*Fishery Technology* 49 (2012) : 132 - 140

# Bycatch Characterization of Shrimp Trawl Landings off Southwest Coast of India

**T.R. Gibinkumar[1]*, S. Sabu[2], P. Pravin and M.R. Boopendranath**
*Central Institute of Fisheries Technology, P.O. Matsyapuri, Cochin-682 029, India*

## Abstract

Bycatch and discards are common and pernicious problems faced by all fisheries globally. It is recognized as unavoidable in any kind of fishing but the quantity varies according to the gear operated. In tropical countries like India, bycatch issue is more complex due to the multi-species and multi-gear nature of the fisheries. Among the different fishing gears, trawling accounts for a higher rate of bycatch, due to comparatively low selectivity of the gear. A study was conducted during 2004 to 2006 using shrimp trawl in the traditional trawling grounds off Cochin in the southwest coast of India to reveal the quality, quantity and monthly variations of bycatch generated by trawlers. Mean monthly bycatch generated by shrimp trawling off Cochin ranged from 1.14 to 38.64 kg $h^{-1}$, in different months with an overall average of 12.85±1.97 (SE, n=12) kg $h^{-1}$. Shrimp-bycatch ratio ranged from 1:0.6 to 1:6908, during different months. The study identified 281 species including juveniles of commercially important fishes and shellfishes from the shrimp trawl bycatch.

**Keywords:** Trawling, bycatch characterization, southwest coast of India

Received 19 December 2011; Revised 10 May 2012; Accepted 14 May 2012

1 *Present address: Marine Products Export Development Authority, Sub Regional Office, Guwahati-781 003, India*

2 *Present address: Central Institute of Fisheries Nautical and Engineering Training, Fine Arts Avenue, Cochin-682 016, India*

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

## Introduction

Bycatch taken by the shrimp trawl fishery is an important issue in the management of fisheries resources given the perceived high mortality of the different fish stocks other than shrimp. In tropical countries like India, bycatch issue is more complex due to the multi-species and multi-gear nature of the fisheries. The changing perspective of bycatch itself offers the greatest challenge, as yesterday's bycatch becomes today's target catch (Boyce, 1996). Quantum of bycatch landed or discarded may depend on factors affecting selectivity of trawl such as codend mesh size, mesh sizes of the wings and belly sections, vertical opening of the trawl mouth, ground rope rigging and bottom contact, overall length of the trawl, otter boards and bridle arrangements, speed and duration of tow, trip duration (single-day or multi-day fishing), storage and preservation facilities available onboard, variation in seasonal abundance of bycatch species and juveniles and variations in export and domestic market demands for target and bycatch species (Boopendranath et al., 2008).

Studies on trawl bycatch has been attempted by several authors in India (Gordon,1991; Sujatha, 1995; 1996; 2005; Pravin & Manoharadoss, 1996; Pillai, 1998; Rao,1998; Kurup et al., 2003; 2004; Dixitulu, 2004; Jagadis et al., 2004; Bijukumar & Deepthi, 2006; 2009; Zacharia et al., 2006; Boopendranath, 2007; 2009; Boopendranath et al., 2008). In Kerala state (India), quantity of discards was estimated at 262 000 t during 2000-2001 and 225 000 t during 2001-2002 (Kurup et al., 2003; 2004). Mean trophic level index of fish fauna associated with trawl bycatch of Kerala has been reported by Bijukumar & Deepthi (2009). The diversity of species is the main cause of the higher magnitude of discards found in tropical waters. With the decline of the shrimp catch, the bycatch began to contribute significantly to the overall income of the shrimp

trawlers. Along the west coast of India, especially in Gujarat, most of the bycatch caught is landed and utilized for fish meal and manure production. It is significant 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). In this study, an attempt is made to characterize the bycatch generated during shrimp trawling to find out seasonal variations in the proportions of shrimps and bycatch, off Cochin, southwest coast of India.

## Materials and Methods

Bycatch samples were collected from the traditional trawling areas in coastal waters off Cochin, southwest coast of India, at a depth ranging between 9 and 32 m. A shrimp trawl of 29.0 m head rope with 20 mm diamond mesh codend, rigged with V-type steel otter boards of size 1420x790 mm (80 kg each) and 20 m double bridles were used for experimental fishing. The gear was operated from the research vessels of Central Institute of Fisheries Technology (Cochin), during April 2004 to December 2006, with trawling duration varying from 0.75 to 2.0 h and a total of 690 hauls were taken. The catch from individual hauls was examined separately and was categorized into target catch (shrimps) and non-target catch or bycatch which included all species other than shrimps. The catch was identified up to species level using Fischer & Bianchi (1984) and Roper et al. (1984), and the taxonomic information was verified using Appeltans et al. (2011), Froese & Pauly (2011) and NIO (2011), and weight of each species was recorded to the nearest g. In the case of mixed catches of small-sized fishes with catch volume exceeding 2 kg, species-wise weight was estimated from a random sub-sample of not less than 1 kg. Mean CPUE based on pooled monthly catch data was used for statistical analysis.

