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***Research Article***

# An account on the emerging gastropod shell-trap fishery of short-armed octopus *Amphioctopus aegina* (J. E. Gray, 1849) in Palk Bay, Southeast coast of India

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Octopuses are bottom-dwelling molluscan species that inhabit both surface and deep waters. Octopuses exhibit camouflaging behaviour and usually hide in the crevices of reefs and rocks. This paper reports the re-emergence of the shell trap fishery for short-armed octopus, *Amphioctopus aegina*, after four decades in the Palk Bay region, following traditional fishing practices and Fiberglass-Reinforced Plastic (FRP) boats with outboard engines. Fishermen use gastropod shells as their base material. About 3000 – 3500 gastropod shells were tied at one-metre intervals on a 2 mm-thin Polypropylene rope. *Amphioctopus Aegina* formed 97 % of the landings with an estimated average catch per unit effort ranging from 40 to 50 kg/unit, followed by *A. marginatus* (2 %), and *A. neglectus* (1 %). The estimated profit margin is 61.3 %, and the labour efficiency is 20 kg.

[**Keywords**: *Baby kanava*, Camouflage, Catch per unit effort, Labour efficiency, Profit margin]

## Introduction

Cephalopods, which include octopuses, squids, and cuttlefishes, are an economically significant export value group. Octopuses are bottom-dwellers that are often restricted to neritic regions. There are approximately 100 identified species of octopuses, which live in all maritime areas around the world[1]. The eight-armed cephalopod order, encompassing the orders Cirroctopoda and Octopoda, contains approximately 300 species[2,3]. Cirroctopoda, which are not part of the octopus fishery, have fins on their bodies and delicate cirri along their limbs. Octopuses of the Order Octopoda lack these characteristics and are divided into seven families of pelagic octopuses in addition to the Family Octopodidae, which has approximately 200 known species of bottom-dwelling octopuses. This family consists of almost all octopuses caught around the world. The enormous octopuses of the *Enteroctopus* genus (Family Enteroctopodidae) and the *Eledone* genus (Family Eledonidae), having a single column of suckers down each arm, are exceptions[4]. *Octopus vulgaris* is the most common and widely distributed species in tropical and temperate seas worldwide[4]. Researchers estimated the lifespan of shallow-water octopuses from tropical and subtropical areas to be 1 to 2 years[5]. There is little evidence available regarding traditional fisheries, even in the relatively recent 18$^{th}$ and 19$^{th}$ centuries. According to Erlandson & Rick[6], the earliest marine fishing operations may have occurred 160,000 years ago (as documented on the Southern African coast). There is little to no technical knowledge regarding ancient nets or how to use them[7]. There are some records of cephalopod fishing in Japan during 60's and 70's[(ref. 8)]. For larger species, Hitomi[9] mentions octopus fishing with nets, a little wooden structure with a cuttlebone or fish bone on one side and a hook on the other, and small octopus pots strung together for *Amphioctopus fangsiao*. Terajima in 1713 wrote about "tako" (*Octopus sinensis* and maybe also *Enteroctopus dofleini*) fishing, which included connecting octopus pots with lines, and "iidako" (*A. fangsiao*) fishing, which involved stringing a line of empty gastropod shells together[10]. Octopus fisheries have grown in importance during the last decade, owing to increased export demand to the United States and Europe. In India during the 1980's and 1990's, there was no special demand for octopuses other than a bait fishery. Despite their widespread distribution along the Indian coastline and neighbouring islands, Sundaram[11] asserts that octopods remain one of India's least exploited species. Cephalopod fisheries have gained importance in India due to their high demand and export value. In 2023, estimated cephalopod landings reached 2,12,517

