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Policy guidance on cuttlefish fishery using Fish Aggregating Devices

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Indian Council of Agricultural Research
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Foreword

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The past decade witnessed cephalopod fishery gaining great commercial interest, regionally and internationally. Consequently, the commercial exploitation of squids, cuttlefishes and octopus from the global oceans surpassed 4 million tonnes during 2012. Concurrent to the international demand, cephalopod production in India recorded a steady growth over the years catering exclusively to the export markets. In India, the inshore waters of Arabian Sea are important geographical locations in the biological cycle of the cuttlefish, *Sepia pharaonis* for their spawning and early development. In artisanal Indian fisheries scenario, the cuttlefishes are caught from this region with highly selective gear and fishing techniques based on the knowledge of their biology and spawning behaviour. Fish Aggregating Devices (FADs) are conventionally used by the artisanal fishermen in rocky areas to attract and aggregate the cuttlefishes closer to the shore.

Increased commercial value of cuttlefish have resulted in targeted exploitation of the resource in appreciable quantities by expansion of aggregation based fishing practices in new fishing grounds where the spawning populations are lured by way of installing more FADs. While FAD-based cuttlefish fishery developed and spread rapidly, their impact on target resources was not investigated in detail. This publication reflects the consequences of using FADs in cuttlefish fishery based on the comprehensive investigation carried out by CMFRI along the south-west coast of India. The study brought to light the devastating effects of FAD-based fishery targeting spawners and its implications on the long term sustainability of cuttlefish fishery. Additionally, there is concern over the massive deployment of non-degradable materials as FADs for cuttlefishes contributing to the "marine debris" in the oceans having ecological consequences.

In the pursuit of ensuring sustainable marine fisheries management, CMFRI will continue to spearhead research activities, focusing on judicious exploitation of the valuable marine resources, which in turn direct the marine fisheries policy of the country. The fact that Karnataka State has considered the prohibition of cuttlefish FADs along coastal Karnataka based on CMFRI's advice is a good example of science based policy intervention. The FAD-associated cuttlefish fishery is a very destructive fishing practice and therefore, the CMFRI recommends the respective State Fisheries Departments to take appropriate steps to totally prohibit this fishing practice in all maritime states of India.

A. Gopalakrishnan

Kochi
February 2015

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Executive Summary

The behavior of cephalopods to aggregate near submerged objects is widely used by fishermen in the deployment of Fish Aggregating Devices (FADs) along the coast of Karnataka, Kerala and Tamil Nadu. Recently, increased commercial value of cuttlefish, has led to targeted exploitation of this resource in sizable quantities by way of extending FAD assisted fishery to new fishing grounds. While the FAD-based cuttlefish fishery is spreading rapidly, an evaluation of the impact of such fishing methods on the targeted resources and their population characteristics is highly significant. This publication documents the findings of the study on the impacts of Fish Aggregating Device based cuttlefish fishery along the south-west coast of India and proposes policy guidance to ensure sustainable exploitation of cuttlefish resources along the region.

The main undesirable impacts of FAD based exploitation of cuttlefish are:

- Indiscriminate fishing of spawning aggregations of cuttlefish population.
- Recruitment overfishing of *Sepia pharaonis* along the eastern Arabian Sea.
- Decrease in free-school cuttlefish abundance.
- Increase in marine debris as result of large-scale usage of synthetic, non-biodegradable materials for FAD construction.
- Probable ecological consequences of torn nets acting as ghost nets, trapping, entangling and killing fish and shellfish.

Management guidance:

- Ban on the use of FADs in the exploitation of cuttlefish resources along all the maritime states of India.
- Extensive maritime surveillance to monitor compliance and a system of fines and fishing license cancellation as a disincentive.

Fishing of cuttlefish by non-conventional methods using FADs is banned along the coast of Karnataka effective from the year 2012. In the management context this measure is effective in checking the overall fishing effort by FADs and help in protecting the fishery by way of minimizing the capture of spawning populations. The enforcement of the ban necessitates extensive maritime surveillance to monitor compliance.

Introduction

Fish Aggregating Devices (FADs) are used in artisanal and commercial fisheries in several nations, by exploiting the behaviour of fish to congregate under floating objects. The artisanal fishermen of the Mediterranean and Southeast Asia noted that the efficiency of fishing operation was higher near objects such as logs, seaweed mats, branches, leaves and other floating objects in comparison to fishing in open-ocean. When these naturally floating objects were sparse or non-existent, fishermen started deploying man-made structures consisting of objects floating on ocean surface. Generally, these materials for FADs were acquired opportunistically from surplus man-made or readily available natural products. Fishery based on natural/ man-made FADs that began incidentally in the traditional fishing sector transformed to modern sophisticated fishing technique, deploying larger FADs equipped with satellite assisted tracking devices and sonar for easy location and remote determination of the presence and size of aggregations beneath them. Among the artisanal, commercial and recreational user interests, seafood harvest is generally the primary objective of such habitat creation worldwide. By definition, a Fish Aggregating Device is 'any method, object or construction used for the purpose of facilitating the harvesting of fish by attracting and thus aggregating them' (Bergstrom, 1983). Essentially these man-made structures are meant to retain migratory species of fish temporarily or to aggregate scattered schools, rendering increased efficiency of fishing operation. Though the precise reasons for fish aggregation are largely unknown, the use of FADs has intensified markedly in recent years, with little data on their overall impact.

The FADs are classified into surface, mid-water and bottom types. Surface FADs are further divided into drifting (deep-water), permanent anchored (shallow and deep-water)

and transferrable classes. Anchored FADs are very common in regions adjoining coastal and Island waters and they require high strength mooring structures. Traditional customised FADs design features intended for attracting a specific group of finfish/ shellfish in a particular geographic area are often kept as a secret by the fishermen, in an effort to maintain their competitive advantage.

The document provides information on the resource-specific moored fish aggregating devices used in cuttlefish fishery along the coast of Karnataka. It provides specific details on the types of FADs used for the purpose, association of cuttlefish with FADs, comparisons of FAD-associated cuttlefish with free-schools and impact of FADs on cuttlefish population. This analysis is an attempt to bring to the notice of fishery managers the methods of limiting the negative impact of FAD-associated cuttlefish fishery. Benthic artificial reefs are not the focus of this study.

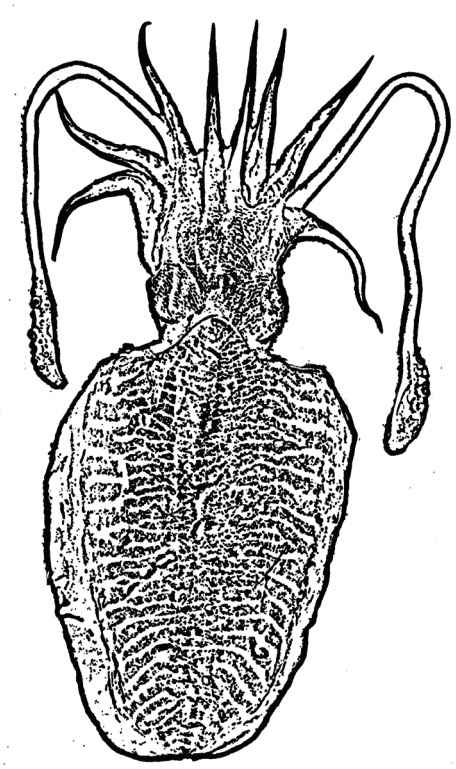
Cephalopod aggregating devices

Cephalopod aggregating devices are structures designed to attract squids, cuttlefish or octopus, based on the observation of their behaviour. Benthic FADs in the form of basket traps has been the most popular cuttlefish fishing method since olden times (Watanuki and Kawamura, 1999). Basket traps were used for capture of cuttlefish around Inland Sea in Japan, Atlantic Coast in Europe and in countries around the Mediterranean Sea. Benthic trapping and potting is carried out mostly in reef areas, where fish and other animals are concentrated by the sheltered nature of the bottom, either for protection or for feeding purpose (Slack-Smith, 2001). Japanese fishermen have been using cuttlefish trap for *Sepia esculenta* as early as in 1660's. Full-scale trap fishery began in 1920's, when fishermen noticed that the introduction of spawning substrates inside the traps facilitated the capture of cuttlefish. Trap fishing practices, which was popular in western Japan later spread to much wider areas including the Korean Peninsula (Yamamoto, 1942). Besides traps, bundled twigs as spawning nests for squids were

Cuttlefishes are primarily bottom-dwellers over a range of habitats, including rocky, sandy, and muddy substrates, seagrass, seaweed and coral reefs. They are slower swimmers than the more streamlined squids. Cuttlefishes are able to attain neutral buoyancy by regulating the relative amounts of gas and fluid in the chambers of the cuttlebone, and they are able to hover in midwater, with fins acting as stabilizers. Cuttlefishes belonging to the family Sepiidae are of significant commercial value to artisanal and commercial fisheries. Large species such as *Sepia latimanus, Sepia officinalis* and *Sepia pharaonis* are restricted to much shallower depths and show very different septal spacing and sutures than the deep water species. Some species migrate seasonally in response to temperature changes and aggregate, usually in shallow water, at spawning time.

also used in Japan. These traps were placed with stone sinkers for luring egg laying squids (spawners) and were targeted by various types of gears including the boat seines (Bergstrom, 1983).