## Results and Discussion

During the period of study, 281 species were encountered in the trawl catch, off southwest coast of India (Table 1). The catch included 191 species of fishes, 11 species of shrimps, 3 species of lobsters, 13 species of crabs, 11 species of cephalopods, 44 species of molluscan shells, 2 species of echinoderms, 2 species of jelly fishes, 2 species of stomatopods and one species each of sea snake and sea turtle. One hundred and ninety-one species of

Table 1. List of species occurring in trawl bycatch off Cochin

**FINFISHES**

Order : **RAJIFORMES**

Family : **Dasyatidae**

1. *Dasyatis kuhlii* (Muller & Henle, 1841)
2. *Himantura bleekeri* (Blyth, 1860)
3. *Himantura uarnak* (Forsskal, 1775)
4. *Himantura gerrardi* (Gray, 1851)

Family : **Myliobatidae**

5. *Aetobatus narinari* (Euphrasen, 1790)

Order : **CARCHARHINIFORMES**

Family : **Carcharhinidae**

6. *Rhizoprionodon acutus* (Ruppell, 1837)
7. *Scoliodon laticaudus* Muller & Henle, 1838

Family : **Sphyrnidae**

8. *Eusphyra blochii* (Cuvier, 1816)
9. *Sphyrna zygaena* (Linnaeus, 1758)

Order : **ANGUILLIFORMES**

Family : **Congridae**

10. *Uroconger lepturus* (Richardson, 1845)

Family : **Ophichthidae**

11. *Pisodonophis cancrivorus* (Richardson, 1848)
12. *Leiuranus semicinctus* (Lay & Bennett, 1839)
13. *Lamnostoma orientalis* (McClelland, 1844)

Family : **Muraenesocidae**

14. *Congresox talabonoides* (Bleeker, 1853)

Order : **CLUPEIFORMES**

Family : **Chirocentridae**

15. *Chirocentrus dorab* (Forsskal, 1775)
16. *Chirocentrus nudus* (Swainson, 1839)

Family : **Clupeidae**

17. *Anodontostoma chacunda* (Hamilton, 1822)
18. *Dussumieria acuta* Valenciennes, 1847
19. *Escualosa thoracata* (Valenciennes, 1847)
20. *Opisthopterus tardoore* (Cuvier, 1829)
21. *Sardinella albella* (Valenciennes, 1847)
22. *Sardinella fimbriata* (Valenciennes, 1847)
23. *Sardinella gibbosa* (Bleeker, 1849)
24. *Sardinella longiceps* Valenciennes, 1847

Family : **Pristigasteridae**

25. *Ilisha elongate* (Anonymous [Bennett], 1830)
26. *Ilisha filigera* (Valenciennes, 1847)
27. *Pellona ditchella* Valenciennes, 1847

Family : **Engraulidae**

28. *Encrasicholina devisi* (Whitley, 1940)
29. *Encrasicholina heteroloba* (Ruppell, 1837)
30. *Encrasicholina punctifer* Fowler, 1938
31. *Stolephorus commersonnii* Lacepede, 1803
32. *Stolephorus indicus* (van Hasselt, 1823)
33. *Stolephorus insularis* Hardenberg, 1933
34. *Stolephorus waitei* Jordan & Seale, 1926
35. *Thryssa dussumieri* (Valenciennes, 1848)
36. *Thryssa kammalensis* (Bleeker, 1849)
37. *Thryssa malabarica* (Bloch, 1795)
38. *Thryssa mystax* (Bloch & Schneider, 1801)
39. *Thryssa purava* (Hamilton, 1822)
40. *Thryssa setirostris* (Broussonet, 1782)

Order : **SILURIFORMES**

Family : **Ariidae**

41. *Arius arius* (Hamilton, 1822)
42. *Arius jella* Day, 1877
43. *Arius sona* (Hamilton, 1822)
44. *Arius maculatus* (Thunberg, 1792)
45. *Nemapteryx caelata* (Valenciennes, 1840)
46. *Arius thalasinus* (Ruppell, 1837)

Family : **Plotosidae**

47. *Plotosus lineatus* (Thunberg, 1787)

Family : **Synodontidae**

48. *Saurida undosquamis* (Richardson, 1848)
49. *Saurida tumbil* (Bloch, 1795)

Order : **SYNGNATHIFORMES**

Family : **Fistularidae**

50. *Fistularia petimba* Lacepede, 1803

Order : **SCORPAENIFORMES**

Family : **Scorpaenidae**

51. *Pterois volitans* (Linnaeus, 1758)
52. *Pterois russelii* (Bennett, 1831)

Family : **Platycephalidae**

53. *Platycephalus indicus* (Linnaeus, 1758)
54. *Grammoplites scaber* (Linnaeus, 1758)
55. *Thysanophrys celebica* (Bleeker, 1854)
56. *Cociella crocodilus* (Tilesius, 1812)

Family : **Dactylopteridae**

57. Dactyloptena macracantha (Bleeker, 1854)

Family : **Synanceiidae**

58. *Minous monodactylus* (Bloch & Schneider, 1801)
59. *Minous dempsterae* Eschmeyer, Hallacher & Rama-Rao, 1979
60. *Synanceia horrida* (Linnaeus, 1766)
61. *Leptosynanceia asteroblepa* (Richardson, 1844)

