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Jellyfish bloom: Abundance, distribution and impact analysis in the commercial dol net fishing ground of Northwest coast of India, Arabian Sea

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Abstract
Globally, jellyfish blooms significantly impact commercial fishing operations, leading to revenue loss. This study investigated the biomass, distribution, seasonality, and hindrance intensity of *Rhopilema hispidum* (Vanhöffen, 1888) blooms in the Dol net fishery along the Palghar coast of the Arabian Sea. The experimental period for the single-day and multi-day dol net fishery during 2022-2023 revealed that *R. hispidum* blooms occurred in two main seasons: October-December and March-May, at depths of 10-40 meters. Estimated bloom biomass in multi-day dol net hauls ranged from 22.57 to 135.86 kg/hr/net, while single-day hauls ranged from 20.73 to 129.78 kg/hr/net. The fish-to-jellyfish catch ratio varied between 3.5:1.5 (October-December) and 2.25:2.75 (March-May) in the dol net catch composition. The fishers' perception of the hindrance intensity of *R. hispidum* bloom with dol net fishing operation decreased in the following order: increased catch sorting time > painful sting > change in fishing ground > closure of fishing > clogging and bursting of nets > reduction in fish catches. Despite these challenges, *R. hispidum* blooms have the potential to develop jellyfish fisheries and offer new livelihood opportunities for local fishers.

Keywords: Scyphozoan bloom, Maharashtra, impact analysis, fishers' perception, economic impact, gelatinous zooplankton

Introduction
Jellyfish blooms of the order Rhizostomeae have been found to contribute to seasonal jellyfish fisheries, resulting in additional revenue generation for small-scale fishermen globally (Kumawat *et al*. 2023; Sreeram *et al*. 2021; Behera *et al*., 2020b; Jarms and Morandini, 2019; Fahrenbruch 2018; Nishikawa *et al*. 2008; Brotz *et al*. 2017 & 2021; Kitamura and Omori, 2010; Hsieh *et al*. 2001; Omori and Nakano, 2001; Kingsford *et al*., 2000) [27, 47, 4, 22, 17, 32, 8, 6, 25, 21, 32, 24]. The species-*Rhopilema hispidum*, *R. esculentum*, *Stomolophus meleagris*, *Catostylus mosaicus*, *C. perezi*, and *Crambionella helmbiru* blooms around the world has gained significance economic viability as delicacy oriented commodity in the south east Asian countries such as, Japan, Korea and China mainly due to its rigid structure and crunchy texture (Dong *et al*., 2018; Raoult and Gaston 2018; Fahrenbruch 2018; Brotz *et al*., 2017; Dong *et al*., 2014; Lopez-Martinez and Alvarez-Tello 2013; Nishikawa 2008) [13, 41, 17, 7, 14, 30, 32]. On the Indian coast, jellyfish swarms in two seasons: the east coast of India (March-June and September-October) and the west coast of India (September-January and April-May) (Saravanan *et al*. 2018) [44]. In India, the potential jellyfish species that can bloom under favourable environmental conditions are *Cyanea rosea*, *C. nozakii*, *Chiropsoides buitendijki*, *Chrysoara chinensis*, *Acromitus flagellates*, *Tripedalia cystophora*, *Crambionella annandalei*, *C. orsini*, *Lobonemoides robustus*, *Marivagia stellata*, *Rhopilema hispidum*, *Cephea cephea, and Lychnorhiza malayensis* (Ramkumar *et al*., 2023; Ramkumar *et al*., 2020; Saravanan 2018; Saravanan *et al*., 2018) [38, 37, 45, 44]. Jellyfish bloom species that contributing to fishery in the Indian waters are *Crambionella annandalei*, *C. orsini*, *Catostylus perezi* and *Rhopilema hispidum* (Ramkumar *et al*., 2023; Kumawat *et al*., 2023; Saravanan 2022; Behera *et al*., 2020b) [38, 27, 46, 4]. Records on the distribution, biomass, and abundance trends of jellyfish blooms aid in understanding

their impacts, both positive and negative, paving the way for policy managers to make informed decisions globally in a particular ecosystem before and during sudden spikes in jellyfish blooms (Ye *et al*. 2024; Randriarilala *et al*., 2014; Eriksen *et al*., 2012; Kim *et al*. 2012; Zavolokin, 2011 & 2010; Uye, 2008) [51, 40, 16, 23, 53, 52, 50]. Historical data on jellyfish blooms in Indian waters are scarce and scattered without a continuous monitoring database; their commercial use and landings are reported in the miscellaneous category in fisheries catch statistics reports (Ramkumar *et al*., 2023; Kumawat *et al*., 2023; Behera *et al*., 2020b; Saravanan 2018; Brotz and Pauly 2017; Krishnan and Perumal 2013; Mohan *et al*. 2011; CMFRI 2010; Chidambaram 1984; Kuthalingam *et al*., 1989) [36, 27, 4, 45, 7, 26, 31, 11, 9, 29]. Hence, this study aims to reveal the biomass abundance, distribution, seasonality, and impacts of *R. hispidum* blooms on commercial dol net fisheries along the Palghar coast, northwest coast of India, and Arabian Sea. In addition, fishers' perception of the hindrance intensity of *R. hispidum* blooms was elucidated from dol net fishers on the coast.