metric tonnes, with 19,857 t (9.3 %) being octopuses[12]. In Palk Bay, *Amphioctopus aegina* accounted for 77 % of all octopod catches. During the 1970s and 1980s, fishermen in Thondi (9° 44' 13.8444" N, 79° 1' 5.4624" E) and Thiruppalaikudi (9° 32' 56.6124" N, 78° 55' 11.532" E) villages began using empty gastropod shells for fishing octopus as bait for subsistence-level hook and line fishing. Until 2019, there was no specific gear for large-scale commercial octopus fishing on India's east coast. Instead, mechanised trawlers use bottom trawl nets on the continental shelf to harvest octopuses. All along the east coast, bottom trawls, traps, and trammel nets now target octopuses due to their increasing economic value[13]. After four decades, the shell trap fishery has seen a commercial resurrection due to changes in the gears and fishery pattern, which involves targeted octopus fishing by depositing gastropod shells on the bottom at an average depth of 4 – 5 metres. Many adjacent villages in the Palk Bay region adopted this indigenously designed octopus fishing method to meet market demand. The study aims to document and analyse the indigenous gastropod shell trap method used for harvesting short-armed octopus in the Palk Bay region and assess its present fishery status.

## Material and Methods

The Palk Bay habitat is distinct, with an enclosed bay receiving input from multiple rivers extending from Point Calimere (Kodikkarai near Vedaranyam) in the north to Dhanushkodi in the south. It is located between latitudes 9°55' and 10°45' N and longitudes 78°58' and 79°55' E. Seagrass ecosystems, salt marshes, estuaries, lagoons, mangroves, and coral reefs can all be found along Palk Bay's coastline[14]. There are significant differences in the region's geographic features and marine environment. The region have a lengthy history of human habitation, use, and exploitation, in addition to being rich in biological diversity.

The indigenous fishing techniques of the gastropod shell-trap-based octopus fishery in the fishing villages along the Palk Bay coast from January 2020 to December 2023 were investigated. Figure 1 depicts the surveyed fishing villages in Palk Bay. Octopus landing data for the Palk Bay coast from 2020 to 2023 were collected from the National Marine Fishery Resources data Centre (NMFDC) of the ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi, India. The data were acquired using an observer-based stratified multi-stage random sampling technique. The Catch Per Unit Effort (CPUE) was calculated by dividing total landings by the number of fishing units. The detailed fishing information seen and gathered was described here. Between January and December 2023, samples were taken every fortnight. A total of 351 specimens (24 – 101 mm DML) were randomly selected for size composition analysis in the fishery. A vernier calliper was used to measure the DML from the eye to the posterior region of the mantle. Approximately 313 males (24 – 98 mm DML) and 38 females (53 – 101 mm DML) were dissected to determine sex and maturity[15]. The sex ratio was also computed using the samples gathered. The economic analysis is conducted in accordance with Geetha *et al.*[16]. Investment in craft, engine, gear and its accessories and the cost of the battery/generator were included in the initial investments. The fixed cost includes the depreciation, initial investments, interest on investment and the expenditure incurred for the repair and maintenance of craft and gears. The operating costs like fuel, crew wages, ration and ice are considered operating cost. The gross revenue obtained from fish sales was calculated by deducting any operational expenses, *viz*., transportation, labour, fuel, and ice cost from the total income generated. The revenue was estimated by multiplying the total quantity of fish sold by the average market price per kilogram during the study period.

The following formulae were used in the economic analysis:

*Depreciation = actual cost - junk value / shelf life*

*Total costs = fixed cost + operating cost*

*Net operating income = gross revenue - operating cost*

*Net profit = gross revenue - total cost*

*Profit margin = net profit / gross revenue*

*Labour productivity (kg) = Average catch (kg) / Number of crews*

*Remuneration (Rs.) = Net profit / Number of crews*

*Fuel efficiency (kg/L) = average catch / amount of fuel used for fishing*

## Results and Discussion

The fishermen of Thiruppalaikudi fishing village, located in the Ramanathapuram district of the Palk Bay region in Tamil Nadu, reinitiated indigenous practices of octopus fishing using gastropod shell traps for commercial purposes in 2020. Later, these practices spread to the coastal villages of the entire