Some of the traditional fish aggregating devices of India still in practice are column FADs composed of a long rope with coconut fronds fastened at 0.3 m intervals and attached to a float at one end and anchored at the other end. These simple but very efficient mid-water FAD made of rope, in combination with natural plant material/ synthetic discarded materials are



Pharaoh cuttlefish, *Sepia pharaonis*

used for attracting cuttlefishes along Gulf of Mannar (Samuel *et al.*, 2005) and southwest Indian coast (Sasikumar *et al.*, 2006; Thomas *et al.*, 2010). Devices for anchoring these FADs are simple sand-filled bags or just stone-and-rope arrangements.

Hand-jigs are used for harvesting the aggregated cuttlefishes near these traditional FADs.

Cuttlefish and squid are also reported to deposit voluminous egg-masses amidst the artificial reefs (Sanjeevaraj, 1996) along the southern Indian coast. Artificial reefs (natural or man-made objects) are conventionally used by artisanal fishermen in rocky areas to attract and aggregate fishes closer to the shore (Kurien, 1996). Coconut leaves and screwpine leaves are dumped in the reefs mainly to attract cuttlefishes. Decaying leaves attract large number of cuttlefishes to the areas and provide ideal environment for the females to spawn (Philipose, 1996). Squid eggs are encountered in the fishing grounds along south-west coast during August and September (Kurup *et al.*, 2004). Trials using submerged FADs constructed using HDPE pipes along the inshore waters of Madras enabled large-scale colonisation of cephalopods (Raja, 1996). Good quantity of cuttlefish eggs were reported on the HDPE net cones attached to the main frame of these FADs, which initially attracted various fishes and later formed a habitat for cuttlefishes. In recent years, natural plant materials are increasingly replaced by discarded plastic bottles and used synthetic fishnets in cuttlefish FADs.

Artificial Reefs (AR) are submerged structures deliberately constructed or placed on the seabed to emulate some functions of a natural reef such as protecting, regenerating, concentrating, and/or enhancing populations of living marine resources (London Convention and Protocol/UNEP, 2009). The ARs range in size, complexity and cost. They are used worldwide to increase the productivity and fisheries potential of relatively barren or unproductive areas. The use of ARs worldwide in 40 countries and six continents are reported to result in increased fish catches from 20% to 4000% (Grove and Sonu, 1991). The ARs have been deployed along the east and west coast of India and are well managed by the fishing communities in coastal villages having exclusive access rights in the reef area (Bergstrom, 1983; D'Cruz, 1994; Vivekanandan *et al.* 2006). The fishing in the reef areas are regulated and customised to avoid overfishing by the fishermen of the coastal villages by accessing the ARs on a self-regulated rotational basis.

Fish Aggregating Devices (FADs)

A FAD is defined as any moored or free-floating structure or material that is designed to attract and/or aggregate fish in order to facilitate fishing activities. FADs also vary from permanent constructions to small floating buoys that are anchored to the seafloor and may be deployed on a seasonal basis.

The concept of using floating or suspended structures to attract harvestable quantities of fish has been used extensively in the Mediterranean and Western Pacific. Unlike benthic artificial reefs, FAD's function as a point of attraction for targeted species.

FADs used for targeting cuttlefish species are unique as they are designed to attract only spawning cuttlefishes, based on the observations made on their behaviour and distinct responses. They are placed during the peak spawning period of the targeted cuttlefish near their spawning grounds, such as, natural reefs/ sheltered areas. Spawning cuttlefishes get aggregated as they are enticed by these structures for laying eggs.

Cephalopod species composition

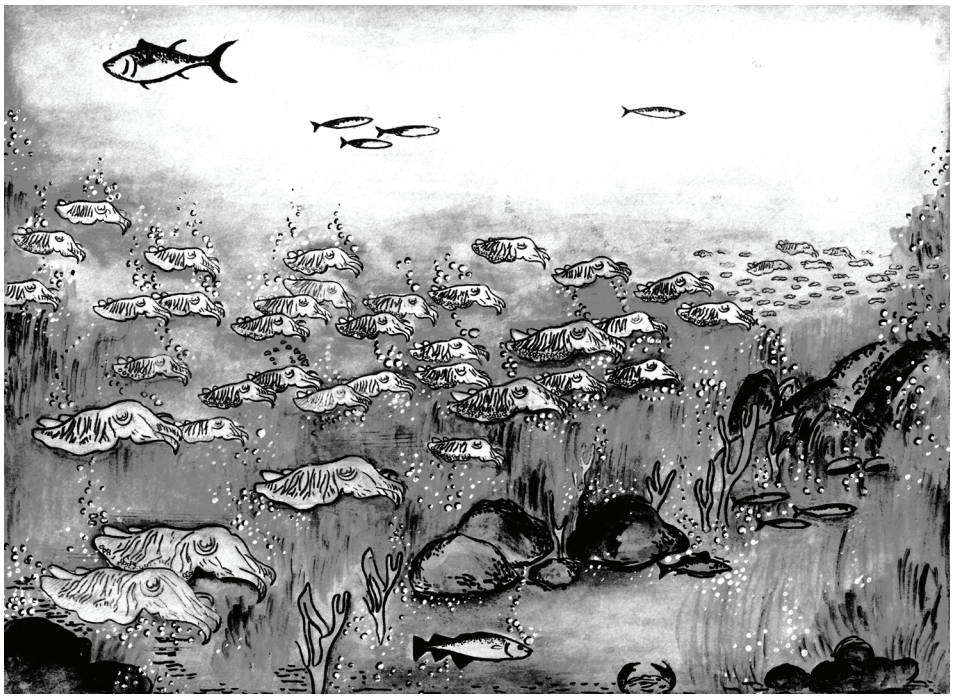
Along the southeast coast of India, both squid and cuttlefishes are caught in FADs fabricated using plant materials. *Sepioteuthis lessoniana*, the big-fin reef squid is reported to dominate the cephalopods fishery near FADs in the region. The pharaoh cuttlefish, *Sepia pharaonis*, is observed to spawn near big-fin reef squid's spawning site, created by FADs as part of community aggregation (Samuel *et al.*, 2005). Such spawning aggregation increases the catchability of cephalopods in hook and line fishing operation near FADs. Besides pharaoh cuttlefish *Sepia aculeata* and *Sepiella inermis* are also fished in small quantities.

Sepia pharaonis dominated the catch from the reefs constructed of granite stones, truck tyres, coconut tree trunks, concrete well rings and concrete slabs along the southern coastal areas (Trivandrum) during February and March months (Lazarus, 1996). The cuttlefish caught from the reef area during December-March period were mostly in their spawning condition. Fishing experiments conducted in the vicinity of the reefs during such period yielded large quantities of cuttlefish egg masses.

Why do cuttlefish aggregate near FADs?

As part of their life cycle cuttlefish exhibit inshore migrations to favoured breeding grounds for maturation and spawning. Coastal species of squid and cuttlefish gather in annual spawning congregations for facilitating one-to-one transfer of spermatophores. Availability of suitable substrate in the inshore areas and the suitability of the bottom substrate conditions for laying the egg masses also play a significant role in migration, aggregation and spawning.

Observations on spawning behaviour of cuttlefish indicates that the females are attracted to hard spawning substrate such as submerged rocks, sunken wood, aquatic plants, seaweeds,



Inshore migration of cuttlefish to spawning grounds

coelenterates etc. for attaching their eggs. This behaviour of cuttlefishes to migrate to inshore areas in search of spawning substrate for laying their eggs on submerged substratum makes them attractive targets for fishery, and they are effectively caught using FADs. The FADs composed of natural or artificial materials with a bushy appearance are reported to serve as 'good' spawning substrate for the female cuttlefish (Samuel *et al.*, 2005). Seabed consisting of either sand or muddy sand or shells mixed with sand around reef is reported to provide excellent fishing grounds for cuttlefish.

Along the Indian coast, *Sepia pharaonis* is the dominant species contributing to the commercial catches.The cuttlefish FADs are positioned on uneven sea beds, which are preferred spawning areas of cuttlefishes. In general, these grounds are not accessible to trawl operations, while the cuttlefish FADs have the advantage of being moored on these uneven sea beds. There are also locations where overlapping of trawling and FAD siting could occur.

