



Structural Changes in Mechanised Trawl Fleet along Maharashtra Coast, India

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Authors' contributions

This work was carried out in collaboration between all authors. Author MSD planned and executed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript.

Authors VVS and LE managed the analyses of the study. Author KAMX managed the literature searches and author LS conceptualized and designed the study. All authors read and approved the final manuscript.

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ABSTRACT

Trawl fisheries is an important component in marine capture fisheries of the major contributing state of India like Maharashtra. In spite of the issues like overfishing, overcapacity and destruction caused, trawlers continue to contribute to major catch in India. Since the introduction of trawlers in many parts of India, there are structural changes due to technological interventions regarding design, construction and numbers of craft and gears. Of the 5613 trawlers in Maharashtra, 2849 trawlers were operated in Greater Mumbai. Considering the importance of the trawlers operated, the present study attempted to study the composition of trawlers, operational details of single-day and multi-day fishing and changing trend of trawl fisheries along Mumbai coast. The study was

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conducted from August 2016 to April 2018 at the major 3 landing centres of the Greater Mumbai i.e., Versova, Sassoon Dock (SSD) and New Ferry Wharf (NFW). Trawlers of length ranged between 16 to 17 m were dominant at Versova while 17-18 m were dominant at SSD and NFW. The dominant installed engine horsepower at Versova, SSD and NFW were 50 to 100, 150-200 and 100-150 respectively. The relationship between length overall (L_{OA}) of trawlers and engine horsepower showed that the value of installed engine power was according to L_{OA} at Versova while this was not true in the case of SSD and NFW. Fibre material for hull construction is on the rise due to its low cost of maintenance. The study reported larger vessels with higher horsepower were involved in multi-day fishing. Multi-day vessels tend to have the fishing endurance of 2 to 23 days. Trawl fisheries of Mumbai coast have undergone major structural changes regarding catch, number of vessels and type of trawling. The study suggested the need for restriction on the installed engine horsepower, number of trawlers operated and strict implementation of mesh size regulation. The study also suggested proper regulation of the vessel registration in the case of trawlers operated at SSD to avoid misuse of the registration for purse-seining.

Keywords: Structural change; overall length; horsepower; single-day; multi-day.

1. INTRODUCTION

Marine fisheries is an important sector in India supporting livelihood for millions of fisher-folk and those engaged in related activities [1]. India ranks 7th in the world's marine capture fisheries production during 2013-14 [2]. In the history of marine fisheries, trawling is one of the most efficient technological interventions that has happened the world over [3]. Trawling has contributed to the increased marine fish production and has led to its widespread adoption by many countries [3]. Trawling in India was introduced in the fifties, and this has brought out the potentialities of many inshore fishing grounds off the coasts of India [4].

Maharashtra is one of the dominant fish producing states in India ranking 5th in marine capture fish production among the states with the production value of 2.92 lakh tonnes during 2016 [5]. Being multi-species, the marine fisheries of the Maharashtra state are typically recognised by the gears rather than species, except for Bombay duck which is characteristic of the northwest coast of the country [6]. Since the late 1960s, trawling has emerged as dominant fishing practice in Maharashtra owing to rapid mechanisation targeting shrimps, cephalopods and demersal finfishes [6]. Trawl net is the primary fishing gear operated in Maharashtra, India which supported 40% to the fishery of the state [7]. Fishing fleet in Maharashtra comprised 5613 trawlers, 2961 gillnetters, 3973 dolnetters, 5 liners, 435 purse-seiners and 29 others [8]. Out of 2849 trawlers in Greater Mumbai, 156, 1178, 800 operated from Versova, SSD and NFW respectively [8].

The fisheries in India are operating unsustainably and this should not continue expanding leading to depletion of stocks and poor economic efficiency of this sector. Thus there is the need for restriction of the existing overcapacity and phasing out of trawlers [9]. Marine fisheries in India have undergone a perceptible change regarding the introduction of advanced fishing technologies, gears and fishing fleet [10]. In the early 70s in India, the single-day craft was economical for shrimp fishing and over the years, multi-day fishing was started due to decreasing catch per unit effort triggered by increasing number of in-shore operating vessels [4]. Hassan and Sathiadhas [11] made comparison of single-day and multi-day trawlers of Kerala. They stated that multi-day units among trawl fleet of Kerala, India will further increase due to better catch and returns. They also revealed the requirements of regulations of trawlers regarding number of units, unit operations or quota systems for the efficient management of marine fishery resources of the state Kerala. It is also indicated that multi-day trawlers are not advisable for the long-term sustainable development of our open access marine fisheries. Intensive shrimp trawling with multi-day operation in Maharashtra, India had also contributed to overexploitation of the resources and decline of commercially essential resources [6].