Materials and Methods

Study area

Scyphozoan blooms were surveyed in the Arabian Sea waters of the Palghar coast of Maharashtra, eastern Arabian Sea, during the period 2022-2023 (Figure 1). The Palghar coast has a wide continental shelf with a depth range is mostly covers 10-50 m that provides suitable fishing grounds for local fishers. The Dol net fishery is a suitable fishery on this coast due to the high tidal fluctuation and muddy bottom nature of the coast, which supports penaeids, non-penaeids, and high-valued finfish fisheries on this coast. Sampling of the scyphozoan bloom was conducted during the full moon and new moon period for every month from 2022 to 2023 from the commercial fishing grounds of the dol net fishery.

Dol net fishery of Palghar coast

The Palghar coast of Maharashtra is dominated by commercial dol-net fisheries. It is a fixed bag net fishery and its operation is influenced by the tidal amplitude of the coast. Flooding and ebbing tidal currents were used to maintain the bag nets in the horizontal position. The cod end of the bag net fisheries ranged from 10 mm to 20 mm. The cod end of the 10 mm mesh size was used to catch prawns such as *Acetes* spp., *Nematopalaemon tenuipes*, and *Exhippolysmata ensirostris*. These fixed bag nets were operated during the full moon and new moon periods of the month, with a self-adjusted mouth opening, allowing the fish to pass through and catch at its cod end. These gears were operated at depths ranging from 35 to 40 m and 15 to 20 m as multi-day and single-day fishing gears, respectively. Fishing starts from the 11th to 4th lunar calendar days of each month, with total fishing days typically from 16 to 20 days. The multi-day dol net fishery operates 18-21 nets at a time in a fixed location through its 'sus' of 20-25. The 'sus' is a framed rope that anchored in the muddy or sandy bottom of the fishing ground with the help of wooden spikes. The location of the 'sus' was marked with buoys floating in the sea. Duration of a 'sus' usually lasts for 3-4 years (Raje and Deshmukh 1989) [35]. The soaking time was 3 hours. Each day, they operate twice. This fishery starts in August and ends in May of every year. In the case of a single-day fishery, it operates 3-4 nets fixed to 4-5 spikes at a time with one haul per day. A minimum of two spikes are required for the operation of a single dol net. The fish catch was landed at Arnala, Vasai, Killa, and Naigoan fish landing centres.

Collection, Identification and Quantification of biomass

Bloom abundance was quantified by catch per unit effort (CPUE), expressed as kilograms per net per hour, by referring to Syazwan *et al*., (2020) [48]. Data such as latitude and longitude of the nets, month of operation, number of nets operated, number of hauls attempted, soaking time, species composition of the catch, and jellyfish caught at the cod end were collected from selected fishing boats by providing logbooks to them. Fishermen were asked to bring the randomly selected jellyfish specimens from the blooms for species identification. For species identification, 5% of formalin-preserved specimens were taken to the laboratory in seawater. In case of single-day dol net, freshly caught specimens were photographed onboard and at the landing centre. Species identification was performed by referring to Jarms and Morandini (2019) [22] and Gomez-Daglio and Dawson (2017) [19]. The sampling area of the jellyfish bloom was mapped with a depth contour using the QGIS software platform (Figure 1).

Fishers' perception-pre-structured questionnaire survey

To understand the impact of jellyfish blooms on the commercial operation of dol net fishing, interviews were conducted with the dol net practising fishermen of Arnala, Vasai, Killa, and Naigoan fishing villages. Respondents were selected based on their years of experience in dol net fishing. We collected information on the impacts of *R. hispidum* blooms on the commercial fishery of dol nets from 60 respondents with fishing experiences of 0-10 years, 10-20 years, 20-30 years, and 30 years. Following questions were asked

1. Have you observed jellyfish blooms in your fishing area?
2. Have the frequency of jellyfish blooms increased over time? if yes, how much?
3. Do jellyfish blooms interfere with fishing operations? if yes, how?
4. What are the impacts of fishing operations, such as a) loss of fishing opportunities and return to port, b) clogging and bursting of nets, c) increase in catch sorting time, d) stings during sorting of catch, and e) prevailing practices in jellyfish sting management?