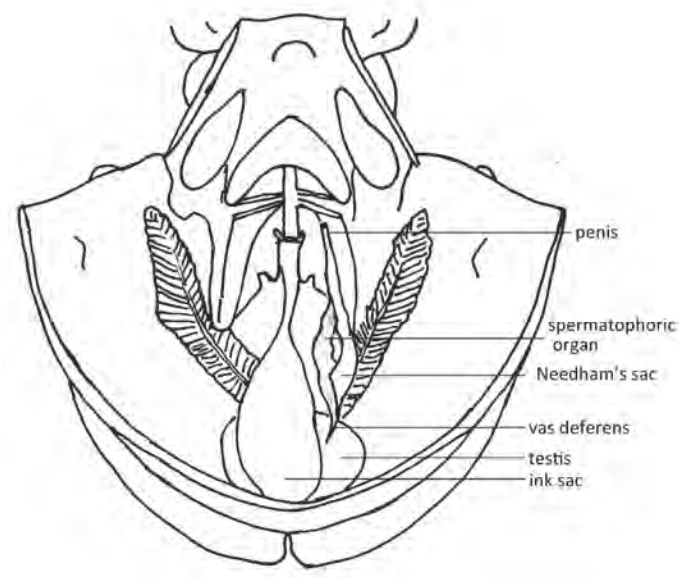
The female cuttlefishes of the species *S. pharaonis* are first attracted to the FADs and are followed by the males. Immature cuttlefishes are rarely encountered near the FADs.

The spawning season of *S. pharaonis* in the southern coastal waters of India occur over an extended period from October to April (Silas *et al.*, 1985). Along Karnataka Coast, spawning occurs in the inshore waters with seasonally intense peak during the post-monsoon period in October/November followed by a weaker spell in March (Sasikumar *et al.*, 2006).

In the south-west coast of India, trends in catch rates and available data from commercial fishing operations indicate seasonal migration of *S. pharaonis* between deeper offshore waters and inshore coastal zones (Sasikumar *et al.*, 2013). The shoreward migration is evident from the increase in abundance of *S. pharaonis* during May/June in the inshore fishing ground. This group sustains the fishery and remains in the inshore waters

Male reproductive system in cuttlefish:

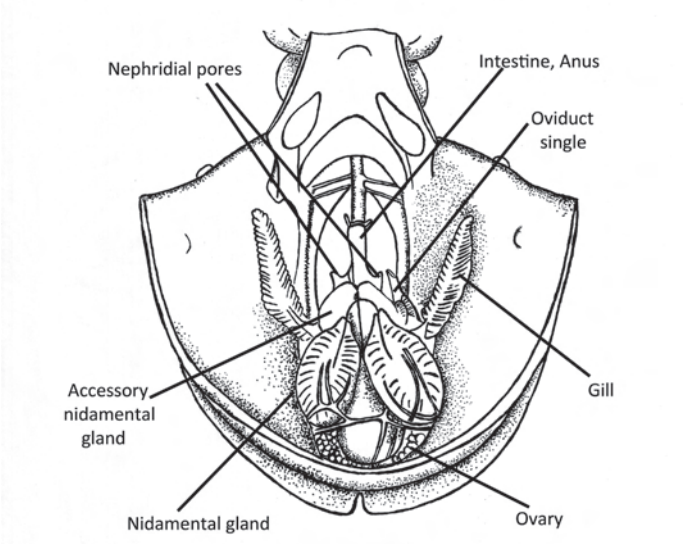
In male cuttlefish, gonads form a single mass at the posterior end of the mantle cavity. Reproductive system is a highly complex structure with ducts, glands and storage organs. In males, the sperm is produced in the testis located in the posterior end of the mantle, which are then picked by the ciliated funnel of the vas deferens that joins the multi-unit spermatophoric organ. While passing through spermatophoric organ the sperms are formed into a spiral mass and coated with the various membranes and tunics to form the spermatophores (sperm packets). The vas efferens takes the fully mature spermatophores and transfer them one at a time into the spermatophoric sac or the Needham's sac, where it is stored until copulation.



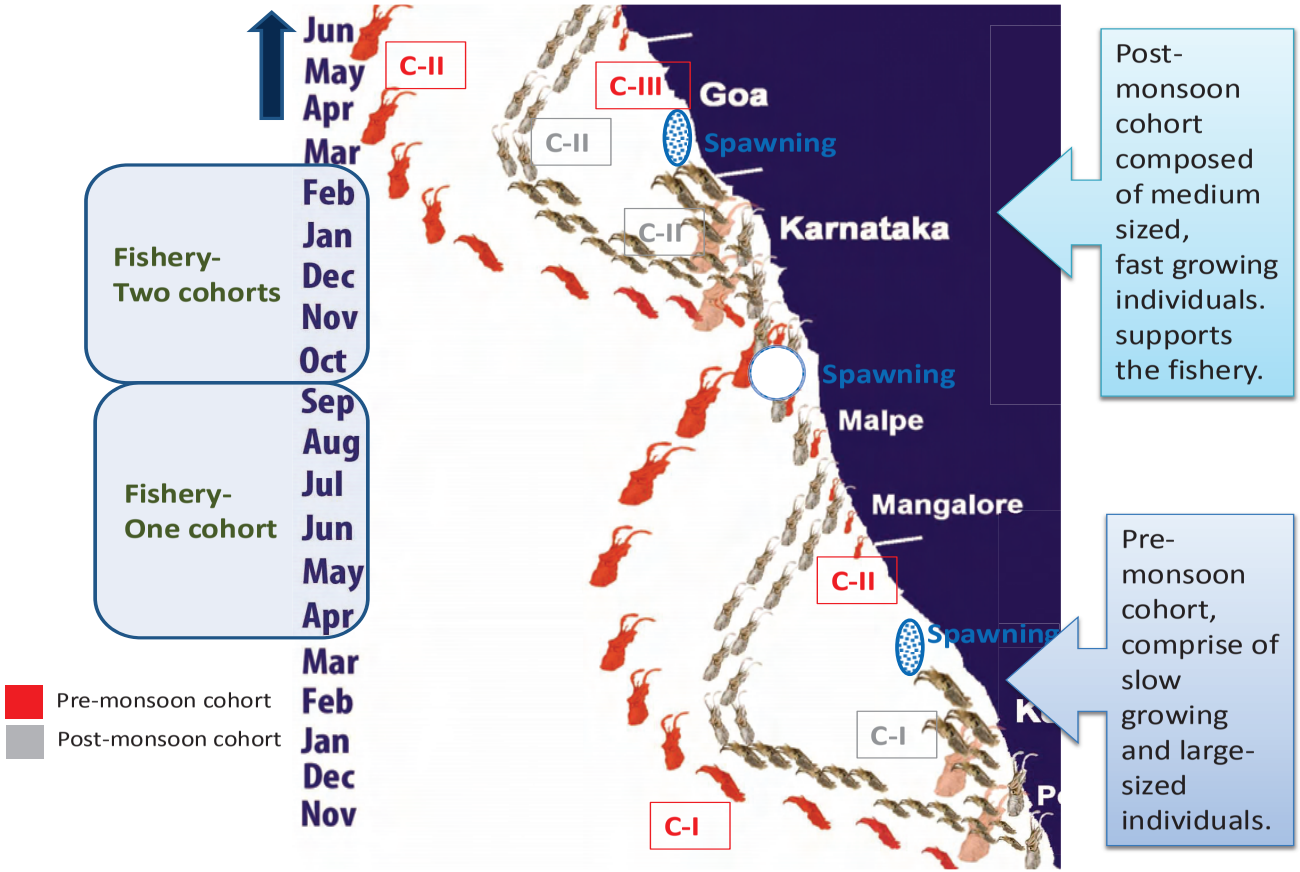
Male reproductive system in cuttlefish (Right gill origin removed in order to show the vas deferens and Needham's sac)

Female reproductive system in cuttlefish:

The female reproductive system consist of a single ovary, a single oviduct having thin walled as well as glandular portions, paired nidamental glands and paired accessory nidamental glands. Once shed, the ova pass into the funnel in the oviduct, where they are stored in the proximal thin walled portion of the oviduct until mating and egg laying. The ova in the more posterior-dorsal part of the ovary are opaque when immature and less clear when still surrounded by the follicular epithelium. From the thin-walled lightly muscular, proximal portion of the oviduct, the eggs are passed during laying through an opaque glandular portion of the oviduct on the left side of the mantle, where they are coated with a layer of egg jelly. The oviducal gland is connected to two large nidamental glands, which contain thick white gelatinous material that is used to embed each ovum into an individual protective capsule. The cuttlefish ovary grows rapidly during sexual maturation. The eggs growing in the same string of germinal epithelium in ovary grow at different rates and vary considerably in size. All eggs in the ovary will not reach maturity at the same time due to the limitation in the physical capacity of the ovary. Therefore the mature eggs in cuttlefish are spawned in batches.



Female reproductive system in cuttlefish (Source: Reid *et al.,* 2005)



Seasonal migration of *Sepia pharaonis* cohorts in Arabian Sea (Adapted from Sasikumar *et al.*, 2013)

until their offshore migration in November/December. The high proportion of fully mature and spawning specimens in the commercial landings during the post-monsoon season suggests that the species undertakes inshore migration for spawning. The egg clusters of *S. pharaonis* are also found attached to the hard substratum during this period on the inshore rocky area along the south-west coast of India (Anil *et al.,* 2005). The hatchlings grow to juveniles in the inshore waters and then migrate offshore where they feed, grow, mature and later return back to shallow waters to complete the life cycle.

