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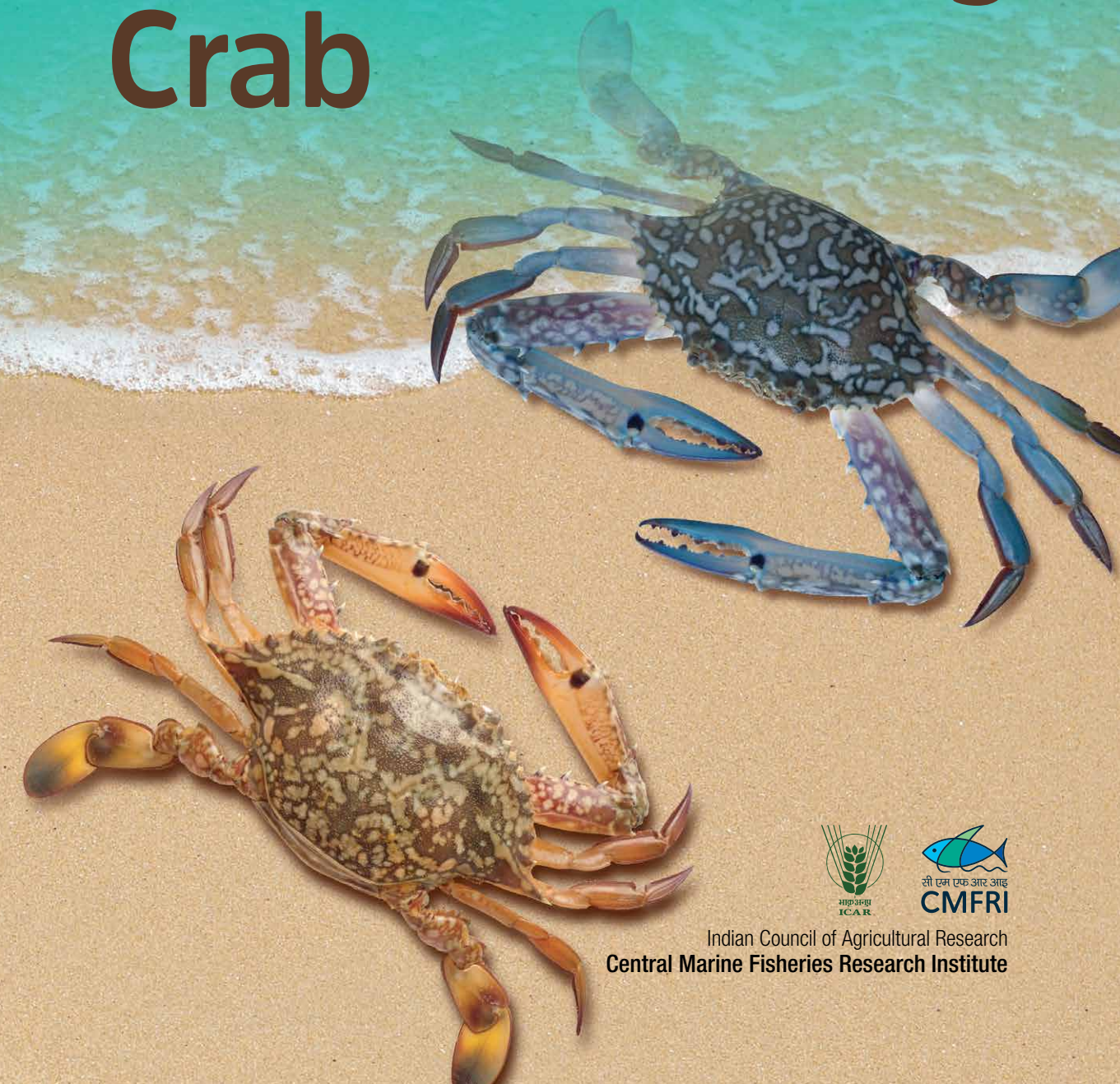
## Fishery Management Plan for

# Palk Bay Blue Swimming Crab



Indian Council of Agricultural Research
**Central Marine Fisheries Research Institute**

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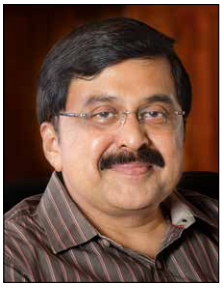


# Foreword

Crabs are widely distributed in Indian seas and form minor fishery at various regions along the east and west coasts. Crabs contribute a share of 11.1 % in total crustacean landings, with an approximate production of 53476 tonnes in 2017. Three portunid crabs, *Portunus pelagicus, Portunus sanguinolentus* and *Charybdis feriatus* form the majority of the regular crab landings in India.

The demand for *Portunus pelagicus*, commonly known as Blue Swimming Crab (BSC) is consistently increasing ever since its export started in the beginning of the century. The State of Tamil Nadu is leading in marine crab landings particularly for the blue swimming crab production in India. The major landing centres for BSC are located in the Palk Bay (PB) and Gulf of Mannar (GoM) areas of Ramanathapuram, Pudukkottai and Thanjavur districts of the state. BSC products form the most important internationally traded commodity from the region and contribute significantly to the livelihood of crab merchants and crab fishers of the area. The Central Marine Fisheries Research Institute has been monitoring the BSC fishery and studying the biology the species along with other marine resources. During the last decade of the 20$^{th}$ century more focused and in-depth studies have been conducted on *Portunus pelagicus* and established the fact that apart from its fisheries importance, BSC is also a suitable candidate species for farming.

This document gives insights on BSC fishing zones, major fishing craft and gears, area wise and centre wise production details, trade, processing industry and export markets. Furthermore, it elucidates the complete life cycle of the species including its growth and reproductive biology as these form essential and integral inputs while formulating the management decisions. As BSC is a highly valuable commodity it necessitates urgent attention to its responsible exploitation and action plan for the judicious management of the resource to accomplish BSC as a sustained fishery. Conclusions have drawn based on the facts and evidences, acquired from exhaustive field and laboratory studies and guidance on a Fishery Management Plan for Palk Bay BSC fishery are presented.

**Dr. A. Gopalakrishnan**
Director, CMFRI

# Contents

# Executive Summary

*Portunus pelagicus*, commonly known as Blue Swimming Crab (BSC) is a highly valuable marine crab in India and bulk of the BSC products are exported to US. The state of Tamil Nadu is the major contributor for the BSC, recording an annual average landing of 8900 tonnes, during 2007-2017. BSC resource is fished continuously from Palk Bay (PB), which is a shallow, confined sea falling between Tamil Nadu and Sri Lanka with a total spread area estimated to be 13,892 sq. km which is equally divided into 6,991 sq.km each between India and Sri Lanka. Crabs are mainly caught as by-catch in bottom trawls and as a target in indigenous bottom-set gillnets known as *Nanduvalai*. Gillnets contribute 70% of the total BSC landings from Palk Bay and rest by the trawl nets. Landed BSC is directly sold to the processing companies under CMPA (Crab Meat Processors Association) and from various centres, freshly steam cooked whole crabs are taken to processing units for final product development for export.

Male and female BSC can be easily differentiated from their colour patterns and the larval phase includes four zoeal stages and a megalopa, which metamorphoses into the crab stage. Males attain sexual maturity by their $12^{th}$ Moult (crab instar-12) at a mean size of 82.25 ± 1.17 mm CW and females by their $14^{th}$ moult (crab instar-14), at a mean size of 120.43 ± 2.23 mm CW. BSC is a continuous breeder, capable of multiple spawnings and spawning usually takes place during night hours. Newly spawned eggs are attached to the pleopods of the mother till hatching and the total days of incubation varied between 8-10 days and fecundity ranged between 60000 and 1976398.

The carapace width-weight relationship in males and females show that there is marked variation from the isometric pattern of growth and which also indicate that in juveniles and pre-adult crabs, weight gain is almost uniform; females are slightly heavier than males until they attain 120-125 mm carapace width. Thereafter males are heavier than females at any given length. Investigations on food habits of BSC in the Palk Bay area revealed that despite the diversity in crab diets and feeding habits, they are opportunistic omnivores with a clear preference for crustaceans in this region. From the growth studies it is assumed that life span of BSC is around three years, although majority of the crabs fished are in the 0- year class. A MLS of 90 mm CW is recommended to prevent growth overfishing.

Results of the Bayesian Schaefer Model (BSM) using 2007-2017 catch and catch rate data indicated that the MSY is 7360 tonnes. Assessment of the fishery clearly

reveals catches are on the declining trend and stock has been overfished. It is also alarming that the berried females indiscriminately exploited without any restriction. It is recommended that to sustain the Blue Swimmer Crab fishery strict management of the fishery is essential and the best possible immediate action is a total ban on landing and sale of berried females. It is estimated that if berried females are not landed in Trawls/gillnets for a month, after a period of five months, an equal quantity of one month's production can be obtained from a trawl centre and 32% of a month's catch can be obtained from a gillnet centre. For the BSC fishery the harvest strategy would be to maintain yields close to the estimated MSY (7360 tonnes) using a catch and effort based harvest control measure (Y/MSY and F/$F_{msy}$) as reference points.

Based on the facts and evidences gathered and proved over by many years systematic studies on BSC, rules and regulations are recommended for the implementation in the Palk Bay region. Initial phase the proposed plan can be implemented in the Palk Bay and later it can be implemented to other main BSC fishing regions also, and these actions would eventually helpful for sustaining the BSC fishery a longstanding.

# Acronyms

| | |
|---|---|
| 'a' | y-intercept or the initial growth coefficient |
| AL | Abdomen Length |
| ANOVA | Analysis of variance |
| AW | Abdomen Width |
| 'b' | the slope or growth coefficient. |
| B | Biomass |
| $B_{msy}$ | Biomass capable of producing MSY |
| BODC | British Oceanographic Data Centre |
| BSC | Blue Swimming Crab |
| BSCFGC | BSC fisheries Governance Council |
| BSM | Bayesian Schaefer Model |
| C-1 | Crab instar-1 |
| CL | Carapace Length |
| CMFRI | Central Marine Fisheries Research Institute |
| CMPA | Crab Meat Processors Association |
| CPD | Chelar Propodus Depth |
| CPH | Catch Per Hour |
| CPL | Chelar Propodus Length |
| CPUE | Catch Per Unit Effort |
| CW | Carapace Width |
| E | Exploitation rate |
| ETP | Endangered Threatened and Protected |
| F | Total instantaneous fishing mortality coefficient |
| FIMSUL | Fisheries Management for Sustainable Livelihoods |
| Fmsy | Rate of fishing mortality compatible with MSY |
| FRAD | Fisheries Resources Assessment Division of CMFRI |
| g | gram |
| GEBCO | General Bathymetric Chart of the Oceans |
| GoI | Government of India |
| GoM | Gulf of Mannar |
| GPS | Global Positioning System |
| HCRs | Harvest Control Rules |
| HP | Horse Power |
| IB | In-Board |
| IBBSGN | Inboard Bottom Set Gillnet |
| ICPA | Indian Crab Processors Association |
| IMBL | International Maritime Boundary Line |
| K | Growth rate coefficient |

| | |
|---|---|
| k | Parameter of the Schaefer model indicating unexploited stock size |
| Kg | Kilogram |
| L∞ | Asymptotic average length |
| LRP | Limit Reference Point |
| MDTN | Multiday Trawl Net |
| MLS | Minimum Legal Size |
| mm | Millimetre |
| MSY | Maximum Sustainable Yield |
| MTN | Mechanised Trawl Net |
| N | Total instantaneous natural mortality coefficient |
| NMBSGN | Non-Mechanised Bottom Set Gillnet |
| NMFDC | National Marine Fishery Resources Data Centre |
| NMTN | Non Mechanised Trawl net |
| OAL | Over All Length |
| OB | Out-Board |
| OBBSGN | Outboard Bottom Set Gillnet |
| OBGN | Outboard Gillnet |
| OMCAR | Organization for Marine Conservation, Awareness and Research |
| PB | Palk Bay |
| q | Catchability coefficient |
| r | Correlation coefficient |
| Rs | Indian Rupees |
| SDMRI | Sugandhi Devadason Marine Research Institute |
| Sp | Singular species |
| Spp | Plural species |
| t | Tonnes |
| TN | Tamil Nadu |
| TRP | Target Reference Point |
| TW | Total Weight |
| USA | United States of America |
| VBGF | von Bertalanffy Growth Function |
| W | expected weight |
| Y/R | Yield-per-recruit |
| Z | Total instantaneous mortality coefficient |
| Z-1 | Zoea 1 |
| $ | US Dollar |

# 1. Introduction

Blue swimming crab, known in Tamil Nadu as *olakkal nandu* was used for consumption since many years and for the last two decades it is a very popular choice of seafood lovers. *Portunus pelagicus* (Linnaeus, 1758) commonly known as the Blue Swimming Crab (BSC) represents a valuable component of crustacean fishery in many parts of the world. In India, it forms a small scale fishery at different regions along the east and west coasts. Along the west coast, the fishery is seasonal except in Gujarat where BSC is landed in almost 8 months. Along east coast, species is landed throughout the year at Palk Bay and Gulf of Mannar and contribute to a major part of the Tamil Nadu BSC catch. A good landing is also recorded from Kakinada Bay, Andhra Pradesh for 3-4 months of the year. Total crab landings in India during 1975-2017 is presented in Figure 1. The landing was around 19,893 tonnes in the 1975, increased over the years and reached 53,476 tonnes in 2017 registering 63% increase in the production. Among the maritime states, Tamil Nadu ranks first in crab landings for the past several years (Fig. 2) and crabs were in the 7$^{th}$ position among the top ten demersal and pelagic fishery resource (12,496 t) obtained from the annual average production in three different sectors (mechanised, motorised & non-motorised) in Tamil Nadu during 2001-2010.

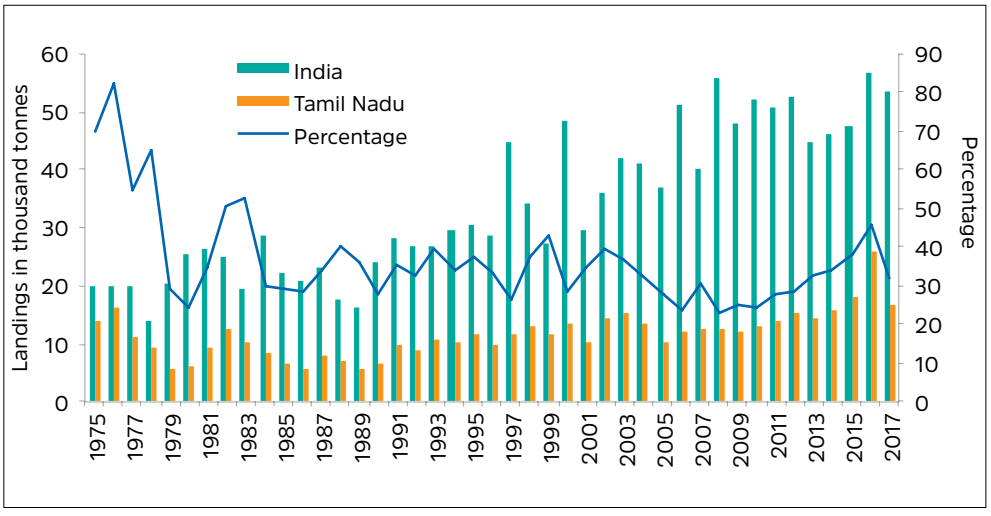



Figure 1- Total crab landings (t) in India and Tamil Nadu and its percentage during 1975-2017

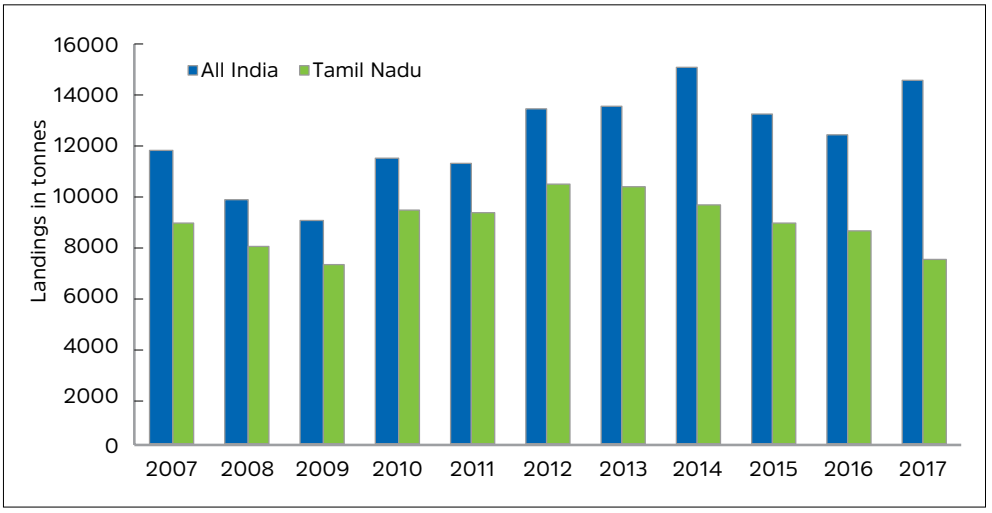



Figure 2- Total *Portunus pelagicus* (BSC) landings (t) in India and Tamil Nadu during 2007-2017

*Portunus pelagicus* is widely distributed throughout the Indo-West Pacific region and there have been indications that it may be a species complex. The systematics of the *Portunus pelagicus* (Linnaeus, 1758) has been recently revised by Lai *et al.*, (2010) and four distinct species, *P. pelagicus* (Linnaeus, 1758), *P. segnis* (Forskål, 1775), *P. reticulatus* (Herbst, 1799) and *P. armatus* (A. Milne-Edwards, 1861), are recognised based on morphological and DNA characters as well as biogeographical considerations. Morphological examinations of *P. pelagicus* from different locations of India show that several distinct colour morphs exist. Josileen *et al.* (2014) studied the taxonomic characters of *Portunus pelagicus* species complex in Palk Bay and Gulf of Mannar region using morphological and mitochondrial DNA markers, which suggest the existence of two species i.e., *Portunus reticulatus* and *P. pelagicus*. However, in this document *Portunus pelagicus* (BSC) is used, as it is widely identified by that name.

## History of BSC Fishery

Blue swimming crab fishing with traditional craft and gears may have started very long back and exact details of its genesis are not available. Perhaps, the first report on its fishery and fishing methods exclusively from the area was published in 1952 by Prasad and Tampi, and later in 1978 by Ameer Hamsa. However, the earlier report does not include estimates on total production or catch per unit effort for this commercially important crab. The latter publication, gave an account of its fishery from Palk Bay and Gulf of Mannar, the catch per unit effort at the three landing places Devipattanam, Vedalai and Mandapam for the period 1972-74. Later, Josileen (2001) and Josileen & Menon (2007) were also elaborated on the fishery and species growth parameters.

# 2. Material and methods

## Estimation of Marine fish landings in India

The catch and effort data in the present work were obtained from the National Marine Fishery Resources Data Centre (NMFDC) of CMFRI. The data was collected through an observer based stratified multi-stage random sampling technique which estimates species-wise/Zone-wise/centre-wise landings. In this, the stratification is over space and time. Over space, each maritime state is divided into suitable, non-overlapping zones on the basis of fishing intensity and geographical considerations. The number of centres may vary from zone to zone. These zones have been further stratified into substrata, on the basis of intensity of fishing. There are some major fisheries harbours/centres which are classified as single centre zones for which there is an exclusive and extensive coverage. The stratification over time is a calendar month. One zone and a calendar month is a space-time stratum and primary stage sampling units are landing centre days (Fig.3).

For example, if in a zone, there are 20 landing centres, there will be 20 x 30 = 600 landing centre days in that zone for that month (of 30 days). For observation purpose, a month is divided into 3 groups, each of 10 days. From the first five days of a month, a day is selected at random, and the next 5 consecutive days are automatically selected. From this three clusters of two consecutive days are formed. For example, for a given zone, in a given month, from the five days if the date (day) selected at random is 4, then these clusters are formed, namely, (4, 5); (6, 7) and (8, 9) in the first ten-day group. In the remaining ten day groups, the clusters are systematically selected with an interval of 10 days. For example, in the above case, the cluster of observation days in the remaining groups are (14, 15), (16, 17), (18, 19) (24, 25), (26, 27) and (28, 29). Normally, in a month there will be 9 clusters of two days each. From among the total number of landing centres in the given zone, 9 centres are selected with replacement and allotted to the 9 cluster days as described earlier. Thus in a month 9 landing centre days are observed. The observation is made from 1200 hrs to 1800 hrs on the first day and from 0600 hrs to 1200 hrs on the second day, in a centre. For the intervening period of these two days, the data are collected by enquiry from 1800 hrs of the first day of observation to 0600 hrs of the 2nd day of observation of a landing centre-day, which is termed as 'night landing '. The `night landing' obtained by enquiry on the second day covering the period of 1800 hrs of the first day to 0600 hrs of the next day are added to the day landings so as to arrive at the landings for one (landing centre day) day (24 hours). From the boats, the catches are normally removed in baskets of standard volume. The weight of resource contained in these baskets being

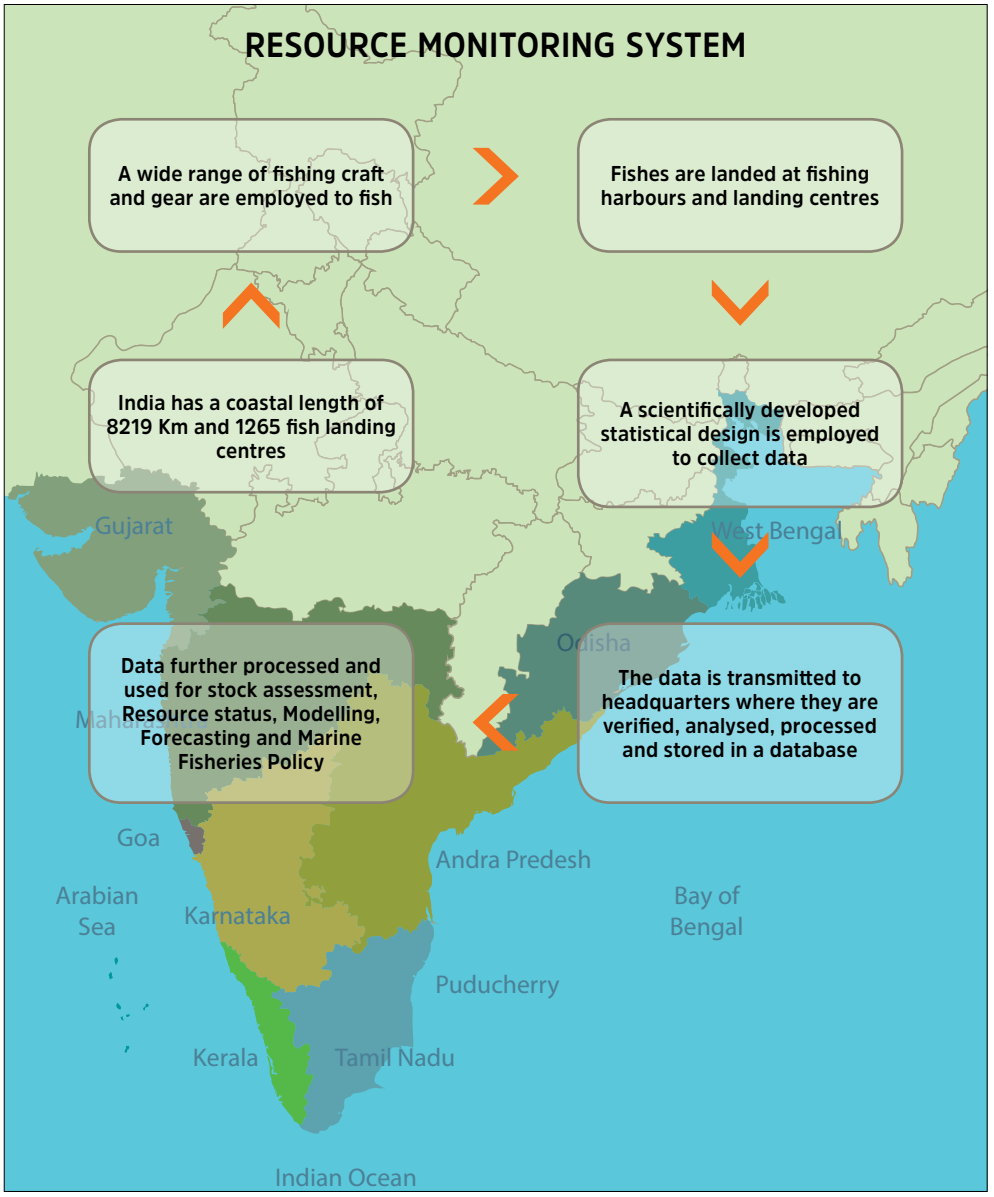



Figure 3- Diagram showing the different steps involved Resource Monitoring System (Source: Srinath *et al*., 2005)

known, the weight of resources in each boat under observation is obtained. The weight is recorded rounded to the nearest kilograms against the sampled boat. From each centre, the landing for all the units are added and observation day's catch is estimated and accordingly monthly zonal landing are estimated and from these, total landings from districts, state and all India are estimated (Srinath *et al*.,2005).

## Maps

Location maps and fishing operation area maps were prepared using ArcGIS 10.0 and QGIS 2.18.14 software. The extent of sea bottom ecosystems of the Indian side of Palk Bay was extracted from Kasim (2015). The contour lines were derived from 30 arc second bathymetric data obtained from GEBCO database (General Bathymetric Chart of the Oceans) hosted by the British Oceanographic Data Centre (BODC). The landing locations and other details were obtained from CMFRI database. Major trawl and gillnet centres, depth contour and details of ecosystems in Palk Bay etc. are presented as separate maps under respective sections. The total area under gillnet operation in the study region is 2457 $km^2$ and that under trawl operation is 4915 $km^2$.

## Estimation of growth parameters in laboratory grown BSC

Growth of BSC from the first instar to stage 16 was studied by rearing the crabs in the laboratory. For this purpose, the juvenile blue swimmer crabs were produced in the hatchery. Forty five healthy crabs (instar I) within a size range of 2.0-2.5 mm carapace width (CW) were used for the experiments (a total of 3 trials, with 15 crabs each). The details are given in Josileen & Menon (2005).

The data of the laboratory rearing experiments on the growth of male and female crabs were entered as a growth increment data file in the computer program FiSAT. Further analysis of growth increment for fitting a growth curve was carried out using Gulland & Holt (1959), Fabens (1965) and Munro's (1982) methods. The estimates of $L_\infty$ and K thus obtained were analysed using the inverse von Bertalanffy growth equation, to arrive at corresponding length at age. The optimum parameters ($L_\infty$ and K) were fixed, based on the data obtained during the laboratory growth studies.

## Maximum Sustainable Yield (MSY)

### Biomass and Yield

*Portunus pelagicus* in the region are caught in motorized, mechanized and non-motorised gears as directed fishery or as incidental catches. Bottom set gillnets and trawls contribute to a sizeable proportion of the landings. The commercial directed fishery for the resource is mainly by bottom set gillnets and trawls. Trawl fleets have been categorized by a combination of gear and horsepower (MTN, NMTN, MDTN) and the corresponding Catch Per Hour (CPH). CPH in this case was estimated by taking the average weight (kg) per one hour of trawling. The fishing efforts in gillnets were similarly estimated as the actual fishing hour (soak time) of the gear. Due to the importance of CPUE in many stock assessments and the

assumption that CPUE is proportional to abundance, it is important that in a multi-gear situation the CPUE is standardized for arriving at the stock abundance. The method used for standardising CPUE is described in Eldho *et al.*, (in press).

The time series catch-effort data for the period 2007 to 2017 was used for estimation of reference points using Catch-MSY method of Froese *et al.* (2017). Probable ranges for *r* (intrinsic rate of growth) and *k* (carrying capacity) are filtered with a Monte Carlo approach to detect 'viable' *r-k* pairs. The ranges for starting and final depletion levels were assumed to be one of possible three biomass ranges: low, medium, and high, using a set of rules based on the trend of the catch series. The search for viable *r-k* pairs is terminated once more than 1000 pairs are found. MSY are obtained as geometric mean of the MSY values calculated for each of the *r-k* pairs where *r* is larger than the median. Viable biomass trajectories were restricted to those associated with a *r-k* pair that fell within the confidence limits of the C-MSY estimates of *r* and *k*.

# Biology

## Estimation of carapace width–weight relationship

To study the carapace width/length-weight relationship, measurements were taken for carapace width, carapace length, and total weight, separate for each sex. Carapace width (CW) was taken as the distance between the tips of the posterior most lateral carapace spines. Carapace length (CL) was measured dorsally along the midline, between the frontal notch and the posterior margin of the carapace (Fig.4). Vernier callipers with an accuracy of 0.5 mm were used for length measurements, and the total weight (TW) of the crab was determined to the nearest gram using a digital balance (1 g).

The carapace width-weight relationship was estimated using the log form of the allometric growth equation $W = aL^b$ (Rickter, 1973), where W = expected weight, L = total carapace width, 'a' = y-intercept or the initial growth coefficient, and 'b' = the slope or growth coefficient. The values of constants of 'a' and 'b' were calculated by the least squares method. The differences in the carapace width-weight relationship between sexes were tested by ANOVA (MS Excel). A total of 468 males and 720 females were used for the study.

