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Status of the squid jigging fishery using biodegradable fish aggregating devices (FADs) in Palk Bay and the Gulf of Mannar, south-east coast of India

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Abstract

This study reports the use of six different plant species as fish aggregating devices (FADs) along with FRP-coated PUF (polyurethane foam) floats, for squid jigging operations in Palk Bay and the Gulf of Mannar, south-east coast of India. The annual average cephalopod landings obtained by squid jigging during 2010-2021 was 1948 and 414 t in the Gulf of Mannar and Palk Bay, respectively. Fishing is carried out at a distance of 6-10 nm (nautical miles) from the shore, at 13-25 m depth in the Gulf of Mannar, whereas in Palk Bay fishing is done at 4 and 6 nm and depths of 5-8 m. The jigs are deployed directly from the *vallam*/FRP (fibre-reinforced plastic) boats or using small thermocol (polystyrene) floats and FRP coated polyurethane foam float (PUF). Whole plants or branches of locally available plant materials are used as fish aggregating devises (FADs). The peak fishing seasons fall during April-June and August-September. The annual average Landings per Unit Effort (LPUE) and Landings per Hour (LPH) for cephalopods during 2010–2021 were 13.37 kg unit^{-1} and 2.86 kg h^{-1} in Palk Bay, whereas in the Gulf of Mannar, the estimates were 9.5 kg unit^{-1} and 1.7 k h^{-1}. The major species contributing to the squid jigging fishery in Palk Bay *were Sepioteuthis lessoniana*, *Acanthosepion pharaonis, Sepioteuthis prabahari* and *Amphioctopus aegina*, whereas *A. pharaonis*, *S. lessoniana* and *Octopus cyanea* dominated the fishery in the Gulf of Mannar. *A. pharaonis* was the dominant species in both regions.

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Introduction

Cephalopods have emerged as valuable seafood resources in recent times because of the demand in export trade due to their high nutritional profile. They are the second major seafood export item from India. Cephalopods are short-lived marine creatures with high metabolic rates, rapid development and maturation, and strong phenotypic plasticity, resulting in significant interannual population variability caused mostly by environmental variations. They perform important ecological roles as predators and prey, and are a valuable resource for human consumption (Villanueva *et al*., 2017). Cephalopod fisheries worldwide have increased from about 0.6 million t in 1950 to a peak of 4.9 million t in 2014 before declining to around 3.7 million t in 2020 (FAO, 2020). In India, the fisheries have developed rapidly, accounting for around 5.13% of national marine fish landings and 4.7% of worldwide cephalopod production (FAO, 2020; CMFRI, 2021). More than half of the global landings come from the north-west Pacific and south-west Atlantic, with significant contributions from the western central Pacific, eastern Atlantic, and eastern Pacific. Squid distribution and fishery dynamics are heavily influenced by environmental factors, particularly seawater temperature and ocean currents, and ongoing climate change is expected to exacerbate population fluctuations, potentially jeopardising cephalopod fisheries' sustainability and economic importance (Huang *et al*., 2024). Nearly 40% of global cephalopod landings are by jigging, 25% by trawling and the rest by other gears (Alagarswami *et al*., 1987; Kavitha, 2018; Mohamed, and Sarvesan, 2004), whereas in Tamil Nadu, 65% of the cephalopod

landings are by trawl, 11% by jigging (handline), and the rest by other gears (CMFRI, 2021). Other gears that exploit cephalopods as bycatch are boat seines, purse seines, traps and dol nets. In India, cephalopods are primarily exploited by single-day and multiday mechanised trawlers.

Jigging, a specialised fishing method developed for catching cephalopods in Japan, has slowly emerged in India and squid jigging practices started in India in 1917. Sundaram and Deshmukh (2011) reported primitive squid jigging by Hornell, which was popularised in 1982-1983 (Lipton *et al*., 1990). Habitually, cuttlefish and squid are demersal forms, and they are coming up to surface waters for feeding and spawning. They have a reproductive strategy of laying eggs on suitable substrata in the pelagic region. This strategy was used to adopt FADs-associated cuttlefish and squid fishery. In India cephalopod jigging by hand has been reported from various places, such as Vizhinjam, Kanyakumari, the Palk Bay Coast, Tuticorin, Karnataka, Devipattinam, and Keelakarai in the Gulf of Mannar (Sundaram and Deshmukh, 2011). Traditional fishermen have been practicing squid fishing by hand jigging in both Palk Bay and the Gulf of Mannar since 1982. The present study documents the status of hand-operated squid jigging operations using FADs in Palk Bay and the Gulf of Mannar.

Materials and methods

The fishery was monitored during 2020–2021, along the coast from Jambavanodai (in Thiruvarur District) to Kanyakumari, covering Palk Bay and the Gulf of Mannar. Fishing villages where squid jigging is practiced were identified. Squid jigs collected from fishers in both regions were used to describe the structures. A multistage stratified random sampling method developed by the ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi was used to estimate the total landings (Srinath, 1998). The data collection framework encompassed enquiries about species caught, date of landing, total length of the fishing vessel, gear measurements, gear quantity per vessel and vessel travel distances. Information on the fishing operational depth, the number of fishermen engaged, the duration of fishing activities, the wet weight of the landed species, pricing, and the count of fishing vessels involved, were also gathered. The data was initially estimated at the landing centre and then extrapolated to the zone, district, and state levels. The landing data estimates from the National Marine Fisheries Resources Data Centre (NMFDC) for the years 2010–2021 were used to analyse the annual cephalopod landings by jigs in the region. The fishing operation was recorded through interaction with the fishermen, gathering insights into the techniques and equipment used. LPUE and LPH were calculated using Microsoft Excel based on the landings and the effort data. A total of 1648 specimens were sampled at random from jigs operating in Palk Bay and the Gulf of Mannar. Dorsal mantle length (DML), body weight, and ovary weight were measured to the nearest 1 mm, 1 g, and 1 mg, respectively. Sex was identified macroscopically by observing the gonads. The mean length and sex ratio were computed in Microsoft Excel.

Results and discussion

Squid jigs

Jigs (Japanese-made hand jigs) are a selective gear used exclusively for catching cephalopods and are locally called "Kanavai thoondil" or "Disco thondil" (Fig. 1). These jigs are moulded to resemble shrimps with surface shadings in green, orange, pink, red, and yellow, with gradually diminishing colouration on the lateral sides and a white underside. The eyes in the lure are prominent and protrude as in the case of shrimps, and a lead weight is attached in the lower portion of the lure to maintain the horizontal trolling position. Double circles of hooks are arranged in two rows of 6–7 hooks each, totaling 12–14 numbers. Commonly used jigs measure 2.5 to 3.0 inch, with 3.0 inch jigs predominant in both Palk Bay and the Gulf of Mannar region. Each jig is tied to a nylon wire (60-80 nos.) with rope length ranging from 6 to 15 m and is wound onto a wooden frame reel. The surface of the jigs is covered with cloth material (ribbon) for better catch efficiency of the jigs. Lipton *et al.* (1990) reported 105-135 mm sized jigs with 12-14 hooks in two rows and 18 hooks in two rows used in Palk Bay, whereas 16-18 hooks are reported in the Gulf of Mannar (Balasubramanian *et al*., 1995) and 18 hooks in two rows in the Coromandel Coast (Vishnu *et al.*, 2021).