Biological attributes exploited in FAD fishery

The biological attributes of the target species are exploited in the traditional and artisanal fishing methods for cephalopods. The tendency of mature females locating a sheltered place for spawning near FADs lead to cuttlefish aggregation, which in turn increases their vulnerability to the moving jig. Moreover, the universal habit of the cephalopod to attack, lures them towards moving jigs, leading to entanglement in the hooks. The elaborate courtship and the frenzied breeding activity, with males seizing at almost any moving objects in an effort to achieve mating, leads to their easy capture by jigs in the spawning ground (Boyle and Rodhouse, 2006).

Cuttlefish mating:

During mating, the male cuttlefish uses the hectocotylized arm, (modified arm in male cephalopods which is used to transfer spermatophores to the female; modifications may involve suckers, sucker stalks, protective membranes, trabeculae) to transfer the spermatophores into the female's buccal area. The spermatophores are stored in the buccal area until fertilization of the eggs. When the female is ready to deposit the eggs in protected areas under rocks or in discarded shells, the females use their arms to wipe the stored spermatophores onto each egg.

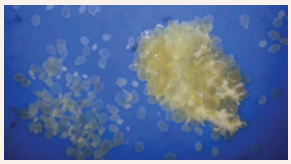
Cuttlefish aggregation method

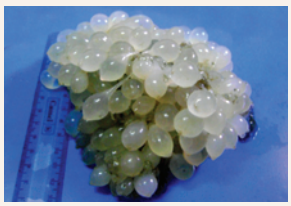
Karnataka: In Karnataka, cephalopods comprising of squid, cuttlefish and octopus are predominantly exploited by trawlers and to a lesser extent by other gears. In 2004, cuttlefish fishing using fish aggregating devices (FADs) became established in Karnataka waters by fishermen from southern coastal Districts of Kerala (Sasikumar *et al.*, 2006). The FADs are placed on uneven rocky areas where operation of gillnets and trawlnets are difficult (although in some fishing locations overlapping of trawing and FAD siting may occur). Good catches of cuttlefishes are taken since these FADs are attractive to the targeted resource during the spawning time. The artisanal hook and line fishermen of the south, migrate seasonally to north for fishing when the weather in their traditional home grounds becomes unfavourable due to northeast monsoon. Initially, when FADs were introduced for cuttlefishes, the migratory fishermen teamed up with the local artisanal fishermen for crafts. The later years witnessed temporary movement of fibre boats operating in the southern coast of Kerala to northern parts of Kerala and Karnataka, during the cuttlefish fishing season (breeding season). Apart from coconut spadices, branches of locally available casuarina plants with firm and slender leaves and bushy branches that are ideal spawning materials were also introduced for FAD construction. Of late, FADs made of non-biodegradable materials such as discarded fishnets and plastic bottles were gaining popularity.

Kerala: Cuttlefishes along the Malabar Coast of Kerala are caught using FADs, locally called 'Kolachil', evolved from the Malayalam word for coconut spadix used in fabrication of the structures (Thomas *et al.*, 2010). The use of FADs is widespread in Kozhikode and Kannur districts. The use of FADs has intensified markedly in recent years by migratory fishermen from Kanyakumari and Kolachil region of Tamil

Nadu. Though large number of boats from the southern districts operates in the Malabar region, there is little data on the overall impact.

Along Munambam-Ponnani coast hooks & line crafts deploy indigenously designed cuttlefish aggregating devices using coconut spadix, 'Kolachils' bundled together and suspended in mid-water column using sand bags at depths ranging from 30-50m during post-monsoon period. Since some of these FAD operations are carried out in trawl fishing grounds, often the 'Kolachils' are entangled in trawls along with the deposited eggs leading to extensive destruction of cuttlefish eggs (CMFRI 2003). Such 'Kolachils' are brought back to the landing centres and again sold to the FAD fishermen. Each FAD units having 150 'Kolachils' were estimated of having 1,50,000 cuttlefish eggs @ 1000 eggs/ 'Kolachil'.





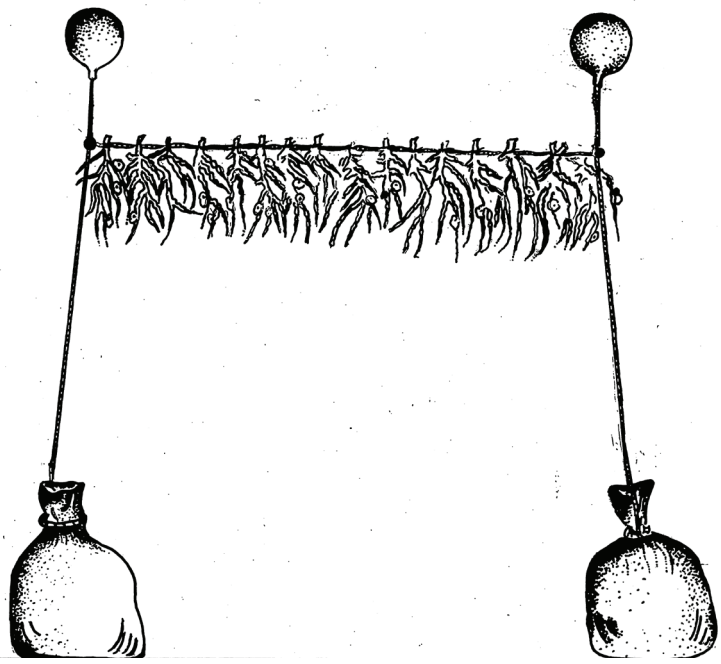
Cuttlefish eggs are individually enclosed in a tough protective external coating, often pigmented black from the ink-sac secretions. These egg clusters are attached to rocky crevices and camouflaged among many encrusting organisms

Deployment of FAD for cuttlefish fishery

The operational area for the Karnataka based cuttlefish fishery extends from Manjeshwara in south (north Kerala) to Karwar in north (Karnataka). Prior to the commencement of actual fishing operation, few trips are made by the fishermen to survey and select suitable areas for laying the FADs. Since rocky reefs and muddy areas in coastal waters are biologically more productive than barren sandy areas, rocky substratum with firm bottom is preferred for deploying the FADs. A preliminary survey of the sea bottom is carried out using ridged lead weight (1-1.5 kg with grooves). A rope is tied to the weight and it is dragged on the sea bottom. Survey is done perpendicularly to the shore from 10 m depth onwards. The lead-weight is periodically lifted for examining the type of sediment adhering to the grooves. The selected sites are marked using GPS and the prefabricated FADs are deployed in these areas at depths ranging from 25 to 55 m.

Casuarina branches used for FAD fabrication

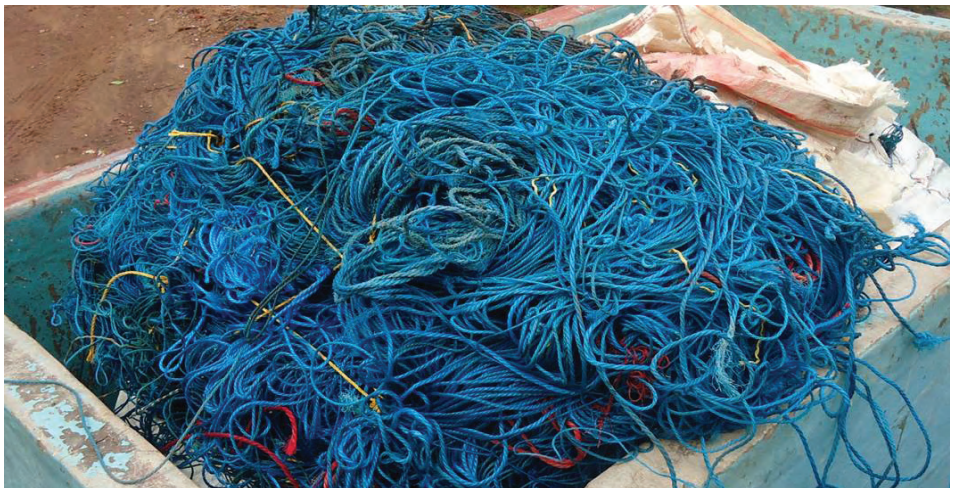
Laying of FADs



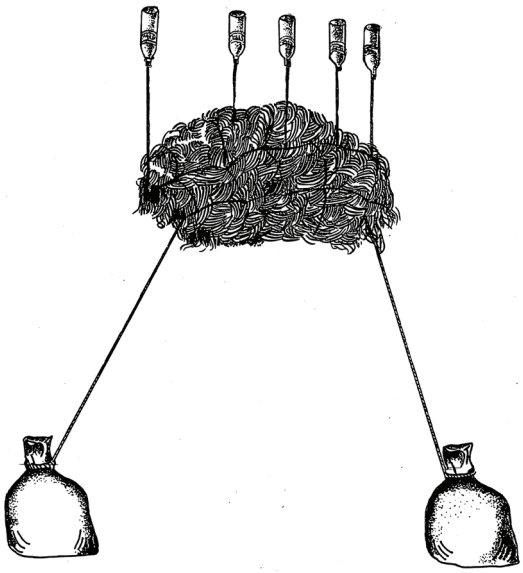
Fish aggregating devices fabricated using coconut spadix

A variety of materials are used as FADs to attract various species of marine organisms and for enhancing the fisheries. FADs first introduced in Karnataka were fabricated using coconut spadix fastened with synthetic ropes. These spadices are bio-degradable and hence eco-friendly. They promote growth of periphyton and other food organisms, which attracts large number of fishes including cephalopods. They provide ideal feeding and breeding ground and provides area for congregation of fishes. Each module of the FAD consists of 50-60 numbers of coconut spadices tied like a bottle-brush at 0.2 m interval using 3 mm nylon rope into a 10 m long section. These modules are placed at marked places on the sea bottom anchored by fixing weight to both ends of the lines. Anchor used are generally gunny bags filled with sand. They are fixed at both ends of the module so that it can neither drift away nor shifted from the site of installation.

