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Fish catch rate and fishing efficiency of trawling off Raigad coast of Maharashtra, India

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Abstract
The present study deals with the fish catch discard rate and fishing efficiency of commercial multi-day and single-day trawlers operated along the Raigad coast of Maharashtra. The trawlers from Raigad coast carried out fishing operations between 18^0 10' 00" N to 19^0 20' 00" N latitude and 72^0 45' 00" E to 73^0 30' 00" E longitude in the depth range between 12 to 52m. The study revealed that the average catch was 32.65 kg/h and 32.09 kg/h with an average discard of 7.63 kg/h and 4.02 kg/h for multi-day and single-day trawler respectively. The t-Test performed on fish catch and discards of multi-day and single-day trawlers did not reveal a statistically significant difference ($p>0.05$) in a fish catch (kg/h) but in the case of multi-day trawlers, there was a statistically significant difference ($p<0.05$) in fish discards (kg/h) between two fishing seasons i.e. 2016-17 and 2017-18 along the Raigad coast. The cod-end mesh size of the trawl net varied from 10 to 30 mm depending on the fishery resources harvested. Analysis of fish catch composition indicated the occurrence of 112 species of fishes in the catch of multi-day and single-day trawlers of the north Konkan region. In this paper changing trends in the catch, discards rates, and efficiency of trawlers are discussed.

Keywords: Catch, trawl net, fishing, Raigad

Introduction

Trawling has contributed to the increased marine fish production and has led to its widespread adoption by many countries. In India, trawlers have contributed a major part of the total marine fish production [21]. Maharashtra state has a total coastline of 720 km and a continental shelf area of 1,11,512 sq. km. The fishing fleet operating along the Maharashtra coast consisted of 13,016 mechanized boats, of which 5,613 were trawlers during 2016-17. The number of total marine fishing boats showed an increase of 3.4% over the previous year [1]. The fishing operations start from August after the monsoon ban period and continue up to May [11]. Marine fisheries around the world and India remain seriously threatened by fishing overcapacity, overfishing, and a range of environmental problems [14]. Trawl net fishing had significant direct and indirect effects on habitat, diversity, structure, and productivity of benthic communities [5]. Information on catch composition or fishing effort is even more limited, leading to data-poor situations [4, 20]. Assessment of the catch composition, bycatch, and monthly variations in catch per unit effort (CPUE) of single-day trawlers along the Mumbai coast from October 2015 to May 2016 was carried out by [17]. Researchers must work with the best available data from different sources to provide sound advice for management decision-makers [2]. The study aimed to assess the efficiency of fish catch rate and their composition, fish discard and mesh size of cod-end, feet structure, and fishing operation information and to understand the changes in resource availability during the study period of commercial multi-day and single-day trawlers operated off Raigad coast.

Material and Methods

The study area of Raigad district is situated in the north Konkan region of Maharashtra and has a coastline of 240 km with a continental shelf area of 21000 km^2 (Fig.1). Trawlers used for sampling in this area operated between 18^0 10' 00" N to 19^0 20' 00" N latitude and 72^0 45' 00" E to 73^0 30' 00" E longitude. About 207 commercial trawlers operated along the Raigad coast of which 40 trawlers were registered at Alibaug. The study was undertaken for two consecutive fishing seasons from September 2016 to May 2017 and September 2017 to May 2018. Four multi-day and single-day commercial trawlers were selected for data collection as per statistical design [19].

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Data on catch and discards of fishes and shellfishes of trawlers were collected fortnightly on regular basis.

Details of fishing operations and vessel information were obtained from the two different sources from 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 the landing center for unloading the catch. The method was applied following [12].