## Fecundity

Fecundity of the crab was calculated by counting the number of eggs deposited on the pleopods of the ovigerous females. Forty-one crabs from different size groups were used for fecundity studies. Egg masses from each crab were carefully

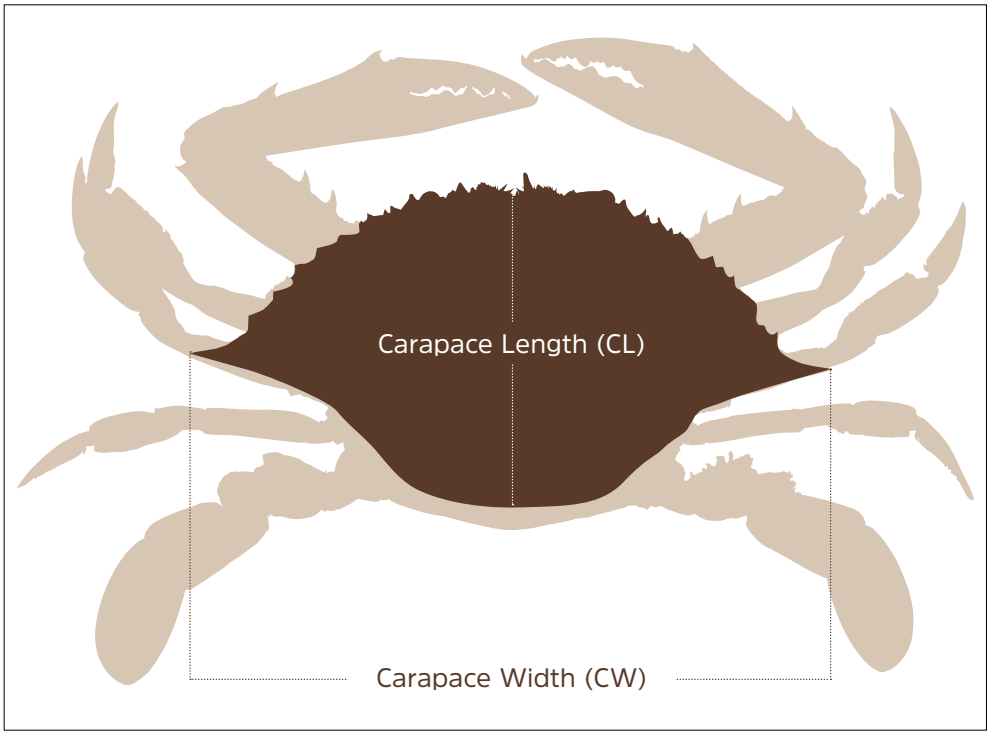



Figure 4- Diagram showing the measurements used carapace width and length in BSC

removed from the pleopods and weighed accurately using electronic balance. A 0.1 g sample was taken from each egg mass, smeared and dispersed in seawater and were counted through binocular compound microscope. The total number of eggs counted in the sample was then computed. Ocular micrometer (ERMA, Japan) calibrated with stage micrometer was used to take micro metric measurements of eggs in different stages of development. Correlation coefficient (r) was used to determine the fecundity relationship (Snedecor and Cochran, 1967). The relationship between carapace width (CW) and egg mass weight/fecundity; crab weight and egg mass weight/fecundity; egg mass weight and fecundity were determined by regression analysis. Egg mass index was determined using the formula: Egg mass index = Mean egg mass weight x 100/ Mean crab weight.

## Food and feeding studies

For food and feeding studies, specimens of *Portunus pelagicus* were collected from the commercial catches of shrimp trawlers in the Mandapam area ($9^{o}$20-25' N $79^{o}$5-10' E). Samples were collected once a month for a period of one year

continuously (1997). Studies on food and feeding were carried out following a method adapted from Sukumaran (1995): after recording the carapace width and length and the total weight of the crab, the dorsal side of the body was cut open and the foregut was removed carefully. The fullness of the stomach was visually examined and assessed as 0, 25, 50, 75 or 100%. The foreguts were preserved in 10% formalin for a week, prior to being cut open and their contents transferred into Petri dishes with distilled water. The food components of the gut contents were separated and identified under a compound microscope. As is characteristic of brachyurans, most of the food items were found to be unidentifiable as a result of having been highly crushed and hence only the hard structures that could be identified were relied upon for determining food composition and further evaluation. Gut contents were broadly classified into five categories, as follows:

1. Crustacean remains — penaeid shrimp appendages; body parts of crabs and crab eggs; isopod and stomatopod parts.
2. Fish remains —fins, scales, bones, and vertebrae.
3. Molluscan remains— parts of bivalve and gastropod shells.
4. Miscellaneous—algal filaments, nematodes, polychaetes, and unidentified items.
5. Debris— sand and mud.

Neither the quantity of food nor the food components were significantly different in males and females, and hence the food data for both sexes were combined. Only stomachs that contained food were considered for analysis and calculation. For each specimen, the whole stomach content was segregated according to food-groups, and each group's contribution was determined visually. Dominance of food groups was evaluated by ranking them by their percentage frequency of occurrence and so-called percentage points. The percentage frequency of occurrence was estimated as: No. of stomachs with particular food group × 100/ Total no. of stomachs with food.

To estimate the volume of the food by food-group, points were assigned to each group as suggested by Stehlik (1993): to quote one example, a food group that formed 50% of the total food content of a stomach that was 50% full, was assigned 25 points (50 points × 0.50). Percentage points were thus estimated as: Point of the particular food group × 100/ Total points of all food groups.

# 3. Results

## 3.1. General description of Palk Bay

Palk Bay is a shallow, confined, comparatively calm sea falling between Tamil Nadu in India on the western side and North western Province of Sri Lanka on the east, with three openings, one into the Bay of Bengal on the northeast, another a shipping channel into the Gulf of Mannar on the south and the third one a shallow opening into the Gulf of Mannar on the east littered with a series of sandy islets called Adam's Bridge. It was being used historically and peacefully by the coastal fishers of both the countries since time immemorial till the time when the International Maritime Boundary Line (IMBL) was introduced dividing the Bay into the Indian side (west) and Sri Lankan side (east) by an agreement in 1974 followed by another in 1976. The IMBL is only 6.9 km away from Dhanushkodi, 11.5 km away from Rameswaram, 15.9 km away from Point Calimere, 23 km away from Vedaranyam and 24.5 km away from Thondi (Kumaraguru *et al,* 2008).

## 3.2. Different sea bottom ecosystems on the Indian side of Palk Bay

The productivity of the near shore water depends mainly on the nature of sea bottom ecosystem. As described by the expert fishers of the respective regions, underwater diving survey carried out by the artificial reef deployment team of CMFRI and the underwater sea grass and sea weed survey team of CMFRI, the sea bottom ecosystem of Tamil Nadu near shore waters of Palk Bay consisted of muddy (13%), sandy(6%), sea grass bed (20%) and rocky (2%) and the so called deeper area of the Indian side of Palk Bay up to all along the International Maritime Boundary Line is reported to be almost sandy/silty (58%), an excellent trawling ground for mechanized trawlers (table 1).

Table 1. Different sea bottom ecosystems of Palk Bay

| Ecosystem | Area (Sq.km) | Area (%) |
|---|---|---|
| Sandy silty sea bottom | 4069 | 58 |
| Seagrass ecosystem | 1430 | 20 |
| Mudflat ecosystem | 933 | 13 |
| Sandy ecosystem | 392 | 6 |
| Rocky ecosystem | 167 | 2 |
| **Total** | **6991** | **100** |

The northern most near shore sea bottom is muddy and it extends up to Sethubavachathram in the south, where the sea grass starts appearing as the sea bottom changes from muddy to sandy and mixture of both. Further down south up to Morepanai in Ramanathapuram district the sea bottom along coastal area is full of sea grasses of different varieties indicating that the sea bottom is sandy and sparsely muddy. The sandy ecosystem mixed sparsely with rocky terrain is witnessed further down south from Morepanai to Mudiveeranpattinam near Aathangarai and then the sea bottom was noticed to be completely rocky from Mudiveeranpattinam to Pamban bridge followed by sandy sea bottom till the end of Tamil Nadu side of Palk Bay up to Arichal Munai near Adam's bridge. Map of the Palk Bay showing different depth contours and different ecosystems are shown in Figure 5.

The entire coast of Pudukkottai and northern Ramanathapuram districts are very rich in seagrasses and seaweeds. Extensive surveys and research on seagrasses and seaweeds were carried out by different research organisations such as, CMFRI, Sugandhi Devadason Marine Research Institute (SDMRI) and OMCAR Foundation. SDMRI (2013) has reported all the 14 species of seagrasses found all over the world to occur and *Thalassia hemprichii, Syringodium isoetifolium* and *Cymodocea serrulata* are the dominant species. The luxuriant growth was reported in Puthupattinam, Mullumunai and Thondi zones. The distribution from shore towards the sea ranged between 3.5 km and 8.56 km. While the zones of Iranianvalasai, R. Puthur, Kottaipattinam and Athiramapattinam had seagrass cover to a distance of 7 km from shore and minimal cover was observed in other zones up to 3.5 km from shore.

The treasure of seagrass in Palk Bay, however, faces threat from human activities and environmental degradation as nearly 20 per cent of healthy seagrass beds were already degraded in the stretch owing to the use of bottom trawling by the mechnaised boats, shore seine and push nets by the traditional fishermen (Mathews *et al.*, 2010). The average macro faunal density on seagrass beds in Palk Bay are given in Table-2 and Table-3 lists the crustacean species/groups in seagrass areas of Palk Bay.

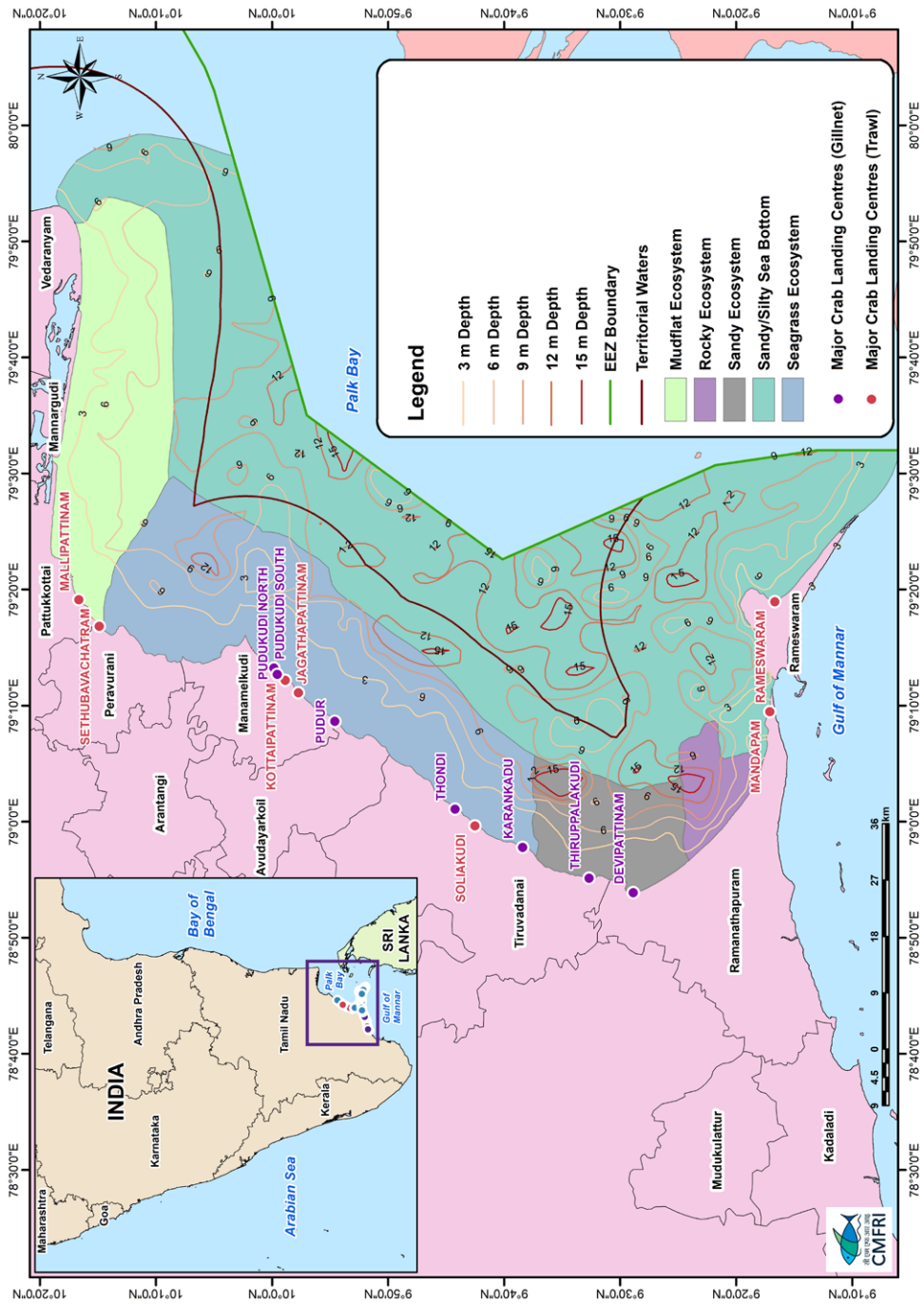



Figure 5- Map Showing the depth contour and nature of ecosystems in Indian Palk Bay (Source: Kasim,2015)

Table 2. Average macro faunal density (no./ 5 $m^2$) in seagrass beds in Palk Bay

| Fauna | Nearshore Zone | Middle Zone | Offshore Zone |
|---|---|---|---|
| Crustaceans | 0.99 | 1.24 | 0.65 |
| Bivalves | 2.34 | 2.85 | 1.23 |
| Gastropods | 3.26 | 4.25 | 1.56 |
| Polychaetes | 1.34 | 1.45 | 0.56 |
| Echinoderms | 1.75 | 1.35 | 0.53 |
| Ascidians | 0.63 | 0.56 | 0.32 |
| Sea Anemones | 1.11 | 1.56 | 0.86 |
| Sponges | 0.62 | 0.78 | 0.34 |

Source: Mathews *et al.*,2010

Table 3. List of Common Crustaceans/groups in the Seagrass Area

| Crustaceans | Gulf of Mannar | Palk Bay |
|---|---|---|
| *Portunus pelagicus* | ✓ | ✓ |
| *Calappa* sp. | ✓ | ✓ |
| *Charybdis natator* | ✓ | ✓ |
| Amphipods | ✓ | ✓ |
| Isopod | ✓ | ✓ |

Source: Mathews *et al.*,2010

## 3.3. Area, districts and Zone-wise landing centres of Palk Bay

The total spread area of Palk Bay is estimated to be 13,892 sq. km which is equally divided into 6,991 sq.km each between India and Sri Lanka. The width of Palk Bay between Tamil Nadu and Sri Lanka varies between 64 and 137 km. The maximum depth recorded is 15 m with an average of 9 m. This critical shallowness is considered to be the backbone of its productivity which in turn supports a wide diversity of marine living resources and also related diversified livelihoods (Kasim, 2015).

Palk Bay covers a coast line of around 296 kilometers (Stephen *et al.*, 2013) along Tamil Nadu, stretching from Kodiakarai (Point Calimere) in Nagapattinam district to Dhanushkodi in Ramanathapuram district, encompassing 5 revenue districts in Tamil Nadu. The split up of the coastline indicate that Nagapattinam district has 58 km, Thiruvarur 19 km, Thanjavur 29 km, Pudukkottai 49 Km and Ramanathapuram 141 Km. Out of the five coastal districts which border the Palk Bay only 3 districts are actively involved in fishing and Ramanathapuram (CMFRI fishing zone -11-Palk

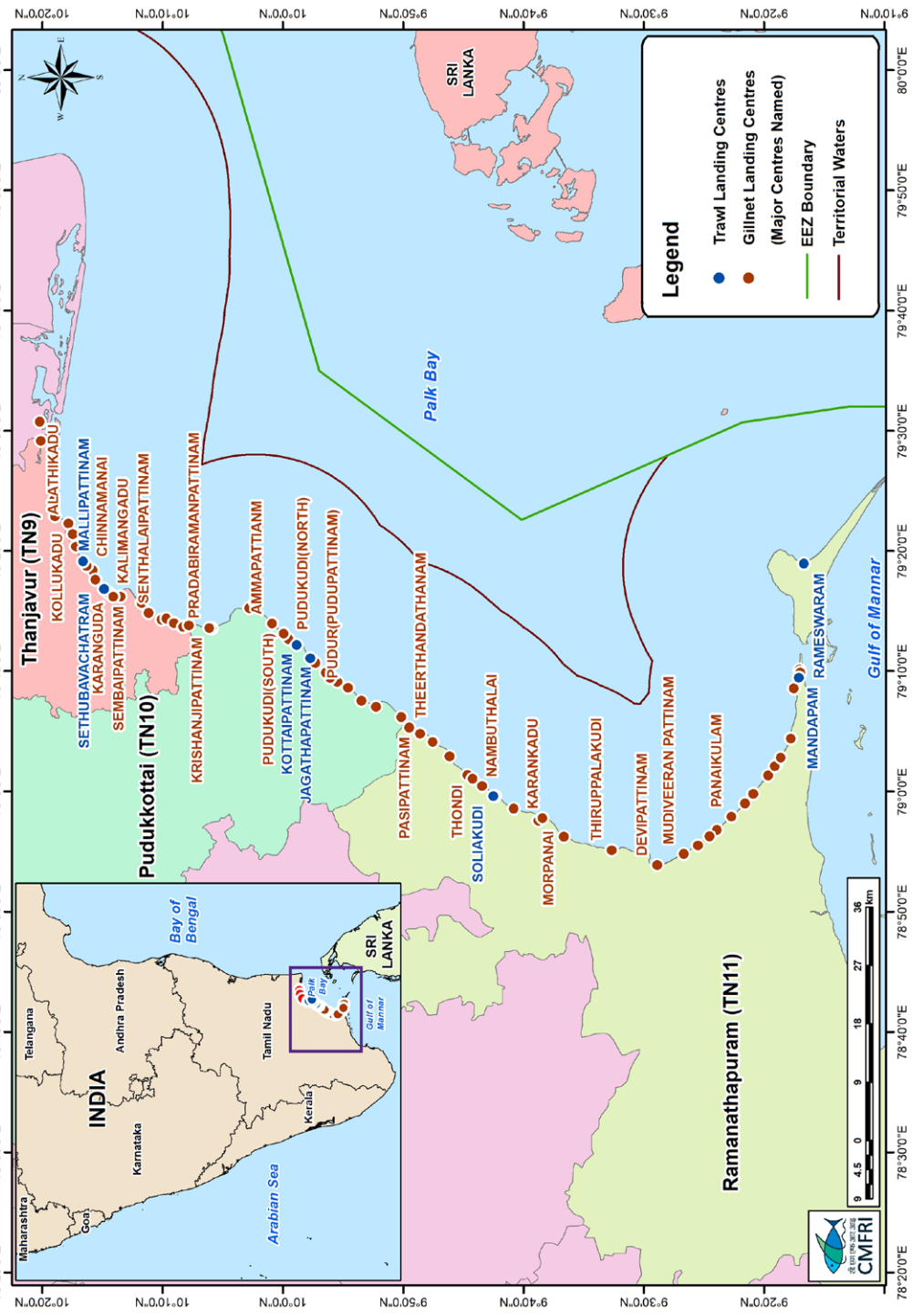



Figure 6- Map of fish landing centres in three coastal districts of Palk Bay showing important BSC centres

Bay) is the major district comprising about 54 major and minor landing centres and also harbours 33 major and minor landing centres along the Gulf of Mannar side. Pudukkottai (CMFRI fishing zone -10) and Thanjavur (CMFRI fishing zone -9) districts have 19 and 25 major and minor landing centres respectively. Details of crab landing centres of the Palk Bay Zones, Ramanathapuram (TN-11), Pudukkottai (TN-10) and Thanjavur (TN-9) are presented in the Figure 6.

## 3.4. Fisher-folk Population and Fishing Crafts of Palk Bay

Tamil Nadu state has 13 coastal districts and among them Ramanathapuram is the major district with maximum share of landing centres (20.6%), fishing villages (31%) and fishermen population (23.7%). General summary of the coastal districts Ramanathapuram, Pudukkottai and Thanjavur bordering the Palk Bay is given in the Table 4.

According to 2016 marine fisheries census conducted by CMFRI, the details of mechanised, motorised (inboard & outboard) and non-motorised fishing crafts at important landing centres of Thanjavur (TN-9), Pudukkottai (TN-10) and Ramanathapuram (TN-11) are presented in Table 5. A total of 1211 mechanised, 6486 motorised and 4854 non-motorised fishing crafts were there used from these landing centres. Ownership (100% /< 100%) of different category of crafts by fisher-folk of Thanjavur, Pudukkottai and Ramanathapuram coastal districts of Palk Bay is presented in Table 6.

As per the 2016 CMFRI census, the fisher population of Ramanathapuram district was 188915, followed by Thanjavur district 30797 and Pudukkottai 28485. The details of fishermen families at important landing centres are given in Table 7.

Table 4. General summary of Coastal districts of Palk Bay

| District | Landing centres No.& (% in Total coastal districts) | Fishing villages No.& (% in Total coastal districts) | Fishermen families No.& (% in Total coastal districts) | Traditional fishermen families No.& (% in Total coastal districts) | BPL families No.& (% in Total coastal districts coastal districts) | Fisher folk population No.& (% in Total coastal districts ) |
|---|---|---|---|---|---|---|
| Thanjavur | 23 (6.59) | 31 (5.39) | 7070 (3.5) | 7062 (3.59) | 7066 (3.85) | 30797 (3.87) |
| Pudukkottai | 21 (6.02) | 34 (5.91) | 6645 (3.29) | 6514 (3.31) | 6456 (3.51) | 28485 (3.58) |
| Ramanathapuram | 72 (20.63) | 178 (30.96) | 42672 (21.14) | 39612 (20.13) | 36605 (19.93) | 188915 (23.74) |
| Total (13 Districts) | 349 | 575 | 201855 | 196784 | 183683 | 795708 |

Source: CMFRI, TN Census report (draft), 2016.

Table 5. Details of different fishing crafts used in the major Crab landing centres of Palk Bay

| Name of the village | Mechanized | Inboard | Outboard | Non-motorized |
|---|---|---|---|---|
| Sethubavachatram | 25 | 2 | 20 | 3 |
| Mallipattinam | 84 | 0 | 57 | 0 |
| THANJAVUR TOTAL | 203 | 5 | 1175 | 94 |
| Percentage in Total TN | 7.72 | 0.20 | 6.21 | 0.63 |
| Pudukudi | 0 | 0 | 237 | 2 |
| Jagathapattinam | 0 | 0 | 18 | 1 |
| Kottaipattinam | 6 | 69 | 37 | 7 |
| PUDUKKOTTAI TOTAL | 199 | 102 | 1363 | 693 |
| Percentage in Total TN | 7.57 | 4.08 | 7.20 | 4.66 |
| Mandapam | 59 | 31 | 0 | 48 |
| Rameswaram | 31 | 2 | 0 | 10 |
| Soliakudi | 33 | 0 | 7 | 16 |
| Devipattinam (North) | 0 | 2 | 131 | 0 |
| Devipattinam (South) | 1 | 0 | 182 | 0 |
| Thiruppalakudi (North) | 0 | 0 | 156 | 622 |
| Thiruppalakudi (South) | 1 | 3 | 73 | 255 |
| Thondi | 0 | 0 | 128 | 56 |
| Karangadu | 0 | 0 | 28 | 1 |
| RAMANATHAPURAM TOTAL | 809 | 1283 | 2558 | 4067 |
| Percentage in Total TN | 30.76 | 51.28 | 13.51 | 27.36 |
| TAMILNADU TOTAL | 2630 | 2502 | 18930 | 14864 |

Source: CMFRI, TN Census report (draft), 2016.

Table 6. Craft Owned by Fisherfolk along the coastal districts of Palk Bay

| Type | Thanjavur | Pudukkottai | Ramanathapuram | Thanjavur | Pudukkottai | Ramanathapuram |
|---|---|---|---|---|---|---|
| | 100% Ownership | | | <100% Ownership | | |
| Mechanized | | | | | | |
| Trawler | 202 | 189 | 778 | 1 | 3 | 113 |
| Gilnetter | 0 | 0 | 13 | 0 | 0 | 5 |
| Ringseiner | 1 | 10 | 7 | 0 | 0 | 0 |
| Liner | 0 | 0 | 0 | 0 | 0 | 0 |
| Others | 0 | 0 | 11 | 0 | 0 | 1 |
| Inboard | | | | | | |
| Wooden Built | 2 | 41 | 884 | 0 | 0 | 106 |
| Iron Built | 0 | 0 | 17 | 0 | 0 | 2 |
| Wood Fiber | 3 | 53 | 366 | 0 | 0 | 46 |
| Others | 0 | 8 | 16 | 0 | 0 | 0 |
| Outboard | | | | | | |
| Catamaran | 5 | 7 | 13 | 0 | 2 | 1 |
| Dugout canoe | 1 | 6 | 10 | 0 | 0 | 0 |
| Plank built boat | 2 | 12 | 204 | 0 | 0 | 5 |
| Plywood boat | 0 | 1 | 118 | 0 | 0 | 4 |
| Fiber glass boat | 1142 | 1240 | 2034 | 8 | 120 | 226 |
| Ferro cement boat | 0 | 6 | 1 | 0 | 1 | 0 |
| Teppa | 0 | 2 | 23 | 0 | 0 | 0 |
| Others | 25 | 89 | 155 | 0 | 2 | 11 |
| Dugout canoe | 1 | 8 | 59 | | | |
| Catamaran | 4 | 171 | 745 | | | |
| Plank built boat | 89 | 472 | 1493 | | | |
| Ferro cement boat | 0 | 1 | 0 | | | |
| Thermocol | 0 | 5 | 1690 | | | |
| Outrigger canoe | 0 | 1 | 1 | | | |
| Musula boat | 0 | 17 | 21 | | | |
| Others | 0 | 18 | 58 | | | |

Source: CMFRI, TN Census report (draft), 2016.

Table- 7. Details of Fishermen at the important landing centres for BSC

| Name of the Village | Fishermen families | Traditional Fishermen families | BPL Families | Fisher-folk Population |
|---|---|---|---|---|
| Sethubavachatram | 450 | 450 | 450 | 1926 |
| Mallipattinam | 465 | 465 | 463 | 1893 |
| **THANJAVUR TOTAL** | **7070** | **7062** | **7066** | **30797** |
| Pudukudi | 491 | 491 | 491 | 2130 |
| Jagathapattinam | 92 | 92 | 92 | 412 |
| Kottaipattinam | 1063 | 1062 | 1033 | 4786 |
| **PUDUKKOTTAI TOTAL** | **6645** | **6514** | **6456** | **28485** |
| Mandapam | 1481 | 1333 | 758 | 6565 |
| Rameswaram | 3192 | 3122 | 3168 | 13762 |
| Soliakudi | 135 | 135 | 131 | 610 |
| Devipattinam (North) | 390 | 376 | 390 | 1719 |
| Devipattinam (South) | 585 | 584 | 585 | 2436 |
| Thiruppalakudi (North) | 735 | 735 | 735 | 3447 |
| Thiruppalakudi (South) | 405 | 405 | 405 | 2686 |
| Thondi | 390 | 390 | 388 | 1771 |
| Karangadu | 375 | 367 | 345 | 1687 |
| **RAMANATHAPURAM TOTAL** | **42672** | **39612** | **36605** | **188915** |

Source: CMFRI, TN Census report (draft), 2016.

## 3.5. Crab Landing Centres & Total BSC Landings

Crabs are mainly caught as by-catch in bottom trawls (main target is shrimps and fishes), and as a target in indigenous bottom-set gillnets. Gillnets with minor modifications, locally known as *Nanduvalai* are employed along Palk Bay and Gulf of Mannar areas.

Total Palk Bay area (Indian side) is 6991 sq.km (Lat $9^{o}$ 5' 38" -$10^{o}$ 18' 28" N and Log $78^{o}$ 54' 0" - $79^{o}$ 59' 31" E) and the total fishing ground available is 5032 sq.km. Out of the available fishing area, trawl and gillnet operated areas are 4915 sq.km and 2457 sq.km respectively, with an overlapping area of 2340 sq.km, where both trawl and gillnets are operated. Trawl alone operated area is 2575 sq.km whereas, gillnets alone operated area is 117 sq.km. The details of fishing areas of BSC is presented in Figure 7.