A detailed account of marine fishing craft and gear of Indian coast was given by Pillai et al. [12]. Mane briefly discussed Maharashtra's three main landing centres (Versova, Sassoon Dock and New Ferry Wharf) and Sundaram [13] on the gears and craft operated, fishing area and season. Structural changes of the mechanised

fishing fleet (gillnetter, purse-seiner and trawler) of Kerala were studied by Ravi et al. [14]. Marine capture fisheries being a common property resource, the competition among fishermen for continuously increasing the catch promotes structural changes in the coastal economy [15]. The structural changes of trawl fleet of Maharashtra were not well documented in the previous literature. Considering the issues and problems associated with trawl fisheries, the present study attempted to estimate the composition of trawlers (regarding overall length and horsepower of trawlers), a difference of single-day and multi-day trawlers, and structural changes of trawl fishery in Maharashtra, India.

2. MATERIALS AND METHODS

2.1 Study Area

Versova (19°08'32.7"N 72°48'10.9"E), Sassoon Dock (SSD) (18°54'43.3"N 72°49'32.6"E) and New Ferry Wharf (NFW) (18°57'30.5"N 72°51'03.1"E) were selected sites (Fig. 1.) of the

present study. These 3 landing centres are major landing centres situated in the Greater Mumbai (GRM) district of Maharashtra, India. The study was conducted from August 2016 to April 2018. Fishing vessels which carried out fishing for more than a day were classified as multi-day units and those that fished for a day or half day as single-day units.

2.2 Specifications of Craft

Information on vessel type, length overall, width, draft, hull material, engine horsepower, number of cylinders, number of crew per fishing trip, endurance, and number of trips in a month, were collected based on the pre-structured questionnaire. The information was collected partly by physically sampling the units in operation and partly from the Vessel Registration Certificates available with the Fishermen cooperative societies as well as the Maharashtra State Fisheries Department. The study analysed information on 34, 539 and 416 trawlers from Versova, SSD and NFW respectively.