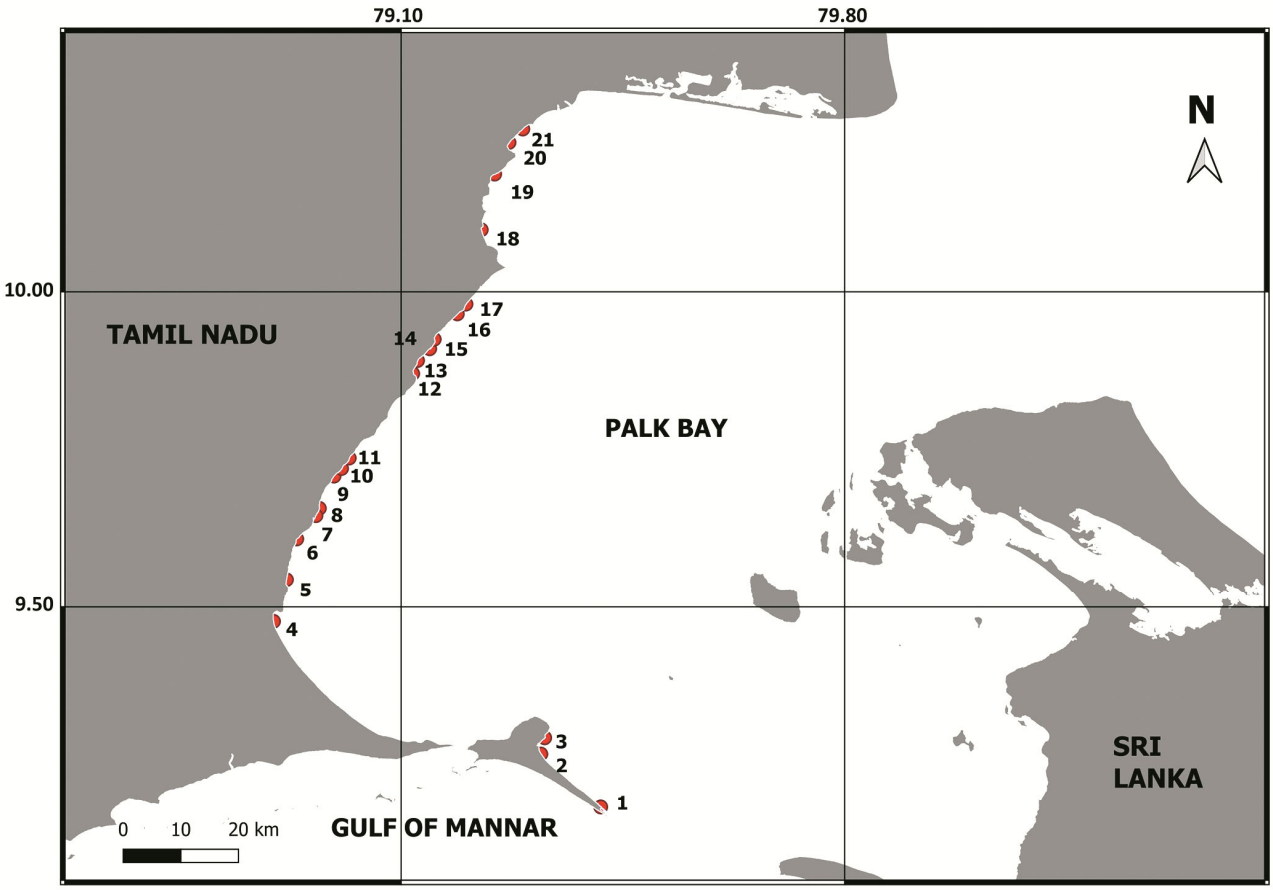


Fig. 1 — The fishing villages practiced gastropod shell trap fishing on short-armed octopus along the Palk Bay coast. 1. Dhanuskodi, 2. Karaiyur, 3. Olaikuda, 4. Devipattinam, 5. Thiruppalaikkudi, 6. Mullimunai, 7. Morppannai, 8. Karangadu. 9. Soliyakudi, 10. Nambuthalai, 11. Thondi, 12. Muthukuda, 13. Arasanagaripattinam, 14. Pudur, 15. Gopalapattinam, 16. Jagathapattinam, 17. Kottaipattinam, 18. Krishnajipattinam, 19. Karanguda, 20. Senthalaipattinam, and 21. Ganesapuram

