



DOL NET FISHERY AND RESOURCE MAPPING OF KARANJA ESTUARY, MAHARASHTRA

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for the degree of

M.F.Sc. (Fisheries Resource Management)

By

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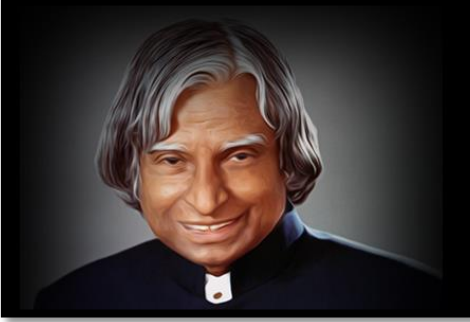
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DEDICATED

TO



எம் மண்ணிற்கு பெருமை சேர்க்கும் இவ் நால்வருக்கும்
சமர்ப்பணம்.

DECLARATION

I hereby declare that the dissertation entitled “**DOL NET FISHERY AND RESOURCE MAPPING OF KARANJA ESTUARY, MAHARASHTRA**” is an authentic record of the work done by me and that no part thereof has been presented for the award of any degree, diploma, associateship fellowship or any other similar title.

30th June 2017
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सारांश

नदीमुखी मछली संसाधनों के प्रबंधन को स्थानिक और अस्थायी आधार-सामग्री के बारे में जानकारी की आवश्यकता है। डोल जाली, मुख्य रूप से महाराष्ट्र के पारंपरिक मछुआरों द्वारा उपयोग की जाने वाली प्रमुख मछली पकड़ने के तरीकों में से एक है। डोल जाली के बनावट और पकड़ने का अध्ययन, पकड़ पर परिचालन मापदंडों के प्रभाव और करंजा मुहाना, रायगढ़ जिले, महाराष्ट्र के चयनित मत्स्य पालन संसाधनों के विषयगत मानचित्र तैयार करना सितंबर 2016 - मई 2017 के दौरान किया गया था। इस अध्ययन के उद्देश्य के लिए कुल 10 एक दिवसीय डॉल-नेटर का चयन किया गया था। अध्ययन के उद्देश्यों को पूरा करने के लिए पाक्षिक सवार नमूनाकरण और प्रश्नावली-आधारित नमूनाकरण किया गया था। डोल जाल के जाल का आकार इसके विभिन्न खंडों में 8 से 165 मिमी के बीच भिन्न होता है। करंजा जेटी से 2 से 5.5 किलोमीटर के बीच अलग-अलग डोल-नेटर द्वारा यात्रा की गई दूरी और जाल 10 मीटर से भी कम की गहराई पर चल रहे थे। ज्वार-आधारित प्रतिबंधों के कारण प्रति माह मछली पकड़ने के दिनों की संख्या 12-16 से थी। डोल जाल पकड़ में फिन की मछलियों की 51 प्रजातियां शामिल हैं, उपास्थिमीनों की 3 प्रजातियां, चिंराट की 13 प्रजातियां, केकड़ों की 10 प्रजातियां, सेफलोपोड की 5 प्रजातियां, जेलिफिश की 2 प्रजातियां, समुद्री साँपों की 4 प्रजातियां, लॉबस्टर की 1 प्रजाति और स्टेटमॉपोड्स की 3 प्रजातियां थीं। अध्ययन के दौरान दर्ज किए गए डॉल जाल की प्रमुख पकड़ संरचना शामिल है *एसिट्स इंडस*, *एरियस मैक्युलटस*, *चारीबीडिस* (चारीबीडिस) *कॉलियानासा*, *क्रिससाओरा एसपी*, *कॉइलिया इयूस्यूमेरी*, *हारपडोन नेहेरियस*, *लेप्टूरेंकथुस सेवला*, *मियाकाले नेपा*, *माइस्टस गुलियो* और *पैरापेनियोप्सिस स्केलप्टीलिस*। औसतन, प्लास्टिक एक **एकांगी** भ्रमण फेरा में कुल जाल से 10.38% पकड़ता था। जेलिफिश जैसे महत्वपूर्ण **पदच्युत**, कई मछलियों और प्लास्टिक के किशोरों को कर्णाजा मुहाना में संचालित डॉल जाल में दर्ज किया गया था। जहाज पर सवार नमूनाकरण के दौरान, डॉल्फिन को देखा गया। आर्क जीआईएस 10.2 सॉफ्टवेयर का उपयोग करके चयनित मत्स्य संसाधनों और मछली पकड़ने के स्थान के विषयगत मानचित्र तैयार किए गए थे। धरमतर पर जेटी निर्माण जैसी मानव-कृत्रिम गतिविधियां इन उत्पादक मछुआरों के कमजोर मत्स्य पालन के संबंध में हितधारकों के बीच एक बड़ी चिंता का विषय हैं। उपायों के सुझाव के लिए वर्तमान अध्ययन के निष्कर्षों का समर्थन उपकरण के रूप में उपयोग किया जा सकता है करणजा मुहाना के डोल नेटर्स के **पदच्युत** का इस्तेमाल करने के लिए प्रबंधन उपायों को अपनाने की आवश्यकता पर प्रकाश डालने पर डॉल जाल मत्स्य संसाधनों की स्थिरता सुनिश्चित करना। यह अन्य नदियां में डॉल नेटर्स के जीआईएस जुड़े मानचित्रण अध्ययनों के लिए आधारभूत **तथ्य** भी तैयार करेगा।

Abstract

Management of estuarine fish resources requires information on spatial and temporal data. Dol netting is one of the major fishing methods used mainly by traditional fishermen of Maharashtra. Study of design and catch composition of dol nets, effect of operational parameters on the catch and preparation of thematic maps of selected fisheries resources of Karanja estuary, Raigad district, Maharashtra was carried out during September 2016 - May 2017. A total of 10 single-day dol-netters were selected for the purpose of this study. Fortnightly on-board sampling and questionnaire-based sampling were carried out to fulfil the objectives of the study. The mesh size of dol nets varied between 8 to 165 mm across its different sections. Distance travelled by dol netters varied between 2 to 5.5 Km from the Karanja jetty and the nets were operated at depth less than 10 m. The number of fishing days per month ranged from 12-16 due to tide-based restrictions. Dol net catch comprised 51 species of fin fishes, 3 species of elasmobranchs, 13 species of shrimps, 10 species of crabs, 5 species of cephalopods, 2 species of jellyfish, 4 species of sea snakes, 1 species of lobster and 3 species of stomatopods. Major catch composition of dol nets recorded during the study included *Acetes indicus*, *Arius maculatus*, *Charybdis (Charybdis) callianassa*, *Chrysaora caliparea*, *Coilia dussumieri*, *Harpadon nehereus*, *Lepturacanthus savala*, *Miyakella nepa*, *Mystus gulio* and *Parapenaeopsis sculptilis*. On an average, plastics formed 10.38 % of the total catch from dol netter in a single trip. Significant discards such as jellyfishes, juveniles of several fishes and plastics were recorded in the dol nets operated in the Karanja estuary. During on-board sampling, dolphins were sighted. Thematic maps of selected fishery resources and fishing locations were prepared by using Arc GIS 10.2 software. Anthropogenic activities like jetty construction at Dharamtar are of great concern among the stakeholders with regard to the vulnerable fishery of these productive estuaries.

Findings of the present study could be used as a support tool to suggest measures to ensure sustainability of dol net fishery resources while highlighting the need to adopt management measures to utilize the discards of dol netters of Karanja estuary. It will also form baseline data for GIS associated mapping studies of dol netters in other estuaries.

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1. INTRODUCTION

Set bagnet is one of the main indigenous gears operated by small-scale fishermen in countries such as Bangladesh, India, Indonesia, Malaysia, Myanmar, and Thailand. There exist some regional variations in net design and mode of operation. Bangladesh and India lead in the usage of this net in their coastal fisheries (Islam *et al.*, 1993). Bagnet operated in the north-west coast of India is locally called *Dolnet*, *Bokshi jal* or *Kavi jal* whereas it is known as *Behundi jal* on the north-east coast. On the Kerala coast; it is named as *ooni vala*.

Dol net can be operated to capture fish not only from near bottom but also from mid-column to a few fathoms below the surface of the water. The techniques of setting, rigging, and operation of the gear are rather complex. It is amazing that the illiterate fishermen have perfected operation of this gear using indigenous knowledge of natural forces such as waves, tides and currents. The bag nets are mostly operated by the poorest segments of coastal communities which majorly involve juvenile fishing in most parts of its existence (Islam *et al.*, 2004).

Compared to other universal passive gears like the gill net, dol net is a non-selective, location-specific gear and is unique in its ingenuity. Thus the area-wise study is an interesting aspect of this gear because of the remarkable skill of fishermen in gear rigging and fishing operations depending on the local conditions and the behaviour of fish.

The design and operation of dol nets in the northwest coast of India have been detailed by Setna (1949), Gokhale (1957), Sehara and Karbhari (1991) and Kunjipalu (2001). Wooden boats of length 12-16 m fitted with 40-100 HP diesel engines comprise the marine dol netters of the north-west coast of India. The cod ends of these nets are fabricated with very small mesh sizes ranging few millimetres and also there is a seasonal change in cod end mesh size and depth of operation to catch diverse fishes in almost all seasons. This results in the capture of juveniles of commercially important fishes such as bombay duck, pomfret, penaeid shrimps, ribbon fish, gholis and other sciaenids which lead to recruitment overfishing and catch of non-targeted species. The main catch of this net in the north-west coast consists of Bombay duck, ribbon fishes, penaeid prawns, non-penaeid prawns etc. Tidal current determines the success of dol net operation. It also determines the number

of operations of the net; normally it is used twice during diurnal tides and four times during semi- diurnal tides.

It was observed that among twenty commercially important fish resources, Bombay duck, silver pomfret, elasmobranchs and lobster resources have declined significantly in Maharashtra. So there is a need for sustainable management of fisheries by appropriate measures such as modifying mesh size and depth of operation to reduce the mortalities of juveniles and bycatch by changing the destructive behavior of gear to a responsible one (Deshmukh,2001). The catches by the dol netters did not respond positively to the effort expended and any change in the effort may not have any impact on the landings (Srinath *et al.*, 1987). The dol net is labour intensive and the effort is regulated depending on the catch/haul (Khan, 1989). Though the net was fishermen-friendly in terms of giving short-term economic benefits, it results in a risk of long-term aggregate environmental impacts due of its non-selective nature of fishing. Usage of dol net was not banned in north- west coast of India due to lack of alternative livelihood for the poor fishermen operating it (Ahmed and Troell, 2010).

Dol nets are mostly restricted to the shallow water regions of 10-30 M depth (Josekutty and Sundaram,2004). The Bag net fishing and its impact on discards or non-targeted species were not fully taken into account by research institutions and mapping of bag net fishery resources and fishing area is lacking. The bag nets are locally constructed and managed and hence there is need to understand aspects regarding selectivity, environmental safety and cost effectiveness of the gear (Kumawat *et al.*, 2015).

There are many issues which hamper development of our estuarine resources such as water flow, port activities, pollution, land use, commercial fishing, aquaculture, climate change etc. The most glaring problems of our estuaries which need to be addressed are lack of proper planning and coordination among the stakeholders in implementation, lack of adequate knowledge of management of resources, low level of awareness about sustainable use of resources and conservation of estuarine environment and its valuable biodiversity. Bycatch is the major issue in fisheries management; it not only creates an imbalance in ecological biodiversity but also leads to huge waste of proteins. It leads to conservation failure in case of bycatch of

endangered species such as aquatic mammals, turtles, fishes etc. (Hall *et al.*, 2000). Dol nets of estuarine regions are loaded with huge bycatch of numerous juveniles which challenges the supply of healthy recruits to the adjacent coastal bodies. Data on month-wise percentage availability of juveniles, bycatch and adults of all marine species in India is needed to take proper management decisions with regard to multi-species and multi-fishery country. (Luther and Sasthri, 1993). Fish communities with spatio-temporal variations could be used as indicator of anthropogenic stress and it should be considered for restoration programs (Nandan *et al.*, 2012).

A multi-layer GIS database integrating local fishers' and scientific knowledge information has been developed with ArcGIS 10.3 ArcView®. This formed a tool to integrate and translate information into an accessible and interpretable format and the geo-spatial database interface allowed the selection of specific data characteristics by target species, harvest areas, fishers' communities, fishing gear, catch-per-unit of effort (CPUE), and monthly landings for the management of artisanal fisheries management in south Brazil (Freitas *et al.*, 2009).

Raigad district has the second highest number (1393) of dol netters in Maharashtra (CMFRI, 2010). Karanja creek (18°50'5.60"N to 18°51'50.71"N Latitudes and Longitudes 72°53'40.12"E to 72°59'5.83"E.), Raigad district, Maharashtra, located along the eastern shore of Mumbai harbour encircles the village Karanja. The creek is continuous with the Dharamtar creek and Pen – Khopoli creek joining the Arabian Sea near Uran. Uran city is towards the south side. On the west side, Uran is encircled by Arabian Sea, have rocky shore towards the seaward side where as remaining part of the creek is marshy and of mud flats. Dharamtar creek is uniformly deep with 10 meters range and has moderate cover of mangroves with mud flats and low lying marshy areas on their sides. The livelihood of most of the fishers living around Karanja village solely depends upon dol net fishing. The areas around Karanja region well known for hectic activities due to the presence of Jawaharlal Nehru Port Trust and a new fishing jetty coming up in the vicinity will probably alter the natural estuarine flow. Further, this could result in several changes in dol net catch, fish resources, mangroves, fishermen livelihood etc. There is very little information available with regard to the estuarine fisheries resources of Karanja. Hence the present study was designed to investigate various aspects of dol net fisheries with the following objectives.

1. To study the design and catch composition of dol nets operated at Karanja estuary
2. To study the effect of operational parameters on dol net catch
3. To prepare thematic maps of the selected dol net fisheries resources

2. REVIEW OF LITERATURE

2.1 Dol net

Dol net is a stationary bag net lowered and hauled based upon the tidal directions. It is operated in places of strong tidal currents with its mouth always facing the direction of tide (Bapat, 1970). West Bengal ranks first in respect of number of dol netters operated in our country with a grand total of 5137 followed by Maharashtra with an aggregate of 3973 dol netters. In contrast, Maharashtra state leads with regard to the number of dol nets owned by fisher folks (CMFRI census, 2010).

2.1.1 Dol nets of northwest coast

Setna (1949) gave a detailed account on the ingenuity of dol net operation that included the net design, pile driving techniques and differences between *sus* fishery and *khunt* fishery of Bombay region. Pillay (1948a) studied the *ghoul jal* (kind of a bag net) operated in kodinar, Kathiawar. Based on the study, the illustration of net was provided along with list of fish species caught in the net with their respective vernacular names and seasonal changes. Gokhalae (1957) described different parts of dol nets used in Saurashtra coast with the local names in addition to stone heap structure. It was pointed out that these differed from the nets operated at Bombay. It was also pointed out that the nets operated in Karanja regions were relatively lengthier. Ramamurthy and Muthu (1969) described the bag net features for prawn fishing and seasonal prawn catch in bag nets of both east and west coast. The *behundi jal* operated in West Bengal estuaries have long wings but the operation is similar to that of *sus* fishing in Kathiawar coast.

Bapat (1970) carried out research on the abundance of Bombay duck fishery in dol nets of Maharashtra and Gujarat and concluded that the fishery is more abundant in Gujarat than Maharashtra. He reported that carrier boats of dol nets together bring the catch of 3-4 dol nets. The catch of Bombay duck was highest in the fourth quarter of the year. Larger bag nets used in Maharashtra are locally called as *Dol nets* or *Kavi* and mainly made up of monofilament twine whereas smaller bag nets are called *bokshi jal* (Silas, 1981). Rajan *et al.* (1982) studied the dol net prawn fishery of Bombay during 1966-1976 and observed fall in the mean annual catch of prawns. Pillai (1983) studied the catch composition of dol net landing in Sassoon dock during January to December 1971 and gave a detailed account of monthly catch composition, fluctuation of catch etc. He observed an inverse relationship between landings of Bombay duck *Harpodon nehereus* and paste shrimp

Acetes indicus in Sassoon dock probably due to prey predatory relationship. The maximum catch in dol nets was noted in July. The Dol-netters operated mostly were fitted with an engine with 25 to 30 HP. (Srinath *et al.*, 1987) reported that the proportion of dol net catch to the mechanised landings of the Maharashtra state decreased from 65-70% in 1980-81 to about 50% during 1982-84. They also observed that catches by the dol netters did not respond positively to the effort expended.

Raje and Deshmukh (1989) studied the prawn catch between 1966-1976 in dol nets of Mumbai region and found that non-penaeid prawn landing was more than that of penaeid landing. Raje and Ramamurthy (1990) reported 178 mechanised boats that were fully engaged in dol net fishing in Versova of which 60 were small (7.5 - 9.0 m) 47 medium (9.3 -12.0 m) and 71 large (over 12 m). They also stated that the duration of net in water depended upon the tides. So during full or new moon days, the soaking time was longer usually between 4.5 to 5 hours whereas during the neap tide, the net was soaked for only 2.5 to 3.5 hours. Bag nets along the Indian coast majorly contribute to low-value non-penaeid prawn production among marine prawn production. Peak season observed for prawn fishing in Maharashtra coast was between October-December and March-May. In Maharashtra coast, the acetes fishery was dominated by *Acetes indicus* and *Acetes johnei*. Extending the dol net operation to deeper waters can make the dol net fishery more profitable by exploiting more penaeid component of the fishery (Suseelan and Rajan, 1993).

Raje *et al.* (1991) gave an account of the disposal of catch from dol nets of Versova, Bombay and reported the multispecies nature of dol net fishery comprising fishes, penaeid prawns and non-penaeid prawns that supported almost 85% of the fishermen families at Versova. Sun drying comprised 85-90% of dol net catch. About 70% of the total catch of *Acetes* spp. was utilised for manure and feed. He reported the size variability of meshes from mouth to cod end that ranged from 280 to 12 mm. Sehara and Karbhari (1991) described the types of dol net operations in north-west coast namely *Khamba*, *khunt sus* of Maharashtra and *Kaba sus* of Gujarat. '*Kaba-sus*' has a permanent stone anchor consisting of a heap of stones with a rope tied to float (*Kaba*) for net operation. In Maharashtra, *Khunt-sus* possess anchor pole or spike (measuring 8-10 feet in length) driven in the mud at bottom of the sea. Another system of 'dol' operation is '*Khamba*' which consists of very long wooden poles or pylons fixed to the bottom. The economic comparison between these nets indicated high returns in *sus* system than that of *Khamba*

system in north-west coast of India. *Khunt sus* method is practiced in Mora-Karanja region of Raigad district.

Kurian and Kurup (1992) studied stock assessment of Bombay duck off Maharashtra coast. The dol nets contributed major share to the landing of Bombay duck *Harpodon nehereus*. They reported that plank- built boats were mostly used for dol net operation. Preparation of dol net station and operation of dol nets requires many skills. Though synthetic filaments were being used in net making, the design and operation of net remained highly traditional. Rao *et al.* (1993) reported that dol net operated in Kakinada had wide mouth tapering to a narrow cod end. The net was divided into 8 segments. The mesh size decreased from mouth to cod end ranging from 10 cm to 1 cm. Patil (1993) studied most indigenous method of using wave energy for fixing pylons or stakes of dol nets in the sea. Five types of mooring materials were observed by him from north to south Konkan like thin bamboo or wooden poles, stone heaps, stakes, spikes and anchor. He also noticed and reported that net setting in the upper, middle or lower column depended on species and season of operation.

Kunjipalu and Boopendranath (1993) observed and documented development of design and specifications of experimental dol net. They reported improved mean size of Bombay duck (*Harpodon nehereus* Ham) landed by the experimental anchored bag net fabricated from ready-made webbing. Manojkumar and Dineshbabu (1999) concluded from their study that 'dol' net operation in Saurashtra was confined to a depth ranging from 15 to 35 m. The fishing craft used for the 'dol' net operation varied from 10 to 15 m in length with tonnage varying from 5 to 20. Twisted cotton yarn of 10 counts was used for making the webbing. Deshmukh *et al.* (2001) studied the penaeid prawn fishery and it's MSY at Versova of Mumbai. The number of dol-netters had reduced in Versova due to the introduction of trawlers. He suggested even more reduction of dol netters for obtaining MSY for penaeid prawn fishery. Kunjipalu (2001) observed the details of dol nets of India and general layout of dol net of Saurashtra and Versova - Satpati regions. He reviewed the status at the time and suggested measures to improve the dol net fishery. He described the gear and operation of dol nets along the north-west coast of India.

Miriam *et al.* (2003) studied the dol net fishery of Maharashtra, the dol nets were main gear in Maharashtra among the fishing gears. Dol net contributed 24.7% to the marine fish production of Maharashtra. He also gave the detailed account of dol net with reference

to cost and earnings. As per the study of Josekutty and Sundaram (2004), dol net operation was mainly confined to a depth range of 10 to 30m and catch consisted of huge quantities of juveniles of pomfrets in dol nets operated in creek regions off Mumbai. Sarang and Sundaram (2004) studied the dol net fishery at Arnala, one of the major dol net landing centers in Maharashtra. The gear was operated from August to May in the depth ranging from 18m–22m. Chavan and Sundaram (2005) observed huge landing of juveniles of *Epinephalus diacanthus* (40-70 mm) in dol net landings of New ferry wharf. George *et al.* (2005) gave an account of responsible craft & gear in mangroves including bag nets. Bag nets of usually mesh size 1.4 cm for fish and 3 mm for shrimp were used in the fringe of mangroves. They suggested that location specific mesh size regulations exclusively for mangroves need to be formulated.