Order : **BERYCIFORMES**

Family : **Holocentridae**

62. *Myripristis adusta* Bleeker, 1853

Order : **PERCIFORMES**

Family : **Teraponidae**

63. *Terapon jarbua* (Forsskal, 1775)
64. *Terapon theraps* Cuvier, 1829
65. *Terapon puta* Cuvier, 1829
66. *Pelates quadrilineatus* (Bloch, 1790)

Family : **Serranidae**

67. *Epinephelus latifasciatus* (Temminck & Schlegel, 1842)
68. *Epinephelus diacanthus* (Valenciennes, 1828)
69. *Epinephelus merra* Bloch, 1793
70. *Epinephelus tauvina* (Forsskal, 1775)
71. *Epinephelus areolatus* (Forsskal, 1775)
72. *Epinephelus chlorostigma* (Valenciennes, 1828)

Family : **Priacanthidae**

73. *Priacanthus hamrur* (Forsskal, 1775)

Family : **Apogonidae**

74. *Apogon aureus* (Lacepede, 1802)
75. *Apogon fasciatus* (White, 1790)

Family : **Pomacentridae**

76. *Neopomacentrus sindensis* (Day, 1873)

Family : **Haemulidae**

77. *Pomadasys maculatum* (Bloch, 1793)

Family : **Lutjanidae**

78. *Lutjanus malabaricus* (Bloch & Schneider, 1801)
79. *Pinjalo pinjalo* (Bleeker, 1850)
80. *Lutjanus argentimaculatus* (Forsskal, 1975)
81. *Lutjanus lutjanus* Bloch, 1790

Family : **Lethrinidae**

82. *Lethrinus nebulosus* (Forsskal, 1775)
83. *Lethrinus ornatus* Valenciennes, 1830
84. *Lethrinus miniatus* (Bloch & Schneider, 1801)

Family : **Nemipteridae**

85. *Nemipterus japonicus* (Bloch, 1791)
86. *Nemipterus mesoprion* (Bleeker, 1853)

Family : **Gerreidae**

87. *Gerres oyena* (Forsskal, 1775)
88. *Gerres filamentosus* (Cuvier, 1829)
89. *Gerres erythrourus* (Bloch, 1791)
90. *Gerres limbatus* (Cuvier, 1830)

Family : **Mullidae**

91. *Upeneus sulphureus* (Cuvier, 1829)
92. *Upeneus vittatus* (Forsskal, 1775)
93. *Upeneus tragula* (Richardson, 1846)

Family : **Sillaginidae**
94. *Sillago sihama* (Forsskal, 1775)
Family : **Lactariidae**
95. *Lactarius lactarius* (Bloch & Schneider, 1801)
Family : **Sciaenidae**
96. *Johnius amblycephalus* (Bleeker, 1855)
97. *Johnius borneensis* (Bleeker, 1851)
98. *Johnius carouna* (Cuvier, 1830)
99. *Johnius carutta* Bloch, 1793
100. *Johnius dussumieri* (Cuvier, 1830)
101. *Kathala axillaris* (Cuvier, 1830)
102. *Nibea maculata* (Bloch & Schneider, 1801)
103. *Otolithes cuvieri* Trewavas, 1974
104. *Otolithes ruber* (Bloch & Schneider, 1801)
105. *Otolithoides biauritus* (Cantor, 1849)
106. *Protonibea diacanthus* (Lacepede, 1802)
107. *Daysciaena albida* (Cuvier, 1830)
Family : **Leiognathidae**
108. *Gazza minuta* (Bloch, 1795)
109. *Leiognathus bindus* (Valenciennes, 1835)
110. *Leiognathus brevirostris* (Valenciennes, 1835)
111. *Leiognathus daura* (Cuvier, 1829)
112. *Leiognathus dussumieri* (Valenciennes, 1835)
113. *Leiognathus elongatus* (Gunther, 1874)
114. *Leiognathus equulus* (Forsskal, 1775)
115. *Leiognathus splendens* (Cuvier, 1829)
116. *Secutor insidiator* (Bloch, 1787)
117. *Secutor ruconius* (Hamilton, 1822)
Family : **Carangidae**
118. *Alectis ciliaris* (Bloch, 1787)
119. *Alectis indicus* (Ruppell, 1830)
120. *Alepes djedaba* (Forsskal, 1775)
121. *Alepes kleinii* (Bloch, 1793)
122. *Atropus atropus* (Bloch & Schneider, 1801)
123. *Atule mate* (Cuvier, 1833)
124. *Carangoides armatus* (Ruppell, 1830)
125. *Carangoides malabaricus* (Bloch & Schneider, 1801)
126. *Carangoides oblongus* (Cuvier, 1833)
127. *Carangoides praeustus* (Anonymous [Bennett], 1830)
128. *Caranx ignobilis* (Forsskal, 1775)
129. *Caranx sexfasciatus* Quoy & Gaimard, 1825
130. *Decapterus russelli* (Ruppell, 1830)
131. *Gnathanodon speciosus* (Forsskal, 1775)
132. *Megalaspis cordyla* (Linnaeus, 1758)
133. *Parastromateus niger* (Bloch, 1795)
134. *Scomberoides lysan* (Forsskal, 1775)
135. *Scomberoides tala* (Cuvier, 1832)
136. *Scomberoides tol* (Cuvier, 1832)
137. *Selar crumenophthalmus* (Bloch, 1793)
138. *Trachinotus blochii* (Lacepede, 1801)139.
139. *Uraspis uraspis* (Gunther, 1860)
Family : **Polynemidae**
140. *Eleutheronema tetradactylum* (Shaw, 1804)
141. *Filimanus heptadactyla* (Cuvier, 1829)
142. *Filimanus similis* Feltes, 1991
143. *Leptomelanosoma indicum* (Shaw, 1804)
Family : **Sphyraenidae**
144. *Sphyraena barracuda* (Walbaum, 1792)
145. *Sphyraena forsteri* Cuvier, 1829
146. *Sphyraena jella* Cuvier, 1829
147. *Sphyraena obtusata* Cuvier, 1829
Family : **Gobiidae**
148. *Oxyurichthys paulae* Pezold, 1998
149. *Trypauchen vagina* (Bloch & Schneider, 1801)
Family : **Trichiuridae**
150. *Lepturacanthus savala* (Cuvier, 1829)
151. *Trichiurus lepturus* Linnaeus, 1758
Family : **Stromateidae**
152. *Pampus argenteus* (Euphrasen, 1788)
153. *Pampus chinensis* (Euphrasen, 1788)
Family : **Ambassidae**
154. *Ambassis ambassis* (Lacepede, 1802)
155. *Ambassis commersonnii* Cuvier, 1828
156. *Ambassis gymnocephalus* (Lacepede, 1802)
Family : **Mugilidae**
157. *Liza microlepis* (Smith, 1846)
158. *Liza parsia* (Hamilton, 1822)
159. *Liza subviridis* (Valenciennes, 1835)
160. *Liza tade* (Forsskal, 1775)
161. *Mugil cephalus* Linnaeus, 1758
162. *Valamugil cunnesius* (Valenciennes, 1836)
163. *Valamugil speigleri* (Bleeker, 1858-59)
Family : **Menidae**
164. *Mene maculata* (Bloch & Schneider, 1801)
Family : **Scatophagidae**
165. *Scatophagus argus* (Linnaeus, 1766)
Family : **Scombridae**
166. *Rastrelliger kanagurta* (Cuvier, 1816)
167. *Scomberomorus commerson* (Lacepede, 1800)
168. *Scomberomorus guttatus* (Bloch & Schneider, 1801)
169. *Scomberomorus lineolatus* (Cuvier, 1829)