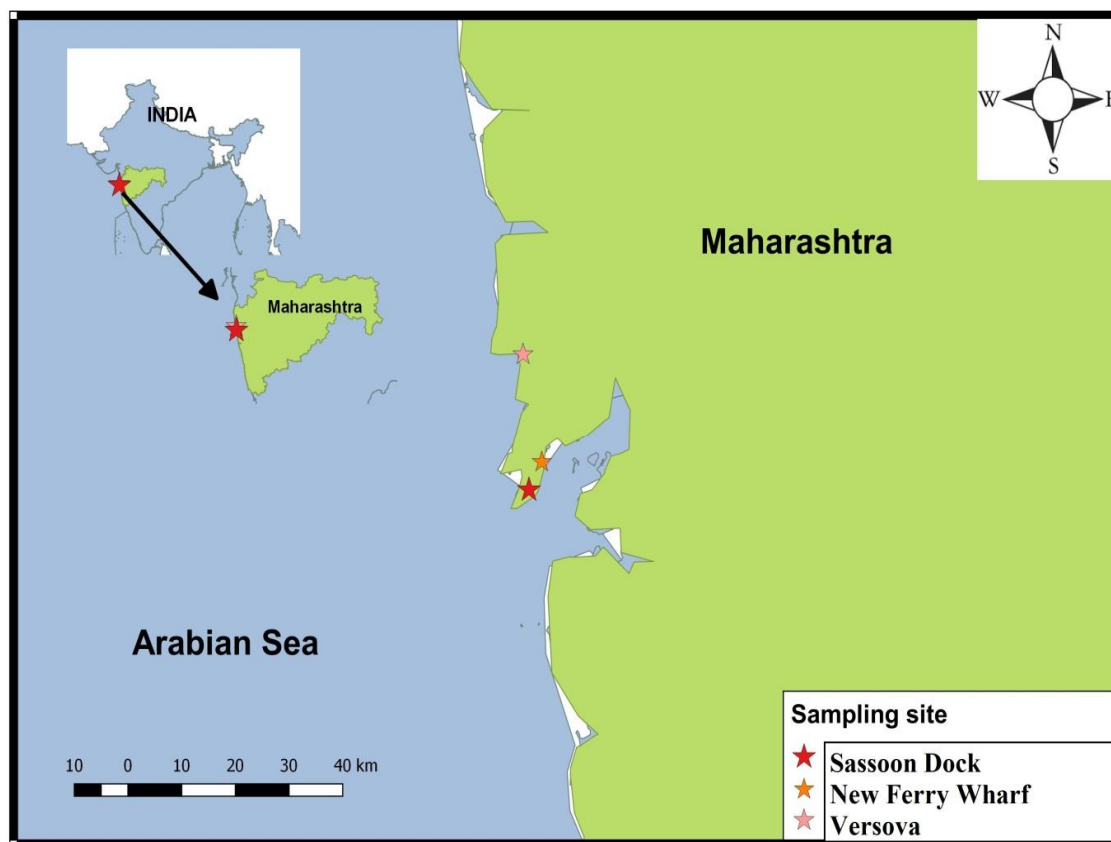


Fig. 1. Map showing the major three landing centres in Mumbai, Maharashtra

3. RESULTS AND DISCUSSION

3.1 Trawl Fisheries along the Mumbai Coast

Trawlers of Versova conducted both single-day and multi-day fishing. Mechanised trawlers from Sassoon Dock and New Ferry Wharf were found to conduct only multi-day fishing. Sassoon Dock has two jetties, i.e., old jetty and New jetty. Some trawlers landed their catch at both the jetties. Species which have high export value were mostly landed at the new jetty. The species landed at new jetty comprised of squid, cuttlefish, penaeid prawn, cobia, mackerel, rainbow runner and bigger carangids. The remaining catch was landed at the old jetty. The major species landed by trawlers along Mumbai consisted of *Parapenaeopsis stylifera*, *Coilia dussumieri*, *Harpadon nehereus*, *Johnius macrophytes*, *Johnnieops vogleri*, *Solenocera crassicornis*, *Otolithes cuvieri*, *Metapenaeus affinis*, *Acetes indicus*, *Trichiurus lepturus*, *L. duvauceli*, *J. macrorhynchus*, and *Nemipterus randalli*. Sharks, catfishes, *Coilia*, Bombay duck, *Nemipterus*, croakers, ribbon fishes, penaeid prawns and cephalopods were the major catches along Mumbai coast during 1998 to 2004 [16].

3.2 Details of Fishing Craft

3.2.1 Length frequency of trawlers

Frequency distribution of (overall length, L_{OA}) length classes of trawlers operated from Versova, Sassoon Dock (SSD) and New Ferry Wharf (NFW), Mumbai during 2016-2018 are given in Fig. 2. Length class of 16-17 m were dominant at Versova landing centre with a contribution of 38.24%. The length of fishing craft varied from 7.3 m (being the smallest trawler) and 18.5 m being the largest. Length class of 17-18 m were dominant at SSD with a contribution of 28.2%. The length ranged between 9.1 m (being the smallest trawler) and 19.9 m being the largest trawler. The length class of 17-18 m were dominant at NFW with a contribution of 43.99% whereas, 12.0 m L_{OA} was the smallest and 20.1 m L_{OA} being the largest at NFW.

During 1998-2004, the overall length of trawlers was mostly dominated by 40 feet (12.19 m) at Mumbai coast [16] which is lower than the dominant group reported in the present study. Since the dominant group of L_{OA} of trawlers reported in the present study is higher than the

past, this indicated a shift in the size of trawlers operated at Mumbai coast. Trawlers at Cochin Fisheries Harbour ranged between 9.1 to 16.0 m L_{OA} with the dominant group being 13.1 to 14.0 m L_{OA} [17].

3.2.2 Installed engine horsepower of the trawlers

Frequency distribution of installed engine horsepower of trawlers operated from Versova, SSD and NFW during 2016-2017 is given in Fig. 3. Low powered engines with hp 50 to 100 were dominant (82.35%) at Versova. High powered engines with 150 to 200 hp (61.22%) were dominant at SSD. But during 1998 to 2004, most of the craft at SSD was installed with 100 hp engines [16]. Installed engines with hp 100 to 150 were dominant (67.07%) at NFW. The dominant installed engine horsepower at NFW was between 90 to 100 hp during 1998-2004 [16]. Trawlers of Cochin Fisheries Harbour are connected with 89 to 122 hp engines and predominated by 106 hp [17]. Installed engine horsepower of 100-150 hp trawlers was dominant (62.3%) during 2000 and the percentage contribution reduced to 24.7% during 2012 due to the increase in 150-350 hp engines in Kerala [14]. The horsepower of engines reported in the present study is higher than the previously reported values.

3.2.3 The relationship between Length overall (L_{OA}) of trawlers and engine horsepower

Correlation between length overall and installed engine horsepower of trawlers operated from Versova landing centre is shown in Fig. 4(a). The scatter plot of length overall and installed engine horsepower of trawlers during 2016-2017 exhibited a power function of the form Engine horsepower = $a \cdot \exp(b \cdot L_{OA})$. The relationship between L_{OA} and installed engine horsepower resulted into nominal R^2 value, and the rate of change of engine horsepower (hp) was 1.4321 concerning change in the L_{OA} . This indicated that the L_{OA} of trawlers at Versova increased with the increase in installed engine horsepower. The engines installed were according to the size of trawlers.

