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

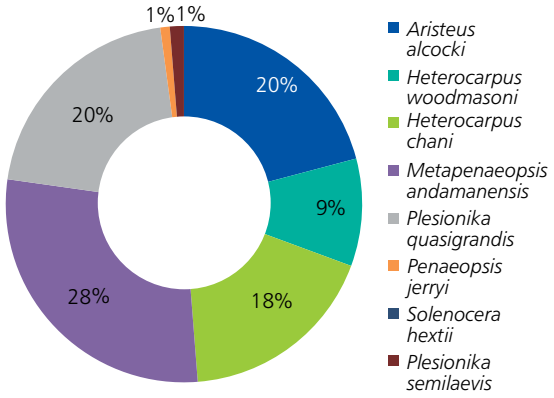

Fig.2. Deep-sea prawn composition of Kerala during the period 2007-2020

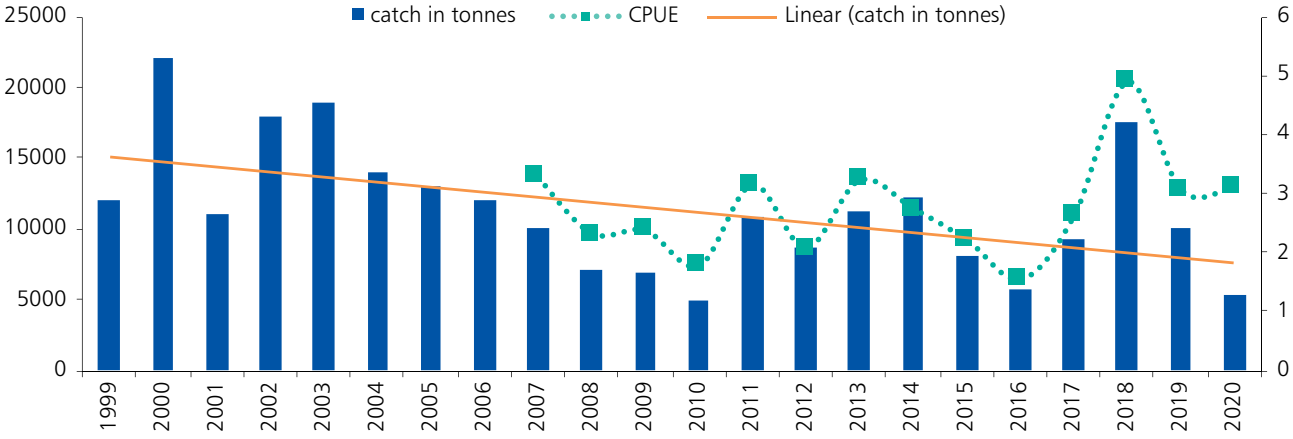

Fig.1. Deep-sea prawn landings along Kerala during the period 1999-2020 and CPUE from 2007-2020

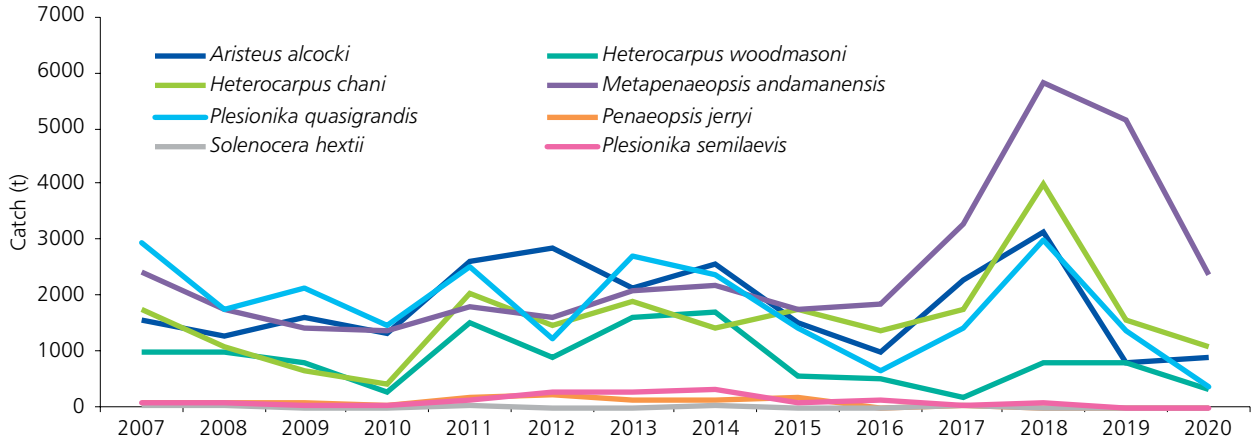

Fig.3. Annual trends in deep-sea prawn composition of Kerala during 2007-2020

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.

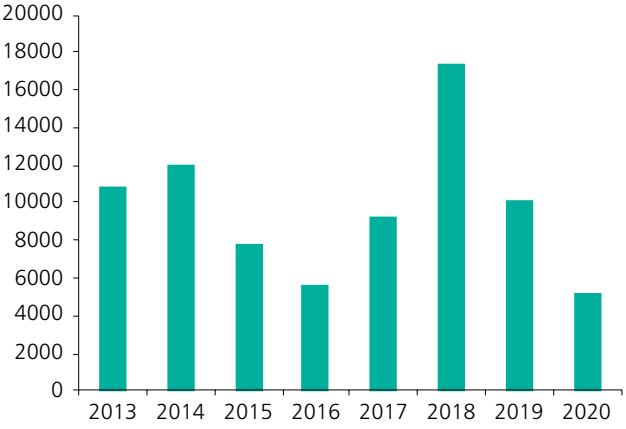

Fig.4. Deepsea prawn catch trends of MDTN, Kerala during 2013-2020

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.,

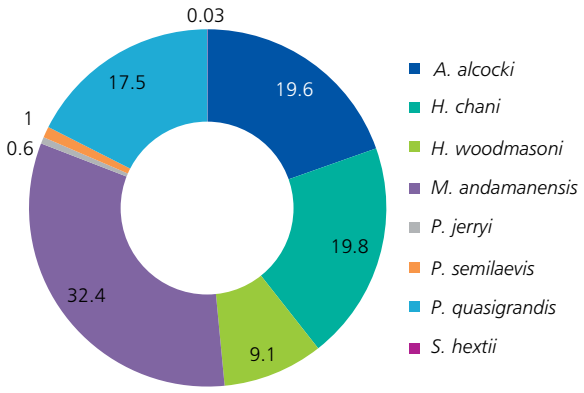

Fig. 5. Deepsea species percentage compostion from Kollam (MDTN) during 2013-2020

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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