Palk Bay region. Fishermen conduct their fishing at a distance of 3 – 4 nautical miles from the shore, at a depth of 4 – 5 m, and by laying shell trap lines up to 3.5 km on the sandy bottom. There are two types of fishing: In the first type, the shooting of traps occurs in the evening (1600 hrs), sheltering the net for 12 – 14 h before hauling it back in the early morning (0400 hrs). In the second type, the traps are deployed in the early morning (0400 hrs), shelter the net for 1 – 2 h, and then hauled back. In the gastropod shell cavities, a needle dislodges the refuged octopus (Fig. 2e). It was noted that the fishermen lay their nets daily for octopus fishing, which peaks between February and June when the intensity of trawling declines. Other days for fishing are Tuesdays, Thursdays, Fridays, and Saturdays, when trawling is not allowed. The shell lines were periodically brought to the shore and dried after a long period of use. The fishery is often discontinued during the rainy season due to low catch and cyclonic warnings.

The fishing is mainly targeted at catching the short-armed octopus *A. aegina*, locally called "Baby Kanava". The Fiberglass Reinforced Plastic (FRP) boats with an Overall Length (OAL) of 10.5 to 11.0 m, fitted with 9 – 10 hp outboard engines, are employed in this fishing (Fig. 2b). Figure 1 provides a list of fishing villages involved in shell trap fishing, and Figure 3 provides the number of units operated. For this practice, each fishing boat employs a total of two crews. The gear is made with locally available materials such as empty seashells, thin Polypropylene ropes, and HDPE (High-Density Polyethylene) floats. A series of 3000 – 3500 gastropod shells is strung along a thin polypropylene rope (2.5 mm polypropylene rope, yellow tufropes) with an interval of one metre, and the mainline extends up to 3500 m (Fig. 2a). The gastropod species include *Tonna dolium*, *Tonna sulcosa*, *Rapana rapiformis*, *Chicoreus ramosus*, *Volegalea cochlidium*, and *Lambis lambis*. The fishers procure the gastropod shells from the


Fig. 2 — Short armed octopus fishery: a) Gastropod shell trap for catching short-armed octopus; b) Craft engaged for shell trap Octopus fishery in Soliyakudi; c) Different sizes of *Amphioctopus aegina*; d) Catch of short arm octopus; e) Live short arm octopus trapped in the gastropod shell

Rameshwaram Shellcraft industry at a cost of Rs. 4 – 8 per chank, with potential hikes based on demand. The trawl ban period, which runs from April 15 to June 14, marks the peak of trap fishing activity. During the ban period, trawling activities are suspended, allowing fishermen to deploy more nets, which results in higher landings. A unique characteristic of Palk Bay is the availability of this resource at shallower depths. Consequently, bottom trawling also exploits this resource. Landings were significantly high during the ban period, attracting an increased number of fishing units engaged in this fishery. During peak seasons, the estimated maximum CPUE ranged from 100 to 110 kg/unit, and the estimated average CPUE ranged from 40 to 50 kg/unit (Fig. 2d). Figure 3 displays the number of units operating in the fishing villages.