The relationship between length overall and installed engine horsepower of trawlers operated from Sassoon Dock was shown in Fig. 4(b). The scatter plot of length overall and installed engine

horsepower of trawlers during 2016-2017 exhibited an exponential function of the form $\text{Engine horsepower} = a \cdot \exp(b \cdot L_{\text{OA}})$. The relationship between L_{OA} and installed engine horsepower resulted into meager R^2 value, and the rate of change of engine horsepower (hp) was 0.1191 concerning change in the L_{OA} . This indicated that trawlers at SSD were installed with high powered engines regardless of the size of vessels (L_{OA}).

The relationship between length overall and installed engine horsepower of trawlers operated from New Ferry Wharf is shown in Fig. 4(c). The scatter plot of length overall and installed engine horsepower of trawlers during 2016-2017 exhibited an exponential function of the form $\text{Engine horsepower} = a \cdot \exp(b \cdot L_{\text{OA}})$. The relationship between L_{OA} and installed engine horsepower resulted into meager R^2 value, and the rate of change of engine horsepower (hp) was 0.0862 concerning change in the L_{OA} . This indicates that the vessels, in general, are overpowered.

The relationship between length overall and engine horsepower of trawlers along Kerala coast showed an exponential relation with moderate R^2 value. The exponential connection was evident which indicated that the installed engine horsepower increased with the increase in length [14]. In the present study, a similar relationship is observed only in the case of Versova trawlers. Overpowering the vessel is wasteful regarding energy as the maximum attainable speed of the boat is dependent on the length of the waterline [4].

3.2.4 Materials used for hull construction

Percentage contribution by types of trawlers based on the materials used for hull construction at Versova, SSD and NFW is shown in Fig. 5. Most of the wooden trawlers at Versova are about 25 years old. Fibre boats were constructed during the last 10 years. Maximum contribution was made by fibre boats along the NFW while the equal participation of both the fibre and wooden ships was found at SSD.

3.3 Operational Details

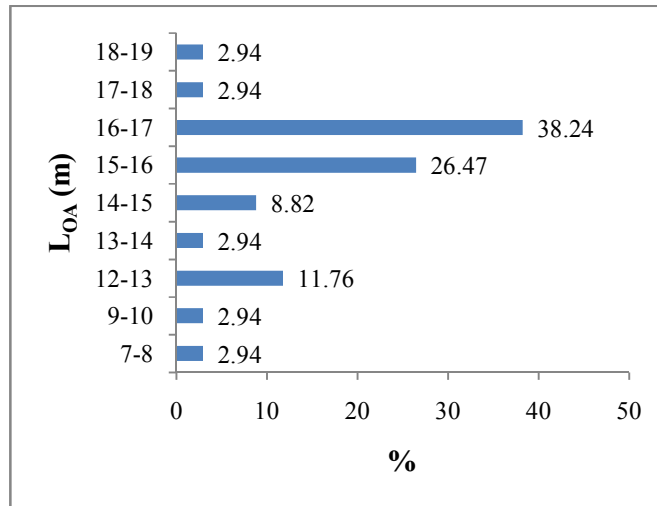
Details of trawlers operated from Versova, SSD and NFW is given Table 1.

Single-day vessels spend about 3:30 to 7:00 hrs for fishing per trip. These trawlers conducted fishing at a depth ranged from 5 to 20 m and at a distance of 5 to 30 km from the shore. About 10 to 25 fishing trips were conducted in a month. They take the half day or one day in between trips to unload the catch, filling of diesel and ice and to arrange food, water, etc. for the next trip. The trawling speed for single-day vessels ranged between 1.5 to 3 km/hr. Target species for the single-day trawlers are shrimps, and hence they carried shrimp trawls (2-3 nos).

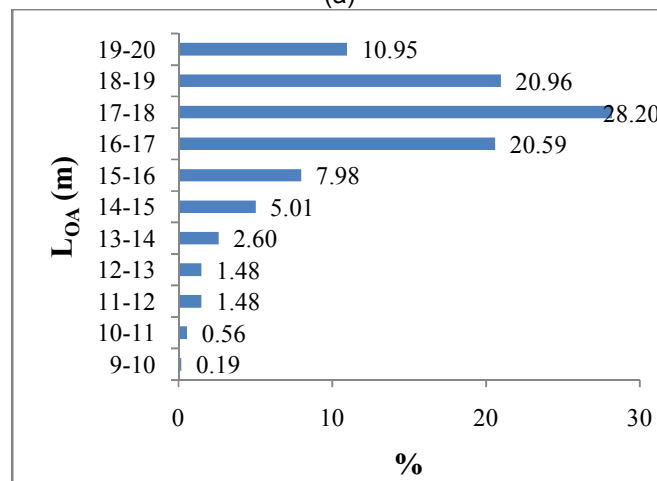
Multi-day trawlers carried out fishing at a depth of range from 10 to 105 m and at a distance of 12 to 400 km from the shore. The number of fishing trips in a month for multi-day trawlers varied from 2 to 6 in a month. Some of the trawlers return within 3 to 6 days, and thus they were able to complete 3 to 4 trips. Most trawlers come back in 8 to 12 days where 2 to 3 were accomplished in a month. Few trawlers were found to go for 13 to 23 days on a trip and were able to carry out 1 to 2 trips in a month. The multi-day trawlers take 1 or 2 days in between the trips to unload the catch, filling of diesel and ice, and to arrange food, water, etc. for the next trip. The trawling speed varied from 2 to 5 km/hr. On average multi-day trawlers carried shrimp trawl (4 nos.), fish trawls (4 nos.) and squid trawls (2 nos.).

