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CATCH EFFICIENCY OF TRAWLERS OFF RATNAGIRI COAST OF MAHARASHTRA, INDIA

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ABSTRACT
The present study on the catch efficiency of commercial multi-day and single-day trawlers operated off Ratnagiri coast showed that fishing operations were conducted between 15°53′ 24"N to 17°22′36"N latitude and 73°25′ 48"E to 72° 22′ 36"E longitude in the depth range of 10 to 45 m. It clearly indicated that average catch by multi-day trawlers was more (43.44kg/ hour) compared to single-day trawlers (35.05 kg/ hour) while average discard by multi-day and single-day trawlers was 7.54kg/ hour to 3.50 kg/ hour respectively. The study showed that single-day trawlers were better in terms of reduced discard rate. Cod end mesh size of trawl net varied from 15 to 30 mm depending on the fishery resources harvested. The study revealed that there was a decrease in the catch per hour per trawler with a decrease in the number of species reported compared to the previous year along the Ratnagiri coast.

INTRODUCTION

Marine fisheries around the world and India remain seriously threatened from fishing overcapacity, overfishing and range of environmental problems (Meaden, 2013). Around 30 percent of fish stocks are overexploited, 57 percent are fully exploited and 13 percent are in-fully exploited (FAO, 2012).Trawlers are the major mechanized fishing fleet which contributes significantly to the fisheries production especially along the west coast of India. Over 90 % of the marine fish catch is presently accounted under mechanized and motorized fishing (Anon, 2000). Analysis of Indian marine fisheries production trend showed that 80% of the marine fish catch was contributed by trawlers (Srinath, 2013). Singh et al. (2017) worked on the spatiotemporal distribution of trawl catch/bycatch and characterization of fishing activities of trawlers along the Ratnagiri coast Maharashtra. Bhendekar *et al*. (2016) studied on participatory GIS in trawl fisheries along Mumbai coast. Bycatch species of marine mammals, seabirds, sea turtles, elasmobranches and fin fishes are vulnerable to over-exploitation and are slow to recover from large population declines (Pawar Prabhakar, 2011). Shabir *et al*. (2015) investigated the proportion of target and non-target fish catch in gill net fishery along the Mumbai coast, Maharashtra.

Maharashtra has 720 km of coastline along with six maritime districts is an important maritime state with respect to marine fish production. The total marine fish landing of India during 2016 was estimated at 3.63million tonnes while the estimated marine fish landing of Maharashtra state was 2.92 lakhs tonnes (CMFRI, 2017). There are 13002 mechanized marine fishing boats in the state (DOF, 2017). Every year mechanized boats show an increasing trend and expending more fishing effort mainly in inshore waters which resulted in excessive fishing pressure on commercially important fishery resources. Information on catch composition or fishing effort is even more limited, leading to data-poor situations (Chuenpagdee *et al*. 2006., Salas *et al*. 2007). In India, the bycatch and discards problem is more due to the multispecies nature of the tropical fisheries and availability of less information on trawl net fishery.

So there is a need to assess the catch efficiency of trawlers to identify and quantify the rates of retained and discarded catches from the commercial trawlers operated along the Ratnagiri coast.The study was undertaken during September 2016 to May 2017with the objective of assessing the catch efficiency (fleet structure, fishing operation, fish catch rate and their composition, fish discards and mesh size of cod-end) of commercial multi-day and single-day trawlers operated off Ratnagiri coast, Maharashtra.

MATERIALS AND METHODS

Data on catch and discards of fishes and shellfishes of trawlers was collected fortnightly on regular basis from September 2016 to May 2017. Five multi-day and single-day commercial trawlers were selected for data collection as per statistical design (Snedecor, 1967). Details of fishing operations were gathered partly from boat owners and crew of the trawlers who were directly involved in fishing and vessel information from vessel registration certificates.

Onboard information collected includes date, depth of shooting & hauling of the net, time of shooting & hauling of the net, type of net, mesh size (Cod end), total discards (kgs) and a number of hauls per day. Species composition and size of the catch was obtained through a sampling of trawlers during unloading on the fishing harbor. Along with fishing information, an unsorted portion of the discarded catch was collected as a sample representing the haul. The catch was identified up to species level using Fischer & Bianchi (1984) and Froese & Pauly (2011). Data were analyzed using the descriptive method and presented as tables and graph. The method was applied following Singh (2017).

