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Marine Fisheries Information Service Technical & Extension Series

The Marine Fisheries Information Service, Technical & Extension Series (MFIS) is a quarterly publication of ICAR-Central Marine Fisheries Research Institute disseminating latest research information on marine fisheries and mariculture in India. Research based technical articles, reporting significant new information, knowledge and understanding of marine fisheries and ecosystems as well as new concepts/technologies in marine fish nutrition, hatchery and larval rearing, fish pathology, fish health management, application of genetics in fish conservation and farming, sea farming technologies, seafood trade and fisheries governance are published. To see all issues since 1978, visit:

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An assorted catch of *Penaeus* spp. landed at Cochin Fisheries Harbour

Photo credit: Josileen Jose

Marine Fisheries Information Service Technical and Extension Series envisages dissemination of information on marine fishery resources based on research results to the planners, industry and fish farmers and transfer of technology from laboratory to the field.

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From the Editorial Board

Warm greetings to all our esteemed readers

Marine prawns (or shrimps) are an important commodity in international trade and their fisheries contribute significantly to bring in foreign exchange as well as create employment opportunities, especially in the post-harvest and processing sectors. During the financial year 2021 -22, the Marine Products Export Development Authority reported seafood exports worth US$ 7.76 Billion, in which frozen shrimp was a major item. The 'sustainability' factor is important to access global markets like US and Europe and factors inherent to global shrimp trawl fisheries such as by-catch, discards and capture of juveniles are best addressed through informed, science-based fisheries management interventions. The current issue of MFIS looks at the development of shrimp fisheries in India and its current status. Also included are articles pertaining to marine fish marketing and value chains, while the Science Corner focusses on a recent stock assessment of the multi-species trawl fishery for sciaenids, in the north eastern Arabian Sea.

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Contents

Saga of marine prawn fishery of Karnataka

A. P. Dineshbabu[1]*, P. T. Sarada[2] and Jose Josileen[3]
[1]Mangalore Regional Centre of ICAR-Central Marine Fisheries Research Institute, Mangaluru - 575 001, Karnataka
[2]Madras Regional Station of ICAR-Central Marine Fisheries Research Institute, Chennai-600 028, Tamil Nadu
[3]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

*e-mail: dineshbabuap@yahoo.co.in

Abstract

Trends in prawn fishery of Karnataka, especially during 1950-2020 are broadly divided into four phases, namely primary phase (1950-1970) in which fishery was confined with traditional gears and also as phase of introduction of exploratory surveys, ii) growth phase in which trawl fishery dominated and ventured into deeper waters for prawn fishing (1971-1990), iii) enhanced growth phase (1991-2000) with intensification on trawl fishery in terms of fishing capacity as well as introduction of innovative methods and iv) the present stagnation phase (2006-2020). Till 1970 the fishery was dominated by indigenous fishing units, but later the trawlers contributed the majority of prawn catch. 28 species of marine prawns were recorded along the Karnataka coast, among which, *Metapenaeus dobsoni, Parapenaeopsis stylifera, Penaeus indicus, M. monoceros, Solenocera choprai, M. affinis, P. monodon, P. semisulcatus* and *P. merguiensis* were the major contributors. Deep-sea prawn fishery from the coast started from the year 2000 and the major species landed were *Aristeus alcocki* and *Heterocarpus* spp. After a promising start, "red ring" landing showed a diminishing trend in catch as well as in mean size. These reductions influenced the feasibility of the deepsea prawn fishery operations and the fishery came to an end by 2009. Prawns were invariably contributing more than 25% of the total revenue in Karnataka fisheries till 1990, but over the period of time, the contribution of prawn in the fishery revenue of Karnataka reduced substantially. An analysis of the trawl economics carried out based on major trawl fishing harbors of Karnataka showed that in 2000, prawns contributed 23% of the revenue of trawlers, which was reduced to 11% in 2010 and to 6% in 2020.

Keywords: *Prawn fishery, Karnataka, growth phases, estuarine fishery, economic performance*

Introduction

Karnataka with 300 km coast line has 156 fishing villages and 88 fish landing centres in 3 coastal districts namely, Dakshina Kannada, Udupi and Uttara Kannada. There are 12 fishing harbors, 5 in Uttara Kannada and 7 in Dakshina Kannada. The fishermen of the coast are highly progressive in adopting modern fishing technologies and qualitative and quantitative changes, in terms of fleet size, methods of trawling, depth of operation, extend of fishing hours and installation of high speed engines were noted. The depth of operation has been the major change, in the early 1960s it was about to 10 to 20 m and it has been extended up to 500 m. In accordance with the developments in fishing operation, prawn fishery of Karnataka also went through various phases. In terms of trends in fishery operation and production, prawn fisheries of Karnataka can be broadly divided into four phases namely primary phase (1950-1970) in which fishery was confined with traditional gears and also as phase of introduction of exploratory surveys, ii) growth phase in which trawl fishery dominated the prawn landing and were ventured into deeper waters (1971-1990), iii) enhanced growth phase (1991-2000) with intensification on trawl fishery in terms of fishing capacity as well as introduction of innovative methods and iv) the present status is the stagnation phase (2006-2020). The paper is

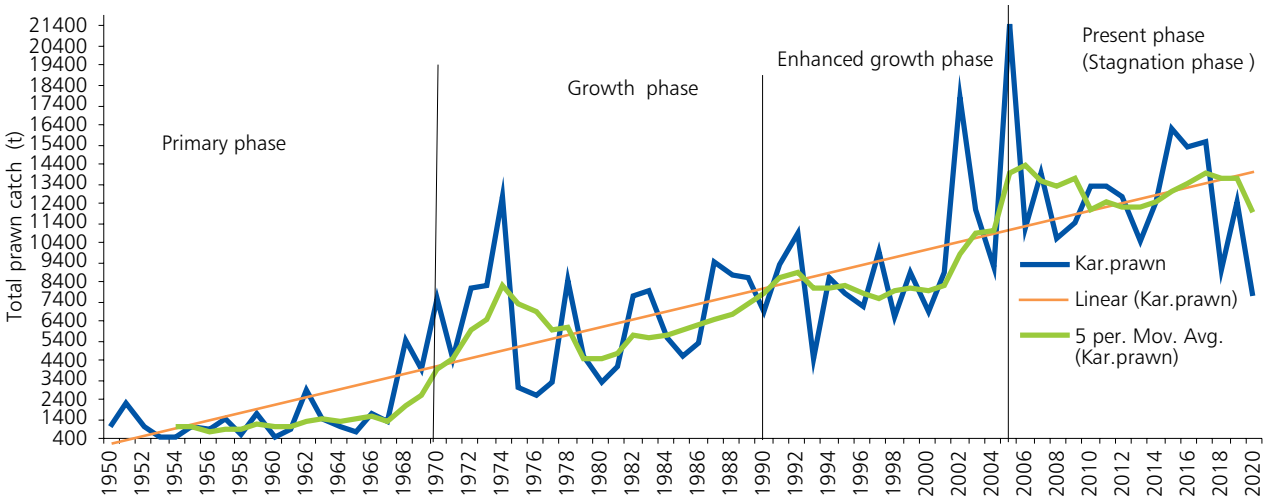

Fig. 1. Different phases Karnataka prawn fishery during 1950-2020 (Source: NMFDC of ICAR-CMFRI, Kochi).

presented based on the observations on the fishery and analysis of fishery data over the period (1950-2020) and also historical data published by earlier workers (Kuthalingam, *et al.,* 1966, Ramamurty and Sukumaran, 1984, Ramamurty, 1972 and Sukumaran, 1982, 1985).

I. Primary phase

Although fishing has been a traditional occupation of the inhabitants on this coastal belt since time immemorial it remained as a traditional activity until the early sixties. Popular gear used by artisanal fishermen include rampan or rampani, small shore seines (Yendi or kairampani), drag nets (Korubalae) cast nets (Beesubale) gillnets and drift nets (Kanthabalae). Mechanized craft include purse seiners, trawlers and gill netters. The important species contributing to the fishery were *Metapenaeus dobsoni, M. affinis, M. monoceros, Parapenaeopsis stylifera, Penaeus indicus* and *P. monodon.* Of these, *M. dobsoni* and *P. stylifera* together contributed to the bulk of the prawn catch (about 85%) and one or the other species was always found to dominate the fishery.

Exploratory Fishing

The first exploratory trawling along the Karnataka coast was conducted by *M. V. Tarpon* during 1962-63 to 1964-65, off Mangalore and Malpe, in 14-54 m depth range. *M. dobsoni* dominated the prawn catch, forming as much as 53.8% followed by *P. stylifera* (26.5%), *M. affinis* (15.7%), *Penaeus* spp. (3.6%) and *M. monoceros* (0.4%). Prawn catches were higher in less than 40 m depths.

Exploratory fishing initiated in 1963 by Indo-Norwegian Project (INP) vessels from Karwar and the Government of India's exploratory fishing vessels (*MFV Tarpon*, *MV Samudra* and *MV Sagarvihari* (all having 42 hp capacity each) also conducted exploratory fishing cruises off

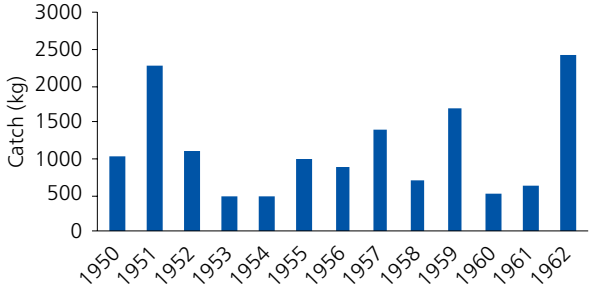

Fig. 2. Prawn catch recorded from Mysore State during early phase of prawn fishery.

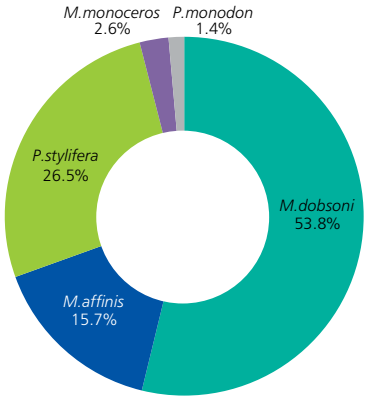

Fig. 3. Species composition of prawns caught from Karnataka during 1959-1970.

Karnataka coast. Catch trends during primary phase of prawn fishery and common species of prawns such as *M. affinis, M. dobsoni, P. stylifera, P. indicus* and *P. merguiensis* were landed during 1959-1970 (Fig. 2 & 3).

Commercial trawl fishery (single day trawling)

The report on the development of mechanised fishing in Mysore published in the Indo-Pacific Fisheries Council (1962) is the first record on the trawl fishery of Karnataka. During the last 50 years history of commercial trawling of Mangalore, gradual changes have occurred especially in the depth of operation, hours of operation per fishing trip and species composition of the landings. In early sixties the depth of operation was up to 10-20 m and during 1967-1970 the depth of operation extended up to 30 m. From 1960s, fishing was augmented with the introduction of mechanized boats (trawlers) and improved gears. In the initial years of trawling boats of 32 feet in length used to conduct single-day trips by leaving for fishing in the early hours of morning and returning by around 2-4 PM. Generally they fish for about 5 hours in the depth range of 10-40m. The first report on the commercial trawler prawn fishery was of Ramamurthy (1972) based on the data collected during 1967-70 from commercial vessels operated from Mangalore. The annual prawn landings varied from 658.7 t in 1969-70 to 1638.7 t in 1968-69 with *M. dobsoni* (37.3-59.0%) dominating the fishery followed by *P. stylifera* (24.3-47.6%), *M. affinis* (13.6-17.2%) and *P. indicus* (0.2-6.9%).

II. Growth phase

Trawl was the major gear operated for capturing prawns from sea. Two categories of bottom trawler units are in operation in Karnataka. The first category consists of small boats (<9.75 m OAL) conducting daily trips. The trawl net has a cod end mesh size of 10-20 mm and catch generally consists of prawns, flatfishes and other finfishes. The second category, comprise of medium sized boats (9.75-15.0 m OAL) are making multi-day fishing cruises. Apart from these ring seines operated along the coast catch good quantity of prawns, especially during monsoon and post monsoon months.

Single-day trawl fishing

Single day trawling (SDT) by fishermen started in 1962 and the fishing effort gradually increased from 27104 boat-days during 1971-72 to 48812 boat-days during 1976-77. The highest catch of 3644.6 t and catch per unit of effort (CPUE) of 120.9 kg were obtained during 1973-74 (Ramamurthy and Sukumaran, 1984). Annual catch trend of prawns from landing centres of Mangalore is given in the fig.4.

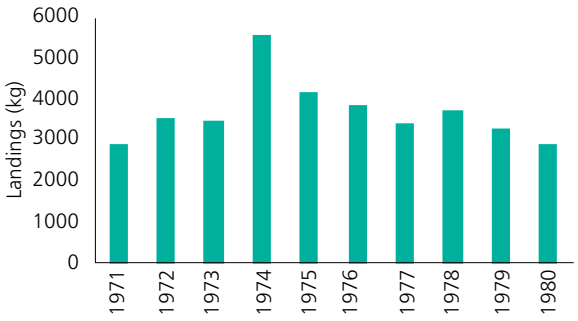

Fig. 4. Prawn landing in Mangalore during 1971-1980

The important species contributing to the fishery were *M. dobsoni* (42.4%), *P. stylifera* (43.4%), *M. monoceros* (5.8%), *P. indicus* (4.6%) and *M. affinis* (3.5%) (Fig.5) Of these, *M. dobsoni* and *P. stylifera* together contributed to the bulk of the prawn catch (about 85%) and one or the other species was always found to dominate the fishery. Prawns like *P. monodon*, *P. merguiensis, Parapenaeus longipes, Trachysalambria curvirostris, M. moyebi* and *P. acclivirostris* were recorded in stray catches.

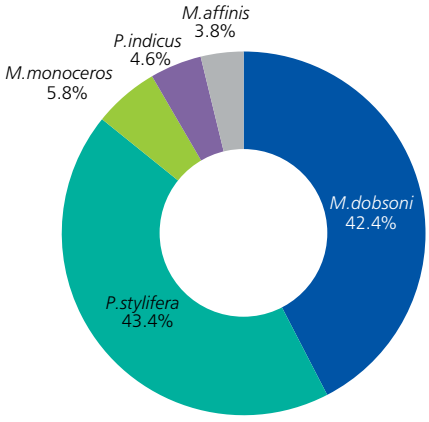

Fig. 5. Species composition of prawns caught from Mangalore during 1971-1980.

Multiday trawl fishing

Multi-day trawl fishing (MDT) in the deeper waters started during the early 1980s with introduction of "night trawling". Initially the fishing trips extended up to three days and the number of stay-over fishing days

gradually increased, due to more profitability of fishing operations in the distant waters by finding new resources in the far off fishing grounds. This led to extend the fishing operations up to 12 days with advancements in the navigational aids and gear materials aiding multi-day trawl fishing for the highly valued prawns.

Night trawling

Exploitation of prawn resources by mechanised trawling has been intensified since the beginning of seventies due to the ever-increasing demand for prawns for export. Even among prawns, there has been greater demand for larger varieties since they fetch very high price. This is prompting more and more entrepreneurs to go in for different types of fishing for catching large sized prawns. Trawl fishing during night time was adopted by trawler owners of Mangalore area and this has been found to yield promising results. Generally, trawlers set out for fishing in the early morning and return by afternoon, sometimes landing even up to 15 or 16 hours. The boats engaged in day fishing are comparatively smaller in size (less than 9.75 m) and usually fish within 25 m depth zone. These units make 1 to 3 hauls per day, each lasting 2-3 hours. Apart from these vessels, there are a good number of larger boats (above 9.75 m) engaged in night fishing, upto a depth zone of 55 m. These units generally set out for fishing in the evening and return after 1-2 days' night fishing. These night units usually make 2 hauls per night, each lasting 4 to 5 hours. In order to keep the prawns and quality fishes in good condition, these boats generally carry 2-3 large ice boxes.

Species composition

The prawn catch in night trawling was composed of larger species, *Metapenaeus monoceros, Penaeus indicus, P. monodon and M. affinis* in the order of their abundance. *P. stylifera* ('karikadi') was the major species of the prawn landings by day trawling. *M. dobsoni* ('poovalan') was the second important species followed by *M. affinis and P. indicus*. *P. monodon*, *Parapenaeus longipes, Trachysalambria curvirostris, Metapenaeus moyebi, Parapenaeopsis acclivirostris, Solenocera crassicornis, Nematopalaemon tenuipes* and *Exhippolysmata ensirostris* also occurred in the catch in stray numbers. Species composition of day trawling and trawling prawn catch from Mangalore during 1983-1990 (Fig.6).

During 1980s, as a result of night trawling, landing of *M. monoceros* an economically important species, increased substantially, (from 53 t in 1981 to 989 t in 1988) with a catch rate of 40 kg/unit during 1987-1988 period. During this period number of fishing hours operated annually ranged between 44,000 to 54,000 fishing hours which was three to four times more, than those operated during 1981 (13,000 hours). As a result of this high fishing pressure, catch per unit reduced from 40 kg in 1988 to 25 kg in 1990, which eventually lead to financial crisis for the trawlers in operation.