Nair *et al.* (2007) studied the catfish fishery by dol netters along the Saurashtra coast where each boat carried 2 to 5 nets, which in turn made 1 to 10 hauls with duration of 5hr/haul. Most of the traditional fishermen of Maharashtra operated bag net fishery. The *teak* wood (*Tectona grandis*) was widely chosen as boat building timber for these bag-netters due to sturdiness, durability, tolerance to swift currents for a long period. The *babul* wood (*Acacia arabica*) in combination with teak wood was also noticed. U shaped or V shaped mechanized crafts of OAL 5.5 m to 12 m were involved in this fishery. The mesh size of dol nets varied between 280 mm at the mouth portion to 5 mm at the cod end. Length of the net ranged from 45-64 m, width between 24-37 m and height between 9-11 m. They were operated 2 to 4 times based on diurnal and semidiurnal tides. The Wind from the north direction (*upercha vara*) during October to March was favourable for large fish catch and catch during high tide was more compared to the low tide. A rich fishery was observed between twelfth day (*Dwadashi*) to third day (*Tritiya*) of lunar cycle whereas moderate catch prevailed during the ninth day (*Navami*) to eleventh day (*Ekadashi*). Very low catch was observed between fourth day (*Chaturthi*) and eighth day (*Ashtami*) due to changes in the intensity of tides. (Nirmale *et al.*, 2007).

Warhekar and Mohite (2016) studied the design of mosquito dol nets operated in creek region of Ratnagiri and recorded that webbing of polyethylene (PE) multifilament of 1.5 mm diameter with specifications of 210DX5X3 and having a mesh size ranging from 150 to 8 mm were used. The nets were operated in the creek throughout the year in the depth ranging from 18 to 20 m. Hodi or Depco (dugout canoe) was used for dol netting operation. The dug-out canoe was fitted with one or two cylinder inboard engine having 5 to 7

horsepower (hp). Boats operating "dol" net, in north-west coast of India, are wooden boats, ranging from 12 m to 16 m in length, powered by marine diesel engines of 40-100 HP. The catch composition was led by Bombay duck and Paste shrimps. Most of the species shown catch abundance between 2 peaks April-May and October-December. They noted that increase in dol net catch compared to previous year (2012).

Bag net fishery of Maharashtra lacks specific policies in terms of regulations, developments and sustainable utilisation of valuable fisheries resources. Research related to effects of climate change and environmental factors affecting the bag net fishery in Maharashtra is yet to be carried out. Fishers prefer this net due to economic viability though it does not result in responsible fishing. Pollution threatens the operation of this net. Excess fishing capacity exists in dol net fisheries of Maharashtra. Bag net fishing and its impacts on discards or non-targeted species were not fully taken into account by research institutions and GIS based bag net fishery information is lacking. The bag nets are locally constructed and managed. Very few studies were carried out regarding the selectivity, environmental safety and cost effectiveness of the gear. (Kumawat *et al.*, 2015).

Sudesh and Nandini (2016) studied the Chrono spatial frequency of fishing gears used along the Ulhas river estuary and reported that the dol nets dominate in the lower reaches of this estuary. Compared to commercial fishing practices, subsistence or artisanal level fisheries dominated this area. The dol nets made up of five parts that are operated here varied with Bokshi jal in having larger meshes. The authors also opined that usage of small mesh size gear threatened the sustainability of resources of the estuary and this issue required special attention.

2.1.2 Dol nets operated in other areas

Akerman (1986) studied the set bag net fishery of Bangladesh. He stated that the usage of this net might threaten the resource due to its small mesh size and he gave some recommendations in respect of material, mesh size and cod end modifications. Islam *et al.* (1993) studied and gave a brief account of the predominant estuarine bag net fishery of Bangladesh. They opined that mesh size regulation in estuarine areas will not benefit the estuarine fishermen in terms of revenue due to the differences between estuarine and marine features. On the other hand, reduction of fishing effort during the months when

juveniles of valuable species of finfishes and shrimp are abundant, would decrease the gear destructiveness and also guide them towards conservation of the valuable resource and increase in the yield of bag nets. *Been jal* or *Behundi jal* operated in the Hooghly estuary have a wide mouth, 7 m wide at the mouth portion with long wings of about 10 m length and 2 m width on both side of mouth. Very small mesh size of about 2mm is used for the cod end and a flap provided near the cod end prevents fish escapement. Wooden anchors or stout wooden spikes are used to fix the net .The operation of this net is extensive during the period November to June in the estuarine areas. Bombay duck (*Harpodon nehereus*) and prawns comprise the major catch (Ramesan *et al.*, 2009). Boopendranath *et al.* (2010) gave detailed description of the design, structure, and operation of the stake nets (Bag net) in the Vembanad Lake. Traditional plank canoes were used for operating the stake nets and carrying the catch. They observed that juveniles were predominant in the catch.

2.2 Estuarine fisheries

Estuaries are semi-enclosed coastal body of water having free contact with the open sea .The salinity of the estuary depends on the relationship between freshwater inflow and evaporation so the salinity may be higher or equal or lower compared to the open ocean (Pritchard *et al.*, 1952).Estuaries and creek waters possess a wonderful self-purification system via diurnal tidal cycle and constant ecological interaction naturally. But the increase in urbanization and industrialization threatens, degrades this habitat particularly close to mega cities (Kulkarni *et al.*, 2010). Most of the great estuaries in the world are restricted to tropical regions where a wide range of taxa are closely related and all forming a part of the overall community with ecological links (Blaber, 2002). Among the types of estuaries, the coastal plain estuaries dominate and support good fishery around the world (Pritchard *et al.*, 1952). Estuaries support the sustenance of marine fisheries resources as the life cycle of many marine fishes has an estuarine phase. Overfishing, inadequate management and habitat degradation etc. results in decline of fish stocks which in turn poses a challenge to the sustainability of estuarine fisheries in tropical areas (Nachowitz, 2008).

The average estuarine fish production yield of our country varies between 45 to 75 kg ha⁻¹ (Talwar and Jhingaran, 1991; Sugunan, 2010). Jha *et al.* (2008) categorised the estuaries of Mumbai regions as minor type. They listed out many issues which hampered

our estuarine resources such as water flow, port activities, pollution, land use, commercial fishing, aquaculture, climate change etc. The most glaring problems which need to be addressed first in our estuaries are lack of proper planning and coordination among the stakeholders in implementation, lack of adequate knowledge of management of resources, low level of awareness about sustainable use of resources and conservation of estuarine environment and their valuable biodiversity. The continuous monitoring of estuarine fisheries was done in the largest estuarine complex Hooghly Malda estuary of India whereas the same scenario does not exist for other estuarine systems. Catch from winter bag net fishery of this estuary comprised about 67% though it was only operative for about three and half months per annum. Traditional fishing craft and gear are still in use in the inland fisheries sector. There is a need for improved designs of craft and gear for sustainable fishing in inland waters. (Sugunan, 2010). Fish communities with spatiotemporal variation could be used as an indicator of anthropogenic stress and it should be considered for restoration programs (Nandan *et al.*, 2012).

Karanja estuary is 10 Km long with an estuarine area of 20.0 Km² and mangrove area of 4.37 km² (Jagatap *et al.*, 1994). This estuary is characterized by rocky shore towards the seaward side whereas rest of the parts of the estuary are covered with marshy and mudflats. The coastal stretches of Uran have considerable stress due to the existence of various industries, JNPT, container freight stations etc (Pawar, 2011). Pawar (2011) reported 31 species of fishes from Karanja estuary with the predominance of order Perciforms, He also suggested that further intensive studies in this estuary may enhance the diversity list. Water quality near the mangrove ecosystem along the Karanja estuary showed deterioration due to industrial pollution and that mangrove along Karanja faced threat due to anthropogenic stress (Pawar, 2013).

Kulkarni *et al.* (2011) predicted that the number of industrial plants in the Karanja region is likely to increase manifold in future. Tide data of Karanja and Dharamtar estuary between 1986-2007 confirms that they have a mixed semidiurnal tide with two unequal amplitudes with the maximum spring tide of 5.1 m and the neap tide of 3 m. Maharashtra Maritime Board maintains the channel with depth of 3.5 m below spring low water and width of 135 m from the mouth to Dharamtar for navigation of barges by dredging (Velamala *et al.* 2016). Swami *et al.* (2011) studied the biodiversity of fouling species at Karanja jetty and found that although heavy boating and shipping activities prevailed, the site supported a rich and varied fauna of fouling species due to healthy status of water

near the jetty with average DO of 5 ppm. The high values of evenness index observed in the estuary implies good condition of the system for growth of biota and also the high value of Shannon's index of general diversity implied that all the species in Karanja estuary were equally abundant (Pawar and Kulkarni, 2007).

Prabhakar (2011) assessed the bycatch and discards in marine capture fisheries from Mora and Karanja of Raigad district. They have recorded 101 species of bycatch that comprised 29 species of fin fishes, 22 species of crustaceans, 31 species of gastropods, 11 species of bivalves, 3 species of cephalopods, 4 species of polychaetes and 1 species of sponges. Ecological studies on Karanja estuary revealed that shrimp culture and brackish-water fish culture could be done in adjacent ponds because of the favourable range of salinity prevailing even in the monsoon season (Shingare *et al.*, 2016).

Naidoo *et al.* (2015) stated estuaries serve as one of the major medium for terrestrial plastics to reach the ocean. Though several studies on macro plastics in estuaries were carried out, available data on plastics ≤ 5 mm in estuaries are scanty. Costa *et al.* (2011) opined that the process governing plastic fragmentation, deposition and behaviour were poorly studied in estuaries compared to oceans or beaches. They came across plastic segments of various types and sizes present in the estuarine segments. Amount of floating debris in estuaries is linked to the tide patterns, winds, riverine inflows, evaporation etc. Estuaries nearer to mega cities are heavily polluted. A significant difference in size frequency of plastic distribution between the spring and neap tides existed whereas the larger size of plastics predominated during spring tides (Sadri and Thompson, 2014). Though the occurrence of plastics in marine environment was reported in the 1970s, the plastic debris is observed within every marine habitat and has accelerated substantially in the recent years. (Ivar and Costa, 2013).

In order to maintain Bombay harbor channel for passage of ships, bottom materials were dredged and dumped towards the Karanja estuary located nearer the port. During the influx of tides, most of these materials travelled through Karanja estuary and found its way up to Dharamtar estuary (Patel *et al.*, 1975). Significant amount of plastic discards were reported by the fishermen in Raigad district. The plastic wastes constituted on an average 30-45 % of total catch in every haul of trawlers in the rainy season. This created difficulties to the fishermen as it increased the sorting time (Prمود, 2010). Increasing non-biodegradable floating materials in the creek waters clogged the fishing nets forcing the

fishermen of Thane creek to change their traditional fishing gears especially dol nets. Commercial fishing in this creek was adversely affected due to plastic pollution (Goldin and Athalye, 2012).

Indo-pacific humpback dolphins (*Sousa chinensis*, Osbeck, 1765) are known to commonly inhabit estuarine and coastal habitats at depth less than 20 m (Sutaria and Jefferson, 2004). Sighting of this dolphin in Raigad region was first reported by (Sterndale, 1887).

2.3 Geographical Information System (GIS)

Population abundance estimates and habitat quality were used with the GIS to predict abundances in areas that were not sampled and to calculate an abundance estimate for the entire stream or stream segment (Toefer *et al.*, 2000). According to Meaden *et al.* (1997) the main functionality of GIS is in producing a range of graphical, textual and mapping output database for fisheries management. Kemp *et al.* (2001) suggested that visualization is a very potent tool in providing decision support in fisheries information systems. Fisheries management involves distinct groups of participants with a common purpose but different perspectives on strategies to be pursued and information is required for effective management. A multi-layer GIS database integrating local fishers' and scientific knowledge information was developed with ArcGIS 8.3 ArcView® tools to integrate and translate information into an accessible and interpretable format and the geo-spatial database interface allowed the selection of specific data characteristics by target species, harvest areas, fishers' communities, fishing gear, catch-per-unit of effort (CPUE), and monthly landings for the management of artisanal fisheries management in south Brazil (Freitas *et al.*, 2009).

Caddy *et al.* (1986) reported the relevance of fisheries thematic mapping in general fisheries and the current importance of resource mapping, particularly in the Exclusive Economic Zones of developing countries. Historical perspective on development of fisheries science in respect of established fishing areas supports recognition of resource mapping as an important preliminary stage to fish stock assessment, particularly for coastal resources. GIS offers advantages over conventional approaches because of the speed and accuracy with which it handles large spatial datasets, so the decision makers can make more informed decisions because multiple scenarios can be evaluated or spatial analyses conducted that would otherwise prove too cumbersome (Isaak *et al.*,

1997). Dineshababu *et al.* (2016) developed protocols for data collection and analysis of dol net data for resource mapping along Mumbai coast.

3. RESEARCH METHODOLOGY

3.1 Study area

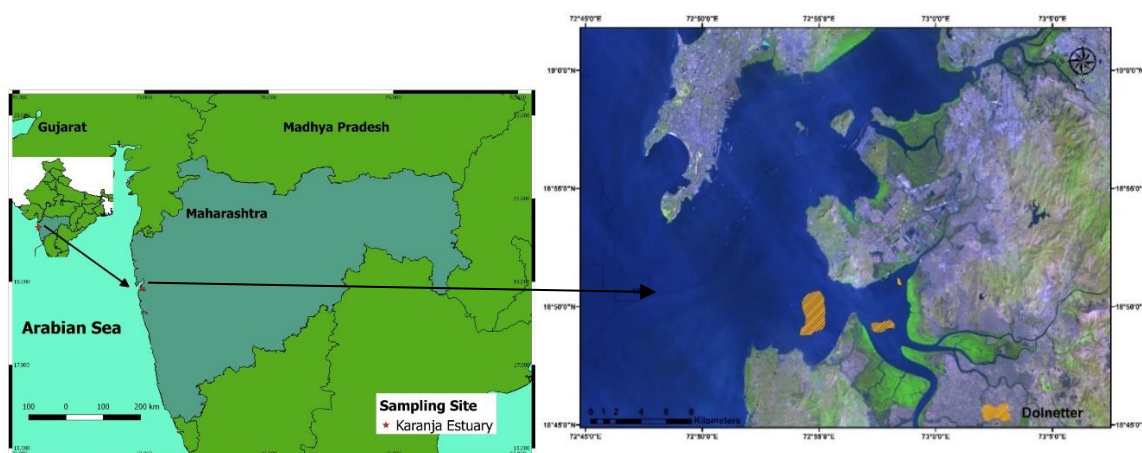
Maharashtra is the third largest state of India which covers 307,713 km² area and found to be one of the major maritime states in India with a coastline of 720 Km that makes it the 4th longest coastal line state of India. There are 6 maritime districts i.e. Palghar, Raigad, Thane, Greater Mumbai, Ratnagiri and Sindhudurg in the state which comes under Konkan coast. About 15 rivers, 30 backwater regions and 5 major creeks have been reported along the Konkan coast (Jagtap *et al.*, 1994). Though Maharashtra lacks major upstream freshwater flowing rivers or estuaries besides few small rivers like Savitri, Vashishti, Shastri, Kundalika and few creeks like Ulhas - Thane complex, Vaitarna, Karanja - Dharmatar complex, Dabhol, Jaigad, Sakhartar, Bhatye, Purnagad, Vijaydurga, Devgarh, Achra and Karl drain in east-west direction and merges with Arabian sea.

Raigad is the coastal district of Maharashtra state, situated on the west coast of India formerly well known as Kolaba district. It has periphery of Mumbai Harbour to the northwest, Thane district in the north, Pune district to the east, Ratnagiri district to the south, and the Arabian Sea in the west. Also it includes Pen-Mandwa natural harbour which is situated immediately south of Mumbai harbour, and making an isolated landform with it. The northern part of district is incorporated in the planned metropolis of Navi Mumbai, and its port, the Jawaharlal Nehru Port.

3.2 Geography

Raigad district forms a major part of northern Konkan and has the Western Ghats on its eastern and southern border with 168 fishing villages (Singh & Yazdani, 1993). Karanja estuary (18°50'5.60"N to 18°51'50.71"N Latitudes and Longitudes 72°53'40.12"E to 72°59'5.83"E) situated along the eastern shore of Mumbai harbour nearer to Colaba, surrounds the Karanja village. The creek joins with Dharamtar and Pen-Khopoli creeks and meets the Arabian Sea near Uran on the west coast of India. In the recent past, coastal belt of Uran has been under heavy process of urbanization due to a number of industries opening on the coast line. Famous port, Jawaharlal Nehru Port Trust (JNPT) lies neighbouring Uran, which is located at 10 km distance from Karanja. JNPT is one of the busiest international ports in the country and

supports a variety of maritime activities. The Uran shore and Karanja estuary areas became the place for hectic activities such as container freight stations.



Map 1: Geographical location of sampling site for dol netters in Karanja estuary (Generated using QGIS ESSEN (2.14.3) and Arc GIS 10.2)

3.3 Raigad fisheries sector

In Maharashtra, Raigad district tops in total fisherfolk population by covering 32 % of state total and also tops in the proportion of unschooled fisher population. Among fisherfolk of Raigad, 38% belongs to adult fisher folk category. Of the total 3973 dol netters of Maharashtra, 27.5 % (1093) belongs to Raigad district. Out of 29701 Fisherfolk population of the district, 60 % are registered in fisheries cooperatives. This makes Raigad district as the highest proportion in fisheries co-operative membership in the state. The fishermen of Raigad district belong to Koli community who were declared under scheduled tribe (ST) by Government of India (Marine fisheries census 2010).

3.4 Study period

In Karanja, fishing season starts from 15th August or Narali Purnima day whichever is earlier and lasts up to end of April or beginning of May. The fishing activities of dol netters are not conducted between 1st June to August 15th. In the present study, data was collected during September 2016 to May 2017.

3.5 Collection of fishery associated data

3.5.1 Type of vessels and their registration status

Information with regard to the type of fishing vessel used based on the materials used in building the boat and overall length (OAL) was gathered by personal visits to the Karanja landing jetty and registration status of vessel was collected from the fishermen and verified from the state fisheries department.

3.5.2 Size and Number of bag nets per vessel

The dimensions of bag nets with respect to single day operation and number of bag nets per bag netter was gathered from boats operated in Karanja estuary.

3.5.3 Mesh size of bag nets

The mesh size of the cod ends of bag nets selected was measured using a Carbon fiber composite digital calliper (Resolution: 0.1 mm and accuracy: ± 0.2 mm)

3.5.4 Discard at sea

The month wise quantity of discard in the estuary from the selected dol netters was documented from the study area.

3.5.5 Status of documentation of fishing information

A number of selected dol netters was observed for documentation status based on quantum of information recorded and regular updating of information regarding fishing operations, retention of fish catch and retention of other species.

3.5.6 Waste (Garbage/Plastics)

The month wise quantity of garbage/plastics in the unsegregated fish samples taken from selected dol netters from Karanja estuary was measured using a digital balance.

3.5.7 Catch per haul and Catch composition

Catch per haul was calculated from the total weight of catch in a haul from single-day dol netters. The month-wise species composition by weight was analyzed after segregation of catch from dol netters. Length measurement of each species was taken using standard measurement scale on-board and in the lab.

3.6 Operational performance

The parameters collected for studying the operational performance of Karanja dol netters comprise number of trips per month, distance from shore, depth of operation (m), duration of fishing trip, departure time, arrival time, average speed and fuel consumption(litres)

3.7 Preparation of thematic maps

Software used

3.7.1 Arc GIS 10.3

Arc GIS developed by Environmental System Research Institute (ESRI) Redlands, California was used for analysing the geographic data. It was used for making thematic maps, build up and edit geographic data, analyse map information, sharing and discovering geographic information, using maps and geographic information in a range of various applications, and managing geographic information in a database. The Arc GIS 10.3 was used for analysis in the present study.

3.7.2 QGIS

QGIS is a free and open-source desktop geographic information system application that is used to edit and analyse geographic information and represent the analysed data. Like other GIS software, it is also used for creating and editing maps with many layers using different map projection. Maps can be assembled in different layers using different map projection. They can be assembled in different formats and for different uses. It was used for making raster and vector layers in the present study. In this software, vector data can be saved in point, line or polygon features and URLS was directly used for mapping. QGIS ESSEN (2.14.3) was used in this study.

3.7.3 Corel Draw 12

Corel draw is a vector graphic editor tool. It was used to draw the scale diagram of dol net.

3.7.4 Microsoft excel 2013

Microsoft excel 2013 was used for calculation of monthly catch, discard, Pie diagram of monthly species composition and also used for conversion of GPS location points into degree decimals. This was also used for calculation of total discard, total catch and percentage of discard for the bycatch study.

3.8 Preparation of Karanja estuary Geo-database

The methodology used in the study with regard to preparation of thematic map of fisheries resources harvested by dol netters in the Karanja estuary, preparations of maps of CPUE and temporal variation is given below.

3.8.1 Conversion of latitude and longitude coordinates

For mapping in Arc GIS, geographic coordinates are required in decimal degree formats but geographic coordinates acquired during fishing operation were in Degree Decimal Minute format. So conversion of geographic coordinates from Degree Decimal Minute to Degree Decimal was done with the help of Microsoft excel.

3.8.2 Preparing data for GIS use

All the primary data collected from various sources, along with the geographic position in Degree decimal minute that was converted to Degree decimal format were entered into Microsoft excel sheet and converted into database file and CSV (Comma Delimited) format. These database files were later used in geo-database.

3.8.3 Preparation of Geo-database

The geo-database is the necessary data structure for Arc GIS and is the primary data format used for editing in Arc GIS. Geo-database is an alternate way to store GIS information and all data (raster, vector etc.) in one large file, using database management system (DBMS) or file system, which can contain multiple points, polygon, and polyline layers. The geo-database helps in data management and with its natural editing features makes GIS analysis more efficient and less time-consuming. For research analysis, Geo-database of Karanja estuary was created in Arc catalogue. Karanja estuary geo-database file needed dataset features (total catch

and distribution of resources). Different features class (polygon, line, point) were created in Arc- catalogue with WGS 84 spatial reference and edited in Arc map.

3.9 Accessories used for the study

3.9.1 Camera

Sony cyber shot 5x optical zoom was used to take the catch composition and Dol net operation photographs

3.9.2 GPS

Garmin oregon@650 GPS was used to take the latitude, longitude of dol net station, distance from the landing place, direction etc.