Discarded PET bottles used for fabrication of FADs
(Photography: Harishkumar, AD of Fisheries, Mangalore)



Discarded synthetic net materials used for fabrication of FADs
(Photography: Harishkumar, AD of Fisheries, Mangalore)



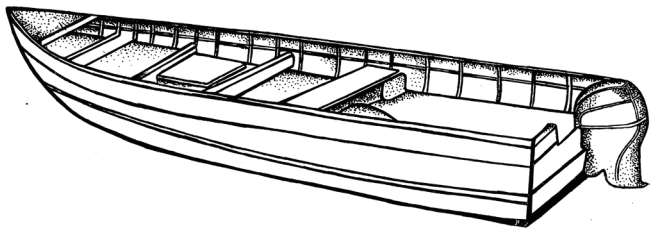
Fish aggregating devices fabricated using
discarded synthetic materials

Cuttlefish fishing method near FADs

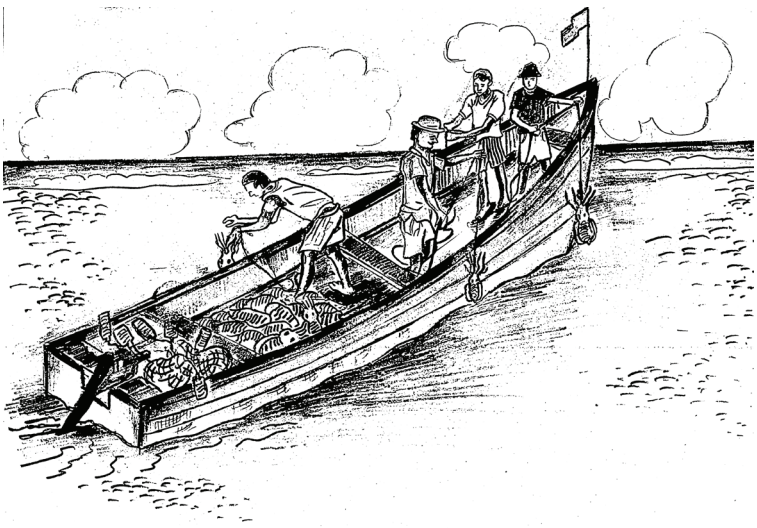
The FADs constructed using coconut spadices and casuarina branches are positioned on the rocky areas 4-5 days prior to the commencement of fishing. The FADs made of non-biodegradable material such as discarded or damaged webbing, when deployed the soaking time is reduced to 1-2 days.

On reaching the site, the modules are dropped overboard at predetermined locations. Each unit sets about 100 numbers of such mid-water floating FADs at 50 to 500 m intervals in the east-west direction along the coast, so as to provide shelter and maximum protection to the shelter-seeking organisms. The modules are kept submerged and positioned in the mid-water column by using 50-kg sand-filled bags as anchors and used plastic bottles as floats. FADs are operated 25-40 km away from the coastline at water depths ranging from 25-55 m. The positions are marked using GPS for easily locating the grounds for fishing.

The cuttlefishes which get aggregated near the FADs, are caught using hand jigs. The jigs are either procured ready-made or fabricated using barbless steel hooks. Four hooks (No.9) are arranged around a cylindrical lead weight of 5-6 inches and secured using metallic wires. Each jig is attached to a monofilament fishing line of 3 mm diameter. Each fisherman uses one line with a single jig at a time.



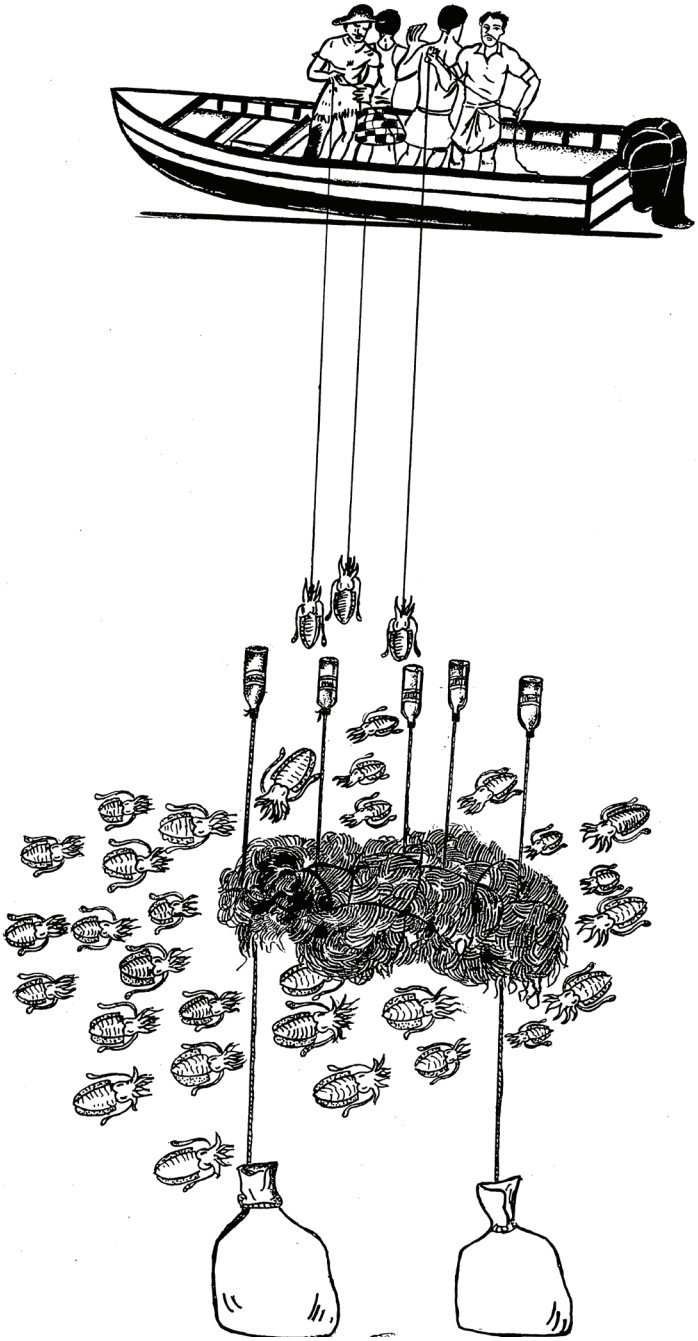
Fibre boat with flat bottom used for FAD fishing



Hand-lining from fibre boat with flat bottom

The craft used for the fishery resemble the regular fibre boat used for operating the drift-gillnet. However, these crafts have a flat raised deck. These fibre boats with flat bottom facilitate easy crew-movement on board. They have an Over-All-Length of 7.5 m and are fitted with 9.6 HP outboard engines.

Fishermen group consisting of five members sets out for fishing between 0400 to 0530 h. Each unit carries GPS for locating the submerged FADs. On reaching the ground the craft is anchored above the FADs, so that the vertical jig lines operate right above the FAD. The jigs are released manually to the bottom and as the jigs pass over the cuttlefish shoals, individual cuttlefish gets hooked. The line is hauled up manually and the cephalopods are unhooked on the raised platform of the craft. The lines are again released down to repeat the operation. Fishing continues as long as cuttlefish are available near the FAD. The craft remain anchored throughout the jigging operation. The fishermen use cotton gloves to protect their hands during the operation. Fishing is done at 30-35 FADs on a day so that each FAD is fished once in three days. Operation



Hand-lining above FADs fabricated using discarded synthetic materials

Jigging hooks

FAD based hand-lining for cuttlefish

Cuttlefish hand-lining above FADs

that commence at dawn continues till dusk (6.00 pm) and the crafts return to the shore.

The crafts do not have storage facilities and the catch is kept covered without ice on the deck till it reaches the shore. Catch consist only of the pharaoh cuttlefish, *Sepia pharaonis*. Cuttlefishes are sorted based on their size and marketed.

Post-harvest handling and marketing

Normal onboard handling practice involves immediate removal of cuttlefish from the jigs as and when they are hauled and placing them in small compartments in the canoe. Icing is not done onboard and seawater is added occasionally to prevent drying.

The crew operating the jigs are migrants and generally belongs to Kerala and Tamil Nadu. Locals involved in this activity finance the fishing unit by providing advance credit to the fishing unit. These locals acts as middlemen in marketing of the catch and recover their advance with profits through the sale of the produce.