III. Enhanced growth phase

To tide over this financial crisis, from 1991 onwards many trawlers extended their operation up to mid shelf region in a depth beyond 70 m which resulted in the landings of non-conventional prawn resources. The trend of prawn landing in trawls in Karnataka during 1991-2005 showed that catch was stagnated during

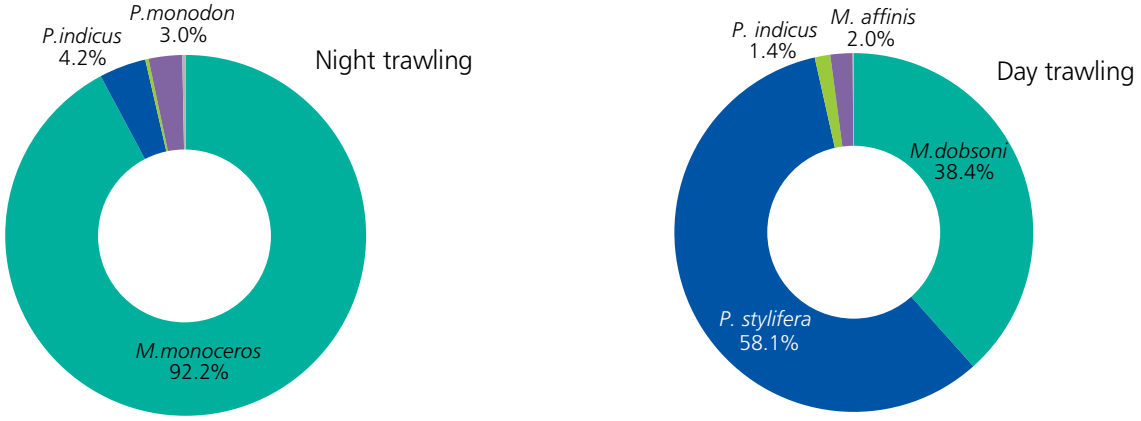

Fig. 6. Species composition in the 'Day' and 'Night' trawlers operated off Mangalore during 1980-1990.

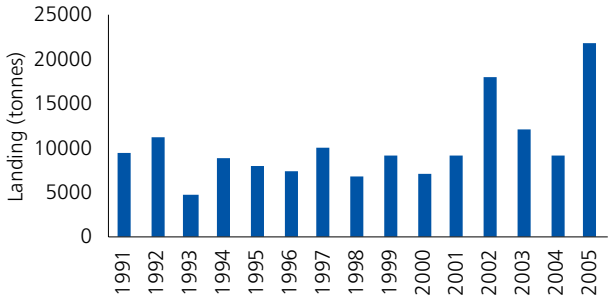

Fig. 7. The trend of prawn landing in Karnataka during 1991-2005

1991 to 2001, but showed improvement later(Fig. 7).

Till early 1990s, *Metapenaeus dobsoni, M. affinis, Parapenaeopsis stylifera, Penaeus indicus, P. monodon* and *P. merguiensis* were the major species landed. During 1991-2015, 11 species of penaeid prawns contributed to the fishery among which *M. monoceros, M. dobsoni, P. stylifera, Solenocera choprai* and *Trachysalambria* spp. were netted in substantial quantities. Other species recorded were *M. affinis, P. indicus, P. monodon, P. canaliculatus, P. semisulcatus* and *Parapenaeus* spp. *M. monoceros* was the most important species as far as the economics of the prawn fishery was concerned. Even though substantial increase was noticed in the penaeid prawn landings during this period, *M. monoceros* did not show corresponding improvement in the catch volumes and even showed a decline later. The increase in prawn landing was mainly due to the economically less important species. In 1998, *M. monoceros* was the most important species contributing 38.1% of the penaeid landings, but by 2000, *S. choprai* became the most dominant species contributing 44.1%. The catch composition during 1991-2005 is given in the Fig. 8. Deep sea trawling operation extending up to 500 m depth commenced during April, 2000 targeted mainly for other prawn species and lobsters using boats made of steel. The other modifications included increasing the warp length sufficient for operation upto 500m, fish hold capacity of about 10 t and engine capacity from 120 to 160 hp with endurance in the sea for 6 to 10 days. Many of them are equipped with GPS and fish finding equipments. The duration of fishing was 6 to 8 days depending on the availability of prawns and other fishes and sometimes operated at depths below 150 m also if the catches from deeper waters were not encouraging. In overall analysis *M. monoceros* formed 31% of the prawn catch during 2001-2015 period, followed by *S. choprai*, *M. dobsoni* and *P. stylifera*.

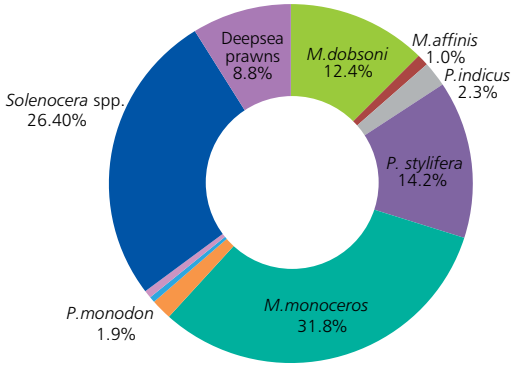

Fig. 8. Species composition of prawns caught from Karnataka during 1991-2005

Rise and fall of deep sea prawn fishery

Deep-sea prawn fishery which started from the year 2000 onwards was dominated by *Heterocarpus* species whereas the feasibility of the fishing operation was determined by "red ring", *Aristeus alcocki.* During 2002-2009, 1,449 t of deep sea prawns were landed by multi-day trawlers and major species landed were *A. alcocki* and *Heterocarpus chani*. After a promising start, "red ring" showed a diminishing trend in catch as well as in mean size which influenced the feasibility of the deepsea prawn fishery operations and the fishery ended by 2009. Decline of fishery after showing an increasing trend of *A. alcocki* and *Heterocarpus* spp. was attributed to the over exploitation of the virgin fishing ground and also to the low reproductive potential of deep sea prawns.

IV. Stagnation phase (present status)

From 2006 onwards prawn catch in Karnataka showed a stagnation, the average catch for the period, 2006-2019 was 12,476 t with highest recorded in 2015 (16,217 t) and the lowest in 2018 (9004 t). However in 2020 the lockdown and pandemic conditions affected fishing operation as a result of which fishing effort reduced considerably and consequently, in 2020 the prawn catch in Karnataka was the lowest recorded for the period (7577 t). The trend of landing in 1991-2020 is given in fig. 9 to illustrate the stagnation on prawn fishery during recent years.

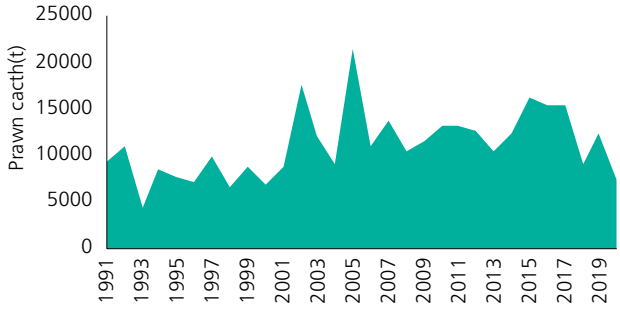

Fig. 9. Prawn landing (t) in Karnataka during 1991- 2020 showing phase of production enhancement (1991-2005) and later the stagnation (2006-2020)

The sharp reduction in catch of *M. monoceros* which was the financial backbone of prawn fishery of Karnataka declined from 3916 t in 2017 to 536 t in 2020 impacting the income from prawn fishery of the State.

Species composition

In overall species analysis of 2016-2020, *P. stylifera* dominated with 25.4% followed by *M. dobsoni* (23.3%) and *M. monoceros* (14.3%). Deep-sea prawn fishery was not attempted during the period and species composition during the period is given in fig. 10.

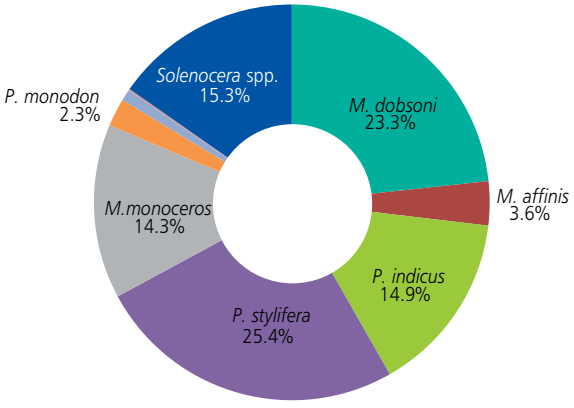

Fig. 10. Species composition of prawns

Monsoon prawn fishery using indigenous gears

Along the Karnataka coast, monsoon fishery has been carried out using ring seines and gillnets operated from canoes fitted by out-board engines. The ring seiners locally known as "matabala" or "ranibala" are a miniature version of purse seine, measuring about 240 m in length and 10-12m in width, with a mesh size of 18 mm which is operated using two canoes fitted with outboard engines. The number of crew vary from 16 to 30 and these units also engage a canoe for transporting part of their catch. Fishing is generally confined to near shore waters within 15 m depth with *M. dobsoni, P. indicus* being the major species landed. This monsoon fishery is highly variable and depending on the weather conditions of the sea.

Prawn landing by other gears

Prawns caught by purse-seine units record good landings during December-January. *M. dobsoni* the major species landed showed annual catch that varied between 19 t (2001) and 34 t (1999). Along Karnataka

Table 1. Marine prawn species landed along Karnataka coast in order of abundance

Rank	Species
1	*Metapenaeus dobsoni*
2	*Parapenaeopsis stylifera*
3	*Penaeus indicus*
4	*Metapenaeus monoceros*
5	*Metapenaeus affinis*
6	*Solenocera choprai*
7	*Penaeus monodon*
8	*Penaeus merguiensis*
9	*Penaeus semisulcatus*
10	*Penaeus japonicus*
11	*Penaeus penicillatus*
12	*Parapenaeopsis acclivirostris*
13	*Aristeus alcocki*
14	*Metapenaeus brevicornis*
15	*Trachysalambria curvirostris*
16	*Penaeus canaliculatus*
17	*Metapenaeopsis stridulans*
18	*Parapenaeopsis maxillipedo*
19	*Hymenopenaeus equalis*
20	*Parapenaeopsis hardwickii*
21	*Parapenaeopsis sculptilis*
22	*Solenocera crassicornis*
23	*Atypopenaeus stenodactylus*
24	*Aristeus semidentatus*
25	*Acetes indicus*
26	*Heterocarpus chani*
27	*Parapenaeus longipes*
28	*Parapenaeus fissuroides indicus*

coast, like other parts of the west coast, operation of mechanized vessels is banned during south west monsoon (June-August), but ring-seine operations allowed from country crafts (canoes) fitted with out-board engines. Fishing generally confined to near shore waters within 15 m depth indicate that as high as 90 to 95% of the prawn catch was constituted by *M. dobsoni* only. Hand trawls and cast-nets are also used by traditional fishermen for capturing prawns. 28 species of marine prawns were recorded along the Karnataka coast, which are listed below, in the order of the species abundance recorded.

Estuarine prawn fishery

Total estimated estuarine area in three coastal districts of Karnataka of is around 7200 hectares. Since estuarine prawn fishery is a not an organized fishery catch data on estuarine fisheries of Karnataka is not available. However, there are number of studies conducted on availability of post larvae, juveniles and adult stages of prawns in Netravati, Gurupur, Gangoli, Sitanadi, Aghanasini, Kali and Sharavati estuaries. Estuaries and backwaters have an important role in the survival of many crustaceans. They provide permanent habitat for many of them and as many others utilize this area as their nursery and breeding ground. 19 species of prawns belonging to 4 families were collected exclusively from the eight estuarine systems in Karnataka during the biodiversity survey conducted during 2006 - 2007 period (Table 2).

Table 2. List of prawn species reported from estuaries of Karnataka

Family	Species
Alpheidae	*Alpheus malabaricus*
	A. paludicola
	A. rapax
Atyidae	*Caridina gracilirostris*
Palaemonidae	*Macrobrachium equidens*
	M. rosenbergii
	M.idae
	M. idella
	M. lamerrei
	M. malcolmsonii
	Leandrites celebensis
Penaeidae	*Metapenaeus dobsoni*
	M. affinis
	M. monoceros
	Penaeus indicus
	P. merguiensis
	P. monodon
	P. canaliculatus
	P. semisulcatus

Prawn fishery economics

Single day trawling (SDT) with limited engine power did not show wide deviations in the operational area and prawn fishery found to influence substantially in SDT operational feasibility. Multiday trawlers (MDT) which were started as a modified version of SDT ventured to night trawling in early eighties (Sukumaran, 1985) was mainly focusing prawn catch beyond 50m depth. By 2000 the trawl fishing was extended to 500m aiming for increasing prawn catch to sustain the feasibility of trawl fishery, but deep sea fishery could not provide anticipated support to profitability of trawling operations thereby by 2006, trawl fishery target was diverted to other fishery resources. Market price is the most important economic driver that influence fishermen's preferences to target specific species modification of gears to catch the new target are derived from the comparative high market demand and better feasibility of operations. Huge differences in appreciation of market prices of finfishes and cephalopods when compared with prawns also become driving force for diversification of trawling from prawns to fishes and cephalopods.

In Karnataka, the influential role of prawn fishery for the ensuring the feasibility of the SDT operations is still prevailing, however due to the reduced economic performance of SDT operations the sector is phasing out gradually. In the case of MDT, which contributes more than 95% of the trawl production, the dependency over prawns is becoming insignificant.

The analysis of prawn landing data also cautions that stock assessment of resources with landing data need a scrutiny since the landing pattern does not necessarily reflect the stock position of the resources. The fishermen's decision to catch them or avoid them is purely depends up on the market demand and economic feasibility of its fishery. Shift in target fishery of deep sea prawns and reduction of *Solenocera* catch after a period of high production are noticeable examples to accentuate this fact. Change in target in Karnataka trawl fishery was evident from the reduction in percentage of prawn in trawl catch and more over the economic performance of prawn fishery was found to be far below to meet the operational cost of trawling.

Till 1990 prawns were invariably contributing more than 25% of the total revenue in trawlers, but over the period of time, the revenue has reduced substantially. An analysis of the trawl economics carried out based on Mangalore-Malpe fisheries harbors (which contribute more than 70% of Karnataka trawl fishery) showed that in 2000, prawns contributed 23% of the revenue of trawlers, that reduced to 11% in 2010 and to 6% in 2020 (Fig. 11). This is not because of reduction in catch of prawns during the period but diversification of trawlers to target other resources like finfishes and cephalopods. Trawl revenue showed multifold increase during 2000-2020 due to diversification in trawling and

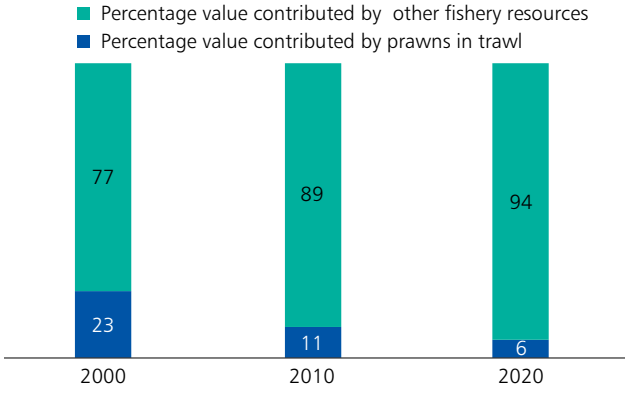

Fig. 11. Percentge contribution of revenue by prawns and other fishery resources in trawl fishery of Karnataka.

the dependency of trawlers on prawns for their revenue has reduced over the period of time.

The economic performance of prawn fishery also analysed in terms of value appreciation of prawns and other fishery resources caught from Karnataka. The economic performance of different groups of prawns and other important fishery resources from Karnataka are given in the table 3. Prawn value in the market is determined by the value in export market. This is highly applicable for the big sized prawns like *P. indicus* and *P. monodon*. The farmed prawns with their competition in the market,

Table. 3. Economic performance of prawn fishery of Karnataka during last 20 years when compared with other resources and diesel price

Group (market terminology)	Price ₹ per kg (1990)	Price ₹ per kg (2020)	Percentage of increase in value
Shrimps (tiny)	40	200	400
Shrimps (medium)	100	350	250
White shrimp	250	450	80
Tiger shrimp	300	550	83
Indian mackerel	30	300	900
White Pomfrets	80	700	775
Cephalopods	30	300	900
Diesel price ₹ per litre	10	80	700

buffered the increase in price of these species and during last 30 years they could not fetch 100% increase in procurement value. In the same time period, because of high domestic demand the value for the small shrimps comprising *M. dobsoni* and *P. stylifera* (called 'tiny' in market terms) achieved 400% increase in the price and the medium sized prawns like *M. monoceros* and *M. affinis* (called 'medium' in market terms) could fetch about 250% increase. In fishermen's perspective high demand for finfishes and cephalopods in the market and their price increase during the same period ranged between 775 to 900%. With trawlers contributing almost 70% of the fish catch in Karnataka, the diesel price is a major influencing factor for the economic feasibility of the fishing operation. While the diesel price showed an increase of 700% in last 30 years with price of diesel (₹ per litre) being 10 and 80 in 1990 and 2020 respectively, a proportional increase in the market prices of prawns was absent. Thus, the focus of target fishing has shifted from prawns, to finfish and cephalopods, along the Karnataka coast.

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Saga of deep sea prawn fishery of Kerala

Rekha Devi Chakraborty[1]*, P. T. Sarada[2], Jose Josileen[1], Kuriakose Somy[1], L. Sreesanth[1], N. Ragesh[1] and Sindhu K. Augustine[1]
[1]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala
[2]Madras Regional Station of ICAR-Central Marine Fisheries Research Institute, Chennai-600 028, Tamil Nadu
*e-mail: rekhadevi7674@gmail.com

Abstract

Deep-sea prawn records from Indian waters date back to early 20th century from the surveys of the RIMS Investigator, University Research Vessel Conch, *M. V. Kalava* and *Varuna* followed by the Indo-Norwegian Project, *FORV Sagar Sampada* off the Southwest Coast of India. The distribution of deep-sea prawns was recorded upto Ratnagiri (lat.16° N) with maximum concentration in the Quilon Bank (lat. 8°- 9°N). The enterprising small and medium prawn trawler operators of Kerala ventured into deep sea fishing for the first time in November 1999 with an annual average estimated landings of deep-sea prawns of 11315 t during 1999-2020 while 9137 t during 2007-2020 from the MDTN at a depth of 200-500 m. The species composition showed the dominance of *M. andamanensis* (27.6%) followed by *A. alcocki* (20%), *P. quasigrandis* (19.9%). *H. chani* (17.6%), *H. woodmasoni* (9.4%). Mitochondrial sequences (COI, 16S, and Cytb) of deep-sea prawn records were deposited in NCBI GenBank for accession numbers.