3.9.3 Measuring accessories

Foot and meter scale, 5 m Fremance steel tape, a Carbon fiber composite digital calliper (Resolution: 0.1 mm and accuracy:±0.2 mm), Ruler scale for gear, craft and species measurements.

4. RESULTS

The Study area of Karanja estuary covers 18°50'5.60"N to 18°51'50.71"N Latitudes and Longitudes 72°53'40.12"E to 72°59'5.83"E. The dol net stations selected for sampling during the study were located in 18°49'58.62"N to 18°51'16.54"N and 72°54'56.84"E to 72°58'18.86"E. Mapping of fisheries resources was done on spatial scale, India coastline map on 1:100,000 scale. Thematic maps of fisheries resources and fishing activities were prepared by utilizing base map and geographical coordinates. Fisheries spatial information system for Karanja estuary region was designed and organised, on ArcGIS 10.2 and QGIS Desktop 2.2.0 platform using spatial and non-spatial data. The time scale of study was September 2016 to May 2017.

Mapping of fisheries resources viz Total catch and Temporal Species availability was achieved on spatial scale using geographical coordinates and base map prepared at 1: 32,000 scale.

4.1 Dol net fishery of Karanja estuary

4.1.1 Type of vessels operated

A total of 10 motorized dol netters were operating in the Navapada of Karanja estuary. Motorized dol netters of with OAL between 5.85-13.6 m fitted with 2- cylinder engines of 7-16 HP were used.



Fig. 1: Dol netters of Karanja region

Table 1: Specification of the Dol netters selected in Karanja for on-board sampling

Name of the Vessel	Shivling	Shree Ganesh	Shiv raj
Type of Vessel	Motorised dol netter	Motorised dol netter	Motorised dol netter
V.R.C number	IND-MH-3-MM-4	IND-MH-1MM-4401	IND-MH-1MM-3233
Date of Purchase	2010	2009	1990
Length of Keel(M)	6	4	4.2
Overall Length (M)	8	5.48	5.82
Cost of vessel (Lakhs)	2	1.5	1

Table 2: Specification of engine of selected dol netter used in Karanja estuary

Name of Company (Make)	Lister
Year of installation	2010
Number of cylinder	2
Stroke	2
Engine power (BHP)	14
Cooling Medium	Air
Average fuel Consumption (L/hr)	1
Cost of engine	1.25 lakhs

Table 3: Details of dol net fishing operation in Karanja region

Fishing ground	Rocky on seaward side , muddy on riverine side
Type of operation	
Based on scale of operation	Small scale
Based on number of vessels used	One boat
Depth of operation	8-10 m
Method of finding the fish shoal	Visual(current),wind direction
Time Required for	
a) setting the net	20 min
b) hauling the net	20 min
Immersion period	4-5 hours (depends upon the lunar cycle)
Duration of single trip	2 hours
Duration of single operation	2 hours
Average number of dol net operations per trip	2-3 Dol nets per trip
Average quantity of fish caught per trip	10-15 Kgs (excluding bycatch)
Average returns from sale of fish per trip	Rs.500-1000/-

4.1.2 Size and number of dol nets / vessel

The size of dol nets varied between 14-18 m. The number of dol nets operated per dol netter varied between 2 and 4. More numbers of dol nets (up to 4) were used during peak fishing months September and October.

4.1.3 Mesh size of dol nets

The dol nets operated in Karanja region is divided into 5 sections known by local names, viz., *Mawr*, *Katra*, *Manjola*, *Moonj* and *Khola* with varying mesh sizes. The mesh size of the dol nets varied between 8 to 165 mm across its different parts.(Table.4)

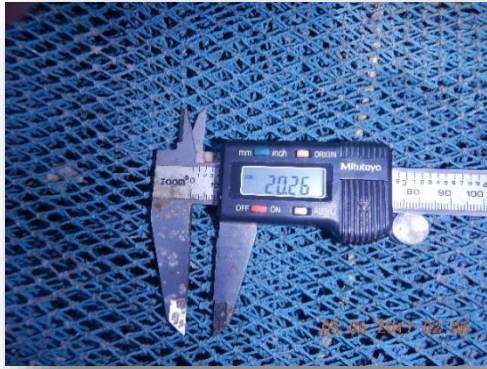


Fig. 2: Mesh size and total length measurements

Table 4: Dimensions of different sections of dol net

Sections	Mawr				Katra					Manjola			Moonj			Khola		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Mesh size (mm)	165	155	145	135	125	115	105	95	85	75	65	55	45	35	25	15	10	8
Upper edge (nos)	950	900	850	800	750	700	650	600	550	550	500	450	400	400	350	300	300	250
Lower edge (nos)	950	900	850	800	750	700	650	600	550	550	500	450	400	400	350	300	300	250

4.1.4 Number of fishing days or trips per month

The month- wise information regarding number of fishing days or trips undertaken by single-day dol netters (Table.5) from Karanja estuary region revealed that September to October is the peak season of dol net fishing operations.

Table 5: Month-wise number of fishing days

Month	Number of fishing Trips
Sep- 2016	16
Oct-2016	16
Nov-2016	14

Dec-2016	12
Jan-2017	12
Feb-2017	14
Mar-2017	14
Apr-2017	14
May-2017	14

Number of fishing trips of single- day dol netters varied from 12-16 in a month.

4.1.5 Distance from shore

The mean distance travelled by dol netters from Karanja jetty was 4.065 Km and a maximum distance of dol net station was located at 5.3 km from landing jetty

Table 6: Distance travelled from the shore and depth of operation

Station	Latitude- Longitude	Depth of operation (m)	Distance travelled from landing centre (Km)	Direction in which travelled
1	18°50'10.24"N- 72°54'39.70"E	8	4.4	NW
2	18°50'11.08"N- 72°54'39.78"E	8	4.6	NW
3	18°50'16.49"N- 72°54'42.57"E	8	4.7	NW
4	18°50'17.25"N- 72°54'42.59"E	8	4.6	NW
5	18°50'17.91"N- 72°54'42.61"E	8	4.5	NW
6	18°50'18.67"N- 72°54'42.60"E	8	4.4	NW
7	18°50'19.36"N- 72°54'42.64"E	8	5.1	NW

8	18°49'16.38"N- 72°54'42.97"E	8	5.1	NW
9	18°49'17.31"N- 72°54'56.98"E	8	5.3	NW
10	18°49'00.73"N- 72°54'32.76"E	8	5	NW
11	18°49'03.98"N- 72°54'31.93"E	8	5	NW
12	18°49'05.09"N- 72°54'31.98"E	8	3.23	SE
13	18°49'16.30"N- 72°57'21.96"E	8	3.24	SE
14	18°49'12.72"N- 72°57'22.66"E	7	3.5	SE
15	18°49'46.96"N- 72°54'50.54"E	7	5.1	NW
16	18°49'44.38"N- 72°54'50.29"E	8	5.1	NW
17	18°51'03.61"N- 72°58'30.30"E	5	2.6	NE
18	18°51'04.75"N- 72°58'28.55"E	5	2.7	NE

4.2 Technical specifications, design and rigging of dol net

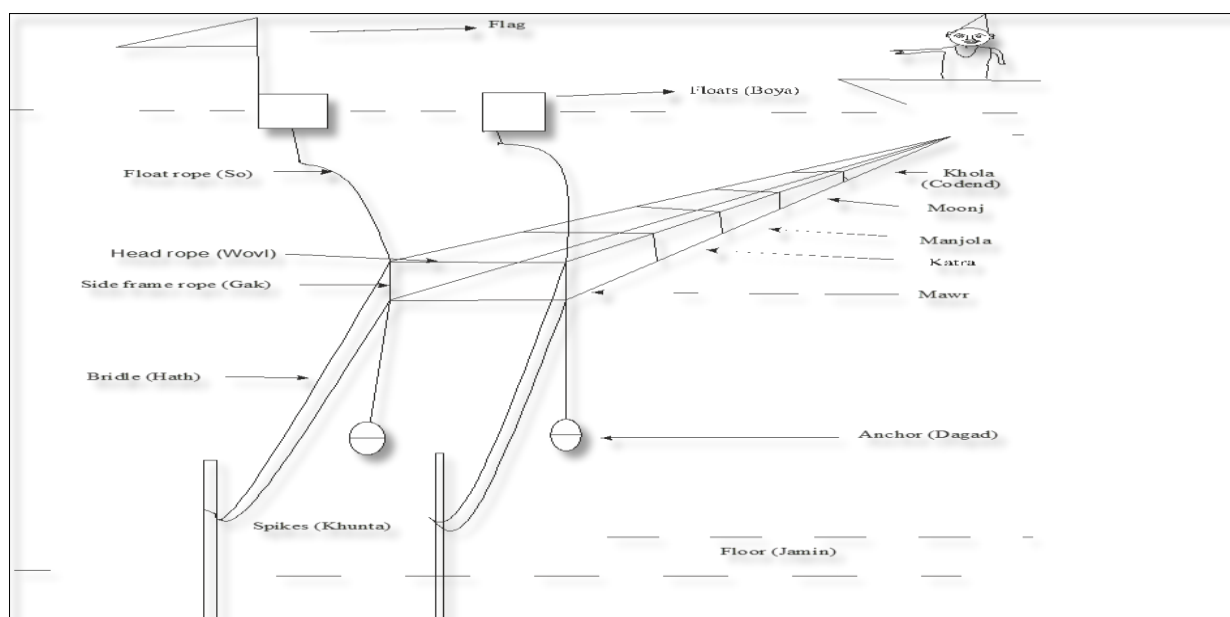


Fig. 3: Dol net of Karanja region (Sketched by using Coral draw)

Table 7: Particulars of dol net

Fishing gear type	Dol net
Type of operation	Small scale
Local name	Dol net
Colour of the net	Blue
Total number of sections	5
Total number of Panels	5
Length of float line (m)	14-18
Length of sinker line (m)	14-18
Depth of stretched netting (m)	12-14
Weight of the net with rigging (Kg)	Approx. 35
Without rigging (Kg)	28-30
Total weight of the net (Kg)	Approx. 35
Cost of net with rigging	Rs. 34000
Without rigging	Rs. 30000
Number of man days for construction of gear	Fishermen buy the machine-made net and

	spend five days to assemble it.
Treatment, if any	Just placing the net under shade

Table 8: Particulars of accessories of dol net

S.no	Specification	
1	Float line	
	Material	Nylon multi-filament
	Length (m)	14-18
	Diameter (mm)	13.9
	Twist(S or Z)	S
2	Lead line	
	Material	Nylon
	Length (m)	14-18
	Diameter (mm)	13.9
	Twist(S or Z)	S
3	Hauling line	
	Material	Nylon multifilament
	Length (m)	4-5
	Diameter (mm)	23
	Twist(S or Z)	S

Table 9: Particulars of rigging of dol nets

1	Floats	
	Types	Thermocole bundle, Empty plastic drums(35 L capacity)
	Shape	Rectangular
	Length (cm)	60
	Breadth (cm)	35
	Total number	3

	Weight of single item	35 litre plastic drums (400 g)
	Total weight (Kg)	1.2
	Rigging	By using nylon ropes
	Other details, If any:	Floating raft made of thermocole is used to travel between the coast and the boat
2	Sinkers	
	Types	Stones/Steel Iron
	shape	Irregular shape
	Length (cm)	25
	Breadth (cm)	10-12
	Total number	2-3
	Weight of single item (Kg)	2.2
	Total weight (Kg)	5-6
3	Spike (Khunts)	
	Types	Wood / Concrete
	Materials	Locally available woods
	Shape	Cylindrical or tubular shape
	Diameter (cm)	10-15
	Length (m)	4-5
	Breadth (cm)	15
	Total number	2
	Weight of single item (Kg)	10-15
	Total weight (Kg)	20-30

4.3 Details of Karanja jetty

There are three fishermen cooperative societies in the Karanja village. Karanja jetty is 50 m long which is subjected to low tide and high tide. The same is used for fish landing and transport purpose. There are no proper ice plants or processing facilities available in the village.

Table 10: Details of Karanja jetty

Berthing capacity (In Nos)	10
Length of the wharf (M)	50
Ice plant	No
Petrol bunk	Yes
Central/State fisheries offices	Yes
Fishermen societies	Yes
Fresh water availability	Yes
Fishermen amenities	Yes
General cleaning facilities	No



Fig. 4: Wharf of Karanja with upcoming constructions

4.4 Discards

The month wise analysis of discard of catch in the estuary from single day dol netters of Karanja evidently revealed that during the entire fishing year (September, 2016-May, 2017) there was more than 5 % discard from total resource caught. Month of February had more discards. The main content of discard in the dol nets was jellyfishes and plastics. The juveniles of several fish species were also seen in discards.

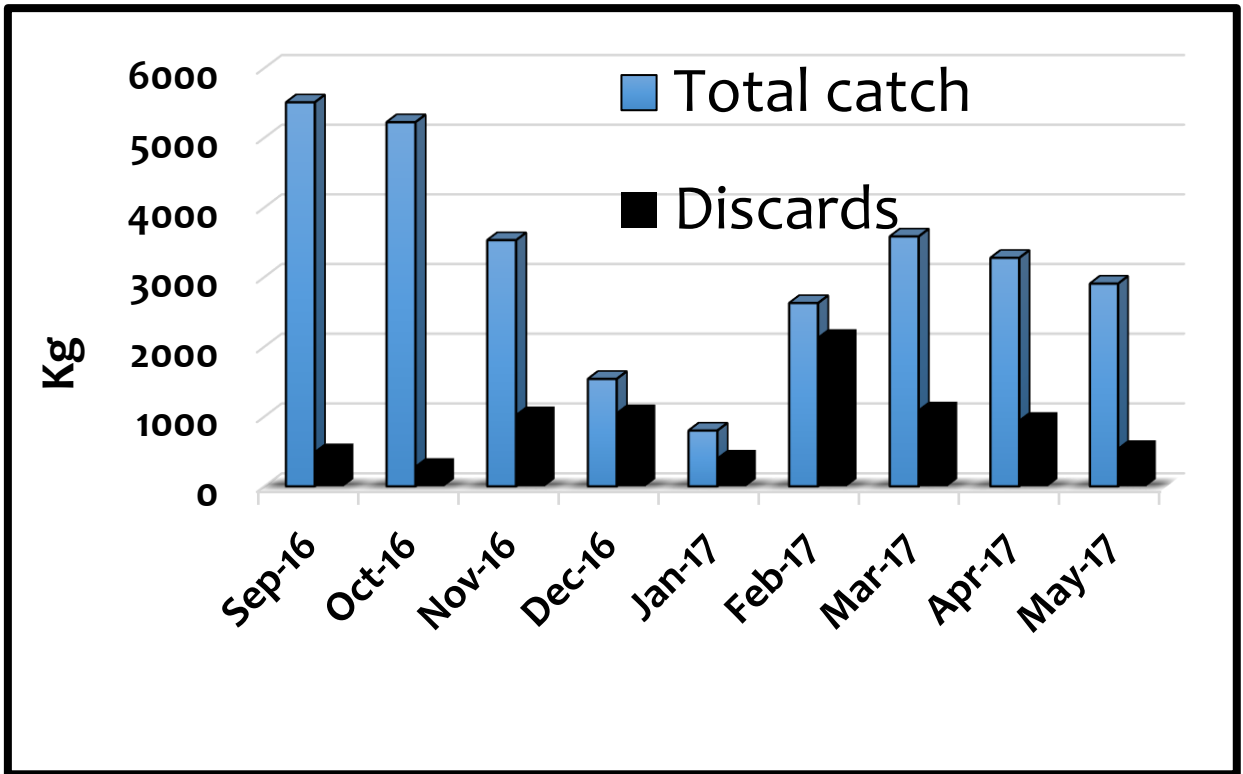


Fig. 5:- Total catch and discard from Single day dol netters

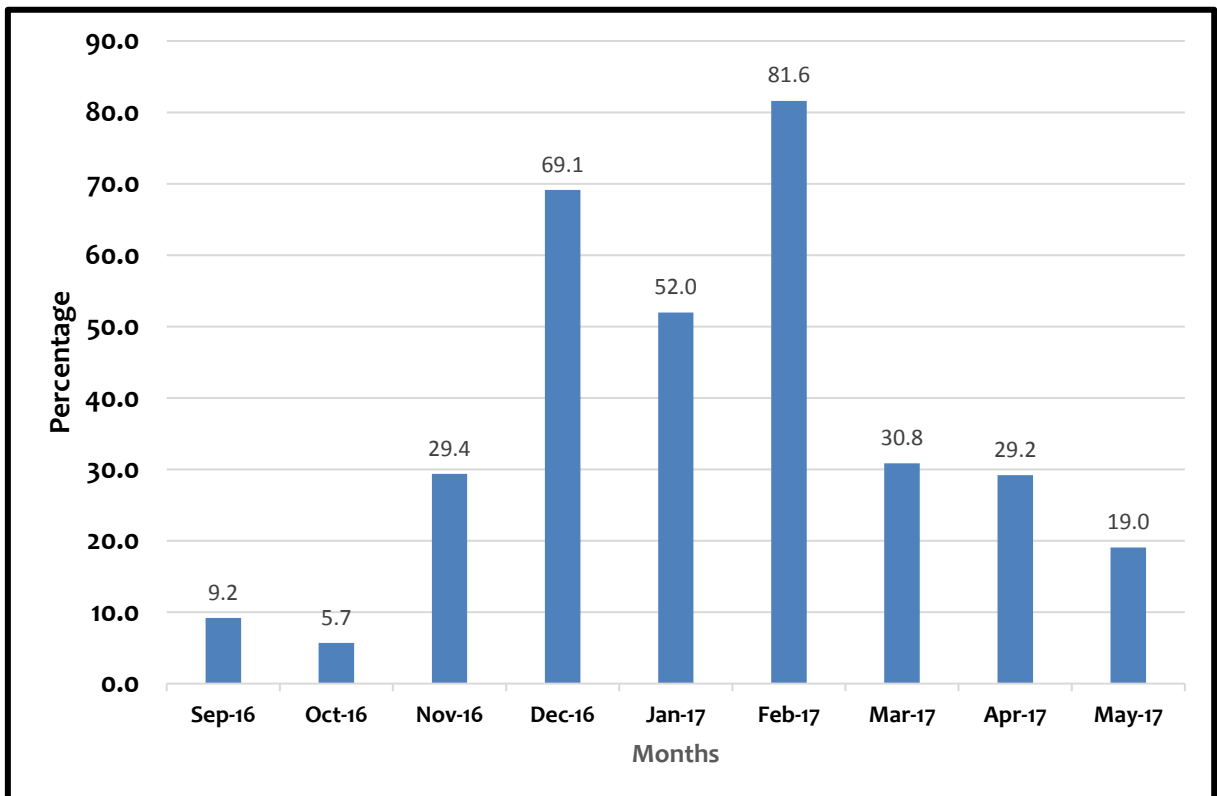


Fig. 6: Discard percentage of catch from dol netters

4.4.1 Plastics

It emerged from the present study that on an average plastics formed 10.38 % (maximum 26.23 %) of total catch from dol netter in single trip. Plastics of various categories are noted in the sampling with the domination of food packet covers.

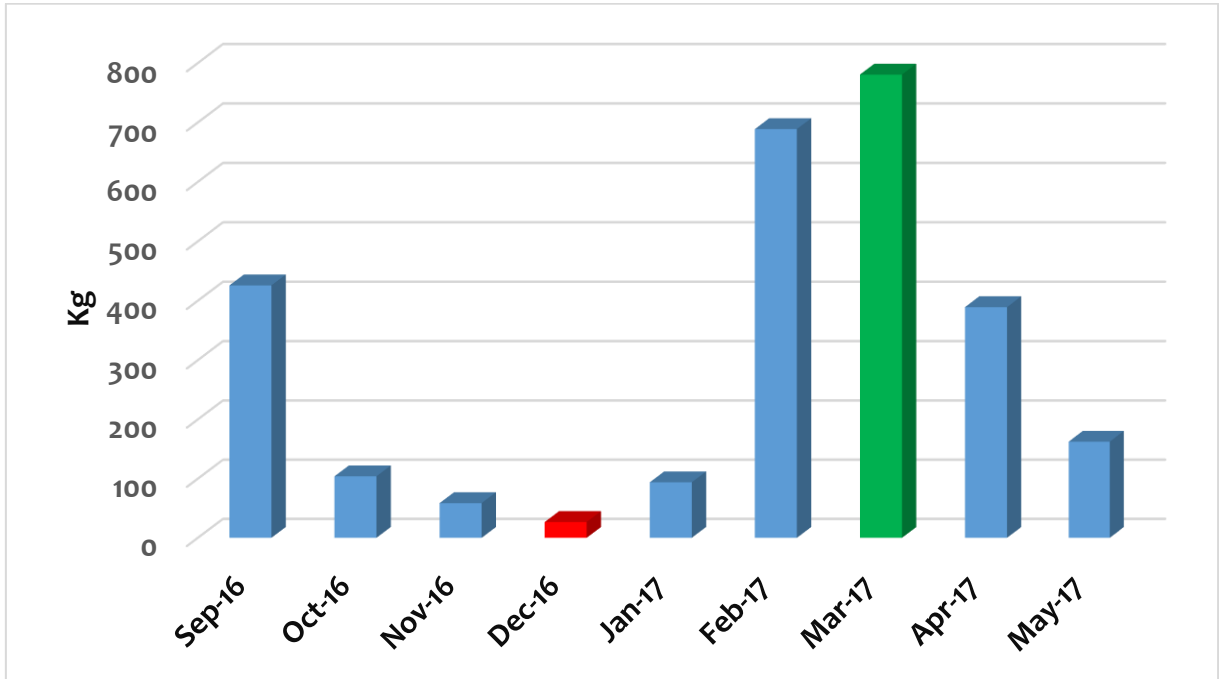


Fig. 7: Month-wise plastic catch in dol nets



Fig. 8: Plastic catch in dolnets

4.5 Catch Composition

Analysis of species wise monthly catch composition of single day bag net fishery showed that the *Acetes indicus*, *Arius maculatus*, *Charybdis (Charybdis) callianassa*, *Chrysaora caliparea*, *Coilia dussumieri*, *Harpadon nehereus*, *Lepturacanthus savala*, *Miyakella nepa*, *Mystus gulio*, *Parapenaeopsis sculptilis* were the major contributors between September 2016- May 2017.