Total BSC landings in Palk Bay for the last eleven years (2007-2017) was 75843 tonnes and major share was contributed by gillnets (74%) and rest by trawls. In

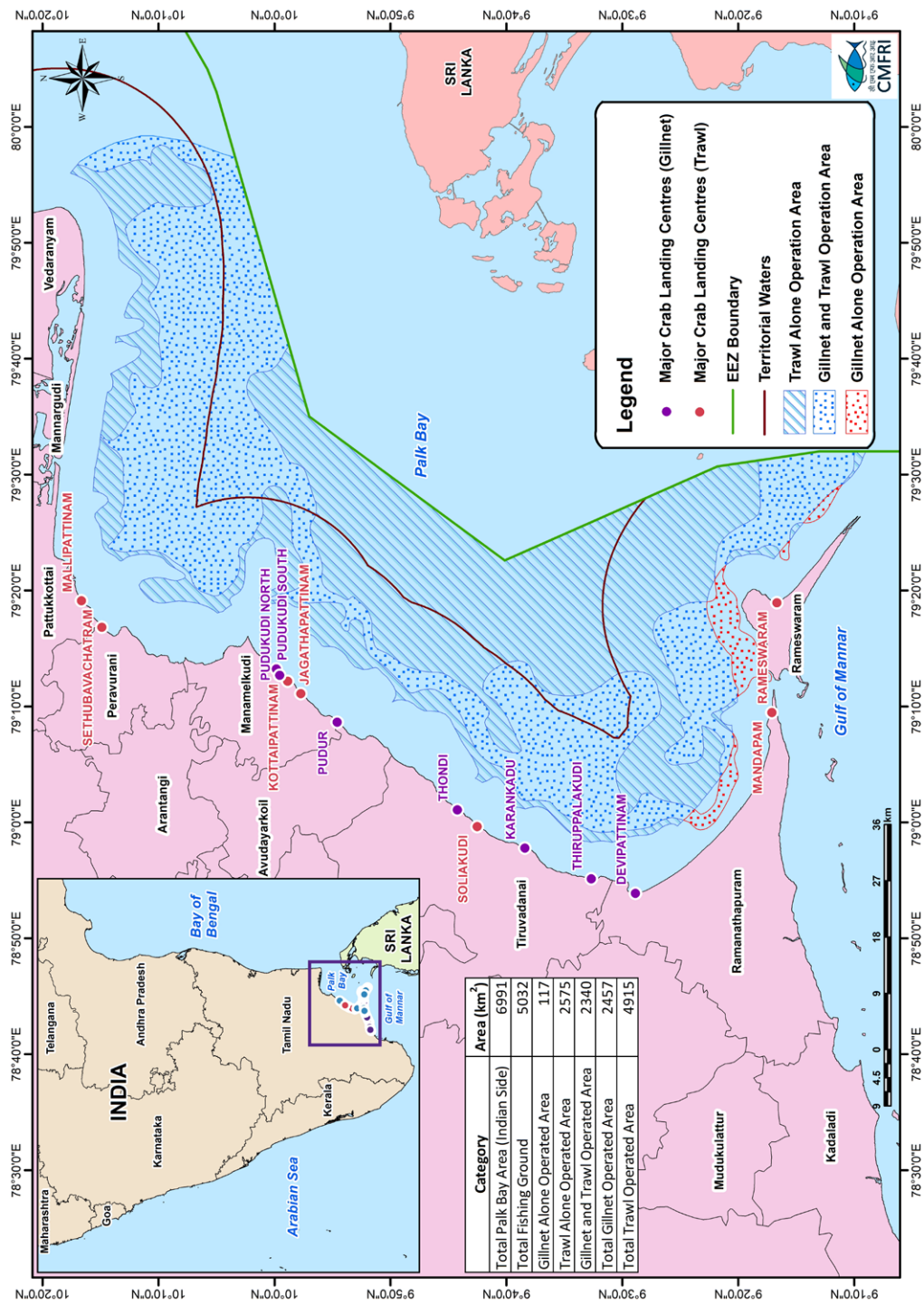



Figure 7. Map showing major crab landing centres and crab fishing areas of the Palk Bay

gillnets maximum landing was recorded in 2010 (6576 tonnes) whereas in trawls maximum was recorded in 2008 (2472 tonnes). During last four years (2014-'17) landings both in gillnet and trawls showed a declining trend. Among the districts, maximum landing (22888 tonnes) was contributed by Pudukkottai (TN-10) followed by Thanjavur (TN-9) and Ramanathapuram (TN-11), 20721 tonnes and 12988 tonnes respectively. Year-wise details are presented in Figures 8 & 9.

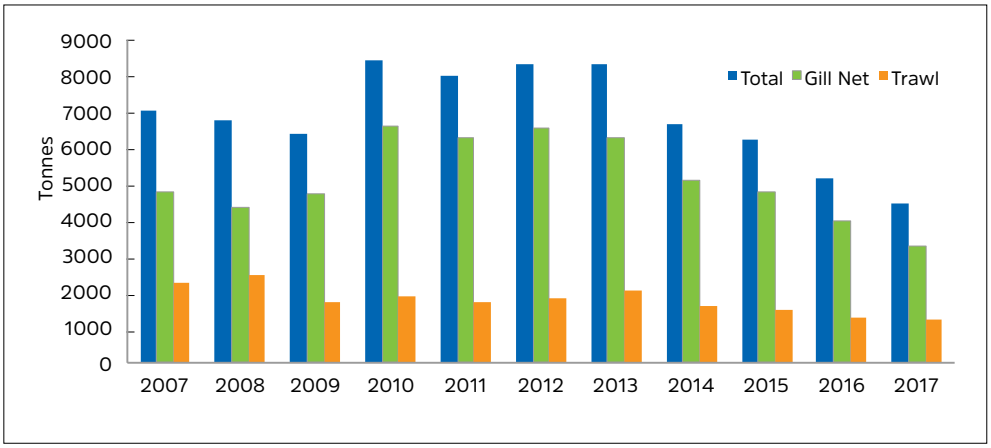



Figure 8- Total *Portunus pelagicus* (BSC) landings at Palk Bay

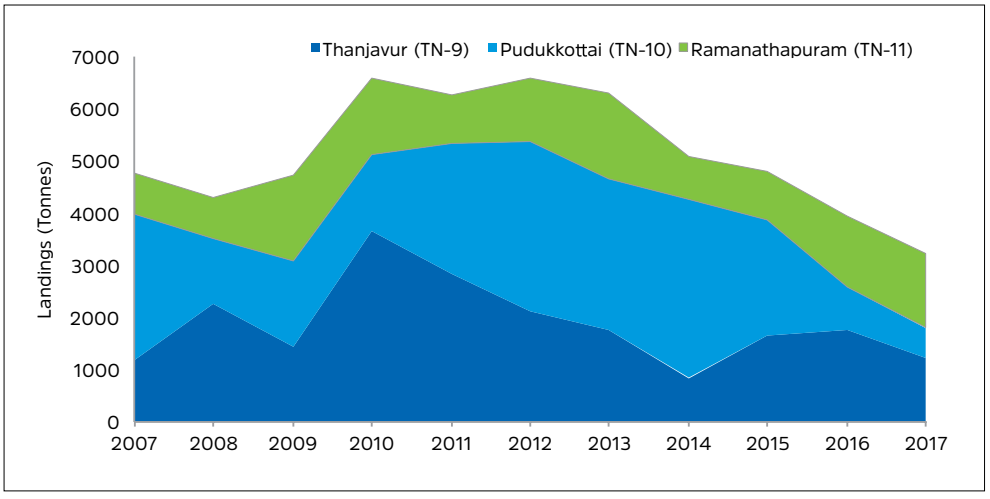



Figure 9- Total BSC landings (other than trawl) from the coastal districts of Palk Bay during 2007-17

## 3.6. BSC Catch and Catch trends

### 3.6a. Trawl

At Mandapam, one of the major BSC landing centre, bottom trawlers land *P. pelagicus* catch along with other resources. This fishing is an year round process (except during ban period of April-May) along Palk Bay while at Gulf of Mannar fishing activities are restricted for the season, October-March. The trawlers either operate both during day-night or night only and the fishing area is upto a maximum of 50 m in the Gulf of Mannar side, with normal fishing in grounds less than 25 m of depth. However, in Palk Bay maximum depth is 15 m and main fishing operation happens in less than 10 m depth (Fig.10).

Among the trawlers, overall length of the boat range is 15-20 m and horsepower varies between 110-400 HP. At Mandapam trawlers engine power ranged between 110-200 HP and at Rameswaram and Pamban boats are bigger with 400 HP engines. The strength of the crew is between 3-4 at Mandapam and 5-6 persons per boat at Rameswaram. Other major trawl landing centres of Palk Bay are Soliakudi, Jagathapattinam, Kottaipattinam, Sethubavachathram and Mallipattinam and their locations are shown in the Figure 11.

Figure 10. Mandapam trawl landing centre at Palk Bay

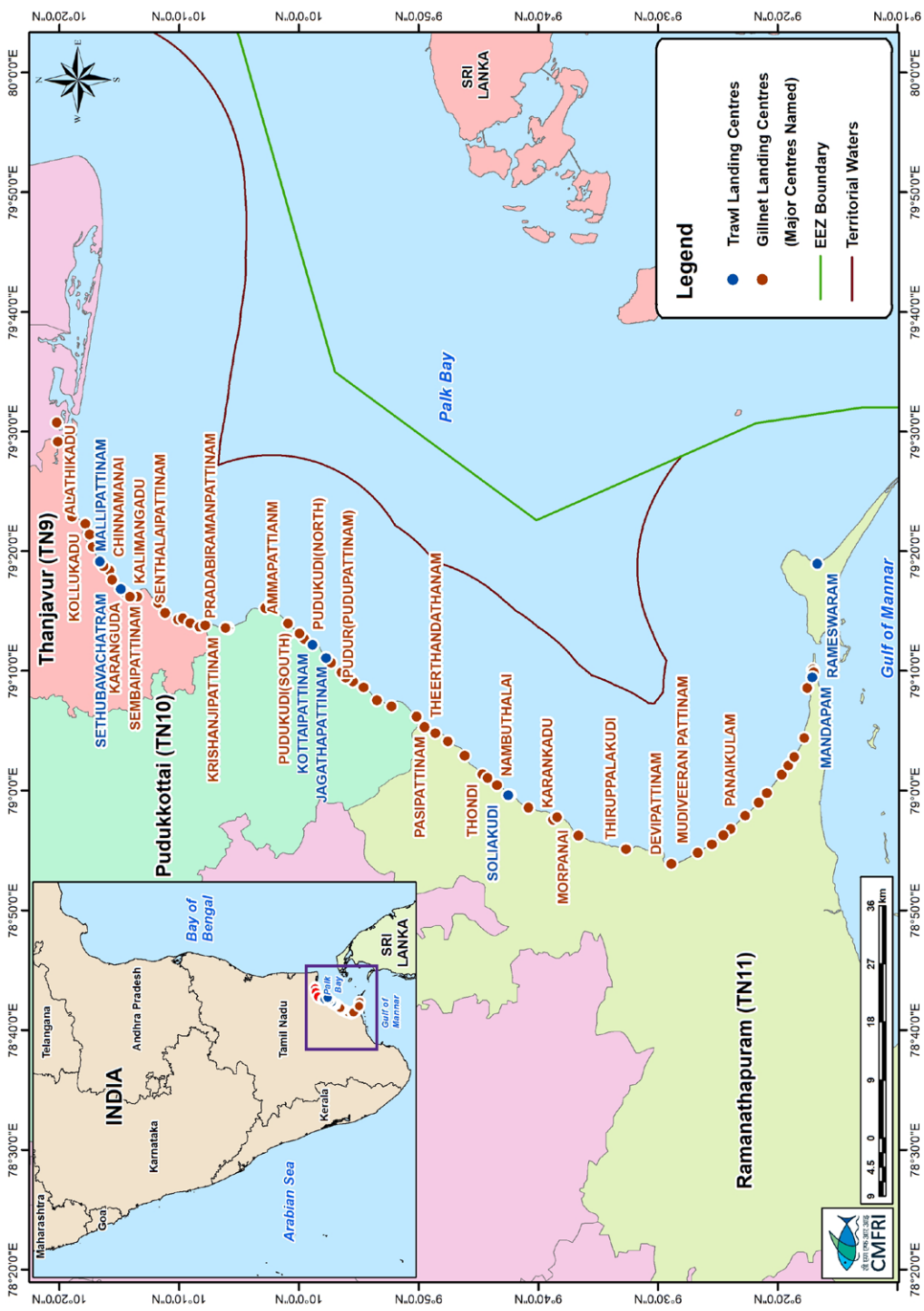



Figure 11. Map showing major trawl landing centres of the Palk Bay

Palk Bay total BSC trawl landings during 2007-2017 was 19320 tonnes with an average landing of 1756 tonnes, catch per unit effort 9.5 kg and catch rate (catch per hour) 0.57 kg. The highest landing was recorded in 2008 (2472 tonnes) and lowest in 2017 (1218 tonnes). Overall, the landings were fluctuating during 2007-2013 period and thereafter showed a declining trend. Maximum share was contributed by Rameswaram (5488 tonnes), followed by Mandapam (4150 tonnes) and Kottaipattinam (2846 tonnes) landing centres. Total BSC landings in trawls and centre-wise landings for the 2007-2017 period are presented in the Figures 12-21.

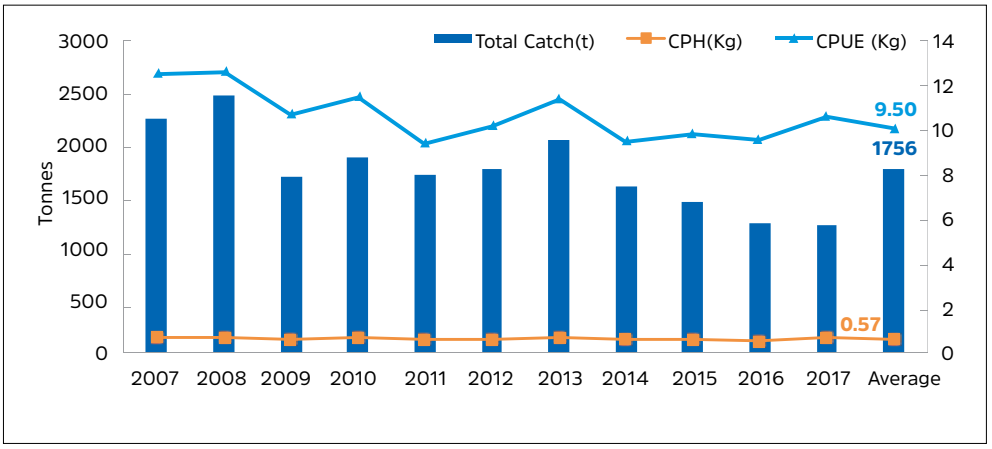



Figure 12- Total BSC landings from trawl at Palk Bay during 2007-2017

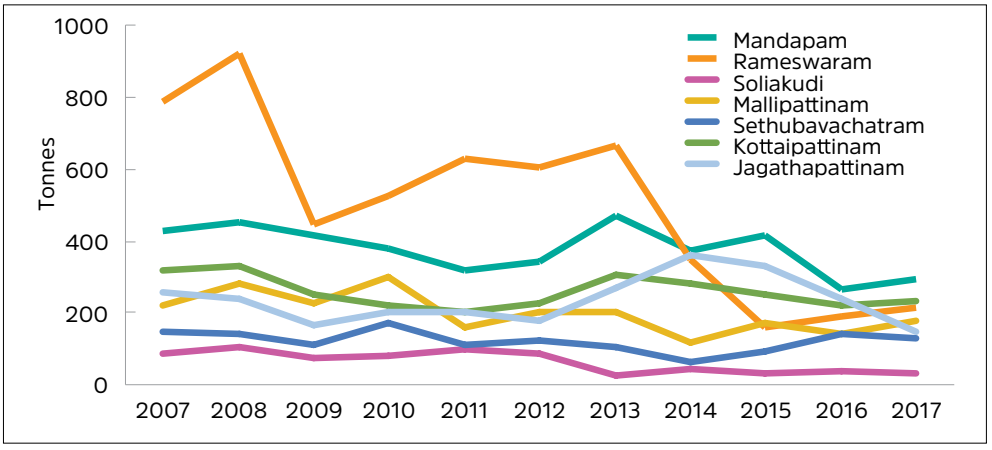



Figure 13- Total BSC landings from trawl centres of Palk Bay during 2007-2017

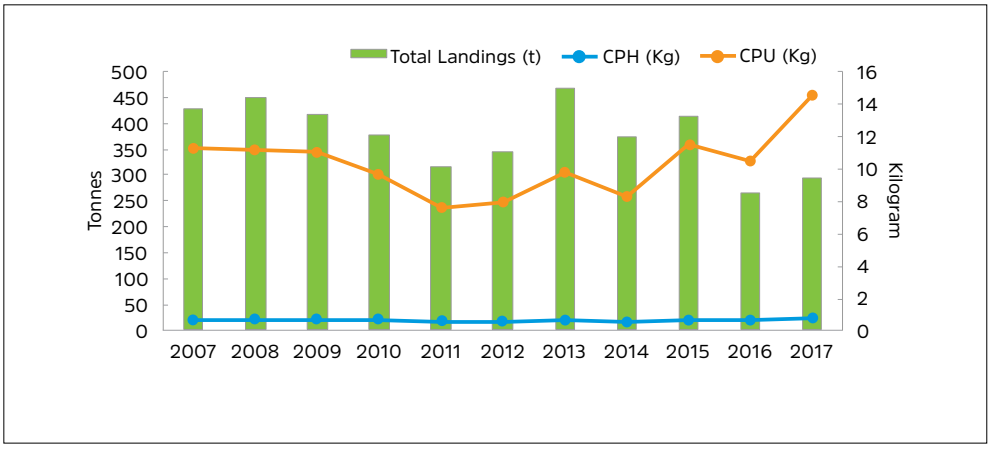



Figure 14- Total BSC landings from Mandapam (PB) during 2007-2017

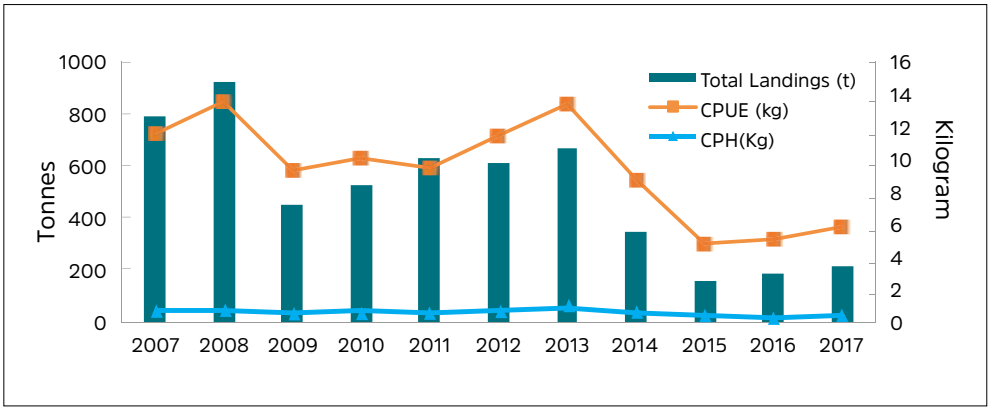



Figure 15- Total BSC landings from Rameswaram (PB) during 2007-2017

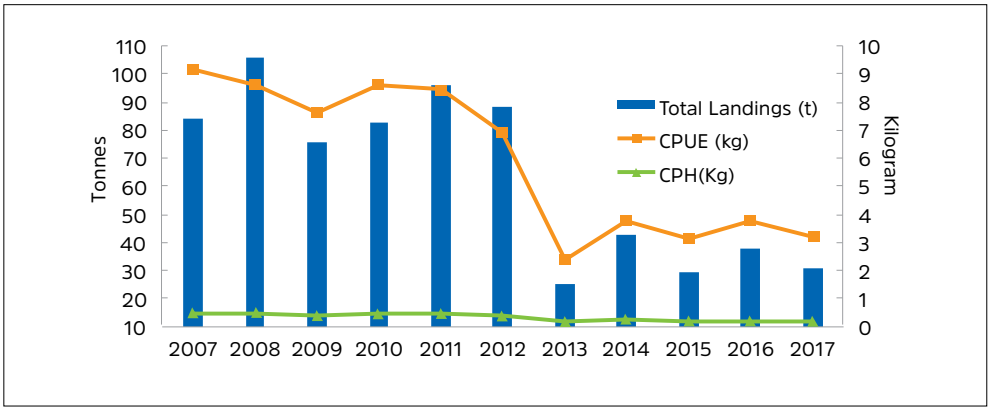



Figure 16- Total BSC landings from Soliakudi (PB) during 2007-2017

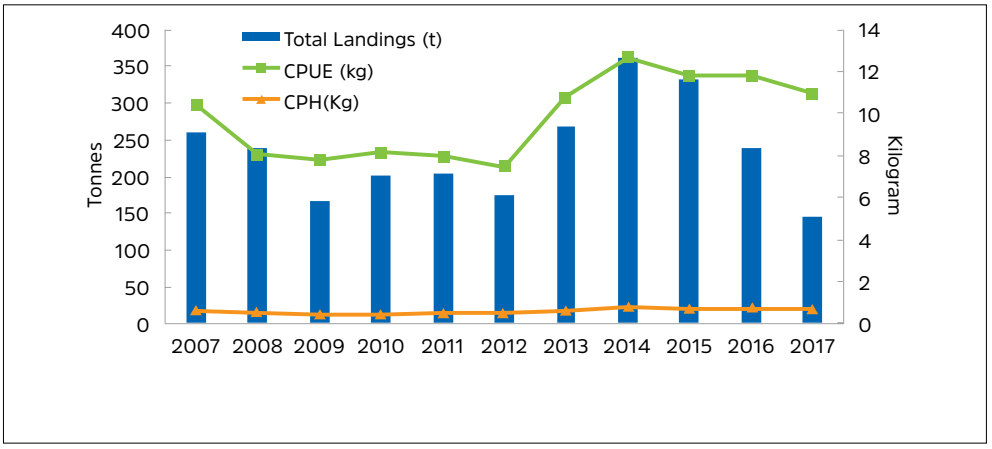



Figure 17- Total BSC landings from Jagathapattinam (PB) during 2007-2017

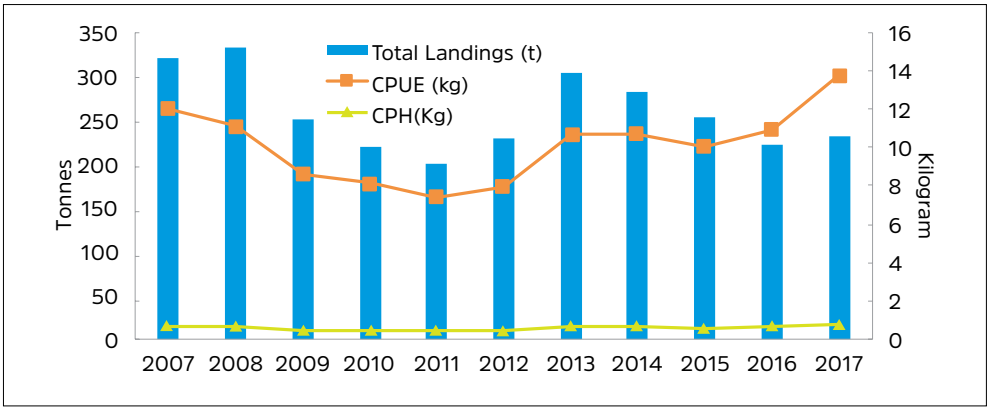



Figure 18- Total BSC landings from Kottaipattinam (PB) during 2007-2017

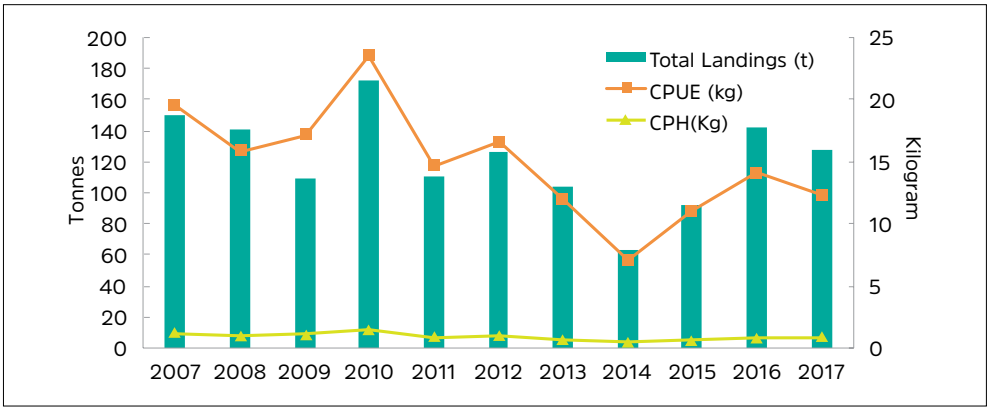



Figure 19- Total BSC landings from Sethubavachatram (PB) during 2007-2017

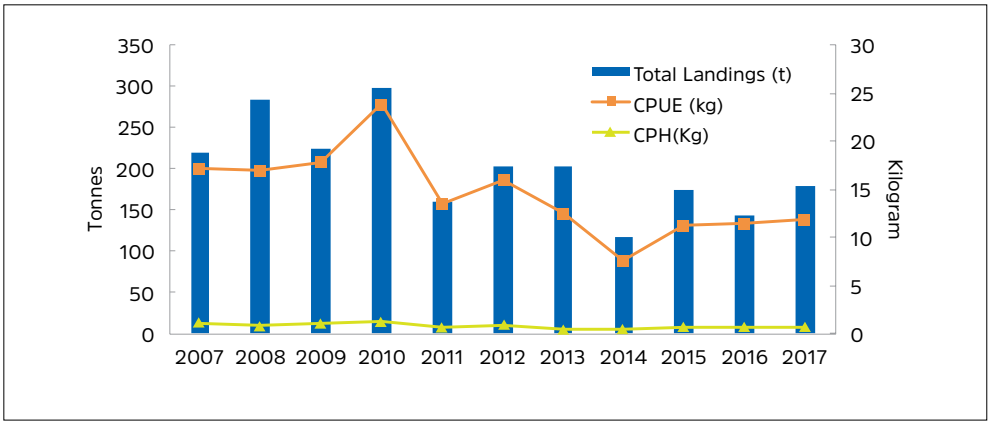



Figure 20- Total BSC landings from Mallipattinam (PB) during 2007-2017

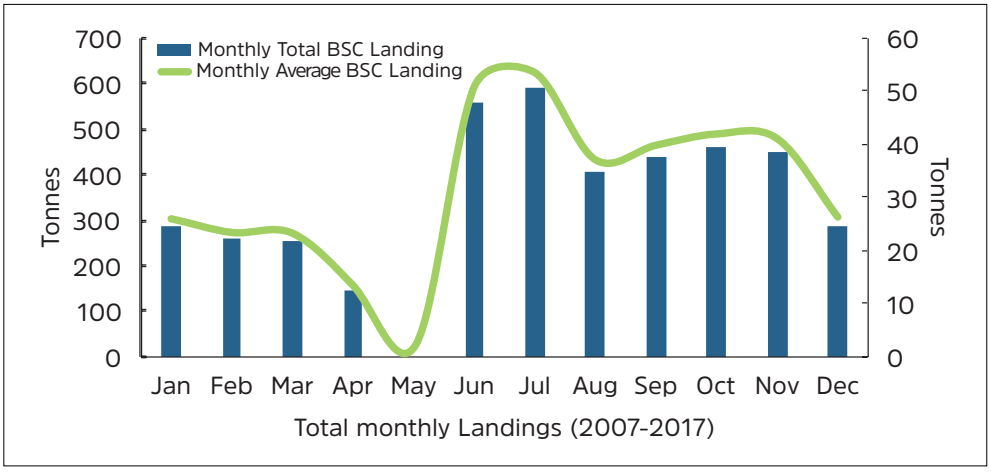



Figure 21- Monthly BSC trawl landings (t) at Mandapam (PB) during 2007-2017

## 3.6b. Gillnet

At many centres in Palk Bay such as Thondi, Karankadu, Devipattinam etc., crab fishery is exclusively by a traditional set gillnet known as *nanduvalai,* which is in use for several decades in the area. Earlier days fishermen used dug-out canoes with overall length varying between 3-7 m with 2-3 crew members which is locally known as *Vathai.* Later they started using similar type of bigger crafts in a size range of 7-12 m, commonly known as *Vallam* and accommodates 3-4 fishermen. These traditional crafts usually carry 15-20 nets depending on the number of crew.

However, in recent years 95% of these wooden crafts been replaced with fibre glass boats and their overall length range between 7.5-10 m. A single craft carries 30-35

nets; boat owner carries 15 numbers and other crew 10 each. Each net is 60-100 m in length and 90-120 cm in height, many of these joints are tied together to make up the length of each *nanduvalai* to 1000-1200 m. The netting is made of high-density nylon mono-filament with a stretched mesh of 80-110 mm. The head rope is a nylon with a 1.5 cm in thickness and small floats are attached at intervals of about one and a half feet or marked by flag and the foot rope is with small sinkers. Each sinker weighs about 20g and in one complete stretch of net a total of 350 numbers of sinkers are used weighing about 7kg in total weight. These help the bottom of the net to rest firmly on the sea bed or little above, and the net form a loose upright wall making the crabs entangle in it. Both sides of the nets also attached to an anchor and flags will be attached as a warning to other fishing crafts passing through the area. Some fishers use GPS to mark the position of the set nets. Each *nanduvalai* weighs about 35-40 Kg, comprising the weight of the nets, sinkers and floats. Total cost of the unit of *nanduvalai* is approximately Rs.7000/-.

The above is a general description about the *nanduvalai*; however, few variations have been noticed in size of the net and other aspects of crab nets used in different localities. Diagrammatic sketch of crab net used in 1950's is shown in Fig. 22 and major gillnet landing centres of Palk Bay are presented in the Figure 23.

The nets are used in fleets; several nets are tied end to end forming a long chain. Nets are spread parallel to the coastal line to a maximum length of 1 to 1.2 km in a single stretch in same direction and then to the opposite direction for the same length so that finally these nets form few rows, covering a considerable area in the sea. A decade back, majority of the boats were non-motorised and fishermen set sail for fishing during evening hours, carrying the fleet of these nets. One person rudders the *Vathai* or *Vallam,* while others lay the net at a depth of 4-5 metres

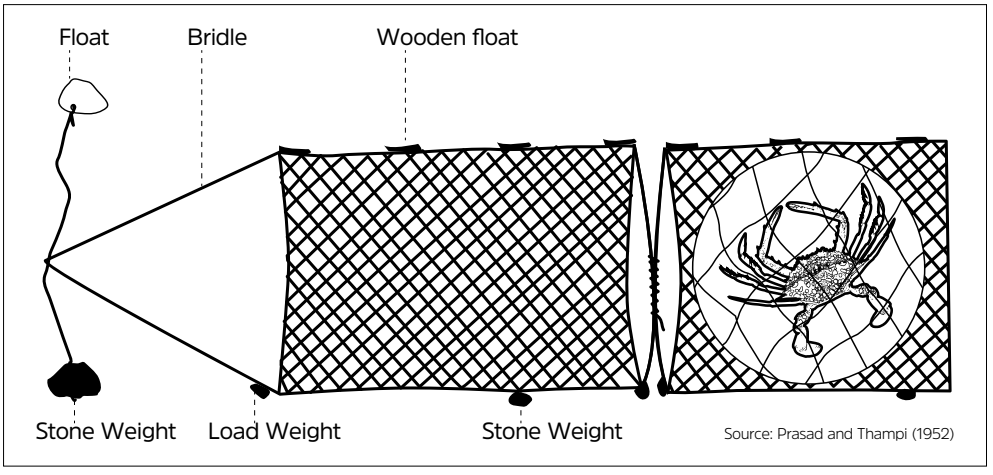



Figure 22- Diagram showing model of a crab net used in 1950's.