Results

Quantification of biomass

In the dol net operation, jellyfish species that form blooms were identified as *Rhopilema hispidum* for the years 2022-2023 on the Palghar coast. *R. hispidum* blooms encountered in the commercial fishing operation during the study period was shown in the Figure 2. Blooms were observed during two seasons: October-December and March-May. *R. hispidum* blooms biomass that caught in the Multi-day dol net cod end was estimated in the range of 42.78 kg-135.86 kg/hr/net during March-May and 22.57-69.32 kg/hr/net during October-December based on the data from 120 hauls during the year 2022-2023. Whereas for single day dol net fishing, jelly fish biomass was estimated as 39.34 kg-129.78 kg/hr/net during March-May and 20.73-66.24 kg/hr/net based on the data from 80 hauls during the year 2022-2023. The mean ratio of fish catches to jellyfish biomass caught at the cod end of the dol net was in the range of 3.5:1.5 during October to December and 2.25:2.75 during March-May, irrespective of the single day, multi-day fishing, depth of operation, and year of the dol net fishery.

Dol net fishery species composition

This fishery targets the fishes such as *Harpadon nehereus, Coilia dussumieri*, Ribbon fish (*Trichiurus lepturus, Lepturacanthus savala, Eupleuragrammus muticus*), silver pomfret (*Pampus candidus*), black pomfret (*Parastromateus niger*), Sciaenids (*Johnius borneensis*, *J. macrorhynus*, *Otolithoides biauritus*, *Protonibea diacanthus*), *Ilisha filigera*, non-penaeid prawns (*Acetes* spp., *Nematopalaemon tenuipes, Exhippolysmata ensirostris, Solenocera crassicornis*), and penaeid prawns (*Parapenaeopsis stylifera, P.sculptilis, P. hardwickii, Metapenaeus affinis, M. brevicornis*) as their main catch. The catch composition of dol net fishing during *the R. hispidum* bloom in single-day and multi-day fishing for March-May and October-December for the year 2022-2023 are shown in figure 3, 4, 5, and 6.

In single day dol net fishing, during March-May the catch composition was dominated by jellyfish (55%), followed by commercially valued species that contributes more than 5% of the total catch are *Acetes indicus* (19.37%), *Nematopalaemon tenuipes* (9.25%) and *Harpadon nehereus* (8.28%). During October-December the catch composition was dominated by jellyfish bloom (30%), followed by species that contributes more than 5% of the total catch are *Harpadon nehereus* (15.23%), *Coilia dussumieri* (11.01%), *Acetes indicus* (11.28%), *Parapenaeopsis hardwickii* (7.67%), *Nematopalaemon tenuipes* (5.63%) and *Johnius* spp (5.24%).

In the multiday dol net fishing during March-May, the catch composition was dominated by jellyfish (55%), followed by commercially valued species that contributed more than 5% of the total catch were *Acetes spp.* (37.02%). During October-December the catch composition was dominated by jellyfish bloom (30%), followed by species that contributes more than 5% of the total catch are *Parapenaeopsis stylifera* (10.85%), *Coilia dussumieri* (9.91%), *Acetes indicus* (12.33%), *Exhippolysmata* spp (7.68%), *Rastrelliger kanagurta* (6.31%), *Nematopalaemon tenuipes* (5.45%) and *Ilisha* spp (5.04%).