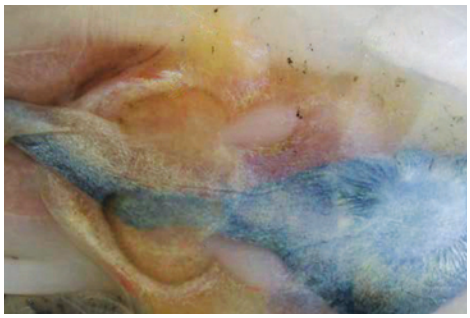
Cuttlefish caught in hand-jigs are unloaded from the canoe in the beach landing centres that are generally located near the facility of the local agent, where it will be weighed and prepared for transportation. The catch is weighed, chilled in ice and transferred to plastic crates for transportation. The cuttlefish fetch premium price in the overseas markets and hence are processed for export. Chilled cuttlefish are initially transported to the pre-processing units for grading and later to seafood processing units for freezing and export.

FAD based cuttlefish catch

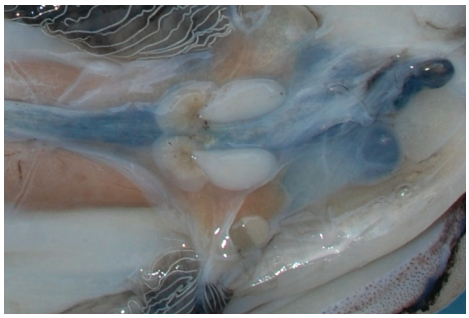
Cuttlefish sorting in progress

Comparison of FAD associated vs unassociated cuttlefishes

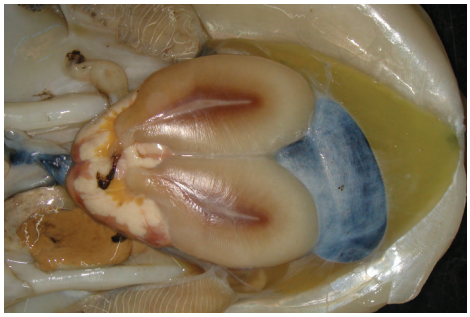
The FAD associated hook and line fishery is a targeted fishing technique for *S. pharaonis*, whereas, the trawl fishery is non-selective and the cuttlefish catches are composed of *Sepia pharaonis, Sepia elliptica, Sepia prashadi, Sepia trygonina* and *Sepiella inermis* (Sasikumar *et. al.*, 2009). The *S. pharaonis* catches from FADs that was less than 1,000 t (16%) until 2004-05, showed a steady increase from 2006-07 to over 6,000 t contributing to 48% of the total production from the region. Hand-jigging accounted for 50% of the mean total production of *S. pharaonis* during 2006-2012 periods.



Immature stage



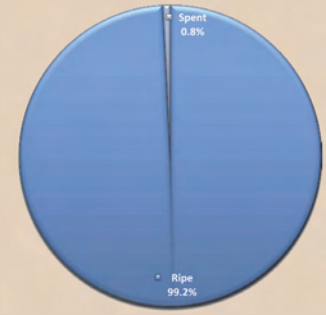
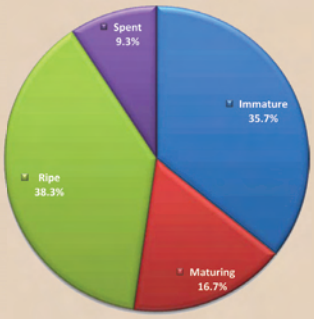
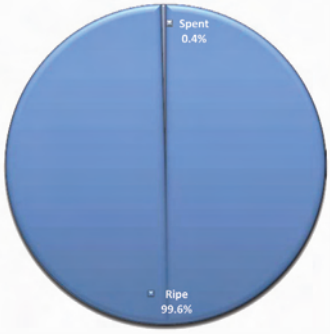
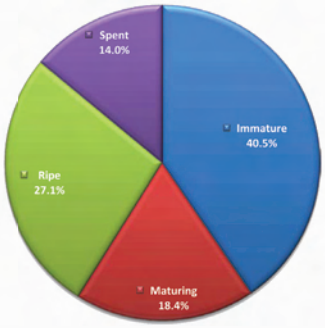
Maturing stage

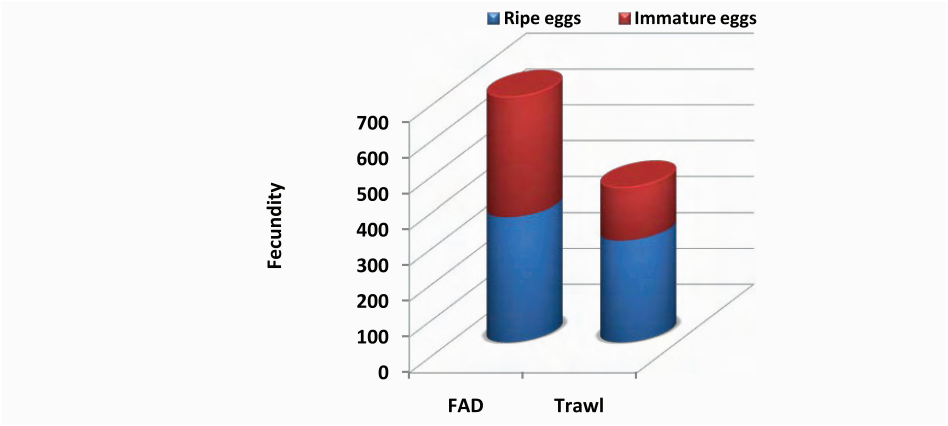


Ripe stage

Spent stage

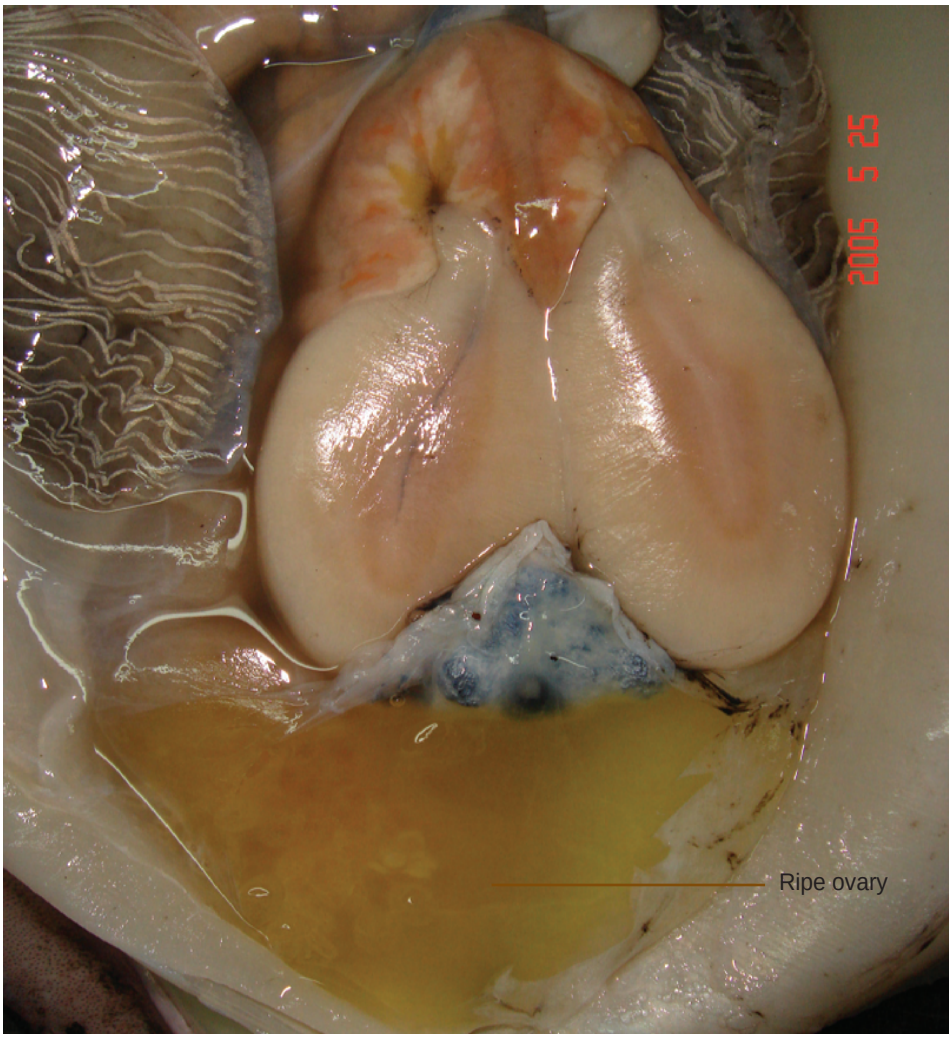
Female maturity stages

Parameters	FAD fishery	Free schools
Species composition	• Single species (*Sepia pharaonis*)	• Multiple species (*S. pharaonis* (dominant), *Sepia elliptica, Sepia prashadi, Sepia trygonina* and *Sepiella inermis*)
Size composition Dorsal Mantle length (DML)	• Adult cuttlefish • Size range: 14-38cm DML • Mean size: 26.8±4.25cm	• Adult cuttlefish with recruits during Jan-Feb • Size range:3-40cm DML • Mean size:16.7±8.05cm
Reproductive status of assemblages	• Spawning • Spent	• Immature • Maturing • Spawning • Spent
Reproductive status of Male cuttlefish	FAD male 	Trawl male 
Reproductive status of Female cuttlefish	FAD female 	Trawl female 
Gonadosomatic index (GSI)	High GSI throughout the fishing season Female GSI: 3.6-6.2 Male GSI: 1.2-1.5	High GSI only during spawning season Female GSI: 0.7-2.2 Male GSI: 0.5-1.0
NidamentalGIand Index (NGI)	High NGI throughout the fishing season Female NGI: 4.4-5.7	High NGI only during spawning season Female NGI: 0.8-2.7
Presence of ripe eggs	Ripe eggs present in females throughout the fishing season	Ripe eggs in females – present only during spawning season