Introduction

Kerala has 188 marine fish landing centres along the coastline of 590 km length and 1.2 lakh marine fishermen families. The annual average estimated marine fish landings of Kerala accounts to 5 lakh tonnes contributing about 14% of the marine fish production in the country. Pelagic finfish contributed 60%, demersal formed about 25% while crustaceans and molluscs formed about 8% and 7% portions of the total landings, respectively. The contribution by mechanised, motorised and artisanal sectors were 63%, 36% and 1%, respectively and the multiday trawlers accounted for about 42% of the landings in Kerala. The annual average estimated prawn landings was 43611 tonnes during 2007-2020 of which, deepsea prawn catch was 8754 tonnes with the penaeid group at 51% and the rest by non penaeid prawns which were landed by the mechanised multiday trawlers.

Deep sea prawn fishery

The prawn species caught in the trawls operated in the deeper waters of 200-500 m constituted the deep-sea prawns. At the Prawn Symposium of the Indo-Pacific Fisheries Council held at Tokyo in 1955 it was decided that the term prawn should be applied to the Penaeids, Pandalids and Palaemonids, while the use of the term shrimp should be restricted to the smaller forms belonging to other families. According to this most of the forms of economic importance here are to be termed as prawns. The major general distinguishing character between the deep-sea and inshore prawns is the presence of bright red colour in the earlier compared to a muddy colour in the latter. The occurrence of large varieties of prawns beyond the continental shelf of Indian coasts is on record from as early as the beginning of this century. Over 55 species of deep-sea prawns chiefly belonging to the Families Penaeidae, Pandalidae, Pasiphaeidae and Oplophoridae, have been reported from the west-coast, particularly from the southern regions.

Reports of Exploratory Surveys

Earlier studies and records of many species of deep-sea prawns from Indian waters date back to early 20th century mainly from the surveys of the RIMS Investigator. In India, exploratory and experimental deepsea fishing operations with powered vessels were conducted by the Government of India off the Bombay-Saurashtra Coast and by the Government of West Bengal in the Bay of Bengal. The operations are aimed at assessing the suitability of different kinds of fishing vessels, gear and methods for Indian conditions, besides charting fishing grounds in offshore waters and training personnel powered fishing methods.

During the cruises of the University Research Vessel "Conch" off the Kerala Coast (1958-1963) two species of deep water prawns and one species of lobster were collected from depths 100 - 180 fathoms. Of these, *Penaeopsis philippi* is found in large numbers occupying almost continuous bed extending from Anjengo to Mangalore, while *P. rectacuta* has a restricted appearance between Cochin and Calicut. However, the latter species being less abundant than the former and occupying deeper waters having a more or less hard sandy bottom predominantly feeding on foraminifera, crustacean appendages, decapod larvae, Isopod and very rarely diatoms and sand grains. Trawl operations of Research vessels *M. V. Kalava* were conducted off Southwest of Cochin and Varuna off Northwest of Cochin revealed the species composition *viz*., *Solenocera pectinata, Solenocera koelbeli, Solenocera hextii, Hymenopenaeus equalis, Aristeus semidentatus, Aristeus alcocki, Aristaeomorpha woodmasoni, Parapenaeus investigatoris, Parapenaeus longipes, Penaeopsis rectacuta, Metapenaeopsis andamanensis* and *Sicyonia lancifer*. However during 1962-64, cruises of the vessels of the Indo-Norwegian Project, *M. V. Kalava* and *R. V. Varuna* from the waters off the Southwest Coast of India indicated slightly different species composition with *Gennadas propinquus, Gennadas scutatus, Sergestes seminudus, Pasiphaea alcocki, Oplophorus gracilirostris, Acanthephyra sanguinea, Plesionika martia var. semilaevis, Parapandalus spinipes var. Plesionika quasigrandis, Heterocarpus woodmasoni* and *Heterocarpus gibbosus var. chani.* Exploratory fishing using the vessel *R. V. Varuna* conducted by Silas (1969) reported the species as *Aristeus semidentatus, Aristeus alcocki, Aristaeomorpha woodmasoni, Metapenaeopsis andamanensis, Penaeus rectacutus, Hymenopenaeus aequalis, Parapenaeus investigatoris, Solenocera hextii, Heterocarpus gibbosus, Heterocarpus woodmasoni, Parapandalus spinipes, Plesionika martia, Plesionika ensis* and *Oplophorus* sp.

Mohammed & Suseelan (1973) conducted exploratory trawling operation by Indo - Norwegian vessel and the species reported were *Heterocarpus woodmasoni, H. gibbosus, Parapandalus spinipes, Plesionika martia, P. ensis, Metapenaeopsis andamanensis, Penaeopsis rectacuta, Aristeus semidentatus, Parapenaeus investigatoris, Hymenopenaeus aequalis, Solenocera hextii* and *Oplophorus gracilirostris.* However, trawling operations conducted by the same vessels in the Indo-Norwegian Project in 1974 recorded the species as *Heterocarpus woodmasoni, H. gibbosus, Parapandalus spinipes, Plesionika martia* and *P. ensis* (Suseelan, 1974). Exploratory fishing was conducted by the Government of India's exploratory fishing vessels indicated the species as *Plesionika williamsi, P. ensis, P. sindoi, Heterocarpus sibogae, Solenocera melantho, Aristeus semidentatus, Solenocera halli*, *Heterocarpus woodmasoni* (38.5%), *H. gibbosus* (6.4%), *Parapandalus spinipes* (18.6%), *A. alcocki* (9.0%), *Penaeopsis jerryi* (9.9%) and *Metapenaeopsis coniger.*

Exploratory survey conducted by Suseelan *et al.*, (1989) using *FORV Sagar Sampada* (40th and 42nd cruises) undertook a detailed survey of deep-sea crustaceans between Trivandrum and Ponnani. And the composition was found to be *H. woodmasoni* (7-41%), *H. gibbosus* (12-17%), *P. spinipes* (33-52%), *P. martia* (1-2%), *A. alcocki* (3-4%), *S. hextii* (1-2%), *P jerryi* (8-13%) and *M. andamanensis* (1-4%). However, during 1985 to 1988 to study the trawl catches by *FORV Sagar Sampada* during cruises 1 - 50 reported the species *Plesionika spinipes* (60.5%), *Penaeopsis jerryi* (26.3%), *S. hextii* (5.6%), *M. andamanensis*(3.7%), *H. woodmasoni* and *H. gibbosus* (2.7%) in zone 4 and *H. woodmasoni* and *H. gibbosus* (44.1%), *Plesionika spinipes* (35.3%), *Plesionika martia* and *P. ensis*(7.9%), *Penaeopsis jerryi* (5.7%), *Aristeus alcocki* (3.4%) and *M. andamanensis*(2.7%) in zone 5.

An exclusive fishing undertaken by cruise, No. 241, *FORV Sagar Sampada* (Ministry of Earth Sciences) Jayaprakash *et al.*(2006) recorded the available species as *Aristeus alcocki* dominated (85%) followed by other species like *Heterocarpus woodmasoni, H. gibbosus, Hymenopenaeus aequalis* and *Solenocera hextii.* Kurup *et al.*, 2008 reported the availability of 11 deep sea prawn species based on results of exploratory cruises

of *FORV Sagar Sampada* during 1999-2002 at depth ranging from 100 to 750 m between 07^0 and 12^0 N lat. Altogether, 2444 Kg of deepsea prawns were caught off Kerala. The main species included *Parapandalus spinipes, Heterocarpus woodmasoni, H. gibbosus, H. alphonsi, Metapenaeopsis andamanensis, Aristeus alcocki, Plesionika martia, P. ensis, Parapenaeopsis investigatoris, Penaeopsis jerryi* and *Solenocera hextii.* Rao (2009) mentioned the common species as *Heterocarpus woodmasoni, H. gibbosus, Parapandalus spinipes* (*Plesionika spinipes*), *Plesionika martia, P. ensis, Metapenaeopsis anadamanensis, Penaeus rectacuta* and *Aristeus semidentatus (Aristeus alcocki)* based on exploratory vessels *Klaus Sunnana, Tuna, Velameen* and research vessel *Varuna*.

The vessels of Fishery Survey of India based at Cochin and Mangalore conducted surveys for deep-sea prawn resources during 1983-88 along the southwest coast of India. The distribution of deep-sea prawns was recorded upto Ratnagiri (lat.16° N) with maximum concentration in the Quilon Bank (lat. 8°- 9°N) and in the areas between lat. 11° and 12° N. The highest CPH of 36.48 kg was recorded from lat. 11° N in the depth range of 200-500 m, followed by lat. 12°N (21.48 kg). Lat. 8° N and 9° N yielded CPH of 19.59 and 18.09 kg respectively. The highest CPH of 429 kg in a single haul was recorded from the area lat.11° 42' N in the depth range of 250- 270 m followed by 105 kg from 363-368 m depth of lat. 8° N. The data on seasonal abundance of deep sea prawns indicated the most productive season as August-May in lat. 8°-10° N, the peak season being January with a CPH of 28.84 kg. The pattern of seasonal abundance in lat.11°-13° N was also more or less similar, but the highest CPH of 32.44 kg was recorded during November. The standing stock of deep sea prawns along the continental slope of the southwest coast between lat 8° N and 15° N was estimated at 3,054 t with an average stock density of 0.30 t per km^2. The lat. 11° N supports the highest stock density of 0.60 t per km^2 followed by lat.12° N (0.35 t), lat.8° N (0.34 t) and lat. 9° N (0.31 t).

Deep sea prawn - commercial multiday trawl fishery

The enterprising small and medium prawn trawler operators of Kerala ventured into deep sea fishing for the first time in November 1999 defying the long held concept that deep sea prawn resources could be harvested only by means of large trawlers. This endeavour proved successful with the realisation of 25,647 t of deep sea prawns in the first fishing season lasting between November '99 and May 2000 (Nandakumar *et al*., 2001). The catch/hour of trawling was estimated as 53 kg against 6 kg of coastal species obtained for the inshore prawn fishery during the period. In Kerala, deep-sea fishing operations started at Sakthikulangara and recorded enormous quantities of deep-sea prawns locally known as *Pullan Konju* off Kollam, deep-sea prawns were also landed in the fishing harbours at Neendakara, Kochi and Munambam. Initially conventional prawn trawlers with overall length 38-65 feet powered by 100-120 hp engines were engaged in deep - sea fishing operations. A few modifications were done in fishing vessels and gear for deep-sea fishing with existing winches modified by increasing the diameter of the drums and the length of the shaft to accommodate more wire rope. The thickness of the wire rope was increased to 9-11 mm in diameter and each drum could accommodate 1000-1800 m of wire rope. Prawn trawls with cod end mesh size of 25-30mm were used in fishing operation and the length of head rope ranged between 100-120 feet. Some of these prawn trawlers were equipped with GPS (Global Positioning System) and echo sounders. With the help of these hi-tech devices, vessels can locate the productive prawn grounds, depth and its terrain. In the beginning (1999-2000), each fishing trip lasted for 2-3 days which consisted of 6-8 members while the voyage lasted for 5-6 days in the next season. Generally trawling was conducted at depths between 175-400 m. Targeted fishing for the prime prawn species *A. alcocki* (Red ring) was conducted in deeper waters beyond 400m (Rajan *et al*., 2001).

Deep sea prawn fishery in Kerala during 2000-'01 widely differed from the previous season (1999-2000) in catch, effort, catch rate, species composition and biological characteristics of component species. The overall catch in 2000-'01 heavily declined by 15,605 t, over the previous season, the shortfall being 61% (Rajan *et al*., 2001). The catch declined in all the fishing centres and the centrewise decline was 26% at Munambam, 77% at Kochi and 64% at Sakthikulangara-Neendakara. *M. andamanensis* (33.60%) was the dominant constituent of the fishery followed by *H. woodmasoni* (25.46%), *A. alcocki* (15.33%), *H. gibbosus* (14.46%) and *P*. spinipes (9.15%). Other species such as *P. martia, P. jerryi*, *P. investigatoris* and *S. hextii* were caught in small quantities.

Deep sea fishery during 2007-2020

The annual average estimated landings of deep-sea prawns accounted to 11315 t during 1999-2020. Catch trend analysis showed highest landing in the year 2000 and lowest during 2010 with continuous rise and fall in the fishery. The annual average estimated landings of deep-sea prawns accounted to 9137 t during 2007-2020. Catch trend analysis showed highest landing in the year 2018 (17,486 t) and lowest during 2010 (4975 t). The catch analysis showed a declining trend from 2001 onwards and indicated a revival after 2010. However the trend shows a declining state with no much variation in CPUE over the years (Fig.1). Heavy landing in one year affect the landing in the succeeding year/years which indicates the existence of limited stocks in the natural ground. After heavy exploitation in 2003, the fishery took almost 15 years for the fishery to recover to previous levels, but again it started declining.

The species composition showed a big variation in their dominance in comparison with the initial phase (1999-2006). During 2007-2020, species composition showed the dominance of *M. andamanensis* (27.6%) followed by *A. alcocki* (20%), *P. quasigrandis* (19.9%). *H. chani* (17.6%), *H. woodmasoni* (9.4%), *P. semilaevis* (1.23%), *P. jerryi* (0.8%), *S. hextii* (0.07%) in the deep-sea prawn fishery (Fig.2). Catch trend analysis of deepsea prawns revealed increasing annual trend only in *M. andamanensis* and *H. chani* (Fig.3) and the rest indicated declining trend.

Deep sea trawling

Along the Kerala coast there exist two types of deep-sea prawn trawling operations, based on the targeted prawn species group. One of the trawling operations targets the 'red ring' (fishing operation conducted at depths >350 m) and other targets deep-sea prawns which primarily constitutes pandalids (operation conducted at depths between 190 and 350 m). Duration of fishing trips extends up to 6-12 days. The trawlers targeting 'red ring'operate for the entire day while for other deep sea prawns target only during the day time. Number of hauls ranged from 3-5 per day with duration of 4 - 5 hours. Most important deep-sea prawn fishing ground along the Kerala coast is off Kollam area with about 81% of the deep-sea prawn trawlers operating here. The entire fishing fleet engaged in the deep-sea prawn fishery was built of steel and are well equipped with modern fishing devices. The trawlers are ranging in size from 15 to 40 m OAL. Majority of

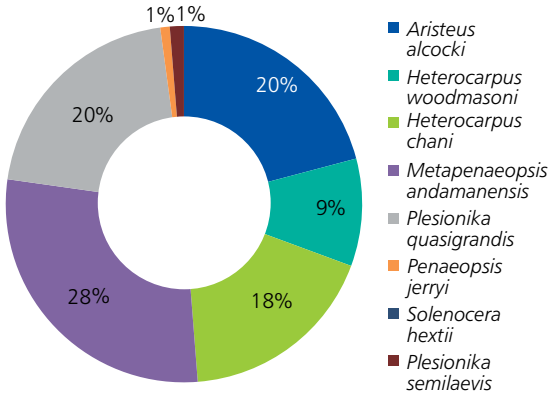

Fig.2. Deep-sea prawn composition of Kerala during the period 2007-2020

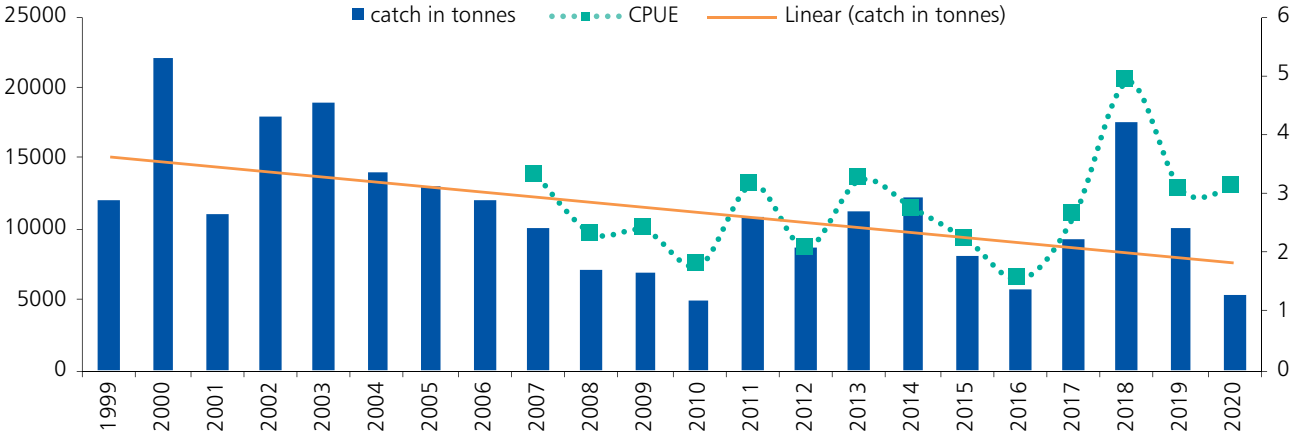

Fig.1. Deep-sea prawn landings along Kerala during the period 1999-2020 and CPUE from 2007-2020

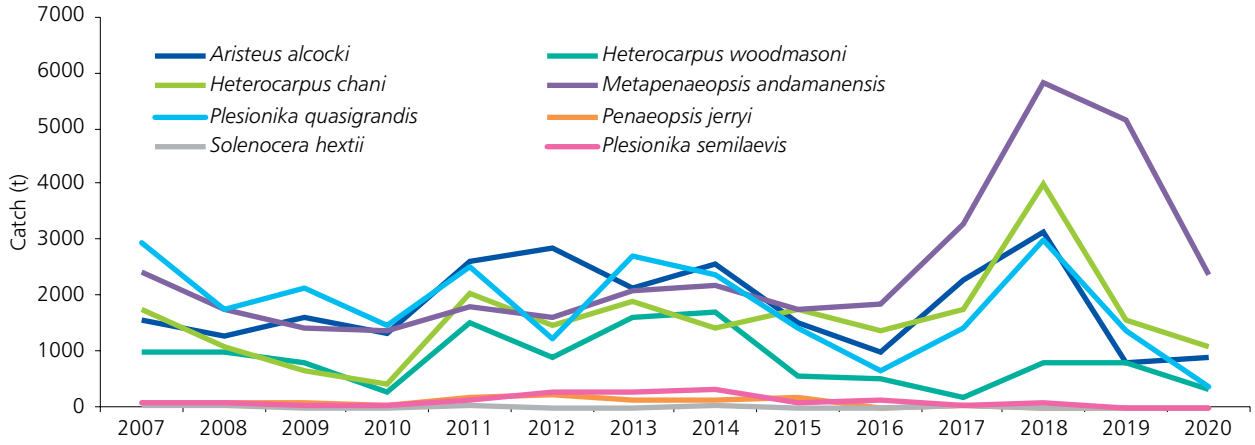

Fig.3. Annual trends in deep-sea prawn composition of Kerala during 2007-2020

the trawlers are powered with high horse power engine (350 - 500 hp) of Chinese made. The trawling speed of Chinese engine was found to be 2-3 nm/hour, it can go upto 3.5-4.5 nm/hour which is twice the speed of normal indigenous engines. The trawlers have yard fabricated winches which were mechanical in nature and length of wire ropes in the winch ranging from 1800 - 2000 meter. Steel wire ropes with 10 mm diameter were used for trawling operations. The head rope and foot rope were made of 14.0 mm diameter made of HDPE (Hi density polyethylene). The head rope's length of net ranged from 32 - 45 meters. Trawlers were equipped with V-shaped steel otterboard, with its average weight of 110-350 kg each. Number of deep-sea prawn trawl nets kept onboard ranged 5-8. The code end mesh size ranges from 25-30 mm. The fish hold capacity of trawlers was ranged from 5-40 t. Trawlers are outfitted with echosounder, GPS, wireless set, mobile phone, television set.