Family : **Siganidae**
170. *Siganus canaliculatus* (Park, 1797)
171. *Siganus javus* (Linnaeus, 1766)
Family : **Acanthuridae**
172. *Acanthurus mata* (Cuvier, 1829)
Family : **Uranoscopidae**
173. *Uranoscopus marmoratus* Cuvier, 1829
Family : **Drepaneidae**
174. *Drepane punctata* (Linnaeus, 1758)
Family : **Pempheridae**
175. *Pempheris mangula* Cuvier, 1829
176. *Pempheris oualensis* Cuvier, 1831
Order : **BELONIFORMES**
Family : **Hemirhamphidae**
177. *Rhynchorhamphus georgii* (Valenciennes, 1847)
Order : **PLEURONECTIFORMES**
Family : **Samaridae**
178. *Samaris cristatus* (Gray, 1931)
Family : **Cynoglossidae**
179. *Cynoglossus arel* (Schneider, 1801)
180. *Cynoglossus bilineatus* (Lacepede, 1802)
181. *Cynoglossus macrostornus* Norman, 1928
182. *Cynoglossus dubius* Day, 1873
Family : **Soleidae**
183. *Zebrias quagga* (Kaup, 1858)
Family : **Paralichthyidae**
184. *Pseudorhombus arsius* (Hamilton, 1822)
Order : **TETRAODONTIFORMES**
Family : **Triacanthidae**
185. *Triacanthus biaculeatus* (Bloch, 1786)
186. *Triacanthus nieuhofii* Bleeker, 1852
187. *Pseudotriacanthus strigilifer* (Cantor, 1849)
Family : **Diodontidae**
188. *Cyclichthys orbicularis* (Boch, 1785)
Family : **Tetraodontidae**
189. *Lagocephalus spadiceus* (Richardson, 1845)
190. *Lagocephalus inermis* (Temminck & Schlegel, 1850)
191. *Chelonodon patoca* (Hamilton, 1822)
SHRIMPS
Order**: DECAPODA**
Family : **Penaeidae**
192. *Fenneropenaeus indicus* (H. Milne Edwards, 1837)
193. *Metapenaeus affinis* (H. Milne Edwards, 1837)
194. *Metapenaeus dobsoni* (Miers, 1878)
195. *Metapenaeus monoceros* (Fabricius, 1798)
196. *Parapenaeopsis stylifera* (H Milne Edwards, 1837)
197. *Penaeus semisulcatus* (De Hann, 1844)
198. *Penaeus monodon* (Fabricius, 1798)
199. *Trachypenaeus curvirostris* (Stimpson, 1860)
Family : **Hippolytidae**
200. *Exhippolysmata ensirostris* (Kemp, 1914)
Family : **Sergestidae**
201. *Acetes indicus* H. Milne Edwards, 1830
Family : **Alphidae**
202. *Alpheus malabaricus* (Fabricius, 1775)
LOBSTERS
Order**: DECAPODA** Family : **Palinuridae**
203. *Palinurus homarus* (Linnaeus, 1758)
204. *Palinurus ornatus* Fabricius, 1798
Family : **Scyllaridae**
205. *Thenus orientalis* (Lund, 1793)
CRABS
Order **: DECAPODA**
Family **: Lucosidae**
206. *Philyra scabriuscula* (Fabricius, 1798)
Family **: Calappidae**
207. *Calappa lophos* (Herbst, 1782)
Family **: Portunidae**
208. *Charybdis feriatus* (Linnaeus, 1758)
209. *Charybdis lucifeara* (Fabricius, 1798)
210. *Charybdis natator* (Herbst, 1789)
211. *Podophthalmus vigil* (Fabricius, 1798)
212. *Portunus pelagicus* (Linnaeus, 1766)
213. *Portunus sanguinolentus* (Herbst, 1783)
214. *Scylla serrata* (Forskal, 1775)
Family **: Matutidae**
215. *Ashtoret lunaris* (Forskål, 1775)
216. *Matuta planipes* Fabricius, 1798
Family **: Epialtidae**
217. *Doclea ovis* (Fabricius, 1787)
218. *Doclea rissoni* Leach, 1815
STOMATOPODS
Order**: STOMATOPODA**
Family : **Squillidae**
219. *Oratosquilla nepa* (Latreille, 1828)
220. *Squilla* sp.
CEPHALOPODS
Order **: SEPIIDA**
Family **: Sepiidae**
221. *Sepia aculeata* Van Hasselt, 1835
222. *Sepia pharaonis* Ehrenberg, 1831
223. *Sepiella inermis* (Van Hasselt, 1835)