The study area of Ratnagiri is located in the South Konkan region of Maharashtra (Fig.1). Trawlers used for sampling in this area operated between 15º53′ 24"N to 17º22′36"N latitude and 73º25′ 48"E to 72º22′ 36"E longitude. About 160 commercial trawlers operated along Ratnagiri coast majority of them landed their catches at Mirkarwada fishing harbor.

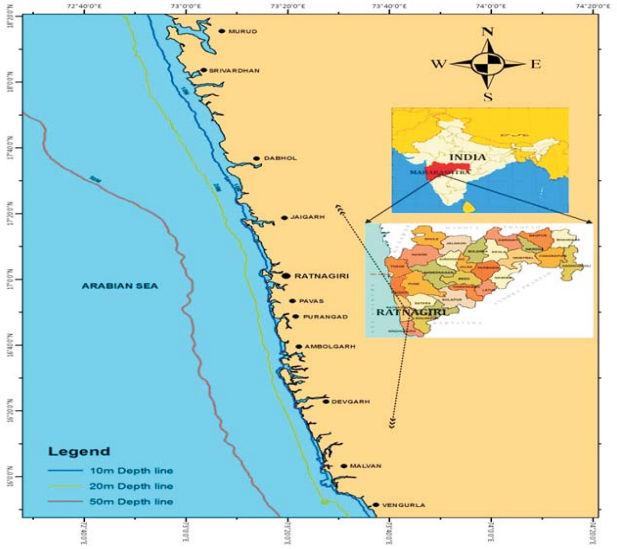

Figure 1: Map showing study sites

RESULTS AND DISCUSSION

Fishing craft and gear

Fishing craft operating at Ratnagiri were made of wood. While multiday trawlers were fitted with 100 to 185 HP engines, single-day trawlers were fitted with 90 HP engines. Overall length (OAL) of trawlers varied from 14.60 to 19.70 m and 10.00 to 15.00m in the case of multiday and single–day trawlers respectively. Their tonnage varied from 20 to 70 tonnes.

Bottom trawl was operated that targeted the demersal fishery resources. Mesh size of the cod end of trawl net varied from 15 to 30 mm depending on the target demersal fishery resources.

Fishing operations

Multi-day trawlers generally carried 6 to 8 crew members who are engaged in fishing operations. Duration of fishing trips by multi-day trawlers varied from 3 to 5 days. The nets were set during the day between 6.00 am to 6.00 pm. On an average, the speed of trawlers was maintained at 1100 rpm for cruising and 1000 rpm for trawling operation. Sawant et al. (2016) reported that the speed of trawlers was maintained at 1200 rpm for cruising and 1000 rpm for trawling by a fishing craft that operated along the Ratnagiri coast. The stern trawling undertook 3 hauls per day, each haul generally of 3 to 4 hours duration, carried out by both multi-day and single-day trawlers. The depth of fishing operation ranged from 10 to 45 m and 10 to 25 m in the case of multi-day and single-day trawlers respectively.

Catch and discards

The present study revealed that the average catch rate of commercially operated multi-day trawlers was 130.33 kg/ haul while in the case of single-day trawlers it was 95.03 kg/ haul during the fishing season. Average catch by multi-day and single-day trawler was 43.44kg/ hour and 35.05 kg/ hour respectively. Maximum catch per hour was 67.78 kg for multi-day and 48.89kg for single-day trawlers. However, discarded catch per haul by multi-day trawlers ranged from 4.44 to 14.20 kg and by single-day trawlers 1.47 to 6.20 kg/ haul. Discards were relatively less in single-day trawlers. Variation in catch per hour and discards per hour multi-day and single-day trawlers is given in fig.2 and fig.3. Maximum discards (14.20kg/ haul) by multi-day trawlers was recorded during October, while it was 6.20 Kg/ haul by single-day trawlers in November.