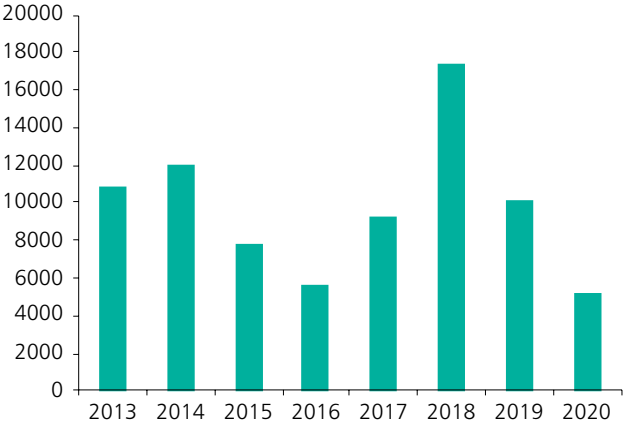

Fig.4. Deepsea prawn catch trends of MDTN, Kerala during 2013-2020

Gear-wise catch of deep sea prawns

The annual average deepsea prawn landings of Kerala constituted to about 9186 tonnes during 2013-2020 with MDTN constituting 98% of the landings followed by MTN. Although the catch trend analysis showed rise and fall over the years during 2013-2020, highest landings were observed in 2018 (Fig.4).

District wise estimated annual average deepsea prawn landings during 2013-2020 from MDTN Kerala, revealed Kollam on top position (86%) followed by Ernakulam (11.2%). Deepsea prawn species percentage composition at Kollam (MDTN)during 2013-2020 revealed the major species composition as *M. andamanensis* (32.4%), *H.chani* (19.8%), *P. quasigrandis* (17.5%), *A. alcocki* (19.6%), *H. woodmasoni* (9.1%), *P. semilaevis* (1.0%) and others (Fig. 5). The annual average catch in tonnes of major deepsea prawn species at Kollam indicated the dominance of *M. andamanensis, H. chani, A. alcocki, P. quasigrandis* and *H. woodmasoni* during 2013-2020.

Biological and taxonomic studies in deepsea prawns

Biology of *H. woodmasoni* and *P. quasigrandis* was studied in detail. The fishery, biology and population parameters of a caridean prawn, *Plesionika quasigrandis* Chace, 1985 from Sakthikulangara Fishing Harbour was studied for the period 2006-2008 (Chakraborty *et al*., 2014). Another commercially important species studied under the caridean group was *Heterocarpus chani* viz.,

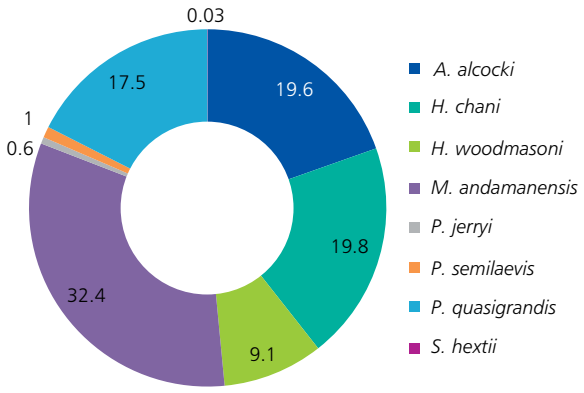

Fig. 5. Deepsea species percentage compostion from Kollam (MDTN) during 2013-2020

Length weight relationship, reproductive biology from southern coast. Apart from this, extensive work on the biology of a deep-sea penaeid prawn, *Aristeus alcocki* viz., Morphological analysis and molecular phylogeny of Aristeus by using mitochondrial genes (COI & 16S), population dynamics, reproductive biology, food & feeding and stock structure analysis by TRUSS morphometry and microsatellite markers (Purushothaman *et al*., 2020 b) was studied in detail. There are 63 COI sequences 55 16S sequences and 29 Cytb sequences of the deep-sea prawn species collected from the southern coast of India and sequence data has been deposited in NCBI GenBank for accession numbers under the DST funded project (SR/FT/LS-73/2012) and 'new records' of deepsea prawns occurring along the coast were published. These included *Plesionika alcocki* (Anderson, 1896) (in 2021); *Metapenaeopsis difficilis* Crosnier, 1991, *Haliporus taprobanensis* Alcock and Anderson, 1899, *Alpheus samudra* De Grave, Krishnan, Kumar K. P. & Christodoulou, 2020 (in 2020); *Glyphocrangon investigatoris* Wood-Mason & Alcock, 1891(in 2019); *Plesionika persica* (Kemp, 1925), *Plesionika reflexa* Chace, 1985, *Acanthephyra fimbriata* Alcock & Anderson, 1894, *Pasiphaea alcocki* (Wood-Mason&Alcock, 1891), *Parapontocaris levigata* (Chace 1984), *Parapontocaris bengalensis* (Wood-Mason & Alcock 1891), *Pontocaris affinis affinis* (Alcock, 1901), *Pontocaris propensalata* Spence Bate, 1888 (in 2018); *Plesionika reflexa* Chace, 1985, *Solenocera barunajaya* Crosnier, 1994, *Solenocera rathbuni* Ramadan, 1938 (in 2017); *Plesionika narval* (Fabricius, 1787), *Heterocarpus chani* Li, 2006 (in 2015); *Glyphocrangon investigatoris* Wood-Mason and Alcock, 1891 (rediscovery), *Sicyonia parajaponica* Crosnier, 2003 (in 2013); *Aristaeopsis edwardsiana* (Johnson,1867), *Plesionika adensameri* (Balss, 1914) (in 2012); *Parapenaeus longipes* (Alcock, 1705), *Pontocaris lacazei* (Gourret, 1887), *Solenocera hextii* Wood-Mason in Wood-Mason & Alcock, 1891 (in 2007); *Pelagopenaeus balboae* (Faxon, 1893), *Funchalia danae* Burkenroad, 1940, *Gennadas praecox* Kemp, 1910, *Gennadas sordidus* Kemp, 1910, *Gennadas scutatus* Bouvier, 1906, *Hymenopenaeus aequalis* (Bate, 1888), *Solenocera hextii* Wood-Mason, 1891, *Sergestes seminudus* Hansen, 1919, *Sergestes semissis* Burkenroad, 1940, *Sergestes orientalis* Hansen, 1919, *Sergia inous* Faxon, 1893 (in 2005); *Parapenaeus fissuroides indicus* Crosnier, 1985 (in 2004).

Conclusion

As the deepsea prawn resource is not showing an increasing trend with intensified fishing practices, judicious exploitation of this resource is needed. Deepsea prawns have longer life span and less fecundity in comparison to inshore prawns and hence the recovery of the resource after heavy fishing pressure is not as fast as in inshore prawn resource. If the present level of exploitation continues, the resource may get over-exploited. The close monitoring and assessing the biology of the dominant species has to be continued diligently in order to sustain the fishery at healthy condition. Minimum Legal Size (MLS) implemented as a part of conservation measures for the marine fishery resources, indicate reduction in growth overfishing in the subsequent years for 2 major deep sea species, *Aristeus alcocki* and *Plesionika quasigrandis* in Kerala.

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Saga of inshore prawn fishery of Kerala

S. Lakshmi Pillai*, P. T. Sarada, Jose Josileen, P. K. Baby, N. Ragesh, L. Sreesanth, T. V. Sathianandan, Somy Kuriakose and Sindhu Augustine
ICAR-Central Marine Fisheries Research Institute, Kochi-682018, India

E-mail:slakshmipillai@rediffmail.com

Abstract

The marine shrimp fishery in Kerala existed even before the advent of the Indo-Norwegian project. (INP), but the genesis of a commercial-scale fishery happened due to the INP. Earlier fished by artisanal crafts and gears, the introduction of trawlers saw the establishment of shrimps as the major marine fishery commodity. The penaeid shrimps *Metapenaeus dobsoni, Parapenaeopsis stylifera, Penaeus indicus, Metapenaeus monoceros* and *Metapenaeus affinis* are prominent in the inshore shrimp fishery of the state. Many developmental changes which happened from time to time in craft and gear technology and the extension of fishing grounds brought considerable changes in the fishing pattern have influenced the inshore shrimp fishery of Kerala which can be classified into five phases – primary, growth, declining, enhanced growth and stagnant.

Introduction

The erstwhile Indo-Norwegian project (INP) in 1953, set in motion a profit oriented prawn fishery in Kerala, bringing remarkable transformation in fishing practices. Prior to this, fishing was by traditional methods, using gears like drift nets and gill nets in small country crafts. Here we discuss the inshore prawn fishery of Kerala for the period 1950-2020 which can be divided into five phases - primary phase (1950-62), growth phase (1963-1973), declining phase (1974-85), enhanced growth phase (1986-2001) and stagnant phase (2002-2020) (Fig.1). Several published works were also referred in the preparation of the article and to cite a few - George *et al.,* 1963; Rao *et al.,* 2013. Kerala has nine coastal districts - Thiruvananthapuram, Kollam, Alapuzha, Ernakulam, Thrissur, Malapuram, Kozhikode, Kannur and Kasargode, with 220 fishing villages (CMFRI, 2016) 21,684 active fishing crafts (3800 mechanised, 13,868 motorised and 4016 non-motorised boats), which contribute to the prawn production of the state.

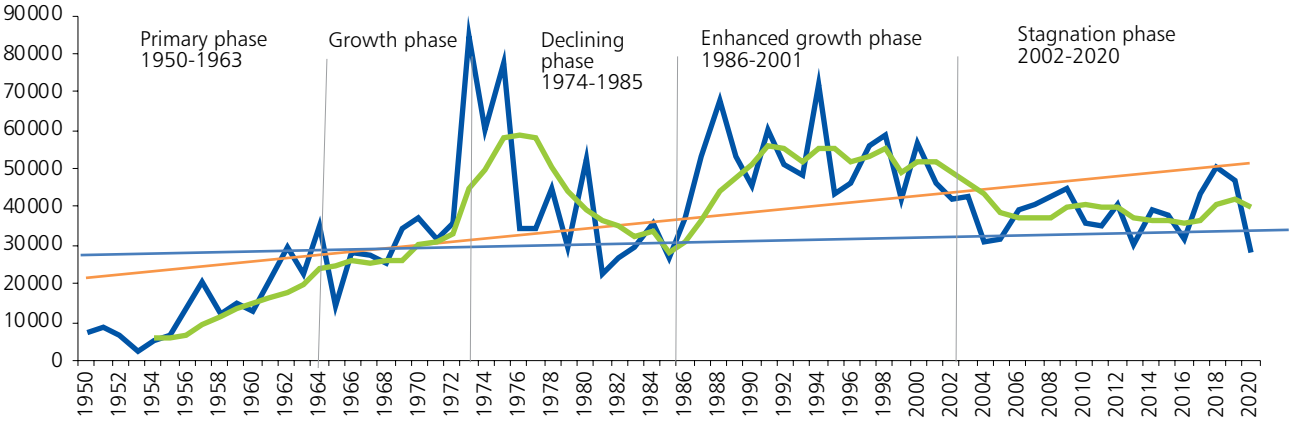

Fig. 1. Different phases of inshore prawn fishery in Kerala during 1950-2020

Primary phase (1950-1963)

Traditional fishing and exploratory fishing

Prior to the advent of the INP, artisanal fishery thrived in Kerala using boat seine, shore seines and gillnets. These gears exploited prawns within a narrow coastal strip of 5 - 20 m depth. The boat seine locally known as *kollivala* or *thanguvala* varied in size from region to region, in Central Kerala it was known as *thanguvala,* having mesh size of 2 cm. Two other boat seines operated were *Vattavala* and *koruvala*. Shore seines locally called *kambavala* was used for catching prawns close to the shore. Along Cochin-Alapuzha coasts, a smaller type of shore seine known as *nonavala* and small drag nets *vadivala* were prevalent. During southwest monsoon season (July to September) cast nets were also used for fishing prawns. Fishing by these gears was vigorous in Cochin especially boat seine, in the late 1950's with peak catches during July to September mainly supported by *Metapenaeus dobsoni* (65-99%). During 1962 catch (96.5%) from traditional vessels declined to an average of 15.5% in 1977-80 and 24.2% during 1980-85. The decline in catch from these gears after 1971-1972 was due to fishing for prawns by single day trawl, mini trawl and ring net.

Exploratory trawling was conducted in the early 1900 along the Malabar coast by SS Margarita in 1908 and off Kannur by Sutherland and Turbinella during 1908-11. In the year 1953, inking an agreement between the Government of Norway and Government of India initiated the Indo Norwegian Project (INP) for the welfare of the fishing community and Neendakara in Kollam District of Kerala was chosen. The project mainly focussed on mechanisation of boats and laying fishing harbours. Three experimental trawler boats (M. O. Christensen, Cochin 65 and Travancore 56) were introduced by the INP in Kochi in 1953. These trawlers located rich prawn ground in the Arabian Sea, outside the Malabar coast which were termed as the richest ground. Between 1957 and 1961 several exploratory surveys were conducted - Asok & Pratap off Cannanore in 1960-61, off Calicut in 1957-58, off Cochin 1957-58, off Alleppey-Quilon 1958-59 and Tarpon & Samudra off Cochin in 1957-58 which started fishing operations with bull trawl, later including other trawls, catching prawns comprising species - *M. dobsoni, Metapenaeus affinis, Parapenaeopsis stylifera, Penaeus indicus, Penaeus monodon, Parapenaeopsis acclivirostris* and *Penaeus semisulcatus*. In the second phase of the project in 1962, boats of 25ft (8-10 HP) was designed for operating prawn trawls for the first time, which landed very high catch of prawns. Later 36 feet stern trawler with 48 HP engine was introduced. The INP vessels *Ashtamudi* and *Norind* reported *M. affinis*, *M. dobsoni*, *P. stylifera* and *P. indicus* from Kannur while exploring depths of 20 m. *Trachypenaeus curvirostris* was reported from 5-10 fathoms off Cochin. *M. monoceros* of 120 mm and *P. indicus* of 150 mm size were captured off Kollam and Kayamkulam during 1961 from 17-22 fathoms pointing towards the need for offshore exploratory survey. Demand for processed prawns from countries like USA and Japan soared, transforming prawns into an export commodity. The INP in 1963, wound up its fishery activities and handed over the extension programs to the Government of Kerala. Thus began mechanisation of crafts with assistance from foreign agencies and later to 1963, most of the developments in craft and gear were carried out by the Kerala State and Central Government organisations.

Growth phase

Single day trawl fishing

Mechanisation took momentum, with prawns becoming much sought after export commodity ensuing in large scale commercial trawling in the inshore waters. Up to 1970 the traditional sector was at the helm after which mechanised vessels took over. Commercial trawling for prawns prevailed during the pre and post monsoon months (January to April and September to December) until 1970. During the southwest monsoon (June to August) due to rough weather, fishing was only by the artisanal crafts and gears but in Cochin and Sakthikulangara, trawling was active during monsoon as these two harbours had developed the infrastructure facilities for the operation of mechanised vessels. The fishery was entirely based on small mechanised vessels 8-13 m powered by 25 to 95 HP engines. The vessels made single day cruises returning in the evening after 3 or 4 hauls, fishing up to a depth of 60 m during the monsoon months and to depth of 25 m rest of the months. The cod end mesh size of the gear was 25 mm. During 1969-71, *P. stylifera*, *M. affinis*, *M. dobsoni* and *P. indicus* formed 57.3% 18.8%, 13.9% and 10.0% respectively. Prawns were available in the catch throughout the year, the best season being July to September with catch rates of 85.17, 96.43 and 115.39 kg respectively. Commercial trawling at major centres - Sakthikulangara-Neendakara, Cochin and Calicut accorded substantially to the landings of inshore prawns in Kerala with 84770 t in 1973 and Neendakara contributing the bulk, with the single species *P. stylifera* caught during

southwest monsoon, providing 80% of the catch, also replacing *M. dobsoni* as the prime species in the prawn landings of the state. Ambalapuzha in the central part of the Kerala coast developed into an important prawn fishing centre during the early 70's, with introduction of mechanised trawlers. The region was also well known for the mud bank formations during the southwest monsoon. Prawn fishery here extended throughout the year, trawling from October to May and from June to September by indigenous gears. Prawn trawls of 18.5 m foot rope length 20 mm cod end mesh and traditional plank built boats operating seine nets (*thanguvala*) were common. Fishery was composed of *M. dobsoni*, *P. stylifera*, *P. indicus* with stray catches of *M. affinis* and *M. monoceros*.