Order : **TEUTHIDA**
Family : **Loliginidae**
224. *Doryteuthis singhalensis* (Ortmann, 1891)
225. *Uroteuthis duvaucelii* (d'Orbigny, 1835)
Order : **OCTOPODA**
Family : **Octopodidae**
226. *Amphioctopus aegina* (Gray, 1849)
227. *Amphioctopus aegina* (Gray, 1849)
228. *Amphioctopus membranaceus* (Quoy & Gaimard, 1832)
229. *Cistopus indicus* (Rapp, 1835)
230. *Octopus globosus* Appelöf, 1886
231. *Octopus vulgaris* Cuvier, 1797
**SHELLS**
Order**: ARCOIDA**
Family : **Arcidae**
232. *Anadara (Cunearca) rhombea* Born, 1780
233. *Anadara granosa* (Linnaeus, 1758)
234. *Barbatia bistrigata* Dunker, 1866
235. *Scapharca inaequivalvis* (Bruguiere, 1789)
236. *Trisidos tortuosa* (Linnaeus, 1758)
Order**: NEOGASTROPODA**
Family : **Babyloniidae**
237. *Babylonia spirata* (Linnaeus, 1758)
238. *Babylonia zeylanica* (Bruguiere, 1789)
Family : **Buccinidae**
239. *Cantharus spiralis* Gray, 1839
Family : **Turridae**
240. *Lophiotoma indica* (Roding, 1798)
241. *Turricula javana* (Lamarck, 1816)
242. *Turris amicta* (E.A. Smith, 1877)
Family : **Harpidae**
243. *Harpa major* Roding, 1798
Family : **Clavatulidae**
244. *Clavatula virgineus* (Dillwyn, 1817)
Family : **Muricidae**
245. *Murex (Murex) carbonnieri* (Jousseaume, 1881)
246. *Rapana bulbosa* (Solander, 1817)
247. *Rapana rapiformis* (Born, 1778)
Family : **Fasciolariidae**
248. *Fusinus nicobaricus* (Röding, 1798)
Family : **Melongenidae**
249. *Hemifusus pugilinus* (Born, 1778)
250. *Pugilina cochlidium* (Linnaeus, 1758)
Order**: LITTORINIMORPHA**
Family : **Bursidae**
251. *Bufonaria echinata* (Link, 1807)
Family : **Ficidae**
252. *Ficus ficus* (Linnaeus, 1758)
253. *Ficus gracilis* (G.B. Sowerby I, 1825)
Family : **Naticidae**
254. *Glossaulax didyma* (Röding, 1798)
255. *Natica lineata* Lamarck, 1838
256. *Natica vitellus* (Linnaeus, 1758)
Family : **Cassidae**
257. *Phalium canaliculatum* Bruguiere, 1792
258. *Semicassis bisulcata* (Schubert & Wagner, 1829)
Family : **Rostellariidae**
259. *Strombus plicatus sibbaldi* Sowerby, 1842
260. *Tibia curta (*G.B. Sowerby II, 1842)
Family : **Tonnidae**
261. *Tona dolium* (Linnaeus, 1758)
Order**: VENEROIDA**
Family : **Veneridae**
262. *Dosinia cretacea* (Reeve, 1851)
263. *Marcia opima* (Gmelin, 1791)
264. *Meretrix casta* (Chemnitz, 1782)
265. *Meretrix meretrix* (Linnaeus, 1758)
266. *Paphia malabarica* (Chemnitz, 1782)
267. *Paphia textile* (Gmelin, 1791)
268. *Sunetta scripta* (Linnaeus, 1758)
Family : **Donacidae**
269. *Donax scortum* (Linnaeus, 1758)
Order**: MYOIDA**
Family : **Pholadidae**
270. *Pholas orientalis* Gmelin, 1791
Family : **Cardiidae**
271. *Cardium flavum* Linnaeus, 1758
Order**: CAENOGASTROPODA**
Family : **Turritellidae**
272. *Turritella acutangula* (Linnaeus, 1758)
273. *Turritella attenuata* Reeve, 1849
Order: **ARCHAEOGASTROPODA**
Family : **Trochidae**
274. *Umbonium vestiarium* (Linnaeus, 1758)
Order: **DENTALIIDA**
Family : **Dentaliidae**
275. *Dentalium octangulatum* Donovan, 1804
ECHINODERMS
Order: **PAXILLOSIDA**
Family : **Astropectinidae**
276. *Astropecten* spp