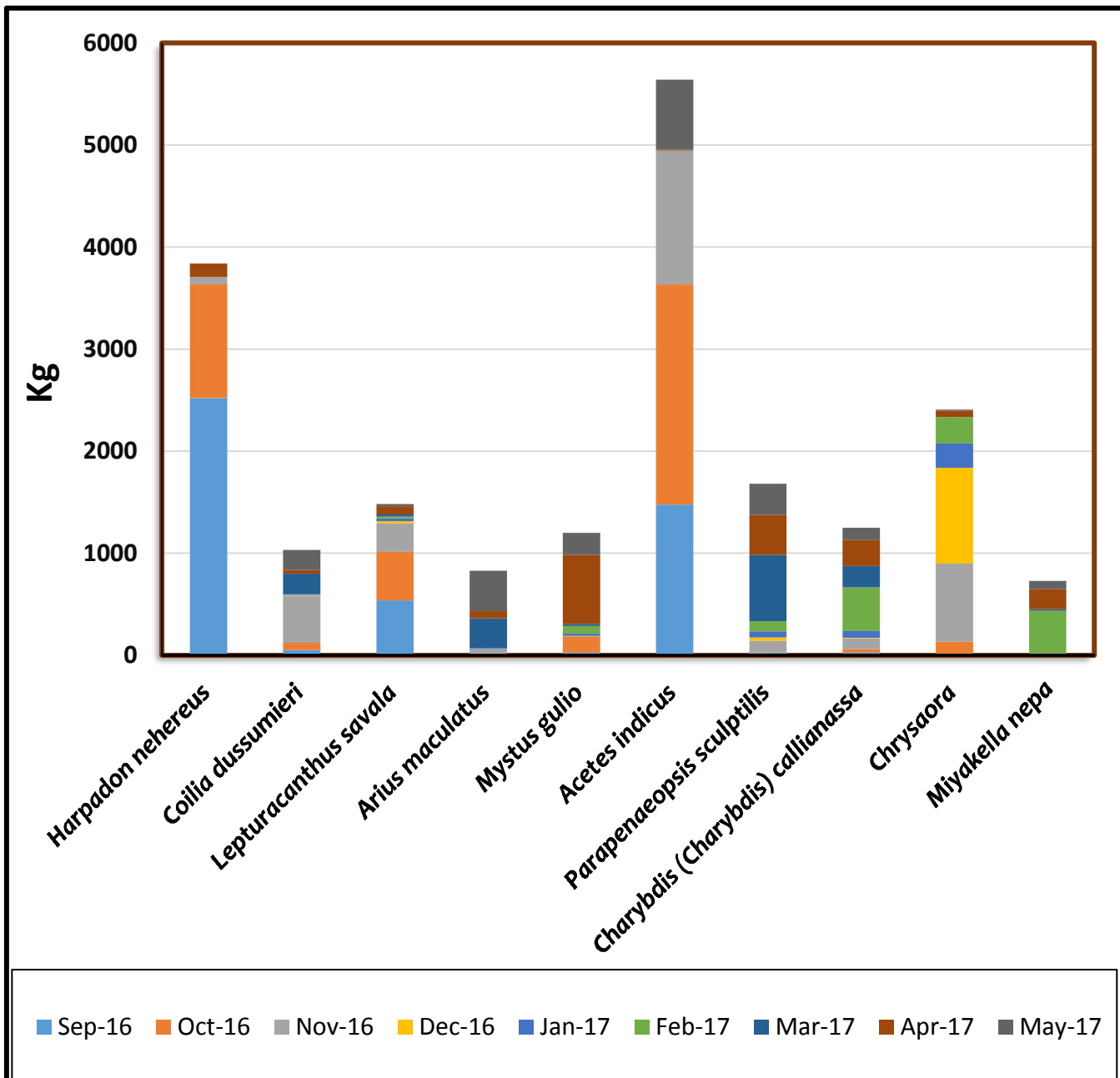


Fig. 9: Species-wise monthly catch composition of dol net fishery of Karanja estuary (Major Contributors)

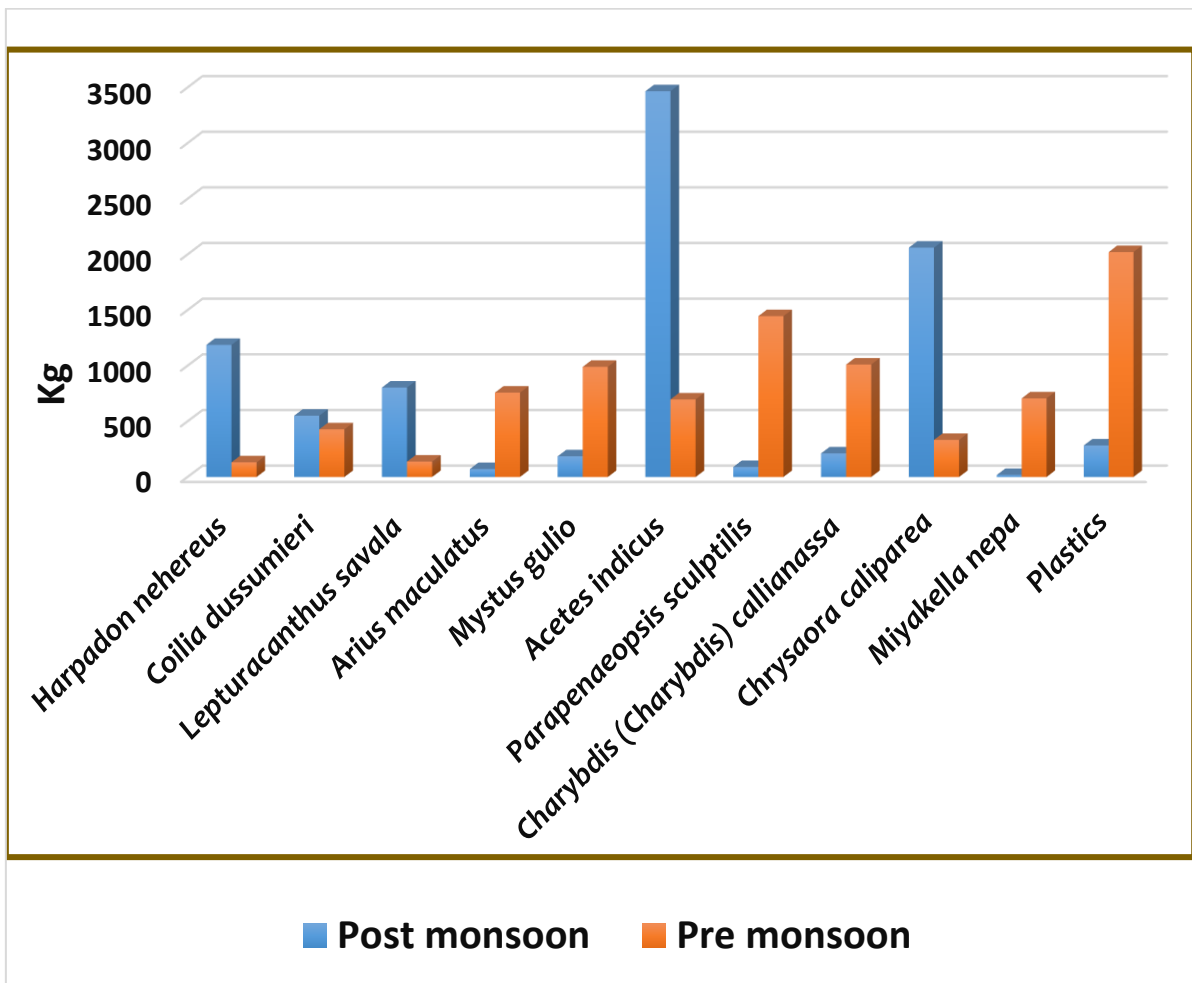


Fig. 10: Catch of major species & plastics in pre monsoon and post monsoon

Pre-monsoon (February–May), Post-monsoon (October–January)