Thiruppalaikudi village pioneered this gastropod shell trap fishing method to exploit short-armed octopus. The economic status of the fishers in Soliyakudi, Kottaipattinam, and Krishnajipattinam is superior to that of their counterparts in Thiruppalaikudi. The fishers in Soliyakudi are investing to increase their units year on year; however, this type of investment has not been observed in Thiruppalaikudi village. From 2020 to 2023, there has been a minimal increase in units in Thiruppalaikudi, Mullimunai, Morpannai, Soliyakudi, and Thondi, while the numbers have doubled in Kottaipattinam and Krishnajipattinam. Soliyakudi, Kottaipattinam, Thondi, and Krishnajipattinam have

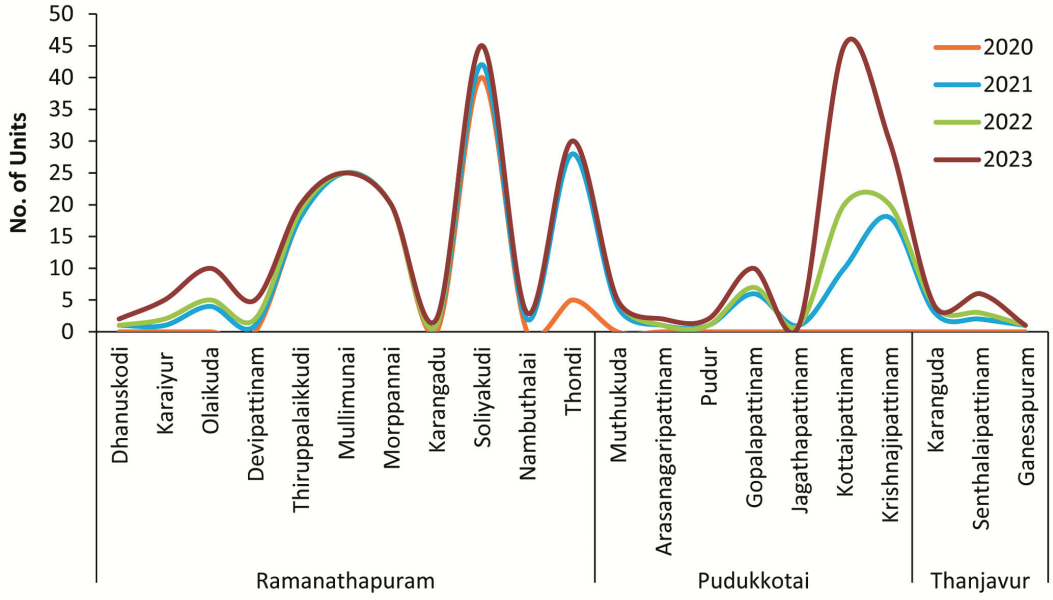


Fig. 3 — Number of units involved in the gastropod shell trap octopus fishery along the Palk Bay coast

emerged as major fishing hubs, whereas villages like Mullimunai, Morpannai, and Thiruppalaikudi maintain a consistent and reliable presence of fishing units, reflecting stable operations. A significant number of villages still operate with minimal fishing units, which may require financial support for their operations. Thus, economic status will play a crucial role in enhancing the efforts of the units within the specific fishing village.

The landing trend shows that the peak landings occurred in May, followed by July. The annual landings increased by 95 % in 2023 (1174 t) compared to 2020 (53 t), showing an increasing trend from 2020 to 2023 (Fig. 4) mainly because of the export market demand. The fluctuation in the landing during November and December is attributed to the available fishing days, which were mostly affected by cyclones during this period. *Amphioctopus aegina* (97 %) dominated the landings, followed by *A. marginatus* (2 %), and *A. neglectus* (1 %) in the fishery from 2020 to 2023 (Fig. 5). The mantle length of the short-armed octopus male and female ranged from 24 – 98 mm and 53 – 101 mm, respectively (Fig. 2c and Fig. 6). The octopuses are sold at ₹ 200 – 250 per kg based on the grade and quality, and the average rate is ₹ 180 per kg. The economic analysis of gastropod shell trap octopus fishing is given in Table 1.