Order: **CLYPEASTEROIDA**
Family : **Laganidae**
277. *Laganum depressum* Lesson, *1841*
JELLY FISH
Order: **RHIZOSTOMEAE**
Family : **Catostylidae**
278. *Crambionella stuhlmanni* (Chun 1896)
Order: **SEMAEOSTOMEAE**
Family : **Ulmaridae**
279. *Aurelia solida* Browne, 1905
TURTLES
Order: **TESTUDINES**
Family : **Cheloniidae**
280. *Lepidochelys olivacea (*Eschscholtz, 1829)
SEA SNAKES
Order: **SQUAMATA**
Family : **Elapidae**
281. *Aipysurus laevis* Lacepede, 1804

fishes belonged to 12 orders and 59 families and 109 genera. Eleven shrimp species belonging to 4 families and 13 crab species belonging to 5 families have been identified. Eleven cephalopod species belonged to 3 orders and 3 families. Molluscan species belonged to 22 families and jellyfishes belonged to 2 families.

Bycatch was generated at levels exceeding 10 kg $h^{-1}$ during January-March and August-November and at levels less than 10 kg $h^{-1}$ during April–July and December (Fig. 1). Organisms other than fish dominated in the bycatch during May, August and September, while fishes dominated during other months. Bycatch formed 87.15 ± 5.77% (SE, n=12) of the monthly shrimp trawl landings, during the period of study (Fig. 2). Shrimps of marketable size accounted for a small percentage of the total trawl landings. The rest of the catch consisted of bycatch consisting of a variety of fishes, cnidarians, molluscs, crustaceans, echinoderms and juveniles of fish which fetch relatively low value.

Mean monthly bycatch generated by shrimp trawling off Cochin ranged from 1.14 to 38.64 kg $h^{-1}$, in different months with an overall average of 12.85 ± 1.97 (SE, n=12) kg $h^{-1}$. Shrimp-bycatch ratio ranged from 1: 0.6 to 1: 6908, during different months. Species numbering 281, including juveniles of commercially important fishes and shellfishes were represented in the shrimp trawl bycatch.

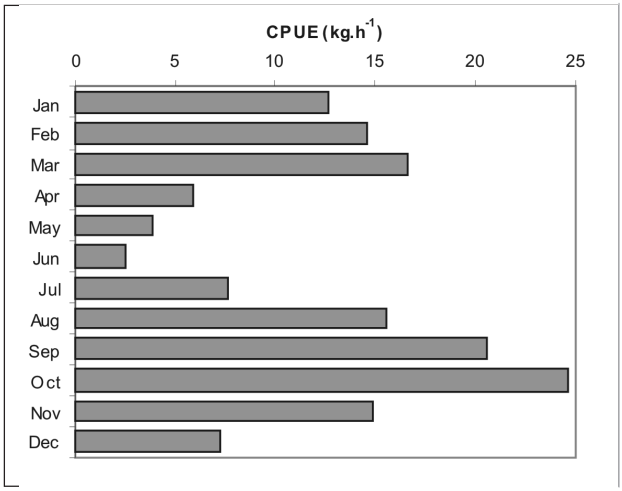


Fig. 1. Monthly variations in shrimp trawl bycatch, off Cochin, India

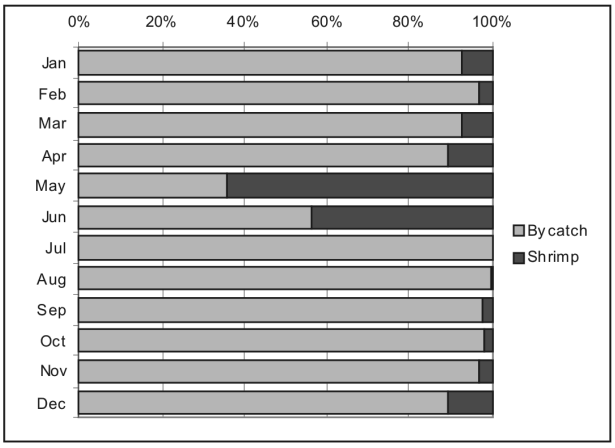


Fig. 2. Monthly variations in shrimp-bycatch proportions in shrimp trawl catches, off Cochin, India