Fig. 1 Squid jigs (*Disco thoondil*) used in the Palk Bay and Gulf of Mannar

Area of operation

Squid jigging is practised in 39 fishing villages across Palk Bay from Point Calimere to Arichalmunai and in 36 villages in the Gulf of Mannar from Arichalmunai to Kanyakumari (Fig. 2a, b; Table 2, 3). Some of the important squid jigging centres in Palk Bay include Pudupattinam, Ganeshapuram, Kalumangadu, Pasipattinam, Morppannai, Nambuthalai, Thondi, Thiruppalaikudi, Palanivalasai, Mandapam, Pamban, Ariyankundu, Sangumaal, Olaikuda and Dhanuskodi, whereas the Gulf of Mannar includes Kilakkarai, Muthupettai, Sadamunivalasai, T. Mariyur, Vembar, Periyasamypuram, Kombuthurai, Punnakayal, Veerapandiapattinam, Amalinagar, Kooduthalai, Kootapanai, Kuthenkuzhi, Thomaiyarpuram, Idinthakarai and Chinnamuttom villages. Lipton *et al*. (1990) reported that almost 50 fishing villages are engaged in squid jigging during the peak season in Palk Bay. Other than these, squid jigging has also been reported from Kilakkarai and Devipattinam (Venkatesan and Shanmugavel, 2008), Tuticorin (Balasubraminian *et al*., 1995), Kombuthurai (Chellamanimegalai *et al*., 2019), Cuddalore (Vishnu *et al*., 2021), Vizhinjam (Surya *et al*., 2019), Karnataka (Sasikumar *et al*., 2006) and Ratnagiri (Sundaram and Sawant, 2013).