Both commercial and artisanal fishing can use octopus traps, depending on the size of the boat and the quantity of traps. When larger boats are used, commercial fishing employs more traps[17]. Each year, the *A. aegina* species accounts for more than 90 % of the octopuses caught, with a minor number of *A. rex* caught during certain seasons[17]. Octopus pots have a lengthy history dating back to Japanese octopus fishing techniques, which are particularly efficient due to the octopus's homing behaviour[18]. Octopus traps, an essential tool for octopus fisheries, first appeared in Thailand's eastern Gulf in 2004[(ref. 19)].

In ancient times, catching octopus was common along the coastal villages of Palk Bay, particularly at Thondi and Thiruppalaikudi, exclusively for the bait, in hook and line fisheries along the Palk Bay[20]. The shell traps are made up of indigenous materials such as empty seashells, thin coir ropes, and wooden floats. The shell traps use the gastropod shells of *Lambis lambis*, *Tonna dolium*, *Rapana bulbosa*, *Murex virgineus*, and *Hemifusus* sp.[21,22]. In earlier days, only 100 – 120 gastropod shells were used in a line for fishing, and nowadays, it's become a commercial

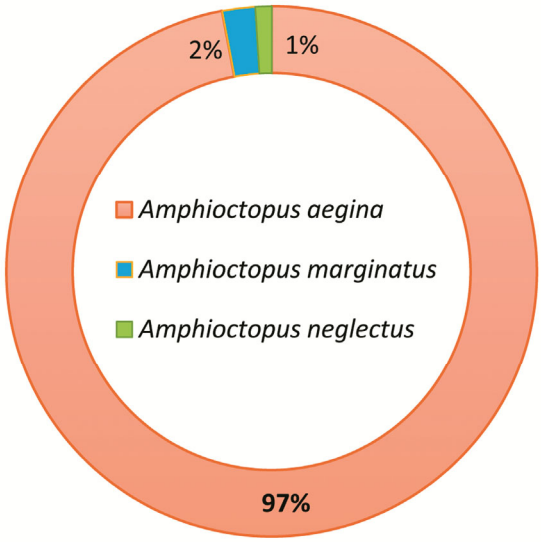


Fig. 5 — Species catch composition of octopuses in gastropod shell trap

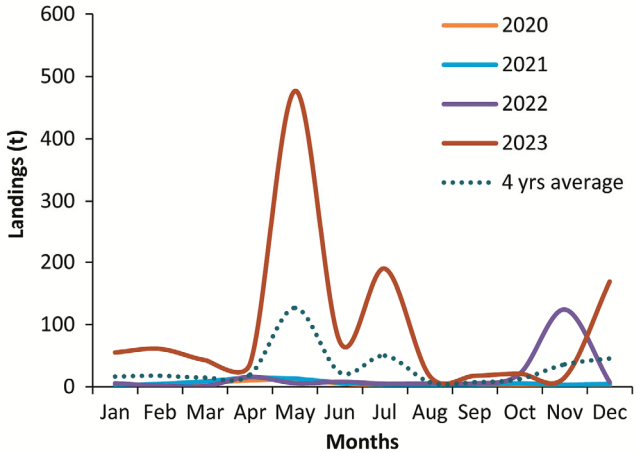


Fig. 4 — Landing trend of octopus by gastropod shell trap on the Palk Bay coast

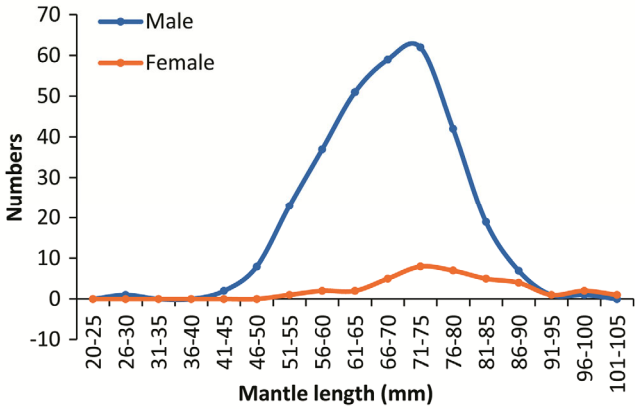


Fig. 6 — Sex-wise size range distribution of short arm octopus caught in the gastropod shell trap fishery along the Palk Bay