Different sampling approaches were considered for collecting detailed information on the characteristics of the fishing fleets and fishing activity- fishing fleet: several vessels; data on overall length (OAL), gross tonnage (GT), engine power (HP), gear in use, license, fishing area, etc. were collected for each boat to update this information for the period covered by the study. Onboard information collected comprised of date, depth of shooting & hauling of the trawl net, geo-location of the fishing operation, time of shooting & hauling of the net, type of net, mesh size (Cod end), total catch per boat per trip, and haul, total discards (kgs), number of hauls per day per haul. Species composition and size of catch 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 [8, 9]. Data were analyzed using Microsoft Excel, 2013. A t-Test (Paired Two Sample for Means) was used to determine whether data is statistically significant or not.
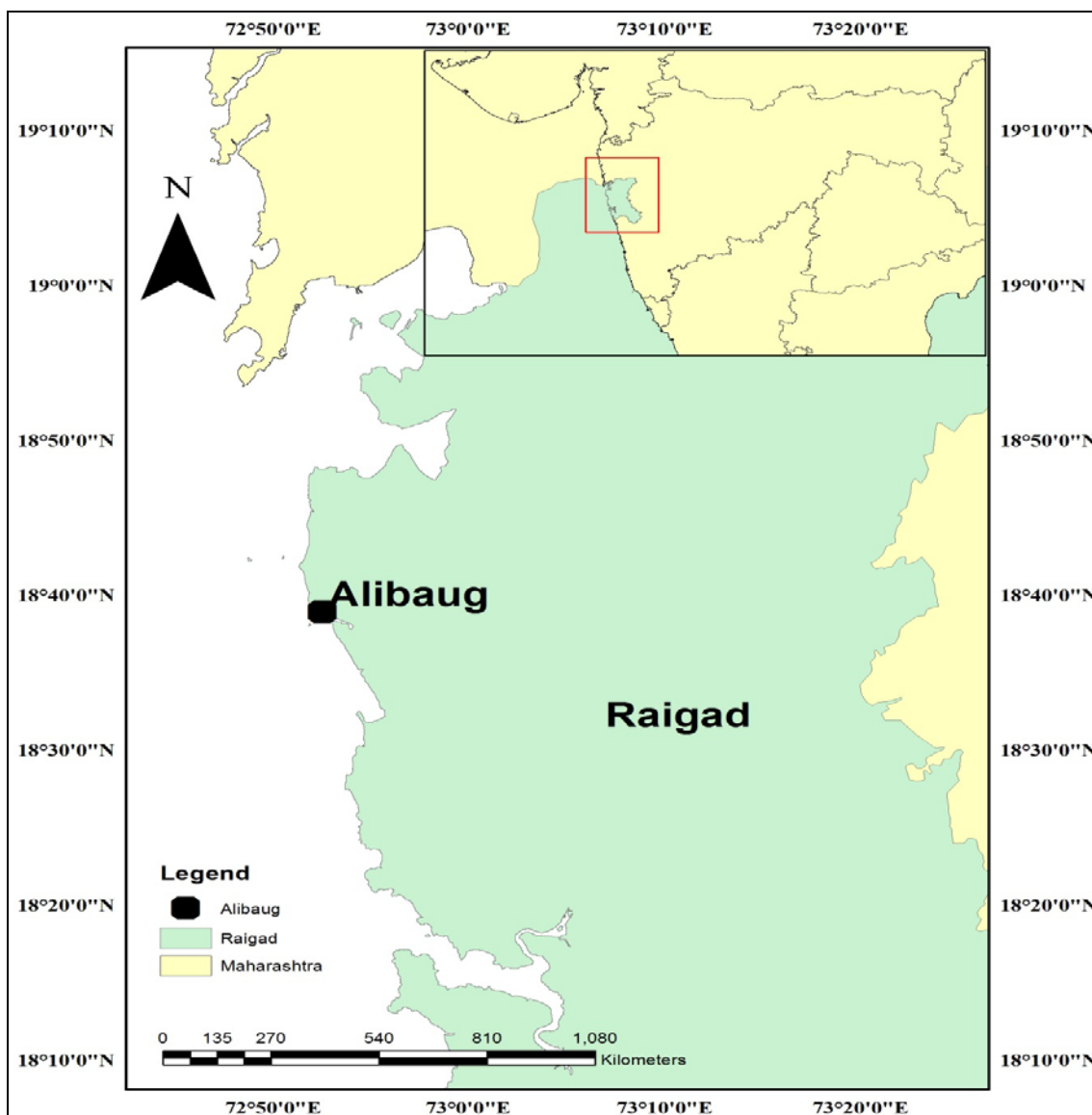

Fig 1: Map showing study area of Alibaug (Raigad) landing center

Results and Discussion
Fisheries characterization
It was observed that about 207 number of commercial multi-day and single-day trawlers were operated along the Raigad coast. Overall length of trawlers varied from 13.50 to 18.10 m and 11.80 to 15.40 m in the case of multi-day and single-day trawlers respectively. Most of the trawlers were fitted with 90 to 195 hp engines according to their size and carrying capacity. All vessels had registered with regulatory authority and obtained a fishing license. Multi-day and single–day trawlers carried 4-6 different types of trawl nets and cod-end mesh size varied from 10-30mm depending on the target of the demersal fishery resources.