The voyage duration of mechanised shrimp trawlers of Maharashtra in the past during 1995-2000 was 4 to 5 days [12], and in the present study, the number of days in a trip recorded up to 23 days. This indicates the increase in the intensity of fishing associated with the increase in capacity of trawlers regarding engine horsepower, size of trawlers, and voyage duration. In India, initially, trawl fisheries restricted to single-day trip and during the latter half of the eighties it was changed into multi-day fishing to save fuel cost, operation in deeper grounds as well as to combine daytime fishing for cephalopods with prawn fishing during nights [18].

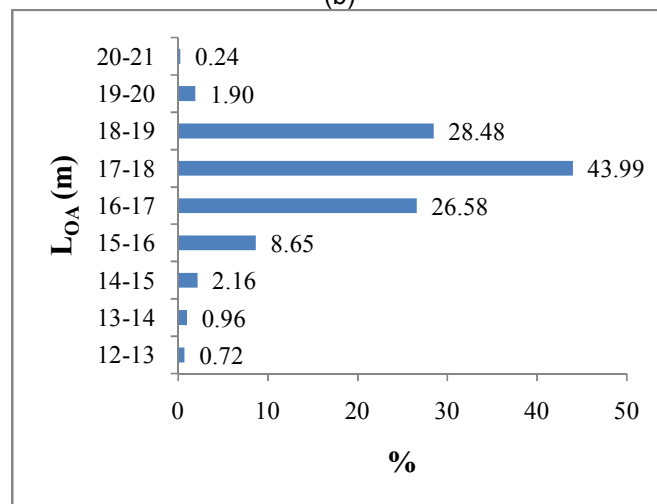
The mesh sizes of cod end of trawls in the Greater Mumbai ranged from 17 mm to 32 mm. Joseph and Jayaprakash [18] reported that the cod end mesh size of trawlers operated along the Indian coast generally reached between 15 mm and 25 mm while the ideal mesh size is 25 mm.



(a)



(b)



(c)

Fig. 2. Frequency distribution of length classes of trawlers along (a) Versova, (b) Sassoon Dock and (c) New Ferry Wharf

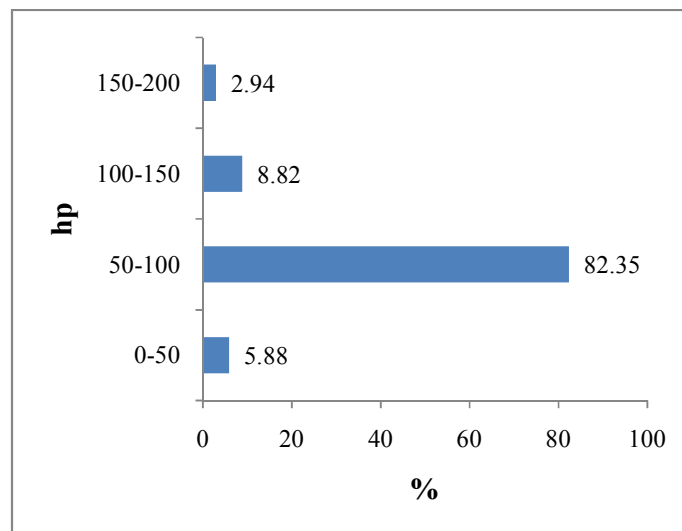
Table 1. Details of trawlers operating from Versova, SSD and NFW

Description	Versova		SSD (Multiday trawlers)	NFW (Multiday trawlers)
	Single-day trawlers	Multiday trawlers		
Overall length (m)	7.315-12.9	9.144-18.5	9.144-19.9	12-20.1
Width (m)	0.914-2	1.295-3.2	1.2-3.36	1.219-3.5
Draft (m)	2.438-5.45	3.455-7.7	2.4-8.6	3.08- 9.53
Gross tonnage	3.6-33.76	9.03-88.55	9.6-99.31	14.31-96.93
Materials used	Wood, Fibre	Wood, Fibre	Wood, Fibre	Wood, Fibre
Horse power (hp)	25-88	86.6-156	68-411	68-400
Number of engine cylinders	3-6	6	6	6
Number of crew	3-5	6-8	7-9	7-9
Endurance (Number of hrs or days in a trip)	1 day (5½-9½hrs)	2-13 days	3-23 days	7-18 days
Number of trips in a month	10-25	2-6	1-4	1-3
Navigational and other equipment	GPS, Compass	GPS, Compass	GPS, Compass	GPS, Compass
Life-saving equipment	Life buoy, Life jacket, First aid box, Fire extinguisher	Life buoy, Life jacket, First aid box, Fire extinguisher	Life buoy, Life jacket, First aid box, Fire extinguisher	Life buoy, Life jacket, First aid box, Fire extinguisher
Durability of boat	Up to 25 years	Up to 28 years	Up to 33 Years	Up to 32 Years

