermi</i> (Van Hasselt, 1835)			
234	<i>Doryteuthis singhalensis</i> (Ortmann, 1891)	Teuthida	Loliginidae	
235	<i>Uroteuthis duvaucelii</i> (d'Orbigny, 1835)			
236	<i>Amphioctopus aegina</i> (Gray, 1849)	Octopoda	Octopodidae	
237	<i>Amphioctopus membranaceus</i> (Quoy & Gaimard, 1832)			
238	<i>Cistopus indicus</i> (Rapp, 1835)			
239	<i>Octopus globosus</i> Appelöf, 1886			
240	<i>Octopus vulgaris</i> Cuvier, 1797			
SHELLS				
241	<i>Anadara (Cunearca) rhombea</i> Born, 1780			
242	<i>Anadara granosa</i> (Linnaeus, 1758)			

243	<i>Barbatia bistrigata</i> Dunker, 1866	Arcoida	Arcidae
244	<i>Scapharca inaequalis</i> (Bruguiere, 1789)		
245	<i>Trisidos tortuosa</i> (Linnaeus, 1758)		
246	<i>Babylonia spirata</i> (Linnaeus, 1758)	Neogastropoda	Babyloniidae
247	<i>Babylonia zeylanica</i> (Bruguiere, 1789)		Buccinidae
248	<i>Cantharus spiralis</i> Gray, 1839		Turridae
249	<i>Lophiotoma indica</i> (Roding, 1798)		
250	<i>Turricula javana</i> (Lamarck, 1816)		
251	<i>Turris amicta</i> (E.A. Smith, 1877)		Harpidae
252	<i>Harpa major</i> Roding, 1798		Clavatulidae
253	<i>Clavatula virgineus</i> (Dillwyn, 1817)		Muricidae
254	<i>Murex carbonnieri</i> (Jousseau, 1881)		
255	<i>Rapana bulbosa</i> (Solander, 1817)		
256	<i>Rapana rapiformis</i> (Born, 1778)		Fasciariidae
257	<i>Fusinus nicobaricus</i> (Röding, 1798)		
258	<i>Fusinus colus</i> (Linnaeus, 1758)		
259	<i>Fusinus salisburyi</i> Fulton, 1930		Melongenidae
260	<i>Hemifusus pugilinus</i> (Born, 1778)		
261	<i>Pugilina cochlidium</i> (Linnaeus, 1758)		
262	<i>Bufonaria echinata</i> (Link, 1807)	Littorinimorpha	Bursidae
263	<i>Ficus ficus</i> (Linnaeus, 1758)		Ficidae
264	<i>Ficus gracilis</i> (G.B. Sowerby I, 1825)		Naticidae
265	<i>Glossaulax didyma</i> (Röding, 1798)		
266	<i>Natica lineata</i> Lamarck, 1838		
267	<i>Natica vitellus</i> (Linnaeus, 1758)		Cassidae
268	<i>Phalium canaliculatum</i> Bruguiere, 1792		Rostellariidae
269	<i>Semicassis bisulcata</i> (Schubert & Wagner, 1829)		
270	<i>Strombus plicatus</i> Sowerby, 1842		
271	<i>Tibia curta</i> (G.B. Sowerby II, 1842)		Tonnidae
272	<i>Tona dolium</i> (Linnaeus, 1758)	Veneroida	Veneridae
273	<i>Dosinia cretacea</i> (Reeve, 1851)		
274	<i>Marcia opima</i> (Gmelin, 1791)		
275	<i>Meretrix casta</i> (Chemnitz, 1782)		
276	<i>Meretrix meretrix</i> (Linnaeus, 1758)		
277	<i>Paphia malabarica</i> (Chemnitz, 1782)		
278	<i>Paphia textile</i> (Gmelin, 1791)		
279	<i>Sunetta scripta</i> (Linnaeus, 1758)	Donacidae	
280	<i>Donax scortum</i> (Linnaeus, 1758)		
281	<i>Pholas orientalis</i> Gmelin, 1791	Myoida	Pholadidae
282	<i>Cardium flavum</i> Linnaeus, 1758		Cardiidae
283	<i>Turritella acropora</i> (Dall, 1889)	Caenogastropoda	Turritellidae
284	<i>Turritella acutangula</i> (Linnaeus, 1758)		