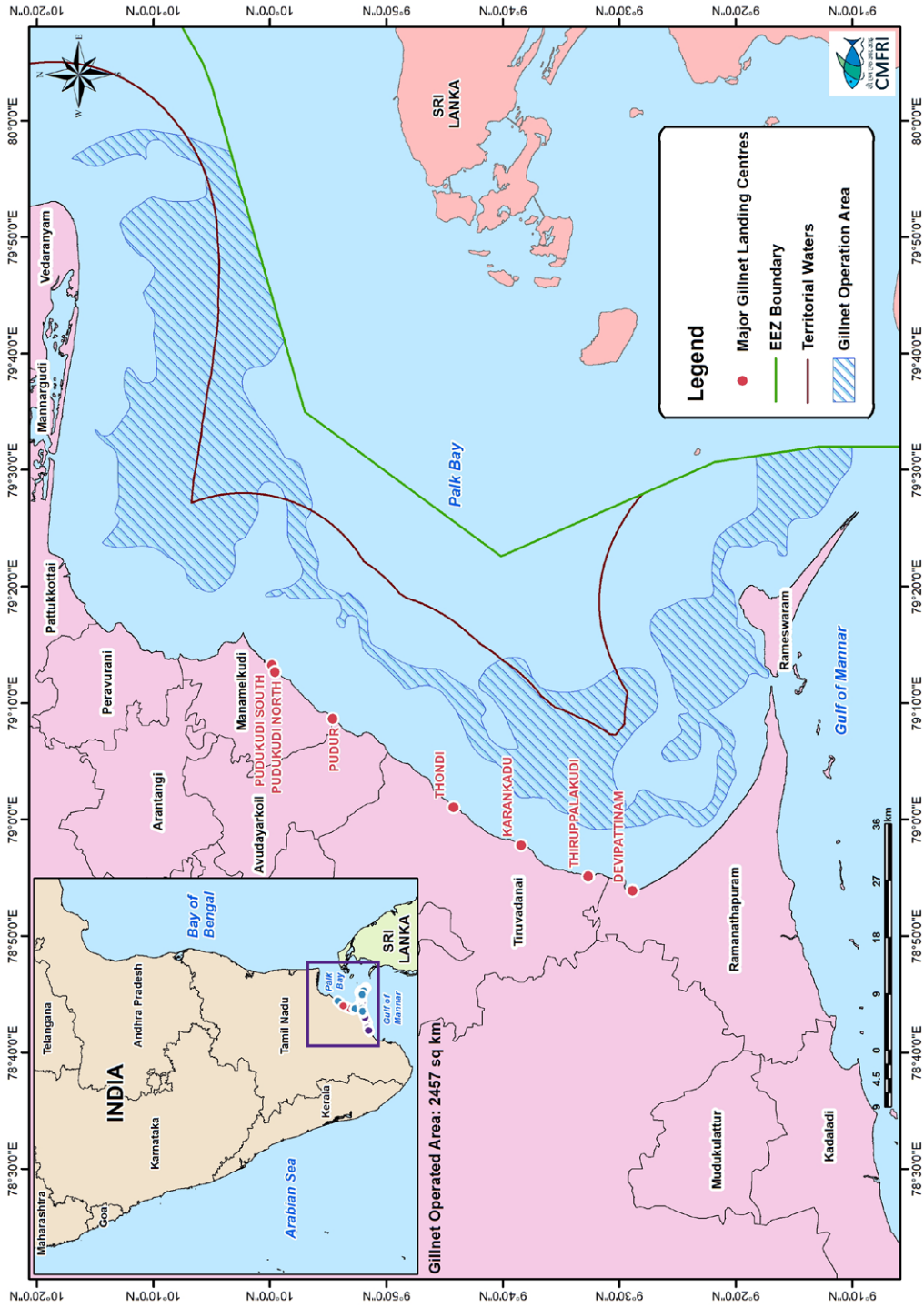



Figure 23- Major Gillnet landing centres in Palk Bay

and about 1.0 to 3 km from the shore. During those days the actual fishing period was three hours only *i.e.* in the first hour they spread the net, next one hour they will wait for entangling crabs and third hour will be spent for hauling the nets with entangled crabs. The crabs which try to cross the long chain of net get themselves further entangled in the meshes and cling to the nets. The entangled crabs are removed from the nets with much care and skill without breaking its appendages. These crabs are either sold in the local market or to the wholesale merchants.

However, this situation is changed, at present majority of the boats are motorised and fishermen go for fishing at afternoon hours and come back early morning hours around 5 am. Some fishermen come back to shore after laying the nets and then go back at the early morning to take out the gears and reach the shore around 7-8 am. They fish from deeper areas of 8-10 meters at a maximum distance of 10-12 Km. The nets are hauled manually, however the fishermen use inboard (IB) or outboard (OB) engines to reach the fishing ground. When gillnets carrying vessels are fitted with IB it is classified as IBBSGN (Inboard Bottom-set Gillnet) and if it

Figure 24- Crab fishing boat with an Outboard (OB) engine

Figure 25- A traditional craft *Vathai* with sail used for crab fishing in Palk Bay

Figure 26- BSC landing centre at Karankad, Palk Bay

is OB, it known as OBBSGN (Outboard Bottom-set Gillnet; Fig. 24). In some areas few crafts are still without any motorisation, working solely with sail and wind, those non-mechanised/ non-motorised are known as NMBSGN (Non-mechanised Bottom-set Gillnet; fig.25). In OBBSGN, an outboard motor is the propulsion system for boats, consisting of a self-contained unit that includes engine, gearbox and propeller or jet drive, designed to be affixed to the outside of the transom. They are the most common motorized method of propelling small crafts. In IBBSGN an inboard motor is a marine propulsion system for boats which is enclosed within the hull of the boat, usually connected to a propulsion screw by a drive-shaft. Motorised units use 9-10 HP engines (Kirloskar, Kangaroo, Texmo etc.) and total cost of the craft including engine ranges between Rupees 2-2.5 lakhs.

Figure 27- A Crab fisherman with *nanduvalai*

Figure 28- Crab fishers cleaning their nets after landing the day's catch – A view from Damodirapattinam, Palk Bay

Figure 29- Devipattinam Crab landing centre at dawn with crab boats

Figure 30- Crab landing centre at Thondi

Major crab landing centres have collection centres of crab processing companies and crab catch is directly sold to the companies. The present whole sale price of BSC is between Rs.250-300/Kg. These centres also have the steam cooking facility and crabs landed are steam cooked in fresh condition. After cooling, the cooked crabs are packed in polythene bags (approximately 8 kg/bag) and transported to the processing units. Details of total BSC landings and catch details (other than trawl) from Palk Bay is presented in the Figure 31.

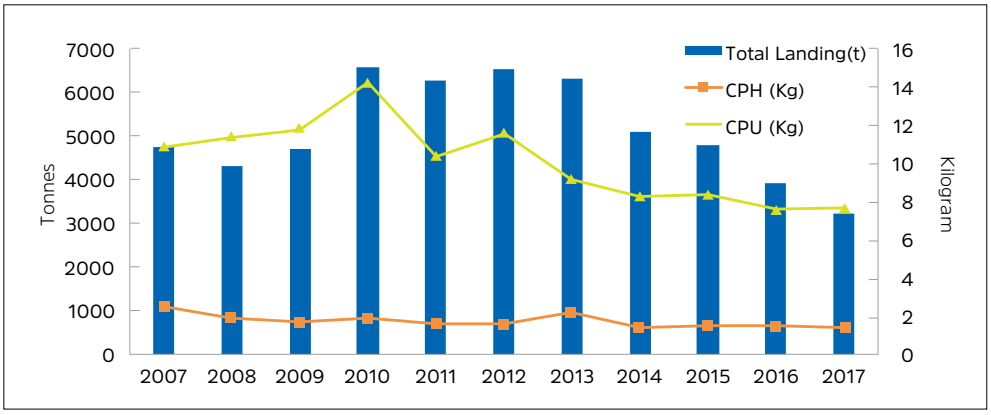



Figure 31- Total BSC landings from Palk Bay (Other than trawl) during 2007-2017

The year-wise total BSC landings in gillnets and catch rate (CPUE & CPH) in Zones TN-11, TN-10 & TN-9 are given in Figures 32 to 36. Crabs are the major species (>95%) landed in this gear. By-catch of other species is very meagre. Species composition of crabs shows that in TN-11 (Ramanathapuram) 98.24% of the landing comprised of BSC, 1.5% by *P. sanguinolentus* and 0.2% by *Charybdis natator* during 2007-2017; In TN-10 (Pudukkottai), 98.65% by BSC and rest by *P. sanguinolentus* and TN- 9 (Thanjavur) 99.53% was by BSC only.

BSC gillnet landings at Ramanathapuram during 2007-2017 mainly contributed by four type of gillnets i.e., OBBSGN (7306 tonnes), NMBSGN (1943 tonnes), IBBSGN (739 tonnes) and OBGN (547 tonnes). Among these, OBBSGN's share was consistently good and during the period contributed 70% of the BSC landings in the zone. From 2013 onwards, NMBSGN and IBBSGN landings were very poor and OBGN showed an increasing trend. Year-wise details are given in Figure 32.

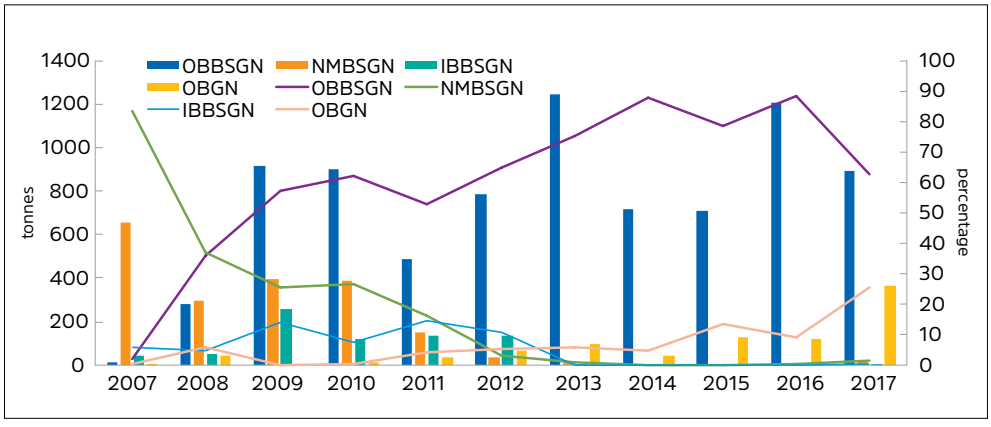



Figure 32- BSC landings in gillnets and their percentage at TN-11 (Ramanathapuram) during 2007-2017

Catch rate of these four gillnets is presented in Figure 33. Catch rate in IBBSGN recorded a sudden increase in 2012 though the catches almost uniform during 2011 & 2012. It was due to drastic reduction in effort (54%) than 2011 and in the following year (2013) number of units further reduced by 93% and contribution by the IBBSGN was only1.68 tonnes, recording reduction in both catch per unit effort (CPUE) and catch per hour (CPH).

At Pudukkottai (TN-10) during 2007-2017, BSC gillnets landings were mainly contributed by OBBSGN. On an average, 89% of the landing was contributed by them and in some years (2009,2011, 2013 & 2014) almost 99 % of the entire catch was landed by OBBSGN. Non- mechanised gillnets (NMBSGN) not been operating since 2013 and OBGN contributed a small share during 2011-2012 & 2015-2017 (<1 to <5%). The OBBSGN landings during the period is presented in the Figure 34.

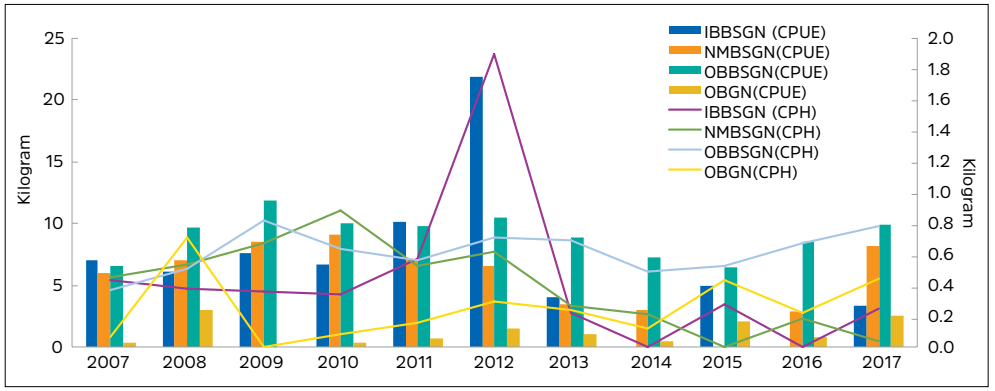



Figure 33- Catch rate of BSC in gillnets at TN-11 (Ramanathapuram) during 2007-2017

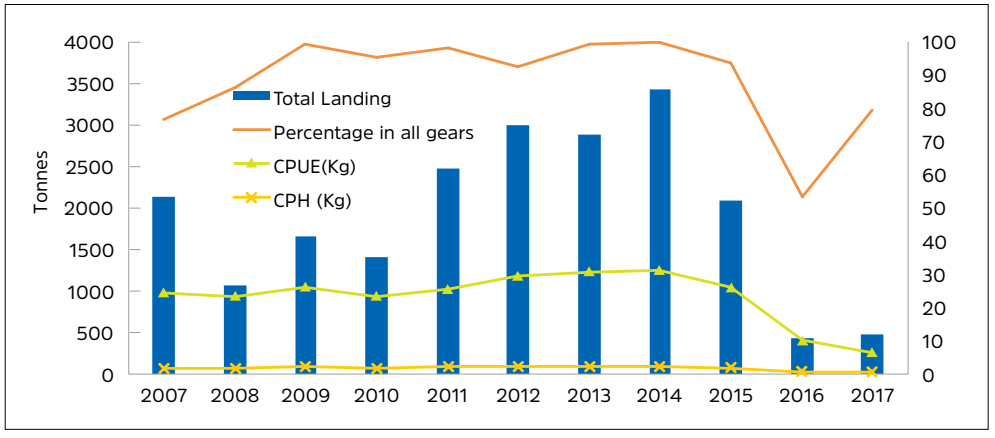



Figure 34- BSC landings in major gillnet at TN-10 (Pudukkottai) during 2007-2017

At Thanjavur, during 2007-2017, major portion of the gillnet landing was contributed by OBBSGN (84%) and other main contribution was by OBGN (10%). In OBBSGN maximum landing was recorded during 2010 (3296 tonnes) and in OBGN during 2012 (384 tonnes). In OBBSGN catch per unit effort (CPUE) ranged between 34.2 kg (2007) & 8.21 kg (2014) whereas, in OBGN it was between 0.5 kg (2009) & 5.65 kg (2010). Catch per hour (CPH) in OBBSGN ranged between 0.51 kg (2014) & 2.2 kg (2007) and in OBGN between 0.1 kg (2007) & 0.45 (2010). Details are presented in the Figures 35-36.

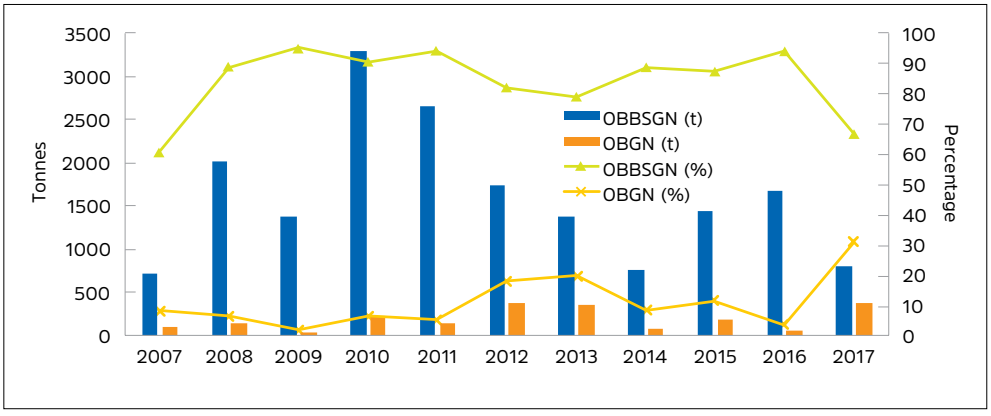



Figure 35- BSC landings in major gillnets at TN-9 (Thanjavur) during 2007-2017

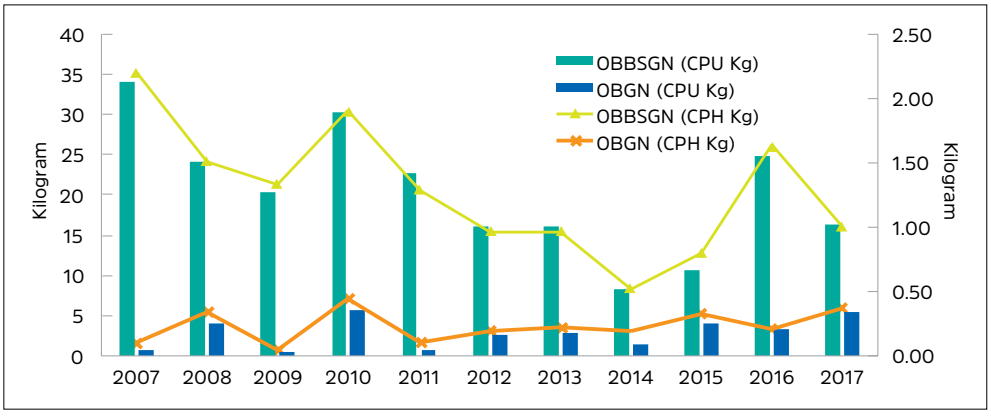



Figure 36- Catch rate of BSC in gillnets at TN-9 (Thanjavur) during 2007-2017

## 3.7. Historic-data in Trawl and Gillnets

Historical information is available on the BSC fishery from the Palk Bay (Ameer Hamsa, 1978; Josileen, 2001; Josileen & Menon, 2007; Rajamani and Palanichmay,2010) included in present study as these would be beneficial to get a better understanding the successive growth of the fishery and to compare the trends.

BSC trawl and gillnet landings in Palk Bay & Gulf of Mannar during 1972-74 was 510 tonnes and 227 tonnes respectively. Year-wise details are presented in the Table 8. During 1995-'98, the total estimated catch of *P. pelagicus* at Mandapam (Palk Bay) was 502.4 tonnes with an average CPUE (catch per unit effort) and CPH (catch per hour) of 4.2 kg and 0.3 kg respectively and details are presented in Table 9. In all the years, the maximum catch was recorded during June at Mandapam (PB) and the size (CW) composition in fishery was contributed by size ranging from 70-195 mm. The major portion of the catch was contributed by 105-170 mm group in both the sexes. The Maximum recorded size was 195 mm for male and 193 mm for female.

Table- 8. Estimated monthly catches of *Portunus pelagicus* (tonnes) at Palk Bay & Gulf of Mannar during 1972-1974.

| Year | 1972 | | 1973 | | 1974 | |
|---|---|---|---|---|---|---|
| Gear | Gillnet | Trawl Net | Gillnet | Trawl Net | Gillnet | Trawl Net |
| Jan | 20.37 | 3.74 | 17.08 | 11.11 | 9.87 | 19.18 |
| Feb | 22.50 | 2.92 | 14.56 | 8.38 | 11.35 | 7.64 |
| Mar | 12.90 | 2.89 | 19.36 | 5.18 | 14.90 | 8.34 |
| Apr | 12.62 | 3.25 | 19.02 | 6.77 | 18.73 | 12.10 |
| May | 11.79 | 2.25 | 19.18 | 3.64 | 15.75 | 7.82 |
| Jun | 13.76 | 2.69 | 14.18 | 3.27 | 15.58 | 9.43 |
| Jul | 13.01 | 3.31 | 14.73 | 4.24 | 9.69 | 6.96 |
| Aug | 15.58 | 2.68 | 13.06 | 7.62 | 13.81 | 3.86 |
| Sep | 12.45 | 2.87 | 17.34 | 8.25 | 11.68 | 5.47 |
| Oct | 11.34 | 2.22 | 14.37 | 10.66 | 11.39 | 9.55 |
| Nov | 11.21 | 2.97 | 11.66 | 4.74 | 12.19 | 12.07 |
| Dec | 10.05 | 2.84 | 12.47 | 6.49 | 10.14 | 9.97 |
| Total | 167.58 | 34.63 | 187.01 | 80.34 | 155.07 | 112.39 |

Source: Ameer Hamsa (1978)

Table- 9. Total Trawl BSC Landings (tonnes) at Mandapam (PB) during 1995-98

| Year | Total Units | Total Fishing Hours | Total Catch (t) | CPH (kg) | CPUE (kg) | % of Crab in Total Landings |
|---|---|---|---|---|---|---|
| 1995-96 | 41110 | 535290 | 197.243 | 0.39 | 4.8 | 3.3 |
| 1996-97 | 41582 | 540697 | 181.755 | 0.33 | 4.4 | 3.5 |
| 1997-98 | 36344 | 475730 | 123.386 | 0.26 | 3.4 | 2.6 |
| Total | 119036 | 1551717 | 502.384 | 0.32 | 4.2 | 3.2 |

Source: Josileen (2001)

At Thirupalakudi the total BSC landings in 2007 & 2008 were 98 t with a CPUE of 5.5 Kg and 57 t with a CPUE of 4.9 kg respectively. The details of BSC landings from Thirupalakudi is given in Table 10. At Devipattinam, the estimated catch for the three years was 108.2 t with a CPUE of 13.3 kg and CPH of 4.4 kg during 1995-'98 (Table 11). The maximum catch was during September in the first year, March in the second year and June in the last year. The fishery was contributed by size range of 81-182 mm. The maximum recorded sizes for male and female were 182 and 176 mm respectively.

Table- 10. Total BSC Landings and catch details at Thirupalakudi (PB) during 2007-08

| | 2007 | | | 2008 | | |
|---|---|---|---|---|---|---|
| Months | No. of Units | Estimated Catch (kg) | Catch rate (CPU) | No. of units | Estimated Catch (kg) | Catch Rate (CPU) |
| Jan | 1625 | 12253 | 7.5 | 1032 | 1649 | 1.6 |
| Feb | 1944 | 14061 | 7.2 | 1012 | 5674 | 5.6 |
| Mar | 1688 | 13631 | 8.1 | 1020 | 5352 | 5.2 |
| Apr | 1938 | 12385 | 6.4 | 1075 | 4475 | 4.2 |
| May | 1553 | 10008 | 6.4 | 588 | 2530 | 4.3 |
| Jun | 336 | 915 | 2.7 | 1038 | 5001 | 4.8 |
| Jul | 1610 | 10259 | 6.4 | 850 | 4928 | 5.8 |
| Aug | 1339 | 6238 | 4.7 | 1274 | 4043 | 3.2 |
| Sep | 1534 | 6281 | 4.1 | 1063 | 5869 | 5.5 |
| Oct | 1840 | 4962 | 2.7 | 840 | 5370 | 6.4 |
| Nov | 1274 | 4479 | 3.5 | 805 | 5877 | 7.3 |
| Dec | 1050 | 2672 | 2.5 | 880 | 5896 | 6.7 |
| Total | 17731 | 98144 | 5.5 | 11477 | 56664 | 4.9 |

Source: Rajamani & Palanichamy (2010)

Table- 11. Total BSC Landings and catch details at Devipattinam (PB) during 1995-98

| Year | Total Units | Total Fishing Hours | Total Catch (t) | CPH (kg) | CPUE (kg) |
|---|---|---|---|---|---|
| 1995-96 | 3937 | 11811 | 30.33 | 2.6 | 7.7 |
| 1996-97 | 2686 | 8056 | 42.615 | 5.3 | 15.9 |
| 1997-98 | 1508 | 4524 | 35.222 | 7.8 | 23.4 |
| Total | 8131 | 24391 | 108.167 | 4.4 | 13.3 |

Source: Josileen (2001)

## 3.8. By-catch

### Crab Gillnets

Crab gillnet, commonly known as *nanduvalai* mainly target *Portunus pelagicus* (BSC) and bulk of the landings from the different centres of Thanjavur (TN-9), Kottaipattinam (TN-10) and Ramanathapuram (TN-11) are composed of BSC. Other species included were other crabs and fishes. None of the ETP species protected by GoI were reported in the gillnet landings. The details are provided below and catch composition of other species in three districts are presented in Tables 12-17 (Annexure).

### Thanjavur (TN-9)

During 2007-2017, bulk of the BSC landings (84.2%) was contributed by bottom-set gillnet (OBBSGN) and other crabs included were *Portunus sanguinolentus* (2011 & 2017) and *Scylla serrata* (2007) and their percentage of contribution was < 1%. Year wise details are presented in the Figure 37 and details of other species are presented in Table 12. Other species contributed 16% and among them, the Waigieu seaperch *Psammoperca waigiensis* was dominant with 29.9% followed by the stingray *Himantura spp.* (23.5%), the flower shrimp *Penaeus semisulcatus* (12%), the Slender bambooshark *Chiloscyllium indicum* (7.4%), the rabbitfish *Siganus spp.* (4%), the emperor *Lethrinus spp.* (3.6%) and the threadfin *Polynemus* spp. (1.3%).

### Pudukkottai (TN-10)

During 2007-2017, more than 50% of the total landings was contributed by bottom-set gillnet (OBBSGN) and it was the dominating gear throughout period, the except for 2016 and 2017 (Fig. 38) and 88.5% of the total BSC catch also recorded from the same gear. Among the crabs landed, 98.7% was BSC, 1.3 % *Portunus sanguinolentus* and 0.009% *Scylla serrata*, which was recorded only in 2017 and

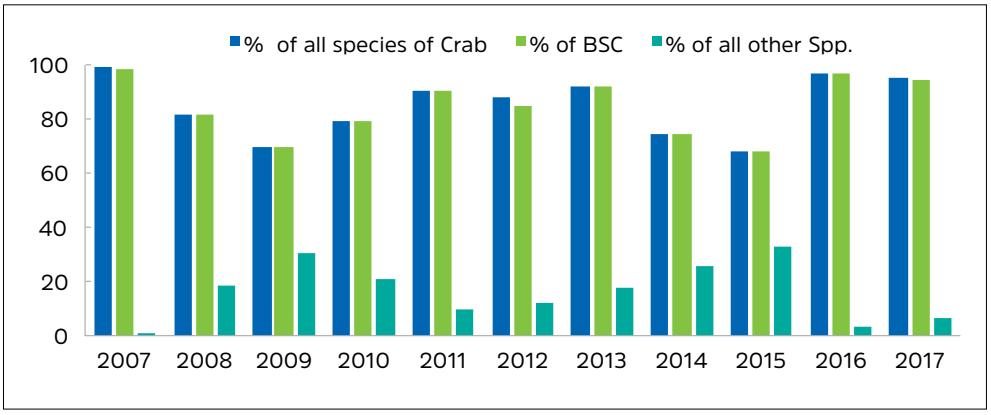



Figure 37- Catch Composition (%) in OBBSGN at Thanjavur (TN-9) during 2007-2017

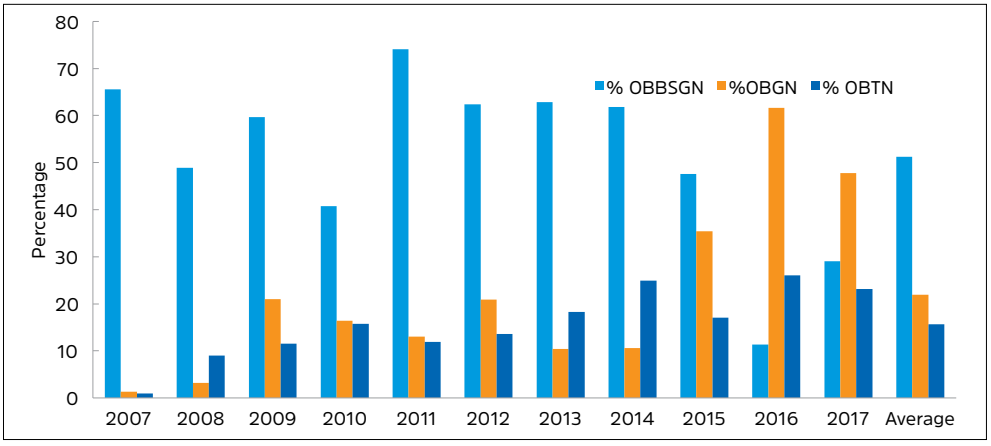



Figure 38- Percentage of gear composition in total Landings (TN-10) during 2007-2017

the details from all the gillnets are presented in the Figure 39. Among the other species *Sardinella* spp. was dominating with 21.2% followed by *Chiloscyllium indicum* (4.87%), *Penaeus semisulcatus* (4.72%), *Arius* spp. (2.71%), *Chiloscyllium* spp. (2.61%), *Himantura* spp. (2.15%) and *Siganus* spp. (1.75%). More than fifty percent (54.5%) of the catch was comprised by miscellaneous group. The details are given in the Table 13.