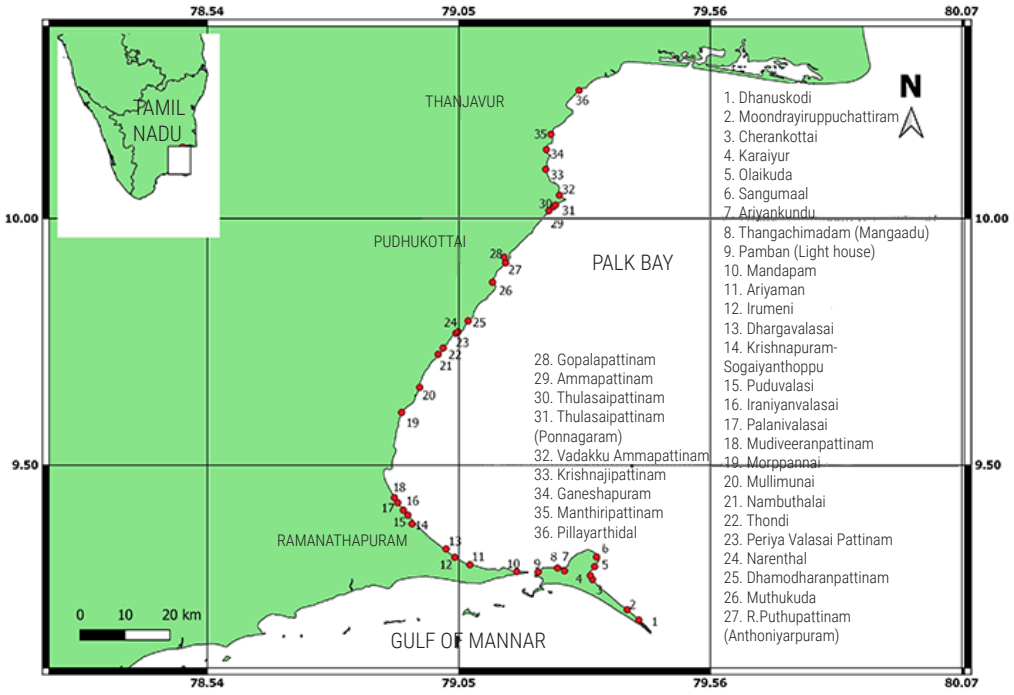

Fig. 2a. Map showing the villages operating squid jigging in Palk Bay

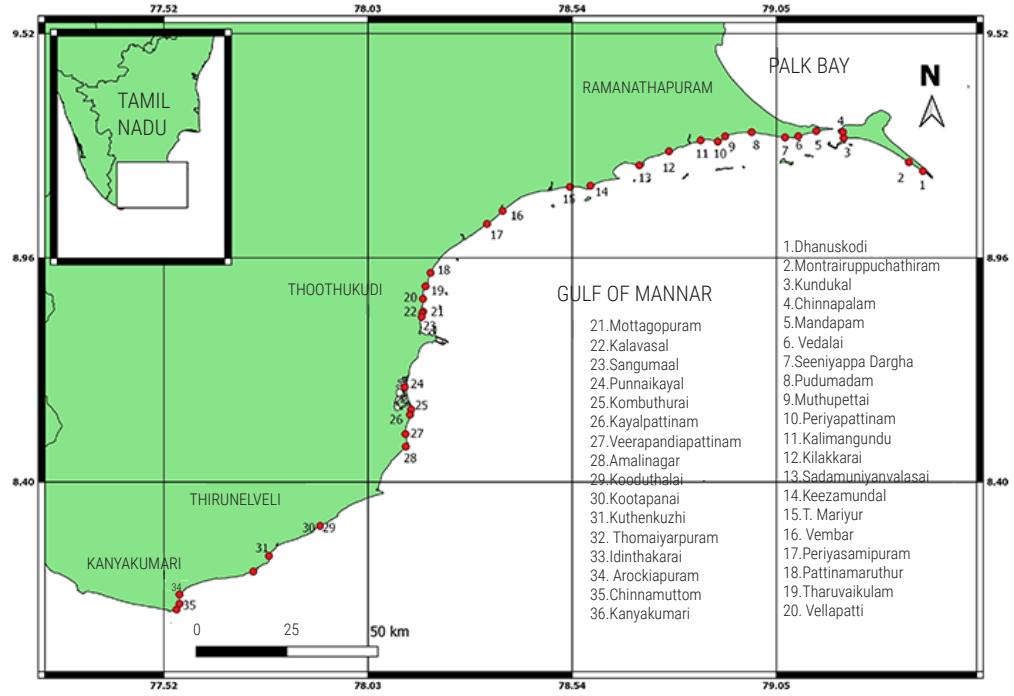

Fig. 2b Map showing the villages operating squid jigging in Gulf of Mannar

Table 1. Details of fishing villages using FADs along Palk Bay

Fishing villages	Geo-location	Type of FADs used	No. of fishers involved	Type of craft	Fishing season
Ramanathapuram District					
Dhanushkodi	9.185842; 79.415002	TP, PP, PJ, AJ, CE	80	OBM-FRP, NM, Polystyrene	Throughout the year
Moondrayiruppuchattiram	9.206805; 79.391195	TP, PP, PJ, AJ, CE	25	OBM-FRP, NM, Polystyrene	Throughout the year
Cherankottai	9.267837; 79.321144	TP, PP, PJ, AJ	30	OBM-FRP, NM	April-June
Karaiyur	9.275942; 79.316622	TP, PP, PJ, AJ	32	OBM-FRP, NM	April-June
Olaikuda	9.3136817; 79.3292967	TP, PP, PJ	35	NM, FRP-PUF, Polystyrene	Throughout the year
Sangumaal	9.2940506; 79.3252854	TP, PP, PJ, AJ	250	IBM-V, Polystyrene	Throughout the year
Ariyankundu	9.285532; 79.2643196	TP, PP, PJ, AJ	25	NM	Throughout the year
Thangachimadam (Mangaadu)	9.2912087; 79.2501025	TP, AJ, PP, PJ	65	OBM-FRP, NM	April-June
Pamban (Lighthouse)	9.283350; 79.210939	TP, AJ, PP, PJ	50	OBM-FRP, NM	April-June
Mandapam	9.2841446; 79.1674148	TP, AJ, PP, PJ	80	OBM-FRP, Polystyrene	April-June
Ariyaman	9.2977535; 79.0724919	TP, PP, CE, CNI	25	OBM-FRP, Polystyrene	April-June
Irumeni	9.313055; 79.0417717	TP, PP, AB, CNI	60	OBM-FRP, Polystyrene	April-June
Dhargavalasai	9.32990; 79.024104	TP, PP, CNI	25	OBM-FRP, Polystyrene	April-June
Krishnapuram-Sogaiyanthoppu	9.3807158; 78.9551058	TP, PP	50	OBM-FRP, IBM-V, Polystyrene	April-June
Puduvalasi	9.3985282; 789466723	TP, PP, AB	80	OBM-FRP, IBM-V, Polystyrene	April-June
Iraniyanvalasai	9.4085286; 78.9374866	TP, PP, CE, CNI	35	OBM-FRP, IBM-V, Polystyrene	April-June
Palanivalasai	9.4235958;78.9261623	TP, PP, CE	100	OBM-FRP, IBM-V, Polystyrene	April-June
Mudiveeranpattinam	9.4340672;78.9193605	TP, PP, CE	25	OBM-FRP IBM-V, Polystyrene	April-June
Devipattinam	9.477647; 78.898493	TP, PP, CE	100	OBM-FRP IBM-V, Polystyrene	April-June
Pathanendal	9.505889; 78.914033	TP, PP, CE	20	IBM-V, Polystyrene	Throughout the year
Thiruppalaikudi	9.544392; 78.918973	TP, PP, CE	80	OBM-FRP Polystyrene	April-June
Morppannai	9.6067633; 78.9339333	TP, PP, AM	500	OBM-FRP, Polystyrene	Throughout the year
Mullimunai	9.657552; 78.9705306	TP, PP	80	OBM-FRP, Polystyrene	Apr-Sep Jan-Mar
Nambuthalai	9.724845; 79.008398	TP, PP	400	OBM-FRP, Polystyrene	Throughout the year
Thondi	9.7375115; 79.0181168	TP, PP	150	OBM-FRP, Polystyrene	Throughout the year
Periya Valasai Pattinam	9.767282; 79.043940	TP	50	OBM-FRP, Polystyrene	Apr-Jun
Narenthal	9.7703155; 79.0483299	TP	25	OBM-FRP, Polystyrene	Apr-Jun
Dhamodharanpattinam	9.7923731; 79.0688687	TP, PP	40	OBM-FRP, Polystyrene	Apr-Jun
Pudukottai District					
Muthukuda	9.870836; 79.118389	TP	35	OBM-FRP	Apr-Jun
R. Puthupattinam	9.9100956; 79.1447791	TP, PP, CE	50	OBM-FRP	Apr-Jun
Gopalapattinam	9.9215291; 79.1423129	CE, TP, PP	55	OBM-FRP, Polystyrene	Throughout the year
Ammapattinam	10.0159432; 79.2326188	TP, PP, CE	25	NM	Apr-Jun
Thulasaipattinam (Anthoniyarpuram)	10.0241527; 79.2416812	TP, PP, CE	45	OBM-FRP, NM	Apr-Jun
Thulasaipattinam (Ponnagaram)	10.027509; 79.246019	TP, PP, CE	50	OBM-FRP, NM	Apr-Jun
Vadakku Ammapattinam	10.0473554; 79.2539957	TP, PP, CE	25	NM	Apr-Jun
Krishnajipattinam	10.099955; 79.2261816	TP, PP, CE	10	NM	Apr-Jun
Thanjavur District					
Ganeshapuram	10.139717; 79.2275561	CE, PK, TP, PP, AM, CNF	80	OBM-FRP, NM	Throughout the year
Manthiripattinam	10.1706833; 79.2366679	CE, AM	15	NM	Apr-Jun
Pillayarthidal	10.259894; 79.2937561	CE, PK, TP, PP, AM, CNF	10	OBM-FRP, NM	Throughout the year

*PK: *Phramites karka* (Sambai/Nanal), CE: *Casuarina equisetifolia* (Savukku), TP: *Tephrosea purpurea* (Kolunji), PJ: *Prosopis juliflora* (Odai maram), PP: *Phoenix pusilla* (Echam), AB: *Alyxia buxifolia* (Beenjan), CNI: *Cocos nucifera* (inflorescence), CNF: *Cocos nucifera* (fronds), ST: *Solanum torvum* (Sundaikkai), AJ: *Aerva javanica (Ponga poo),* AM: *Avicennia marina (Alayathi)*

Crafts used in squid jigging

There are different types of crafts employed in fishing, *viz*., non-mechanised wooden plank-built boat with an overall length (OAL) of 5–12 m locally called '*vathai*; motorised FRP boat with an OAL of 8–14 m and 10–12 hp; plank-built boat with inboard engines (14–20 hp) and an OAL of 13–15 m locally called '*vallam*; small thermocol (polystyrene) float with a length of 1.8 m locally called '*theppam*'; and FRP-coated PUF float with a 2 m length (the outside of the float is made with plywood and the inner side is filled with PUF). Along both east and west coasts of India, different types of crafts used for jigging have been reported, *viz*., 5–12 m non-motorised plank-built boats (Lipton *et al*., 1990), catamaran and vallam boats (Balasubramanian *et al*., 1995), catamarans (Surya *et al*., 2019), fibreglass boats of 8 m OAL with outboard engines of 10 hp (Vishnu *et al*., 2019), FRP boats with outboard engines of 9.9 hp (Chellamanimegalai, 2019), and polystyrene boats (Venkatesan and Shanmugavel, 2008). The thermocol floats are usually made by the fishers of low-income groups. The normal floats cost about ₹3000-4000/-, whereas typical boat-shaped thermocol floats fetch ₹9000-10000/-. Some fishermen are using the broken-tied thermocol as a float, or "*theppam*". The manufacturing cost of the FRP-coated PUF float varies from ₹25000 to 30000/-, which have a long shelf-life.