Declining phase

P. stylifera recorded landings above 90% most of the years except during 1973, 1975, 1979 and 1982. During the early 1980's Neendakara was the most important harbour along the Kerala coast landing maximum quantity of prawns by mechanised trawlers and the fishery was exclusively for *P. stylifera*. During June to August of 1973 to 1982, Neendakara-Sakthikulangara recorded maximum prawn landings - 56750 t in 1975 and lowest 9,399 t in 1981. *M. dobsoni, M. monoceros*, *M. affinis* and *P. indicus* were the other species represented in the prawn fishery of the state. The prawn landings in Kerala declined considerably to 26684 t in 1985. Contribution of prawn fishery from Saktikulangara-Neendakara declined from 51% in seventies to 30% in eighties and 24% in nineties due to overfishing with both traditional and mechanised vessels operating in the same grounds and effort in terms of units being added almost every year to meet the demand of prawns in the export market.

Enhanced growth phase

Multiday and night fishing

The phase marked the introduction of night trawling and extension of fishing to deeper waters, leading to multiday trawl operations. Up to mid 1980's, trawling for prawns was confined to the near shore waters. Decline in prawn catch led to fishing at night during the early 1980's which later extended to the day. Trawlers voyaging for 7-9 days with navigational equipments were initiated. New species emerged from night trawling - *Penaeus canaliculatus*, *T. curvirostris*, *Megokris sedili*, *Metapenaeopsis mogiensis* and *Solenocera choprai*. Multiday trawlers ventured into deeper grounds catching *T. curvirostris, P. canaliculatus, S. choprai* in addition to *M. dobsoni*, *P. stylifera*, *P. indicus*, *M. monoceros*, *M. affinis*, *P. semisulcatus* and *P. monodon*. Prawn landings which had diminished during 1981, improved appreciably, peaking in 1994 (71871 t), with an average of 51665 t for the period. The phase besides adding species of prawns to the fishery replaced *P. stylifera* with *M. dobsoni* as the dominant species in the landings.

Stagnant phase

From 2002 prawn landings stagnated at around 35,000 to 40,000 t and in certain years going down beyond 30000 t. Comparatively, 2018 recorded high landings (50472 t) and lowest in 2014 (27463 t), average being 35697 t. Average landings of *M. dobsoni* during 2007 - 2020 was 20042 t with highest in 2018 (26014 t) and *P. stylifera* during the same period was 8410 t with highest landings in 2019 (14106 t). The reason for the stagnant state can be attributed to divergence of fishing for other market driven resources -fish and cephalopod and also perhaps decreased availability of

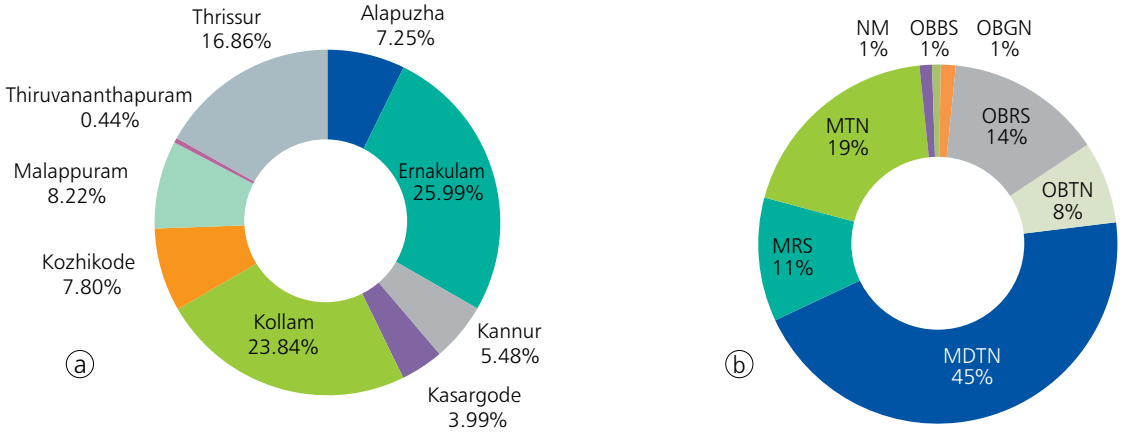

Fig. 2. Inshore prawn catch during 2013-2020 (a). District wise average catch (%) (b). Gear wise average catch (%)

prawn resources. During certain years' reduction in landings observed was due to reduced man-days at sea because of turbulent weather conditions/cyclone/pandemic. During 2013-2020, Ernakulam District recorded the highest catch of inshore prawns (25.99%) followed by Kollam (23.84%) (Fig. 2a). Mutltiday trawlers dominated in landing inshore prawns (45%), single day trawlers contributing 19% and other gears together (36%) (Fig.2b).

Species composition in trawler landings

During 1970 to 1980's, in single day trawlers *P. stylifera* was the dominant species, subsequently multiday trawling relegated *P. stylifera* to the second position, *M. dobsoni* occupying the first spot. But in Neendakara-Sakthikulangara *P. stylifera* continued to be in the prime position followed by *M. dobsoni* and during 1983-86, *T. curvirostris* was second to *P. stylifera.* During 1984-88, *P. indicus*, *M. dobsoni*, *M. monoceros* and *P. stylifera* formed the main components of the fishery. *P. stylifera* dominated (80-98%) during monsoon and *M. dobsoni* during pre-monsoon (45%) and post-monsoon (69.5%). In Kozhikode District, *M. dobsoni*, *P. stylifera* and *P. indicus* formed major fishery during 1978-1983. From 1984 to 1988, *P. stylifera*, *M. dobsoni*, *P. indicus* along with small quantities of *M. affinis* constituted the fishery. *P. stylifera* formed the bulk of the catch (64-79%). Till 1995 *P. stylifera* was the major prawn species in the fishery later replaced by *M. dobsoni*. *M. dobsoni* formed 37% followed by *P. stylifera* 34% and *T. curvirostris* formed a fishery from 2003 onwards, contributing 0.5 to 6.7% during 2003-2006. Other species in the fishery were *M. monoceros*, *M. affinis*, *P. indicus*, *S. choprai*, *P. semisulcatus* and *P. canaliculatus.* During 2007-2020, the average landings of *M. dobsoni* was 20042 t, highest in 2018 (26014) and *P. stylifera* during the same period was 8410 t with highest landings in 2019 (14106 t). *M. dobsoni* continued to dominate the inshore prawn fishery of Kerala during 2002-2020 followed by *P. stylifera*, *M. monoceros* etc. The species composition of inshore prawns from Kollam (Neendakara), Kochi (Munambam, Vypin) and Malabar (Malappuram, Kozhikode, Kannur and Kasargode) are depicted in Fig.3a-c.

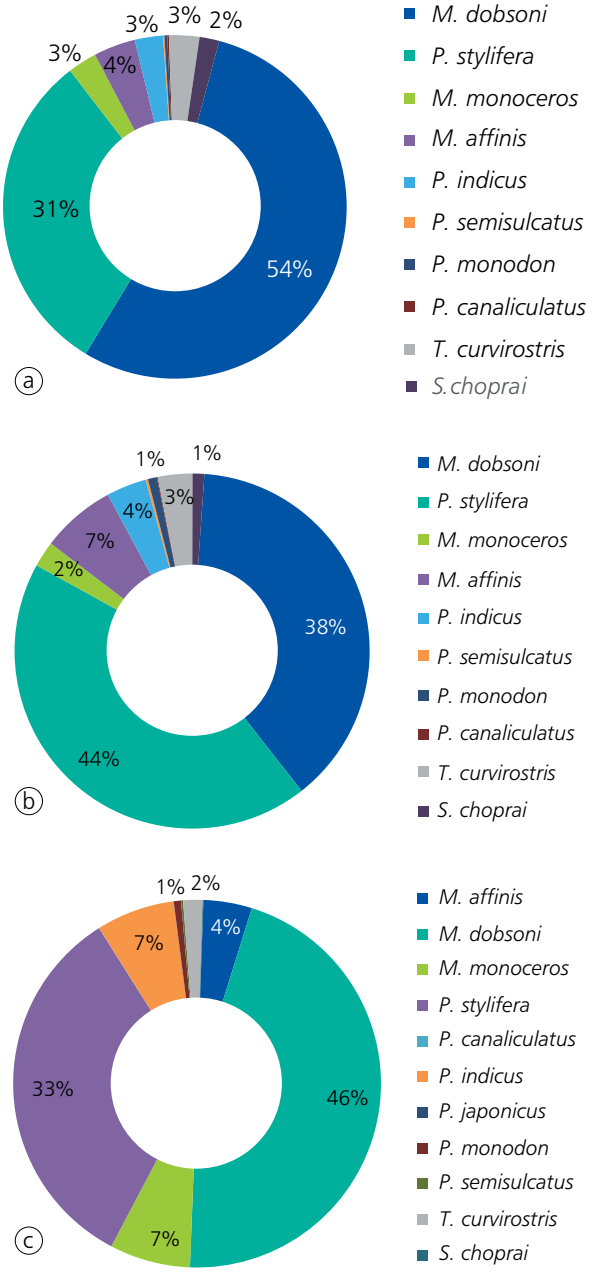

Fig. 3. Species composition of inshore prawns in landings by trawlers at (a) Kochi, (b) Neendakara during 2011-2020 and (c) Malabar during 2015-2020

List of inshore prawn species from Kerala

- *Metapenaeus dobsoni* (Miers, 1878)
- *Metapenaeus affinis* (H. Milne Edwards, 1837)
- *Metapenaeus monoceros* (Fabricius, 1798)
- *Parapenaeopsis stylifera* (H. Milne Edwards, 1837)
- *Parapenaeopsis maxillipedo* Alcock, 1905
- *Parapenaeopsis uncta* Alcock, 1901
- *Penaeus indicus* H. Milne Edwards, 1837
- *Penaeus monodon* Fabricius, 1798
- *Penaeus semisulcatus* De Haan, 1844
- *Penaeus latisulcatas* Kishinouye, 1896
- *Penaeus canaliculatus* (Olivier, 1811)
- *Metapenaeopsis stridulans* (Alcock, 1905)

- *Metapenaeopsis toloensis* Hall, 1962
- *Trachysalambria aspera* (Alcock, 1905)
- *Trachysalambria curvirostris* (Stimpson, 1860)
- *Solenocera crassicornis* (H. Milne Edwards, 1837)
- *Solenocera choprai* Nataraj, 1945 (H. Milne Edwards, 1837)

Mini trawl fishery

Mini trawling was launched first in Alapuzha in 1987 mainly to target inshore prawns and fishermen in other coastal districts of the state too adopted the crafts. Initially made by cutting worn out canoes into two halves, later due to increased demand they were specially constructed. The 9 -10 m long net with 15-20 mm cod end and two small otter boards is employed for fishing within 10 m from the shore at depths of 15-20 m. During 1994-1997 *P. stylifera* was the predominant species (88-94%) in the mini trawlers from Alapuzha. *M. dobsoni, P. indicus* and *M. affinis* were caught in minor quantities. The gear was reported to effect recruitment overfishing of *M. dobsoni* and *P. stylifera*, reflected from the trawl landings of Neendakara-Sakthikulangara and Cochin.

Monsoon fishery

The ban on trawl fishing during southwest monsoon in Kerala commenced in 1988. Prior to the ban, trawl operations were carried out throughout the year with peak fishing operations during the southwest monsoon from June to August/September. During 1984-1988, fishery in the monsoon months was relatively poor in 1984 and 1985 and subsequently increased with the maximum catch (61.7%) in 1987. Mud bank associated with the southwest monsoon is a phenomenon unique to Kerala and usually reported from Purakkad to Thottapally region where boat seines/ring seines are mainly operated. The prawn fishery is composed of *M. dobsoni*, *P. stylifera* and *P. indicus* along with minor quantities of *M. monoceros* and *M. affinis*. Analysis of catch data during 1972 to 1979 revealed the highest catch of 4284 t during 1973 and least in 1979 (29 t) after which it progressively declined.

Estuarine/backwater fishery

Fishery for prawns is prevalent in the backwaters/estuaries of Kerala, where the juveniles of several prawn species spend a phase of their life and later return to the sea for spawning. The gears mostly used are cast net, fixed nets - stake net and Chinese dipnet which are operated throughout the year. The species caught are mostly -

Penaeus indicus H. Milne Edwards, 1837
Penaeus monodon Fabricius, 1798
Penaeus semisulcatus De Haan, 1844
Penaeus canaliculatus (Olivier, 1811)
Penaeus latisulcatus Kishinouye, 1896
Metapenaeus dobsoni (Miers, 1878)
Metapenaeus monoceros (Fabricius, 1798)
Metapenaeus affinis (H. Milne Edwards, 1837)

In the Ashtamudi backwaters (Kollam), during 1980, catch in cast net constituted *P. semisulcatus* and *P. indicus* whereas more species (*P. indicus*, *M. dobsoni, M. monoceros* and *P. semisulcatus*) were recorded in stake net. Studies from stake net fishery in Vembanad during 2018-2019 revealed presence of *M. dobsoni*, *P. indicus*, *M. monoceros*, *M. affinis*, *P. semisulcatus, P. monodon* and *P. canaliculatus.* Developments in the marine fisheries sector of Kerala triggered by the INP in 1953 and a decade later taken over by the central and state government, revolutionised the sector from subsistence to profit driven. Many technological innovations and transformations happened over the years in the sector besides also enduring natural disasters - cyclones, flood and the recent COVID pandemic. The Kerala Marine Fisheries Regulation Act promulgated in 1980, the Kerala Marine Fisheries Regulation rules 2018, the monsoon trawl ban 1988, the MLS (Minimum Legal Size) in 2017, that includes four important species of inshore prawns (*M. dobsoni*, *P. stylifera*, *M.monoceros* and *M. affinis*) are measures the government periodically introduced to sustain marine fisheries of Kerala. In the initial phase of mechanised fishing operations inshore prawns dominated the landings and during the course of modernisation, other fishery resources such as finfishes and cephalopods were tapped. Though *M. dobsoni* was the major species in the primary phase, with advent of single day trawling *P. stylifera* took over. However, in the enhanced growth phase, *M. dobsoni* regained the topmost position and *P. stylifera* was relegated to the second position. Interestingly, *P. stylifera* still enjoys prime place in the inshore prawn landings of Neendakara-Sakthikulangara. In the future, prawn fishery management requires prudent measures to ensure sustainability of the resource as well as the livelihood of fishers.

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Market structure analysis of fish markets in coastal districts of West Bengal

Subal Kumar Roul[1], S. S. Raju[2]*, J. Charles Jeeva[2], Shyam S. Salim[3], Indranil Mukharjee[1] and Phalguni Pattnaik[2]

[1]Digha Regional Station of ICAR-Central Marine Fisheries Research Institute, Ramnagar- 721 441, West Bengal
[2]Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute, Visakhapatnam -530 003, Andhra Pradesh
[3]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

*e-mail: ss.raju@icar.gov.in

West Bengal with three coastal viz., North 24-Parganas, South 24-Parganas and East Medinipur with 49 marine fish landing centres (3.9% of total marine fish landing centers of India), with about 81,067 fishermen families comprising of 3.69 lakh fisher folks (9.5% of the total fisher folk population of India) residing in 171 marine fishing villages (5.7% of the total marine fishing villages of India). Most of the fisher folk (about 70%) are traditional fishermen (Marine Fisheries Census, 2016). A major chunk (about 55,301 families) of the fisher population is socio-economically vulnerable as they are below poverty level and about 81% of the fishermen houses are *Kutcha* houses and 19% are *Pucca* houses. Despite Covid 19 lockdowns and the devastating *Amphan* cyclone, in the year 2020, the estimated marine fish landings was 2.60 lakh tonnes compared to 2.49 lakh tonnes in 2019 (CMFRI-Marine Fish Landings in India, 2020). The coastal districts South 24 Parganas and East Medinipur respectively contributed 49% and 51% of the total marine fish landings, with contribution of pelagic (49%), demersal (32%), crustacean (16%) and molluscan (3%) resources. About 4,014 mechanized crafts and 6,564 motorized and 476 non-motorized crafts are engaged in marine fishing activities in the state (Table 1). The mechanized and motorized sectors contributed 89.7% and 10.1% of the total landings respectively, while the non-motorized sector contributed only 0.2%. Although gill netters form 33% of the total fishing crafts in the state, major portion (about 60%) of the marine resources are landed by trawlers in West Bengal, mainly consisting of anchovies, penaeid shrimps, croakers, Bombay duck, pomfrets and Hilsa.

Fish market structure analysis

The marine fish market structure of West Bengal was studied using pre-tested schedule from the various stakeholders for the year 2021-22. The marine fish

Table 1. Marine fisheries profile of West Bengal coast

Particulars	West Bengal	East Medinipur	South 24 Parganas
Length of the coastline (km)	158	65.5	92.5
Number of landing centres	49	29	20
Number of fishing villages	171	70	84
Number of fishermen families	81067	23149	55138
Total fisher folk population	368816	107582	251111
Total fishing craft	11054	2518	8536
Mechanized fishing crafts	4014	1581	2433
Motorized fishing crafts	6564	481	6083
Non mechanized fishing crafts	476	456	20
Point of first sales (₹ Crores)	4148	2115	2033
Point of last sales (₹ Crores)	5822	2969	2853

* Sources: Department of Fisheries, Government of West Bengal
West Bengal Marine Fisheries Census, 2016, ICAR-CMFRI
Marine Fish Landings in India, 2020, ICAR-CMFRI

marketing operations were performed/controlled by a large number of intermediaries who were well organized locals with good network on fish trade and other facilitating functions. The fish market channels were in operation with the wholesalers buying fish in bulk quantities from auctioneers and selling it to retailers or other traders. The wholesalers imparted value addition in terms of sorting, grading, cleaning, icing and packing fish prior to sale. Subsequently the retailers sold the fish directly to consumers over the counters or with the help of vendors. In several cases, groups of retailers were found participating in the auction process for buying fish directly from the auctioneer.