Impacts of jellyfish bloom

All the respondents who were interviewed acknowledged that they had to spend extra time to sort the fish catches due to jellyfish encounters during the fishing operation. 94.54% of the interviewed respondents expressed the painful sting of jellyfish on their skin as the second most important factor that affected them. The induced change in fishing area due to jellyfish blooms in the 'sus' location resulted in extra fuel consumption, which was expressed by 65.34% of the interviewed respondents. 8.94% of the respondents have expressed that jellyfish blooms prevented them fishing, when all the nearby 'sus' locations, were affected by heavy blooms of jellyfish populations that created no opportunity for fishing operations of dol net leading to fishing boats returning empty-handed. Clogging and bursting of the dol net were experienced by 3.62% of the respondents. This impact was minimal because fishermen first operated very few nets to see the bloom intensity for half an hour; if the bloom intensity is high, they will stop fishing and look for a chance to utilise the nearby 'sus' where the bloom intensity is very low or zero otherwise, they return to shore in case of single-day fishing. On the other hand, in multi-day fishing, they wait for the jellyfish intensity to reduce for a few hours, resulting in a reduction in the number of operations in a day, instead of two hauls they go for one haul only. Fishermen experienced a reduction in fish catches from March to May, which is generally considered a lean fishing period on the Palghar coast. The frequency of various impacts of heavy *R. hispidum* blooms on commercial dol net fishing operations is shown in Table 1. The frequency of bloom occurrence over the last three decades (1991-2023) was analysed based on the questionnaire method. It was found that 37.5% of the respondents agreed that *R. hispidum* blooms have increased over the years, 37.5% reported that there was no change in the frequency of bloom occurrence over the years, and 25% reported that bloom frequency has decreased over the years. The total number of fishing days lost during the bloom period from October to December was eight days, and for the period from March to May, it was six days for the multi-day dol net fishery for the year 2022-2023. In the case of the single-day dol net fishery, the number of fishing days lost for the period from October to December was four days, and for the period from March to May was six days. Fishermen often have a chance of changing the fishing area during the jellyfish blooming period; therefore, they use the 'sus' location of other fishermen groups where the jellyfish blooms are not in their 'sus' location. The cost of repairing a damaged net incurred due to jellyfish blooms is 500-1500 INR per damaged net. *R. hispidum* once sorted from the fish catch onboard was thrown back to sea and in the fish landing centre, it has been thrown along with the fish catches that stuck inside the umbrella, oral arms and cavity. This results in the wastage of a portion of the fish caught during sorting.

Sting management

Fishermen were stung by *R. hispidum* cnidocytes while handling the specimens at the time of catch sorting. They have a practice of treating cnidocyst stings on their skin in various ways, such as applying coconut oil or tamarind seawater (*Tamarindus indica*) or kokam juice (*Garcinia indica*) on the stung area of the skin after washing the stung area with seawater.