According to the preliminary assessment by Central Marine Fisheries Research Institute, Cochin, in 1979, bycatch formed 79.18% (35 902 t) of total shrimp trawl landings in India, which was utilized either for human consumption or as fish meal and fish manure (George et al., 1981). During 1980-82, trawl bycatch was estimated at 85% of the trawl landings off Mangalore and Malpe in Karnataka (Sukumaran et al., 1982). A study conducted during 1985-90 along the states of Kerala, Karnataka and Tamil Nadu observed that target groups such as shrimp (16%) and cephalopods (4%) together constituted only 20% and others such as finfishes (65%) and benthic organisms (15%) constituted the rest of the trawl landings (Menon, 1996). Bycatch landings

from shrimp trawling along Cochin, Visakhapatnam and in Saurashtra region (Gujarat) was about 70 to 90% and average discards was 15 to 20% (Pillai, 1998). Gordon (1991) estimated that juvenile discards from trawling operations, off Visakhapatnam was 25 to 30%. Rao (1998) assessed the bycatch generated by the fleet based at Visakhapatnam at 40 410 t, of which 32 421 t was discarded and 8 258 t was retained. In Karnataka, during 2001-2002, the bycatch from trawlers formed 47.9 to 54.4% and discards formed 33.9 to 35.1% of the total catch (Zacharia et al., 2006). Studies by Kurup et al. (2003; 2004) during 2000-2002 period, along Kerala coast, has indicated the discards from trawlers to be between 2 25 000 t and 2 62 000 t during 2000-2002 constituted by finfishes, crabs, stomatopods, gastropods, juvenile shrimps, soles, jelly fishes, cephalopods, echinoderms, sea snakes and eggs. Kelleher (2004) has estimated total bycatch discards in Indian fisheries at 57 917 t, which formed 2.03 % of the total landings. Pramod (2010) estimated the bycatch discards from mechanised trawlers operating in Indian EEZ at 1.2 million t.

Various types of bycatch reduction technologies have been developed in the fishing industry around the world in order to improve the selectivity of the shrimp trawls and minimize the impact of trawling on non-target resources and juveniles (Prado, 1993; Eayrs, 2005; Boopendranath, 2007; 2009; Boopendranath et al., 2008, 2010; Kennelly, 2007; Pravin et al., 2011). The degree of adoption of bycatch reduction technologies is strongly dependent on the robustness of the fisheries management system. Bycatch reduction technologies have been mandated and effectively implemented in several scientifically managed fisheries in the world. However, its adoption in less effectively managed fisheries may require the active involvement of stakeholders in the process, supported by a system of incentives and disincentives, education and training (Boopendranath, 2007). The present study has highlighted the imperative need for improving the selectivity of the trawl system, in order to mitigate its impacts on non-targeted resources.

## Acknowledgement

The authors thank the Director, Central Institute of Fisheries Technology, Cochin, for granting permission to publish this paper. This study was conducted under ICAR Ad-hoc Research Scheme 0644003 titled *Bycatch Reduction Devices for Selective Shrimp Trawling.*

## References

Appeltans, W., Bouchet, P., Boxshall, G.A., Fauchald, K., Gordon, D.P., Hoeksema, B.W., Poore, G.C.B., van Soest, R.W.M., Stöhr, S., Walter, T.C., Costello, M.J.. (Eds) (2011) World Register of Marine Species (WoRMS), http://www.marinespecies.org (Accessed 10.11. 2011)

Bijukumar, A. and Deepthi, G.R. (2006) Trawling and bycatch: Implications on marine ecosystem. Curr. Sci. 90(7): 922-931

Bijukumar, A. and Deepthi, G.R. (2009) Mean trophic index of fish fauna associated with trawl bycatchof Kerala, southwest coast of India. J. Mar. Biol. Ass. India. 51(2): 145-157

Boopendranath, M.R. (2007) Possibilities of bycatch reduction from trawlers in India. In: Indian Fisheries - A Progressive Outlook (Vijayan, K. K., Jayasankar, P. and Vijayagopal, P., Eds), pp12-29, Central Marine Fisheries Research Institute, Cochin

Boopendranath, M.R. (2009) Responsible fishing operations, In: Handbook of Fishing Technology (Meenakumari, B., Boopendranath, M. R., Pravin, P., Thomas, S. N. and Edwin, L., Eds), pp 259-295, Central Institute of Fisheries Technology, Cochin

Boopendranath, M.R., Pravin, P., Gibinkumar, T. R. and Sabu, S. (2008) Bycatch reduction devices for selective shrimp trawling. ICAR Ad hoc Project Report, 220 p, CIFT, Cochin

Boopendranath, M.R., Sabu, S., Gibinkumar, T. R. and Pravin, P. (2010) Soft bycatch reduction devices for bottom trawls: a review. Fish. Technol. 47(2): 99-110

Boyce, J. R. (1996) An economic analysis of the fisheries bycatch problem. J. Environ. Econ. Manag. 31(3): 314-336

Dixitulu, J. V. H. (2004) Bycatches of shrimp trawling off upper east coast, In: Large Marine Ecosystems: Exploration and Exploitation for Sustainable Development and Conservation of Fish Stocks (Somvanshi, V.S., Ed), pp 594-597, Fishery Survey of India, Mumbai