Under the study, 15 fish markets, seven wholesale cum retail, six retail and two terminal fish markets were surveyed in Coastal districts of West Bengal. The market structure analysis was based on the major dimensions namely, location, type of market, timing, access, arrival and disposal sources, conduct, infrastructure amenities, market union and regulation. The market structure of these markets was analyzed and the details are given in Table 2. The market access indicated that the distance from the landing center to the nearest railway station for these markets are almost 40 m to 28 km and bus station is about 40 m to 12 km. Dumdum airport and Haldia/Shyama Prasad Mookherjee seaport is the nearest airport and seaport to these markets. Due to good connectivity by highway roads and rail, transportation of fishes from one place to another is done in a very short span of time.

The observations on market arrivals and disposals indicated that fish arrive mainly from Digha Mohana, Udaypur,

Table 2. Market structure analysis of major fish markets in West Bengal

Market Dimension	Market (1) Old Digha Nehru Market	Market (2) New Digha Sabuj Market	Market (3) Ramnagar Mecho Bazar	Market (4) Deulihat Bazar	Market (5) Balisai Market
A. Location					
Year of establishment	1986	1996	1970	1973	1979
Type of market	Retail and Wholesale	Retail and Wholesale	Retail and Wholesale	Terminal & Retail	Terminal
Area of the market (acres)	110 Decimal	80 Decimal	40 Decimal	30 Decimal	20 Decimal
Lat/Long position	21°37'22.3464"N, 87°31'26.9796"E	21°37'16.752"N, 87°30'14.454"E	21° 40' 40.764"N, 87° 33' 53.01"E	21°41'07.878"N, 87°29'40.02"E	21°40'39.5436"N, 87°35'30.2208"E
Market control	Market Association	Market Association/ Local Body	Local bodies/ Market Association	Market Association	Local Body (Land owner)
B. Market access					
Nearest landing centre (km)	Digha Mohana 3km	Digha Mohana 4km	Digha Mohana 9km	Digha Mohana 18km	Sankarpur 6km
Nearest railway station (km)	New Digha 2km	New Digha 400m	Ramnagar 300m	Ramnagar 12km	Ramnagar 5km
Nearest bus station (km)	Old Digha 100m	New Digha 100m	Ramnagar 100m	Ramnagar 12km	Balisai 100m
Nearest airport (km)	Dumdum 220km	Dumdum 225km	Dumdum 210km	Dumdum 215km	Dumdum 213km
Nearest seaport (km)	Haldia 90km	Haldia 90km	Haldia 87km	Haldia 90km	Haldia 87km
C. Market timing	6:00 AM-1:00 PM & 4:00PM -9:00 PM	6:00 AM-12:00AM & 4:00PM -10:00 PM	6:00 AM-12:00AM & 4:00PM -9:30 PM	6:00 AM-12:00AM	6:00 AM-12:00AM
D. Market conduct					
Wholesalers	4	2	3	0	7
Retailers	31	38	33	27	65
Middlemen	0	0	0	0	0
Commission agents	2	3	2	0	0
Brokers	0	0	0	0	0

Market Dimension	Market (6) Kathi Nona Bazar	Market (7) Kathi Super Market	Market (8) Mukundapur Bazar (Basantia market)	Market (9) Hirapur Market	Market (10) Gobra Market
A. Location					
Year of establishment	1984	1991	1950	1970	1972
Type of market	Wholesale and Retail	Retail	Retail	Terminal	Terminal
Area of the market (acres)	32 Decimal	25 Decimal	140 Decimal	12 Decimal	10 Decimal
Lat/Long position	21°46'30.9072"N, 87°44'46.2912"E	21°46'41.1924"N, 87°45'06.7748"E	21°48'13.7196"N, 87°48'33.822"E	21°40'21.396"N, 87°32'12.8256"E	21°39'49.9752"N,87°30'51.5088"E
Market control	Market Association/ Commission agents / Local bodies	Market Association / Local bodies	Local bodies/ Market Association	Local bodies	Local bodies/ Market Association
B. Market access					
Nearest landing centre (km)	Purusattampur 8km	Purusattampur 9km	Patuaghat 9km	Digha Mohana 11km	Digha Mohana 10km
Nearest railway station (km)	Kathi 7km	Kathi 6km	Kathi 12km	Ramnagar 4km	Ramnagar 8km
Nearest bus station (km)	Contai 4km	Contai 5km	Contai 12km	Thikra 3km	Fatehpur 5km
Nearest airport (km)	Dumdum 155km	Dumdum 155km	Dumdum 140km	Dumdum 220km	Dumdum 220km
Nearest seaport (km)	Haldia 77km	Haldia 75km	Haldia 72km	Haldia 90km	Haldia 90km
C. Market timing	6:30 AM – 2.00 PM & 4:30 PM – 9:00 PM	6:00 AM – 11.00 AM	6:00 AM – 12.30 PM & 5:00 PM– 9:00 PM	6:00 AM – 12.00 AM	6:00 AM – 12.00 AM
D. Market conduct					
Wholesalers	22	2	0	0	0
Retailers	135	19	39	27	18
Middlemen	0	0	0	0	0
Commission agents	1	0	0	0	0
Brokers	0	0	0	0	0

Market Dimension	Market (11) Raidighi Market	Market (12) Diamond Harbour Market	Market (13) Kakdwip Pal Bazar	Market (14) Namkhana Bazar	Market (15) Freserganj Market
A. Location					
Year of establishment	1975	1975	1972	1977	1980
Type of market	Retail and Wholesale	Retail	Retail and Wholesale	Retail and Wholesale	Retail
Area of the market (acres)	1 acre	33 Decimal	20 Decimal	15 Decimal	10 Decimal
Lat/Long position	21°59'39.4368"N, 88°26'36.384"E	22°11'35.2068"N, 88°11'28.2768"E	21°052'09.966"N, 88°11'07.8"E	21°45'56.2212"N, 88°14'18.2256"E	21°34'56.658"N, 88°15'42.4152"E
Market control	Local Body	Local Body	Local Body	Local Body	Local Body
B. Market access					
Nearest landing centre (km)	Raidighi 100m	Sultanpur fish harbour 4km	Kakdwip Akshynagar 2km	Namkhana 300m	Freserganj 2km
Nearest railway station (km)	Mathurapur 22km	Diamond Harbour 40 m	Kakdwip 3km	Namkhana 1.5km	Namkhana 28km
Nearest bus station (km)	Raidighi 200m	Diamond Harbour 40m	Kakdwip 150m	Namkhana 1km	Jettyghat 200m
Nearest airport (km)	Dumdum 110km	Dumdum 85km	Dumdum 120km	Dumdum 135km	Dumdum 157km

Nearest seaport (km)	Shyama Prasad Mookherjee 75km	Shyama Prasad Mookherjee 60km	Shyama Prasad Mookherjee 100km	Shyama Prasad Mookherjee 115km	Shyama Prasad Mookherjee 135km
C. Market timing	6:00 AM-12:30 PM & 5:00PM -9:00 PM	6:00 AM-12:00AM & 5:00PM -9:00 PM	6:00 AM-12:00AM & 5:00PM -9:00PM	6:00 AM-12:00AM & 5:00PM -9:00PM	6:00 AM-12:00AM & 5:00PM -8:00PM
D. Market conduct					
Wholesalers	15	0	2	12	0
Retailers	55	30	22	26	20
Middlemen	0	0	0	0	0
Commission agents	15	0	0	12	0

Table 3. Market arrivals and disposal of various fish species in selected markets of West Bengal

Market	Arrival	Disposal
Old Digha Nehru Market	Digha Mohana (70%), Talsari (10%), Udaypur (10%) & Odisha (10%)	Old Digha & New Digha
New Digha Sabuj Market	Digha Mohana (65%), Talsari (10%), Udaypur (15%), New Digha (5%) & Odisha (5%)	New Digha
Ramnagar Mecho Bazar	Digha Mohana (65%), Udaypur (10%), Jaldha (5%) & Odisha (20%)	Old Digha, New Digha, Ramnagar, Deulihat, Paniparul, Gobra, Mangalpur, Hirapur & Contai
Deulihat Bazar	Digha Mohan (50%), Talsari (25%), Udaypur (15%) & Others (10%)	Deulihat
Balisai Market	Digha Mohana (45%), Sankarpur (10%), Jaldha (35%) & Chandpur (10%)	Balisai, Ramnagar, Deulihat, Paniparul, Old Digha, Sapuya & Depal
Kanthi Nona Bazar	Digha Mohana (60%), Purusattampur (10%), Junput (10%) & Patuaghat (20%)	Kanthi, Kolkata, Bajkul, Henria, Egra & Marishda
Kanthi Super Market	Digha Mohana (40%), Purusattampur (25%) & Junput (35%)	Kanthi, Ramnagar, Balisahi, Satmile, Junput, Soula, Kanthi Nona Bazar, Pichhabani, Kalindi, Old Digha, New Digha & Majna Tajpur market
Mukundapur (Basantia) Bazar	Digha Mohana (65%), Patuaghat (30%) & Junput (5%)	Mukundapur, Kanthi Super Market & Kanthi Nona Bazar
Hirapur Market	Digha Mohana (70%), Talsari (15%), Udaypur (10%) & Others (5%)	Hirapur
Gobra Market	Digha Mohana (70%) & Udaypur (30%)	Gobra
Raidighi Market	Patharpratima (50%), Maipith (10%), Kultali (10%), Basanti (10%), Gosaba (10%) & Mothurapur (10%)	Kolkata, Sealdaha & Howrah
Diamond Harbour Market.	Freserganj (40%), Namkhana (20%), Kakdwip (20%), Sultanpur (10%) & Sagardeep (10%)	Jaynagar, Magrahat, Falta & Geokhali
Kakdwip Pal Bazar	Kakdwip (50%), Freserganj (40%) & Namkhana (10%)	Gangadharpur, Durbachati, 5 no Hat & Nischintapur
Namkhana Bazar	Namkhana (40%), Freserganj (20%), Sagardeep (20%) & Pathar Pratima (20%)	Howrah, Basirhat, Kolkata & Pathar Pratima
Freserganj Market	Freserganj (70%), Baliyara (20%), Mousuni (5%) & Gangasagar (5%)	Namkhana, Kakdwip & Diamond Harbour

Freserganj and Purusattampur and goes for sale to the Old Digha, New Digha, Kolkata, Howrah and Ramnagar etc. (Table 3).

Around 35-40 marine species were marketed in these 15 selected markets. The most common species/groups traded were anchovies, penaeid shrimp, croakers, Bombay duck, pomfrets and Hilsa. Price discrimination exists for the different fish species. The Kathi Nona Bazar wholesale cum retail market trades to an average of 12.93 tonnes (t) followed by Old Digha Nehru Market (4.47 t), Raidighi Market (4.19 t), Mukundapur (2.99 t), Diga Sabuj (2.67 t) and Ramnagar Mecho Bazar (2.73 t). The average daily market capitalization of the fish trade was found to be ₹13.5 lakhs in wholesale market of Kathi Nona Bazar, ₹5.5, ₹3.6, ₹1.45, ₹2.8 and ₹2.4 lakhs in other retail and wholesale markets respectively (Table 4).

Table 4. Species traded in different fish markets of West Bengal

Name of the Market	Major Marine fish species traded	Quantity traded /day (kg)	Daily market capitalization value (₹)
Old Digha Nehru Market	*Rastrelliger kanagurta, Harpadon nehereus, Pampus griseus, Johnius* spp., *Hilsa kelee, Tenualosa ilisha*	4470	360,000
Digha Sabuj Market (New Digha)	*Johnius* spp., *Parastromateus niger, H. nehereus, P. griseus, T. ilisha*	2665	280,000
Ramnagar Mecho Bazar	*P. niger, R. kanagurta, Coilia dussmieri, Sardinella fimbriata, T. ilisha*	2732	240,000
Deulihat Fish Market	*R. kanagurta, Trichiurus lepturus, H. nehereus, C. dussmieri, Thryssa* spp.	1355	54,000
Balisai Market	*H. nehereus, C. dussmieri, Thryssa* spp., *Stolephorus* spp., *Solenocera crassicornis, S. fimbriata*	1735	260,000
Kathi Nona Bazar	*C. dussmieri, R. kanagurta, H. nehereus, Thryssa* spp., *P. griseus*	12925	1,350,000
Kathi Super Market	*P. niger, R. kanagurta, T. ilisha, P. griseus, C. dussmieri*	1690	130,000
Mukundapur Market	*Thryssa* spp., *S. fimbriata, C. dussmieri, R. kanagurta, Johnius dussumieri, Lepturacanthus savala*	2985	145,000
Hirapur Market	*Sardinella* spp., *R. kanagurta, Trichiurus* spp., *Johnius* spp., *Arius* spp.	965	54,000
Gobra Market	*L. savala, S. fimbriata, Johnius* spp., *C. dussmieri, R. kanagurta*	1255	32,400
Raidighi Market	*T. ilisha, H. nehereus, Johnius* spp., *Ilisha filigera, Anodontostoma chacunda, Escualosa thoracata*	4188	550,000
Diamond Harbour Market	*H. nehereus, P. griseus, P. niger, Plicofollis dussumieri, Johnius* spp.	450	112,500
Kakdwip Pal Bazar	*T. ilisha, C. dussmieri, Johnius* spp., *R. kanagurta, P. griseus*	357	87,500
Namkhana Bazar	*T. ilisha, H. nehereus, C. dussmieri, Ilisha filigera, Setipinna* spp.	447	100,000
Freserganj Market	*T. ilisha, Johnius* spp., *H. nehereus, P. dussumieri, P. griseus, Sillaginopsis panijus*	205	50,000

In conclusion, coastal districts of West Bengal are the major zones where fish markets and trading operations are widely distributed covering different parts of the state and other distribution and consumption destinations. Among these markets Kathi Nona Bazar which is one of the largest wholesales cum retail markets in the zone offers significant marketing functionaries and trade and caters to the fish demand of the nearby towns and cities as well as the neighboring states. However, lack of appropriate infrastructure and adequate amenities and low product diversity act as limiting factors in fish trade in majority of the markets studied. Hence, appropriate government interventions in terms of strengthening infrastructure and imparting value addition may be created to facilitate better functioning of these markets, thereby augmenting revenue and catering to the increase demand for marine fish from nearby states.

Effect of glucose on the enhancement of biomass on microalgae *Nannochloropsis oculata* and *Isochrysis galbana*

Biji Xavier[1]*, Vamsi Balla[1], Chinnibabu Bathina[1], Ritesh Ranjan[1], Sekar Megarajan[1], Narsimhulu Sadhu, Shubhadeep Ghosh[1], Loka Jayasree[1] and Shoji Joseph[2]
[1]Visakhapatnam Regional Centre of ICAR-Central Marine Fisheries Research Institute, Visakhapatnam -530 003, Andhra Pradesh
[2]ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

*e-mail: bijicmfri@gmail.com

Microalgae are primary producers, which can convert light, nutrients and carbon dioxide into energy-rich cell molecules such as lipid, protein and carbohydrate and can be designated as a bio-factory of several high-value functional products, e.g., pigments (carotenoids and phycobiliproteins) and polyunsaturated fatty acids. They can grow under photoautotrophic, heterotrophic and mixotrophic growth conditions. Under natural conditions, phototrophic microalgae rely mostly on sodium bicarbonate and carbon dioxide as potential carbon sources with several reports stating the effects of different carbon sources on the growth and nutrient profile of various microalgae. In this study, glucose (as a carbon source) was used for the culture of two important microalgae namely, *Nannochloropsis oculata* and *Isochrysis galbana* to assess its impact on cell count during the heterotrophic and mixotrophic culture conditions.

Experimental trial was conducted with glucose at various concentrations of 10, 25, 50 and 100mM as the carbon source for *Nannochloropsis* and *Isochrysis* culture. Cultures were maintained with Convey and F/2 medium and light (autotrophic) was used as the control for *Nannochloropsis* and *Isochrysis* culture respectively. Heterotrophic (only carbon source) as well as mixotrophic (light and carbon source) cultures were studied with different glucose concentrations. Algal growth curve was determined by measuring the optical density of the culture at 750nm. The experimental treatments were maintained at optimum culture conditions of salinity, temperature and light intensity (30ppt, 19^0C and 2500 lux respectively).

In the *Nannochloropsis* culture in mixotrophic culture condition, the addition of glucose at various concentrations had the advantage of an overall increase in the cell count during the culture when compared to the control. The lag phase continued for 2 days in the treatment groups 0 and 10 mM and in the groups treated with 25, 50 and100mM glucose, the culture was already in the exponential phase. The *Nannochloropsis* cultured with 25mM glucose was steadily in exponential phase from 3rd day onwards while in the culture with 100mM glucose, the algal cells got into their logarithmic growth phases and reached the maximum cell count on 4^{th} day of inoculation, thereafter in the declining phase and followed by the stationary phase on 6^{th} day (Fig.1).

In the *Nannochloropsis* culture in heterotrophic culture condition, the lag phase continued for 2 days in the 25 and 50mM glucose treatments and only the 50mM group could enter into exponential culture till the 4^{th} day followed by stationary and declined phase. In comparison, in the 100mM glucose treatment group, the culture was in exponential phase on 2nd day itself and was progressing with minimum increase in cell count. The control culture, as well as the 10mM glucose treated culture, could not progress in the heterotrophic condition. However, compared to the mixotrophic culture of *Nannochloropsis*, there was not much improvement in cell count for the culture in heterotrophic conditions.