Fishing operations
In Raigad coastal district, fishing operations carried out by trawlers between 18^0 10' 00" N to 19^0 20' 00" N latitude and 72^0 45' 00" E to 73^0 30' 00" E longitude, the duration of

fishing trips by multi-day trawlers varied from 2 to 5 days. The depth of fishing operation ranged from 12 to 52 m and 12 to 26 m in the case of multi-day and single-day trawlers respectively. The trawling operations were carried out during the daytime between 6.00 am to 6.00 pm. Generally, trawlers maintained cruising speed at 1250 rpm and trawling operation at 1100 rpm. On an average, trawlers undertook 3 hauls per day, each haul of 3 hours duration.

Catch and Discards

The present study investigated that the beginning and the end of the fishing season; was characterized by low fishing intensity and varied from year to year depending on the recruitment of the commercial species. After the fishing closure (June- July), trawl activities were low in the month of August and September, as weather conditions were not suitable and trawling operations were concentrated near the coast (beyond 10m but within 20m depth). High exploitation rate was detected from October to March with a peak in September and October months during the fishing season. Fishing intensity decreased from April to 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 the multi-day and single-day trawler was 33.66 kg/h and 33.19 kg/h respectively during 2016-17. The maximum catch rate of 44.17 kg/h for multi-day and 42.50 kg/h for single-day trawlers was reported in November. However, discards by multi-day trawlers ranged from 6.67 to 10.67 kg/h and by single-day trawlers 3.00 to 6.00 kg/h. Discards were relatively less in single-day trawlers is given in Fig.2 and Fig.3. During the second year study period 2017-18, the average catch rate of the multi-day and single-day trawler was 31.64 kg/h and 30.19 kg/h with average discards of 6.22 kg/ h and 3.89 kg/h, respectively. Peak fishing activities were observed during November followed by January to February in terms of landing is given in Fig.4 and Fig.5.
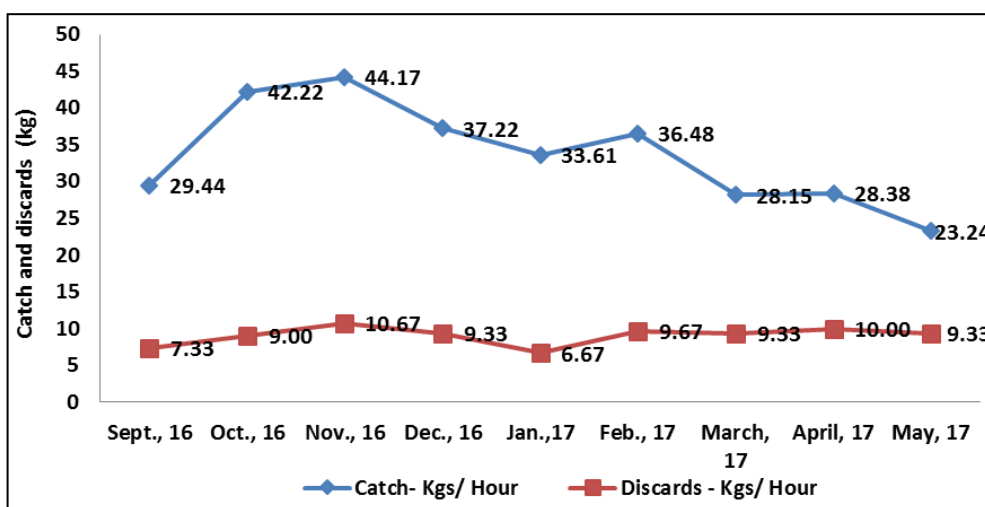