## Ramanathapuram (TN-11)

During 2007-2017, more than 60% of the BSC catch in the zone was contributed by bottom set gillnet OBBSGN followed by NMBSGN (17.6%) and the details are presented in the Figure 40. Among the crabs landed, 98.3% was BSC, 1.5 % *Portunus sanguinolentus* and 0.2% *Charybdis natator*, which was recorded only

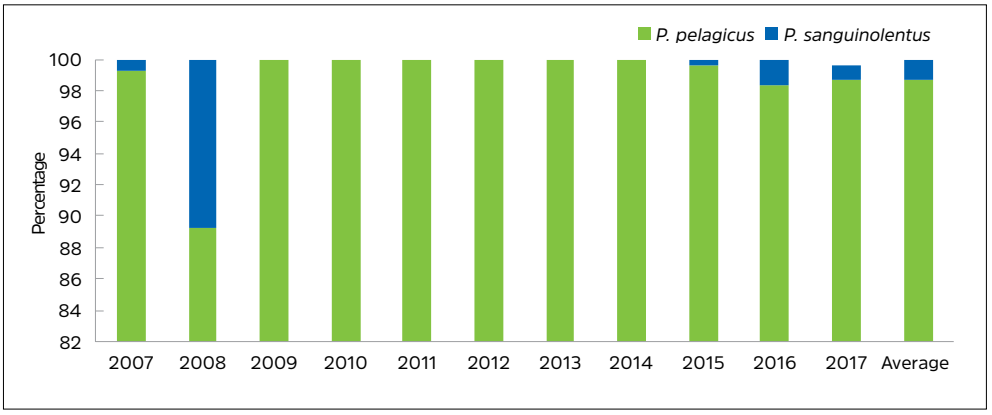



Figure 39- Catch Composition (%) of crabs in gillnets at Pudukkottai (TN-10) during 2007-2017

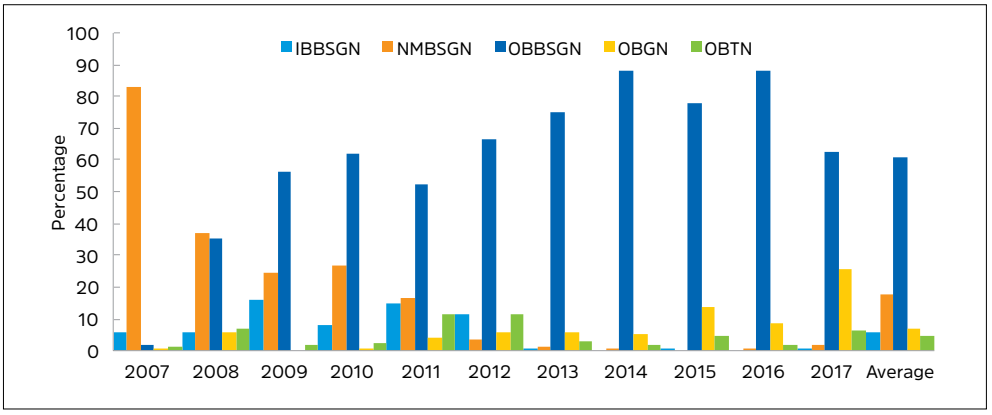



Figure 40- Percentage composition of BSC in different gears at TN-11 during 2007-2017.

in four years in negligible quantities. The details of the species composition are presented in the Figure 41.

Percentage of by catch is less in NMBSGN (8.6%) and IBBSGN (19%) whereas in major contributing gear OBBSGN nearly 40% comprised of other species. The details are presented in Figure 42 and Tables-14-17 (Annexure).

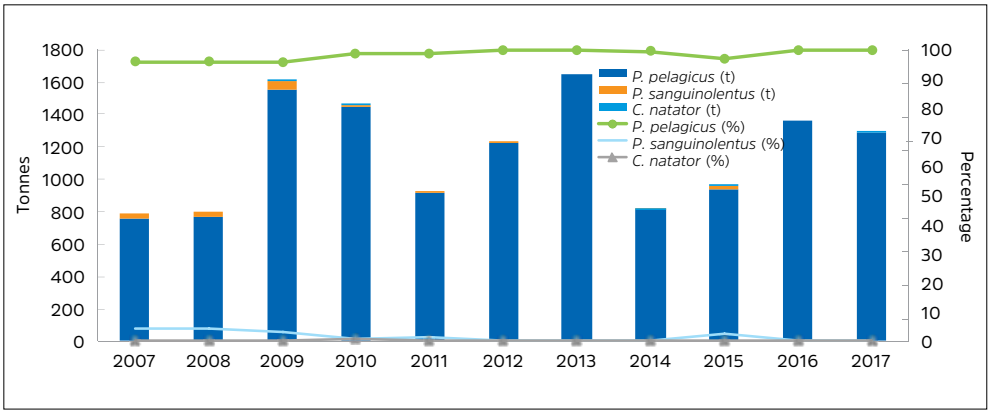



Figure 41- Species composition of crabs in gillnets at TN-11 during 2007-2017

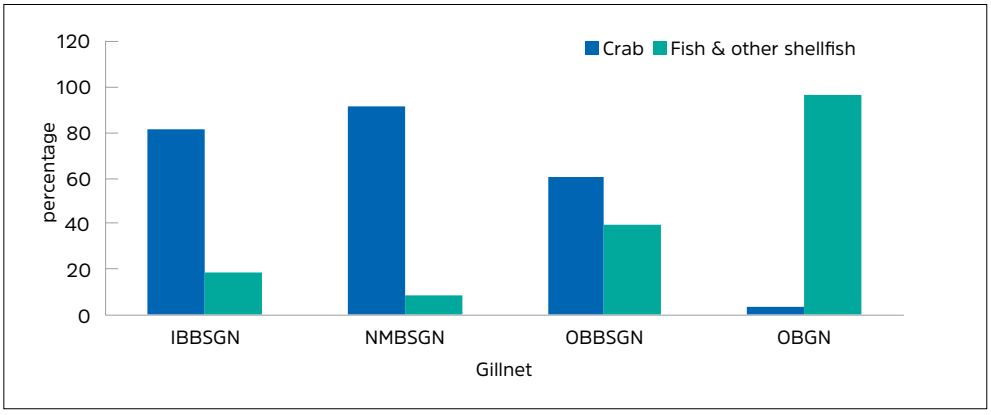



Figure 42- Percentage of resources in gillnets at TN-11 (Ramanathapuram) during 2007-2017

## Trawl

Crabs are landed as bycatch in trawls which targets for fishes and shrimps. The crabs (BSC) are kept live and individually tied and brought the shore for selling to the merchants in live condition. Among the crabs landed at Mandapam during this period, 89% were BSC and the for the last 4 years their percentage was 99-100%. Other species were *Calappa* spp. (8%), *Portunus sanguinolentus* (2.3%), negligible quantities of *Charybdis natator*, *Charybdis* spp., and *Scylla serrata* (only 0.1% in 2010). The details are presented in Figures 43 & 44.

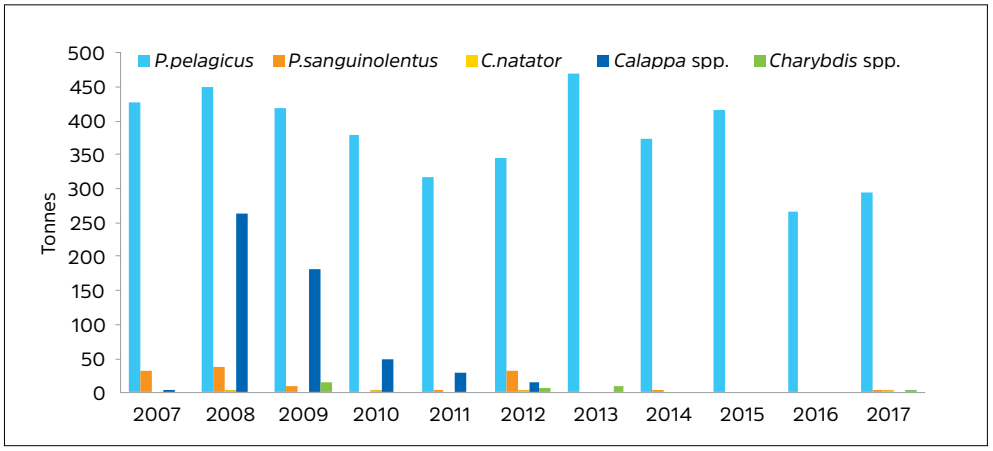



Figure 43- Estimated crab landings (t) at Mandapam (PB) during 2007-2017

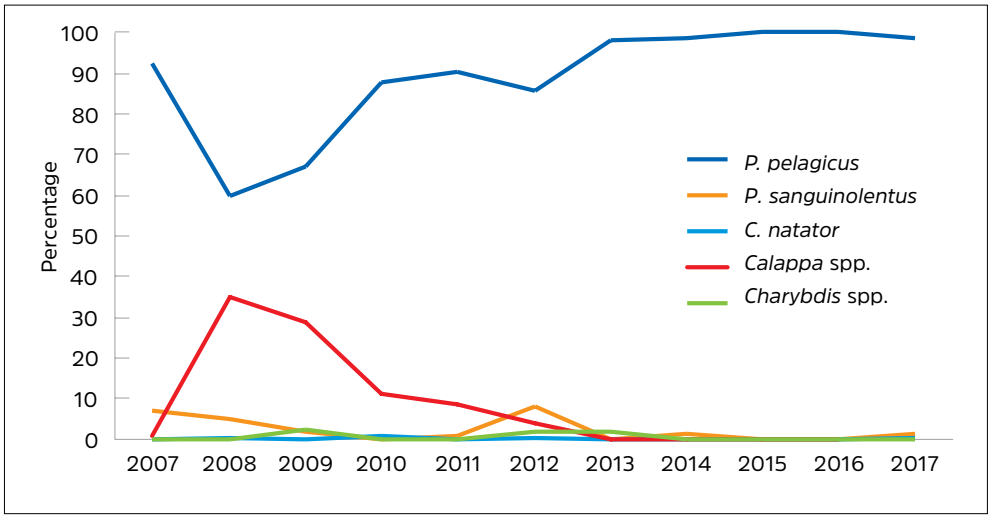



Figure 44- Species composition of crabs (%) at Mandapam (PB) during 2007-2017

## 3.9. Annexure for Tables

Table 12- Catch of other species recorded in OBBSGN (tonnes)– Thanjavur district (TN-9)

| Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total (t) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Arius* spp. | | | | | | 1 | 13 | 7 | | | | 21 | 0.6 |
| *Caranx* spp. | | | | | | | 8 | | | | | 8 | 0.2 |
| *Chiloscyllium indicum* | | 16 | 3 | 94 | 73 | 9 | | 80 | | | | 275 | 7.4 |
| *Gerres* spp. | | | | | | | | | | | 1 | 1 | 0 |
| *Himantura* spp. | 2 | 168 | 99 | 432 | 118 | 14 | 0 | 45 | 0 | 0 | 0 | 878 | 23.5 |
| *Kathala axillaris* | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 5 | 0.1 |
| *Lethrinus* spp. | 0 | 0 | 134 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 134 | 3.6 |
| Miscellaneous | 6 | 114 | 38 | 0 | 0 | 61 | 66 | 56 | 185 | 51 | 39 | 616 | 16.5 |
| *Mugil* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 6 | 0.2 |
| *Penaeus semisulcatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 446 | 0 | 0 | 446 | 12 |
| *Polynemus* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 48 | 0 | 0 | 0 | 0 | 48 | 1.3 |
| *Psammoperca waigiensis* | 0 | 151 | 234 | 242 | 107 | 169 | 95 | 63 | 54 | 1 | 0 | 1116 | 29.9 |
| *Scomberoides* spp. | | | | | | | 21 | | | | | 21 | 0.6 |
| *Sepia aculeata* | | | | | | | | | 3 | | 0 | 3 | 0.1 |
| *Sepia* spp. | | | | | | | | | 3 | | | 3 | 0.1 |
| *Sepioteuthis lessoniana* | | | | | | | | | 3 | | 0 | 3 | 0.1 |
| *Siganus* spp. | | | 101 | 34 | | | | 12 | | | 2 | 149 | 4 |
| Total (t) | 8 | 449 | 608 | 802 | 298 | 253 | 261 | 262 | 694 | 51 | 43 | 3729 | 100.0 |

Table 13- Catch of other species recorded in OBBSGN–Pudukkottai district (TN-10)

| Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total (t) | % in Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Arius* spp. | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 61 | 65 | 2.71 |
| *Carcharhinus sorrah* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.03 |
| *Chiloscyllium indicum* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 56 | 116 | 4.87 |
| *Chiloscyllium* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 62 | 62 | 2.61 |
| *Dasyatis* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0.09 |
| *Gerres* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0.13 |
| *Himantura* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 51 | 2.15 |
| *Metapenaeus* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 0.23 |
| Miscellaneous | 170 | 70 | 101 | 93 | 150 | 142 | 154 | 169 | 115 | 47 | 85 | 1296 | 54.52 |
| *Octopus* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 28 | 28 | 1.20 |
| *Penaeus semisulcatus* | 11 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 2 | 16 | 72 | 112 | 4.72 |
| *Psammoperca waigiensis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 8 | 32 | 1.36 |
| *Sardinella* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 252 | 252 | 0 | 0 | 503 | 21.17 |
| *Scoliodon laticaudus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 0 | 19 | 0.78 |
| *Sepia pharaonis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 4 | 0 | 6 | 0.26 |
| *Siganus canaliculatus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 13 | 0.55 |
| *Siganus* spp. | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 29 | 6 | 42 | 1.75 |
| *Terapon* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.03 |
| *Triacanthus* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0.03 |
| *Trichiurus lepturus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.2 | 0.01 |
| *Upeneus* spp. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 14 | 0.57 |
| *Uroteuthis duvaucelii* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 6 | 0.25 |
| Total | 191 | 70 | 101 | 93 | 162 | 142 | 154 | 420 | 371 | 220 | 452 | 2377 | 100.00 |

Table 14- Catch of other species recorded in IBBSGN–Ramanathapuram district (TN-11)

| Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total (t) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Arius* spp. | | 10059 | 53634 | | 0 | 0 | | 0 | 0 | 0 | | 63693 | 36.12 |
| *Caranx* spp. | | | 10584 | | | | | | | | | 10584 | 6.00 |
| *Carcharhinus* spp. | 2790 | | | | | | | | | | | 2790 | 1.58 |
| *Gerres* spp. | | | 24108 | | | | | | | | 1680 | 25788 | 14.62 |
| *Himantura* spp. | | | 2940 | 5712 | | | | | | | | 8652 | 4.91 |
| *Lethrinus* spp. | | | 1764 | | | | | | | | 1680 | 3444 | 1.95 |
| *Lutjanus* spp. | | | | | | | | | | | 560 | 560 | 0.32 |
| Miscellaneous | | | 280 | 1395 | | | | | | | | 1675 | 0.95 |
| *Mugil* spp. | | | 3724 | | | | | | | | | 3724 | 2.11 |
| *Penaeus indicus* | | 1929 | | | | | | | | | | 1929 | 1.09 |
| *Penaeus semisulcatus* | | | 3920 | | | | | | | | | 3920 | 2.22 |
| *Pennahia* spp. | | 406 | | | | | | | | | | 406 | 0.23 |
| *Platycephalus indicus* | | 609 | | | | | | | | | | 609 | 0.35 |
| *Platycephalus* spp. | | | 4410 | | | | | | | | | 4410 | 2.50 |
| *Psammoperca waigiensis* | | | 2058 | | | | | | | | | 2058 | 1.17 |
| *Scomberoides* spp. | | | 4704 | | | | | | | | | 4704 | 2.67 |
| *Scomberomorus commerson* | | | 8820 | | | | | | | | | 8820 | 5.00 |
| *Sepia aculeata* | | | 6416 | | | | | | | | | 6416 | 3.64 |
| *Sepia pharaonis* | 1116 | | 2713 | | | | 630 | | | | | 4459 | 2.53 |
| *Sepioteuthis lessoniana* | | | 4774 | | | | | | | | | 4774 | 2.71 |
| *Siganus* spp. | | | | | | | | | | | 280 | 280 | 0.16 |
| *Upeneus* spp. | | | 12642 | | | | | | | | | 12642 | 7.17 |
| Total | 3906 | 13003 | 147491 | 7107 | 0 | 0 | 630 | 0 | 0 | 0 | 4200 | 176337 | |

Table 15- Catch of other species recorded in OBBSGN–Ramanathapuram district (TN-11)

| Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total(t) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Arius* spp. | | | | 32550 | | 4340 | 46293 | 30042 | 152935 | 118680 | 12462 | 397302 | 7.3 |
| *Arothron (=Tetradon)* spp. | | | | | | | | | | 2940 | 3780 | 6720 | 0.1 |
| *Caranx* spp. | | | | 9114 | | | 15913 | 3388 | 17360 | 19752 | | 65527 | 1.2 |
| *Carcharhinus* spp. | | | | | 9548 | | | 8463 | | | | 18011 | 0.3 |
| *Chanos chanos* | | | | | | | | | 3472 | | | 3472 | 0.1 |
| *Chiloscyllium indicum* | | | | 9765 | | 3892 | 20364 | 4557 | | 17188 | 1800 | 57566 | 1.1 |
| *Cynoglossus* spp. | | | 2240 | | | | 5787 | | | 5840 | | 13867 | 0.3 |
| *Decapterus* spp. | | | | | | | | | | 8820 | | 8820 | 0.2 |
| *Gerres* spp. | | | | 36022 | | 36750 | 119535 | 43811 | 232883 | 183097 | 26623 | 678721 | 12.5 |
| *Himantura* spp. | | | | 22360 | 16501 | 6500 | 15419 | | 7595 | 71742 | | 140117 | 2.6 |
| *Himantura uarnak* | | | | | | 10633 | | | | | | 10633 | 0.2 |
| *Holothuria (Metriatyla) scabra* | | | | | | | | 5880 | | | | 5880 | 0.1 |
| *Hypolophus (=Pastinachus) sephen* | | | | | | 2387 | | | | | | 2387 | 0.0 |
| *Leiognathus* spp. | | | 6720 | | | | | | 36260 | 4620 | | 47600 | 0.9 |
| *Lethrinus* spp. | | | | 9440 | | | | 24617 | 11935 | | 1890 | 47882 | 0.9 |
| Miscellaneous | | | 388 | 3906 | | 6076 | | | 33869 | | | 44239 | 0.8 |
| *Mugil cephalus* | | | | | | | | 19502 | | 17240 | 26505 | 63247 | 1.2 |
| *Mugil* spp. | | | | | 2315 | | 2219910 | | 5208 | | | 2227433 | 41.0 |
| *Nematalosa nasus* | | | | | | | 12727 | | | | | 12727 | 0.2 |
| *Octopus* spp. | | | | | 2170 | | | | | 7233 | 11768 | 21171 | 0.4 |
| *Otolithes ruber* | | | | | | | | | 20832 | | | 20832 | 0.4 |
| *Pateobatis bleekeri (H. bleekeri)* | | | | | | 1302 | | | | | | 1302 | 0.0 |

| Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total(t) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pellona ditchela* | | | | | | | | 4410 | 20615 | 61540 | 17955 | 104520 | 1.9 |
| *Penaeus indicus* | | | 7140 | | | | | | 4600 | 9779 | 17457 | 38976 | 0.7 |
| *Penaeus monodon* | | | | | | | | | | | 2539 | 2539 | 0.0 |
| *Penaeus semisulcatus* | | | 26880 | | 19964 | | 26040 | | 1996 | 17850 | 68185 | 160915 | 3.0 |
| *Pennahia anea (macrophthalmus)* | | | | | | | | | | 2940 | | 2940 | 0.1 |
| *Pennahia* spp. | | | 2352 | 7595 | | | | | | | 1116 | 11063 | 0.2 |
| *Platycephalus indicus* | | | | | | | 15273 | | | 84 | | 15357 | 0.3 |
| *Polynemus* spp. | | | | 5425 | | | | | | | | 5425 | 0.1 |
| *Pomadasys* spp. | | | | | | | | | 868 | | | 868 | 0.0 |
| *Psammoperca waigiensis* | | | | | 3472 | 9135 | 20482 | 20615 | 19468 | 9859 | | 83031 | 1.5 |
| *Sardinella albella* | | | | | | | 53340 | | | | | 53340 | 1.0 |
| *Sardinella gibbosa* | | | | | | | 14980 | | | | | 14980 | 0.3 |
| *Sardinella longiceps* | | | | | | | | | | 2520 | | 2520 | 0.0 |
| *Scarus (=Callyodon)* spp. | | | | | | | | | 248 | | | 248 | 0.0 |
| *Scomberoides* spp. | | | | 22785 | | | 6837 | | | | | 29622 | 0.5 |
| *Selaroides leptolepis* | | | | | | | | | | | 10416 | 10416 | 0.2 |
| *Sepia aculeata* | | | 6160 | 7378 | | | 43171 | 14463 | 30359 | 50647 | 6548 | 158726 | 2.9 |
| *Sepia pharaonis* | | | 2240 | 9765 | 6923 | | 51028 | 9290 | | 39038 | 3259 | 121543 | 2.2 |
| *Sepia* spp. | | | | | | 36540 | 26040 | 24705 | 35986 | | 36386 | 159657 | 2.9 |
| *Sepiella inermis* | | | | | | | | | | 16275 | | 16275 | 0.3 |
| *Sepioteuthis lessoniana* | | | | | | | 20365 | | 10831 | 58783 | 11624 | 101603 | 1.9 |
| *Sepioteuthis* spp. | | | | | 13671 | | | | | | 10769 | 24440 | 0.4 |
| *Sepioteuthis* spp. | | | | | | | | | | | 10769 | 10769 | 0.2 |
| *Siganus* spp. | | | | 3255 | 2170 | 210 | 32285 | 14000 | 496 | 7368 | 26281 | 86065 | 1.6 |

| Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total(t) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sillago* sihama | | | | | | | | | 37240 | 27125 | 6944 | 71309 | 1.3 |
| *Sphyraena* spp. | | | | | | | 16520 | | 1984 | 35452 | 6820 | 60776 | 1.1 |
| *Terapon* spp. | | | | | | | 2893 | 3600 | | 168 | 3100 | 9761 | 0.2 |
| *Triacanthus biaculeatus* | | | | | | | 19091 | | | | | 19091 | 0.4 |
| *Triacanthus* spp. | | | | | | | | | | | 9792 | 9792 | 0.2 |
| *Turbinella(= Xancus) pyrum* | | | | | 3906 | | | | | | | 3906 | 0.1 |
| *Upeneus* spp. | | | 2352 | 7812 | | | 65329 | | 24322 | 40983 | | 140798 | 2.6 |
| *Uroteuthis (=L. duvaucelli)* | | | | | | | 6491 | | | | | 6491 | 0.1 |
| *Uroteuthis(Photololigo) (=Loligo)* spp. | | | | | | | 5063 | | | | | 5063 | 0.1 |
| Total | | | 56472 | 187172 | 80640 | 117765 | 2881176 | 231343 | 711362 | 837563 | 334788 | 5438281 | 100.0 |

Table 16- Catch of other species recorded in NMBSGN–Ramanathapuram district (TN-11)

| Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total(t) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Arius* spp. | 7903 | 3823 | | | 868 | | 1910 | 0 | 0 | 0 | | 14504 | 7.8 |
| *Gerres* spp. | 1380 | 2170 | | | | | | | | | | 3550 | 1.9 |
| *Himantura* spp. | | | | | | | | | | | 1240 | 1240 | 0.7 |
| *Leiognathus* spp. | | | 651 | | | | 1085 | | | | | 1736 | 0.9 |
| *Lethrinus* spp. | | | 217 | | | | 155 | | | | | 372 | 0.2 |
| *Lutjanus* spp. | | | | | | | 310 | | | | | 310 | 0.2 |
| Miscellaneous | 21916 | 13373 | 35748 | 17083 | 6541 | 6222 | | | | | | 100883 | 54.4 |
| *Mugil cephalus* | | 8680 | | | | | | | | | | 8680 | 4.7 |
| *Mugil* spp. | 6311 | | | | | | | | | | | 6311 | 3.4 |
| *Nematalosa nasus* | | | 2713 | | | | | | | | | 2713 | 1.5 |
| *Penaeus indicus* | 2615 | | 21571 | | | | | | | | | 24186 | 13.0 |
| *Penaeus monodon* | 3020 | | | | | | | | | | | 3020 | 1.6 |
| *Penaeus semisulcatus* | | | 3325 | | | | | | | | | 3325 | 1.8 |
| *Platycephalus indicus* | | 723 | | | | | | | | | | 723 | 0.4 |
| *Psammoperca waigiensis* | | | 651 | | | | | | | | | 651 | 0.4 |
| *Sardinella longiceps* | | | | | | | 3720 | | | | | 3720 | 2.0 |
| *Sardinella* spp. | | 2170 | | | | | | | | | | 2170 | 1.2 |
| *Sepia pharaonis* | | 400 | | | | | | | | | | 400 | 0.2 |
| *Siganus* spp. | | | | | | | 155 | | | | | 155 | 0.1 |
| *Sillago sihama* | | | | | | | 3410 | | | | | 3410 | 1.8 |
| *Terapon* spp. | | 1447 | | | | | 620 | | | | | 2067 | 1.1 |
| *Upeneus* spp. | | | | | | | 1395 | | | | | 1395 | 0.8 |
| Total | 43145 | 32786 | 64876 | 17083 | 7409 | 6222 | 12760 | 0 | 0 | 0 | 1240 | 185521 | 100.0 |

Table 17- Catch of other species recorded in OBGN–Ramanathapuram district (TN-11)

| Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total(t) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ablennes hians* | 6975 | | | | | | | | | | | 6975 | 0.03 |
| *Amblygaster sirm (=Sardinella sirm)* | | | | | | | | | | | 8370 | 8370 | 0.04 |
| *Arius* spp. | 54336 | 140725 | 105381 | 157441 | 170016 | 104314 | 76674 | 57092 | 217147 | 251702 | 183170 | 1517998 | 6.35 |
| *Arothron(=Tetradon)* spp. | | | | | | | | | | 1176 | 27260 | 28436 | 0.12 |
| *Caranx* spp. | 9293 | 69603 | 42309 | 23380 | 96859 | 6510 | 29326 | 109410 | 84287 | 135762 | 50797 | 657536 | 2.75 |
| *Carcharhinus* spp. | | | | | 8680 | | | | | | 5355 | 14035 | 0.06 |
| *Chanos chanos* | | | | 3472 | 8333 | | | | | | 3301 | 15106 | 0.06 |
| *Chiloscyllium indicum* | | | | 11848 | 15190 | 10416 | 4340 | | 65884 | 25976 | 80106 | 213760 | 0.89 |
| *Chirocentrus* spp. | | | | | | | | 5580 | | 12152 | | 17732 | 0.07 |
| *Cynoglossus* spp. | | | | | | 868 | 10223 | | | 13755 | 1457 | 26303 | 0.11 |
| *Dasyatis* spp. | | | | | | 19096 | | | | | | 19096 | 0.08 |
| *Decapterus* spp. | | | | | | | | | | 6468 | | 6468 | 0.03 |
| *Dussumieria* spp. | | | | | | 6300 | 71749 | | | | 4960 | 83009 | 0.35 |
| *Gerres* spp. | 16149 | 28841 | 89531 | 243512 | 128357 | 134001 | 190728 | 285401 | 171843 | 347401 | 373078 | 2008842 | 8.40 |
| *Hemiramphus* spp. | 79980 | 31249 | 32800 | 17360 | 128257 | 868 | 140798 | 29211 | 66640 | 75534 | 50319 | 653016 | 2.73 |
| *Hilsa kelee* | | | | | | | | | | | 15314 | 15314 | 0.06 |
| *Hilsa* spp. | | | | | 4629 | | | | | 34944 | | 39573 | 0.17 |
| *Himantura* spp. | | | | | 3038 | 8680 | 60326 | | 8820 | | 5425 | 86289 | 0.36 |
| *Kathala axillaris* | | | | 3780 | | | | | | | | 3780 | 0.02 |
| *Leiognathus* spp. | | 29241 | 68204 | 38366 | 50610 | 5642 | 20317 | 110236 | 4340 | 14880 | 49674 | 391510 | 1.64 |
| *Lethrinus* spp. | 5400 | | 42290 | 54964 | 75591 | 11228 | 26786 | 55759 | 37155 | 50231 | 36648 | 396052 | 1.66 |
| *Loliolus (Nipponololigo)* spp. | | | | | | | 23725 | | | | | 23725 | 0.10 |
| *Lutjanus* spp. | 1350 | | | | 248 | 2548 | 4517 | 900 | | 20641 | 3342 | 33546 | 0.14 |
| *Megalaspis cordyla* | | | | | | | 2100 | | | 7750 | | 9850 | 0.04 |
| Miscellaneous | | 420 | 6615 | 1260 | 2205 | 8736 | | 2170 | | | | 21406 | 0.09 |
| *Mugil cephalus* | 10881 | 4340 | | | 16478 | 10705 | | 41520 | | 130741 | 71202 | 285867 | 1.20 |
| *Mugil* spp. | | 6510 | 15190 | 79227 | 92939 | 6944 | 61655 | | 30184 | | | 292649 | 1.22 |
| *Nematalosa nasus* | | | | | | | | | | | 18879 | 18879 | 0.08 |

| Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total(t) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Notarius lentiginosus (=A. lentiginosus)* | | | | | | | 21989 | | | | | 21989 | 0.09 |
| *Octopus* spp. | | | | | | | 3906 | 15700 | 32116 | 3617 | 56248 | 111587 | 0.47 |
| *Otolithes ruber* | | | | | | 2604 | | 5780 | 103460 | 49544 | 12783 | 174171 | 0.73 |
| *Pellona ditchela* | | | 3780 | | 16458 | 23581 | 51329 | 140728 | 137883 | 349888 | 1262 | 724909 | 3.03 |
| *Penaeus indicus* | | | | | | 8680 | 14616 | | 11920 | 12203 | 2232 | 49651 | 0.21 |
| *Penaeus monodon* | | | | | | | | | 1505 | | | 1505 | 0.01 |
| *Penaeus semisulcatus* | | 3183 | | | | 1736 | 11718 | 34284 | | 37044 | 7556 | 95521 | 0.40 |
| *Pennahia anea (macrophthalmus)* | | | | | | | | 41995 | | 32253 | | 74248 | 0.31 |
| *Pennahia* spp. | | 11772 | 9929 | | | | | | | | 10149 | 31850 | 0.13 |
| *Platax* spp. | | | | | | | 12731 | | | | | 12731 | 0.05 |
| *Platycephalus indicus* | | | | | | 1736 | 3992 | 600 | 11312 | 2025 | | 19665 | 0.08 |
| *Platycephalus* spp. | | | | | | 4340 | | | | | 372 | 4712 | 0.02 |
| *Plectorhinchus (=Gaterin)* spp. | | | 2520 | 12600 | | 4620 | | | | 800 | | 20540 | 0.09 |
| *Polynemus* spp. | | | | | | | | | 6944 | 3100 | 372 | 10416 | 0.04 |
| *Pomadasys* spp. | | 9259 | | | | | | | 45136 | | | 54395 | 0.23 |
| *Psammoperca waigiensis* | | 10416 | 7425 | 3255 | 38977 | 56960 | 17234 | 64223 | 6121 | 69236 | 5699 | 279546 | 1.17 |
| *Rastrelliger kanagurta* | | | | | | | 392 | | | | | 392 | 0.00 |
| *Sardinella albella* | 133920 | | | | | 562086 | 1567982 | 695110 | 272841 | 3749903 | | 6981842 | 29.21 |
| *Sardinella gibbosa* | 26505 | | | | | 264978 | 477739 | 143766 | 57288 | 485171 | 701299 | 2156746 | 9.02 |
| *Sardinella longiceps* | | | | | | | | | | 155311 | | 155311 | 0.65 |
| *Sardinella* spp. | | 6697 | 45000 | | | 30886 | 2170 | 4500 | 85560 | | 14467 | 189280 | 0.79 |
| *Saurida tumbil* | | | | | | | | 289 | 1736 | | | 2025 | 0.01 |
| *Scarus (=Callyodon)* spp. | | | | 1736 | | | | 145 | | | 900 | 2781 | 0.01 |
| *Scomberoides* spp. | | 3038 | 11700 | | | | 8506 | | | 31234 | 22801 | 77279 | 0.32 |
| *Scomberomorus commerson* | | 21700 | | | | | 3100 | | 8990 | 21700 | 504 | 55994 | 0.23 |
| *Selaroides leptolepis* | | | 63900 | | | | 5840 | | | | 20977 | 90717 | 0.38 |
| *Sepia aculeata* | | | | 3570 | 4166 | 9548 | 42853 | 92602 | 85279 | 110501 | 201389 | 549908 | 2.30 |
| *Sepia pharaonis* | | 217 | 13104 | 488 | 78430 | 3038 | 58825 | 51270 | 54544 | 74913 | 87996 | 422825 | 1.77 |

| Species | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Total(t) | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sepia* spp. | | | | | | 46230 | | | | | | 46230 | 0.19 |
| *Sepiella inermis* | | | | | | | | | | 8138 | 506 | 8644 | 0.04 |
| *Sepioteuthis lessoniana* | | 1736 | 8820 | 8409 | 39866 | 6510 | 51141 | 56584 | 46774 | 97682 | 315031 | 632553 | 2.65 |
| *Sepioteuthis* spp. | | | | | | | | | | | 18643 | 18643 | 0.08 |
| *Siganus canaliculatus* | | | | 5040 | 5670 | | | | | 1395 | | 12105 | 0.05 |
| *Siganus* spp. | 10463 | 6412 | 10800 | | 45327 | 17187 | 52087 | 104032 | 55860 | 111543 | 38447 | 452158 | 1.89 |
| *Sillago sihama* | | 11393 | 37632 | | | 2604 | 19560 | | 10230 | 61162 | 48474 | 191055 | 0.80 |
| *Sphyraena* spp. | 10881 | 13356 | 61612 | 35371 | 106186 | 81977 | 88173 | 28770 | 50489 | | 112224 | 589039 | 2.46 |
| *Stolephorus* spp. | | | | | | | | | | 210134 | 3750 | 213884 | 0.89 |
| *Strongylura* spp. | 4590 | | 43344 | 6076 | 104098 | 23800 | 162202 | 18491 | 21480 | 198121 | 98112 | 680314 | 2.85 |
| *Tenualosa ilisha (=Hilsa ilisha)* | | 3640 | | | | | | | | | 14868 | 18508 | 0.08 |
| *Terapon* spp. | | 8377 | 13888 | 3780 | 9383 | 4666 | 14637 | | 69440 | 38196 | | 162367 | 0.68 |
| *Thryssa dussumieri* | | 11139 | | | | | | | | | | 11139 | 0.05 |
| *Thryssa* spp. | | | | | | | 588 | 53494 | | 775 | | 54857 | 0.23 |
| *Trachinotus* spp. | | | | | 13888 | | | | | | | 13888 | 0.06 |
| *Triacanthus biaculeatus* | | 12586 | | | | | | | | | | 12586 | 0.05 |
| *Triacanthus* spp. | | | | | | | | 27900 | | | 19136 | 47036 | 0.20 |
| *Trichiurus* spp. | | | | | | | 1500 | | | 620 | | 2120 | 0.01 |
| *Tylosurus crocodilus* | 21168 | 2279 | | | 27082 | | | | | | | 50529 | 0.21 |
| *Upeneus* spp. | 12555 | 22568 | 40816 | 30059 | 77966 | 55948 | 138936 | 181248 | 92916 | 422058 | 260838 | 1335908 | 5.59 |
| *Uroteuthis(L. duvaucelli)* | | | | | | | 60890 | 4130 | | 756 | 9367 | 75143 | 0.31 |
| *Uroteuthis=Loligo)* spp. | | | | | | | 4687 | | | | | 4687 | 0.02 |
| Total | 404446 | 470697 | 776590 | 744994 | 1368927 | 1550571 | 3622587 | 2462920 | 1956124 | 7468136 | 3075059 | 23901051 | 100.00 |

# 4. BSC Price Structure

During 1995, when detailed studies on *P. pelagicus* was initiated, price of BSC was Rs.35/kg and by the year 2000 it has increased to Rs. 50/kg. Thereafter, the price has gone up as the local/export market, demand of the BSC was increasing steadily and currently the prices varies between Rs. 250-300/ Kg at the wholesale rate. Retail prices are much higher than this.

## 4.1. Value Chain

The fishers bring the BSC in live condition and sell them to the local merchants, most of them are associated with one of the processing companies. In some areas these traders are selling their crabs exclusively to one company. All the main BSC landing centres have their own crab cooking facilities and are set and maintained by

Figure 45–Steam cooked whole crabs (BSC).

the processing companies of the respective areas. After cooking the crabs in steam for 15 minutes and they are spread-out in steel trays for cooling to atmospheric temperature and then packed and transported to mini plants located nearby areas of the landing centres for meat picking (Fig. 45).

The details of raw crab meat utilized by the processing companies are presented Figure 46. This process would be completed within 24-48 hours and from there the picked meat is transported to the main processing plants of the companies ensuring strict quality control protocols. At the processing plants, final products are packed in appropriate cans or plastic containers after grading and shell removal. These containers are pasteurized with automated temperature controlled facilities and stored till shipment. The details of the products are presented in the Figure 47 (Source:CMPA).

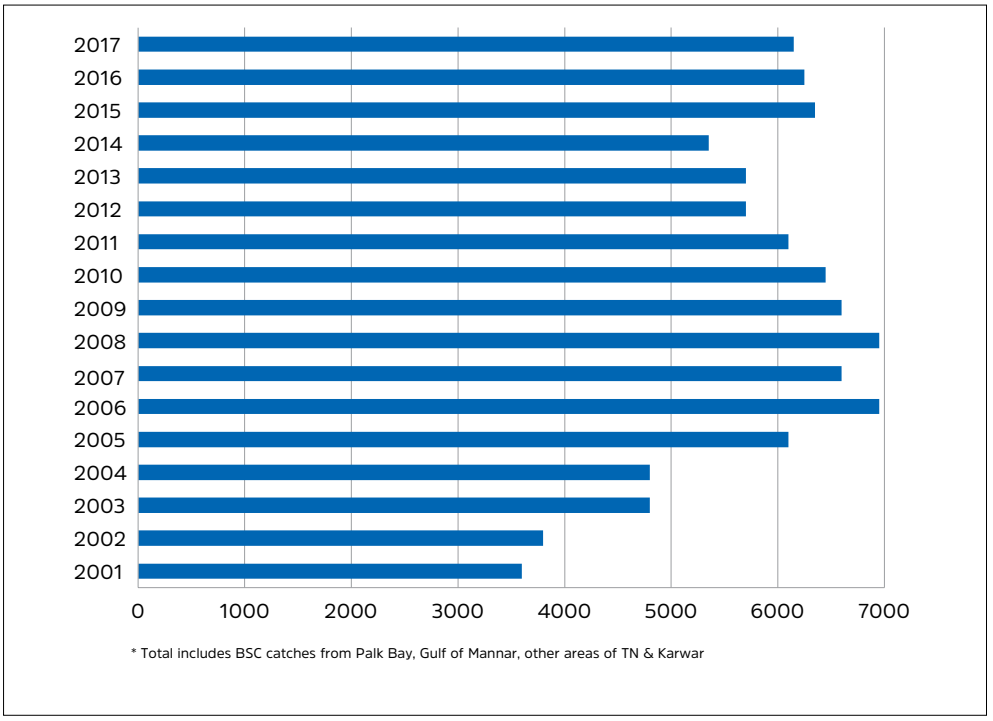



Figure 46- Total Raw Crab (t) utilized by processing companied during 2001-2017

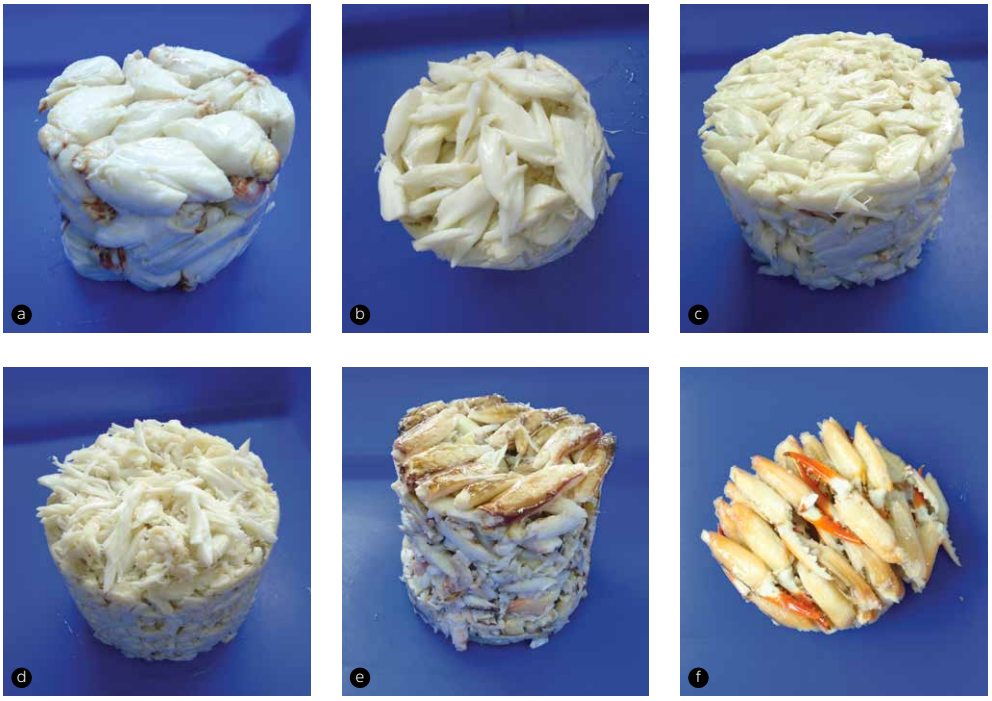


Figure 47- Different BSC pasteurised products exported from India
a) Jumbo b) Super lump c) Lump d) Special e) Claw meat f) Claw finger

## 4.2. Export

United States of America (USA) has been the biggest market for BSC and 99% of the Indian BSC products are exported to US and the remaining to Australia, Italy, Lebanon, Mauritius and Hong Kong. From India, BSC export is happening since 2001 and for the first four years the import was monopolised by Phillips Foods Inc., Baltimore, Maryland and currently apart from Phillips, five more US companies are importing Indian BSC products. The other companies are Chicken of the Sea Frozen Foods, Handy Seafood Incorporated, Newport International, Trans-Global Inc. and Harbor Seafood Inc.

The current export price for the crab meat ranges between 10-11 US $/ Can (454 g) and it was 12-13 US $/ Can in 2017 and 8-9 US $/ Can during 2015& 2016.

## 4.3. Crab Processing Companies

Presently seven processing companies are exporting the BSC resource from the region as well as other BSC fishing areas. The Indian Crab Processors Association

(ICPA) was established in 2013 with their head office at Tuticorin, Tamil Nadu. In 2016, they have rechristened the association as Crab Meat Processors Association (CMPA), to promote the crab meat industry in various aspects. The list of the companies (not an exhaustive list) is given in the Table 18.

Table 18- Details of Processing Companies with Crab Meat Processors Association (CMPA)

| Sl. No. | Name of the Company | Year of Establishment | Head Office |
|---|---|---|---|
| 1 | Phillips Foods India Pvt Ltd. | 2000 | Thoothukudi, Tamil Nadu |
| 2 | Handy Water Base India Pvt Ltd. | 2002 | Thoothukudi, Tamil Nadu |
| 3 | Sandy Bay Seafoods Pvt Ltd. | 2005 | Visakhapatinam, Andhra Pradesh |
| 4 | Vitality Aquaculture Pvt Ltd | 2008 | Thoothukudi, Tamil Nadu |
| 5 | Peninsular Fisheries Pvt Ltd | 2014 | Kanyakumari, Tamil Nadu |
| 6 | Britto Sea Foods Exports Pvt Ltd | 2015 | Thoothukudi, Tamil Nadu |
| 7 | Hirawathy Marine Products Pvt Ltd | 2017 | Porbandar, Gujarat |

# 5. BSC Biology & Life History

## 5.1. Life cycle

In *Portunus pelagicus* sexes can be easily differentiated from their colour patterns of dorsal exoskeleton. Males are brightly coloured and more attractive than females. The carapace of the male crab is brilliantly coloured with irregular white patches and the tips of chelate and walking legs bright blue, hence the name 'blue swimming crab'. But female crabs are dull brown in colour with small irregular white patches on the carapace and tips of chelate and walking legs are dark brown (Figs. 48 & 49).


Figure 48 Male crab of *Portunus pelagicus* (BSC) a) dorsal view b) ventral view


Figure 49 Female crab of *Portunus pelagicus* (BSC) a) dorsal view b) ventral view

Other sexual dimorphic characters in *P. pelagicus* are similar to that of other crabs. Sex is readily distinguished in larger individuals by the shape of the abdomen which is narrow and has the shape of inverted 'T' in males. In females, it is triangular in juveniles and changes to semi-circular in adult. In addition, male has relatively larger chelae than female. In mature crabs pleopods can be seen very clearly when abdominal flap is opened. Male has two pairs of pleopods modified as copulatory organs on the first and second abdominal somites. In the case of females, the first four abdominal somites carry pleopods, and are biramous and possess fine setae for attachment of the extruded eggs till hatching.

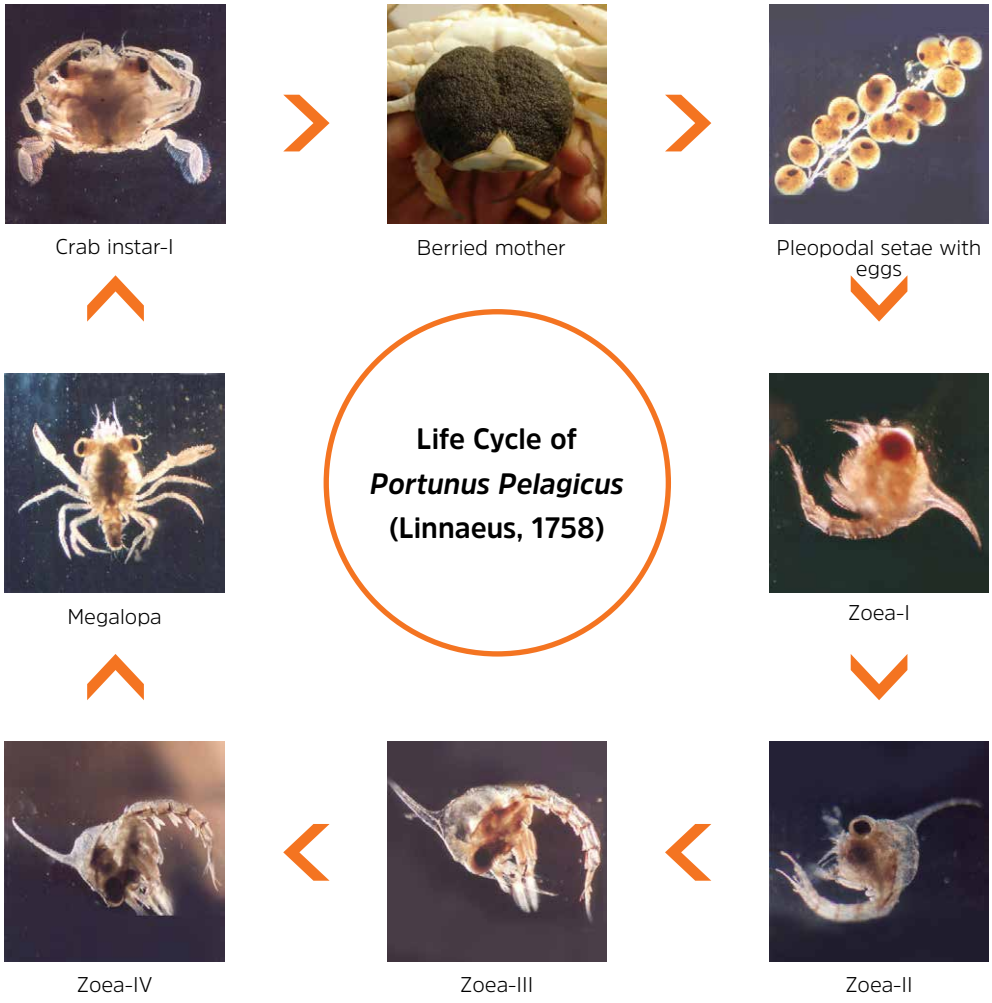



Figure 50- Life cycle of *Portunus pelagicus* (BSC) (Source: Josileen, 2001)

## 5.2. Larval Phase

The larval development of *Portunus pelagicus* includes four zoeal stages and a megalopa (Josileen and Menon, 2004). The megalopa stage metamorphoses into the crab stage (Fig.50).

## 5.3. Size Composition and Sex Ratio

At Mandapam (Palk Bay), the fishery was contributed by size ranging from 70-195 mm. The major portion of the catch was contributed by 105-170 mm group in both the sexes.

The dominant size group during 1996-97 was 106-110 mm in males and 126-130 mm in females. At Devipattinam, the fishery was contributed by size range of 81-182 mm. The maximum recorded sizes for male and female were 182 and 176 mm respectively. The bulk of the catch was comprised of size range 101-150 mm in both sexes. In pooled data of males and females the dominating size group was 121-130 mm (Josileen, 2007).

Earlier (1995-98) studies conducted from trawl catches at Mandapam showed that females were dominating the catches during most of the months; whereas in *nanduvalai* catches at Devipattinam, females were dominating during 1995 and for the rest of the period males were dominating in most of the months. At Mandapam, females outnumbered the males, the male: female ratio was 0.72: 1 and in Devipattinam there was a preponderance of males, the sex ratio was 1.26: 1 during the study period (Josileen, 2001) and the present observations also showed a clear domination of females in trawls and males in gillnet.

## 5.4. Size at Maturity

Close laboratory examination of gonads indicated that males of *P. pelagicus* attained sexual maturity when they attained a size above 80 mm carapace width. The minimum size at which males were mature was 82 mm CW. In females the minimum size at which maturity (ovary stage-IV) recorded was 88 mm CW. In females, mature ovaries were very rare in those below 100 mm CW size. The minimum size of berried females encountered during the study was 105 mm/ 80 g (Josileen,2001).

## 5.5. Breeding cycle and composition of berried crabs

*P. pelagicus* is a continuous breeder and berried females were recorded in the landings throughout the year. Berried crabs were more in trawl catches and in near-shore gillnet

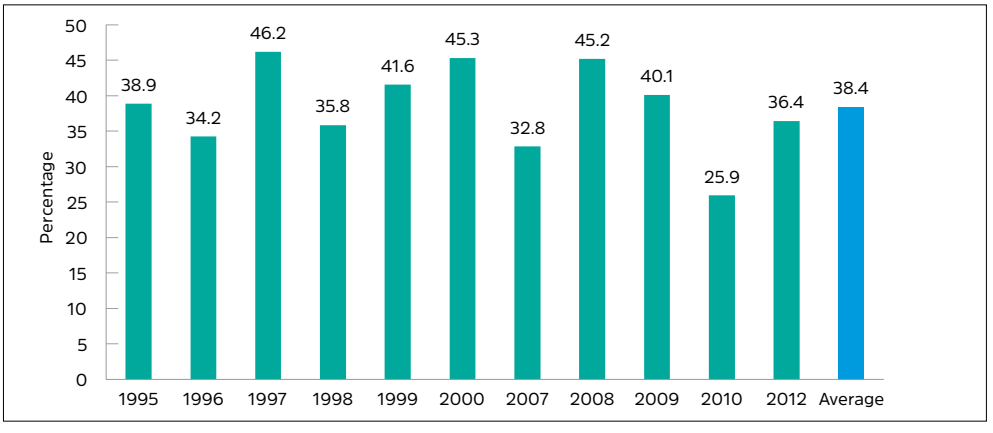



Figure 51- Annual Percentage of berried crabs in BSC Trawl fishery at Mandapam (PB)

catches the percentage was very less and in some months berried females were not represented in the fishery. For maturation and breeding crabs move towards deeper waters (breeding migration) and apparently mature crabs are caught in trawls than in gillnets, as their operational area is deeper than gillnets. So, the annual percentage of berried crabs in trawl is 38.4% (for a period of 11 years) whereas, in gillnets it is only 11.7% (for six years). The details for the composition of berried females from the trawl and gillnets are presented in the Figures 51 & 52.

In trawls in some months more than fifty percent of the female population comprised berried crabs and maximum percentage (84.4%) was recorded during February 2009. BSC is a continuous breeder as the percentage of berried females in the

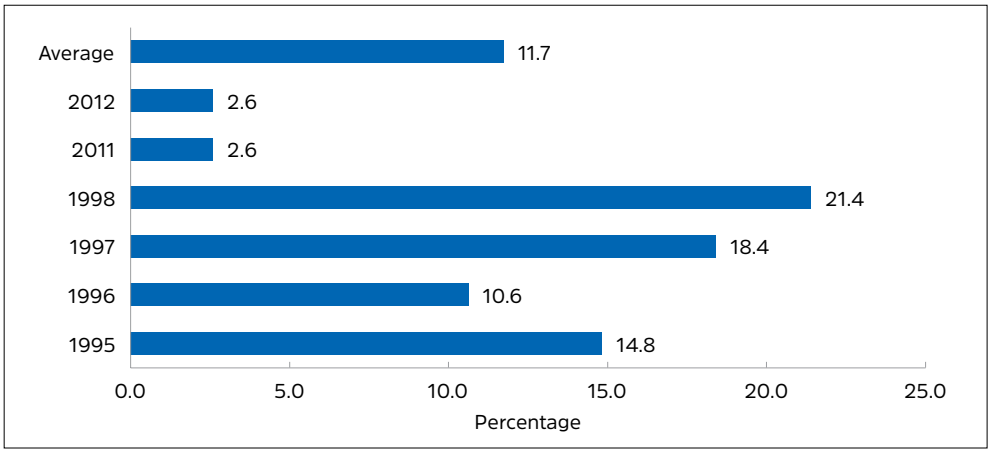



Figure 52- Percentage of berried crabs in BSC *nanduvalai* fishery in Palk Bay

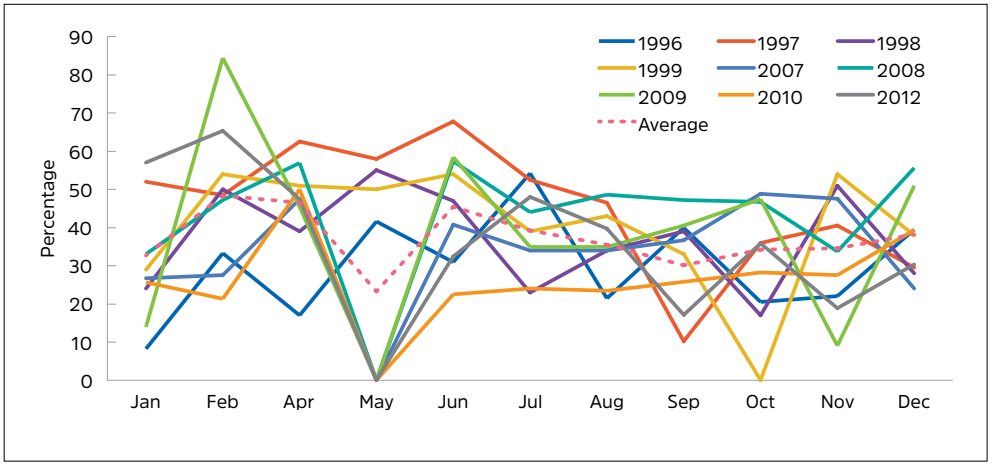



Figure 53- Monthly Percentage of berried crabs in BSC Trawl fishery at Mandapam (PB)

catches did not follow a definite pattern over seasons and annual percentage was always above 25%. Monthly percentage of the berried crabs landed in trawls during different years are presented in Figure 53. At present, there is no ban for fishing berried crabs and hence they are exploited throughout the year.

## 5.6. Spawning

Spawning usually takes place during night hours and crabs are capable of multiple spawnings and spawn a maximum of 3 times during an intermoult cycle. The newly spawned eggs are bright yellow and as the development progresses colour changes to dull yellow and finally to dark grey just one day before hatching (Fig.54). Spawned eggs are attached to the pleopods of the mother till the hatching. In mature crabs pleopods can be seen very clearly when abdominal flap is opened. In females the first four abdominal somites carry pleopods and are biramous and possess setae for attachment of the extruded eggs till hatching. Male has two pair of pleopods modified as copulatory organs on the first and second abdominal somites. (Fig.55).

The total days taken for embryonic development (incubation period) varied between 8-10 days, depends on the health & size of the mother and water temperature. The incubation time taken by the same crab may also vary between spawnings during the same intermoult period.

Figure 54- Female BSC with newly spawned eggs (yellow) and ready to hatch eggs (Black)


Figure 55- Male (a) and Female (b) BSC with open abdomen showing the pleopods

## 5.7. Fecundity

The number of eggs present in the sponge/berry in *P. pelagicus* ranged between 60000 and 1976398. Fecundity increased from smaller to larger size groups. In the landings, it was found that the berried crabs that belonged to the size group 120-129 mm were the more frequent, which coincides with the first maturation moult. The egg mass index did not show any clear pattern in relation with the size group of the crab. The increase of the egg mass weight was proportional to the carapace width of the crab, with the highest values in the larger size groups.

The relationships between fecundity (as number of eggs per clutch) and egg mass weight, both related to carapace width and total weight, showed significantly positive correlations, however, the relationships show that, of these parameters, the carapace width and the fecundity constitute the more reliable indices for the estimation of the reproductive potential of *P. pelagicus*, rather than the weight of the crab (Josileen, 2001 & 2007). The average number of eggs for the different size classes and details are presented in the Table 19.

Table 19- Reproductive potential of BSC females in different size groups.

| Size range (mm) | No. | Carapace width (mm) | Average weight (g) | Egg mass weight (g) | Average total no.of eggs | Egg mass index |
|---|---|---|---|---|---|---|
| 100-109 | 2 | 104.7 | 87.5 | 13.96 | 203455 | 15.95 |
| 110-119 | 6 | 113.6 ± 2.66 | 110.96 ± 16.66 | 11.96 ± 4.07 | 214175 | 11.39 |
| 120-129 | 12 | 124.9 ± 2.93 | 124.2 ± 19.87 | 20.84 ± 5.54 | 640431 | 16.78 |
| 130-139 | 5 | 133.8 ± 3.91 | 148.0 ± 17.18 | 19.20 ± 8.57 | 470092 | 12.97 |
| 140-149 | 4 | 144.8 ± 3.54 | 210.0 ± 60.14 | 28.37 ± 12.00 | 936731 | 13.51 |
| 150-159 | 2 | 157.5 | 287.5 | 30.36 | 1267022 | 10.56 |
| 160-169 | 2 | 166.6 | 320.0 | 34.50 | 1230900 | 10.78 |
| 170-179 | 4 | 176.1 ± 2.36 | 406.3 ± 39.87 | 49.74 ± 5.55 | 1472240 | 12.24 |
| 180-189 | 4 | 183.1 ± 2.01 | 532.5 ± 32.27 | 53.41 ± 4.84 | 1677168 | 10.03 |

Source: Josileen (2013)

## 5.8. Carapace width and Total weight relationship

Carapace width/length-total weight relationship in males and females of *Portunus pelagicus* are given the Table 20.

Table 20- Carapace width/length-total weight relationship *Portunus pelagicus* (BSC)

| Measurements | Logarithmic equation | Parabolic equation |
|---|---|---|
| Male | | |
| Carapace Width-Total Weight | Log = -12.589 + 3.607 log L | $W = 0.000003409\ L^{3.607}$ |
| Carapace Length-Total Weight | Log = -7.339 + 3.049 log L | $W = 0.0006497\ L^{3.049}$ |
| Female | | |
| Carapace Width-Total Weight | Log = -11.077 + 3.293 log L | $W = 0.00001546\ L^{3.293}$ |
| Carapace Length-Total Weight | Log = -6.231 + 2.774 log L | $W = 0.001967\ L^{2.774}$ |
| Pooled | | |
| Carapace Width-Total Weight | Log = -11.779 + 3.438 log L | $W = 0.000007664\ L^{3.438}$ |
| Carapace Length-Total Weight | Log = -6.746 + 2.902 log L | $W = 0.001176\ L^{2.902}$ |
| Source: Josileen (2011b) | | |

The scatter diagram for males and females was obtained by plotting the weight against carapace width /length of individual crabs (Figs. 56 to 59). It is found that there exists a good relation between width and total weight from the closeness of the scatter and from parabolic nature of the plot.