Table 1 — Economics analysis of octopus fishing with gastropod shells (values in ₹)

| **Particulars** | **Cost (in Rupees)** |
|---|---|
| 1. Initial investment | |
| i. Craft and engine | 1,50,000 |
| ii. Nylon rope (15 bundle) | 3,000 |
| iii. Gear and accessories | 15,000 |
| Total | 1,68,000 |
| 2. Fixed cost | |
| a. Depreciation | |
| i. Craft and engine (20 %) | 200 |
| b. Interest on investment | 33.6 |
| c. Repair and maintenance | 41.6 |
| Total | 275.2 |
| 3. Operating cost | |
| i. Fuel (3.3 L) | 300 |
| ii. Crew wages | 2,000 |
| iii. Food | 200 |
| Total | 2,500 |
| 4. Total cost (2+3) | 2,775.2 |
| 5. Gross revenue (Avg. 40 kg octopus @Rs. 180/kg) | 7,200.00 |
| 6. Net operating income (5-3) | 4,700 |
| 7. Net profit (5-4) | 4,424.8 |
| 8. Profit margin (7/5) *100 | 61.46 |
| 9. Annual days of operation | 180 |
| Average catch (kg) | 40 |
| No. of crews | 2 |
| 10. Productivity measures | |
| Labour productivity (kg) | 20.0 |
| Remuneration (Rs.) | 2209.7 |
| Fuel efficiency (kg/L) | 12.1 |

fishery where up to 3500 gastropod shells are lured in a single line.

Developments in fishing gear have led to a number of issues for the fishery. During the mini trawl and trawl operations, the shell trap rope line may be entangled in the trawl net, and the trawl fishermen get the chance to cut the rope, which leads to damage and loss of gear. As a result, shell trap fishermen operated a greater number of gears during the monsoon fishing ban period. The profit margin from the fishery is 61.3 %, and the estimated labour efficiency is 20 kg. The labour efficiency was higher for the Multiday mechanised Gillnetter (MDGN) as the catch per man-day was 60.4 kg as compared to 58.5 kg for Multiday mechanised Trawler (MDTN)[16]. In Hokkaido, fishermen tie ceramic pots of various sizes and shapes or wooden boxes containing 50 – 100 pots or boxes in series to a 600 – 800 m mainline and lay them on the sea bottom, either with or without bait. After 1 – 3 days, fishermen lift the pots. Vinyl chloride boxes have replaced ceramic pots and wooden boxes in recent years[23]. Its targeted fishing, less damage to juveniles, and high fuel efficiency show that it is sustainable fishing when compared to gill nets. Even if trawling accidentally damages or loses the net, it serves as a shelter for the octopus, thereby increasing their productivity. During the fishing ban period, large-scale octopus fishing with more than 3 km of trap line is a worrying trend. In the absence of trawling, small-scale fishers find this period to maximise resource extraction from the seas, using the traditional method in an upscaled manner. At present, this supports a thriving fishery in Palk Bay.

Surprisingly, there were very few females on the landings, and the sex ratio was 1:0.12 (male: female), indicating that the males were more dominant. The reason is that most females generally avoid using the shell as a spawning refuge if the internal shell diameter is equal to or less than the species' mean egg string length, which is a deciding factor for attaching, managing, and ventilating the egg mass inside the shell. Due to this reason, females are generally absent and will pick a larger, more natural, and suitable spawning area. In Brazil, the *Octopus tehuelchus* inhabits the inner shelf on gravel and soft bottoms, seeking sanctuary and spawning in large gastropod shells. Octopus shell traps are size-selective and monospecies fishing gear. Their large size typically excludes juveniles, primarily targeting subadult and adult animals. The shells have minimal to no physical impact on the seafloor, making this a fuel-efficient capture technique. Ghost-fishing mortality is not an issue (as opposed to basket traps or trammel nets), because short-armed octopuses can freely enter and exit the shell. For these reasons, octopus shell trap fishing is a low-impact, environmentally friendly activity. In the *O. vulgaris* fishing area off Morocco, researchers recovered 50 % of the plastic objects, 94 % of which originated from lost plastic octopus pots[24].