Discussions

In the present study, *R. hispidum* bloom was found to interact with detritivore and planktivorous species of finfish and shellfish on the Palghar coast, as evidenced by the species composition of the total catch of both single-and multi-day dol net fishing operations. In addition, the *R. hispidum* jellyfish bloom was found to occupy the entire water column at a depth of 10-50 m, as the dol net fishery targets pelagic and demersal fishery resources on the coast. Furthermore, *R. hispidum* species bloom heavier in warmer months: March-May (pre-southwest monsoon), which results in 55% of the total catch of the dol net fishing catch. Similarly, Zavolokin estimated the biomass of jellyfish in the Sea of Okhotsk during 1992-2005 using the Trawl swept area method with a cod end mesh size of 10 mm in the trawl net, and the average biomass ranged from 166 to 1271 kg/km^2 and 173-1591 $individual/km^2$. The study further stated that the increased abundance of jellyfish blooms observed in the warm season coincides with active polyp strobilation and the rapid growth rate of juvenile jellyfish (Zavolokin 2010) [52]. Another decadal study by Zavolokin in the Sea of Okhotsk, Bering Sea, Sea of Japan, and the Northwestern Pacific Ocean in 1991-2009 revealed that jellyfish bloom intensity was high in summer and fall seasons, with maximum biomass recorded in summer with a range of 13-15 million tons. Lion mane jellyfish (*Cyanea capillata*) formed blooms during August-September in the barrent sea during the warmer months of the 2015 survey and August-October 2016 in the Barents Sea. This bloom was observed in the entire survey area. An increasing trend was witnessed during 2011-15 with the estimated jellyfish biomass being higher than the long-term mean biomass of 1.1 million tonnes (Eriksen *et al*., 2016; Falkenhaug *et al*., 2017) [15, 18]. Similar to our study, heavy bloom scyphozoan jellyfish of *Crambionella annandalei* of the northern Bay of Bengal coast were found to occur during summer months (March-May) and completely disappear at the onset of the southwest monsoon (Behera *et al*., 2022, 2020a, 2020b) [2, 3, 4]. *Netrostoma coerulescens*, a scyphozoan jellyfish, swarms during warmer months along the coast of Puri in the northwestern Bay of Bengal, causing a negative impact on its coastal fishery and coastal tourism. Furthermore, summer jellyfish swarms are associated with higher temperature-induced strobilation and rapid population growth (Dash *et al*., 2023) [12]. In the present study, two blooming periods were observed for *R. hispidum*, one during the summer season and another during the post-monsoon period from October to December. This period when, seawater is generally slightly warmer and may trigger strobilation in *R. hispidum*, leading to the blooming of this species. Salinity also plays a significant role in the blooming of jellyfish in a particular ecosystem. Takao and Si (2018) [49] reported that higher salinity during the summer monsoon in the East Asian marginal sea triggers strobilation of *Rhopilema esculatum*. Similarly, the Palghar coast of the Arabian Sea is found to have higher salinity during the summer months, which may result in *R. hispidum* blooms on this coast. Ramkumar *et al*., (2018) [39] reported that September to December and March to May was the jelly fish bloom period in the north coast of Maharashtra in the year 2017-2018. The species that contributed to the jellyfish bloom were *Chiropsoides buitendijki*, *Chrysaora* sp., *Cephea* sp., and *Rhopilema* sp. and were encountered in the commercial dol net fishery. The study also revealed that jellyfish caught in the dol net fishery ranged from approximately 30 to 100 kg per hour. The study also recorded the estimated biodiversity loss of 7.98 million US dollar due to discards of jelly fish bloom infested commercially valued species in the cod end of dol net. Another study reported that jellyfish bloom affects the commercial trawling sector of the Indian coast to the tune of increased fuel cost through the rise of fuel consumption from 30 to 100 litres per day due to an increase in drag resistance created by jellyfish bloom caught in the cod end of the trawl net (Chinnadurai *et al*., 2023) [10]. In the Andra coast of the Bay of Bengal, jellyfish blooms were found to interfere with the shore seine fishery, and the estimated jellyfish mean biomass was 224.89 ± 65.91 kg/km^2 (Behera *et al*., 2023) [5]. Blooms of the giant jellyfish *Nemopilema nomurai* have been reported to cause severe damage to coastal trawl and set-net fisheries in the Japan Sea (Uye 2008) [50]. Economic damage caused by jellyfish blooms to the commercial fishery of Korean waters estimated between 68.2 to 204.6 million US$ with its negative interference in delay in fishery timing, fishing gear damage, decrease in product value and decrease in fishery catches (Kim *et al*., 2012) [23]. Using environmental DNA (eDNA) technique in the Bohai Sea, the distribution pattern of the jellyfish blooms was analysed and it was found that *Aurelia coerulea* occupied the surface water layer, whereas *Nemopilema nomurai* was distributed in the upper middle of the water column and *Cyanea nozakii* in the middle bottom layer in the study depth range of 2.45 to 70.9 m and further concluded that these species have a strong correlation with temperature, salinity, and nutrients with respect to their blooming intensity (Ye *et al*., 2024) [51]. In the present study, the depth range of *R. hispidum* blooms was 10-50 m. A study on the decadal trend in the biomass of jellyfish blooms showed that biomass was low during the 1980s, increased during the 1990s, and declined in the latter part of the 2000s. This study also found that jellyfish blooms in the Barents Sea are associated with the fishery of haddock (*Melanogrammus aeglefinus*), herring (*Clupea harengus*), and capelin (*Mallotus villosus*). Jelly fish biomass was positively correlated with 0-group haddock in coastal and western areas, herring in central, eastern and coastal area and cod in eastern area whereas for capelin in the northern area of the Barents Sea (Eriksen *et al*., 2012) [16]. Studies have to be conducted to determine the association of *R. hispidum* blooms with the target fishery of the Dol net in the Arabian sea waters of the Palghar coast. Hence, trendline data on jellyfish blooms in any particular ecosystem are needed to understand their positive and negative impacts on the commercial fishery.