The exponential values (b) for the carapace width-weight relationship in males and females (3.607 and 3.293 respectively) show that there is marked variation from the isometric pattern of growth. The 't' test confirmed that 'b' significantly differ

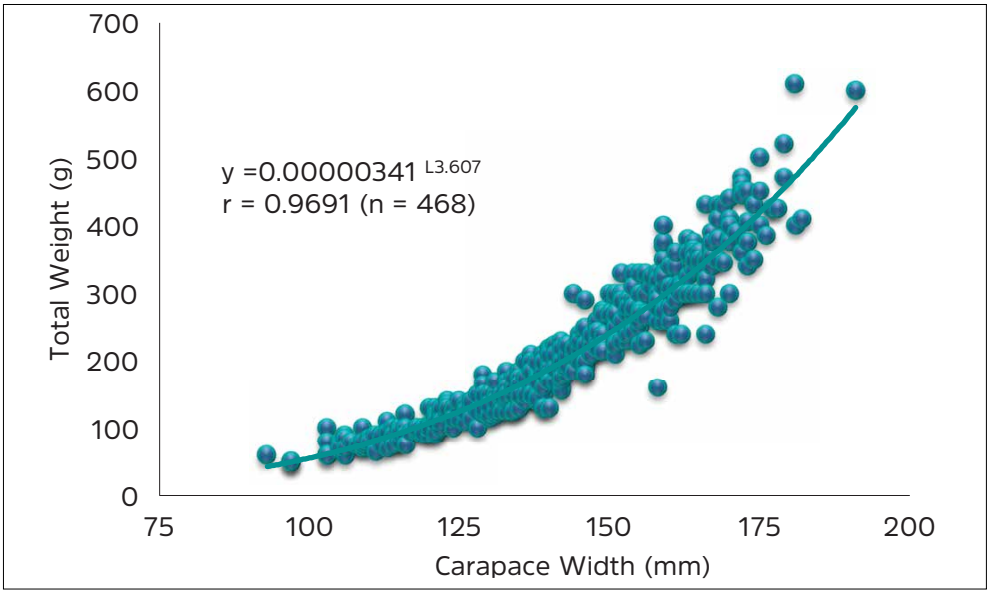



Figure 56- Carapace width- weight relationship in male *Portunus pelagicus* (BSC)

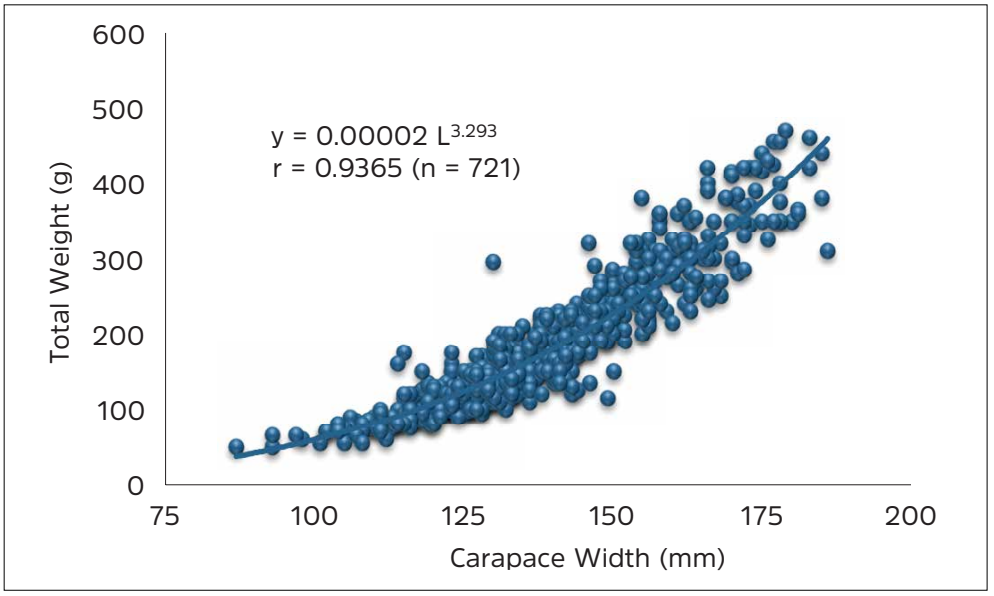



Figure 57- Carapace width- weight relationship in female *Portunus pelagicus* (BSC)

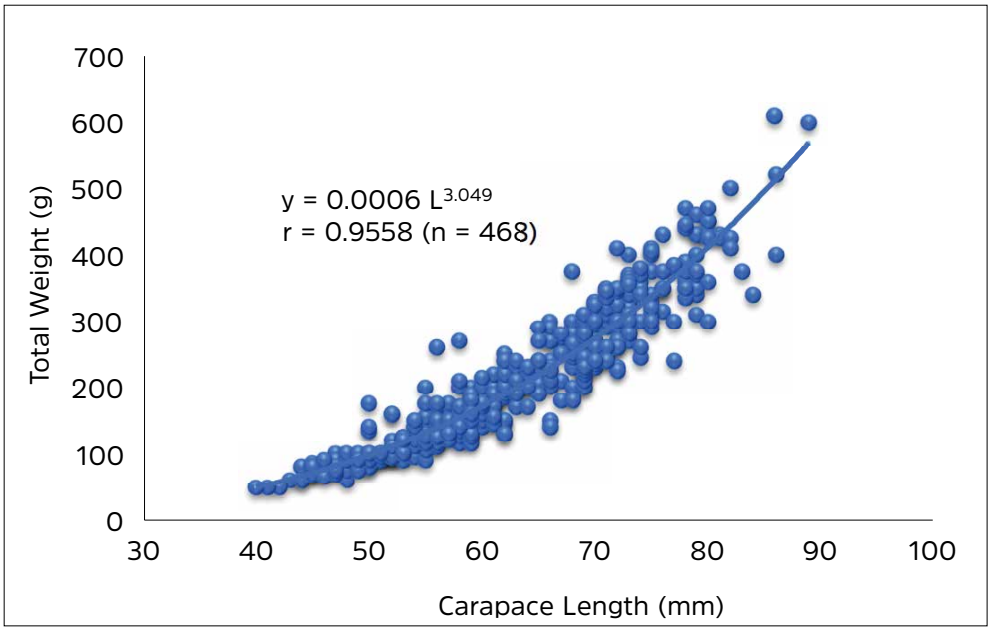



Figure 58- Carapace length–weight relationship in male *Portunus pelagicus* (BSC)

from 3, in both sexes. The exponential values (b) for carapace length – weight in males and females (3.049 and 2.774 respectively) indicate that, the significant departure from isometric growth is only evident in females.

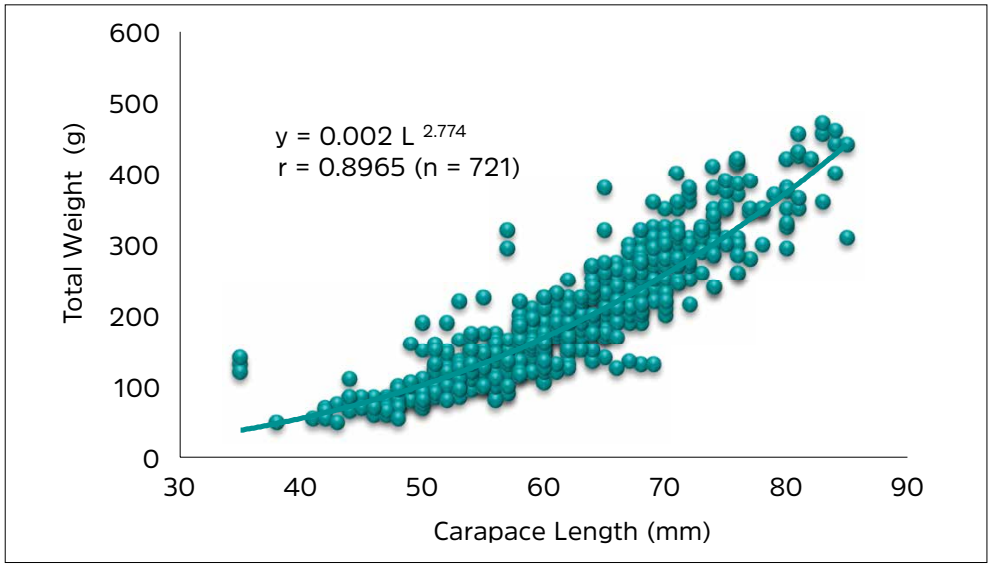



Figure 59- Carapace length–weight relationship in female *Portunus pelagicus* (BSC)

The results of the length-weight relationship analysis in *P. pelagicus* indicate that in juveniles and pre-adult crabs, weight gain is almost uniform; females are slightly heavier than males until they attain 120-125 mm carapace width. Thereafter males are heavier than females at any given length.

## 5.9. Food & feeding

Investigations on food habits of BSC in the Palk Bay area revealed that despite the diversity in crab diets and feeding habits, they are opportunistic omnivores with a preference for animal food. In adult (>100 mm CW) crabs, crustaceans constituted the dominant food source and these were present in 78.43% of the stomachs analysed, followed by molluscs and fishes (Josileen, 2011a). The stomach contents of juveniles (< 80 mm CW) and sub-adults (81-100 CW) were dominated by debris. There was no significant difference between sexes in the frequency of occurrence of food items or in their percentage. However, there was a difference between the stomachs of ovigerous and non-ovigerous females. There were also significant differences in the preference for food items in the different size groups of the crab. The results showed that *P. pelagicus* exhibits, in this region at least, a clear preference for crustaceans (Josileen, 2011a).

## 5.10. Growth in the laboratory

Male crabs grew from an initial average carapace width of 2.38 ± 0.18 mm to 159.86 ± 3.52 mm CW, i.e., from first instar to 16$^{th}$ instar in a mean period of 272 days. Males were reared to a maximum of 455 days. The average total weight gained

was 275.00 ± 25.41 g from an initial weight of 0.008 g (table 21 & Fig.60). Male crabs attain maturity by the 12th moult (crab instar-12), at a mean size of 82.25 ± 1.17 CW and the chelar propodus length (CPL) recorded twofold increase, than the previous crab stage (crab instar-11).

Table 21–Growth details of Male BSC in laboratory

| Crab stage | Average days from previous instar | CW (mm) | CL (mm) | CPL (mm) | CPD (mm) | TW (g) |
|---|---|---|---|---|---|---|
| 1 | 0 | 2.38 ± 0.18 | - | - | - | 0.008 |
| 2 | 2.83 ± 0.76 | 4.23 ± 0.24 | - | - | - | 0.014 |
| 3 | 3.40 ± 0.55 | 5.13 ± 0.18 | - | - | - | 0.042 |
| 4 | 4.33 ± 1.03 | 6.55 ± 0.33 | - | - | - | 0.082 |
| 5 | 5.60 ± 1.14 | 9.10 ± 0.39 | - | - | - | 0.1 |
| 6 | 5.63 ± 1.19 | 12.13 ± 0.85 | 6.94 ± 0.31 | - | - | 0.189 |
| 7 | 6.00 ± 1.15 | 16.63 ± 0.25 | 9.00 ± 0.50 | - | - | 0.299 |
| 8 | 7.88 ± 1.73 | 23.17 ± 1.04 | 12.17 ± 0.29 | - | - | 1.088 ± 0.91 |
| 9 | 8.38 ± 1.41 | 33.86 ± 1.77 | 16.20 ± 0.41 | - | - | 2.41 ± 0.70 |
| 10 | 14.83 ± 3.31 | 46.38 ± 3.45 | 19.50 ± 0.50 | 20.38 ± 0.48 | 4.94 ± 0.43 | 5.13 ± 0.68 |
| 11 | 16.33 ± 1.51 | 60.80 ± 1.82 | 26.14 ± 1.35 | 24.85 ± 1.24 | 8.05 ± 0.93 | 14.90 ± 1.10 |
| **12** | **15.80 ± 3.11** | **82.25 ± 1.17** | **36.07 ± 1.73** | **49.08 ± 2.33** | **11.73 ± 0.25** | **36.22 ± 3.31** |
| 13 | 25.83 ± 5.42 | 99.01 ± 3.45 | 44.00 ± 1.87 | 60.67 ± 2.52 | 13.20 ± 0.57 | 68.33 ± 10.18 |
| 14 | 30.33 ± 6.53 | 122.13 ± 3.50 | 56.50 ± 1.91 | 84.50 ± 1.38 | 17.18 ± 0.96 | 123.14 ± 4.74 |
| 15 | 50.67 ± 14.77 | 141.39 ± 2.66 | 62.78 ± 2.77 | 102.71 ± 4.31 | 18.00 ± 1.31 | 188.92 ± 15.83 |
| 16 | 73.71 ± 8.96 | 159.86 ± 3.52 | 72.22 ± 2.99 | 121.56 ± 2.96 | 20.91 ± 4.12 | 275.00 ± 25.41 |

(CW- Carapace width; CL-Carapace length; CPL-Chelar propodus length; CPD- Chelar propodus depth & TW – Total weight)

Source: Josileen & Menon (2005)

Female crabs grew from an initial average CW of 2.43 ±0.34 mm CW to 154.31± 2.73 mm, and reached the 16th instar in a mean of 332 days. The average weight gain during that period was from 0.006 g to 210.33 ± 18.39 g (table-22).

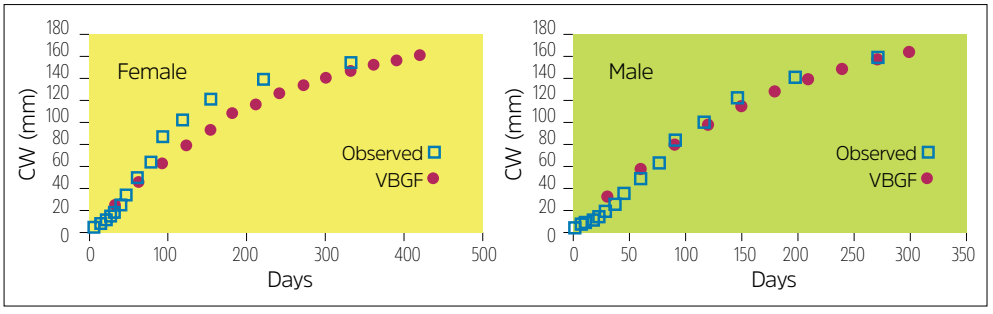



Figure 60- Observed and fitted growth (VBGF) in laboratory grown males and females of BSC

Female crabs attain maturity by the 14th moult (crab instar-14), at a mean size of 120.43 ± 2.23 CW and the abdominal width (AW) recorded about forty percent increase, than the previous crab stage (crab instar-13).

Table 22- Growth details of Female BSC in laboratory.

| Crab Stage | Average days from previous instar | CW (mm) | CL (mm) | AW (mm) | AL (mm) | TW (g) |
|---|---|---|---|---|---|---|
| 1 | 0 | 2.43 ± 0.34 | - | - | - | 0.006 |
| 2 | 2.83 ± 0.75 | 4.10 ± 0.14 | - | - | - | 0.01 |
| 3 | 3.80 ± 0.84 | 5.20 ± 0.25 | - | - | - | 0.024 |
| 4 | 3.83 ± 0.75 | 6.58 ± 0.57 | - | - | - | 0.075 |
| 5 | 5.80 ± 1.09 | 9.62 ± 1.10 | 5.40 ± 0.29 | - | - | 0.099 |
| 6 | 5.60 ± 1.79 | 13.40 ± 0.60 | 7.25 ± 0.25 | - | - | 0.177 |
| 7 | 6.20 ± 1.79 | 17.20 ± 1.20 | 9.38 ± 0.14 | - | - | 0.32 |
| 8 | 7.00 ± 1.22 | 24.27 ± 2.06 | 12.25 ± 0.32 | - | - | 1.44 ± 0.32 |
| 9 | 8.80 ± 1.30 | 33.33 ± 3.78 | 16.97 ± 1.44 | - | - | 2.43 ± 0.50 |
| 10 | 14.0 ± 3.54 | 48.00 ± 4.76 | 22.30 ± 1.26 | 9.63 ± 0.95 | 14.13 ± 1.31 | 5.98 ± 0.72 |
| 11 | 16.6 ± 2.07 | 62.88 ± 3.57 | 27.63 ± 2.29 | 15.13 ± 1.93 | 17.88 ± 2.25 | 15.63 ± 1.70 |
| 12 | 16.0 ± 2.92 | 85.50 ± 6.75 | 36.20 ± 3.46 | 20.50 ± 0.71 | 24.13 ± 2.59 | 32.22 ± 2.85 |
| 13 | 25.2 ± 6.66 | 101.78 ± 2.78 | 44.11 ± 2.15 | 25.07 ± 3.12 | 30.56 ± 3.01 | 64.33 ± 7.50 |
| **14** | **36.4 ± 7.37** | **120.43 ± 2.23** | **51.83 ± 1.17** | **34.88 ± 3.71** | **37.00 ± 1.15** | **106.50 ± 9.94** |
| 15 | 68.2 ± 21.04 | 139.29 ± 1.81 | 62.50 ± 1.16 | 42.75 ± 1.76 | 47.28 ± 2.17 | 150.50 ± 2.90 |
| 16 | 112.0 ± 11.89 | 154.31 ± 2.73 | 68.23 ± 2.01 | 50.73 ± 1.38 | 55.86 ± 2.22 | 210.33 ± 18.39 |

(CW- Carapace width; CL-Carapace length; AW-Abdomen width; AL- Abdomen length & TW- Total wieght )

Source: Josileen & Menon (2005)

Laboratory grown crabs: Based on the L∞ and K values monthly growth of *P. pelagicus* male and female was computed using the inverse VBGF and the monthly growth estimates of male *P. pelagicus* following the Faben's method, when compared to actual observed values, gave very close values, while in females the observed mean growth was close to that observed in the Munro's method. Accordingly, males and females attained a length of 176.9, 203.3 and 207.3 mm and 151.3, 181.2 and 187.2 mm at the end of 1st, 2nd and 3rd year respectively (table 23).

The VBGF estimated for the cultured crabs (laboratory grown) and wild crabs are comparable and the details are presented in the Table 23 and a group of laboratory grown juveniles of BSC are shown in Figure 61.

Table 23- Details of von Bertalanffy Growth Function (VBGF) in male and female crabs of BSC

| Male | Gulland & Holt (mm) | Munro's (mm) | Faben's (mm) | Female | Gulland & Holt (mm) | Munro's (mm) | Faben's (mm) |
|---|---|---|---|---|---|---|---|
| **$L_\infty$ (Lab)** | 219.8 | 204.1 | 208.0 | **$L_\infty$ (Lab)** | 211.8 | 188.6 | 211.0 |
| **K** | 1.82 | 1.9 | 1.8 | **K** | 1.7 | 1.64 | 1.62 |
| **$L_\infty$ (Wild)** | 199.4 | 191.9 | 195.0 | **$L_\infty$ (Wild)** | 196.9 | 190.4 | 190.0 |
| **K** | 1.56 | 1.68 | 1.71 | **K** | 1.05 | 1.37 | 1.42 |
| **Observed $L_{max}$** | 195 | | | **Observed $L_{max}$** | 193 | | |
| **1st year** | | | | **1st year** | | | |
| **culture** | 184.2 | 170.4 | 176.9 | **culture** | 173.1 | 151.3 | 170.1 |
| **wild** | 157.5 | 156.1 | 159.1 | **wild** | 128.0 | 142.0 | 144.1 |
| **2nd year** | | | | **2nd year** | | | |
| **culture** | 214.6 | 198.5 | 203.3 | **culture** | 204.7 | 181.2 | 203.1 |
| **Wild** | 190.6 | 185.2 | 188.6 | **Wild** | 172.8 | 178.1 | 178.9 |
| **3rd year** | | | | **3rd year** | | | |
| **culture** | 218.9 | 203.2 | 207.3 | **culture** | 210.5 | 187.2 | 209.5 |
| **Wild** | 197.5 | 190.6 | 193.8 | **Wild** | 188.4 | 187.2 | 187.3 |

Source: Josileen (2001)

Figure 61- Five weeks old laboratory grown Blue Swimming Crab

## 5. 11. Growth in Wild Crabs

In wild, the male crabs attained CW of 156.1-159.1 mm in the 1st year, 185.2-190.6 in the 2nd year and 190.6-197.5 mm in the 3rd year. The females recorded a size of 128.0-144.1 mm in the 1st year, 172.8-178.9 mm in the 2nd year and 187.2-188.4 mm in the 3rd year (Table 23). The growth curve by Gulland and Holt approach is presented in Figure 62.

From the Gulland and Holt growth curve it is found that in the 3rd year male and female attain a respective carapace width of 197.5 mm and 188.4 mm. Hence it is reasonable to assume that the life span of these crabs may be around three years, although majority of the crabs is fished out by intensive trawling in the early phase of their life (0- year class).

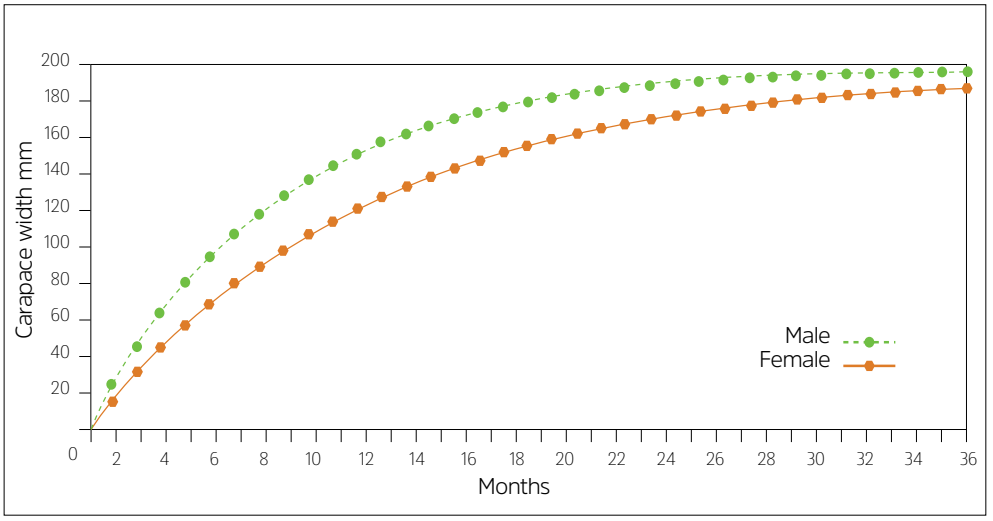



Figure 62- von Bertalnffy's growth curve for wild *Portunus pelagicus* (BSC)

# 6. Earlier Stock Assessment

## 6.1. Probability of capture

In males, the $L_{25}$, $L_{50}$ and $L_{75}$ values were 115.2, 124.7 and 130.4 mm respectively and at carapace width (CW) of 137 mm and above, all the crabs were retained by the trawl. In females these values were 115.4, 122.9 and 129.0 mm respectively and at carapace width of 142 mm and above, all the crabs were retained by the trawl (Fig. 63).

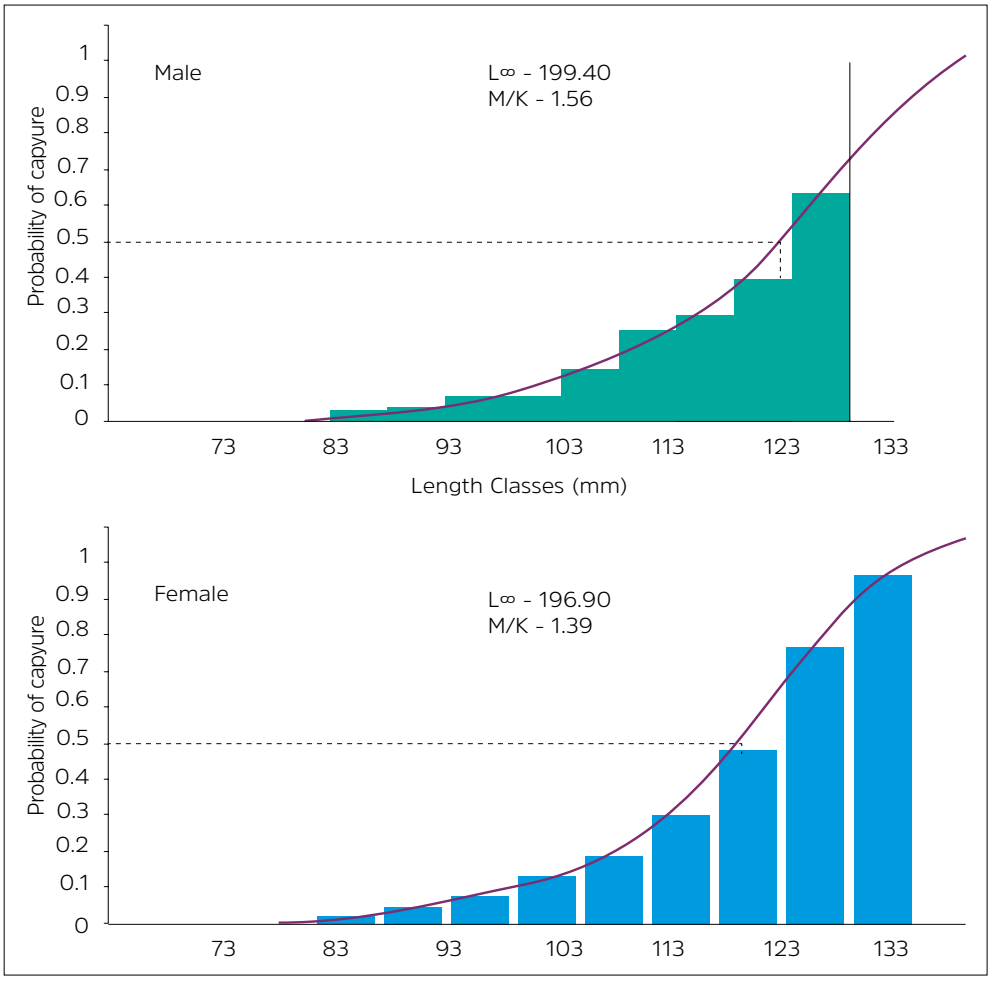



Figure 63- Probability of capture in male and female *Portunus pelagicus* (BSC)

## 6.2. Mortality parameters

The total instantaneous mortality coefficient (Z) estimated by length converted catch curve method was 4.54 for males and 3.03 females. The instantaneous natural mortality coefficient (M) estimate for males by following Rikhter & Efanov and Pauly were 2.09 and 2.76. In females the M was 1.46 and 2.11 respectively by the two methods. The instantaneous fishing mortality coefficient (F) was 2.45 for males and 1.57 for females. The exploitation rate (E) was almost similar in males and females, *i.e.*, 0.54 and 0.52 respectively. The details are presented in the Figure 64.

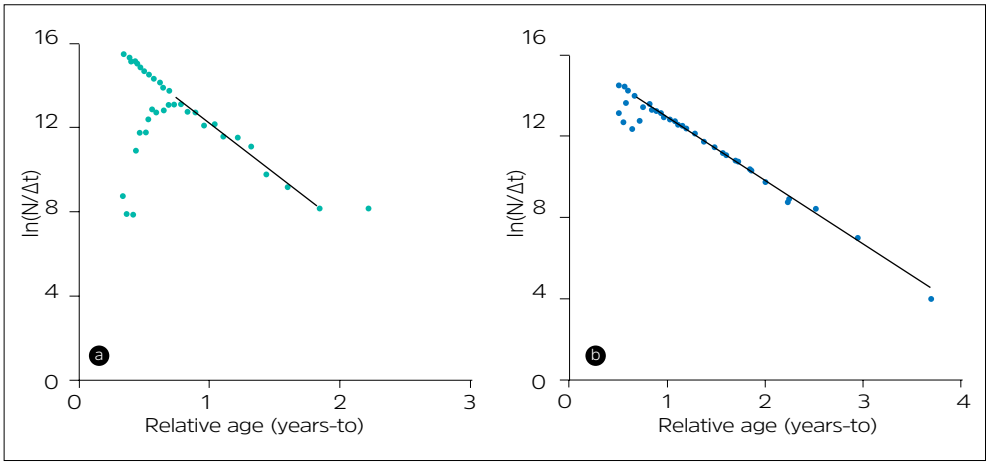



Figure 64 –Catch curve of *Portunus pelagicus* (BSC) in males (a) & females (b).

Males: Cut off CW (L'): 130.5 mm; mean CW (from L'): 149.6 mm; Z from the catch curve: 4.54; Natural Mortality (M for T= 29$^{o}$C): 2.72; M value used: 2.09; Fishing Mortality: 2.45; Exploitation rate: 0.54.
Females: Cut off CW (L'): 90.5 mm; mean CW (from L'): 120.5 mm; Z from the catch curve: 3.03; Natural Mortality (M for T = 29$^{o}$C): 2.11; M value used: 1.46; Fishing Mortality: 1.57; Exploitation rate: 0.52.

## 6.3. Yield-per-recruit (Y/R)

Analysis of the stock using 1995-1998 data indicated that the $E_{max}$ was estimated as 0.64, E 0.1 as 0.62 and E 0.5 as 0.37 for males and 0.64, 0.61 and 0.38 respectively for females. The exploitation rate of males (0.54) and females (0.52) was almost equal. These values are very close to the $E_{max}$ level (males: 0.638; females:0.648) and well above the 50% exploitation level (males-0.371: females – 0.379) and then yield was close to the MSY level (Figures 65 & 66).