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

Fischer, W. and Bianchi, G. (Eds) (1984) FAO species identification sheets for fishery purposes. Western Indian Ocean (Fishing Area 51). Prepared and printed with the support of the Danish International Development Agency (DANIDA), Rome; Food and Agriculture Organization of the United Nations, Vols. 1-6

Froese, R. and Pauly, D. (Eds) (2011) FishBase. World Wide Web electronic publication, www.fishbase.org (Accessed 10.11. 2011)

George, M. J., Suseelan, C. and Balan, K. (1981) By-catch of shrimp fisheries in India. Mar. Fish. Inf. Serv. Tech. Ext. Ser. 28: 3-13

Gordon, A. (1991) The bycatch from Indian shrimp trawlers in the Bay of Bengal, 29 p, Bay of Bengal Programme, BOBP/WP/68

Jagadis, I., Menon, N. G. and Shanmugavel, A. (2004) Observations on the effect of bottom trawling on dislocation of non-edible biota in the Palk Bay and Gulf of Mannar, Southeast coast of India, In: Large Marine Ecosystems: Exploration and Exploitation for Sustainable Development and Conservation of Fish Stocks (Somvanshi, V.S., Ed), pp 607-624, Fishery Survey of India, Mumbai

Kelleher, K. (2004) Discards in the World's Marine Fisheries: An Update, FAO Fisheries Technical Paper. No. 470, FAO, Rome

Kennelly, S.J. (Ed.) (2007) Bycatch Reduction in the World's Fisheries, Reviews: Methods and Technologies in Fish Biology and Fisheries. Vol. 7, 288 p, Springer, The Netherlands

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

Kurup, B. M., Premlal, P, Thomas, J. V., and Anand, V. (2004) Status of epifaunal component in the bottom trawl discards along Kerala Coast (South India). Fish. Technol. 41(2): 101- 108

Menon, N.G. (1996) Impact of bottom trawling on exploited resources. In: Marine Biodiversity, Conservation and Management (Menon, N.G. and Pillai, C.S.S., Eds), pp 97–102, Central Marine Fisheries Research Institute, Cochin

NIO (2011) BioSearch, Bioinformatics Centre, National Institute of Oceanography, Goa, India, http://www.biosearch.in (Accessed 10.11. 2011)

Pillai, N. S. (1998) Bycatch reduction devices in shrimp trawling. Fishing Chimes 18(7): 45-47

Prado, J. (1993) Selective shrimp catching devices: a review. INFOFISH International 1/93: 54-60

Pramod, G. (2010) Illegal, Unreported and Unregulated Marine Fish Catches in the Indian Exclusive Economic Zone, Field Report (Pitcher, T.J., Ed), 29 p, Policy and Ecosystem Restoration in Fisheries, Fisheries Centre, University of British Columbia, BC, Vancouver, Canada

Pravin, P. and Manoharadoss, R. S. (1996) Constituents of low value trawl catch caught off Veraval. Fish. Technol. 33(2): 121-123

Pravin, P., Gibinkumar, T. R., Sabu, S., and Boopendranath, M.R. (2011) Hard bycatch reduction devices for bottom trawls : a review. Fish. Technol. 48(2): 107-118

Rao, G. S. (1998) Bycatch and discards of shrimp trawlers in Visakhapatnam. In: Advances and Priorities in Fisheries Technology (Balachandran, K.K., Iyer, T.S.G., Madhavan, P., Joseph, J., Perigreen, P.A., Raghunath, M.R. and Varghese, M.D., Eds), pp 501-505, Society of Fisheries Technologists (India), Cochin

Roper, C. F. E., Sweeney, M. J. and Nauen, C. E. (1984) FAO Species Catalogue. Vol 3. Cephalopods of the World. An annotated and illustrated catalogue of species of interest to fisheries. FAO Fish. Synop. 125(3): 277

Sujatha, K. (1995) Finfish constituents of trawl bycatch off Visakhapatnam. Fish. Technol. 32(1): 56-60

Sujatha, K. (1996) Trash fish catch of the trawl fishery off Visakhapatnam. J. Aquatic Biol. 11 (1&2): 17-23

Sujatha, K. (2005) Finfish Bycatch of Trawls and Trammel Nets off Visakhapatnam, Andhra Pradesh, In: Sustainable Fisheries Development: Focus on Andhra Pradesh (Boopendranath, M.R., Mathew, P.T., Gupta, S.S., Pravin, P. and Jeeva, J.C., Eds), pp 87-94, Society of Fisheries Technologists (India), Cochin

Sukumaran, K.K., Telang, K.Y. and Thippeswamy, O. (1982) Trawl fishery of South Kanara with special reference to prawns and bycatches. Mar. Fish. Inf. Ser. Tech. Ext. Ser. 44: 8-14

Zacharia, P.U., Krishnakumar, P. K., Muthiah, C., Krishnan, A. A., and Durgekar, R. N. (2006) Quantitative and qualitative assessment of bycatch and discards associated with bottom trawling along Karnataka coast, India. In: Sustain Fish (Kurup, B.M. and Ravindran, K., Eds), pp 434-445, Cochin University of Science and Technology, Cochin