Table 2. Details of fishing villages using FADs along the Gulf of Mannar

Fishing villages	Geo-location	Type of FADs used	No. of fishers involved	Type of craft	Fishing season
Ramanathapuram District					
Dhanushkodi	9.176744; 79.416025	TP, PP, PJ, AJ, CE	25	OBM-FRP, IBM-V, NM	Apr-May
Montrairuppuchathiram	9.199086; 79.380916	TP, PP, PJ, AJ, CE	20	OBM-FRP, Polystyrene	Apr-May
Kundukal	9.259101; 79.217788	TP, PP	35	IBM-V, NM	Apr-May
Chinnapalam	9.274146; 79.215943	TP, PP	26	NM	Apr-May
Mandapam	9.276812; 79.149355	TP, PP, CNI	20	NM	Apr-May
Vedalai	9.263849; 79.104391	TP, PP, CNI	20	NM	Apr-May
Seeniyappa Dargha	9.260862; 79.071563	TP, PP, CNI	15	NM	Throughout the year
Pudumadam	9.2740367; 78.9880539	TP, CNI	10	OBM-FRP, Polystyrene	Apr-May
Muthupettai	9.2636507; 78.9218722	TP, CNI	30	OBM-FRP, Polystyrene	Apr-May
Periyapattinam	9.250570; 78.903331	TP, CNI	45	OBM-FRP, Polystyrene	Apr-May
Kalimangundu	9.253772; 78.860728	TP	25	OBM-FRP, Polystyrene	Apr-May
Kilakkarai	9.2262667; 78.7815567	TP	30	OBM-FRP, NM, Polystyrene	Throughout the year
Sadamuniyanvalasai	9.1911407; 78.707545	TP	35	OBM-FRP, NM, Polystyrene	Apr-May
Keezamundal	9.1401989; 78.5853583	TP, CNI	20	OBM-FRP, NM, Polystyrene	Apr-May
T. Mariyur	9.1370917; 78.5343433	TP, CE, CNI, CNF, ST	85	OBM-FRP, NM, Polystyrene	Throughout the year
Thoothukudi District					
Vembar	9.077203; 78.366001	TP, CNI PJ, CE	200	OBM-FRP, IBM-V	Apr-May; Sep-Nov
Periyasamipuram	9.044834; 78.326994	TP, CNI PJ, CE	50	OBM-FRP	Apr-May; Sep-Nov
Pattinamaruthur	8.922665; 78.186043	TP, CNI PJ, CE	30	OBM-FRP, IBM-V	Apr-May; Sep-Nov
Tharuvaikulam	8.888968; 78.173368	TP, CNI PJ, CE	180	OBM-FRP, IBM-V	Apr-May; Sep-Nov
Vellapatti	8.857584; 78.166987	TP, CNI PJ	75	IBM-V	Apr-May; Sep-Nov
Mottagopuram	8.825730; 78.167349	TP, CNI PJ	150	IBM-V	Apr-May; Sep-Nov
Kalavasal	8.821446; 78.165051	TP, CNI PJ, CE	52		Apr-May; Sep-Nov
Sangumaal	8.812710; 78.163774	TP, CNI PJ, CE	175	OBM-FRP, IBM-V	Apr-May; Sep-Nov
Punnaikayal	8.637248; 78.121462	TP, CNI PJ	70	OBM-FRP	Apr-May; Sep-Nov
Kombuthurai	8.581230; 78.137455	CNI, TP, PJ, CE	100		Apr-May; Sep-Nov
Kayalpattinam	8.568234; 78.134559	CNI, TP, PJ	50	OBM-FRP	Apr-May; Sep-Nov
Veerapandiapattinam	8.519869; 78.123176	CNI, TP, PJ	100	OBM-FRP	Apr-May; Sep-Nov
Amalinagar	8.488516; 78.124123	CNI, TP, PJ, CE	40	OBM-FRP	Apr-May; Sep-Nov
Tirunelveli District					
Kooduthalai	8.299524; 77928939	CE, CNI, TP	35	OBM-FRP	Mar-May; Oct-Dec
Kootapanai	8.290244; 77.909982	CE, CNI, TP	50	OBM-FRP	Mar-May; Oct-Dec
Kuthenkuzhi	8.215499; 77.782425	CE, CNI, TP	60	OBM-FRP	Mar-May; Oct-Dec
Thomaiyarpuram	8.191430; 77763146	CE, CNI, TP	85	OBM-FRP	Mar-May; Oct-Dec
Idinthakarai	8.176558; 77.743351	CE, CNI, TP	65	OBM-FRP	Mar-May; Oct-Dec
Kanyakumari District					
Arockiapuram	8.119276; 77.558904	CE, CNI, TP	45	OBM-FRP	Mar-May; Oct-Dec
Chinnamuttom	8.095988; 77.559178	CE, CNI, TP	150	OBM-FRP	Mar-May; Oct-Dec
Kanyakumari	8.081416; 77.551460	CE, CNI, TP	75	OBM-FRP	Mar-May; Oct-Dec

* PK: *Phramites karka* (Sambai/Nanal), CE: *Casuarina equisetifolia* (Savukku), TP: *Tephrosea purpurea* (Kolunji), PJ: *Prosopis juliflora* (Odai maram), PP: *Phoenix pusilla* (Echam), AB: *Alyxia buxifolia* (Beenjan), CNI: *Cocos nucifera* (inflorescence), CNF: *Cocos nucifera* (fronds), ST: *Solanum torvum* (Sundaikkai), AJ: *Aerva javanica (Ponga poo), AM: Avicennia marina (Alayathi)*

Establishment of FADs

Fish aggregating devices, commonly called FADs, are anchored or drifting objects placed in the sea to attract fish. These may be permanent, semi-permanent, or temporary structures or devices made from any material and used to aggregate fish. The artisanal FADs are smaller and used by subsistence, artisanal, and recreational fishermen. These FADs are primarily anchored either offshore, nearshore, or in lagoons, and they can be found at the surface or subsurface. Driftwood and branches of trees were commonly used as surface/midwater artisanal FADs. The FADs employed in cephalopod fishery are locally known as *'Kadu vaithal'* or '*Maaru vaithal*' and '*Akkadi*' in Palk Bay and the Gulf of Mannar, respectively. The FADs are made with bunches of dried or semidried plants/branches tied to sandbags weighing 5-6 kg and linked to the lower end of the plant line. Small pieces of thermocol are attached to the plant, which serve a floating object, and act as attractant to the squids. The white colour of the thermocol, attracts

squids to the FADs. The sandbag attached to FADs acts as a sinker. After spotting the movements of a few squids in the fishing grounds, the fishermen place the FADs on the sandy or seagrass bottom, mark the GPS location, and return to the shore. Generally, squids aggregate within 24 h after placing the FADs. Usually, jigging begins the day after the FADs are deployed. In Kombuthurai Village, inflorescence of coconut trees are tied in series to make FADs. This is tied to a sandbag at the lower end which serves as a sinker.Chellamanimegalai (2019) reported that floating devices are made by drilling a hole in coconut shells and tying it to the upper end.