285	<i>Turritella attenuata</i> Reeve, 1849		
286	<i>Umbonium vestiarius</i> (Linnaeus, 1758)	Archaeogastropoda	Trochidae
ECHINODERMS			
287	<i>Asterias aranciata</i> Parelus, 1768	Paxillosida	Astropectinidae
288	<i>Astropecten aranciatus</i> (Linnaeus, 1758)		
289	<i>Astropecten indicus</i> (Doderlein, 1888)		
290	<i>Astropecten irregularis</i> (Pennant, 1777)		
291	<i>Laganum depressum</i> Lesson, 1841	Clypeasteroidea	Laganidae
292	<i>Laganum decagonale</i> (Blainville, 1827)		
293	<i>Laganum laganum</i> (Leske, 1778)		
JELLY FISH			
294	<i>Crambionella stuhlmanni</i> (Chun, 1896)	Rhizostomeae	Catostylidae
295	<i>Aurelia solida</i> Browne, 1905	Semaeostomeae	Ulmaridae

Table 2: Diversity of trawl bycatch landings in Karaikal Fishing Harbour

S. No.	Bycatch	Order	Family	Genus	Species
1	Finfishes	12	55	114	199
2	Shrimps	1	3	7	11
3	Lobsters	1	2	3	4
4	Crabs	1	5	9	14
5	Stomatopods	1	1	2	2
6	Cephalopods	3	3	6	10
7	Shells	7	21	35	46
8	Echinoderms	2	2	3	7
9	Jelly Fish	2	2	2	2
Total		30	94	181	295

targeted resources as well as the food web (Dineshbabu and Radhakrishnan, 2009; Bijukumar and Deepthi, 2009; Mahesh *et al.*, 2019). The use of smaller cod end mesh size (25–35 mm) as against the recommended cod end mesh size for trawlers is in India of 40 mm (Rajeswari *et al.*, 2013) is also one of the main reason for higher rate of bycatch and discard.

Alverson *et al.* (1994) have discussed about various approaches for reducing bycatch and discard from fishery. These devices include juvenile fish excluder (Chokesanguan *et al.*, 2000),

square mesh net (Broadhurst and Kennely, 1994; Kunjipalu *et al.*, 1994), Radial Escapement Device (RED) (Robins *et al.*, 1999; Pillai *et al.*, 2003), Sieve net Bycatch Reduction Device, Separator Panel Bycatch Reduction Device and Bigeye Bycatch Reduction Device (Boopendranath *et al.*, 2008), Turtle Excluder Devices (Mitchell *et al.*, 1995; Dawson and Boopendranath, 2001), etc. These have been developed to reduce bycatch of non-target fishes, juvenile fishes and other animals in trawl fishery. The another important method of reducing bycatch is mesh size

regulation and the same is being incorporated in most of the maritime states' Marine Fisheries Regulation Acts, but these are not enforced in a stringent manner (Boopendranath, 2009). Therefore, effective control of bycatch and discards in trawl fishery need to be developed. Further, at present there is no comprehensive mechanism to collect data from the trawlers about the bycatch as most of the owners of the trawlers tend to hide information on the bycatch. The researchers often have to depend upon the results based on the information received from sampling boats in participatory programmes (Dineshbabu *et al.*, 2016), experimental trawling (Behera *et al.*, 2021) and selected trawler operators willing to share data (Pramod, 2010).

In Asia, the aquaculture industry is growing in an alarming rate and has resulted in increased fish meal production and therefore the discards from trawlers have been found to be reducing and trash landing is increasing. Trawlers generally discard non-commercial species (Van Beek, 1998) but as there is an increasing demand for raw material for feed industries the percentage of discards has come down significantly and bycatch from trawl fishery is used widely to feed livestock/fish, either directly or through reduction to fish meal/oil (Simon *et al.*, 2005). In the present study area also, the major quantity of the bycatch is supplied to the fish meal/oil industries only. Without better community awareness and bottom-up approach, the management of bycatch in any area would be challenging, as the coastal communities depend heavily on these fishes for the livelihood security. The present study has revealed base line information on the species-specific data of trawl fishery landings of Karaikal Fishing Harbour. Strict enforcement of mesh size regulation, enactment of regulations for installing bycatch reduction devices in trawl nets, sensitization of the fishers on the deleterious effects of trawl bycatch could be the better solution to this issue.

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