Fecundity of cuttlefish caught in FAD and trawl fisheries

Cuttlefishes from trawl (free school) having spent ovary



Cuttlefish with ripe ovary caught in FAD fishery

From 2008-09 onwards both the FAD associated fishery and the trawl fishery registered a declining trend in total production and CPUE. Clear difference existed in the abundance of cuttlefish near FADs, where, mean catch rates was initially 36 times more than the catch rates in trawl.

Catch per unit effort near FADs registered a decreasing trend from 120 kg/h in 2005-06 to 59 kg/h in 2011-12. Catch rates in trawl varied between 1.2 kg/h in 2004-05 and 3.5 kg/h in 2008-09 and thereafter fell to 1.2 kg/h in 2011-12. Prices of cuttlefishes have been on the rise for the past ten years, though there were fluctuations. Average price of *S. pharaonis* increased from INR 50/kg in 2004 to INR 200/kg in 2012 yielding higher value per unit hours in recent years.

Sustainability and Ecological havoc

The artisanal hook and line fishermen, known for their intricate practical knowledge of coastal fisheries and fishing skill have designed and fabricated these structures based on their understanding of cuttlefish behaviour. The method of FAD construction and deployment also includes designing of suitable structures for egg deposition, selection of spawning season as well as suitable sheltered area for their deployment based on the characteristics of the targeted species. The relative ease of FAD structure deployment, the availability

FAD with cuttlefish eggs *(Photography: J. Chembian, FSI)*

Coconut spadix entangled in trawl net *(Photography: J. Chembian, FSI)*

of inexpensive fabrication materials, precise positioning of the FADs aided by GPS, information on near-shore cuttlefish spawning areas which are generally unsuitable for trawling, the minimum soak time required for aggregation of cuttlefish post-deployment and the proximity of FAD fishing grounds for undertaking daily fishing trips make this fishing activity a viable alternative to small-scale fishers operating motorised fishing crafts.

It is evident from the biological aspects of cuttlefish assemblages caught near FADs that the hook and line fishery targets the pre-breeding/ breeding cuttlefishes. On an average nearly 1.2 million spawning females were exploited by the FAD associated fishery annually along Karnataka. Over the years the loss in cuttlefish eggs due to FAD based fishery is estimated to be ranging from 630 to 1,235 million eggs per year in Karnataka. In addition, introduction of torn and worn out net material, plastic bottles and other synthetic materials as a replacement to the biodegradable materials of plant origin can

Synthetic net material with cuttlefish eggs

lead to significant environmental consequences. The ecological concerns of the abandoned net material acting as ghost nets, trapping, entangling and killing fishes and shellfishes also requires serious consideration.

Impact of FADs

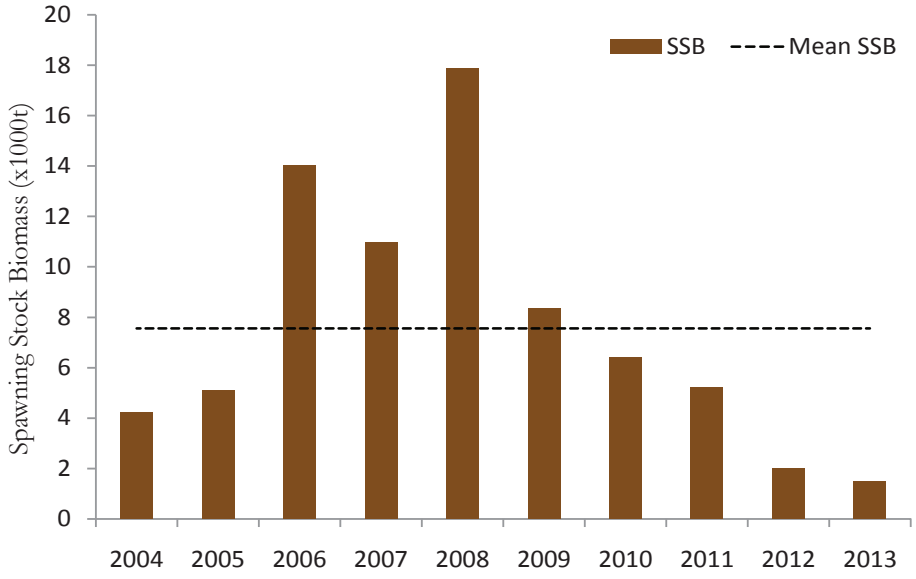
The main adverse impacts of FAD-associated exploitation of cuttlefish are

Indiscriminate fishing of spawning aggregations:

The fish aggregating devices placed in the inshore waters attracts and congregate cuttlefish spawners facilitating their easy harvest. The FADs entices only larger (mean DML of 26.8 ± 4.25 cm; 14-38 cm) ripe individuals (99% mature) in all months, as immature individuals are not attracted towards the spawning substrate. The placement time of the FADs also coincides with the inshore spawning migration of *S. pharaonis*. Consequently the spawning cuttlefish populations became increasingly vulnerable to the exploitation by the fishing gears.

Recruitment overfishing of *Sepia pharaonis* along the eastern Arabian Sea:

Cuttlefishes caught near the FADs are reproductively mature and having high organ indices indicating their capture before egg laying. Hence, the capture of spawning females, has led to an incomplete reproductive cycle as evident from the progressive decrease in the number of recruits from 93.2 million in 2008 to 35.6 million in 2013 in the fishing area. The average annual loss in cuttlefish eggs was estimated at 927 million, ranging between 630 and 1,235 million eggs. Detailed analysis indicated that the annual spawning stock biomass was reduced to one fifth of the mean value (2004-2013) by 2013. Introduction of FADs in significant numbers has led to recruitment overfishing.



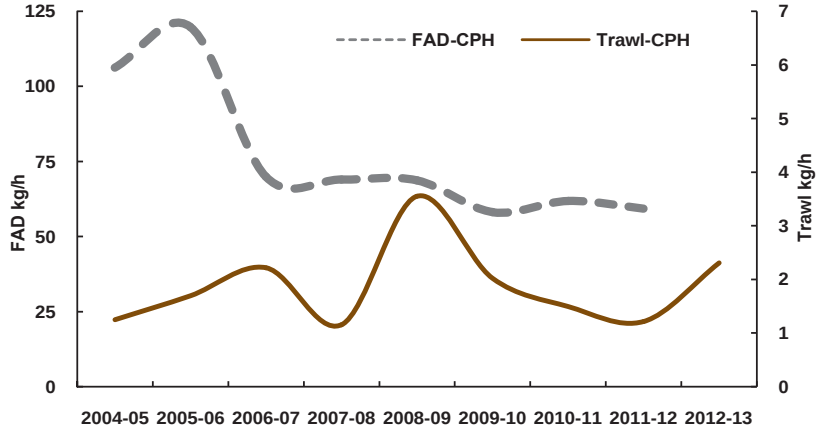
Annual spawning stock biomass of *S. pharaonis*

Decrease in free-school cuttlefish abundance:

The mean catch rate (abundance) of cuttlefish near FADs was initially ca.36 times more than the catch rates in trawl. The catch rates of pharaoh cuttlefish in trawling ground reduced from 3.5 kg/h in 2008-09 to 1.2 kg/h in 2011-12.

Decrease in *S. pharaonis* yield:

The impact of the eight year FAD based cuttlefish fishery began to reflect in the cuttlefish yields both in FAD and



Catch rates of *S. pharaonis* by trawl and FAD fisheries

trawl based fisheries in Karnataka. The total *S.pharaonis* yield registered a declining trend from 17,278 t in 2008-09 to 7,409 t in 2011-12.

The *S. pharaonis* catch by trawl and FAD fisheries

Increase in marine debris:

In FAD construction plant materials were replaced with synthetic, non-biodegradable materials due to their easy availability and low cost. As a result, discarded plastic bottles replaced the floats and discarded damaged webbings replaced the coconut spadices or other plant materials. These synthetic non-biodegradable materials add to the marine debris, often posing problems for navigation and operation of other fishing gears.