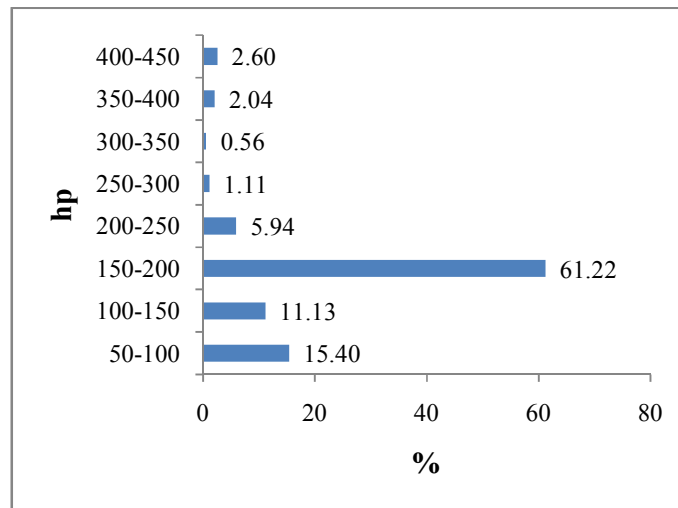
3.4 Changing Trend of Trawl Fisheries along Maharashtra

The number of trawlers operated at SSD and NFW during 1998-2004 was 2000 and 1000 respectively [16]. About 156 trawlers operated in Versova, 1178 in SSD and 800 in NFW during 2010 [8]. Out of 5613 trawlers operated in Maharashtra, 2134 were found to operate in Versova, SSD and NFW [8]. According to

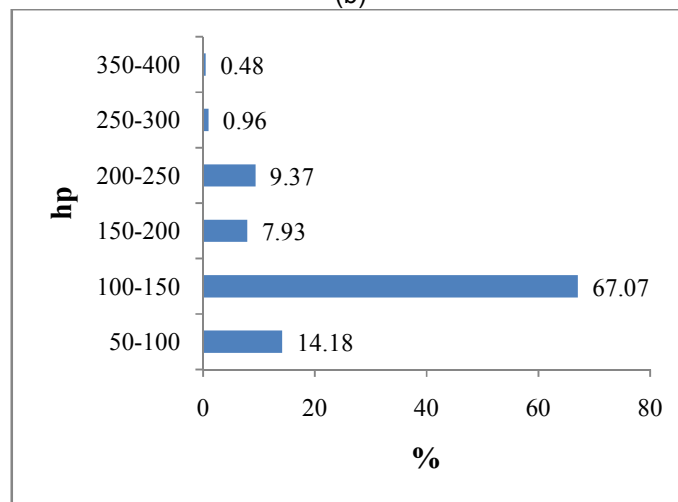
present study, the numbers of registered vessels were 300 trawlers at Versova, 585 at SSD and 1125 at NFW during 2010-2018 (Table 2). The number of registered trawlers of Versova increased from 156 in 2010 to 300 in 2016-18. Similarly, the numbers at NFW increased from 800 in 2010 to 1125 in 2016-18. This was opposite in the case of SSD as the number declined from 1178 in 2010 to 585 and this may be due to the conversion of trawlers into



(a)



(b)

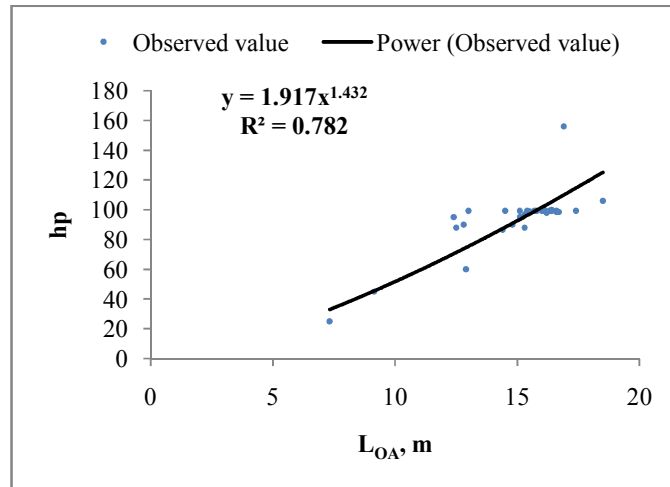


(c)