Singh *et al.* (2017) reported an average catch rate of 49.90 kg/ hour and 28.20kg/ hour with fish discards at an average of 7.7 kg/ hour and 3.84 kg/ hour by commercially operated multi-day and single-day trawlers respectively from Ratnagiri coast of Maharashtra. Findings of a study by Bhendekar *et al.* (2016) showed that catch percentage by multi-day trawlers varied from 66 to 92% while it varied from 70 to 95% in case of single-day trawlers. Maximum discards per hour by multi-day trawlers *i.e.* 15.6 kg was during September, while it was October for single-day trawler (4.03 kg) from Mumbai coast of Maharashtra. Rao *et al.* (1967) reported the catch per hour by otter trawling in the Arabian Sea was 198 kg /hour. Gordon (1991) estimated that juvenile discards from trawling operations, off Vishakhapatnam, were 25 to 30 %. In Karnataka, during 2001-2002, the by catch from trawlers formed 47.9 to 54.4 % and discards formed 33.9 to 35.1 % of the total catch (Zacharia *et al.,* 2006). Bycatch and discards by trawlers at Mumbai have shown that 1671 tonnes of bycatch with a catch rate of 200 kg/hr was landed during January to December 2007, which formed 22% of the total catch. 73 species of fin fishes and shellfishes constituted the Low-Value Bycatch (LVB) and considering the size at maturity, all were juveniles (CMFRI, 2008).

The annual trawl landings along the eastern Arabian Sea showed an increasing trend over a period of time. The catch trend was subjected to wide fluctuations in earlier years but since 2009, catch showed a steady increase and reached 1.18 M Tonnes in 2012. Technological advancements in trawl fisheries can be attributed as the major reason for this high production. The catch rate of trawlers fluctuated from 30 to 50 kg per hour during 1990 2007. From 2008onwards, the catch rate increased and reached about 75kg per hour in 2012. Dineshbabu *et al.* (2013) attributed the increase in catch rates to the introduction of high-speed engines since 2010.

Table 1: List of species occurring in trawl catch off Ratnagiri coast of Maharashtra

Finfish	Family: Serranidae
Order: RAJIFORMES	34. *Epinephelus diacanthus* (Valenciennes, 1828)
Family: Dasyatidae	Family: Priacanthidae
1. *Himantura gerrardi* (Gray, 1851)	35. *Priacanthus hamrur* (Forsskal, 1775)
Order: CARCHARHINIFORMES	Family: Lutjanidae
Family: Carcharhinidae	36. *Lutjanus lutjanus* Bloch, 1790
2. *Scoliodon laticaudus* Muller & Henle, 1838	Family: Nemipteridae
Family: Sphyrnidae	37. *Nemipterus japonicus* (Bloch, 1791)
3. *Sphyrna zygaena* (Linnaeus, 1758)	38. *Nemipterus mesoprion*(Bleeker, 1853)
Order: ANGUILLIFORMES	Family: Mullidae
Family: Congridae	39. *Upeneus sulphureus* (Cuvier, 1829)
4. *Uroconger lepturus* (Richardson, 1845)	Family :Sillaginidae
Family: Ophichthidae	40. *Sillago sihama* (Forsskal, 1775)
5. *Pisodonophis cancrivorus* (Richardson, 1848)	Family :Lactariidae