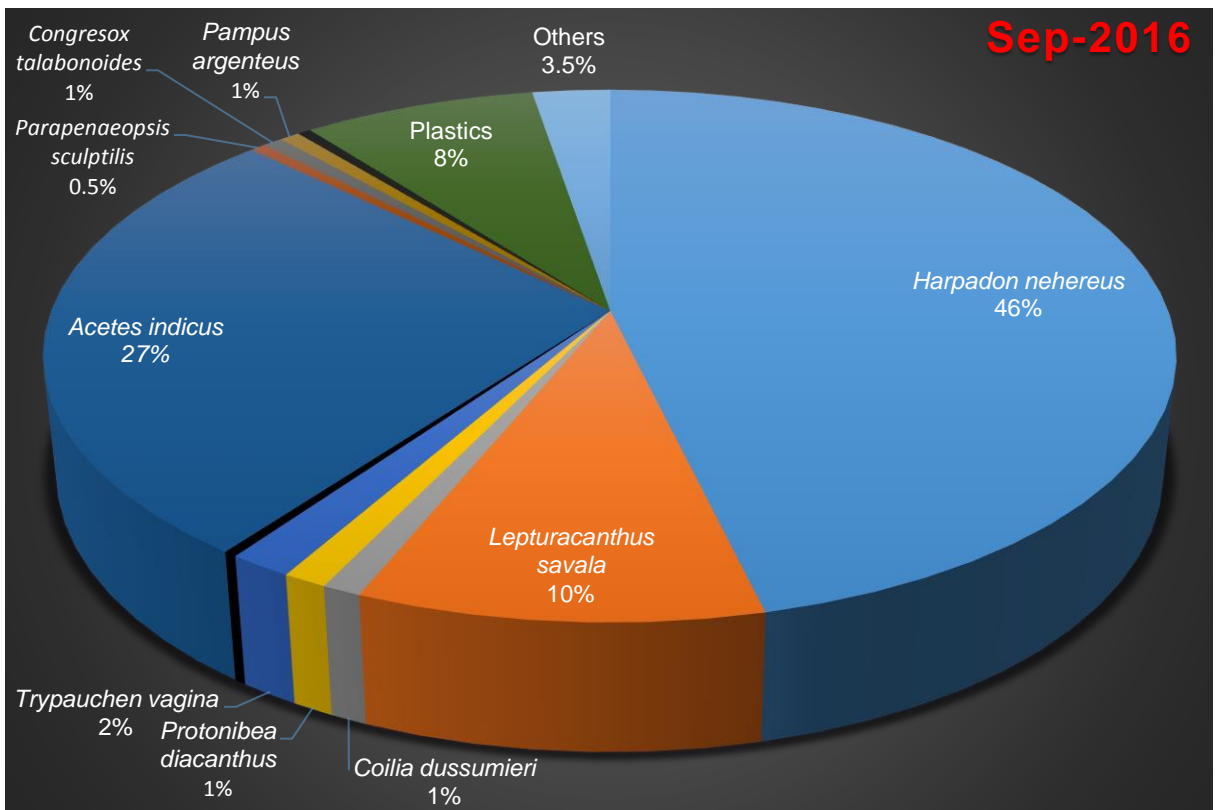


Fig. 11: Catch composition of major species for September

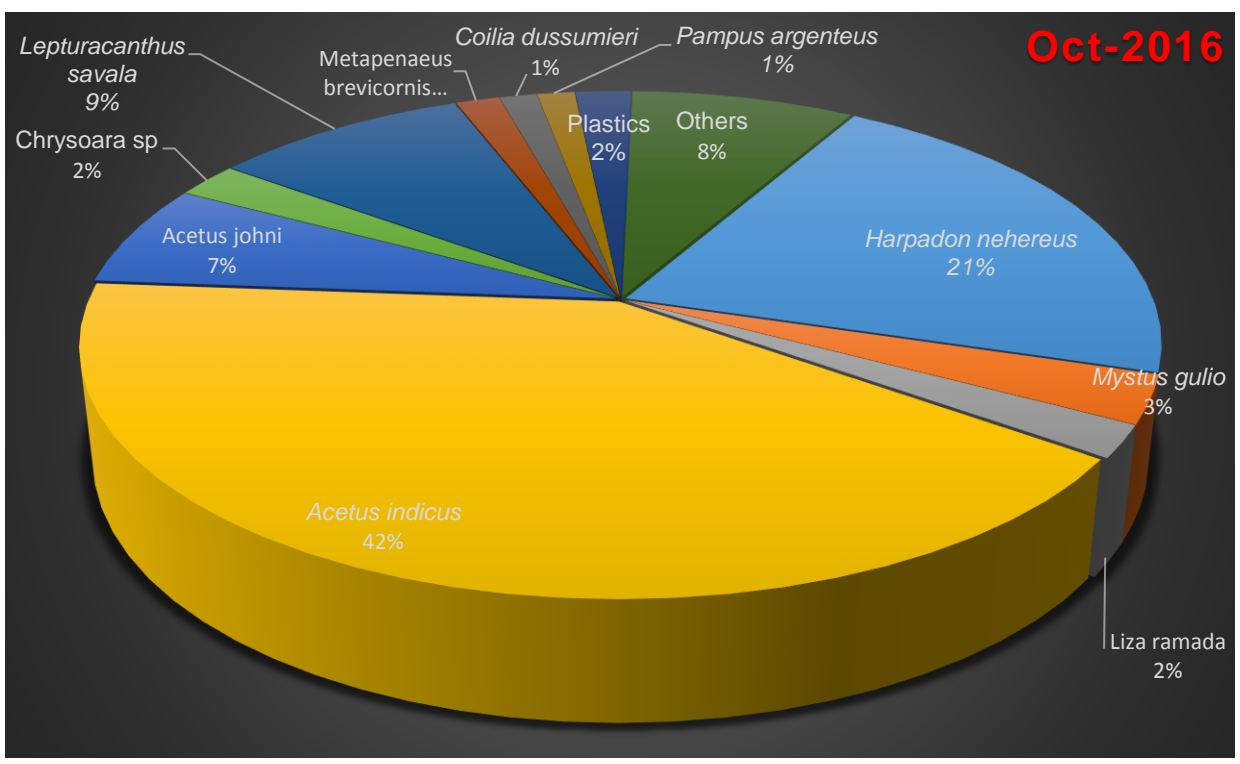


Fig. 12: Catch composition of major species for October

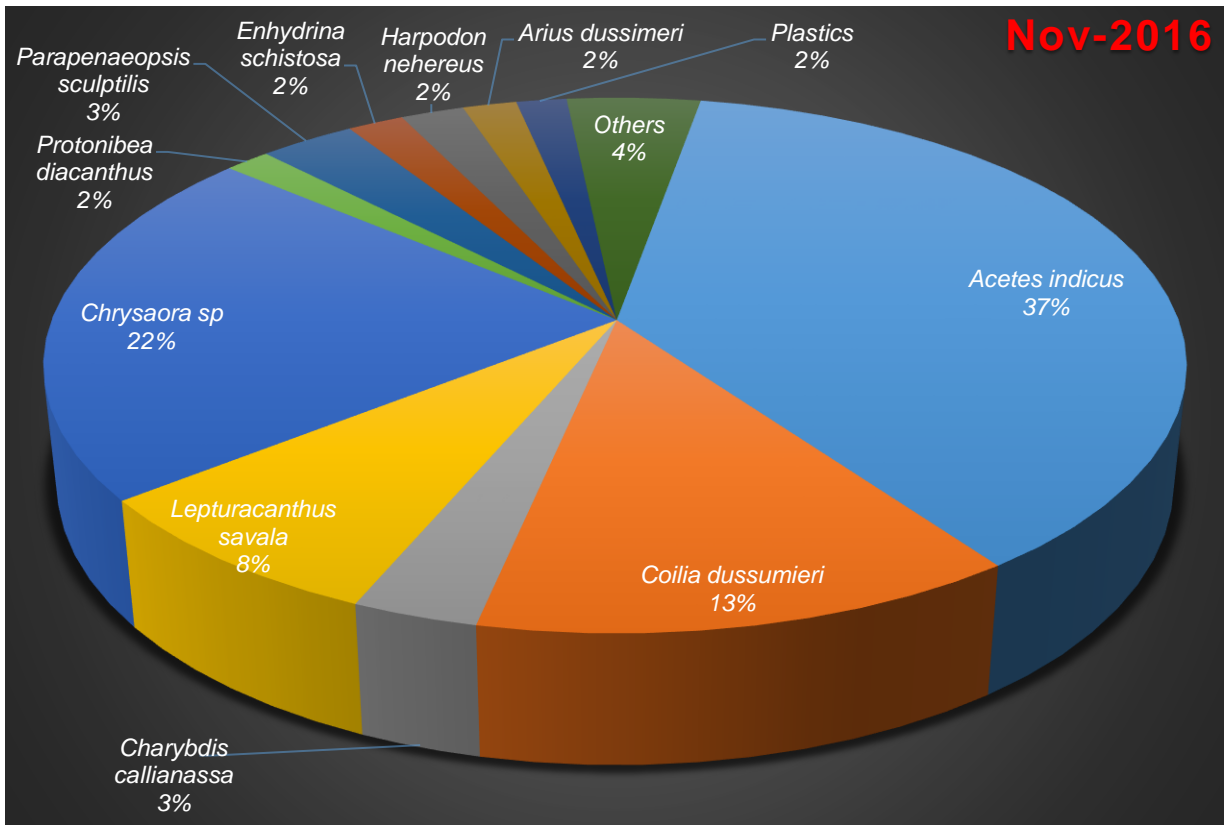


Fig. 13: Catch composition of major species for November

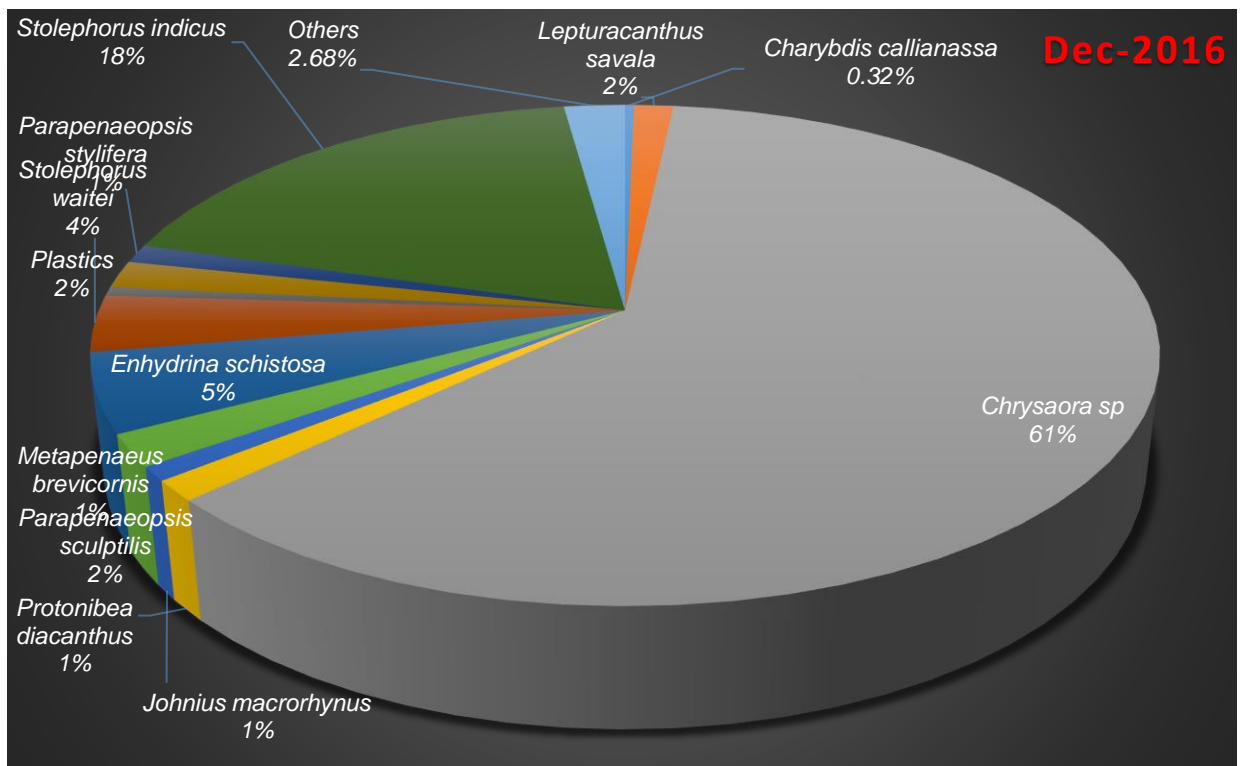


Fig. 14: Catch composition of major species for December

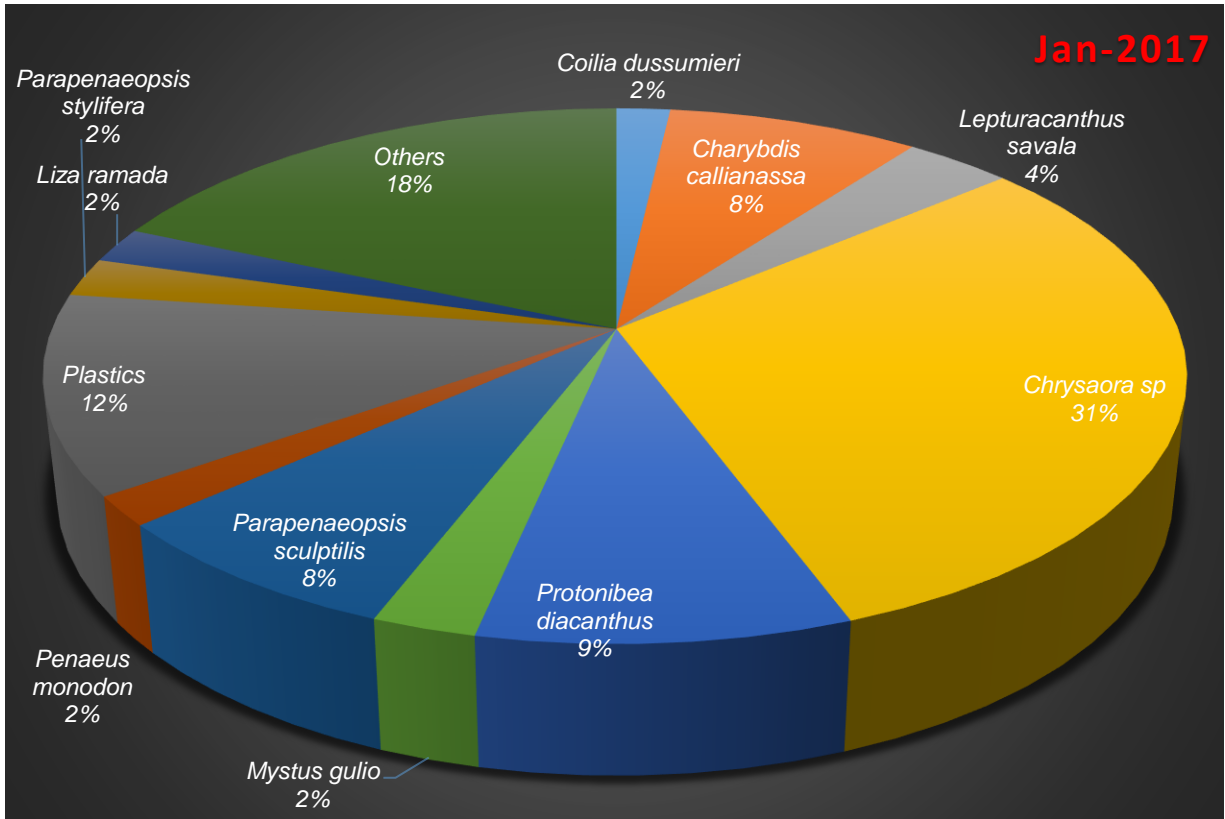


Fig. 15: Catch composition of major species for January

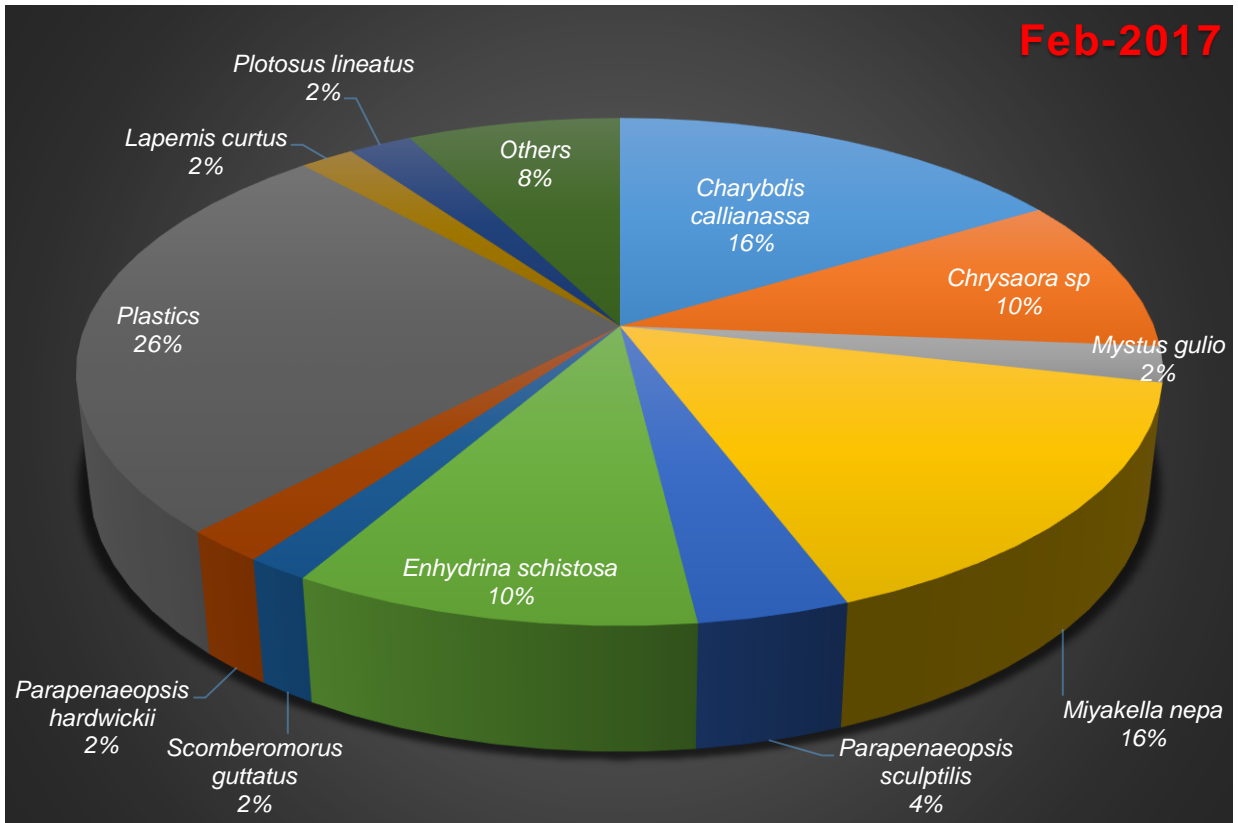


Fig. 16: Catch composition of major species for February

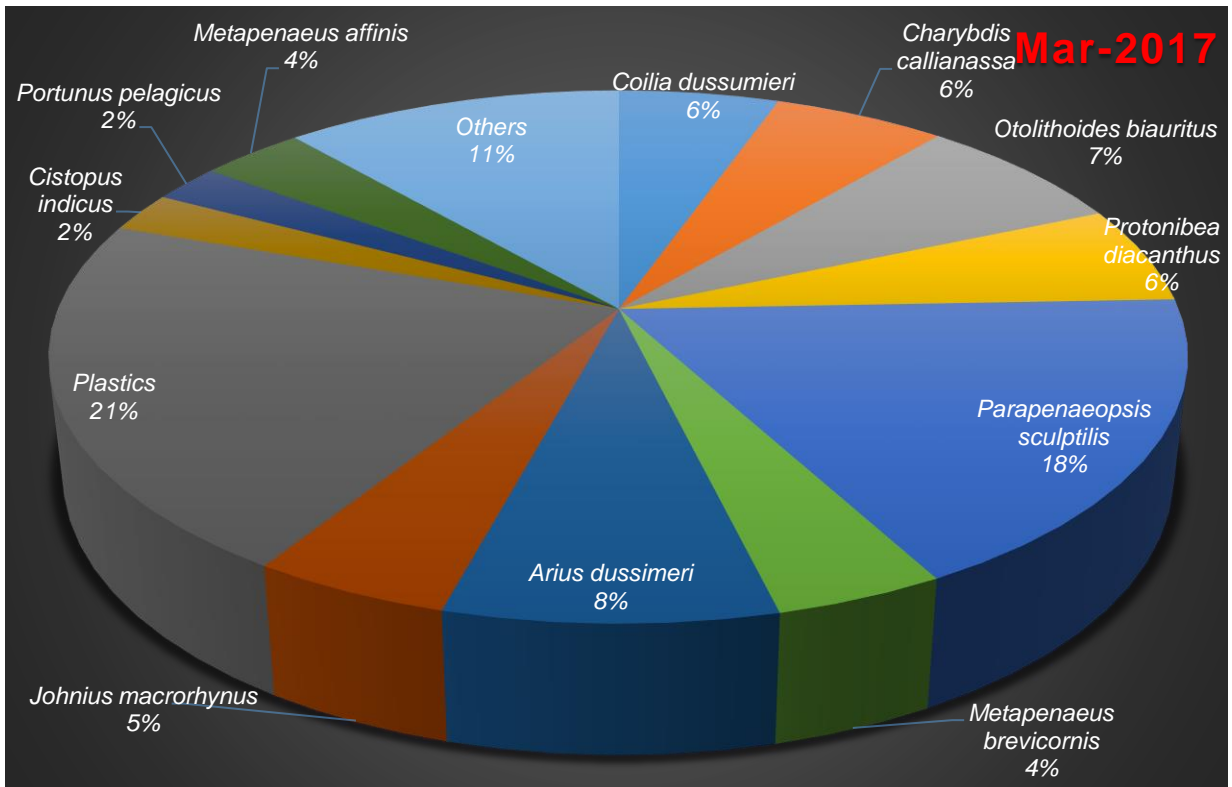


Fig. 17: Catch composition of major species for March

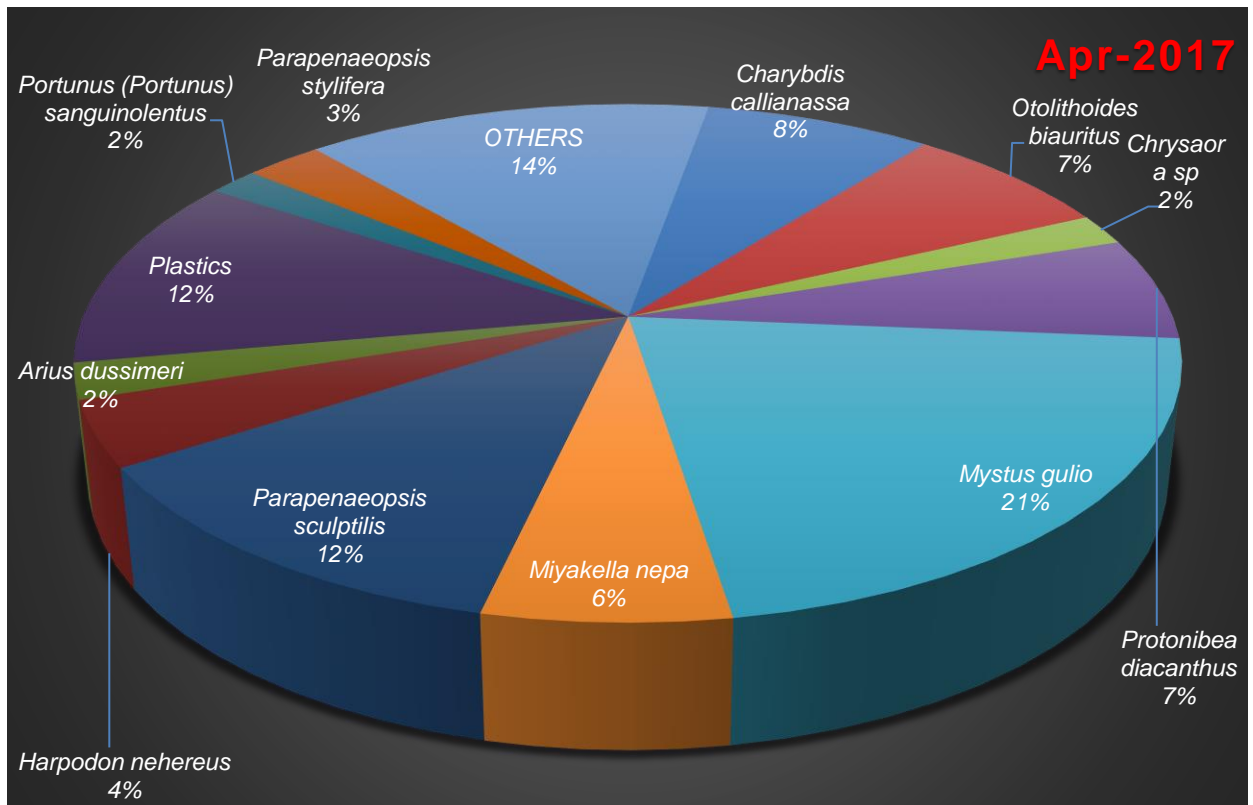


Fig. 18: Catch composition of major species for April

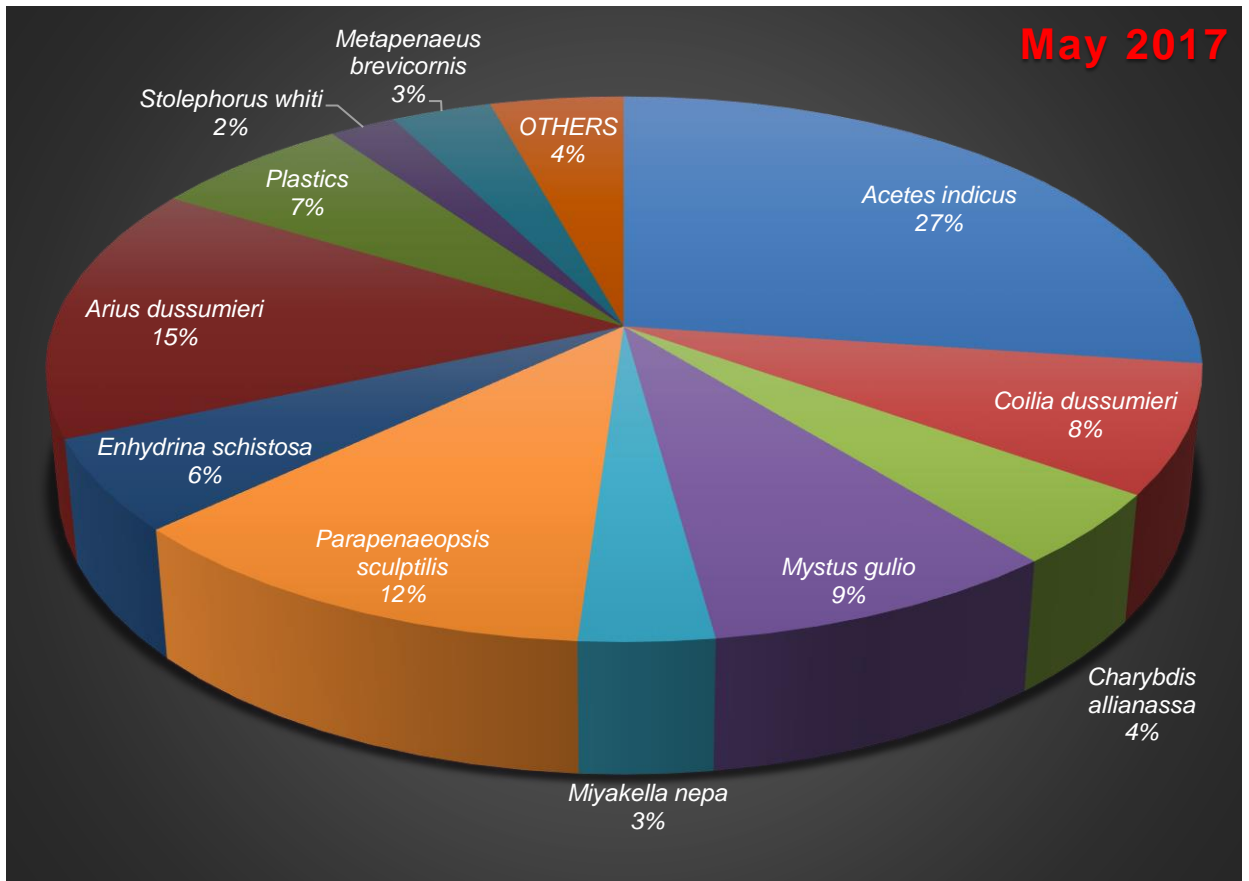


Fig. 19: Catch composition of major species for May

4.6 Temporal distribution of fishes

Details of monthly abundance of the species caught by single day dol netters of Karanja estuary is given in (Table 11). Some species like *Charybdis (Charybdis) calianassa*, *Coilia dussumieri*, *Enhydrina schistosa*, *Harpiosquilla harpax*, *Lepturacanthus savala*, *Metapenaeus brevicornis*, *Miyakella nepa*, *Parapenaeopsis sculptilis*, *Parapenaeopsis stylifera* were present in all the months sampled (Sep-2016 to May 2017) (Fig.20) gives details of number of fish species caught in each month. Maximum Number of species i.e. 53 was caught during October 2016.

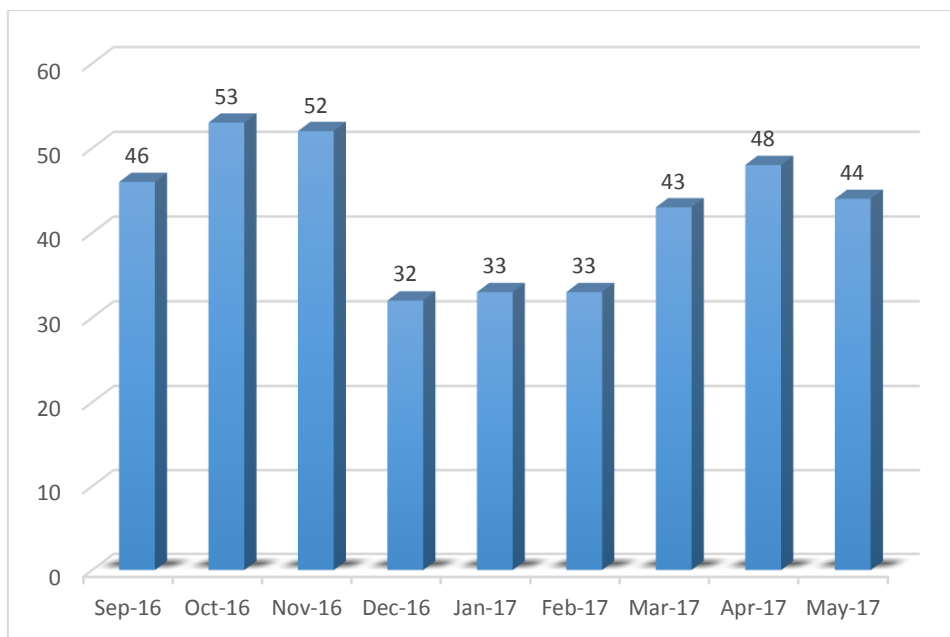


Fig. 20: Temporal distribution of fishes along Karanja estuary

Table 11: Temporal distribution of fishes in the Karanja estuary

Species										
Fishes										
Scientific name	Family									
anguilliformes										
<i>Congresox talabonoides</i> (Bleeker, 1853)	Muraenesocidae	+	-	+	+	-	-	-	-	-
<i>Pisodonophis boro</i> (Hamilton, 1822)	Ophichthidae	-	-	+	-	+	+	-	-	-
Aulopiformes										
<i>Harpadon nehereus</i> (Hamilton, 1822)	Synodontidae	+	+	+	-	-	-	-	+	+
<i>Saurida tumbil</i> (Bloch, 1795)	Synodontidae	+	-	-	-	-	-	+	+	+
Beloniformes										
<i>Strongylura strongylura</i> (van Hasselt, 1823)	Belonidae	-	+	-	-	-	+	+	+	+
Clupeiformes										
<i>Anodontostoma chacunda</i> (Hamilton, 1822)	Clupeidae	-	-	-	-	-	-	+	+	+
<i>Coilia dussumieri</i> Valenciennes, 1848	Engraulidae	+	+	+	+	+	+	+	+	+
<i>Nematalosa nasus</i> (Bloch, 1795)	Clupeidae	-	-	-	-	-	-	+	+	+

<i>Pellona ditchela</i> Valenciennes, 1847	Pristigasteridae	+	+	+	+	-	+	+	-	-
<i>Stolephorus indicus</i> (van Hasselt, 1823)	Engraulidae	-	-	-	+	+	-	-	-	+
<i>Thryssa dussumieri</i> (Valenciennes, 1848)	Engraulidae	-	+	+	+	-	-	-	-	-
<i>Thryssa hamiltonii</i> Gray, 1835	Engraulidae	-	-	+	+	+	-	-	-	-
<i>Thryssa mystax</i> (Bloch & Schneider, 1801)	Engraulidae	-	+	+	-	-	-	-	-	-
<i>Thryssa dayi</i> Wongratana, 1983	Engraulidae	-	-	+	+	-	-	-	-	-
<i>Thryssa setirostris</i> (Broussonet, 1782)	Engraulidae	-	-	+	-	-	-	+	+	-
<i>Stolephorus waitei</i> Jordan & Seale, 1926	Engraulidae	-	-	+	+	-	+	-	-	+
Gadiformes										
<i>Bregmaceros mccllellandi</i> Thompson, 1840	Bregmacerotidae	-	+	+	-	+	+	+	+	-
Perciformes										
<i>Alepes kleinii</i> (Bloch, 1793)	Carangidae	-	+	+	+	+	+	+	-	+
<i>Alepes djedaba</i> (Forsskål, 1775)	Carangidae	-	-	-	-	-	-	+	+	+
<i>Boleophthalmus dussumieri</i> Valenciennes, 1837	Gobiidae	+	+	-	-	+	+	+	+	+
<i>Decapterus russelli</i> (Rüppell, 1830)	Carangidae	-	+	-	-	-	+	+	+	+
<i>Eleutheronema tetradactylum</i> (Shaw, 1804)	Polynemidae	+	+	+	-	-	-	-	+	+
<i>Eupleurogrammus glossodon</i> (Bleeker, 1860)	Trichiuridae	+	+	+	-	-	-	-	-	-
<i>Eupleurogrammus muticus</i> (Gray, 1831)	Trichiuridae	+	+	-	-	-	-	-	-	-
<i>Johnius macrorhynchus</i> (Lal Mohan, 1976)	Sciaenidae	-	+	+	-	+	-	-	+	-
<i>Johnius dussumieri</i> (Cuvier, 1830)	Sciaenidae	-	-	-	+	+	-	-	+	+