At present, there is no ban on fishing the berried crabs and the minimum size at capture is not restricted in India except in state of Kerala, where MLS is fixed at 90 mm carapace width (CW). Recently, Sivadas *et al.*, (2019), has recommended 90 mm CW as the MLS for BSC fishery in Tamil Nadu. As a conservation measure,

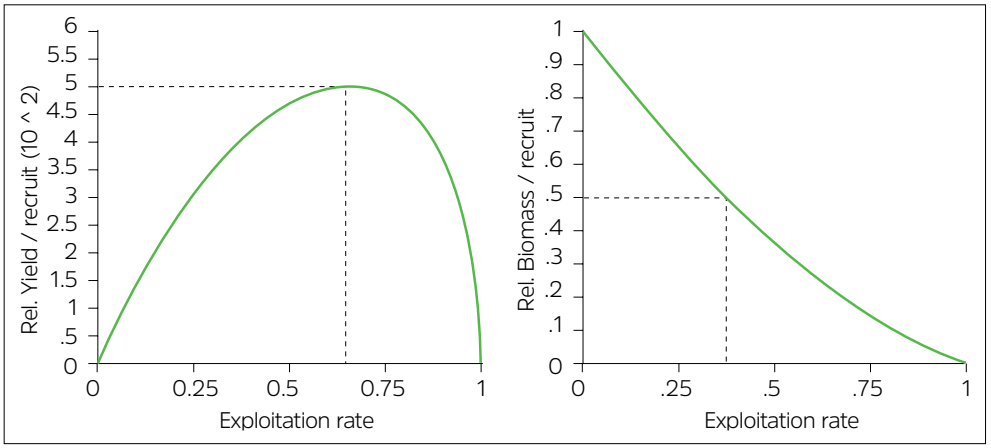



Figure 65 – Yield per recruitment analysis in male crabs of *Portunus pelagicus* (BSC)

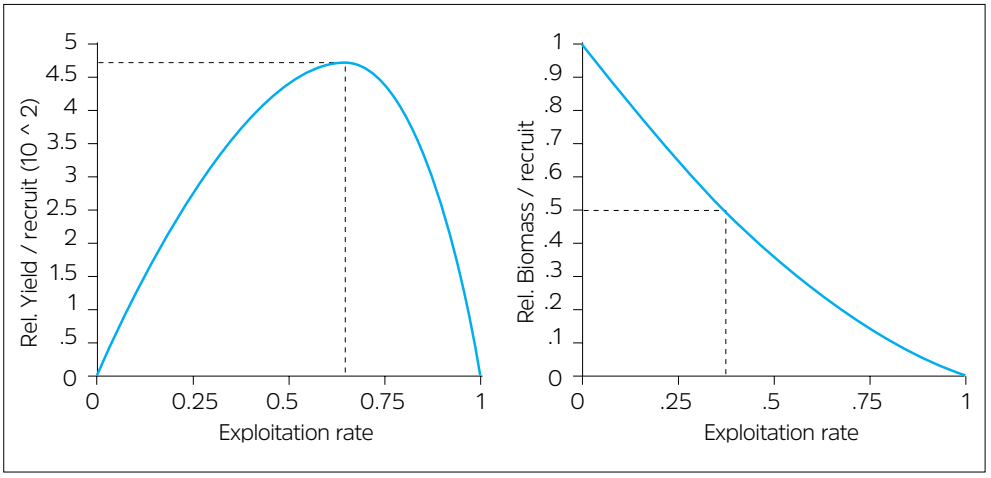



Figure 66– Yield per recruitment analysis in female crabs of *Portunus pelagicus* (BSC)

fishermen should be educated to release the berried and soft crabs to the sea while they are alive. The governments should take steps to implement the ban on landing and marketing the berried females, certainly these would ensure a sustainable BSC fishery as well as improve the quality of the yield.

# 7. Current Estimation of Maximum Sustainable Yield (MSY) – Palk Bay BSC

Results of the Bayesian Schaefer Model (BSM) using 2007-2017 catch and catch rate data indicated that the MSY is 7360 tonnes. When compared with the total BSC landings of Palk Bay during the period 2007-2017 indicated that during four years (2010-2013), total catch from the region was more than MSY limits and rest of the years it was below the MSY estimates. The exploitation (F/Fmsy) during 2017 was 0.726 and most of the years this value was above 1. The B/Bmsy in 2017 was 0.833 and from 2012 onwards it is below 1, indicating that stringent management is required for the BSC stock. The details are presented in Figures 67-69 and Table 24.

Assessment of the fishery clearly reveals catches are on the declining trend and stock has been overexploited. It is also alarming that the berried females indiscriminately exploited without any restriction of fishing on berried females.

Currently trawls are operating on three days per week and they are allowed to fish beyond 3 nautical miles as the state jurisdiction. Also total fishing ban of 61 days during April-May every year is implemented for the trawlers. However, for gillnetters or other traditional fishers presently no such ban is prevailing and also no strict enforcement of total fishing days is in place. To bring the fishery to the

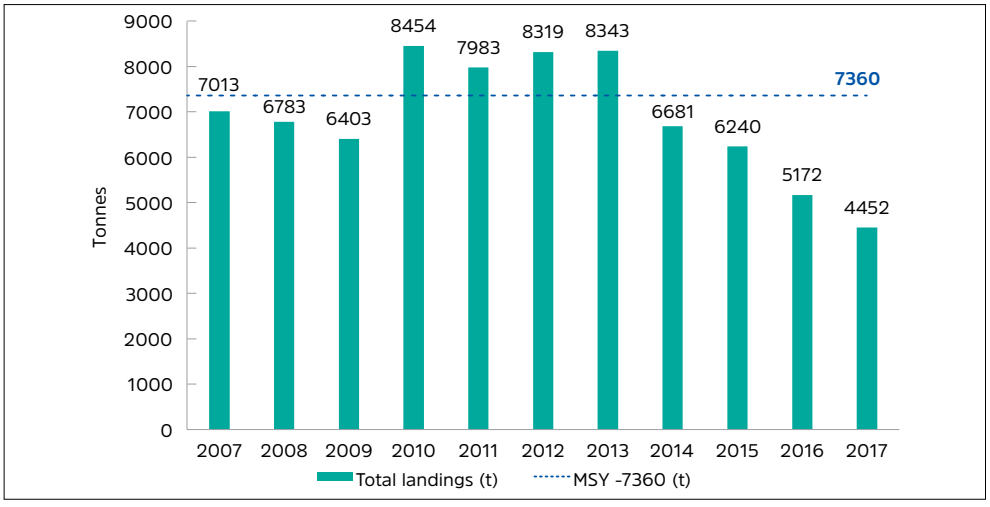



Figure 67- Total *Portunus pelagicus* (BSC) landings in Palk Bay during 2007-17 and MSY level

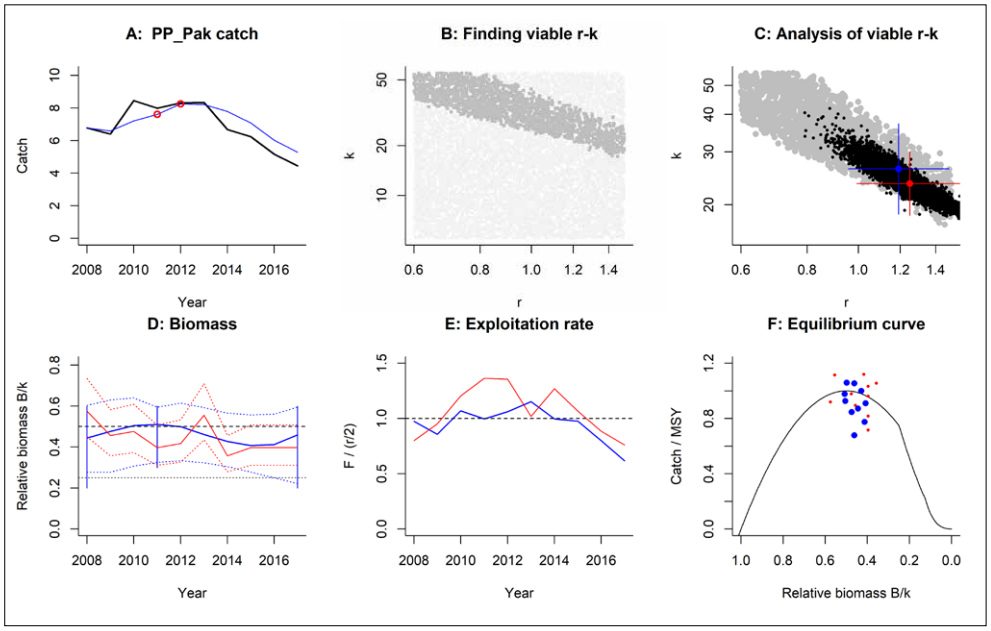



Figure 68- Results of CMSY analysis for *Portunus pelagicus* (BSC) landings in Palk Bay during 2007-17

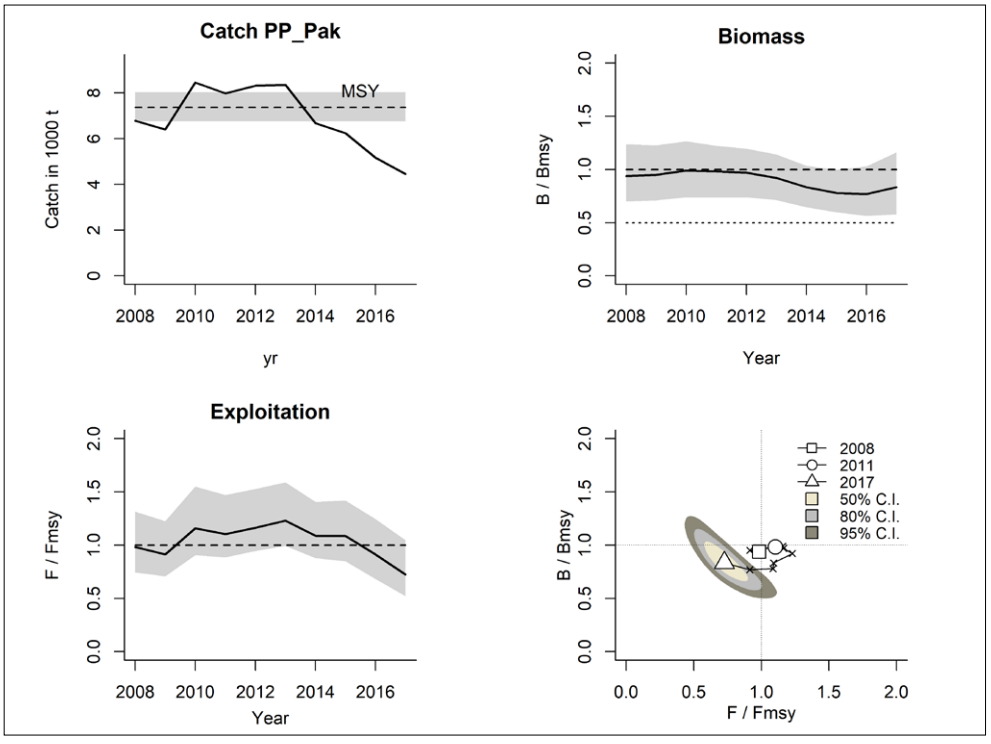



Figure 69- Summary of CMSY analysis in *Portunus pelagicus* (BSC) for Palk Bay during 2007-2017

sustainable level, the best possible immediate action is the total ban on fishing and landing berried females. This must be immediately bringing to enforcement for all the gears which are exploiting the BSC. The total fishing days of the gillnetters also must be reduced. If these regulatory measures are implemented at the earliest within a couple of years, the BSC stock can be increased. Other suggestions and recommendations are given in the proposed management plan.

Table 24- Estimates of MSY and model parameters of BSC along with confidence limits

| Parameters | CMSY | BSM |
|---|---|---|
| MSY | 7820 | 7360 |
| | (6060 – 10100) | (6760–8020) |
| r | 1.19 | 1.25 |
| | (0.957-1.48) | (0.99-1.58) |
| k | 26300 | 23500 |
| | (18500-37200) | (18400-30100) |
| Relative biomass in last year (B 2016/k) | 0.457 | 0.417 |
| | (0.218–0.595) | (0.289–0.580) |
| Exploitation F/(r/2) in last year | - | 0.726 |
| | | (0.521-1.05) |
| q | - | 0.000214 |
| | | (0.000181-.000254) |
| $B_{msy}$ | - | 11800 |
| | | (9220-15000) |
| Fishing mortality ($F_{msy}$) | - | 0.626 |
| | | (0.496-0.788) |
| $F_{msy}$ in last year | - | 0.454 |
| | | (0.326 – 0.654) |

MSY–Maximum sustainable yield; MSY = r k/4; r = Maximum intrinsic rate of population increase; k = Parameter of the Schaefer model indicating unexploited stock size; B = Biomass, total weight of exploited fish in the water; q-Catchability coefficient; CPUEt = q Bt; $B_{msy}$ -Biomass capable of producing MSY; $F_{msy}$ -Rate of fishing mortality compatible with MSY; $F_{msy}$ = 0.5 r

# 8. Projection on advantages of not fishing berried females

It is well understood that to sustain the Blue Swimming Crab fishery strict management of the fishery is essential and the best possible immediate action is the total ban on landing and sale of berried females. When berried females exploited indiscreetly that would directly affect the recruitment of the young ones into the fishery.

Tables 25-27 describe the situation/scenario if berried females are not fished and how fishery is going to be benefitted. BSC is a continuous spawner and highly fecund, which ranges between 60000 – 1976398. BSC fishery mainly comprised, of 120-159 mm CW females and the average fecundity of this group is about 828569 nos. Hatchery seed production of crablets proved on an average 5% survival from Zoea 1 to first baby crab stage (Crab instar-1). However, considering the natural predation in the wild, for estimating the seed production survival is fixed at very low percentage (@0.1%). With this survival rate, about 830 baby crabs (crab instar-1) can be produced from a single female and out of that 1 % would survive to the catchable size (100 g) after a period of 4 months. Total duration to obtain this size including the larval phase would be approximately 5 months.

Table 25 – Details of fecundity and survival rates used for the estimation

| Size range (mm) | No. of eggs *(Josileen, 2013) | Average fecundity of the major size group in fishery | Facts & Assumptions |
|---|---|---|---|
| 100-109 | 203455 | | # For further estimation, average no. of fecundity taken as 830000. |
| 110-119 | 214175 | | |
| **120-129** | **640431** | 828569 | # Mass seed production of crablets obtained on an average of 5% survival from Zoea-1 to Crab instar (Josileen, 2001 & Maheswarudu, *et al.* 2008). However, for estimation in the wild, survival fixed @ 0.1% considering natural predation. |
| **130-139** | **470092** | | |
| **140-149** | **936731** | | |
| **150-159** | **1267022** | | |
| 160-169 | 1230900 | | |
| 170-179 | 1472240 | | |
| 180-189 | 1677168 | | |

Tables 26 & 27 explain the scenario in trawls and gillnets respectively. In trawl landings generally females are dominating, however for estimation 1:1 ratio has taken and in

gillnets males are pre- dominant and hence 60:40 ratio used for estimation. Previous studies assessed that in trawls, 38% of the landed females are berried (Fig.51) and in gillnets berried females formed 12% (Fig. 52) and these are also taken for the present calculation. The stages of estimation are shown in the respective tables.

In trawls, if berried crabs are not fished for a month, an equal quantity of that month's total production can be harvested after a period of 5 months. Similarly, from gillnets, 32% of the particular month's production can be obtained after a period of 5 months.

Table 26- Illustration – What happens if Berried females are not landed in Trawls for a month

| Parameter | Logic | Estimated value |
|---|---|---|
| Expected number of first baby crabs (crab instar-1) from one female | Average fecundity is 830000 and survival from zoea-1 (Z-1) to crab instar-1 (C-1) is presumed to be @ 0.1% | 830 nos. |
| Expected number of recruits from one spawning mother | Out of 830 nos., 1% survive to the catchable size (further 4 months) | 8 marketable size crabs |
| Total landing of females in a trawl centre in one month | Suppose 50 tonnes of crabs are landed in the centre in a month and male: female ratio is 1:1, 25 tonnes would be females | 25000 kg |
| Number of females in one kilogram | Average weight of the female is 150 g | 7 nos. |
| Number of berried females in one kilogram | @ 38% of females–considering annual average of berried female for 11 years= 2.66 nos. ~ 2.5 crabs | 2.5 nos. |
| Total number of berried females in one-month catch | 25000*2.5 | 62500 nos. |
| Potential production of crabs after 5 months | If no fishing of berried crabs for a month, 62500*8 | 500000 nos. |
| Total production of marketable size crabs after 5 months | Marketable size = 100 g; 500000*100=50000000 g =50000 kg | 50 tonnes |
| Total value of the 50 tonnes crabs | 50000 kg @ 250 Rs. /kg | Rs. 12.5 million. |
| **Conclusion: In trawls, if we save berried females for a month, after a period of 5 months*, an equal quantity of one month's production can be obtained.** | | |
| (* includes–spawning to hatching period (duration of embryonic development ~ 10 days) & larval development period (zoea-1 to first crab stage ~ 15-18 days) together taken as one month plus four months, duration taken by the first crab (C-1) to reach marketable size) | | |

Table 27–Illustration – What happens if Berried females are not landed in Gillnets for a month.

| Parameter | Logic | Estimated value |
|---|---|---|
| Expected number of first baby crabs (crab instar-1) from one female | Average fecundity is 830000 and survival from zoea-1 (Z-1) to crab instar-1 (C-1) is presumed to be @ 0.1% | 830 nos. |
| Expected number of recruits from one spawning mother | Out of 830 nos., 1% survive to the catchable size (further 4 months) | 8 marketable size crabs |
| Total landing of females in a gillnet centre in one month | Suppose 100 tonnes of crabs are landed in the centre in a month and male: female ratio is 60:40 | 40,000 kg |
| Number of females in one kilogram | Average weight of the female is 125 g | 8 nos. |
| Number of berried females in one kilogram | @ 12% of females–considering annual average of berried female for 6 years= 0.966 nos. ~ 1 crab | 1 no. |
| Total number of berried females in one-month catch | 40000*1=40000 | 40000 nos. |
| Potential production of crabs after 5 months | If no fishing of berried crabs for a month, 40000*8 | 320000 nos. |
| Total production of marketable size crabs after 5 months | Marketable size = 100 g; 320000*100=32000000 g =32000 kg | 32 tonnes |
| Total value of the 32 tonnes crabs | 32000 kg @ 250 Rs. /kg | Rs. 8 million. |
| **Conclusion: In gillnets, if we save berried females for a month, after a period of 5 months*, 32 % of a months catch can be obtained.** | | |
| (* includes–spawning to hatching period (duration of embryonic development ~ 10 days) & larval development period (zoea-1 to first crab stage ~ 15-18 days) together taken as one month plus four months, duration taken by the first crab (C-1) to reach marketable size) | | |

# 9. Harvest Control Rules for BSC Fishery of Palk Bay

Harvest control rules (HCRs) identify a pre-agreed course of management action as a function of identified stock status and other economic, social or environmental conditions, relative to agreed reference points (Berger *et al.*, 2012). Thus, HCRs formulate a procedure for making harvest policy decisions, such as converting the outcomes from a stock assessment into management actions (i.e. increasing, maintaining, or decreasing levels of fishing) to achieve the desired state. Pre-agreed harvest rules allow managers to act immediately when the state of the fishery degrades beyond acceptable limits like a limit reference point (LRP).

Although harvest strategy and HCRs are not a mandatory requirement as per the current regulatory acts of maritime states in India, it is necessary to develop these

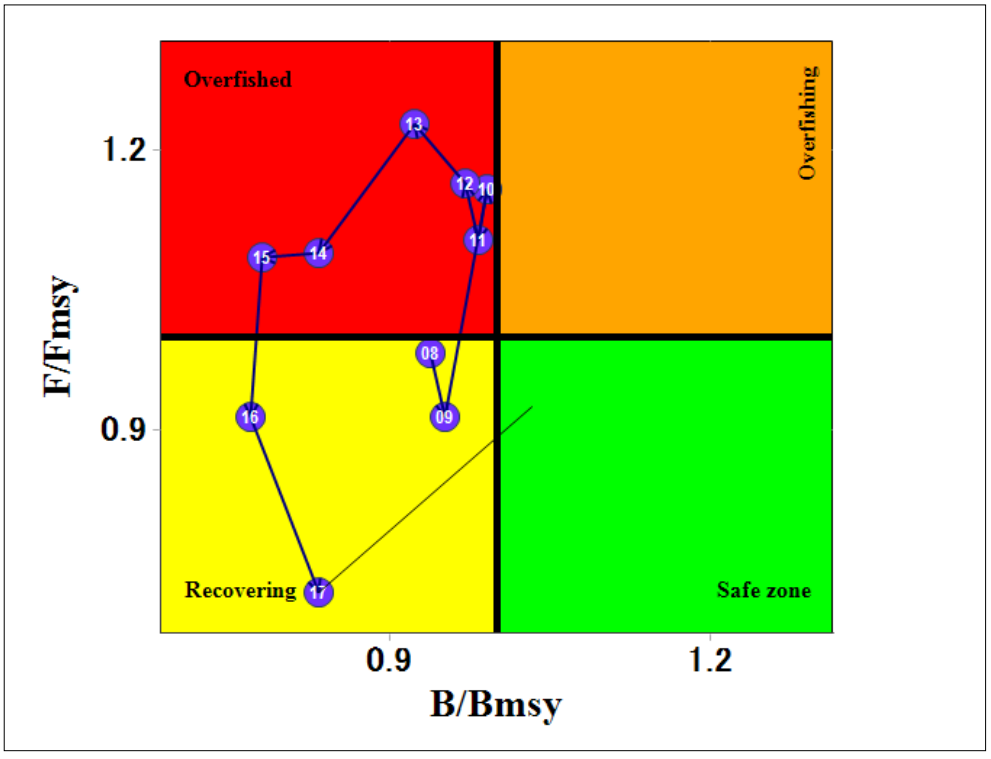



Figure 70- Kobe plot of the BSC fishery in Palk Bay showing the status of the stock during 2007 to 2017.

so that the fishery managers can judiciously act based on the status of the stock for sustainability of the resources. Berger *et al.* (2012) further state that without explicit rules to govern harvest levels, there is a tendency for exploitation rates to move towards levels that maximize short-term gains rather than levels that achieve long-term objectives (e.g., stable yields, maximizing catch rates, maintaining sufficient reproductive capacity, or preventing overfishing).

For the BSC fishery the harvest strategy would be to maintain yields close to the estimated MSY (7360 tonnes) using a catch and effort based harvest control measure (Y/MSY and $F/F_{msy}$) as reference points. The Kobe plot of the fishery (Fig. 70) shows the stock status of the fishery during the past 11 years. The plot indicates that the stock was overfished during 2011 to 2015 period with high effort and low biomass, subsequently in 2016 and 2017, the effort was considerably less placing the stock in rebuilding status. In order to turn the stock trajectory to healthy status, the recommendation on protection of berried crabs given in this document would help to build up the crab biomass.

The target reference point (TRP) for the fishery would be the MSY of 7360 tonnes allowing for a fluctuation of plus or minus 20%. Once the fishery yields exceed these limits (lower limit -5888 tonnes & higher limit–8832 tonnes) effort limitation should be introduced to maintain the stock at healthy levels. Should the yields increase or decrease by 50% of the TRP, more stringent effort control by way of fishery closures should be put in place as a precautionary approach.

# 10. Strengths and Weakness

The strength and weakness of the BSC fishery and related aspects are listed out as following:

## Strengths

1. Regular monitoring of fishery i.e. Trawl as well as Gillnet fishery is in place
2. Details of the fishing zones and landing centres are available
3. Information available on ecological and geographical parameters of Palk Bay
4. Total landing of the BSC and other resources are available
5. Details of the population characters and biological parameters of the BSC from the area available
6. Complete life cycle of the species studied from wild as well as from captive stock and published data on growth and development, food & feeding, fecundity etc. available
7. Biological studies state that BSC is a continuous breeder with high fecundity
8. Fast growing species reaching 100 g size within 6 months' time with a short life span of 2.5 to 3 years
9. Mass seed production and farming of the species are proven
10. The marine fisheries policy guidance to the Tamil Nadu state is prepared by CMFRI
11. Crab Meat Processors Association (CMPA) is active and ready to accept and implement the management plan
12. Crab gillnet –*Nanduvalai*- is a non-destructive gear
13. No ETP species caught in *Nanduvalai*

14. In Crab gillnet, only Crabs are targeted; BSC is the major species caught with minor quantities of other crab spp.

## Weakness

1. No fishery management plan in place in general and also no specific management plan for BSC other than 61 days' ban for trawlers during April-May of every year

2. No self-imposed management measures from local fishermen/groups other than compulsory withdrawal from fishing during unfavourable weather.

3. Traditional sector also has no regulation in number of boats & nets and no harvesting strategies & rules are in place.

4. No management plans for the crab fishing habitat especially for the seagrass beds, which form the nursery ground for BSC

5. No serious Fishermen awareness programme.

6. No limits or specifications fixed for the crab buyers/traders.

# 11. BSC Management Plan (BSCMP)

## Objectives

The proposed fishery management plan is intended to judiciously sustain and improve the BSC stock from the region through strict adherence to the rules and regulations with active participation and co-operation of all the stakeholders of the BSC fishery. The proper management requires an integrated approach, each stake-holder should adhere to the proposed measures and ensure the compliance with strict enforcement. Ultimately the goal is to achieve a sustainable exploitation of the BSC without causing any damage or harm to the ecosystem and also protecting its biodiversity through careful observation of the rules and regulations from fishing to trade. Hence, the proposed management plan necessitates an early streamlining of all the concerned activities as a precautionary approach which leads to attain a long-term status for BSC fishery as a well sustained fishery without overfishing or stock depletion. Reflections of a well-managed fishery can be observed not only in the sustenance of the fishery but also in the promotion of the environmental, economic and social sustainability.

Based on the facts and evidences gathered and proved over by many years' systematic studies on BSC, the following rules and regulations are recommended for the implementation in the Palk Bay region. Initial phase the proposed plan can be implemented in the Palk Bay and later it can be implemented to other main BSC fishing regions also.

## Rules and regulations:

1. Minimum Legal Size (MLS) should be fixed at 90 mm CW – a MLS measuring device (Fig. 71) must be distributed to the fishers, traders, etc.

2. Total Ban on landing of berried females- berried crabs must be put back to the sea as early as possible.

3. Soft shelled crabs caught also must be put back to the sea.

4. No trade of berried crabs–Crab processors/merchants should not buy berried crabs/ undersized crabs

5. BSC nursery grounds like coastal seagrass beds must be declared as Protected Area; no fishing should be permitted in these areas.

6. Number of fishing days should be restricted to traditional crab fishers – 200 days.

7. Compulsory registration and licenses should be given for BSC fishers, boats, gears and collection centers & processing plants.

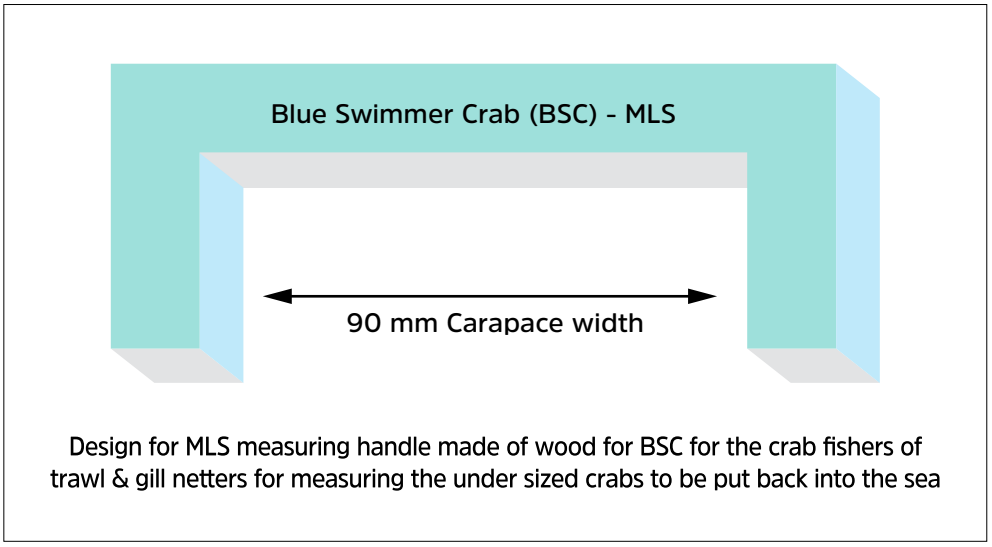
8. Strict enforcement through regular monitoring and punishment for violation.

9. Formation local fisher groups /leaders for regulating the crabbers at main BSC landing areas.

10. Fisherfolk must adhere to the management measures and ensure the implementations are followed by themselves through patrolling activities.

11. BSC fisheries Governance Council (BSCFGC) should be formed with specific responsibilities for each unit to fulfil the regulations and management plan.

12. Fishermen must cooperate with other stakeholders and share information, data to implement the management plan.




Design for MLS measuring handle made of wood for BSC for the crab fishers of trawl & gill netters for measuring the under sized crabs to be put back into the sea

Figure 71- Design for MLS measuring device for BSC fishery

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Fishery Management Plan for

# Palk Bay Blue Swimming Crab

*Portunus pelagicus,* commonly known as Blue Swimming Crab (BSC) is a highly valuable marine crab in India and bulk of the BSC products are exported to US. BSC is fished continuously from Palk Bay (PB), mainly by indigenous bottom-set gillnets known as *Nanduvalai*. Growth studies revealed that life span of BSC is around three years, although majority of the crabs are fished in the 0-year class. A Minimum Legal Size (MLS) of 90 mm carapace width is recommended to prevent growth overfishing. To sustain the BSC fishery strict management of the fishery is essential and the best possible immediate action is a total ban on landing and sale of berried females. For the BSC fishery the harvest strategy would be to maintain yields close to the estimated Maximum Sustainable Yield (7360 tonnes) using catch and effort based harvest control measure as reference points. Based on the facts and evidences, guidance on a Fishery Management Plan for Palk Bay BSC fishery are presented.


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