Fig 2: Monthly variation in catch and discards from multi-day trawlers at Alibaug (Raigad) during 2016-17
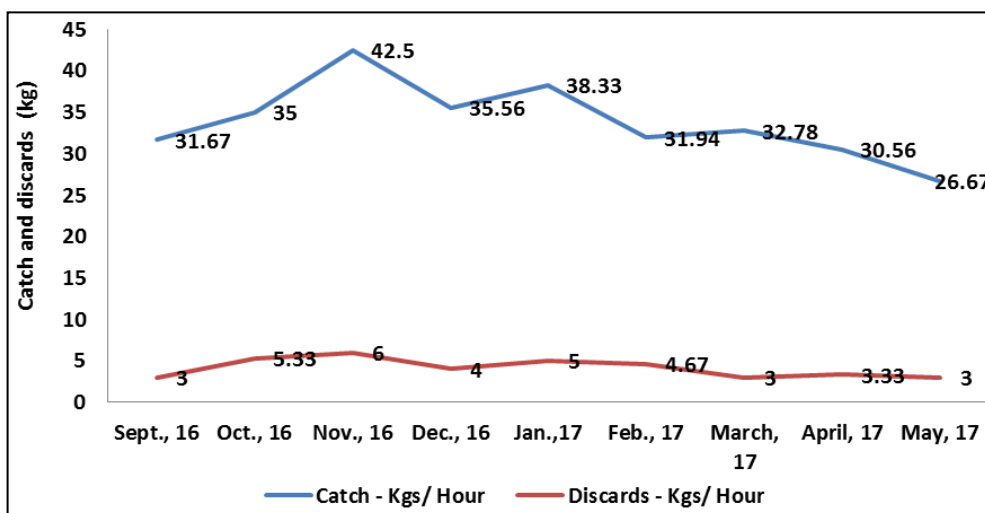

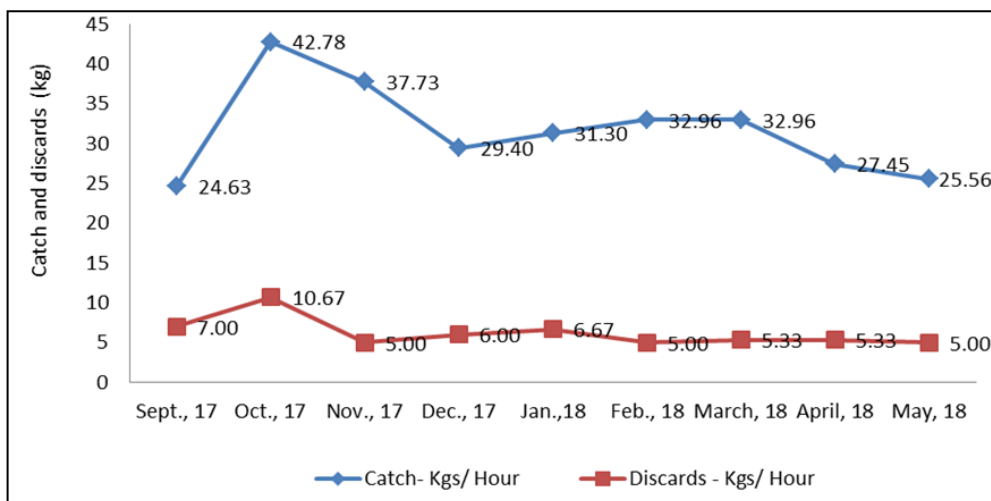**Fig 3:** Monthly variation in catch and discards from single-day trawlers at Alibaug (Raigad) during 2016-17

Fig 4: Monthly variation in catch and discards from multi-day trawlers at Alibaug (Raigad) during 2017-18
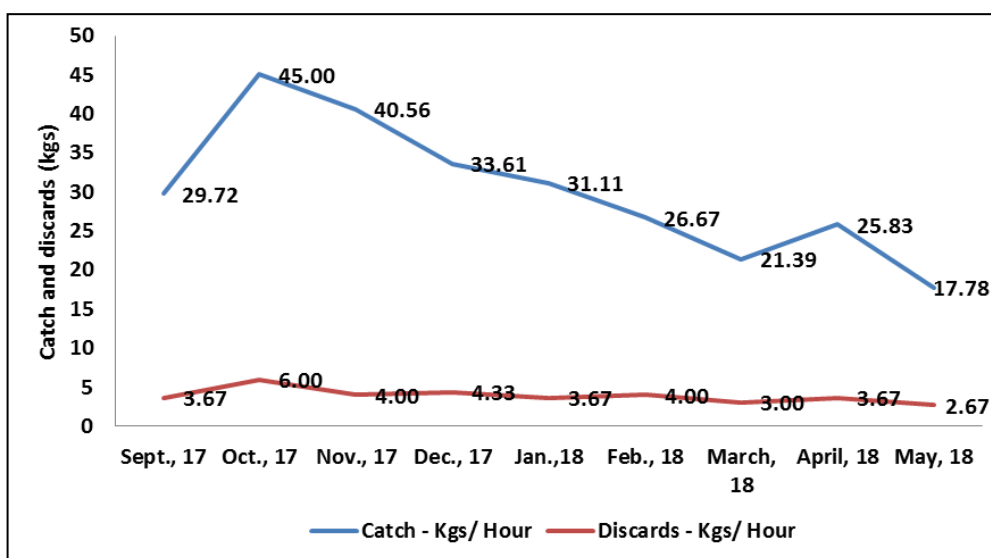

Fig 5: Monthly variation in catch and discards from single-day trawlers at Alibaug (Raigad) during 2017-18

Considering the data for two years, the study revealed that the average catch was 32.65 kg/h and 32.09 kg/h with average discards of 7.63 kg/h and 4.02 kg/h for multi-day and single-day trawler respectively.