Plant materials used for FADs

Various plant materials which are abundantly available locally are employed in making FAD in both Palk Bay and the Gulf of Mannar (Table 3; Fig. 3).

Fig. 3. Artisanal FADs used in Palk Bay and Gulf of Mannar. (a) *Phramites karka* (Sambai/Nanal); (b) *Casurina equisetifolia* (Savukku); (c) *Tephrosea purpurea* (Kolunji); (d) *Prosopis juliflora* (Odai maram); (e). *Phoenix pusilla* (Echam); (f) *Alyxia buxifolia* (Beenjan); (g) *Cocos nucifera* (inflorescence); (h) *Solanum torvum* (Sundaikkai); (i) *Cocos nucifera* (Fronds); (j) *Aerva javanica* (Ponga poo); (k) *Avicennia marina (Alayathi).*

Table 3. Plant materials used for making FADs in both Palk Bay and the Gulf of Mannar (n=No. of villages).

Scientific name	Common/English name	Vernacular name	Parts used for FADs	Role in FADs	No.
Phragmites karka (Retz.) Trin. ex Steud.	Tall reed	Sambai/Nanal/Perunanal	Branches*	Attractor	55
Casuarina equisetifolia L.	Horsetail Tree/Beach She-Oak	Savukku	Branches	Attractor	23
Tephrosea purpurea (L.)	Purple Tephrosia	Kolinchi/Kolluk-Kay-Velai, Kawati	Whole plant	Attractor	63
Prosopis juliflora (Sw.) DC.	Mesquite	Odai maram/*Velikathan*	Whole plant or branches	Attractor	15
Phoenix pusilla Gaertn.	Ceylon date palm	Echam	Fronds*	Attractor	42
Alyxia buxifolia R.Br.	Dysentery bush / sea box	Beenjan	Branches*	Attractor	7
Cocos nucifera L.	Coconut palm	Kathirampalai/Thennankolanji	Inflorescence	Attractor	15
Cocos nucifera L.	Coconut palm	Thenna olai/Kidugu/Shettal	Fronds	Attractor	17
Avicennia marina (Forssk.) Vierh.	Grey mangrove	*Kanna chedi/Alayathi*	Branches*	Attractor	9
Aerva javanica (Burm.f.) Juss. Ex-Schult.	Kapok bush.	Ponga poo	Whole plant*	Attractor	6
Solanum torvum Sw.	Turkey berry	Sundaikkai	Whole plant or branches*	Attractor	4

*First report of FADs in this region

Sasikumar et al. (2006) reported on the coconut frond-based FADs used by the migrant Tamil Nadu (Kanyakumari) fishermen in Karnataka for exploitation of cephalopods. This fishery was later banned by the local government in 2005 due to conflicts between trawl and jig fishers.

FADs based fishing operation

Fishermen usually commence the activity early in the morning between 03.00 and 04.00 hrs in '*Vallam*' or fibreglass-reinforced plastic boats (FRP). Fishing is carried out at a distance of 6-10 nm from the shore, at 13-25 m depth in the Gulf of Mannar, whereas in Palk Bay it is between 4 and 6 nm at 5-8 m depth. Two types of squid jigging methods are practiced. In the first type, jigs are deployed directly from the *vallam*/FRP boats and the crew size is limited to 6-9 individuals. In the second type, fishing is carried out from small thermocol (polystyrene) floats. Twelve to twenty individuals, each carrying one thermocol float, travel in the main boat (*Vallam*). Upon reaching the fishing ground, they dismount and individually jig while sitting on their thermocol floats around the FADs. One person may operate two or three jigs at a time. After aggregation of the squids, the jigs are gently thrown towards them and slowly drawn towards the boat. The squids are attracted by the movement of the shrimp-shaped jig and get hooked. Then they are gently lifted, and the squids are collected. The numerous recurved hooks in the jigs prevent squids from escaping due to their sudden backward propulsion. The fishing duration may vary according to the prevailing season. Fishing is carried out for about 5-7 h, mainly during the daytime. Good sunlight and a clear sky with a mild wind favour the squid catch. After completing the fishing, fishers may reach the landing centre between 11.00 and 13.00 hrs. during the peak fishing season, but during the lean season they will return between 15.00 and 16.00 hrs. The absence of night fishing and the ban on artificial lights for squid jigging in this area significantly influenced fishing efficiency and species composition.

Fishery and species composition

The landings of cephalopods in Palk Bay showed a fluctuating trend from 2010 to 2021, with the peak during 2012 (Fig. 4). Squids are dominant in the landings, followed by cuttlefish and octopus. By 2021, there was a gradual 50% decrease in the unit effort, and a similar 63% decrease in the fishing hours. The annual average landings of cuttlefish during the period 2010-2021 were 173 t (41.8%), squid 215.4 t (52.06%), and octopus 25.2 t (6.06%). The landings of cephalopods in the Gulf of Mannar show a declining trend from 2010 to 2021. Cuttlefish are dominant in the landings, followed by squid and octopus (Fig. 5). The unit effort decreased

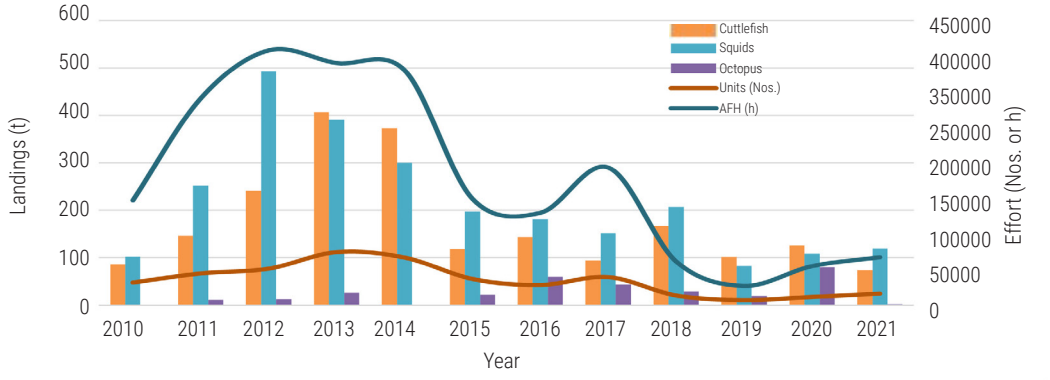

Fig. 4. Cephalopods landing in Palk Bay by squid jigging (2010-2021)