<i>Johnius glaucus</i> (Day, 1876)	Sciaenidae	-	-	-	-	-	+	+	-	-
<i>Johnius vogleri</i> (Bleeker, 1853)	Sciaenidae	-	-	+	-	-	-	-	-	-
<i>Lepturacanthus savala</i> (Cuvier, 1829)	Trichiuridae	+	+	+	+	+	+	+	+	+
<i>Filimanus heptadactyla</i> (Cuvier, 1829)	Polynemidae	-	-	+	-	-	-	-	-	-
<i>Leptomelanosoma indicum</i> (Shaw, 1804)	Polynemidae	-	-	+	-	-	+	-	-	-
<i>Otolithoides biauritus</i> (Cantor, 1849)	Scienidae	+	-	+	+	+	-	+	+	+
<i>Pampus argenteus</i> (Euphrasen, 1788)	Stromateidae	+	+	-	+	-	+	-	+	+
<i>Pampus chinensis</i> (Euphrasen, 1788)	Stromateidae	-	-	+	-	-	-	+	-	-
<i>Parastromateus niger</i> (Bloch, 1795)	Carangidae	+	+	+	+	+	-	-	+	+
<i>Protonibea diacanthus</i> (Lacepède, 1802)	Scienidae	+	-	+	+	+	+	+	+	+
<i>Scatophagus argus</i> (Linnaeus, 1766)	Scatophagidae	-	+	+	+	+	+	+	+	+
<i>Scomberomorus guttatus</i> (Bloch & Schneider, 1801)	Scombridae	-	-	+	+	+	+	-	+	-
<i>Sillago sihama</i> (Forsskål, 1775)	Silaginidae	-	+	-	-	-	-	+	+	+
<i>Trichiurus lepturus</i> Linnaeus, 1758	Trichiuridae	+	+	-	-	-	-	-	-	-
<i>Trypauchen vagina</i> (Bloch & Schneider, 1801)	Gobiidae	+	+	+	-	+	-	-	+	+
<i>Terapon jarbua</i> (Forsskål, 1775)	Terapontidae	-	-	-	-	-	+	-	+	-
<i>Terapon theraps</i> Cuvier, 1829	Terapontidae	+	+	-	-	-	-	-	-	-
<i>Liza ramada</i> (Risso, 1827)	Mugilidae	-	+	-	-	+	-	+	+	+
Pleuronectiformes										
<i>Cynoglossus arel</i> (Bloch & Schneider, 1801)	Cynoglossidae	-	-	-	-	+	-	+	-	+

Siluriformes										
<i>Arius maculatus</i> (Thunberg, 1792)	Ariidae	-	-	+	-	+	-	+	+	+
<i>Mystus gulio</i> (Hamilton, 1822)	Bagridae	+	+	+	-	+	+	+	+	+
<i>Osteogeneiosus militaris</i> (Linnaeus, 1758)	Ariidae	+	+	-	-	-	-	-	-	-
<i>Plotosus lineatus</i> (Thunberg, 1787)	Plotosidae	+	+	+	-	+	+	+	+	+
Tetraodontiformes										
<i>Lagocephalus spadiceus</i> (Richardson, 1845)	Tetraodontidae	+	-	+	+	-	+	-	+	-
Elasmobranch										
Carcharhiniformes										
<i>Scoliodon laticaudus</i> Müller & Henle, 1838	Carcharhinidae	-	-	-	-	-	-	+	+	+
Myliobatiformes										
<i>Himantura uarnak</i> (Gmelin, 1789)	Dasyatidae	+	-	-	+	-	-	-	-	+
Orectolobiformes										
<i>Chiloscyllium griseum</i> Müller & Henle, 1838	Hemiscylliidae	+	-	-	-	-	-	-	-	-
Shrimps										
Decapoda										
<i>Acetes indicus</i> H. Milne Edwards, 1830	Sergestidae	+	+	+	-	-	-	-	+	+
<i>Acetes johni</i> Nataraj, 1949	Sergestidae	+	+	-	-	-	-	-	-	-
<i>Exhippolysmata ensirostris</i> ensirostris (Kemp, 1914)	Lysmatidae	-	+	-	-	-	-	+	+	+
<i>Exopalaemon styliferus</i> (H. Milne Edwards, 1840 [in H. Milne Edwards, 1834- 1840])	Palaemonidae	-	+	-	-	-	-	-	-	-
<i>Metapenaeus affinis</i> (H. Milne Edwards, 1837 [in Milne Edwards, 1834- 1840])	Penaeidae	+	-	-	-	-	-	+	-	-
<i>Metapenaeus brevicornis</i> (H. Milne	Penaeidae	+	+	+	+	+	+	+	+	+

Edwards, 1837 [in Milne Edwards, 1834-1840])										
<i>Metapenaeus monoceros</i> (Fabricius, 1798)	Penaeidae	-	+	+	-	-	-	-	-	-
<i>Parapenaeopsis hardwickii</i> (Miers, 1878)	Penaeidae	-	+	+	-	-	+	+	-	-
<i>Parapenaeopsis stylifera</i> (H. Milne Edwards, 1837 [in H. Milne Edwards, 1834-1840])	Penaeidae	+	+	+	+	+	+	+	+	+
<i>Parapenaeopsis sculptilis</i> (Heller, 1862)	Penaeidae	+	+	+	+	+	+	+	+	+
<i>Penaeus indicus</i> H. Milne Edwards, 1837	Penaeidae	+	+	+	-	-	-	-	-	-
<i>Penaeus monodon</i> Fabricius, 1798	Penaeidae	+	+	+	-	+	-	+	+	-
<i>Solenocera crassicornis</i> (H. Milne Edwards, 1837 [in Milne Edwards, 1834-1840])	Solenoceridae	+	-	+	-	-	+	+	+	-
Crabs										
Decapoda										
<i>Ashtoret lunaris</i> (Forskål, 1775)	Matutidae	-	-	+	+	-	-	-	+	+
<i>Charybdis (Charybdis) annulata</i> (Fabricius, 1798)	Portunidae	+	-	-	-	-	-	-	-	+
<i>Charybdis (Charybdis) callianassa</i> (Herbst, 1789)	Portunidae	+	+	+	+	+	+	+	+	+
<i>Charybdis (Charybdis) feriata</i> (Linnaeus, 1758)	Portunidae	-	-	-	-	-	-	-	+	+
<i>Charybdis (Charybdis) lucifera</i> (Fabricius, 1798)	Portunidae	-	+	+	+	-	-	-	-	-
<i>Charybdis (Charybdis) orientalis</i> Dana, 1852	Portunidae	+	+	-	-	-	-	-	-	-
<i>Portunus (Portunus) sanguinolentus</i> (Herbst, 1783)	Portunidae	+	+	+	+	+	+	+	+	-
<i>Scylla serrata</i> (Forskål, 1775)	Portunidae	+	-	-	-	-	-	+	+	+

<i>Scylla tranquebarica</i> (Fabricius, 1798)	Portunidae	-	+	-	-	-	-	-	-	-
<i>Thalamita crenata</i> Rüppell, 1830	Portunidae	+	+	+	+	-	-	-	-	-
cephalopods										
Myopsida										
<i>Loliolus (Loliolus) hardwickei</i> (Gray, 1849)	Loliginidae	+	+	+	+	-	-	-	-	-
<i>Uroteuthis (Photololigo) duvaucelii</i> (d'Orbigny [in Férussac & d'Orbigny], 1835)	Loliginidae	+	+	+	+	-	-	-	+	-
Octopoda										
<i>Cistopus indicus</i> (Rapp, 1835)	Octopodidae	-	+	+	+	-	+	+	-	-
<i>Octopus vulgaris</i> Cuvier, 1797	Octopodidae	-	+	-	-	-	-	-	-	-
Sepiida										
<i>Sepiella inermis</i> (Van Hasselt [in Férussac & d'Orbigny], 1835)	Sepiidae	+	+	-	-	+	+	+	+	-
Jellyfish										
Semaeostomeae										
<i>Chrysaora calliparea</i> (Péron & Lesueur, 1810)	Pelagiidae	+	+	+	+	+	+	-	+	+
<i>Chrysoara budjenkii</i> (Péron & Lesueur, 1810).				+	+					
Hermit crab										
Decapoda										
<i>Clibanarius padavensis</i> de Man, 1888	Diogenidae	-	-	-	+	-	-	+	-	-
Sea Snakes										
Squamata										
<i>Acrochordus granulatus</i> (Schneider, 1799)	Acrochordidae	-	-	-	+	-	-	-	-	-
<i>Enhydrina schistosa</i> (Daudin, 1803)	Elapidae	+	+	+	+	+	+	+	+	+
<i>Hydrophis cyanocinctus</i> Daudin, 1803	Elapidae	-	-	+	-	-	-	-	-	-
<i>Lapemis curtus</i> (Shaw, 1802)	Elapidae	+	+	+	-	-	+	+	+	+

Lobster										
Decapoda										
Scyllarus Fabricius, 1775	Scyllaridae	+	-	-	-	-	-	-	-	+
Squilla										
Stomatopoda										
<i>Oratosquilla interrupta</i> (Kemp, 1911)	Squillidae	-	-	-	+	+	+	+	+	+
<i>Miyakella nepa</i> (Latreille in Latreille, Le Peletier, Serville & Guérin, 1828)	Squillidae	+	+	+	+	+	+	+	+	+
(+: Found; -: Not found)										

4.7 Effect of operational parameters on catches of dol net

Depth-wise monthly variation in catch of dol nets was noted from each station. The dol net stations located in 8m depth showed maximum catch whereas dol net stations located at 5 m depth showed comparatively lesser catch. There is a significant difference in catch observed between depth 8m, 6m with 5 m depth during September, October, November, December months.

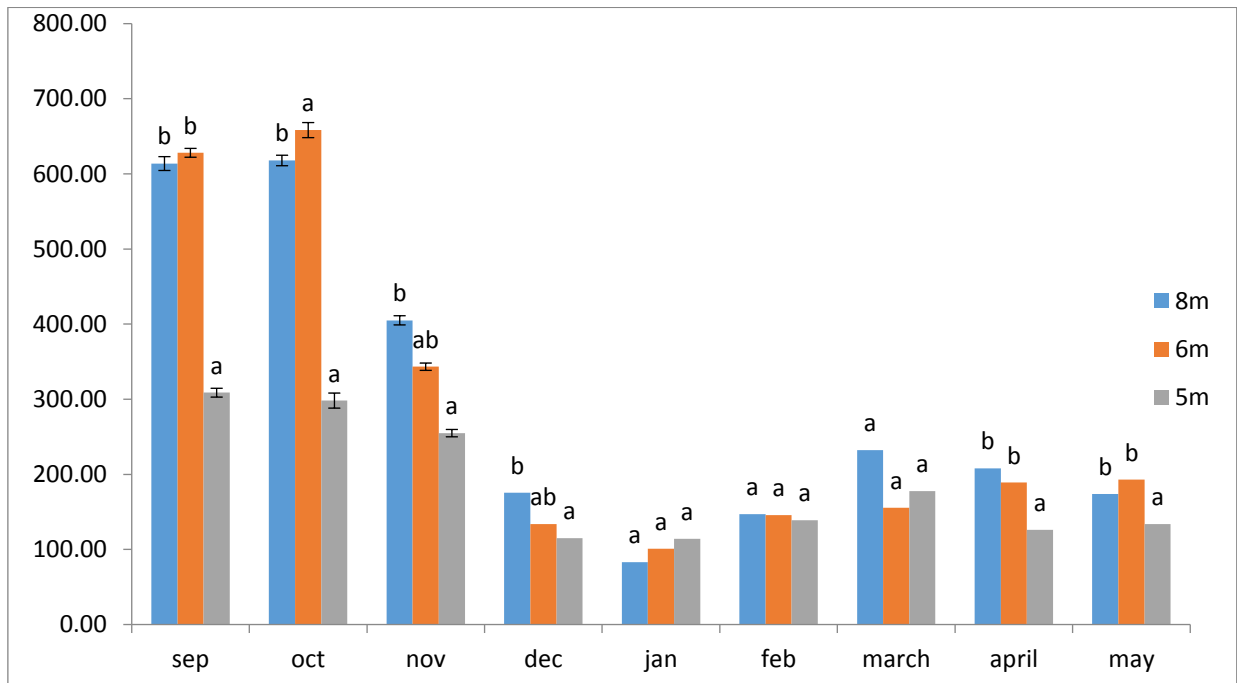


Fig 21: Depth wise Monthly variation of catch



Fig. 22: Unsegregated catch



Fig.23: Segregating Sample in Laboratory



Plate 1: Venomous species caught in dol net

- A. *Lapemis curtus* B. *Enhydrina schistosa* C. Release of Sea snake into Estuary
 D. Fishermen Holding Chrysaora Jellyfish E. *Chrysaora* sp F. *Chrysaora calliparea*



Plate 2: Parasite and plastic catch in dol net

a. Jelly fish b. *Chrysoara budjenkii* c. Isopod Parasite d. *Alepes kleinii* with isopod parasite e. Plastic weighing in lab f. Plastic weighing in on-board g. Fishermen throwing back the plastic catch h. comparison between plastic caught and fishes caught



Plate 3a: Fish species landed in Karanja Dol net

1. *Trypauchen vagina*
2. *Arius maculatus*
3. *Anodontostoma chacunda*
4. *Boleophthalmus dussumieri*

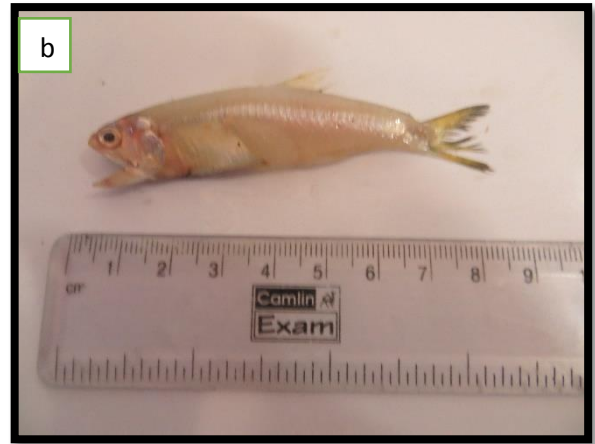


Plate 3b: Fish species landed in Karanja Dol net

a. *Coilia dussumieri* different size range b. *Thryssa mystax* c. *Lagocephalus spadiceus* d. *Cynoglossus arel* e. *Coilia dussumieri* f. *Parastromateus niger*



Plate 3c: Fish species landed in Karanja dol net

1. *Trichiurus lepturus* 2. *Stolephorus indicus* 3. *Lagocephalus lunaris* 4. *Johnius macrorhynus* 5. *Arius maculatus* 6. *Boleopthalmus boddarti*

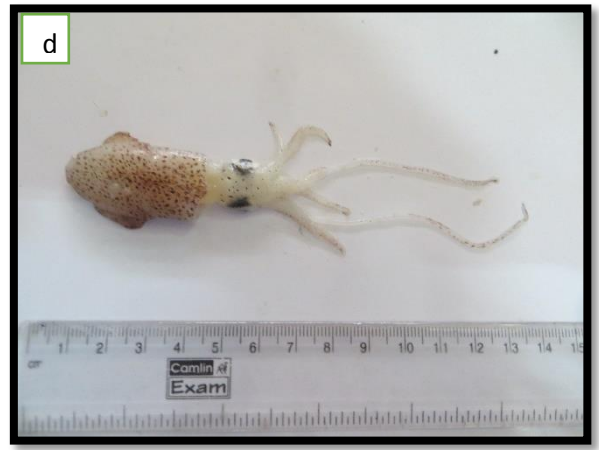


Plate 3d: Fish, mollusc species landed in Karanja dol net

a. *Pisodonophis boro* b. *Scatophagus argus* c. Egg mass d. *Uroteuthis (Photololigo) duvaucelii* e. *Sepiella inermis* f. *Cistopus indicus*



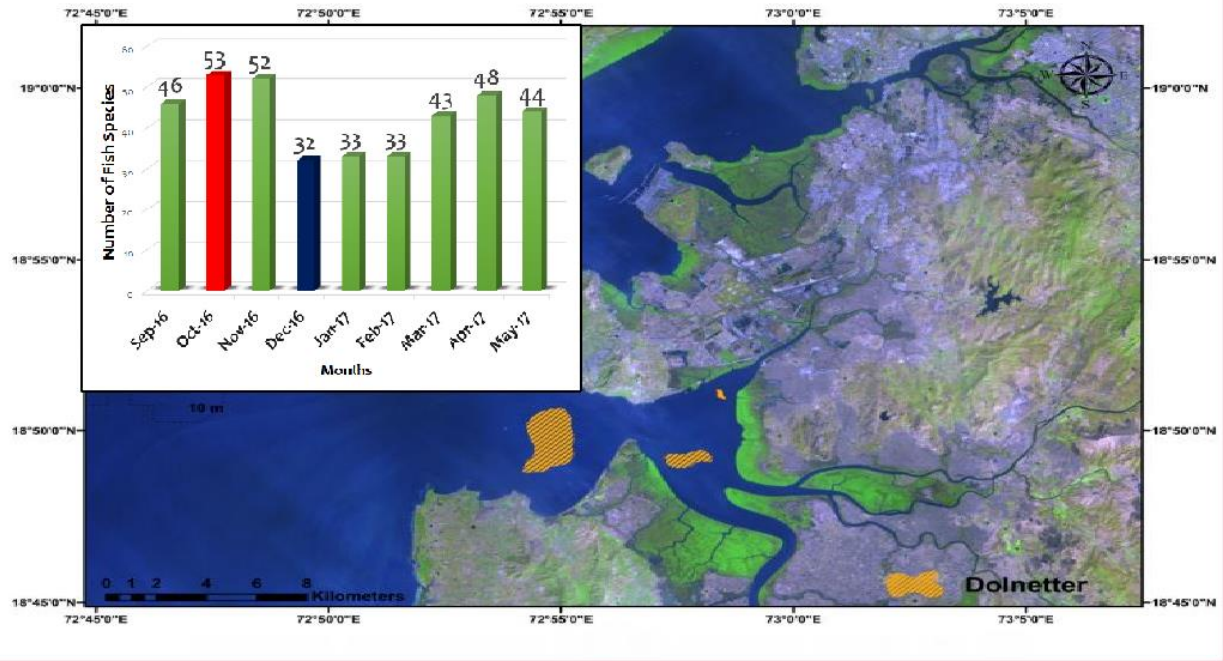
Plate 3e: Fish, mollusc and crab species landed in Karanja dol net

1. *Chiloscyllium griseum* 2. *Scoliodon laticaudus* 3. *Loliolus (Loliolus) hardwickei* 4. *Charybdis (Charybdis) feriata* 5. *Charybdis (Charybdis) callianassa* dorsal view 6. *Charybdis (Charybdis) callianassa* ventral view



Plate 3f: Crustacean species landed in Karanja dol net

a. Ashtoret lunaris b. *Portunus (Portunus) pelagicus* c. *Miyakella nepa* d. *Parapenaeopsis sculptilis* e. *Exhippolysmata ensirostris* f. *Metapenaeus Monoceros*