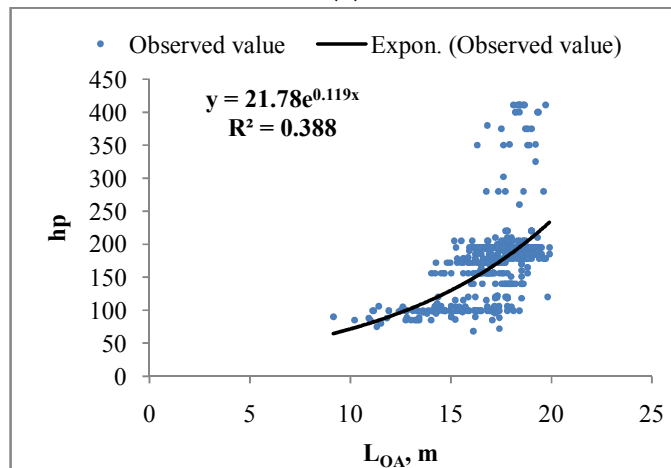
Fig. 3. Frequency distribution of installed engine horsepower of trawlers in (a) Versova, (b) SSD and (c) NFW

purse-seiners. Fishers also reported that some trawlers were registered for trawling and used for purse-seining at SSD. Overall the total number of trawlers at Versova, SSD and NFW has little changed, but the major changes occurred in the size and horsepower of vessels. Boopendranath [19] had estimated that mechanised trawlers were in excess by a factor of 3.2 from that of optimum fleet size for Indian shelf waters (excluding islands). He also concluded that elimination of excess fishing capacity by appropriate management measures could entail in enormous savings in terms of fuel consumption, emissions and bycatch discards from the excess fishing fleet, capital and operational investments and labour deployment in capture fisheries. Some authors reported that

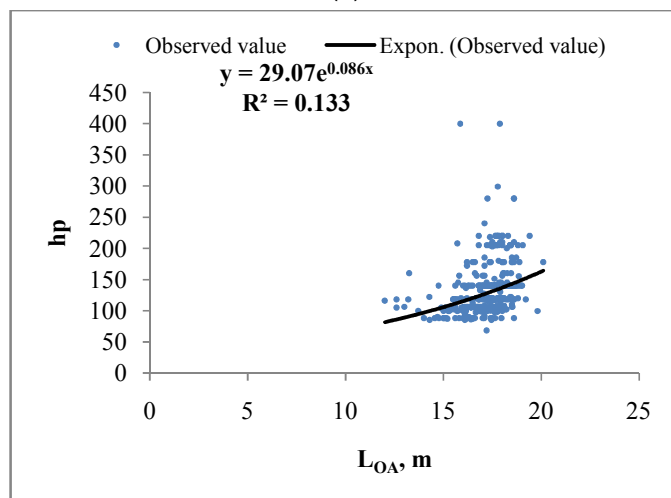
the number of mechanised boats in India increased from 9289 in 1980 to 72749 in 2014 [20]. They also noted that in spite of the increase in a number of mechanised boats, the marine fish catch was almost stagnant since 1998-1999 in India. Joseph and Jayaprakash [18] also mentioned that the number of trawl units should be restricted based on the stock assessment study and the respective state government should stop issuing a license to new trawl units for prawn fishery in inshore waters. In other parts of India, like Thoothukudi Fishing Harbour, a landing centre in Tamil Nadu where only single-day fishing is allowed, with minimum distance from shore to be 3 Nautical miles, restricted time of operation and restriction on multi-day fisheries [21].



(a)



(b)



(c)

Fig. 4. Relationship between length and engine horsepower of trawlers in (a) Versova, (b) SSD and (c) NFW during 2016-2018