Family: Muraenesocidae	41. *Lactarius lactarius* (Bloch & Schneider, 1801)
6. *Congresotalabonoides* (Bleeker, 1853)	Family :Sciaenidae
Order: CLUPEIFORMES	42. *Johnius borneensis* (Bleeker, 1851)
Family: Chirocentridae	43. *Johnius dussumieri* (Cuvier, 1830)
7. *Chirocentrus dorab* (Forsskal, 1775)	44. *Otolithes cuvieri* Trewavas, 1974
8. *Chirocentrus nudus* (Swainson, 1839)	45. *Otolithes ruber* (Bloch & Schneider, 1801)
Family: Clupeidae	46. *Otolithoides biauritus* (Cantor, 1849)
9. *Opisthopterus* tardoore (Cuvier, 1829)	47. *Protonibea diacanthus* (Lacepede, 1802)
10. *Sardinella albella* (Valenciennes, 1847)	Family :Leiognathidae
11. *Sardinella Fimbriata* (Valenciennes, 1847)	48. *Leiognathus bindus* (Valenciennes, 1835)
12. *Sardinella gibbosa* (Bleeker, 1849)	49. *Leiognathus brevirostris* (Valenciennes, 1835)
13. *Sardinella longiceps* Valenciennes, 1847	50. *Leiognathus dussumieri* (Valenciennes, 1835)
Family: Pristigasteridae	51. *Leiognathus splendens* (Cuvier, 1829)
14. *Elisha elongate* (Anonymous [Bennett], 1830)	52. *Secutor insidiator* (Bloch, 1787)
15. *Ilishafiligera* (Valenciennes, 1847)	53. *Secutor ruconius* (Hamilton, 1822)
Family: Engraulidae	Family : Carangidae
16. *Stolephorus indices* (van Hasselt, 1823)	54. *Alectis ciliaris* (Bloch, 1787)
17. *Stolephorus insularis* Hardenberg, 1933	55. *Alectis indicus* (Ruppell, 1830)
18. *Stolephorus waitei* Jordan & Seale, 1926	56. *Alepes djedaba* (Forsskal, 1775)
19. *Thryssa dussumi*eri (Valenciennes, 1848)	57. *Atropus atropus* (Bloch, 1801)
20. *Thryssa malabarica* (Bloch, 1795)	58. *Atule mate* (Cuvier, 1833)
21. *Thryssa mystax* (Bloch & Schneider, 1801)	59. *Carangoides armatus* (Ruppell, 1830)
22. *Thryssa purava* (Hamilton, 1822)	60 *Carangoides malabaricus* (Bloch, 1801)
23. *Thryssa setirostris* (Broussonet, 1782)	61. *Carangoides oblongus* (Cuvier, 1833)
Order: SILURIFORMES	62. *Decapterus russelli* (Ruppell, 1830)
Family: Ariidae	63. *Megalaspis cordyla* (Linnaeus, 1758)
24. *Arius arius* (Hamilton, 1822)	64. Scomberoides tala (Cuvier, 1832)
25. *Arius jella* Day, 1877	65. *Parastromateus niger* (Bloch, 1795)
26. *Arius maculatus* (Thunberg, 1792)	
27. *Arius thalasinus* (Ruppell, 1837)	Family : Polynemidae
Family : Synodontidae	66. *Eleutheronema tetradactylum* (Shaw, 1804)
28. *Saurida tu*mbil (Bloch, 1795)	67. *Filimanus heptadactyla* (Cuvier, 1829)
29. *Harpodon nehereus* (Hamilton, 1822)	Family :Sphyraenidae
Family: Dactylopteridae	68. *Sphyraena jella* Cuvier, 1829
30. *Dactyloptena macracantha* (Bleeker, 1854)	Family :Trichiuridae
Family: Teraponidae	69. *Lepturacanthus savala* (Cuvier, 1829)
31. *Terapon jarbua* (Forsskal, 1775)	70. *Trichiurus lepturus Linnaeus*, 1758
32. *Terapon theraps* Cuvier, 1829	Family :Stromateidae
33. *Terapon puta* Cuvier, 1829	71. *Pampus argenteus* (Euphrasen, 1788)
	72. *Pampus chinensis* (Euphrasen, 1788)