The t-Test performed on fish catch and discards of multi-day and single-day trawlers did not reveal a statistically significant difference ($p>0.05$) in a fish catch (kg/h) but in the case of multi-day trawlers, there was a statistically significant difference ($p<0.05$) in fish discards (kg/h) between two fishing seasons i.e. 2016-17 and 2017-18 along the Raigad coast.

Catch composition, bycatch characterization, and monthly variations in catch per unit effort (CPUE) generated by single day trawlers along Mumbai coast 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 [17].

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 [3]. 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 [12]. Studies showed variation in the catch composition and discard percentage compared to the present study along the coast of Mumbai [15]. Earlier studies recorded about 101 species from the marine capture fisheries bycatch and discard 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. Juvenile discards from trawling operations, off Vishakhapatnam, were 25 to 30% [10].

Catch per hour by otter trawling in the Arabian Sea was 198 kg/hour [16]. The catch rate of trawlers fluctuated from 30 to 50 kg per hour during 1990-2007. From 2008 onwards, the catch rate increased and reached about 75kg per hour in 2012. Attributed the increase in catch rates due to the introduction of high-speed engines since 2010 [6].

Catch Composition
Major catch composition of multi-day and single-day trawlers included non-penaeid prawns, *Rastrelliger kanagurta, Lepturacanthus savala, Otolithus cuvieri, Harpodon nehereus, Coilia dussummieri, Arius maculatus,* Penaeid

prawns, *Lactarius lactarius,* and *Scomberomorus guttatus.* Species like *Otolithus cuvieri* contributed the maximum to landings of the multi-day trawler. In the case of single-day trawlers, non-penaeid prawns contributed maximum followed by *Lepturacanthus savala* and *Rastrelliger kanagurta* in terms of mean landing during the study period along the Raigad coast.

The findings of the present study revealed the abundance of non-penaeid prawns, *Rastrelliger kanagurta,* and *Lepturacanthus savala* in terms of catch percentage in both single-day and multiday trawlers. Major fish catch percentage during the study period of Raigad coast by multi-day and single-day trawlers is given in Fig.6 and Fig.7.
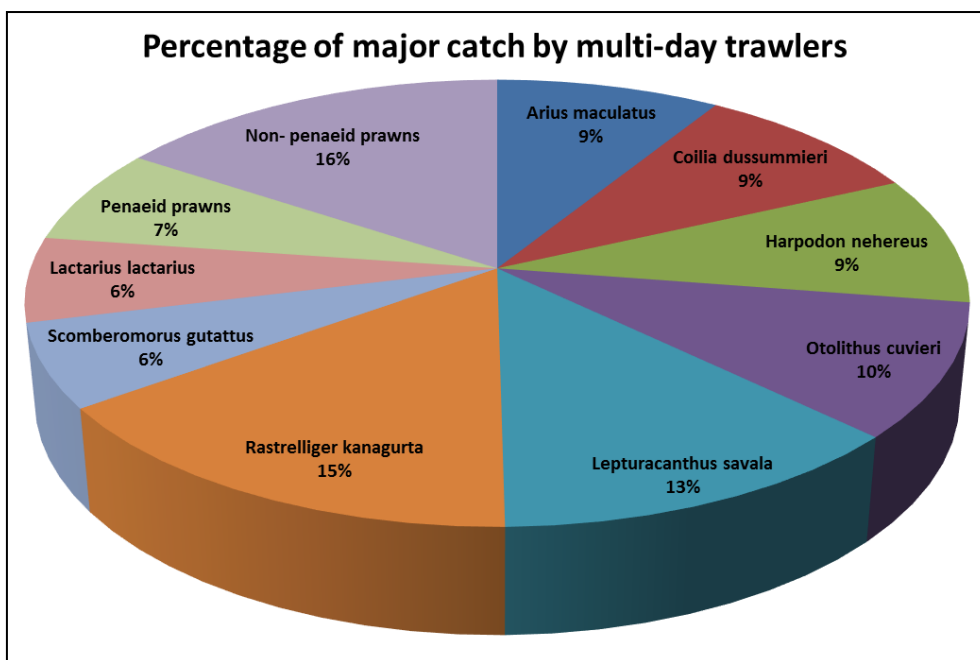

