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Fishing characteristics of trawling off Mumbai coast of Maharashtra, India

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Abstract
The study deals with the characteristics of fishing activities of commercial trawlers operated in the study area off Mumbai coast of Maharashtra during September 2016 to May 2017. The trawlers from Mumbai coast carried out fishing operations between 20^0 22' 50"N to 18^0 12'20"N latitude and 72^0 21' 50"E to 72^0 52' 00"E longitude in the depth range between 10 to 70m. The catch by multi-day and single-day trawler was 44.75 kg/ hour and 38.24 kg/ hour respectively. Discards comprised juveniles of commercial species and adults of low market value fishes. Cod end mesh size of trawl net varied from 15 to 30 mm depending on the fishery resources harvested. Average discard by multi-day and single-day trawlers was 10.93 kg/ hour and 4.63 kg/ hour respectively. The study clearly indicated that the beginning and the end of the post-monsoon period had low fishing intensity with a decrease in the catch per hour per trawler along Mumbai coast.

Keywords: characteristics, trawl net, fishing, Mumbai

Introduction

Trawling is the major fishing method along the Northwest coast of India, contributing to about 56% of the total catch [4]. Trawling was introduced in Maharashtra in 1961 [19]. It contributed 57.2% of total landings of the state during 2015-16 [7]. The state has total coast line of 720 km and continental shelf area of 1,11,512 sq. km. There are 13002 mechanized marine fishing boats in the state [7]. The fishing operations start from August after the monsoon ban period and continue up to May [13]. The total marine fish landing of India during the year 2016 was estimated at 3.63 million tonnes and estimated marine fish landing of Maharashtra state was 2.92 lakhs tonnes [5]. 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 [6].

Fisheries around the world are reported to be in crisis. Around 30 percent fish stock are overexploited, 57 percent are fully exploited and 13 percent are non-fully exploited [8]. Marine fisheries around the world and India remain seriously threatened from fishing overcapacity, overfishing, and range of environmental problems [17]. Changes in fish community structure and diversity pattern have been related to the fishing pressure prevailing in the ecosystem [14]. Information on catch composition or fishing effort is even more limited, leading to data-poor situations [3, 20]. Researchers must work with the best available data from different sources to provide sound advice for management decision-makers [1]. Studies were conducted on participatory GIS in trawl fisheries along Mumbai coast [2]. Impact of depletion of marine fishery resources along Gulf of Mannar coast, Tamil Nadu on the livelihoods of fishermen communities was studied [16]. The aim of the study was to characterize the fishing operations by multi-day and single-day trawlers in terms of catch rate, fish discards per hour, fish catch composition, fishing fleet information and to understand the changes in resource availability along Mumbai coast during the study period.

Materials and Methods

(i) Study area

The study area of Mumbai is located in the North Konkan region of Maharashtra state (Fig.-1). The Greater Mumbai region comprises the Mumbai city district and Mumbai Suburban district, which extends up to Dahisar and Mulund. This study area covers the near shore and off shore fishing grounds located between 20^0 22' 50"N to 18^0 12'20"N latitude and 72^0 21' 50"E to 72^0 52' 00"E longitude. About 2010 commercial multi-day and single-day trawlers

operated along Mumbai coast and majority of them landed their catches at Sassoon Dock, Ferry Wharf and Versova fishing harbor.

Fig 1: Map showing study sites

(ii) Craft and gear specification
Information on craft and gear specifications like type of net, mesh size (Cod end), depth of operation, towing and hauling speed, total catch per boat per trip and per haul, total discards (kgs) and number of hauls per day were studied.

(iii) Sampling methodology
Data for the study was collected from seventeen each of randomly selected commercially operated multi-day and single-day trawlers of Sassoon dock landing center at Mumbai as per statistical design [24]. Data on catch and discards of fishes and shellfishes of trawlers was collected fortnightly on regular basis from September 2016 to May 2017. Details of fishing operations and vessel information were obtained from two different sources; boat owners and crew of the trawlers who were directly involved in fishing and partly from vessel registration certificates. Information was obtained by conducting interviews of randomly selected fishers when they arrived at landing center for unloading the catch. The method was applied following Jasprit [14]. Different sampling approaches were considered for collecting detailed information on the characteristics of the fishing fleet and fishing activity; fishing fleet- number of vessels; data on overall length (OAL), gross tonnage (GT), engine power (HP), gear in use, license, fishing area, etc. were collected for each boat in order to update this information for the period covered by the study. Onboard information such as date, depth of shooting & hauling of the trawl net, geo-location of fishing operation, time of shooting & hauling of the net, type of net, mesh size (Cod end), total catch per boat per trip and per haul, total discards (kgs) and number of hauls per day was collected.