Fisher perception of jellyfish bloom interference in fishing operations was studied on the Gujarat coast during 2017-2020. The study revealed that 95% of respondents confirmed that changes in fishing grounds, extra hauls, or distance fishing were done to avoid jellyfish blooms in their regular fishing grounds; 78.75% respondents agreed to the clogging of fishing gear due to blooms; 81.87% of respondents experienced temporary closure of fishing operations; and 91.87% of respondents had experienced painful stings (Kumawat *et al*., 2021) [28]. In the present study, fishermen stated that the factors most impacted by jellyfish bloom interference in their fishing operations were increased catch sorting time (100%), change of fishing ground (22-30%), and painful sting (80%). In 2019, researchers studied how tourists perceived the increase in jellyfish (*Pelagia noctiluca; Physalia physalis*) on the beaches of the Balearic Islands in the northwestern Mediterranean Sea. The results showed about 20-40% of tourists are not ready to return to beaches affected by jellyfish blooms. Furthermore, if precautionary measures such as jellyfish in formation provision, warning flags, deployment of jellyfish exclusion nets, and presence of health services at the beaches could lead to a reduction of 66-83% of non-returning tourists (Ana Ruiz-Frau 2023) [1]. In the Bay of Bengal coast, jellyfish blooms negatively impact the shore seine artisanal fishery of the Andra coast in terms of net clogging, increased sorting time, skin irritation due to jellyfish sting, net damage while hauling the catches, and loss of fishing days (Behera *et al*., 2023) [5]. Negative impacts of blooms of box jellyfish, *Chiropsoides buitendijki*, in the commercial dol net fishery were recorded *viz*., temporary fishing closures, clogging, damage to fishing nets, and loss of fish catches along the Palghar coast during the year 2022-2023 (Ramkumar *et al*., 2023) [39]. In another incident bloom of box jellyfish, *Tripedalia cystophora*, stopped the stocking of *Penaeus vennamei* seeds in the extensive commercial shrimp farming practices of Palghar district during 2022-2023 resulted in the complete cessation of vennamei farming during the jellyfish blooming period (Ramkumar *et al*., 2023) [36]. Another study in northeast Pacific finds a negative correlation between sea nettle (*Chrysaora fuscescens*) jellyfish biomass and adult coho and Chinook salmon returns, indicating that high jellyfish biomass may reduce salmon production by competing for zooplankton prey. Additionally, salmon have fewer full stomachs in areas with higher sea nettle abundance (Ruzicka *et al*., 2016) [43]. *R. hispidum* bloom found to pose series of potential negative economic threats in the Malaysian waters in the field of commercial fishery, aquaculture, power plant operation, coastal tourism and in human health whereas positive effects are *R. hispidum* contributing to jellyfish fisheries and in aquarium trading (Syazwan *et al*., 2020) [48]. Similar to the present study, the Veraval coast of the Arabian Sea witnessed jellyfish blooms during the post-monsoon period, to the tune of 25% of the total trawl catches and contributed 63% of each haul, excluding non-jellyfish hauls in the trawl fishery of the coast during 2009. Cephalopods, sciaenids, and ribbon fish have a high degree of association with jellyfish blooms (Panda and Madhu 2009) [34]. The small-scale commercial fishery of jellyfish blooms recorded in the Gulf of Kutch during 2017-2020 was supported by the scyphozoan species *Catostylus perezi* and *Rhopilema hispidum*, with an economic value at first sale is 1.14 million US$. Fishery is supported by two seasons, March-May and October-December, with an estimated harvest of 13569.95 metric tonnes (Kumawat *et al*. 2023) [27]. Similarly, in the present study, the *R. hispidum* swarm season was from March to May and October to December. The jellyfish bloom of *Crambionella annandalei* forms a seasonal small-scale fishery to the traditional gillnetter of the Puri coast of the Bay of Bengal, with a first sale price of US$ 6.88-US$ 7.57 per Kilogram (Roul *et al*., 2021) [42]. *C. annandalei* also reported to form seasonal gillnet fishery with an estimated first sale value of $5.65 Million in 2018 along the Andra Pradesh coast of Bay of Bengal (Behera *et al*., 2020b) [4]. Likewise, the bloom of *R. hispidum* in the present study pertaining to the Palghar coast can be utilised for jellyfish fishery purposes that certainly open new business avenues for the dol net fisher folk of the Palghar coast.