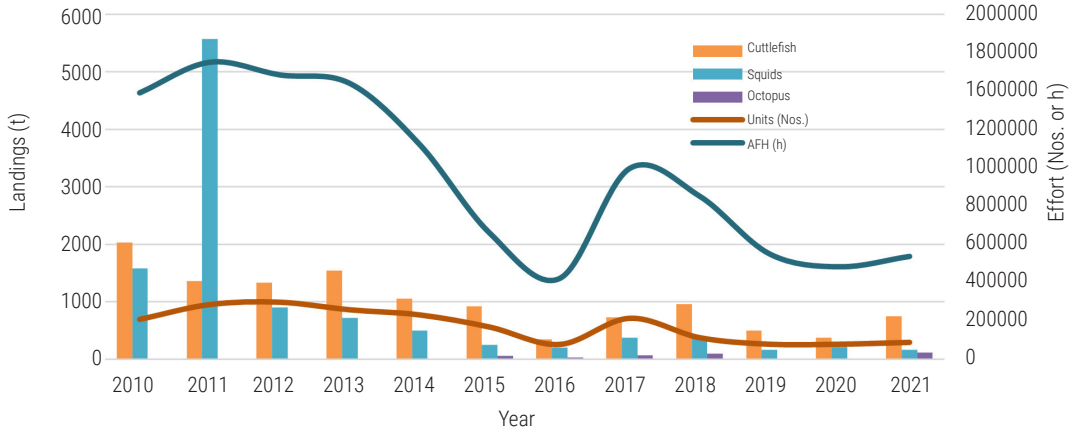

Fig. 5. Cephalopods landing in Gulf of Mannar by squid jigging (2010-2021)

gradually by 52%, while the effort in terms of fishing hours decreased by 47% in 2021. The annual average landings of cuttlefish during the period 2010-2021 were 992.8 t (51%), squid 920.8 t (47.2%) and octopus 34.6 t (1.8%).

From 2010 to 2021, the cephalopod landings showed a fluctuating trend both in the Gulf of Mannar and Palk Bay, with peak landing during 2018 (25761 t) in the Gulf of Mannar and 2012 in Palk Bay (6961 t) (Fig. 6). During this period, the average annual landing of cephalopods in the Gulf of Mannar and Palk Bay was 16502 and 4873 t, respectively. The annual average landings by hand squid jigging in the Gulf of Mannar and Palk Bay were 1948 and 413 t, respectively. The percentage of total landings in the Gulf of Mannar and Palk Bay that came from squid jigging was 11 and 8.5%, respectively. The fishing unit effort in the Gulf of Mannar and Palk Bay showed a gradual decrease of 47% in the Gulf of Mannar and 16.5% in Palk Bay. Fishing effort in terms of hours decreased by 13.26% in the Gulf of Mannar and 33.6% in Palk Bay (Fig. 7).

The annual average LPUE of cephalopods during 2010–2021, for squid jigging, was 13.37 kg unit^{-1} and 2.86 kg h^{-1} in Palk Bay, whereas in the Gulf of Mannar it was 9.5 kg unit^{-1} and 1.7 kg h^{-1} (Fig. 8). Cephalopod LPUE varies by craft category, reflecting variances in fishing capacity and operational efficiency. Medium-sized crafts recorded an average LPUE of 100-120 kg, while larger crafts achieved significantly higher values (200-250 kg) along the Ratnagiri Coast, indicating the advantage of larger vessels in terms of gear handling, fishing duration, and spatial coverage, as previously reported by Sundaram and Sawant (2013). The fishing was observed throughout the year except during the monsoon season. There are two fishing seasons *viz*., December to May and July to September in the Gulf of Mannar and Palk Bay. Balasubramanian *et al*. (1995) reported a similar observation. The peak landing was observed

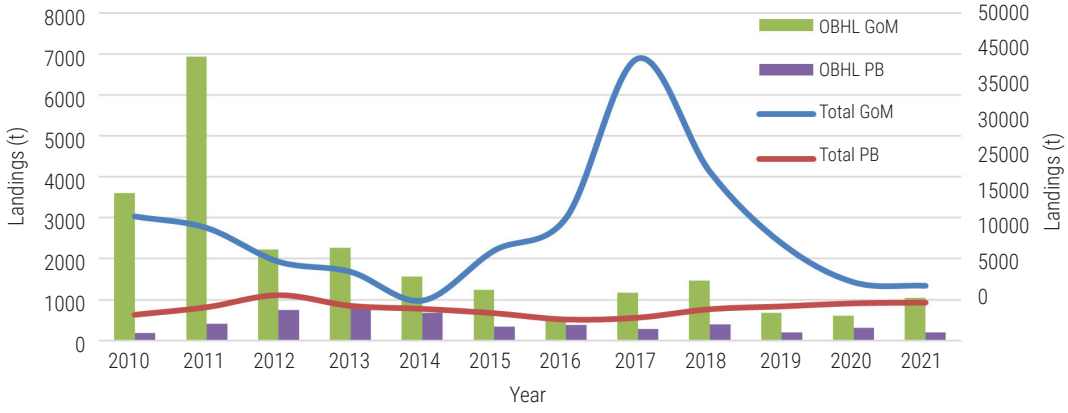

Fig. 6. Comparison of total cephalopod landings by squid jigging, in Palk Bay and Gulf of Mannar (2010-2021)

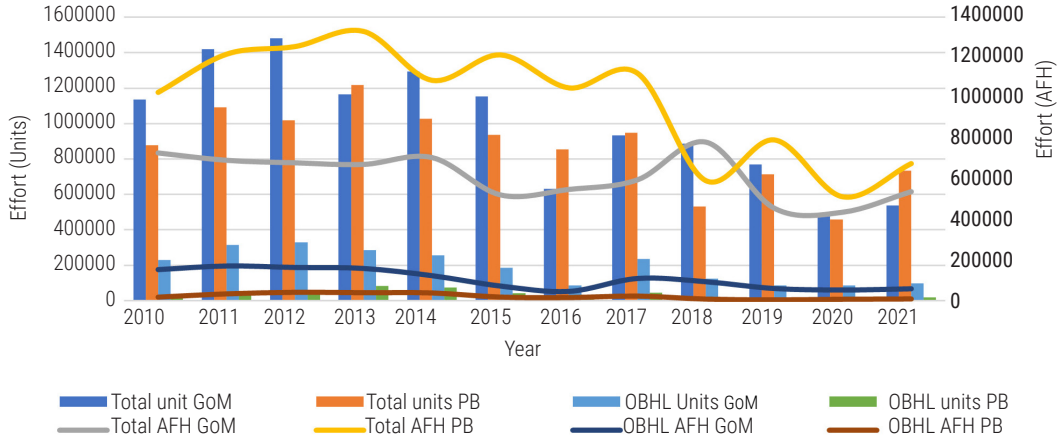

Fig. 7. Comparison of total effort by squid jigging in Palk Bay and Gulf of Mannar (2010-2021)

in April-May and July-August in Palk Bay and the Gulf of Mannar, respectively. Lipton *et al*. (1990) reported that squid fishing in Palk Bay primarily occurred during two seasons; from May to July and from October to November, with landings predominantly comprising of Palk Bay squid, *S. lessoniana* (90-230 mm), while cuttlefish were rarely recorded.