(iv) Species identification
Species composition and size of catch was obtained by sampling of trawlers during unloading in 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 [10, 11].

Results and Discussion
(i) Fishing Fleet
It was observed that about 2010 commercial multi-day and single-day trawlers operated along Mumbai coast. They were registered at Sassoon Dock (585 trawlers), Ferry Wharf (1125 trawlers) and Versova (300 trawlers) and they landed their catch at the respective fishing harbor. Multi-day trawlers were fitted with 110 to 220 HP engines, whereas single–day trawlers were fitted with 90 to 100 HP engines. Overall length (OAL) of trawlers varied from 15.00 to 19.90 m and 12.50 to 15.00m in the case of multi-day and single–day trawlers respectively. Their tonnage varied from 30 to 90 tonnes. All vessels were registered with regulatory authority and had valid fishing license. Multi-day and single–day trawlers carried 4-6 different types of trawl nets and cod end mesh size varied from 15-30mm depending on the targeted demersal fishery resources.

(ii) Fishing Operations
Medium and small trawlers usually undertake single-day fishing trips while large vessels (>15.00m) remain out at sea for more days, depending on the weather conditions. The fishing grounds off Mumbai were mostly exploited by the medium and large sized vessels throughout the year. 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 7 to 15 days. The nets were set during day time between 6.00 am to 6.00 pm. On an average, the speed of trawlers was maintained at 1250 rpm for cruising and 1100 rpm for trawling operation. Along the Ratnagiri coast, the speed of trawlers was maintained at 1200 rpm for cruising and 1000 rpm for trawling [23]. Both multi-day and single-day trawlers undertook 3 hauls per day, each haul generally lasted for 3 to 4 hours. The depth of fishing operation ranged from 10 to 70m and 10 to 25m in the case of multi-day and single-day trawlers respectively.

(iii) Catch and Discards
The beginning and end of the fishing season was characterized by low fishing intensity that varied depending on the recruitment of commercial species. Subsequent to mandatory fishing closure (June- July), trawling intensity was low in the months of August and September due to lack of suitable weather conditions. Trawling operations were concentrated near the coast (beyond 10m but within 20m depth). High exploitation rate was noticed during October to March with peaks in October and November. Fishing intensity decreased in April and May when the low availability of demersal resources made it economically unprofitable to fish in the area.

The present study revealed that the average catch rate of commercially operated multi-day trawlers was 127.36 kg/ haul while in the case of single-day trawlers it was114.71kg/ haul during the fishing season. Average catch by multi-day and single-day trawler was 44.75kg/ hour and 38.24 kg/ hour respectively. Maximum catch per hour was 57.28 kg for multi-day and 48.37 kg for single-day trawlers. However, discarded catch per hour by multi-day trawlers ranged from

5.33 to 16.00 kg and by single-day trawlers 3.00 to 7.67 kg/ hour. Discards were relatively less in single-day trawlers. Variation in catch per hour and discards per hour by multi-day and single-day trawlers is given in Fig.2 and Fig.3. Maximum discards 16 kg/ hour by multi-day trawlers was recorded during October, while it was 7.67 Kg/ hour by single-day trawlers in November.
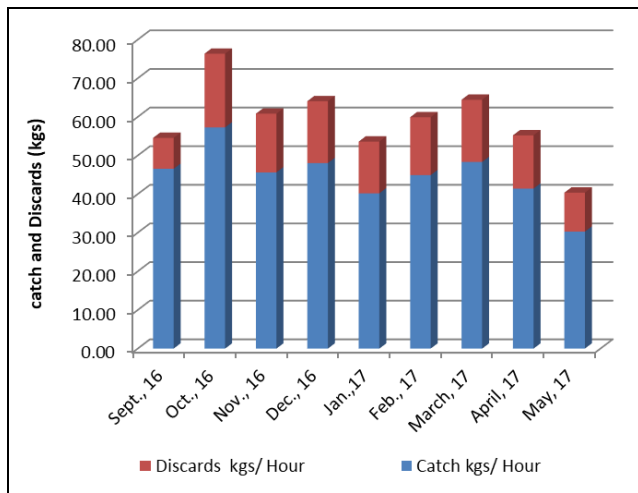