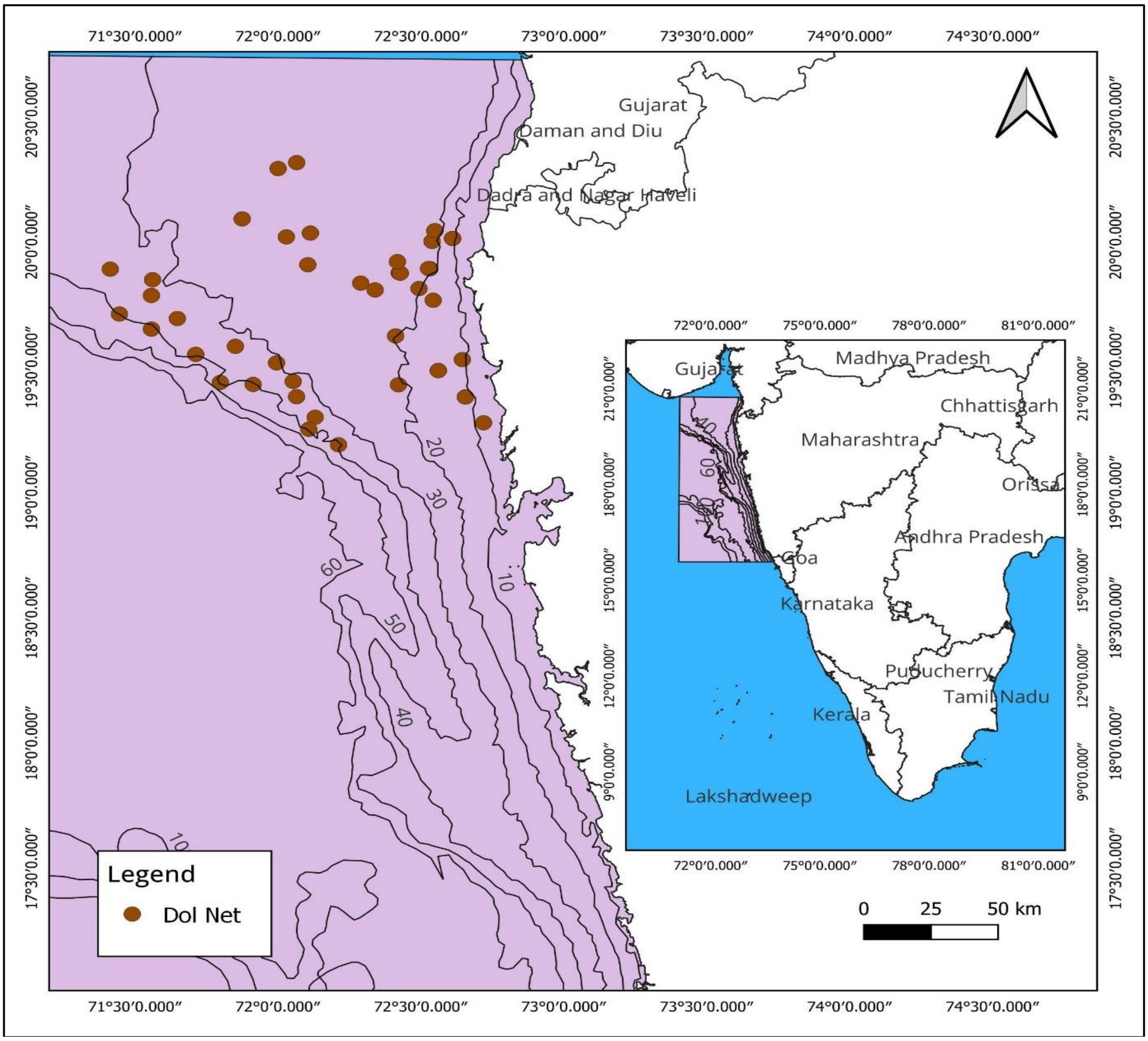

Fig 1: Map showing study area of *Rhopilema hispidum* bloom: a) Red dots indicates bloom hindrance in dol net fishing ground, Palghar coast, Arabian Sea,

(a) (b)

(c) (d)

(e) (f) (g)

Fig 2: a) unsorted fish catch with *R. hispidum*; b) *R. hispidum* specimens caught in the cod end of the dol net; c) bottom and d) top view of fresh specimen of *R. hispidum*; e) *R. hispidum* was thrown out of the dol net catches while sorting at the fish landing centre; f) *R. hispidum* was thrown back to sea at the time of sorting the total catch on-board; g) Interview with commercial dol netters on the impact of jellyfish bloom.

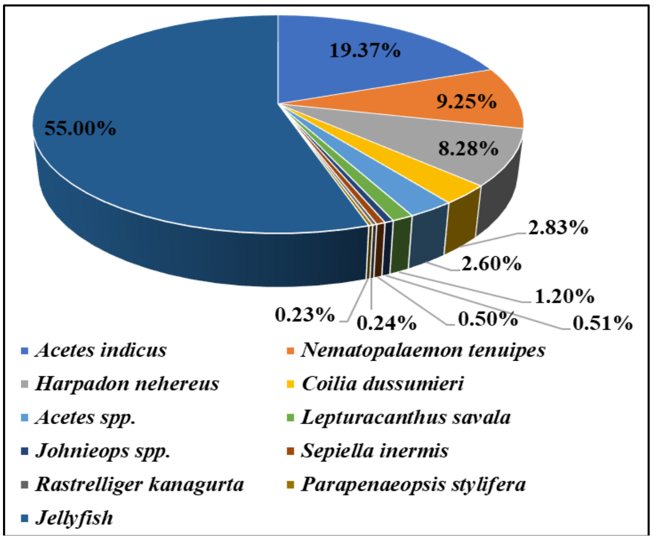

Fig 3: Catch composition of single day dol net fishing during *R. hispidum* bloom in March-May (2022-2023)