Map. 2: Temporal catch of dol net stations

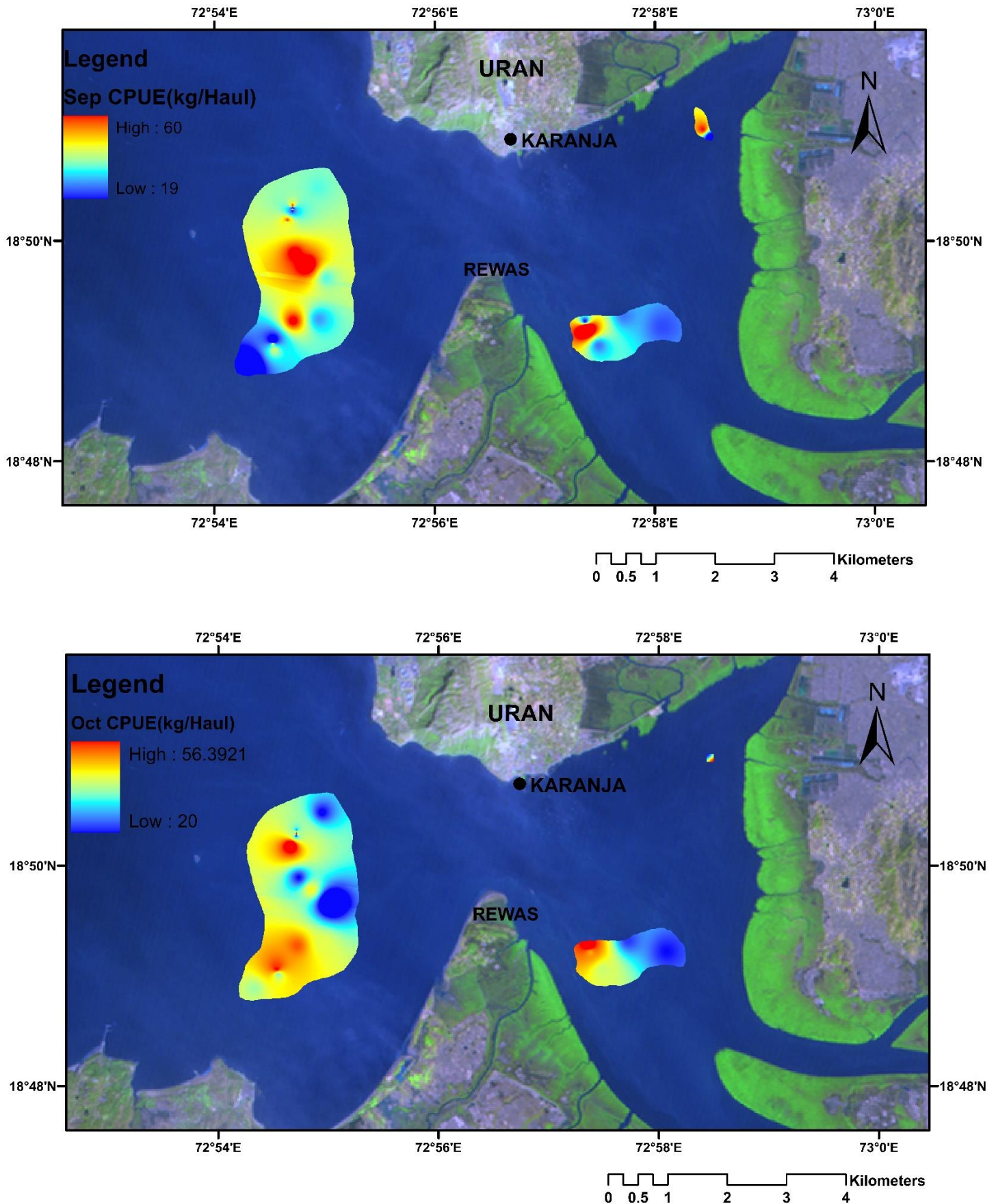
4.8 Dolphin sighting during sampling

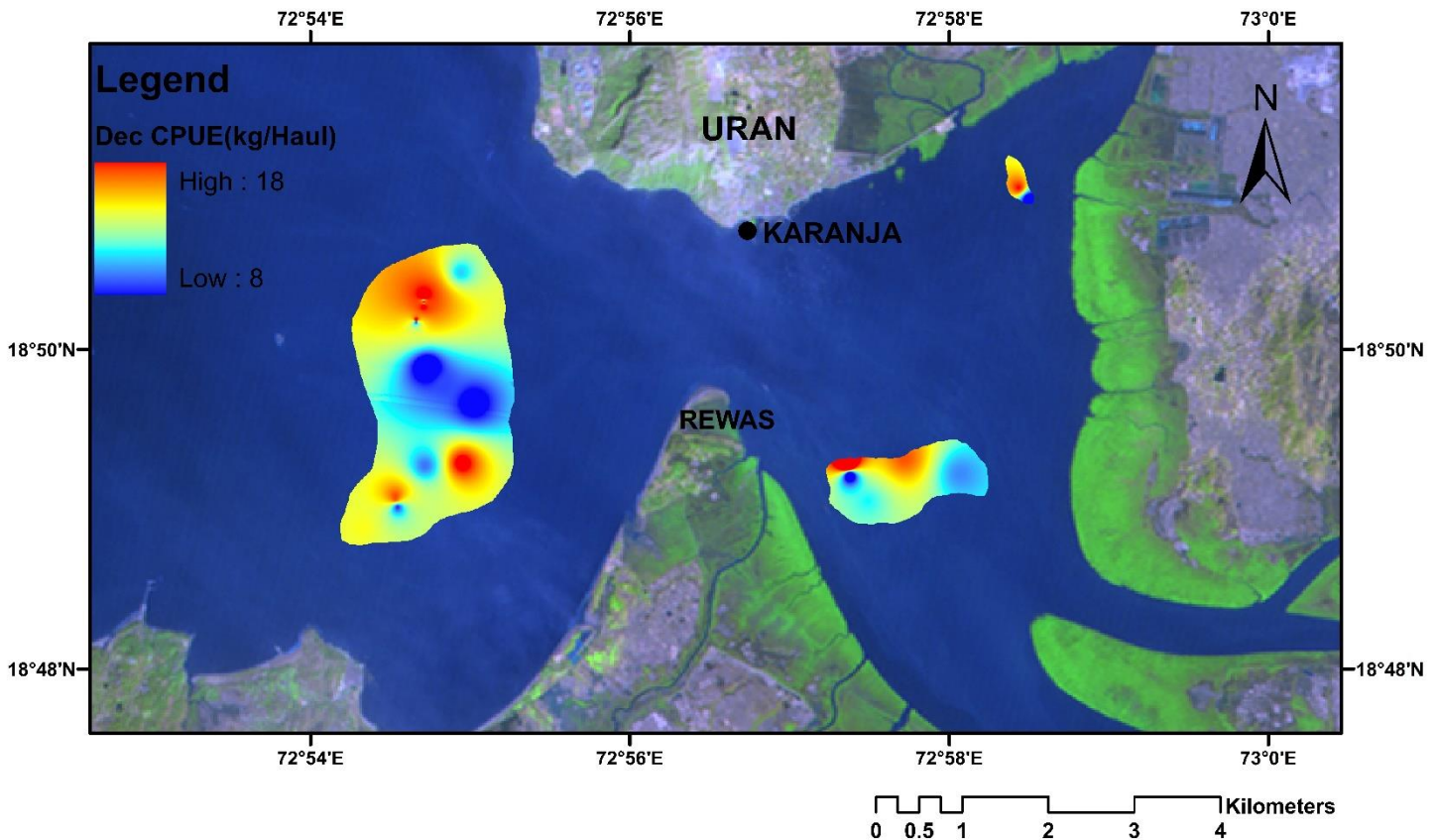
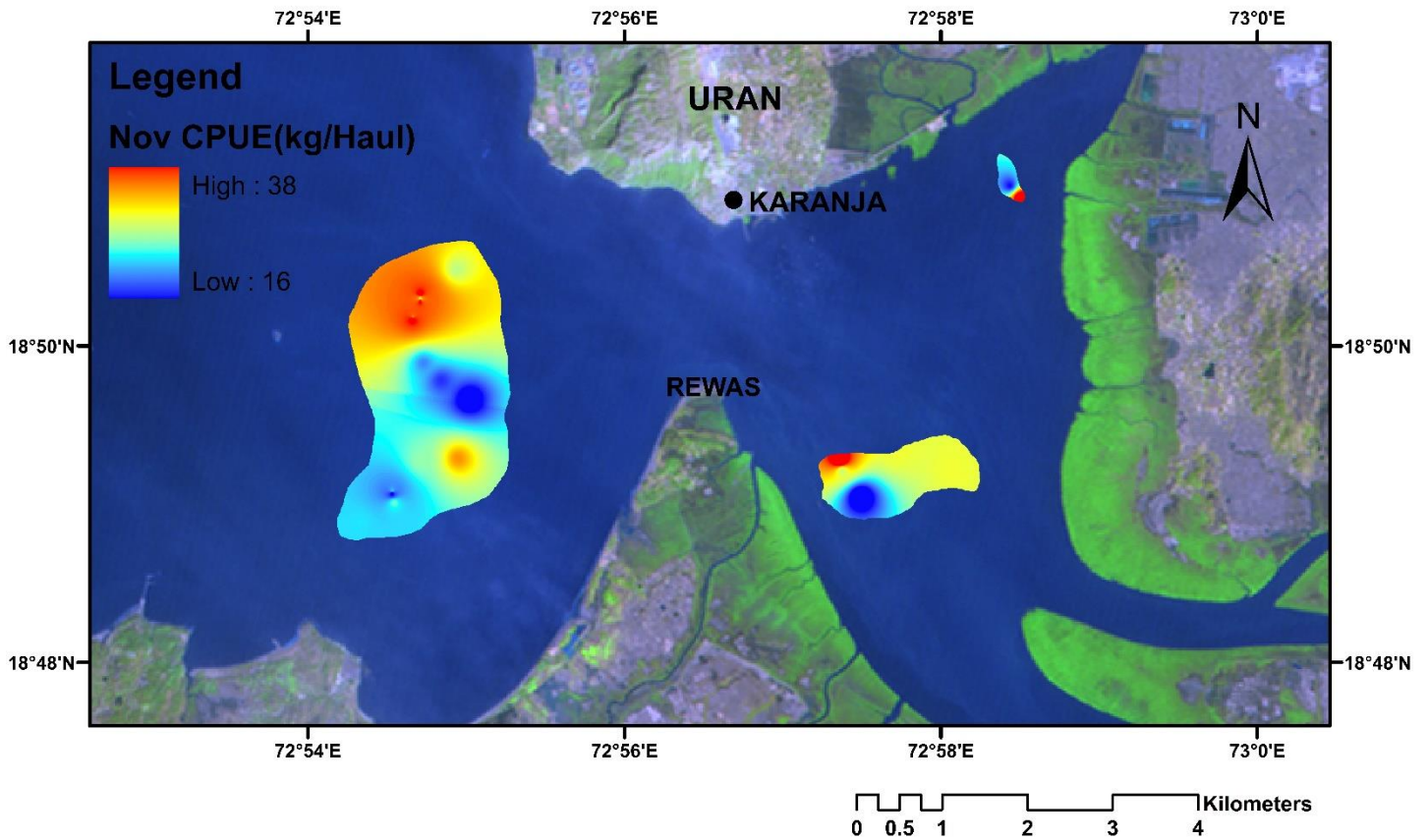
On October, November, December, January pods of Dolphins are spotted near to the sampling stations during fishing. The dolphins were identified as Indo-Pacific humpbacked dolphins *Sousa chinensis plumbea*-type (Osbeck, 1765) by using surface photo identification (photo-ID) techniques that rely on the natural marks on their dorsal fins, flukes, and spot patterns (Waring *et al*, 2011). The Dol net Fishermen were of the opinion that these intelligent dolphins makes problem to them by tearing the cod end part of the dol nets from backside of the net to eat fishes that get caught in the net and this paving way to escapement of the fishes get caught and also compels the fishermen to mend their nets before next operations. Also they pointed out that normally the dolphins does not get caught in dol nets, sighting of this dolphins near to dol net stations was common in this region during hauling of catch from the nets. Stranding of dead Indo pacific humpback dolphin's incidences around the Mumbai and Raigad districts is noted more occasionally in past years evident that this species is in immense pressure. The IUCN lists this species as Near threatened in the Red List of threatened species (IUCN 2008).



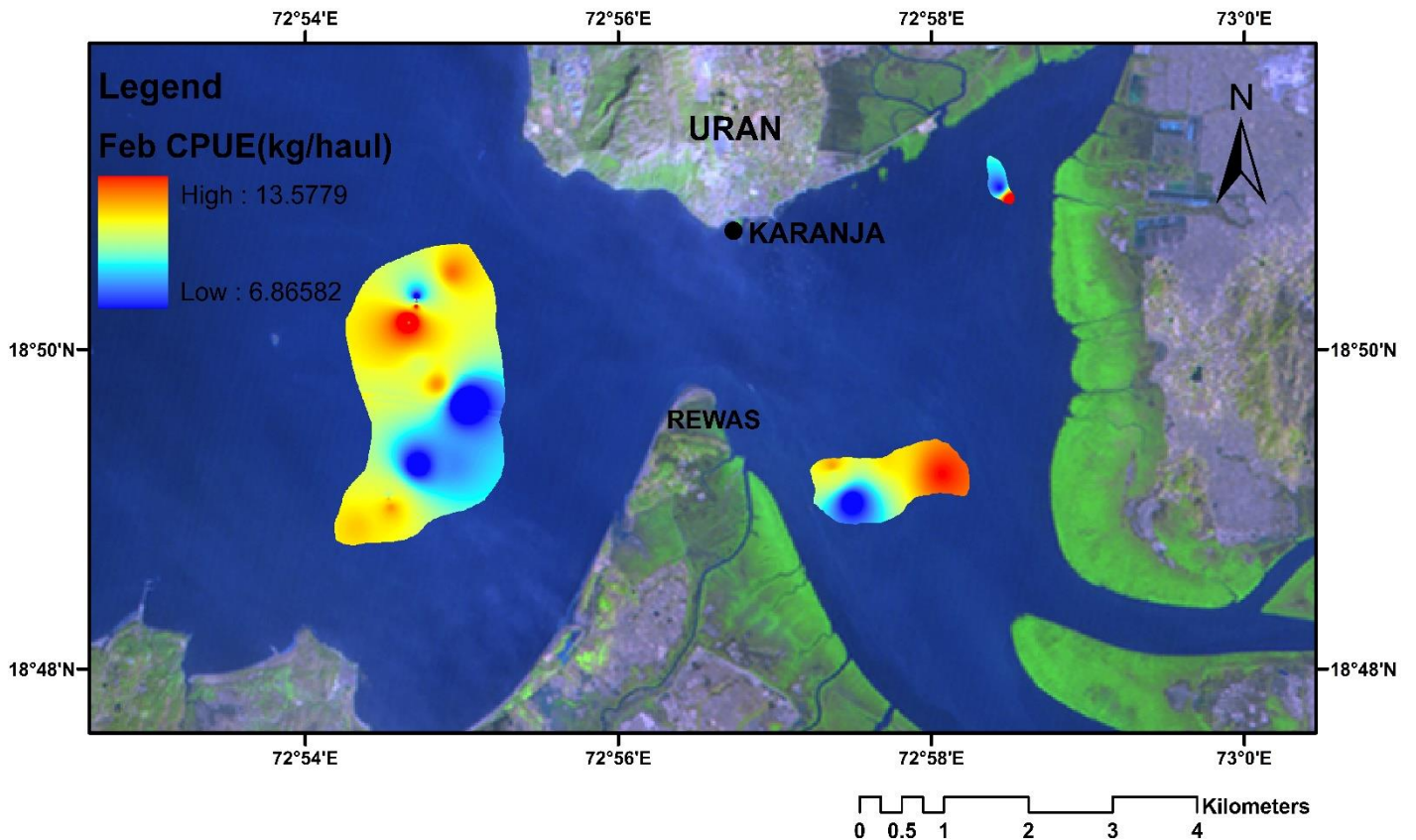
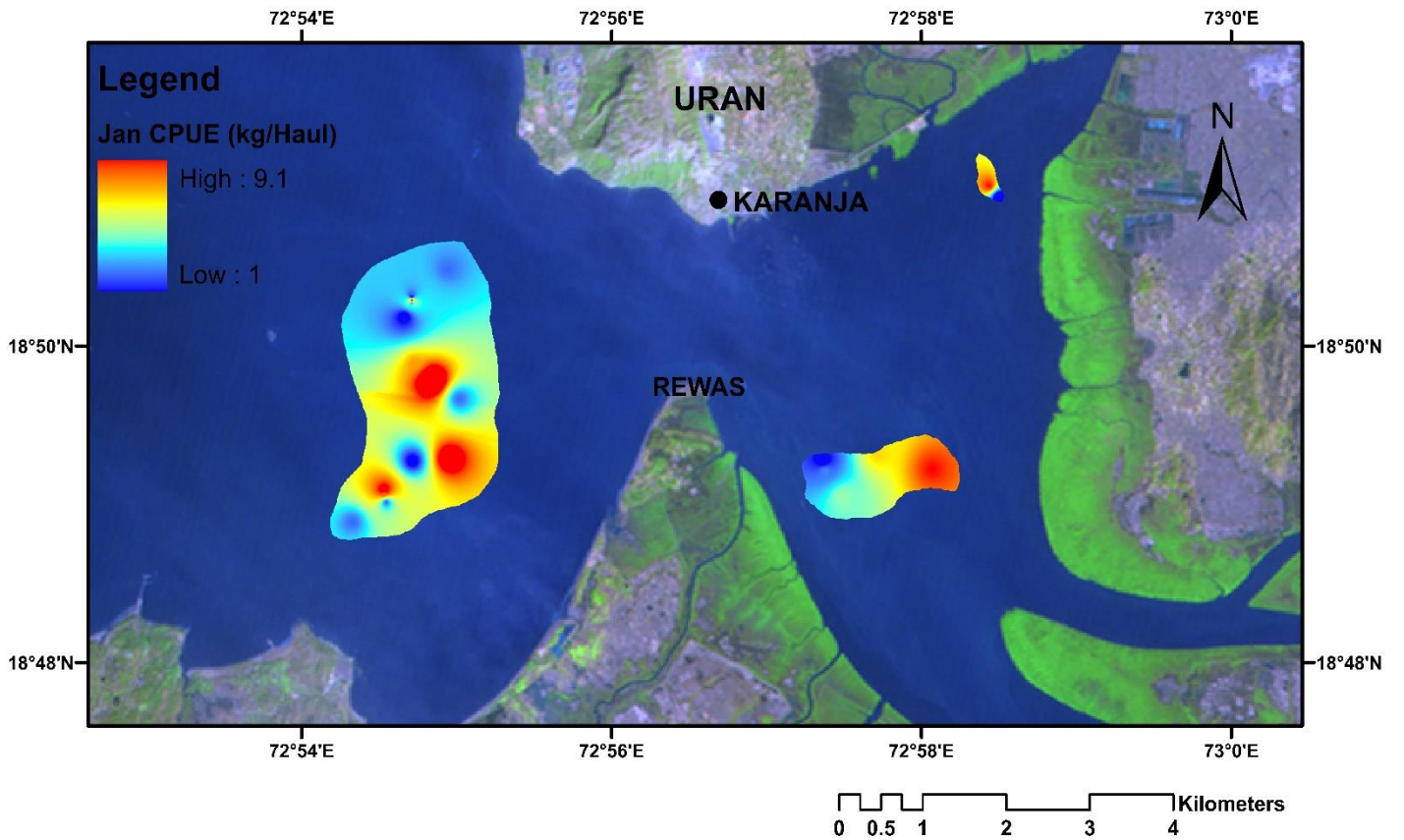
Fig.24: Location of Dolphin sightings

4.9 Thematic Maps

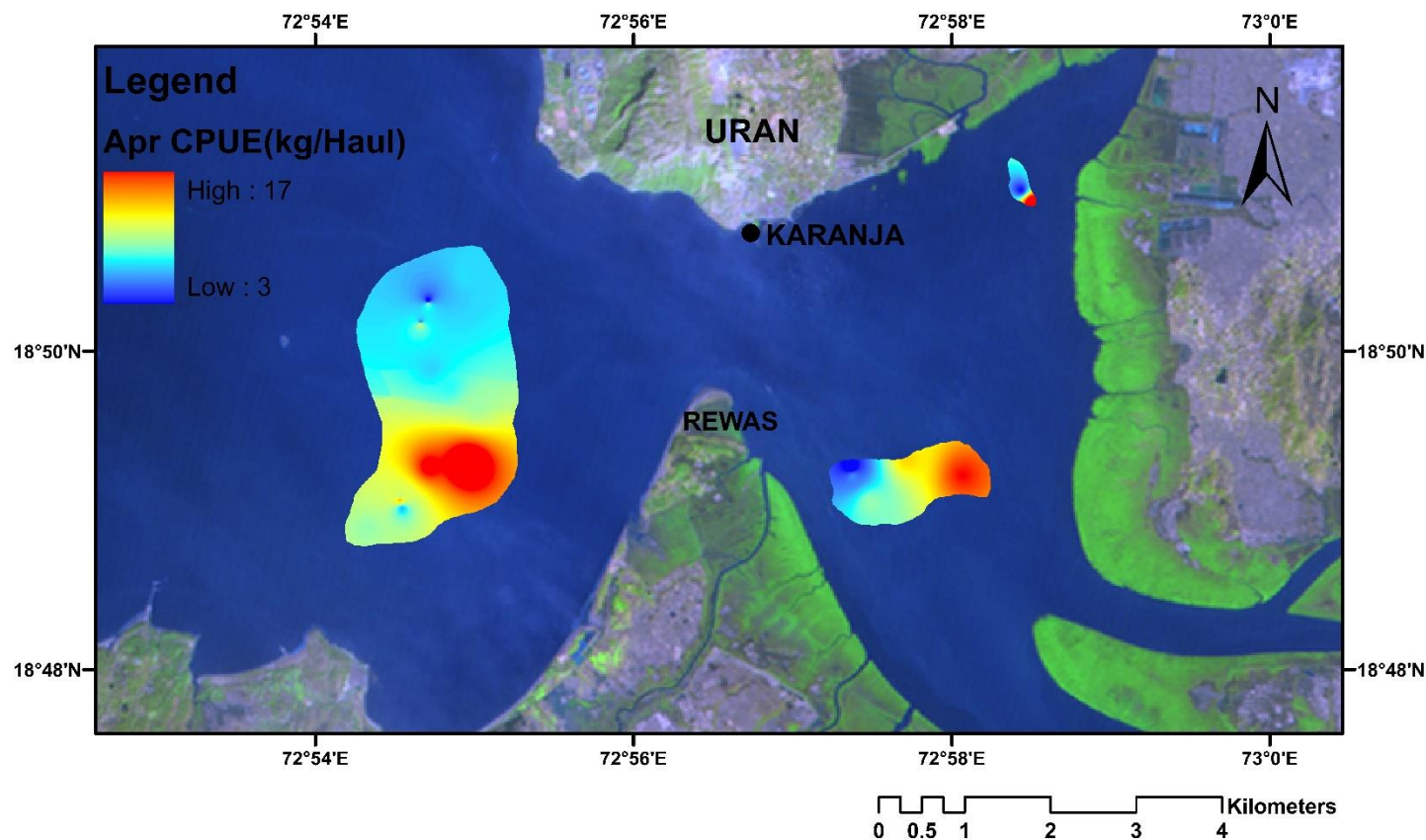
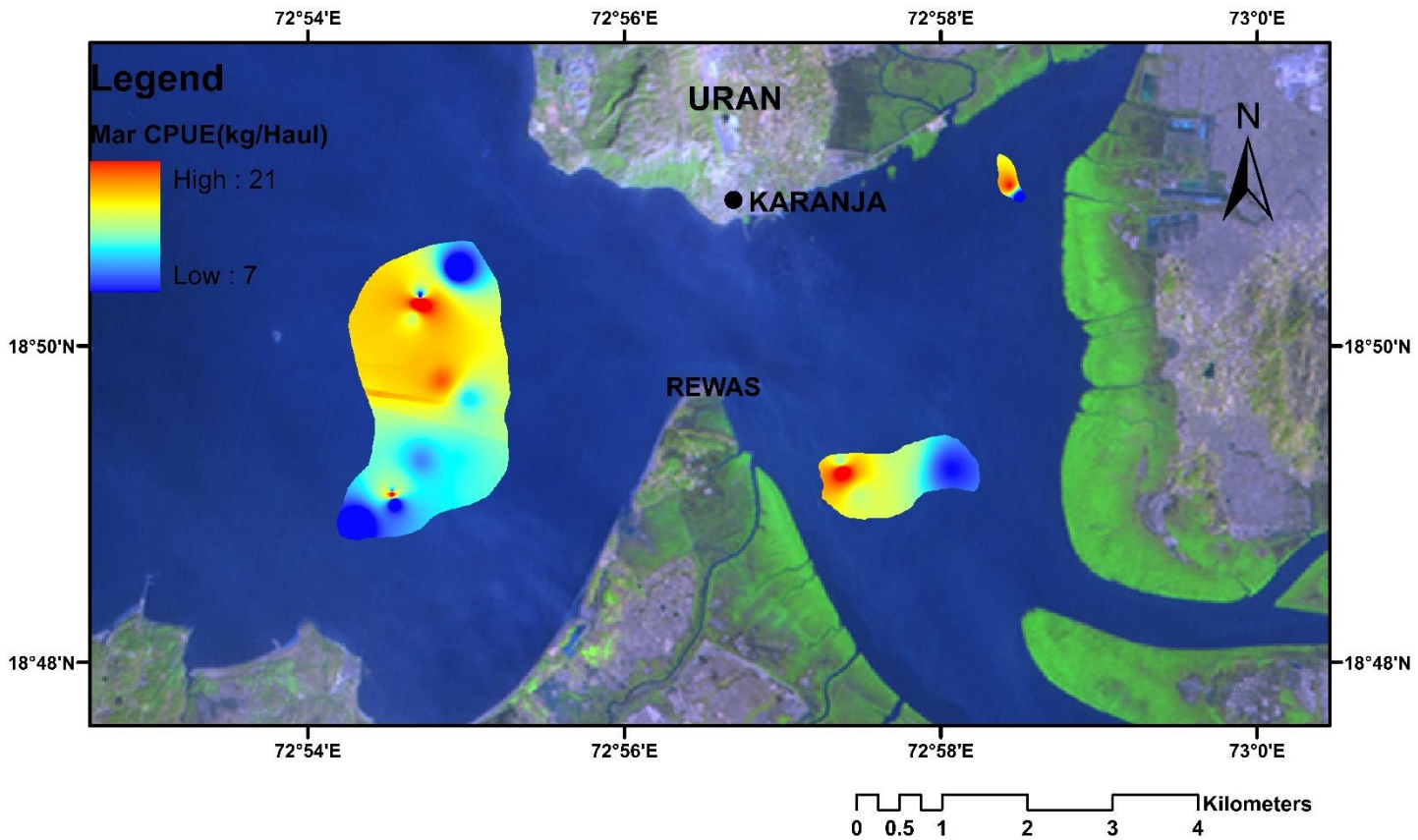