In the present study, *S. lessoniana*, *A. pharaonis, S. prabahari,* and *A. aegina* were the dominant species in Palk Bay, whereas *A. pharaonis*, *S. lessoniana* and *O. cyanea* were the major species in the Gulf of Mannar. *A. pharaonis* was the most dominant species in the landings in both regions, which could be attributed to the distributional abundance of the species in the coastal region. The prevalence of *A. pharaonis* in the squid jigging fishery is mostly due to its preference for reef-abundant coastal environments in the Gulf of Mannar, while the expansive seagrass meadows of Palk Bay facilitate the predominance of *S. lessoniana*. Cuttlefish, squid, and octopus contributed 61, 35, and 4% of the landings in Palk Bay, while they contributed 40, 35, and 25% of the landings in the Gulf of Mannar, respectively.

The peak fishing season in Karnataka occurs between September and October, during which the landings primarily consist of *A. pharaonis* in the size range of 160–280 mm caught through jigging (Sasikumar *et al*., 2006). Venkatesan and Shanmugavel (2008) reported that the landings in Palk Bay comprised *S. lessoniana* (40-240 mm), *S.aculeata* (50-150 mm), and *A. pharaonis* (60-259 mm), and the squids contributed 54% and followed by cuttlefish at 46%. Peak landings were reported during March and June. From 2018 to 2021, there was an increasing effort in squid jigging in Palk Bay and the Gulf of Mannar, driven by local demand for cephalopods during the COVID-19 pandemic. During the COVID period, migrant fishers returned to their home fishing villages and engaged in local fishing activities. This may be a reason for the increased fishing effort in this region. Chellamanimegalai *et al*. (2019) reported the seasonal abundance of cuttlefish from June to September and the maximum landings in July by jigging. The LPUE reported in Devipattinam (Palk Bay) and Kilakkarai (GoM) was 8 to 19.5 and 10.5 kg, respectively. The peak landing times were June to July in the Gulf of Mannar and March to June in Palk Bay. *S. lessoniana* was the dominant species on the coast, accounting for 70.79 and 54% in the Gulf of Mannar and Palk Bay, respectively (Venkatesan and Shanmugavel, 2008).

The mean length, size range, and sex ratio of cephalopods caught by jigging in Palk Bay and the Gulf of Mannar in 2020 are given in Table 4 and Fig. 9 . The females dominated in the landings, and the sex ratio was always more than one in females. Venkatesan and Shanmugavel (2008) reported the sizes of male *S. aculeata*, *A. pharaonis*, and *S. lessoniana* in the range of 50-140, 60-220, and 40-290 mm (DML), whereas the females were 50-150, 60-259, and 92-240 mm (DML), respectively. Sasikumar *et al*. (2006) observed that the 160-280 mm size group of *A. pharaonis* supported the fishery during October-November, and the females dominated in the landings with a sex ratio of 2.1 (male=1).

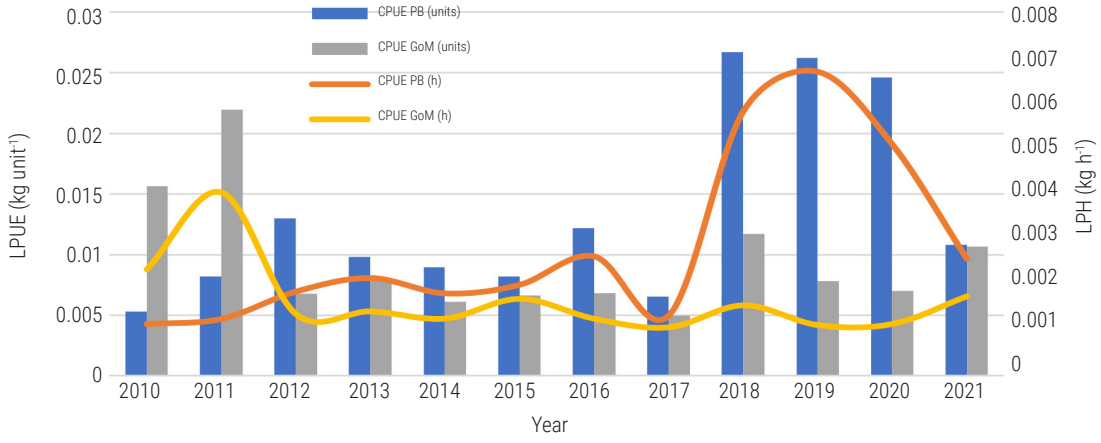

Fig. 8. LPUE of cephalopods (OBHL) in Palk Bay and Gulf of Mannar

Table 4. Size and sex ratio of cephalopods caught by squid jigging in the Gulf of Mannar and Palk Bay during 2020

Species	Gulf of Mannar					N	Palk Bay					n
	Length DML (mm)		Weight (g)		Sex ratio		Length DML (mm)		Weight (g)		Sex ratio	
	Min-max	Mean	Min-max	Mean			Min-max	Mean	Min-max	Mean		
A. pharaonis	80-415	229	100-2900	1153	1.8	393	50-280	140	90-1800	925	2.0	345
S. lessoniana	110-370	203	100-1600	535	1.1	488	70-300	135	60-1500	528	1.5	317
O. cyanea	70-260	163	375-5000	1905		105						

Sex ratio: Male=1; DML: Dorsal mantle length

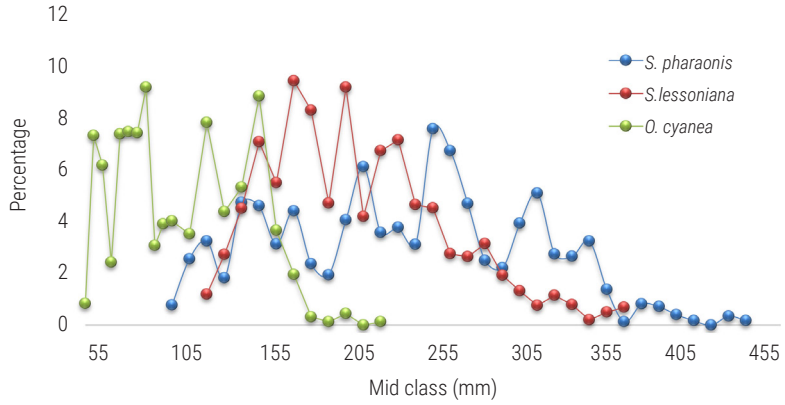

Fig. 9. Size distribution of cephalopods in Gulf of Mannar landed by hand jigging (2019-2020)