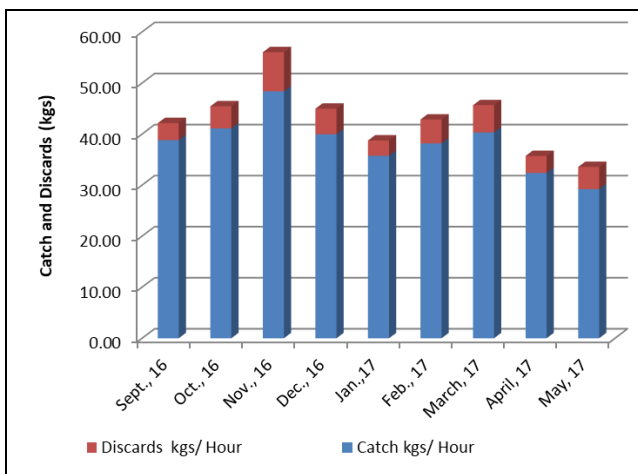**Fig 2:** Catch and discards per hour from multi-day trawlers

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

Catch per hour was maximum during October for multi-day trawlers (73.27 kg) and during December for single-day trawlers (22.70 kg) with 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 [2]. Study on catch composition, bycatch characterization and monthly variations in catch per unit effort (CPUE) generated by single day trawlers along Mumbai coast reported that the maximum catch was contributed by Sciaenids (35%), followed by Sharks and Rays (10%), Anchovies (10%), Prawns (8%), Bombay duck (6%) and other demersal species. Mean monthly bycatch generated by shrimp trawling ranged from 11.82 to 20.65 kg h−1, in different months with an overall average of 16.82 kg h−1 [21]. 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 was reported from Ratnagiri coast [14]. Previous studies showed variation in the catch composition and discard percentage compared to the present study along the coast of Mumbai. Earlier studies recorded about 101 species from the marine capture fisheries bycatch and discards at Karanja and Mora landing centers from Uran (Raigad), Navi Mumbai, Maharashtra during October- November, 2009. The catch recorded juveniles and sub-adults of commercially valuable organisms [18]. Juvenile discards from trawling operations, off Vishakhapatnam, were 25 to 30 % [12]. By-catch from trawlers formed a significant quantity of the total marine fish landings along the northwest coast of India, particularly in the state of Gujarat, which contributed about 23 percent of the total marine fish landings. The major species in trawl by-catches were Sciaenids, Engraulids, Ribbon fish, Penaeid and Non-penaeid prawns, Squids, Cuttle fish, etc. [25]. Catch per hour by otter trawling in the Arabian Sea was 198 kg/hour [19]. The catch rate of trawlers fluctuated from 30 to 50 kg per hour during 1990-2007. Since 2008, the catch rate increased and reached 75kg per hour in 2012. The increase in catch rates could be attributed to the introduction of high-speed engines since 2010 [6].

(iv) Catch Composition
Species such as *Otolithus cuvieri* contributed maximum followed by *Arius maculatus, Lepturacanthus savala* and *Megalaspis cordylla* in terms of catch percentage. Major fish catch percentage off Mumbai coast during the study period by multi-day and single-day trawlers is given in Fig.4 and Fig.5 respectively.
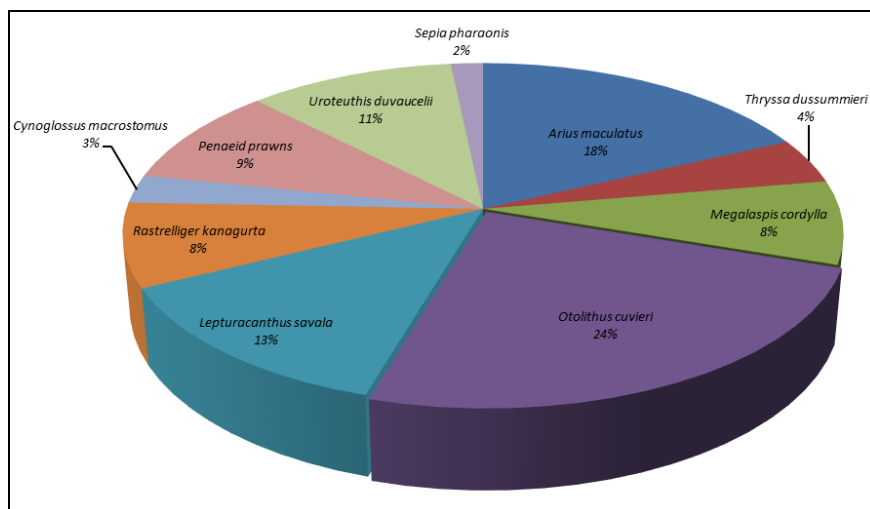