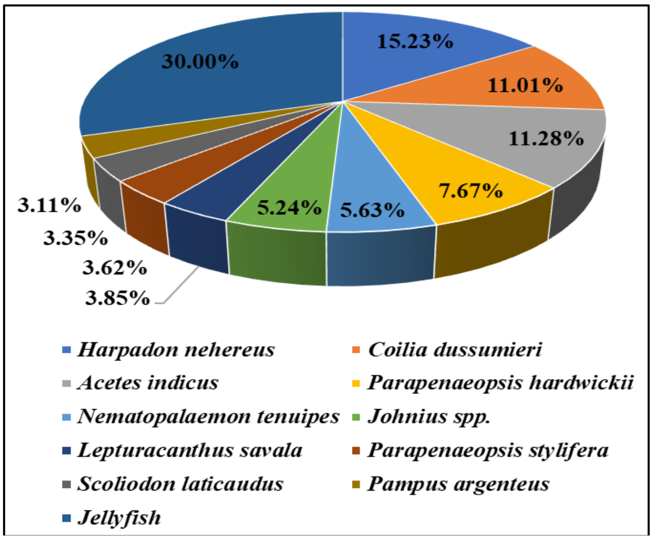

Fig 5: Catch composition of single day dol net fishing during *R. hispidum* bloom in October-December (2022-2023)

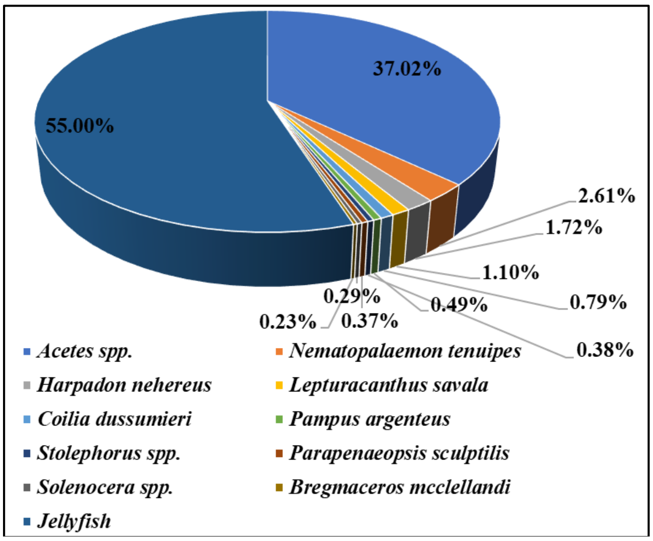

Fig 4: Catch composition of multi day dol net fishing during *R. hispidum* bloom in March-May (2022-2023)

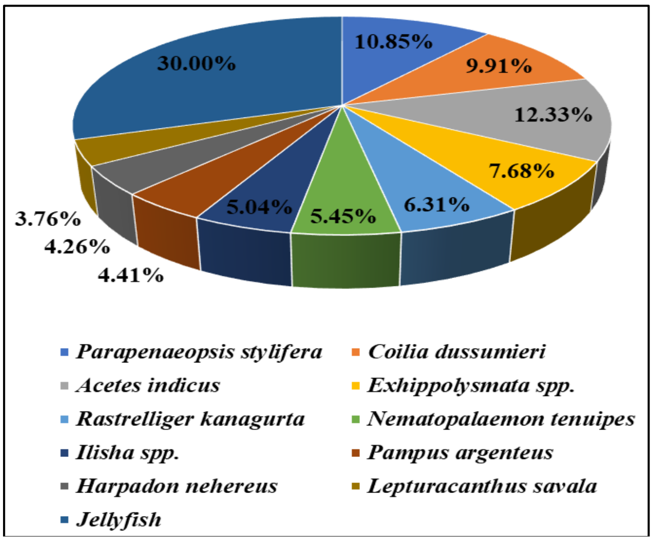

Fig 6: Catch composition of multi day dol net fishing fishing during *R. hispidum* bloom in October-December (2022-2023)

Table 1: Frequency of jellyfish bloom hindrance in the dol net fishery of Palghar coast

S. No	Impacts	Frequency of impact during jelly fish bloom period (%)
1	Loss of fishing opportunity & return to the port	2-6%
2	Induced change of fishing ground	22-30%
3	Clogging & bursting of nets	1-4%
4	Increase in catch sorting time	100%
5	Painful sting	80%

Conclusion

Rhopilema hispidum bloom abundance, distribution, seasonality variation, and its impact on the commercial dol net fishery are presented in the present study. Knowledge of these aspects of the *R. hispidum* bloom of the Palghar coast has not been documented earlier. Hence, this study will provide baseline data on the bloom of *R. hispidum* that will certainly help fishery managers to take a call if the bloom is persistent over the years. In such situations, bloom areas can be demarcated as jellyfish bloom focal points and allow fishermen to utilise the bloom in a positive way, thereby establishing seasonal fisheries that will certainly result in millions of dollars business for the fishermen of the Palghar coast as it has demand in export markets as delicacy commodity in Asian countries.

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