In the Palk Bay and the Gulf of Mannar, FADs are made of eco-friendly, natural biodegradable materials, which decay within 2-3 months, according to the local fishers. These FADs are small in size and serve as beneficial habitat enhancement components that support the aggregation of cuttlefish in particular. The peak squid jigging takes place during the monsoon trawl ban in Palk Bay and the Gulf of Mannar, and in some places with minimal trawling pressure, jigging occurs throughout the year. The trawl ban period favours this type of fishing due to the reduced disturbance of fishing grounds. Cephalopods are attracted to FADs for spawning and egg mass deposition (Fig. 10). Despite these, concerns remain regarding the sustainability of FAD use. The use of FADs can increase the landings of ripe spawners, potentially leading to rapid resource depletion. Many nations discourage unregulated FAD use, citing concerns about unregulated numbers of FADs used and the need to reduce fishing pressure. Apart from these, social conflicts arise due to gear interactions and competition for fishing grounds. FADs often become entangled in the trawl nets operating in the same fishing areas, leading to conflict between trawl and jig fishers. Jiggers may also lose their FADs during such interactions, which can even lead to destroying attached egg masses by trawling activities. To address this, fishers in the area primarily use biodegradable FADs during the trawl ban period, (15 April to 14 June), for cephalopod fishing.

This study emphasises that hand-operated, daytime squid jigging in the Palk Bay and the Gulf of Mannar is a selective artisanal fishery reliant on biodegradable, plant-based FADs.The fishery is characterised by the dominance of *A. pharaonis* in reef-associated habitats of the Gulf of Mannar and *S. lessoniana* in the seagrass meadows of Palk Bay. Although FADs enhance catch efficiency and provide substrates for egg deposition, unregulated deployment may increase fishing pressure on spawning stocks and intensify gear conflicts, necessitating the need for targeted management interventions. To ensure the sustainability of this artisanal fishery, we recommend controlling the number and spacing of FADs, restricing FAD-assisted jigging to specific periods (*e.g.* during the trawl ban period), strengthening monitoring of fishing effort and landings, and conducting regular assessment on impacts on stock and FADs decay rates. The absence of night fishing and prohibition of artificial lights for squid jigging in this region significantly affect fishing efficiency and species composition. Under these non-illuminated conditions mandated by local governance, squid availability for jigging gears is limited, potentially reducing catch rates and favouring species adapted to natural light and habitat-specific conditions.

(a) (b)

Fig. 10. Cephalopod eggs attached in artisanal FADs

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References

Alagarswami, K. and Meiyappan, M. M. 1987. Prospects for increasing cephalopod production of India. In: *CMFRI Bulletin: National Symposium on Research and Development in Marine Fisheries Sessions, I and II*. ICAR-Central Marine Fisheries Research Institute, Kochi, India, pp. 146–155.

Balasubramanian, T. S., Rajapackiam, S., Mohamad Kasim, H. and Ameer Hamsa, K. M. S. 1995. Emergence of hand jigging for cephalopods along Tuticorin coast. *Mar. Fish. Infor. Serv. T&E Ser.*, 137: 13–16.

Chellamanimegalai, P., Abisha Juliet Mary, S. J., Manickavasagam, S., Kantharajan G., Dhayanath, M. and Sundaramoorthy, B. 2019. Traditional fishing knowledge followed in Kombuthurai along the Gulf of Mannar:

A new approach on hand jigging of cuttlefishes using biodegradable FAD. *Int. J. Curr. Microbiol. App. Sci.,* 8(07): 1703–1711. https://doi.org/10.20546/ijcmas.2019.807.202

CMFRI 2021. *MarineSTAT,* National Marine Fisheries Data Centre, ICAR-Central Marine Fisheries Research Institute, Kochi, India.

FAO 2020. *FAO yearbook. FAO Directory. Fisheries and Aquaculture Statistics 2018*. Food and Agriculture Organisation of the United Nations, Rome, Italy.

Huang, H., Zhou, Z., Peng, D. and Chu, J. 2024. Potential impacts of climate change on cephalopods in a highly productive region (Northwest Pacific): Habitat suitability and management. *Sci. Total Environ*., 953: 175794. https://doi.org/10.1016/ j.scitotenv.2024.175794.

Kavitha, M., Jagadis, I., Vidya, R., Jasmin, F., Willington, S. and Manojkumar, P. P. 2018. Cephalopod fishery off Thoothukudi coast, Tamil Nadu. *Mar. Fish. Infor. Serv. T&E Ser.*, 237: 17-19.

Lipton, A. P., Rao, P. V., Ganapathy, A. and Thillairajan, P. 1990. Emerging squid jigging fishery along the Palk Bay Coast of Tamil Nadu. *Fish. Chimes*, 10(9): 28–31.

Mohamed, K. S. and Sarvesan, R. 2004 Trends in world cephalopod fisheries and India's status. ICAR-Central Marine Fisheries Research Institute, Kochi, India, pp. 1-10.

Sasikumar, G., Rohit, P., Nagaraja, D., Lingappa, K. and Naik, A. R. 2006. Fish aggregating devices used for cephalopod fishery along the Karnataka coast. *Mar. Fish. Infor. Serv. T&E Ser.*, 189: 10–13.

Sundaram, S. and Sawant, D. D. 2013. Emerging light and hand jigging fishery for cephalopods along Ratnagiri coast, Maharashtra. *Mar. Fish. Infor. Serv. T&E Ser.,* 215: 1-3.

Sundaram, S. and Deshmukh, V. D. 2011. Emergence of squid jigging in India. *Fishing Chimes,* 30: 18-20.

Surya, S., Anil, M. K., Jasmine, S., Ambarish, G. P., Gomathi, P., Kingsly, H. J. and Suresh, K. K. 2019. Artisanal fishing methods along the Vizhinjam Coast, Kerala. *Mar. Fish. Infor. Serv. T&E Ser.*, 239: 24-28.

Venkatesan, V. and Shanmugavel, A. 2008. Note on hand jigging fishery for squids and cuttlefishes at Devipattinam in the Palk Bay and at Keelakarai in the Gulf of Mannar, south-east coast of India. *Mar. Fish. Infor. Serv. T&E Ser.*, 197: 11–12.

Villanueva, R., Perricone, V. and Fiorito, G. 2017. Cephalopods as predators: A short journey among behavioral flexibilities, adaptations, and feeding habits. *Front. Physiol.,* 8: 598. https://doi:10.3389/fphys.2017.00598

Vishnu, P. G., Pradeep, S. and Narayanakumar, R. 2021. Cuttlefish fishery using FADs in Sothikuppam, Cuddalore District. *Mar. Fish. Infor. Serv. T&E Ser.*, 247: 33-33.