Fig 4: Percentage of major catch by multi-day trawler
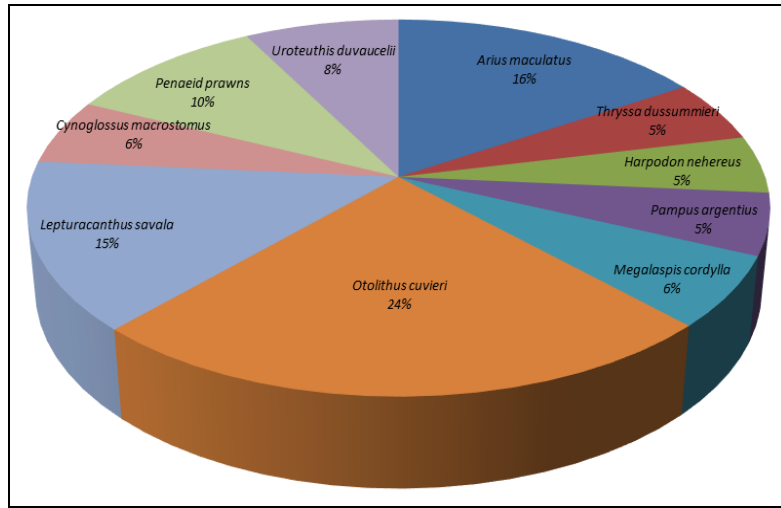
Fig 5: Percentage of major catch by single-day trawler

In the present study, 112 species of fishes are reported from the catch of commercially operated multi-day and single-day trawlers. Dominant species belonged to the Order Perciformes. List of species occurring off Mumbai coast is given in Table-1.

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

Order: RAJIFORMES	Family : Sciaenidae	SHRIMPS
Family: Dasyatidae	*Johnius vogleri*	Order: DECAPODA
Himantura imbricata	*Johnius sina*	Family: Penaeidae
Order: CARCHARHINIFORMES	*Johnius belangerii*	*Fenneropenaeus indicus*
Family: Carcharhinidae	*Johnius elongates*	*Metapenaeus affinis*
Scoliodon laticaudus	*Johnius glaucus*	*Metapenaeus dobsoni*
Family: Sphyrnidae	*Otolithes cuvieri*	*Metapenaeus monoceros*
Sphyrna obtusata	*Otolithes ruber*	*Metapenaeus brevicornis*
Sphyrna zygaena	*Otolithoides biauritus*	*Parapenaeopsis stylifera*
Order: ANGUILLIFORMES	*Protonibea diacanthus*	*Parapenaeopsis hardwickii*
Family: Muraenesocidae	Family : Leiognathidae	*Parapenaeopsis nana*
Congreso talabonoides	*Leiognathus blochi*	*Parapenaeopsis sculptilis*
Order: CLUPEIFORMES	*Leiognathus daura*	*Penaeus semisulcatus*
Family: Chirocentridae	*Leiognathus dussumieri*	*Penaeus monodon*
Chirocentrus dorab	*Leiognathus splendens*	Family: Sergestidae
Family: Clupeidae	*Secutor insidiator*	LOBSTERS
Opisthopterus tardoore	*Secutor ruconius*	Order: DECAPODA
Sardinella albella	Family : Carangidae	Family: Palinuridae
Sardinella fimbriata	*Alectis ciliaris*	*Panulirus polyphagus*
Sardinella longiceps	*Alectis indicus*	*Panulirus homarus*
Family: Pristigasteridae	*Alepes djedaba*	*Panulirus ornatus*
Ilisha filigera	*Atropus atropus*	Family: Scyllaridae
Family: Engraulidae	*Atule mate*	*Thenus orientalis*
Stolephorus commersonnii	*Carangoides armatus*	CRABS
Stolephorus indicus	*Carangoides malabaricus*	Order : DECAPODA
Stolephorus insularis	*Carangoides oblongus*	Family : Portunidae
Stolephorus waitei	*Decapterus russelli*	*Charybdis feriatus*
*Thryssa dussumi*eri	*Megalaspis cordyla*	*Charybdis lucifeara*
Thryssa hamiltoni	Scomberoides tala	*Charybdis natator*
Thryssa mystax	*Parastromateus niger*	*Portunus pelagicus*
Thryssa purava	Family : Polynemidae	*Scylla serrata*
Thryssa setirostris	*Eleutheronema tetradactylum*	STOMATOPODS
Order: SILURIFORMES	*Filimanus heptadactyla*	Order: STOMATOPODA
Family: Ariidae	Family : Trichiuridae	Family : Squillidae
Arius caelatus	*Lepturacanthus savala*	*Oratosquilla nepa*
*Arius dussumi*eri	*Trichiurus lepturus*	*Squilla sp.*
Arius jella	Family : Stromateidae	CEPHALOPODS
Arius maculatus	*Pampus argenteus*	Order : SEPIIDA
Arius tenuispinis	*Pampus chinensis*	Family : Sepiidae
Family : Synodontidae	Family: Scombridae	*Sepia pharaonis*
*Saurida tu*mbil	*Rastrelliger kanagurta*	*Sepiella inermis*
Harpodon nehereus	*Scomberomorus commerson*	Order : TEUTHIDA