In the *Isochrysis* culture in mixotrophic culture condition, the addition of glucose at different concentrations had a synergistic effect with all the treated groups showing exponential phase from 2nd day onwards. 100mM treated group performed better with increased cell count with a maximum on the 4^{th} day of the culture. The 50mM glucose treatment also followed the same trend as that

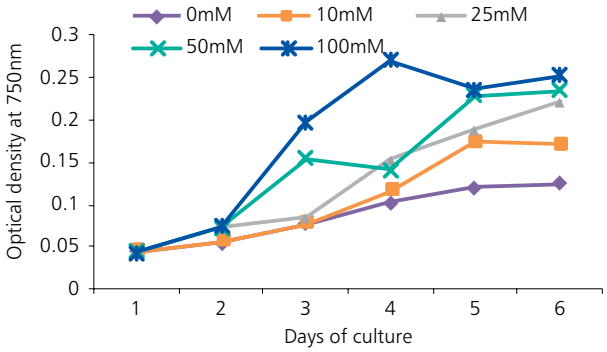

Fig. 1. *Nannochloropsis* culture in mixotrophic condition with different glucose concentration

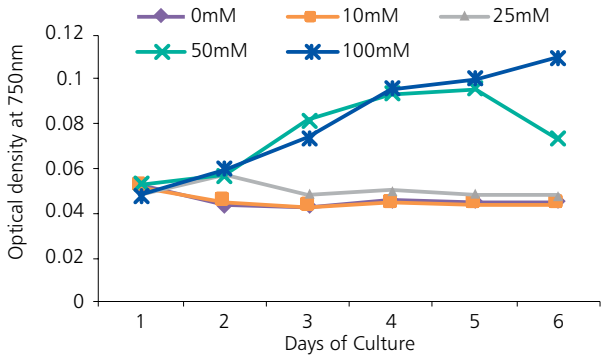

Fig. 2. *Nannochloropsis* culture in heterotrophic conditions with different glucose concentration

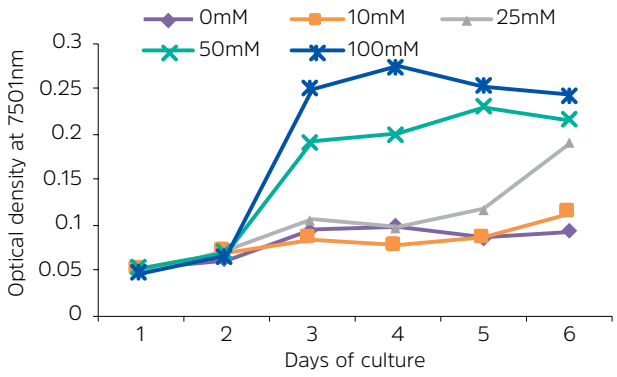

Fig. 3. *Isochrysis* culture in mixotrophic conditions with different glucose concentration

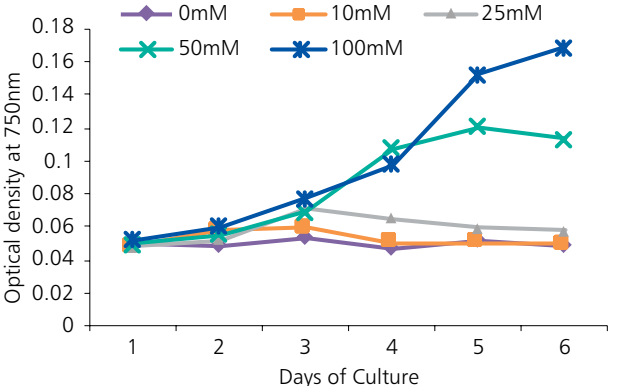

Fig. 4. *Isochrysis* culture in heterotrophic conditions with different glucose concentration

of 100mM, with less cell count. The culture with 25mM glucose exhibited a gradual increase during the culture period of 6 days.

Inclusion of 50mM and 100mM glucose only had an advantageous effect on *Isochrysis* culture during the heterotrophic condition. At 100mM glucose inclusion, the culture was progressing with improved cell count during the culture period (6 days). Whereas in the 50mM glucose treated group, the culture showed a slow increase in cell count compared to the 100mM glucose, with maximum cell count on the 5th day followed by the declining and stationary phase. The rest of the glucose treated groups were in a declining phase from 3rd day of the culture in heterotrophic culture conditions.

Conclusion drawn is that the inclusion of glucose at different concentrations ranging from 0 to 100mM had the advantage on improvement of cell count of both *Nannochloropsis* and *Isochrysis* culture during mixotrophic culture conditions and among the different glucose concentrations, the 100mM inclusion could perform better with improved cell count. There was not much benefit on microalgal culture during heterotrophic conditions over the mixotrophic condition.

Distribution extension of mangrove box jellyfish, *Tripedalia cystophora* along the eastern Arabian Sea

Divya Viswambharan[1]*, Raju Saravanan[2], Prathibha Rohit[1], Smruthu Mohan[1] and Geetha Sasikumar[1]
[1]Mangalore Regional Centre of ICAR-Central Marine Fisheries Research Institute, Mangaluru - 575 001, Karnataka
[2]Mandapam Regional Centre of ICAR-Central Marine Fisheries Research Institute, Mandapam Camp- 623 520, Tamil Nadu
*e-mail: divyaarinu@gmail.com

A regular microplankton sampling in the estuarine stretches of Udyavara in Karnataka, has revealed the presence of *Tripedalia cystophora* Conant, 1897 a cubozoan jellyfish with cube shaped medusa and known for their potent venom. This estuarine stretch of Udyavara is known for the clam fishery and its proximity to the Malpe Fisheries Harbour. The study confirms the occurrence of *Tripedalia cystophora* Conant, 1897 in the estuaries of Karnataka and the northward extension in the distribution of this species along the estuaries of eastern Arabian Sea. Among the 40 species of box jellyfish described around the globe *Tripedalia cystophora* Conant, 1897 is one of the widely distributed small box jellyfish and to the best of our knowledge, no box jellyfishes have been recorded from the estuaries of Karnataka until this report.

Micro-zooplankton sampling was done at 3 sampling sites in Udyavara River on 25th January 2020 with surface water filtered through a 20-micron net at each sampling site. The samples preserved with Lugol's solution were observed under Magnus MS 24 stereo microscope and the micro-zooplankton were classified to major taxonomic groups. The identification of the specimen was based on the morphological character of medusa and nematocyst and measurements like Bell height (BH), Diagonal bell width (DBW) and Inter-rhopalial width (IRW) was measured using vernier callipers. A small part of the tentacle was squashed on a glass slide under a coverslip and examined through a microscope at 400x magnification. The nematocysts were identified using the microphotographs of the nematocysts which were taken using the camera attached to Nikon Eclipse Ci Trino microscope. The environmental parameters assessed from all the sampling sites included Surface Water Temperature (SWT), salinity, pH, measured in-situ using multiparameter probe. Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) was measured following Winkler's titration method and Chlorophyll and measured spectrophotometrically.

The single specimen of *Tripedalia cystophora* Conant, 1897 was small with a BH of 6.07mm, DBW of 7.67mm and IRW of 5.37mm (Fig. 1). The major characters of the medusa used for the identification of *Tripedalia cystophora* Conant, 1897 were the presence of four groups of tentacular pedalia, one at each corner of the bell; three pedalia per group; and each pedalium with one tentacle. Nematocysts from the tentacles were identified based on the shapes of undischarged capsules. Among the three types of nematocysts, *viz.,* heteronemes, round and oval haplonemes observed in tentacles, the quantity of hetronemes was found to dominate over the other two (Fig. 2). Three velarial canals per quadrant was also

Fig. 1. *Tripedalia cystophora* Conant, 1897

Table 1. Environmental parameters of sampling sites of Udyavara River on the day of sampling

Sampling Site	SWT (°C)	pH	Salinity (ppt)	DO (mg/l)	BOD mg/l	Chl a (mg pigment/m^3)
Site 1	28	7.02±0.038	17.3±0.20	3.40±0.01	2.00±0.03	0.13±0.01
Site 2	28	7.559±0.01	26.5±0.10	2.99±0.05	2.02±0.02	0.152±0.02
Site 3*	28	7.92±0.01	31.60±0.01	2.84±0.03	1.89±0.03	0.20±0.01

*Site of occurrence of mangrove box jellyfish

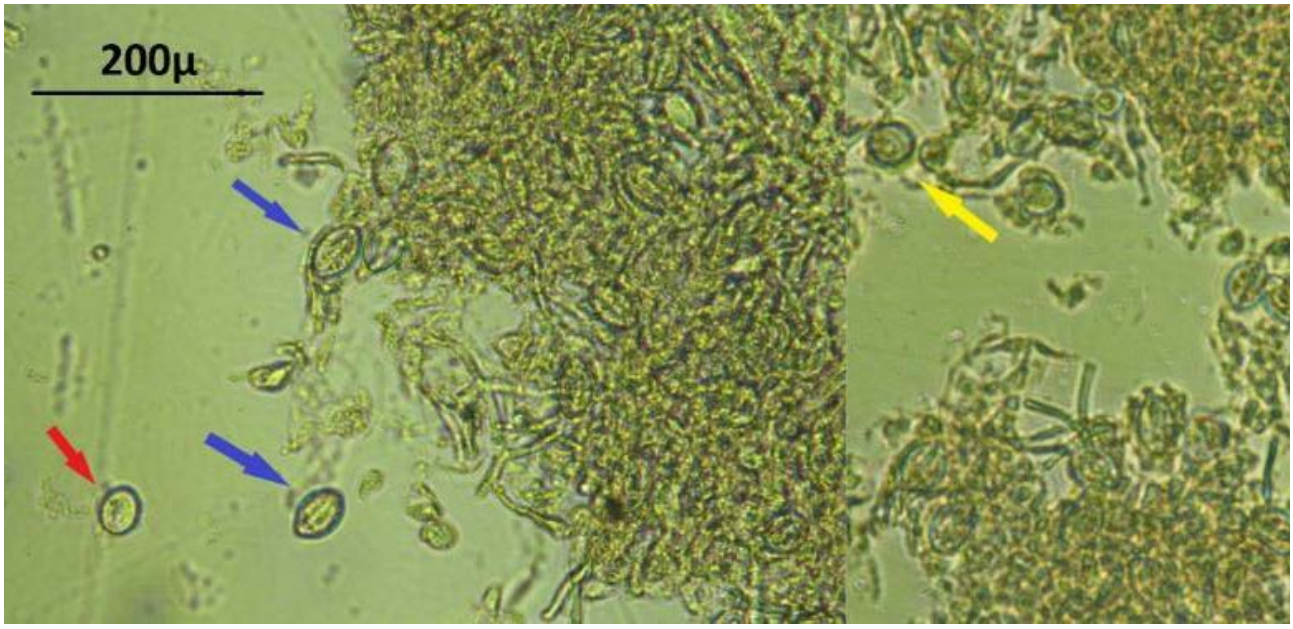

Fig. 2. Different types of nematocysts *ie*, heteronemes (blue arrow), round haplonemes (yellow arrow) and oval haplonemes (red arrow), found in the tentacles of *Tripedalia cystophora* Conant, 1897

observed. Each quadrant of the bell had rhopalial niches. The bell had random cover of nematocyst warts and bands of nematocysts were observed in the tentacles. The manubrium when contracted was cruciform in cross-section. Spermatophores or ovaries were not seen in the current specimens and hence the gender could not be identified. The environmental parameters of the 3 sampling sites indicated except for salinity, no other environmental parameter varied widely between sites.

The micro-zooplankton communities found along with mangrove box jellyfish were ciliates, dinoflagellates and copepod nauplii. The zooplankton assemblages showed a dominance of copepod nauplii (12667 ind. L^{-1}) followed by ciliates (7333 ind. L^{-1}) and dinoflagellates (5667 ind. L^{-1}). Of the 3 described box jellyfish from the Family Tripedaliidae, only 2 species, *T. cystophora* and *T. binate* are reported from India. The species is known to prey upon dense swarms of copepods and the presence of good quantity of copepods in the estuary, might have attracted *T. cystophora* to the site, as these cubozoans rely on the visual clues. Most likely, distributional records of *T. cystophora* based on recorded sightings along the eastern Arabian Sea may be low, as the characteristics of organism such as small size, transparent bell and preference for mangrove habitat make them difficult to spot. Although, many box jellyfishes are known for their poison and cause painful 'Irukandji syndrome', the *Tripedalia cystophora* Conant (1897), is not known to produce any venom harmful for humans. Hence the presence of this species will not have any negative impact on people involved in the clam fishing or for the fishers at Malpe Fisheries Harbour.

Valuation of marine fish landings in India for period 2019-2021

Shyam S. Salim*, R. Narayanakumar, S. S. Raju, P. S. Swathilekshmi, Swatipriyanka Sen , A. R. Anuja, N. R. Athira, P. V. Sunil and Akhila Kumaran
ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

*e-mail: shyam.icar@gmail.com

The present study portrays the trend in the valuation of marine fish landings during the period 2019-2021 based on the price data of the commercially traded fish species which is collected on a weekly/ fortnightly basis through a well-structured schedule MAP (market price). The collected data is tabulated and the average prices are worked out taking into consideration the parameters of seasonality and size ranges. The study throws light on the average price realized and marketing efficiency of major species across the country. The data has been generated/ collected in the shadow of an important underlying event - the covid pandemic which certainly played (and continues to play) an important role in reconfiguring and restructuring the world fisheries sector including for India. A rapid assessment by the ICAR-CMFRI pointed to an estimated revenue loss of ₹10,000 crores for the marine fisheries sector for the 21-day lockdown imposed initially in 2020. However, as the lockdown restrictions eased and activities including fishing activities resumed, in addition to the recovery due to lesser human activities, several adaptation and mitigation measures were adopted by the fishers and other stakeholders portraying the resilience of the sector and this has been reflected in the landings data. During 2021, the estimated value of marine fish landings at various landing centres was ₹53648 crores, (14.24% increase over 2020), in 2020 it was ₹46,962 crores, (22.86% decrease over 2019) and in 2019 it was ₹60,881 crores, (15.66% increase over 2018). The COVID pandemic resulted in reduced fishing efforts and resultant landings during the year 2020. However, the fishing holidays during 2020 resulted in increased landings and resultant valuation increase during 2021. At the retail level, the estimated value during 2021 was ₹76,640 crores (14.06% increase over 2020), ₹67194 crores (-27.24% decrease over 2019) in 2020 and ₹92356 crores (14.98% increase over 2018) in 2019 (Table 1).

The valuation of the marine fish landings at the landing centre (LCV) and retail centre (RCV) across the coastal states (Table 2) indicated that Gujarat registered the highest valuation of marine fish at the LCV and RCV during the period 2019 (20.64%), 2020(19.77) and the third position in 2021(18.90%). Kerala held the first position in LCV (21.70%) during 2021 and hold second during 2020 (16.43%) and 2019 (20.35%). Karnataka holds the second position in LCV during 2021 (19.11%) and retained the third position in LCV throughout the periods of 2020 (11.81%) and 2019(11.69%). The analysis of Retail Centre valuation indicates that Gujarat retained the first position over the period 2021 (21.06%) - 2019 (20.98%) and Kerala registered the second during 2021 (18.66%) - 2019 (18.96%) respectively.

Average Landing Centre and Retail Centre Price realization

The unit price realized at the first point sales and last sales indicate that prices have increased progressively from 2010-2021(Fig.1). The landing centre price (LCP) shows a steady increase from ₹67.67 to ₹176.04 crores (160% increase over 2010) and the retail centre price (RCP) have increased from ₹110.44 to ₹251.49 (128% increase over 2010) respectively. It was found that the landing centre prices realized better growth when compared to retail centres.

Table 1. Percentage changes in the valuation of fish landings - 2019-2021

Parameters	2021	2020	2019
Landing Centre Valuation(LCV)	53648	46,692	60881
(Crores)	(14.24)	(-22.86)	(15.66)
Retail Centre Valuation(RCV)	76640	67194	92356
(Crores)	(14.06)	(-27.24)	(14.98)

Table 2. Valuation of fish landings across states (₹ crores)

	Landing Centre Valuation			Retail Centre Valuation		
State	2021	2020	2019	2021	2020	2019
Andhra Pradesh	2808 (5.23)	2675 (5.49)	3341 (5.70)	4048 (5.28)	4345 (6.47)	5480 (5.93)
Goa	1139 (2.12)	1162 (2.47)	601 (0.99)	1301 (1.70)	1471 (2.19)	874 (0.95)
Gujarat	10138 (18.90)	9285 (19.77)	12568 (20.64)	16138 (21.06)	13159 (19.58)	19379 (20.98)
Karnataka	10253 (19.11)	5547 (11.81)	7118 (11.69)	12685 (16.55)	7171 (10.67)	10030 (10.86)
Kerala	11639 (21.70)	7714 (16.43)	12387 (20.35)	14304 (18.66)	10215 (15.20)	17515 (18.96)
Maharashtra	2625 (4.89)	4164 (8.87)	6402 (10.52)	3317 (4.33)	5428 (8.08)	9835 (10.65)
Odisha	3084 (5.75)	2784 (5.93)	1563 (2.57)	4274 (5.58)	4560 (6.79)	2526 (2.74)
Puducherry	594 (1.11)	786 (1.67)	832 (1.37)	815 (1.06)	1104 (1.64)	1265 (1.37)
Tamil Nadu	7908 (14.74)	7492 (15.95)	10054 (16.51)	15179 (19.81)	12667 (18.85)	16696 (18.08)
West Bengal	2336 (4.35)	4723 (10.06)	4306 (7.07)	2934 (3.83)	6176 (9.19)	6370 (6.90)
Daman Diu	1124 (2.10)	630 (1.34)	1709 (2.81)	1644.6 (2.15)	897 (1.33)	2386 (2.58)
Total	53648	46962	60881	76640	67194	92356

The marine fisheries show seasonal variations to a great extent and the valuation of landings of the major species are given in Table 3. Indian mackerel's contribution to share in landings has increased from 6.13% to 6.98% during 2019-2021. Due to reduced volumes of the landings in 2020, the share in landings of oil sardine, ribbon fishes and non-penaeid prawns came to a low of 4.06% to 3.03%, 6.13% to 5.27% and (5.04% to 3.7%) respectively.

Marketing efficiency, measured as the Fishermen Share of the Consumer's Rupee (FSCR), across the major species of the different coastal states during the year 2019-2021 is indicated in Table 4. The marketing efficiency has improved over the period from 57.15% to 78.44%.