Shell-trap fishing is recommended to capture live octopuses for laboratory experiments. This method of fishing captures octopuses with almost no damage to their skin, less stress after capture, and higher survival rates in captivity than other methods, such as bottom trawling, which has a high mortality rate after capture. Ignatius *et al.*[1] studied *A. aegina*'s growth and mortality rates using length-based approaches. The estimated mortality rates are 5.68 for total mortality (Z), 3.02 for natural mortality (M), and 2.66 for

fishing mortality (F). This analysis found that the maximum exploitable rate was 0.5730, compared to 0.47 from October 2000 to December 2002. According to growth metrics, *A. aegina*'s estimated growth was 7.45 cm DML at the end of the first year and 9.34 cm at the end of the second year. The study found that this species takes 1.5 years to reach its observed length of 8.7 cm and more than 36 months to reach an asymptotic length of 10 cm, with a life span of ~ 3 years.

Trawlers predominantly exploit octopuses, and a 61-day seasonal restriction on mechanised trawling throughout India's east coast governs the activity. In India, there is no specific octopus fishery management plans. Most research investigations identify the octopus as an underutilised resource. Furthermore, stock assessments of octopus species on India's east coast are considered poor. Indian seafood producers are eyeing octopus markets in the United States and Europe. The demand for Indian octopus has surged as a result of overfishing in West African nations such as Morocco and Mauritania. The majority of the exported products are whole cleaned, frozen, fresh chilled, and baby octopus, as well as Individual Quick Frozen (IQF) octopus tentacles, IQF whole cleaned octopus, and additional value-added products, including IQF octopus cut and cooked (V cut) and frozen octopus tray packs[13]. In 2014, there was an unexpected increase in demand for immature octopods weighing 10 – 100 g because of unsafe landings in the Vietnamese market. The west coast saw vast numbers of *A. neglectus*, a smaller octopus species. Processing factories in Kerala, India's west coast, transport short-armed octopuses harvested from the east coast in Palk Bay and the Gulf of Mannar regions for processing (IQF and block frozen) as "baby" octopuses for export. Baby octopod exports are currently in high demand, particularly along India's southeast coast. Octopus is an unusual cuisine in India's domestic seafood markets[21,25]. On the Andaman and Nicobar Islands, people routinely hunt octopuses for food. It was used as bait on India's south-east coast[21,24]. Traditionally, fishermen would dry and sell these octopuses at the local market. The recent establishment of a lucrative export market for octopus has resulted in increased exploitation and frozen processing[24]. The highest landing is reported during the ban period, when this species' spawning season along the coast was not at its peak. Continuous monitoring of shell trap fishing activities is essential to assess their long-term implications for coastal fishery sustainability and to better understand the population dynamics of short-armed octopuses in the Palk Bay ecosystem. The shell trap fishery, being highly selective, primarily targets mature individuals, which may alter the natural size and age composition of the population and gradually reduce species abundance and reproductive potential. When the annual harvest rate exceeds the species' natural replenishment rate, population recovery becomes limited, potentially leading to stock decline. This study is first of its kind which primarily focuses on the octopus fishery and further dedicated study is required to arrive at the sustainability and stock status. However, at present shell traps are relatively eco-friendly and cause minimal habitat disturbances.

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**Conflict of Interest**

Authors declare no competing or conflict of interest.

**Authors Contributions**

MR: Conceptualization, writing - original draft, analysis and editing; ST: preparation of map and data collection; RR, MM, SJJ & KS: Data collection in the field. RS, MK, and SJK: Critical review of this manuscript.

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