Catch Composition

During the present study, diverse groups/species of fishes, crustaceans, and mollusks were recorded from the commercial trawlers. List of species caught from Ratnagiri coast is given in Table 1.

Based on a study conducted by Singh *et al*. (2017) that incorporated traditional knowledge with geographic information system for preparation of thematic maps of marine fisheries resources along the Ratnagiri coast, Maharashtra during 2015-16, around 134 species landed by commercial trawlers were reported. Considering findings of the present study that recorded one hundred sixteen species landed by multi-day and single-day trawlers of Ratnagiri during 2016-17, there is a clear indication that there is a decrease in the number of species recorded compared to the previous year. Major decrease in the dominant species belonged to Order-Perciformes - 10 species (*Apogon fasciatus, Scatophagus*

Table 1: Contt.....

Family:Mugilidae	Family: Scyllaridae
73. *Liza microlepis* (Smith, 1846)	98. *Thenus orientalis* (Lund, 1793)
74. *Liza parsia* (Hamilton, 1822)	CRABS
75. *Liza tade* (Forsskal, 1775)	Order: DECAPODA
76. *Mugil cephalus* Linnaeus, 1758	Family: Portunidae
Fmily:Menidae	99. *Charybdis feriatus* (Linnaeus, 1758)
77. *Mene maculata* (Bloch & Schneider, 1801)	100. *Charybdis luciferase* (Fabricius, 1798)
Family:Scombridae	101. *Charybdis natator* (Herbst, 1789)
78. *Rastrelliger kanagurta* (Cuvier, 1816)	102. *Portunus pelagicus* (Linnaeus, 1766)
79. *Scomberomorus commerson* (Lacepede, 1800)	103. *Scylla serrata* (Forskal, 1775)
80. *Scomberomorus guttatus* (Bloch,1801)	STOMATOPODS
81. *Scomberomorus lineolatus* (Cuvier, 1829	Order: STOMATOPODA
Family: Acanthuridae	Family: Squillidae
82. *Acanthurus mata* (Cuvier, 1829)	104. *Oratosquilla nepa* (Latreille, 1828)
Family: Drepaneidae	105. *Squilla sp.*
83. *Drepane punctata* (Linnaeus, 1758)	CEPHALOPODS
Family: Cynoglossidae	Order: SEPIIDA
84. *Cynoglossus area (Schneider, 1801)*	Family: Sepiidae
*85. Cynoglossus*bilineatus (Lacepede, 1802)	106. *Sepia pharaonis* Ehrenberg, 1831
86. *Cynoglossus macrostornus* Norman, 1928	107. *Sepiella inermis* (Van Hasselt, 1835)
Family: Soleidae	Order: TEUTHIDA
87. *Zebras quagga* (Kaup, 1858)	Family :Loliginidae
Family: Tetraodontidae	108. *Uroteuthis duvaucelii*(d'Orbigny, 1835)
88. *Lagocephalus inermis* (Temminck & Schlegel, 1850)	Order : OCTOPODA
SHRIMPS	Family :Octopodidae
Order: DECAPODA	109. *Cistopus indicus* (Rapp, 1835)
Family: Penaeidae	110. *Octopus vulgaris* Cuvier, 1797
89. *Fenneropenaeus indicus* (H. Milne Edwards, 1837)	Order: NEOGASTROPODA
90. *Metapenaeus affinis* (H. Milne Edwards, 1837)	Family :Babyloniidae
91. *Metapenaeus dobsoni* (Miers, 1878)	111. *Babylonia spirata* (Linnaeus, 1758)
92. *Metapenaeus monoceros* (Fabricius, 1798)	Family :Turridae
93. *Parapenaeopsis stylifera* (H Milne Edwards, 1837)	112. *Turricula javana* (Lamarck, 1816)
94. *Penaeus semisulcatus* (De Hann, 1844)	Family :Muricidae
95. *Penaeus monodon* (Fabricius, 1798)	113. *Murex (Murex) carbonnieri* (Jousseaume, 1881)
Family: Sergestidae	Family : Rostellariidae
LOBSTERS	114. *Tibia curta* (G.B. Sowerby II, 1842)
Order: DECAPODA Family: Palinuridae	Family :Turritellidae
96. *Panulirushomarus* (Linnaeus, 1758)	115. *Turritella acutangula* (Linnaeus, 1758)
97. *Panulirusornatus Fabricius*, 1798	116. *Turritella attenuata* Reeve, 1849

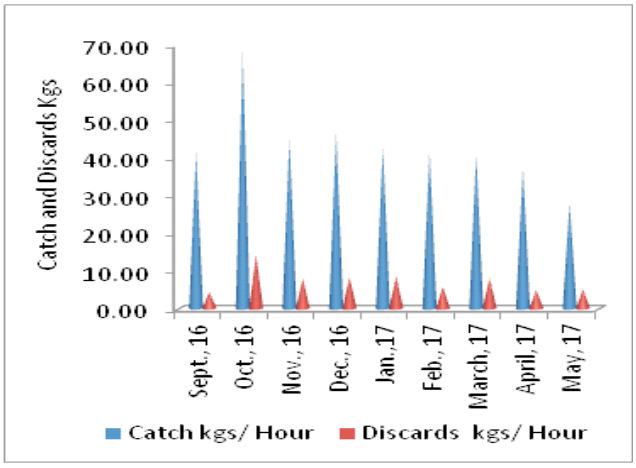

Figure 2: Catch and discards per hour from multi-day trawlers

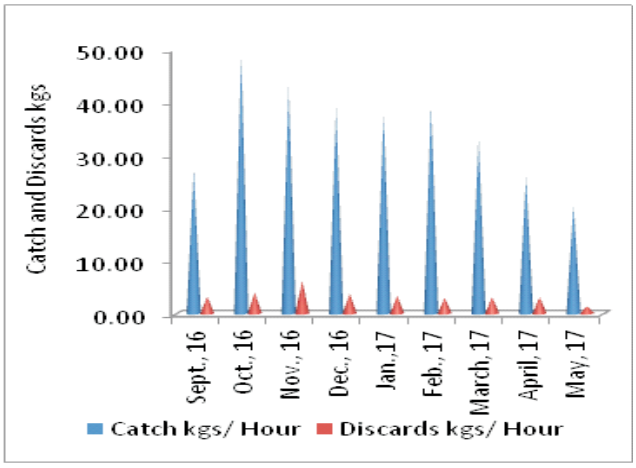

Figure 3: Catch and discards per hour from single-day trawlers

argus, Pomadasys maculatus, Upeneus sulphureus, Pinjalo pinjalo, Lethrinus somatus, Gerres filamentosus, Siganus maculatus, Siganus javus and *Siganus vermiculatus*), Order-Scorpaeniformes- 4species (*Platycephalus indicus, Grammoplites scaber, Cociella crcodilus* and *Minous monodactylus*) and Order-Clupeiformes- 3 species