The high-value fishes showed the maximum percentage share of fishermen in the consumer's rupee than the low-value fishes. In general, the high-value species like penaeid prawns(78.62), Black pomfret(78.06), Silver pomfret(77.2), cuttle fish (75.49) and Indian mackerel (73.32) registered higher marketing efficiencies compared to Lizard fish (62.58), Bombay duck (62.16), Crabs(61.92), Soles (60.96) and Oil sardine (58.44) which registered low marketing efficiencies. Several intermediaries and high marketing margins lead to the decline in marketing efficiency of the low-value fishes.

The estimate of the value of marine fish landings during 2021 have got 14.24% increase over 2020 and a 22.86%

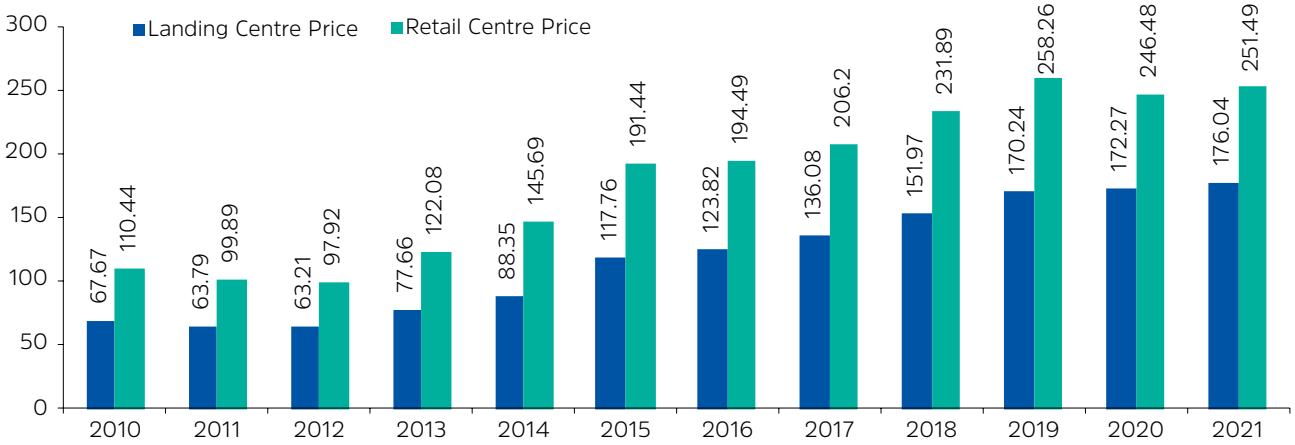

Fig. 1. Unit price at LC and RC levels (₹/kg) 2010-2021

Table 3. Species wise share in Landings (in %)

	2019		2020		2021	
Species	Landings	Share %	Landings	Share %	Landings	Share %
Indian mackerel	166124	4.35	178735	6.56	212593	6.98
Ribbon fishes	219165	6.13	143596	5.27	141299	4.64
Non-penaeid prawns	180103	5.04	100749	3.7	155926	5.12
Penaeid prawns	194650	5.44	156434	5.74	168243	5.52
Threadfin breams	9078	0.25	123059	4.51	145446	4.77
Oil sardine	145292	4.06	82712	3.03	108041	3.37
Other perches	95720	2.08	74232	2.72	88962	2.92

Table 4. Marketing efficiency across states

State	2021	2020	2019	Average
Andhra Pradesh	69.37	61.57	60.97	63.97
Goa	87.55	78.99	68.76	78.44
Gujarat	62.82	70.56	64.85	66.08
Karnataka	80.83	77.35	70.97	76.38
Kerala	81.37	75.52	70.72	75.87
Maharashtra	79.14	76.71	65.09	73.65
Odisha	72.16	61.05	61.88	65.03
Puducherry	72.88	71.20	65.77	69.95
Tamil Nadu	52.10	59.15	60.22	57.15
West Bengal	79.62	76.47	67.60	74.56
Daman Diu	68.34	70.23	71.63	70.07
Total	70.00	69.89	65.92	68.60

increase over 2019. The price of low-value fish was not stable for many reasons resulting in exorbitant fluctuations over the time period. Covid Pandemic is one of the major reasons for these fluctuations and the long-term impact of the pandemic caused disruptions in the supply chain, including major uncertainties in production and marketing. The availability, quality of fish and consumption patterns were severely affected by the pandemic. Some species earned a comparatively lower price due to pandemics and fell into the low category. However, the prices of many of the low-value fishes are likely to go up during the pandemic owing to the widening gap between demand and supply. It is not the quantum of fish landed but the value of the fish landed that is important as it could offer breathing space to the fishermen if they fail to produce(or catch) adequate quantity. But, alterations occurred in the fish landed due to pandemics and because of the demand-supply relationship they fetch a higher price leading to better price realization.

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CMFRI - Annual Report 2020, p. 176-178

CMFRI- Annual Report 2019, p. 249-252

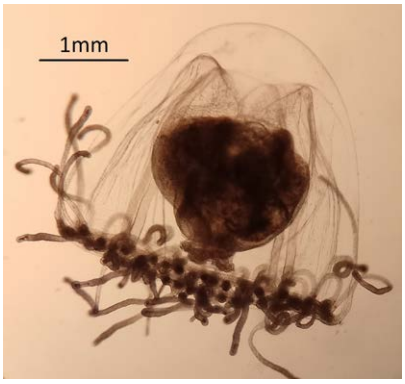
Occurrences of immortal jellyfish *Turritopsis cf. dohrnii* from the Mandapam coastal waters of the Gulf of Mannar

During the routine jelly plankton survey along the Mandapam coastal waters, a swarm of hydrozoans was collected in February 2022. These were identified as the immortal jellyfish *Turritopsis cf. dohrnii.* The hydrozoan jellyfish swarm is the medusa stage of the organism, whereas the larval phase is sedentary and attached to some hard substratum at the bottom. Once a larva metamorphoses into a polyp, it buds off as a jellyfish, causing a bloom.

The term "aging" refers to a persistent decline in the age-specific fitness components of an organism due to internal physiological deterioration, and *T. dohrnii* is successful in reversing that process. When *T. dohrnii* is physically damaged or weak, it shrinks its body and settles into a dormant cyst like cluster that further develops into a new polyp, which asexually propagates during favourable conditions. This life cycle reversal can be repeated many times and is a classic example of reversing the ageing process. Also called transdifferentiation, it is a very rare occurrence in animals.

The immortal jellyfish originally reported from the Caribbean and Mediterranean region but has now spread all over the world, possibly through ship ballast water discharge. The *Turritopsis* jellyfish is considered invasive outside of its native range. In jellyfish, the sexes are separate and free-swimming larva settles at the bottom on a suitable substratum. The newly released medusae have 8–12 tentacles which increase in number with age. Adult medusa can reach up to 2.7 mm in height and 3.2 mm diameter, with 14 and 32 tentacles. The *T. dohrnii* collected in the present study were in the size range of 2-3 mm.

Seven species are found such as *T. dohrnii, T. lata, T. minor, T. nutricula,*



T. pacifica, T. polycirrha and *T. rubra*. In India, *T. nutricula* has been reported from the Vasista Godavary estuary. Morphological identification with molecular barcoding and a phylogenetic approach is crucial in the identification of various *Turritopsis* species.

Reported by R. Saravanan*, S. Thirumalaiselvan, I. Syed Sadiq and M. Sikkandar Batcha | Mandapam Regional Centre of ICAR-Central Marine Fisheries Research Institute

Unusual catch of Mottled fusilier landed in trawlers

During the regular survey of fish landings at Munambam Fisheries Harbour, it was observed on that the trawlers had unusual catches of *Dipterygonotus balteatus* popularly known as Mottled fusilier, on 24th April 2021. The presence of this reef associated fish in the catch is often considered an indicator to the disturbances in the underwater sea which might have occurred or yet to occur as per the fishers. The multiday trawlers had operated Northwest of Munambam Harbour at a depth of 50 to 80 metres. The major commercially important fishes caught along with this included *Saurida* spp, *Nemipterus* spp., *Priacanthus* spp., *Upeneus* spp., *Rastrelliger kanagurta* and the less valued fishes such as *Trachinocephalus myops, Bembrops* spp., *Ariosoma* spp. and *Grammoplites* spp. On an average, about 150 kg of mottled fusilier per boat was landed and sold along with the other miscellaneous fish at a rate of ₹6 per kg. This trend of landings was observed for next few days and slowly subsided.

Reported by M. A. Jishnudev* and Sijo Paul | ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, Kerala

Species specific fishery assessment for Croakers of the northeastern Arabian Sea

Sustainable marine fisheries resource harvest and management depend heavily on the sound scientific investigation of the stock status of the resources on a periodic basis. In the Indian context, given the sheer diversity of fishery resources tapped with numerous craft gear combinations, the task of evaluating the individual management units (or stock) is intrinsically challenging. The complexity increases manifold when several similar looking species of a fishery group are landed together, posing difficulties in enumerating species wise abundance data from the field observations. Croakers with a high α-diversity and overlapping distribution form a significant component of the high value marine fish landings in India. Around a dozen species on the north-west coast of India are contributing significantly to the commercial landings. Since these individual species vary considerably in their life history traits, abundances and distribution pattern, species specific assessment of the resource status is desirable. The trawl fishery of the region has experienced significant 'technology creep' in terms of gear modification as well as species targeted, especially during the last one and half decade. Hence, the species-specific information gaps needed to be identified and addressed scientifically with advisories for sustainable management of croaker fishery.

[1]Rahangdale, S., Zacharia, P. U., Kumar, R. and Vase, V., 2022. Evaluating the stock status of 10 croaker species landed along the north-eastern Arabian Sea using the length-based Bayesian biomass approach. *Frontiers in Marine Science*, 9: 952759. doi: 10.3389/fmars.2022.952795.

The wide continental shelf along the northwest coast is especially abundant with croaker resources and accounts for more than half of the total croaker landings along the entire Indian coast. The several species of croakers landed along the coast can be classified into two broad biological groups, namely larger sciaenids (L_{max} > 100 cm) and smaller sciaenids (L_{max} < 100 cm). The coast has a long history of commercial exploitation of the croaker resources, primarily through the operation of bottom trawls. Recognizing the importance of sustainable management of croakers in the region, a number of species-specific population dynamics and stock assessments were conducted between 1990 and 2000, particularly along the Mumbai coast. Most of the assessed stocks of lesser sciaenids during 1990-2000 were fully exploited or overexploited, warranting a reduction in fishing pressure. Since then, however, there has been a lack of species-specific stock assessments for the group, resulting in a gap in the scientific advisories needed for sustainable management.

The recent catch trends in croaker catches of Gujarat showed a declining trend, especially in the last decade (2012-19) despite the increase in hours spent for fishing by trawlers (a major means to harvest croakers). The observation on time series catch and effort for croakers hinted at possible depletion in resource abundance along the coast. However, a parallel development in the trawling sector with increasing use of pelagic or column trawling could result in a drastic reduction in effective fishing pressure on conventional demersal resources, such as croakers. The changing fisheries dynamics in the region necessitate a reassessment of the croaker fishery in the region.

To understand the implications of such dynamics, specific species stock assessment of lesser sciaenids landed along the Gujarat coast was taken up. As species-wise time series catch and effort data was not available, a length-based, species specific approach to stock assessment was adopted over catch based methods like CMSY and BSM (Froese *et al.*, 2017) in the study. The other factors, like seasonal fishery of some of the species, significant

Table 1. Details of stock status, life history traits, economic importance and management measures of the lesser sciaenid species landed along the Gujarat coast.

Species	Current stock status (Previous status)	Life history characteristics	Any other comments/(management advised, economic importance and any other unique traits)
 *P. semiluctuosa*	UE (NE)	L∞ = 46.4 M/K = 1.52	Prefer shallow depth (< 30 m), used in fish meal, can be utilized for salt drying as landed in good quality, reduce landings of small sized specimens
 *A. alcocki*	UE (NE)	L∞ = 37.2 M/K = 1.76	Deep water species, used in fish meal, poor quality at landings, can be used in salted form if landed fresh
 *O. ruber*	FE (NE)	L∞ = 51.2 M/K = 1.61	Most preferred species among lesser sciaenids, surimi from smaller specimens, exported as silver croaker (whole frozen), maintain current level of fishing pressure
 *O. cuvieri*	FE (OE)	L∞ = 40.4 M/K = 1.52	Domestic trade in salted form, surimi from smaller specimens, exported as silver croaker (whole frozen), maintain current level of fishing pressure
 *J. belangerii*	FE (NE)	L∞ = 28.4 M/K = 1.61	Fish powder & surimi production, maintain current level of fishing pressure

Species	Current stock status (Previous status)	Life history characteristics	Any other comments/(management advised, economic importance and any other unique traits)
 *J. macrorhynus*	FE (FE)	L∞ = 30.1 M/K = 1.42	Fish powder & surimi production, exported as yellow croaker (whole frozen), maintain current level of fishing pressure
 *J. glaucus*	OE (OE)	L∞ = 34.2 M/K = 1.58	Fish powder & surimi production, domestic trade in salted form, exported as yellow croaker (whole frozen), reduction in the fishing pressure recommended
 *J. dussumieri*	FE (OE)	L∞ = 27.6 M/K = 1.90	Fish powder & surimi production, maintain current level of fishing pressure
 *J. borneensis*	FE (FE)	L∞ = 33.4 M/K = 1.57	Fish powder & surimi production, domestic trade in salted form, exported as yellow croaker (whole frozen), maintain current level of fishing pressure
 *P. anea*	FE (FE)	L∞ = 28.0 M/K = 1.57	surimi production, domestic trade in salted form, maintain current level of fishing pressure

UE: Under-exploited, FE: Fully exploited, OE: Over-exploited, NE: Not evaluated

evolution in the trawl fishery (rendering effort data in present form erroneous) and prevalence of COVID-19 during the study period (affecting the conventional month wise data collection) further led to the adoption of Length-Based Bayesian Biomass (LBB) estimation approach (Froese *et al.,* 2018). The length frequency (LF) data was collected over the period 2020-21 from the commercial trawlers only as trawl type selection was assumed in the model. The growth trajectory of the species was assumed following von Bertalanffy's growth curve and ten species of lesser sciaenids namely *Atrobucca alcocki* Talwar, 1980, *Otolithes cuvieri* Trewaves, 1974, *Otolithes ruber* (Bloch & Schneider, 1801), *Pennahia anea* (Bloch, 1793), *Paranibea semiluctuosa* (Cuvier, 1830), *Johnius dussumieri* (Cuvier, 1830), *Johnius belangerii* (Cuvier, 1830), *Johnius macrorhynus* (Lal Mohan, 1976), *Johnius glaucus* (Day, 1876) and *Johnius borneensis* (Bleeker, 1851) having a significant share in commercial catches were assessed in the study. The B/B_0, B/B_{MSY}, F/F_{MSY}, $L_{mean}/L_{opt,}$ $L_C/L_{opt,}$ and L_{95th}/L_{inf} were the outputs of the LBB of which, the B/B_{MSY}, F/F_{MSY} were used to group the resource in different status categories following Palomares *et al.* (2018).

Out of total 10 evaluated croaker stocks, four falls in the green quadrant of the conventional Kobe plot, one in yellow and three in the red quadrant. However, as per the classification of Palomares *et al.* (2018), only *J. glaucus* (red square) falls in the category of being overfished and hence the adoption of management strategies that ensure improvement in stock status is essential for the species. Five species classified as fully exploited requires close monitoring and periodic assessment. Two species namely, *A. alcocki* and *P. semiluctuosa* were found under exploited.

Four species *viz. A. alcocki, P. semiluctuosa, J. belangerii* and *O. ruber* have been assessed for the first time from the region. Former two species were found underutilized as they are not the preferred species for direct human consumption because of their soft texture and black-tinged body. However, in recent times, they are landed in significant amount and consumed as raw materials in fish meal plants. The other two species form seasonal fishery in the region and are preferred species for human consumption, especially *O. ruber* which commands a good price in local markets. Despite the long existence of these resources in commercial fishery, they were not assessed earlier from the region. The current stock status of these two stocks is fully exploited.

Six species which have been earlier assessed from the region (1990-2000) were reassessed to visualize any change in the status during the last two decades. Four species: *J. borneensis, P. anea, J. macrorhynus* and *J. glaucus* were found to retain their previously assessed status. However, two stocks, *J. dussumieri* and *O. cuvieri* have registered improvement in the stock status (Table 1). The improving stock status of the resources reflects a reduction in fishing pressure on this resource, which can be explained by the diversification of the major proportion of trawl effort towards pelagic and column trawling.

Length-based indicators like L_{mean}/L_{opt} and L_{95th}/Linf, estimated by LBB, highlights the truncated length structure if present. The ideal value of these indicators is unity and value lower than 0.90 (threshold value) shows truncated length structure, an unhealthy sign for the fishery. The higher incidence of sub-optimal size individuals was only observed for *P. semiluctuosa.* The sufficient number of larger individuals in the population is known to provide resilience to the fishery, a lack of which is evident in *O. cuvieri, O. ruber* and *J. belangeri*.

Conclusion

Most of the resources were found either fully exploited or under exploited, which is a good sign for the croaker fishery of the region. However, for most of the resources estimated stock indices were close to the centroid of the Kobe plot and hence a higher level of volatility with regard to stock status. Hence, close monitoring and periodic assessments for these resources should be in place. None of the resource showed further depletion from the previous assessment done almost two decades ago, despite an increase in fishing intensity. Rather, two stocks showed improvement in the status, which can be attributed to the release in effective fishing pressure due to diversification of trawl effort. Hence the need for periodic species specific stock assessment approach in the context of highly dynamic fisheries like the above mentioned croaker fishery, is highlighted.

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Indian Council of Agricultural Research
Central Marine Fisheries Research Institute

Post Box No.1603, Ernakulam North P.O., Kochi-682 018, Kerala, India.
Phone: +91 484 2394357, 2394867 Fax: +91 484 2394909
E-mail: director.cmfri@icar.gov.in **www.cmfri.org.in**