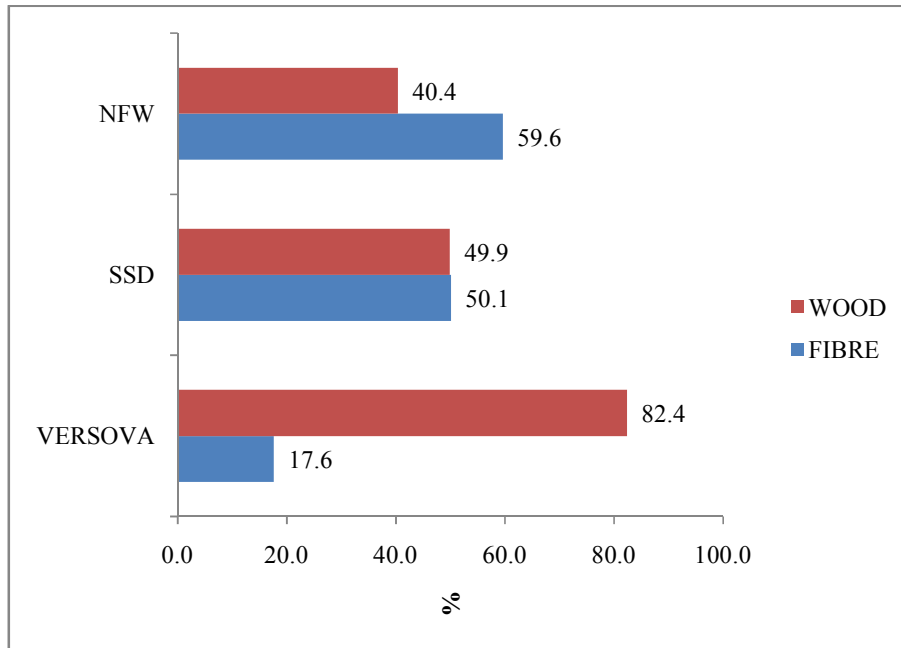


Fig. 5. Percentage contribution of types of trawlers operating from Versova, SSD and NFW

Table 2. Changes in the number of trawlers operated at Versova, SSD and NFW

Landing centre	1998-2004*	2010**	2016-2018***
Versova	Not recorded	156	300
Sassoon Dock	2000	1178	585
New Ferry Wharf	1000	800	1125
Total	NA	2134	2010

* Annam and Sindhu (2005); **CMFRI, 2012; *** State fisheries department

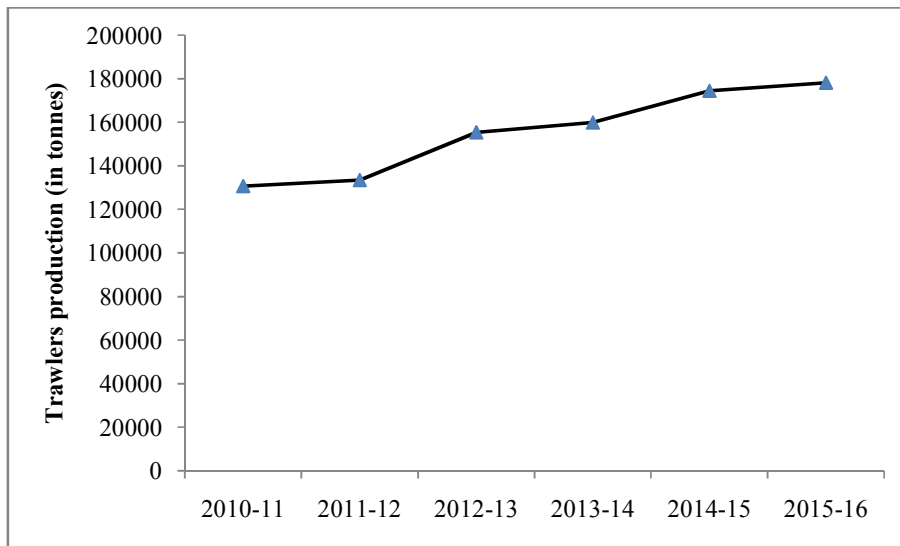


Fig. 6. Trawlers production in Maharashtra during the last 6 years [22]

There was increase in landings from trawlers in Maharashtra during the last 6 years (Fig. 6). This may be due to increase in capacity and extension of the fishing ground of trawlers of the state. Hand trawls were operated at SSD during 1998-2004 [16] while it was not observed at SSD in the present study. It is also reported that gears operated by the vessels of SSD consisted of trawl net, gillnet, purse-seine and dolnet and same were reported during 1998-2004 [16]. Also, a difference was observed in the present study that there were landing of only trawlers, gillnetters and dolnetters while during 1998-2004, trawlers, gillnetters and purse-seiners unloaded their catch at NFW [16].

4. CONCLUSION

Overexploitation, overcapacity, overpowering of trawlers, increase in multi-day fishing activities, use of small codend mesh sizes are the major issues facing trawl fisheries in Maharashtra. The study highlighted the changing trends of trawl fisheries of the Mumbai coast of Maharashtra in terms of catch, catch composition, major structural changes in craft and intensity of fishing, voyage duration and fishing capacity. Trawlers of length 16-18 m were dominant in Versova, Sassoon Dock and New Ferry Wharf. High powered engines were installed regardless of length overall in trawlers operated from SSD and NFW. The trawlers of Versova installed lower horsepower of range 50 to 100 hp while the trawlers of SSD and NFW installed 150 to 200 hp and 100 to 150 hp. Though the number of trawlers registered showed slight decrease in comparison with previous years, the increase in installed engine horsepower and increase in number of fishing days in a trip is a clear indication of high intensity and high fishing pressure. There is the need for strict implementation of mesh size regulation and restriction on the capacity and number of trawlers operating off the Mumbai coast, Maharashtra.

CONSENT

As per international standard or university standard was written patient consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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