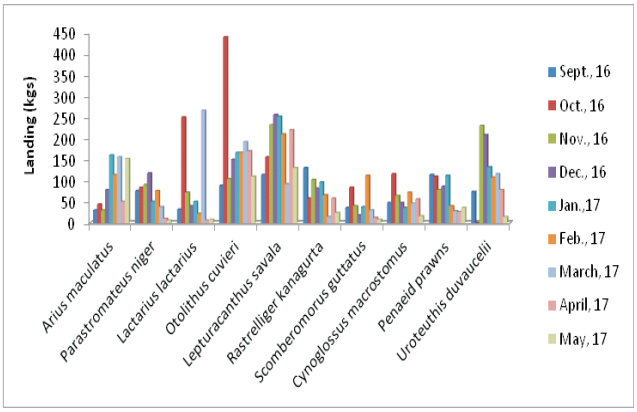

Figure 4: Month-wise major catch composition of multi-day trawlers

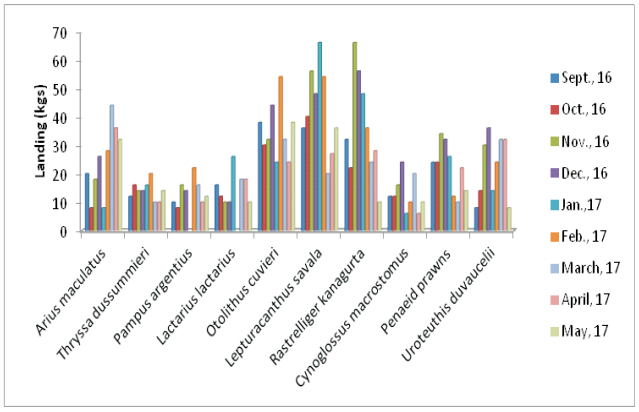

Figure 5: Month-wise major catch composition of single-day trawlers

(*Anodontostoma chacunda, Escualosa thoracata* and *Coilia dussumieri*). One such typical example is Canada, where one of the world's most fertile and once apparently inexhaustible marine fisheries in the 'Grand bank' had collapsed (Bensam, 1999). Report of the Working Group on "Revalidation of the potential marine fisheries resources of EEZ of India", 1991 emphasised the need for regulation and conservative measures for ensuring sustained production of some of the heavily exploited resources in the inshore waters. About 101 species were recorded from the marine capture fisheries bycatch and discards at Karanja and Mora landing centers from Uran (Raigad), Navi Mumbai, Maharashtra(Pawar Prabhakar, 2011). Bhendekar *et al*. (2016) reported 126 species from multi-day and single-day trawlers operating from Mumbai coast.

Major catch composition of multiday trawlers comprised *Arius maculatus, Parastromateus niger, Lactarius lactarius, Otolithes cuvieri, Lepturacanthus savala, Rastrelliger kanagurta, Scomberomorus guttatus, Cynoglossus macrostornus, Uroteuthis duvaucelii* and Penaeid prawns. In the case of singleday trawlers, the major catch was constituted by *Arius maculatus, Thryssa dussummieri*, *Lactarius lactarius*, *Pampus argenteus*, *Otolithes cuvieri*, *Lepturacanthus savala*, *Rastrelliger kanagurta, Cynoglossus macrostornus*, *Uroteuthis duvaucelii* and Penaeid prawns. Month-wise major catch composition of species by multi-day and single-day trawlers are given in Fig.4 and Fig.5 respectively. Considering the catch composition of commercially operated multi-day trawlers off Ratnagiri coast, in terms of mean landings *Lepturacanthus savala* was the major species followed by *Otolithus cuvieri* and *Uroteuthis duvaucelii*. Peak landing of *Otolithus cuvieri* was observed during October and March. In the case of single-day trawlers in terms of mean landings *Lepturacanthus savala* was contributed the major speciesfollowed by *Rastrelliger kanagurta* and *Otolithus cuvieri* . Peak landing of *Rastrelliger kanagurta*was observed during November and December.

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