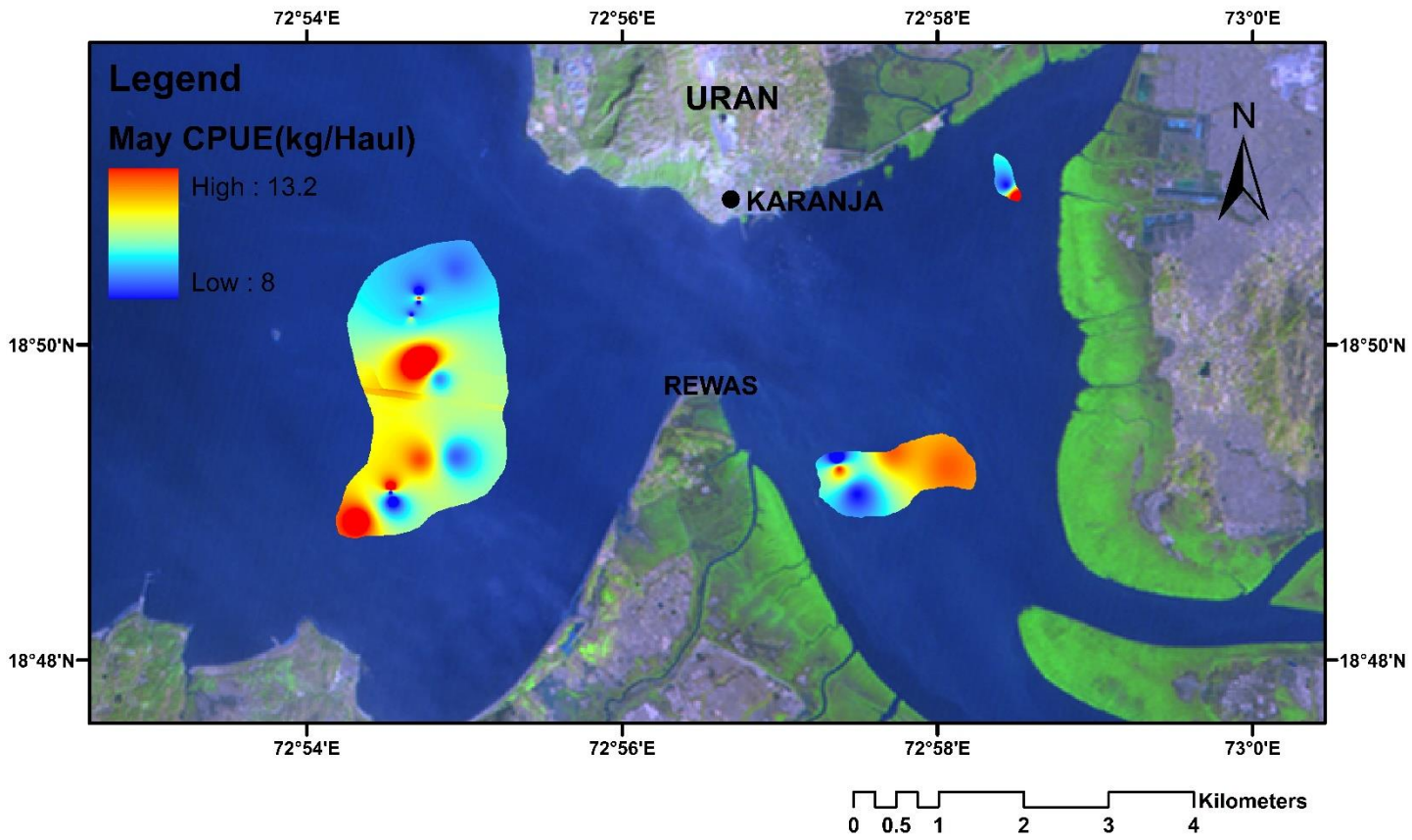
Map 2: Thematic map of CPUE (kg/haul) of dol net for November & December



Map 3: Thematic map of CPUE (kg/haul) of dol net for January & February



Map 4 : Thematic map of CPUE (kg/haul) of dol net for March & April



Map 5 : Thematic map of CPUE (kg/haul) of dol net for May

5. DISCUSSION

Present study was conducted to study the design and catch composition of dol nets, effect of operational parameters on their catch and to prepare thematic maps of the selected dol net fisheries resources of Karanja estuary, Raigad district, Maharashtra. Resource mapping was done using GIS technology. Findings of the study will immensely benefit fishers, researchers, fishery managers, policy makers and other stakeholders.

5.1 Dol net Fishery

5.1.1 Type of vessel

The fishers of Karanja estuary use a special plank-built boat locally called as *Hoondy/Tony/Hodkav* with OAL between 5.8-13.6 m and fitted with two cylinder 7-16 HP engines. Large dol netters having overall length of 12 to 14 m were used along the Saurashtra coast. (Mohammed *et al.*, 2010) Raje and Ramamurthy (1990) reported that small dol netters used at Versova had a length of 7.5 to 9.0 m and medium size boats were in the range of 9.3 to 12.0m. Hotagi *et al.* (2007) reported that the dol netter used at Bassien Koliwada, Maharashtra had length of 15 m. Thus, it is observed that the size of dol netters varied from place to place. All the dol netters operating in Karanja estuary were motorised and registered at the Port office or MMB. Authorization to fish in Maharashtra state was carried out by registration and licensing of fishing vessels by the state fisheries department. It was found that all the surveyed bag- netters were registered according to MFRA but nets were not registered. The registration number was displayed on the stern side of boats.

5.1.2 Engine power

Dol netters operating from Karanja were fitted with two-cylinder inboard engines of 7-16 horse power (HP). Mohammed *et al.* (2010) reported that the dol netters of Saurashtra coast vessels were fitted with engines having higher power (87 to 105 HP) than the dol netters used in Ratnagiri. Srinath *et al.* (1987) observed that dol netter of Navedar – Navgaon, Madh and Navabunder had 2 to 4 cylinder diesel engine. Akerman (1986) reported that dol net vessel of Sonadia had diesel engines of 15 to 22 HP. Raje and Deshmukh (1989) recorded the engine power which ranged from 5 to 25 HP, 30 to 35 HP and 50 to 100 HP in Mumbai, Maharashtra. Hotagi *et al.*

(2007) observed that 90 HP engine was used in Bassien Koliwada, Maharashtra. Thus, it was observed that the engine power of dol netters operating from Karanja was very low, whereas higher horsepower engines were fitted to dol netters in other regions. The dol netters of Karanja operated only in creeks/estuaries whereas the dol net operation was mostly carried out in the sea at different depth range at varying distance from the coast in other regions, thus requiring higher horsepower engines to be fitted. The cost of engines ranged between 1.25 Lakhs to 1.50 Lakhs.

5.1.3 Depth of operation

Dol nets were operated at depth less than 10 m in estuarine waters of Karanja. Josekutty and Sundaram (2004) observed that dol nets off Mumbai were generally limited to the fishing grounds having depth of 10 to 30 m. Sarang *et al.* (2004) reported that dol nets off Arnala were generally operated in the fishing grounds having depth of about 40 m. Findings of research carried out by Kizhakudan (2002) in Gujarat recorded 8 m depth of operation of dol nets. Rao and Bindu (1976) reported that depth of operation of 'kav' was 5 –6 m. Raje and Deshmukh (1989) reported that at Versova, dol nets were operated at a maximum depth of 30 to 40 m. As per Rajan *et al.* (1982) dol netters were operated at a depth of 30 to 40 m at Versova and at 10 to 15 m at Sassoon Docks. Hotagi *et al.* (2007) recorded that the nets were operated at a depth of 30 to 35 m at Bassien Koliwada, Maharashtra. According to Khan (1987) dol nets were operated at a depth of 27 to 40 m in Gujarat. It was observed that in most of the locations, dol nets were operated in coastal waters whereas in Karanja they were exclusively operated in estuarine waters.

In the current study, depth wise (5 m, 6 m and 8 m) variation in the catch was observed. Josekutty and Sundaram (2004) had observed that dol nets off Mumbai were generally limited to the fishing grounds in the depth range 10 to 30 m and reported species-wise and quantity-wise variation in catch.

5.1.4 Size and number of bag nets per Vessel

There is variation in the number of bag-nets used for fishing operation. The average number of single-day bag netters used at Karanja estuary varied between 2-4 with an average of 3 by the dol netter. Number of net usage depended on the local conditions and seasons. The maximum number of dol nets per vessel was observed during September to October (3-4 nos.). Present study found

that average number of dol nets per vessels operated in Karanja estuary was somewhat equal to that of reports of earlier researchers i.e. 2-3 at Versova (Raje and Deshmukh,1989) and low compared to 5-7 at Bassein Koliwada, Madh, Alibag and Bankot (Kumawat *et al.*, 2015), This implies that number of dol nets operated per vessel was low in estuarine areas compared to shallow seas.

5.1.5 Mesh size of dol net

It was observed that each of the five sections of dol nets locally named as *Mawr*, *Katra*, *Manjola*, *Moonj* and *Khola* was fabricated by using rectangular pieces of webbing which had different mesh sizes in the Karanja estuary. *Mawr* section had mesh size between 165 to 135 mm, *Katra* section with 125 to 95 mm, *Manjola* with 75 to 55 mm, *Moonj* with 45 to 25 mm and *Khola* (Cod end) with the least mesh size of 8 to 15mm. Raje and Deshmukh (1989) reported that in Mumbai–Saurashtra region, the mesh size varied from 10 to 40 mm at the cod end. Thomas *et al.* (2007 and 2008) stated that in Kerala, the mesh size was 8 to 10 mm at the cod end which was in the same range as observed for dol net in Karanja. Kunjipalu *et al.*(1993) reported that mesh size of cod end was 20 mm along the Gujarat coast which was higher compared to Karanja which implied that dol nets operated in the estuary regions were fabricated with small mesh cod ends.

5.1.6 Number of fishing days or trips per month

As per the present study, September to October is the peak season of dol net fishing operations. The average number of fishing days per month was 14. Which was far less than the sea operating dol netters. Dol net operation in estuarine region is limited and temporally restricted within a month due to tidal cycle. It was observed that trips were mostly conducted from 12th day (*Dwadashi*) to 3rd day (*Tritiya*) of lunar cycle (Nirmalae *et al.*, 2007) as fishers observed that catches of dol nets were more between twelfth day to third day of lunar cycle.

5.1.7 Distance travelled from the jetty

The month-wise distance travelled from the Karanja jetty showed that there was no difference for the same dol netters as their locations were fixed but between dol netters variation was observed because of the difference in the location of their dol net stations. Fishermen stated that they were forced to abandon their stations near

the upcoming jetty across the estuary and compelled to shift their stations towards sea.

5.1.8 Status of documentation of fishing information

It was noted during the present study that there were no logbooks maintained in the boats. Also, limited visits of the state fisheries department personnel to the landing centre of Karanja implied that there was less importance given to the catches from estuarine areas. Jha *et al.* (2008) stressed that the catch from estuarine regions of India by indigenous gears should be closely monitored temporally as the estuaries are the nursery grounds for several species.

5.1.9 Discards

Findings of the present study revealed that there was more than 5 % discard from total resource caught. Month of February had more discards. Main component of discard from the dol netters were jelly fishes. Kumawat *et al.* (2015) stressed the need for management measures to reduce huge discards in dol nets of Maharashtra.

5.1.10 Waste (Garbage/Plastics)

Analysis of data revealed that an average 10.38 % (maximum 26.23 %) of total catch of waste material got filtered in dol net. The plastic filtration was maximum in February-March 2017. Most of the waste material was garbage/plastics that included plastic bags, disposable water bottles, cold drink bottles, disposable cups, milk pouches, soap covers, synthetic ropes, synthetic gear etc. Fishermen usually segregated plastics from their catch which increased their working time. All such garbage/plastics were the indicators of intensity of pollution leading to long term and high adverse impacts on ecosystem. The waste had increased considerably and effected fishing operations (Boopendranath, 2012). Huge amount of debris in the nets is an indication of substantial increase in the pollution of the Karanja estuary which is also well documented in the present study.

5.1.11 Catch composition

Observations during the present study revealed that the catches in dol net fishing operations consisted of 51 species of fin fishes, 3 species of elasmobranchs, 13 species of shrimps, 10 species of crabs, 5 species of cephalopods, 2 species of jellyfish, 4 species of sea snakes, 1 species of lobster and 3 species of stomatopods. The catch composition in the present study varied from the work of earlier researchers (Rajan *et al.*, 1982; Pillai, 1983; Khan, 1987 and 1989; Srinath *et al.*, 1987; Raje, 1991; Srinath, 2003; Raje *et al.*, 2004). Among the catch composition, *Acetes indicus*, *Harpadon nehereus*, *Chrysaora caliparea*, *Parapenaeopsis sculptilis*, *Lepturacanthus savala*, *Charybdis (Charybdis) callianassa*, *Mystus gulio*, *Coilia dussumieri*, *Arius maculatus*, *Miyakella nepa* were the major contributors in the dolnet fishery during the present study. Among the several reasons for variation in catch, climate change and pollution could be major factors. Huge catch of juvenile species was recorded from the study area in almost all the months. This rings the alarm bell highlighting the need for sustainable use of fishery resources.

5.1.12 Development activities around Karanja

Fishermen of Karanja area are compelled by the developments happening around the estuary such as construction of KTPL which degrades the estuarine ecosystem and pressurize the fishers to modify the gear to make it more efficient and in the process it leads to destructive fishing to earn their livelihood. Developmental activity around Karanja village that disturbed the fishing activity was also reported by Sudesh and Nandini (2016). Velamal *et al.* (1998) had also indicated that the estuaries of Maharashtra were more prone to degradation due to developments around the city.

5.1.13 Mapping of dol net fisheries resources

Thematic maps of fisheries resources of Karanja estuary were prepared using GIS. Information on the catch of major contributing species of dol net was updated in the Geographical Information System (GIS) software and the catch per unit effort (CPUE) along the fishing ground area of the fishermen documented. Researchers in the past had recognised GIS as a decision support tool for fishery managers. Bhendekar *et al.* (2016) mapped spatio-temporal distribution and abundance of fishes and juveniles

from commercial catches of trawlers along the Mumbai coast. Based on the abundance of estuarine fish resources, estimation of CPUE etc. spatial and seasonal restrictions on fishing efforts can be advocated for maintaining sustainable production in estuaries.

5.2 Recommendations that emerged from fishers and Karanja Machimar Society during the study

- Availability of inshore fishes is getting reduced due to the effluent water from the chemical companies situated close to sea shore, which adversely affects the livelihood of fishermen. Government should take some strict action against it. Though the number of boats have not increased, availability of fishes has decreased.
- Provision of fish processing unit or fish storage unit would help in preservation/storage of fish so as to avoid selling the catch for a meagre price.
- As there is no proper dock with basic facilities for landing of the fish, such a facility may be provided at Karanja.
- Fishers are not aware of the techniques to avoid juveniles in the fish catch. Awareness programs to protect fish resources need to be conducted.
- Maharashtra Fisheries Regulation Act, 1981 is more than 25 years old, it has to be amended now by taking opinions of various stakeholders.
- Provision of compensation/loan waiver etc. for fishermen may be made as is available for farmers engaged in agriculture as both are adversely affected by climate change.
- Near shore and small creeks are vanishing due to landfill. Mangroves in the vicinity are under threat. There is need of protecting mangroves which in turn would conserve juvenile fishes of various species. Total ban on effluents/chemical water from industries should be made effective.

SUMMARY

A study of design and catch composition of dol nets, effect of operational parameters on catch and preparation of thematic maps of selected fisheries resources and fishing location at Karanja estuary, Raigad, Maharashtra was carried out during September 2016 - May 2017.

Estuaries are overly used inland water bodies which harbour rich biodiversity and are the nursery grounds for several species. They support livelihood of several traditional fishermen. Management of estuarine fish resources requires information on spatial and temporal data. Dol netting is one of the major fishing methods used mainly by traditional fishermen of Maharashtra. Dol net is a non-selective, location-specific gear and is unique in its ingenuity. Due to indiscriminate fishing by dol nets, the catch from estuarine regions by these gears should be closely monitored temporally.

Single-day dolnetters (10 Nos) operating at Karanja estuary were selected for the study. Fortnightly on-board sampling and questionnaire-based sampling were carried out to fulfil the objectives of the study. Information on the dol net fishery associated data (Type of vessels, their registration status; size and number of dol nets operated per vessel; mesh size of dol nets; number of fishing days or trips per month; distance from shore and depth of operation) was collected from Karanja village. Discard at sea, plastic catch, catch composition, temporal variation in catch were analysed for fish samples from the study area.

Plank built motorized dol netters with OAL varying from 5.8-13.6 m were used. These vessels were fitted with two-cylinder engines with 7-16 HP and the vessel registration status (100%) was highly satisfactory. The overall length of dol net varied between 14-18 m. The numbers of dol net/ dol netter varied between 2 and 4. Each dol net is constructed by joining five sections locally named *Mawr*, *Katra*, *Manjola*, *Moonj* and *Khola*. Mesh size ranged from 8mm at the codend (*Khola*) to 165 mm at the mouth part (*Mawr*). September to October comprised the peak fishing season. Distance travelled by dol netters varied between 2 to 5.5 Km from the Karanja jetty. The number of fishing days / month ranged from 12-16 due to tide based restrictions.

The catch in dol nets consisted of 97 species (51 species of fin fishes, 3 species of elasmobranchs, 13 species of shrimps, 10 species of crabs, 5 species of

cephalopods, 2 species of jellyfish, 4 species of sea snakes, 1 species of lobster and 3 species of stomatopods). Major contributors to dol net fishery catch were *Acetes indicus*, *Arius maculatus*, *Charybdis (Charybdis) callianassa*, *Chrysaora caliparea*, *Coilia dussumieri*, *Harpadon nehereus*, *Lepturacanthus savala*, *Miyakella nepa*, *Mystus gulio* and *Parapenaeopsis sculptilis*. The discard percentage varied from 5.1 % to 83.6% with an average of 36.2 %. Jellyfishes, plastics and juveniles of several fish species comprised the main components of discard in the dol nets. On an average, plastics formed 10.4 % (maximum 26.2 %) of total catch from dolnetter in a single trip. During October, November and December 2016, pods of dolphins were spotted near the sampling stations during on-board sampling from dolnetters. The dolphins are identified as Indo-Pacific humpbacked dolphins *Sousa chinensis plumbea* (Osbeck, 1765) by using surface photo identification (photo-ID) techniques.

The Arc GIS 10.2 was used to produce the thematic maps of selected dol net fishery resources of Karanja estuary. Information on the catch of major contributing species of dol net was updated in the Geographical Information System (GIS) software and the catch per unit effort (CPUE) along with the fishing ground area of the fishermen documented. It will form baseline data for GIS associated mapping studies of dol netters in other estuaries.

This study highlighted the type of dol nets used in estuarine areas and their specifications, temporal difference in catch composition, unused discards due to poor market demand, impact of developments in the vicinity of estuarine area on the dol net fishing operations. Findings of the present study could be used as a support tool to suggest measures to ensure sustainability of dol net fishery resources of estuarine regions while highlighting the need to adopt management measures to utilize the discards of dol netters of Karanja estuary. The basic information on the design specifications, parts and operation of dol nets in Karanja would help in bringing out technological innovations in the structure of nets and their operation in the coming decades.

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Appendix I
Central Institute of Fisheries Education
(University under Sec.3 of UGC act)
Mumbai-400061

**Dissertation topic: DOL NET FISHERY AND RESOURCE MAPPING OF
KARANJA ESTUARY, MAHARASHTRA**

(Operational Performance)

Number of trips per month :
Distance from shore :
Depth of operation(m) :
Duration of fishing trip :
Departure time :
Arrival time :
Average speed :
Fuel consumption(litres) :