Ecological consequences:

When FADs made of webbings are abandoned in the sea they are capable of ghost fishing when unattended, trapping, entangling and killing fish and shellfish. The net panels continue to fish without anyone profiting from the catches, affecting already depleted commercial fish stocks. The entangled fishes/ shellfishes perish and in turn attract scavengers which will get caught in that same net, thus creating a vicious circle.

Inter-sectoral conflicts:

The higher catch rates in FAD-associated cuttlefish fishery, higher unit value of the cuttlefish and because of the fact that FADs get entangled in other fishing gears operating in the same location leads to inter-sectoral conflicts between trawl fishermen (local) and FAD fishermen (migratory).

Management guidance

The foregoing analysis clearly indicates that cuttlefishes are successfully aggregated by FADs and are very efficiently caught by hand-lines with jigs. The cuttlefishes aggregated are the spawning population comprising of large females with ripe eggs.

Large-scale deployment of cuttlefish FADs has resulted in recruitment overfishing (excessive capture of spawners) leading to decline in catch and catch rates both in the FAD and trawl fishing of cuttlefishes.

The capture of ripe females has resulted in a net loss of 630 to 1,235 million cuttlefish eggs per annum and an estimated annual revenue loss to the tune of INR 1,130 crores to the fishermen of Karnataka State.

The recent use of non-biodegradable materials in FAD constructions adds another highly damaging dimension to this fishing practice. The indiscriminate use of non-biodegradable materials add to the marine litter, the environmental consequences of this are long-term and very difficult to assess.

Apart from the biological threat caused by such fishing practices, social problems too have emerged in this area due to conflicts and access to resource. The high profits of the fishermen engaged in this method of fishery, and the fact that such activity is carried out only by the migrant fisher-folk from Tamil Nadu and Kerala have resulted in discontent among the locals. Further, the FADs get entangled in the trawl nets of boats that operates in the inshore waters leading to conflict between trawl and jig-operators.

All these impacts make the FAD-associated cuttlefish fishery a very destructive fishing practice and therefore, the CMFRI recommends the respective State Fisheries Departments

to take appropriate steps to totally ban and prohibit this fishing practice in all maritime states of India.

The FAD fishing for cuttlefishes should be banned either by amending the respective MFR Act or by passing a suitable ordinance. The pro-active steps taken in this regard by the Karnataka State Fisheries Department is given below as an example.

- During 2011-12, based on scientific advice from CMFRI cautioning the impact of this destructive fishing method and to avoid conflict between the trawl and FAD fishermen, FAD fishing for cuttlefish was banned in the State under Section 3 of the Karnataka Marine Fishing (Regulation) Act, 1986 by a Government Order. Regulations were enacted by the State Fisheries Department in July, 2012 prohibiting the FAD based cuttlefish fishery in the coastal waters of the State of Karnataka.
- The notification dated 9th July, 2012 stated that (notification in Kannada translated to English) 'Exercising the powers granted under the provisions of Karnataka Marine Fisheries Act 1986, subsection (1) (B) and (C), fishing of cuttlefish by non-conventional methods using coconut fronds (Chowri) is banned along the coast of Karnataka with immediate effect'. This notification was further amended on 21st December, 2012 to ban materials such as 'Chowri, torn nets, decaying material and other marine polluting materials/ items'.

The implementation of the ban requires extensive surveillance by fisheries department to monitor compliance, with a system of heavy penalities to ensure compliance.

GOVERNMENT OF KARNATAKA

No. AHF 74 FDD 2012

Secretariat, Govt. of Karnataka
Vikasa Soudha, Bangalore.
Dated: 09-07-2012

NOTIFICATION

Exercising the powers granted under the provisions of Karnataka Marine Fisheries Act 1986, Subsection(1)(B) and (C), fishing of cuttlefish by non-conventional methods using coconut fronds (Chowri) is banned along the coast of Karnataka with immediate effect.

By order of Governor of Karnataka and in his name

Sd/-
(D.M.Rajanna)
Under-Secretary to the Government,
Dept.of Animal Husbandry & Fisheries (F)

To:
1. Director of Fisheries, Bangalore
2. Deputy Commissioner, D.K./U.K./Udupi District
3. Deputy Director of Fisheries, Mangalore/Karwar
4. Department Guard File:Coordination:Weekly Gazette: Additional Copies

Karnataka State notification to ban fishing of cuttlefish by non-conventional methods – English translation

GOVERNMENT OF KARNATAKA

No.AHF 158 FDD 2012

Secretariat, Govt. of Karnataka
Vikasa Soudha, Bangalore.
Dated: 21-12-2012

CORRIGENDUM

The second and third lines "using Chowri along the Karnataka coast" vide Notification No. AHF 74 FDD 2012 dated 09-07-2012 may be corrected and read as "using Chowri, torn nets, decaying material and other marine polluting materials/ items along the Karnataka coast"

By order of Governor of Karnataka and in his name

Sd/-
(D.M.Rajanna)
Under-Secretary to the Government,
Dept.of Animal Husbandry & Fisheries (F)

To:
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Karnataka State corrigendum to ban fishing of cuttlefish by non-conventional methods

ಕರ್ನಾಟಕ ಸರ್ಕಾರ

ಸಂಖ್ಯೆ:ಪಸಂಮೀ 74 ಮೀಇಇ 2012

ಕರ್ನಾಟಕ ಸರ್ಕಾರದ ಸಚಿವಾಲಯ
ವಿಕಾಸಸೌಧ
ಬೆಂಗಳೂರು, ದಿನಾಂಕ:09-07-2012

ಅಧಿಸೂಚನೆ

ಕರ್ನಾಟಕ ಕಡಲ ಮೀನುಗಾರಿಕೆ (ವಿನಿಯಮನ) ಅಧಿನಿಯಮ 1986ರ ಪ್ರಕರಣ 3ರ ಉಪ ಪ್ರಕರಣ (1)(ಬಿ) ಮತ್ತು (ಸಿ)ರಲ್ಲಿ ಪ್ರದತ್ತವಾದ ಅಧಿಕಾರವನ್ನು ಚಲಾಯಿಸಿ ರಾಜ್ಯದ ತೀರ ಪ್ರದೇಶದಲ್ಲಿ ಬೌರಿ ಹಾಕಿ ಅಸಾಂಪ್ರದಾಯಿಕ ರೀತಿಯಲ್ಲಿ ಕಟ್ಲೆಬಂಡಾಸ್ ಮೀನು ಹಿಡಿಯುವುದನ್ನು ತಕ್ಷಣದಿಂದ ಜಾರಿಗೆ ಬರುವಂತೆ ನಿಷೇಧಿಸಲಾಗಿದೆ.

ಕರ್ನಾಟಕ ರಾಜ್ಯಪಾಲರ ಆದೇಶಾನುಸಾರ
ಮತ್ತು ಅವರ ಹೆಸರಿನಲ್ಲಿ,

(ಡಿ.ಎಂ.ರಾಜಣ್ಣ)
ಸರ್ಕಾರದ ಅಧೀನ ಕಾರ್ಯದರ್ಶಿ
ಪಶುಸಂಗೋಪನೆ ಮತ್ತು ಮೀನುಗಾರಿಕೆ ಇಲಾಖೆ(ಮೀ)

ಇವರಿಗೆ:

ಸಂಕಲನಕಾರರು, ಕರ್ನಾಟಕ ರಾಜ್ಯ ಪತ್ರ, ಬೆಂಗಳೂರು – ಈ ಅಧಿಸೂಚನೆಯನ್ನು ಮುಂದಿನ ಸಂಚಿಕೆಯಲ್ಲಿ ಮುದ್ರಿಸಲು ಮತ್ತು ಮುದ್ರಿತ 100 ಪ್ರತಿಗಳನ್ನು ಈ ಇಲಾಖೆಗೆ ಒದಗಿಸಲು ಕೋರಿದೆ.

ಪ್ರತಿ:

1. ಮೀನುಗಾರಿಕೆ ನಿರ್ದೇಶಕರು, ಬೆಂಗಳೂರು.
2. ಜಿಲ್ಲಾಧಿಕಾರಿಗಳು, ದಕ್ಷಿಣ ಕನ್ನಡ/ಉತ್ತರ ಕನ್ನಡ/ಉಡುಪಿ ಜಿಲ್ಲೆ.
3. ಮೀನುಗಾರಿಕೆ ಉಪ ನಿರ್ದೇಶಕರು, ಮಂಗಳೂರು/ಕಾರವಾರ.
4. ಶಾಖಾ ರಕ್ಷಾ ಕಡತ:ಸಮನ್ವಯ:ವಾರದ ರಾಜ್ಯ ಪತ್ರ:ಹೆಚ್ಚಿನ ಪ್ರತಿಗಳು.

:: ನಕಲು ::

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Original Karnataka State notification to ban fishing of cuttlefish by non-conventional methods

Acknowledgements

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- Director, CMFRI for facilities and encouragements
- Latheesh Puthran, fisherman from Thotta Bengre; Ashoka & Mohan Chandra, fishermen from Someshwara and Shankar Dombe fisherman from Byndoor for providing valuable technical inputs on the fabrication and operation of FADs along Karnataka Coast.
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- P. Nagaraja, artist, for all the illustrations.

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