Family: Teraponidae	*Scomberomorus guttatus*	Family : Loliginidae
Terapon jarbua	*Scomberomorus lineolatus*	*Uroteuthis duvaucelii*
Terapon theraps	Family: Acanthuridae	Order : OCTOPODA
Terapon puta	*Acanthurus mata*	Family : Octopodidae
Family: Serranidae	Family: Drepaneidae	*Cistopus indicus*
Epinephelus diacanthus	*Drepane punctata*	*Octopus vulgaris*
Family: Priacanthidae	Family: Cynoglossidae	Order: NEOGASTROPODA
Priacanthus hamrur	*Cynoglossus arel*	Family : Turridae
Family: Nemipteridae	*Cynoglossus bilineatus*	*Turricula javana*
Nemipterus japonicus	*Cynoglossus macrostornus*	Family : Muricidae
Nemipterus randalli	Family: Soleidae	*Murex carbonnieri*
Family : Sillaginidae	*Zebrias quagga*	Family : Rostellariidae
Sillago sihama	Family: Tetraodontidae	*Tibia curta*
Family : Lactariidae	*Lagocephalus inermis*	Family : Turritellidae
Lactarius lactarius		*Turritella acutangula*

Study conducted on the participatory geographic information system in trawl fisheries for preparation of thematic maps of marine fisheries resources along the Mumbai coast, Maharashtra during 2013-14, around 121 species landed by commercial trawlers were reported [2]. Considering findings of the present study that recorded one hundred twelve species landed by multi-day and single-day trawlers of Mumbai 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 catch composition of multi-day trawlers comprised *Otolithus cuvieri, Arius maculatus, Lepturacanthus savala, Megalaspis cordylla, Thryssa dussummieri, Rastrelliger kanagurta, Cynoglossus macrostomus, Uroteuthis duvaucelii,* *Sepia pharaonis* and Penaeid prawns. In the case of single-day trawlers, the major catch was constituted by *Otolithus cuvieri, Arius maculatus, Lepturacanthus savala, Thryssa dussummieri, Harpodon nehereus, Pampus argentius, Megalaspis cordylla, Lepturacanthus savala, Cynoglossus macrostomus, Uroteuthis duvaucelii* and Penaeid prawns. Month-wise major catch composition of species by multi-day and single-day trawlers are given in Fig.6 and Fig.7 respectively. Peak landing of *Otolithus cuvieri* was observed during March and October. In the case of single-day trawlers, *Otolithus cuvieri* contributed maximum followed by *Arius maculatus* and *Lepturacanthus savala* in terms of mean landing.
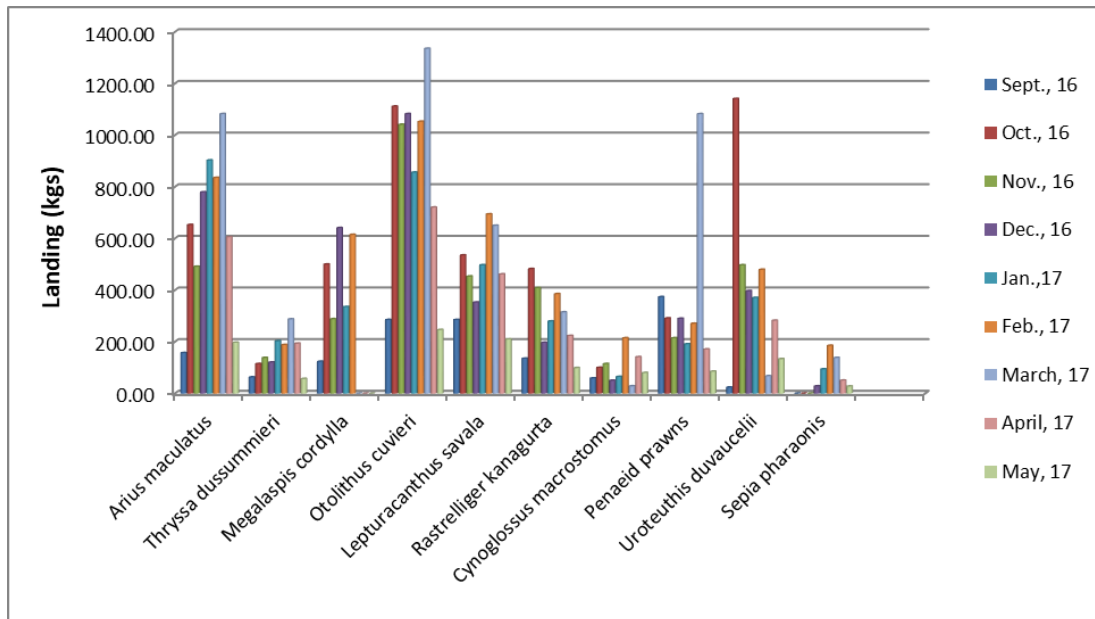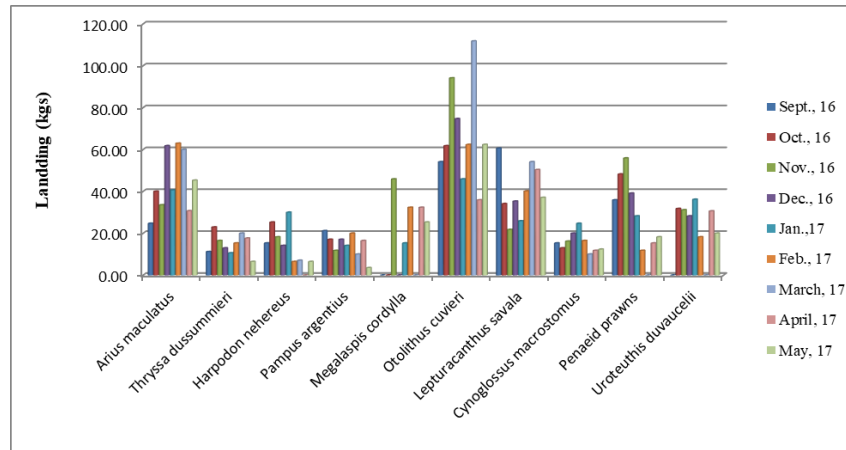