Fig 6: Percentage of major catch by multi-day trawler
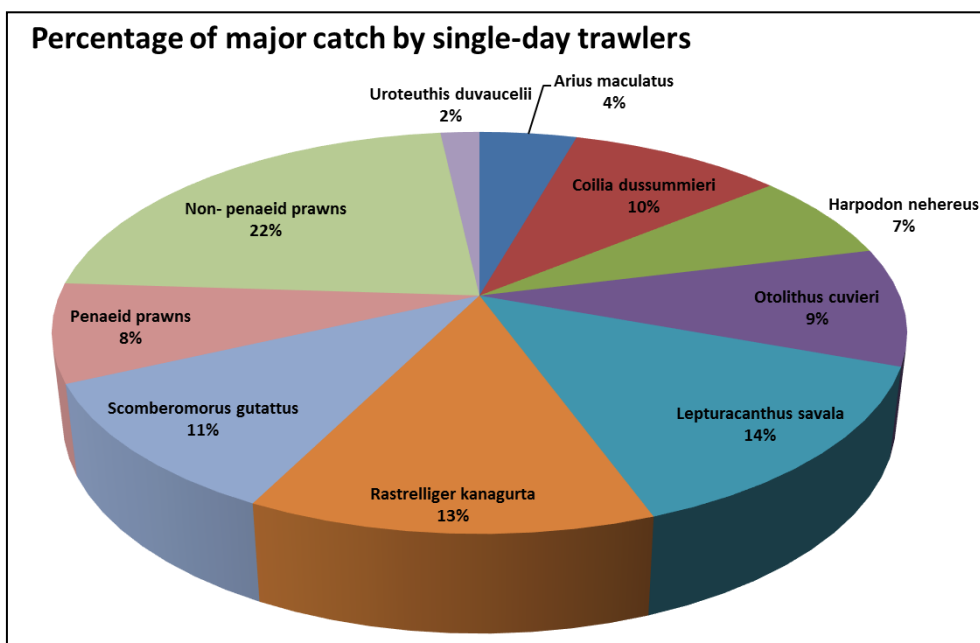

Fig 7: Percentage of the major catch by single-day trawler

In the present study, 112 species of fishes were reported from the catch of commercial operated multi-day and single-day trawlers. Dominant species belonged to the Order Perciformes. Based on a study conducted by [3] that 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. 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.

The exploitation of groups like the Seer fishes, Mackerels, Pomfrets, Crabs, Prawns, and Lobster has reached the near optimum level. Increasing fisher population and fishing efforts and the level of dependency on marine fishery resources are the major causes of overexploitation [13]. The

underexploited stock includes anchovies, other clupeids, billfishes, perches, mackerels, elasmobranches, carangids, and sciaenids [18]. To avoid overexploitation and to ensure sound growth, the state has to adopt a rationalized approach to determining the number and size of fishing vessels, the type of fishing gears, and operational equipment for reducing the fishing efforts from a specific area to ensure sustainable marine living resources for posterity. FAO Code of conduct responsible fisheries (1995) [7], states some principles and international standards of behavior for responsible practices with the view to ensure the effective conservation, management, and development of marine living resources, with due respect for the ecosystem and biodiversity. Database which was created in the present study on fishing fleet, fishing operation, fish catch (kg) per hour, fish discards (kg) per hour, etc. would assist policymakers in preparing conservation and resource management policies

Conclusion
Analysis of fish catch composition in the present study indicated the occurrence of 112 species of fishes in the catch of multi-day and single-day trawlers. Dominant species belonged to the Order Perciformes. An average catch was reported 33.66 kg/h and 33.19 kg/h and discards of 9.04 kg/h and 4.15 kg/h for multi-day and single-day trawlers respectively. Depth of trawl net fishing operation by multi-day trawlers was varied from 12 to 52 m along the Raigad coast of Maharashtra. Diversification of fishing efforts in the deep sea requires serious consideration 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 and discards (kg) per hour, etc. would assist policymakers in preparing conservation and resource management policies.

Acknowledgments

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