Fig 6: Month-wise major catch composition of multi-day trawlers

Fig 7: Month-wise major catch composition of single-day trawlers

The exploitation of groups like the Seer fishes, Mackerels, Pomfrets, Crabs, Prawns, and Lobster has reached near optimum level. Increasing fisher population and fishing efforts and level of dependency on marine fishery resources are the major causes for overexploitation [16]. The under exploited stock includes Anchovies, other Clupeids, Bill fishes, Perches, Elasmobranches, Carangids and Sciaenids [22]. FAO Code of Conduct for Responsible Fisheries, states principles and international standards of behavior for responsible practices with the view to ensure effective conservation, management, and development of marine living resources, with due respects for the ecosystem and biodiversity [9].

Conclusion
In the present study, 112 species of fishes were reported from the catch of multi-day and single-day trawlers. Dominant species belonged to the Order Perciformes. The study indicated that there was a decrease in the catch (kg) per hour and increase in the by catch and discards of juvenile percentage per trawler compared to the previous study along the Mumbai coast. Excessive increase in fishing efforts particularly within the 50m depth area has led to overexploitation of the resources, as a result, catch rates of most of the commercially important fisheries resources have declined and share of catch per hour per vessel in case of multi-day and single-day trawlers decreased over the years. In order to ensure long-term sustainability of living marine resources, the public and the government have to step in and enforce rigid conservation measures for biological, social and economic reasons. Efforts should be directed towards reduction of total fishing effort in the inshore area. Diversification of fishing efforts in the deep sea requires serious consideration in order to reduce overcrowding in inshore waters, reducing fishing pressure on fish stocks and minimizing juvenile catch and discards. The database created on fishing fleet, fishing operation, fish catch (kg) per hour per boat, fish discards (kg) per hour etc. would assist policy makers in preparing conservation and resource management policies.

Acknowledgments

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