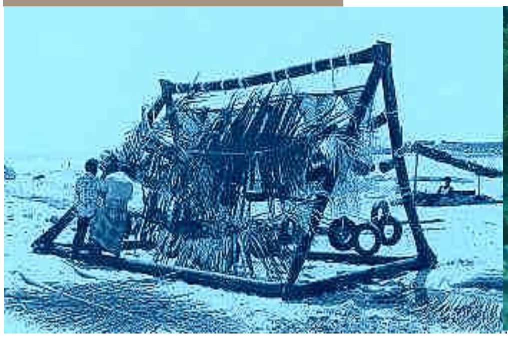
Training Manual

Impact of Aggregating Devices on Cuttlefish fishery

Geetha Sasikumar, A.P. Dineshbabu, K.M. Rajesh, Bindu Sulochanan
Swathilekshmi P.S., Sujitha Thomas, Prathibha Rohit

5 - 7 December, 2013 Mangalore



Mangalore Research Centre of
Central Marine Fisheries Research Institute

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By

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Research Centre of CMFRI, Mangalore
P.B. 244, Hoige Bazar, Mangalore, Karnataka-575 001

Programme Schedule

Awareness program on the '*Impact of aggregating devices on cuttlefish fishery*'
5-7 December, 2013, M.R.C. of CMFRI, Mangalore

Date	Time	Title	Resource Person
5.12.13	09.00-10.00	Registration	
	10.00-10.30	Inauguration	
	10.30-12.00	Artificial Reefs (ARs)	Dr. K.K. Philipose
	12.00-01.00	Fish Aggregating Devices (FADs)	Dr. Prathibha Rohit
		Break	
	02.00-03.30	Captive behaviour of Cephalopod	Dr. M.K.Anil
	03.30-04.30	Practical - Cuttlefish biology	Dr. Geetha Sasikumar
6.12.13	10.00-10.30	Cuttlefish biology	Dr. Geetha Sasikumar
	10.30-11.30	Fishery and biology of pharaoh cuttlefish *Sepia pharaonis*	Dr. Geetha Sasikumar
	11.30-01.00	Aggregation based cuttlefish fishery	Dr. Geetha Sasikumar
		Break	
	02.00-03.30	Prohibition of cuttlefish fishing using unconventional methods: A case study along Karnataka coast	Mr. Harishkumar
	03.30-04.30	Conservation Criteria and red listed marine resources of India	Dr. Sujitha Thomas
7.12.13	10.00-11.00	Fisheries legislation in Karnataka	Dr. K.M. Rajesh
	11.00-12.00	Migrant labourers in the Primary sector of marine fisheries – A case study in Karnataka	Dr. Swathilekshmi P.S
	12.00-01.00	Mangroves and its impact on fisheries	Dr. Bindu Sulochanan
		Break	
	02.00-04.30	Feedback, Discussion, Certificate distribution	

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Cuttlefish biology

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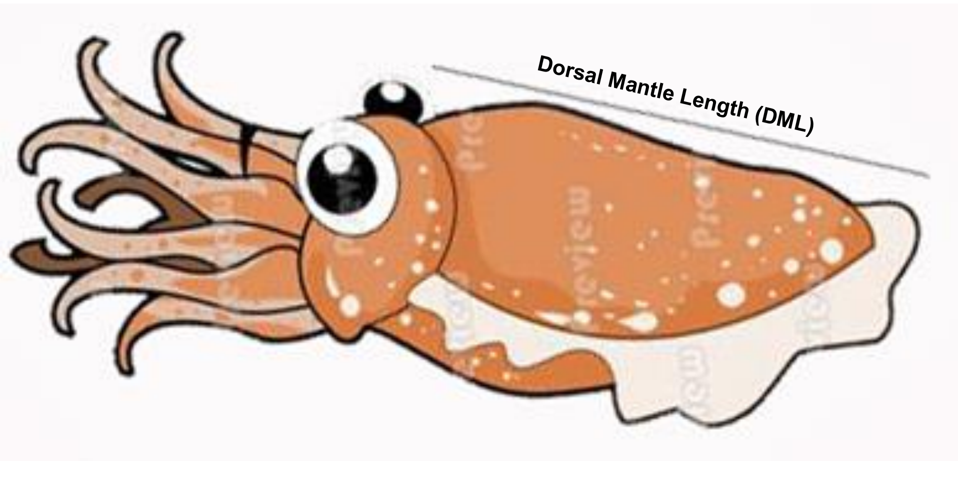
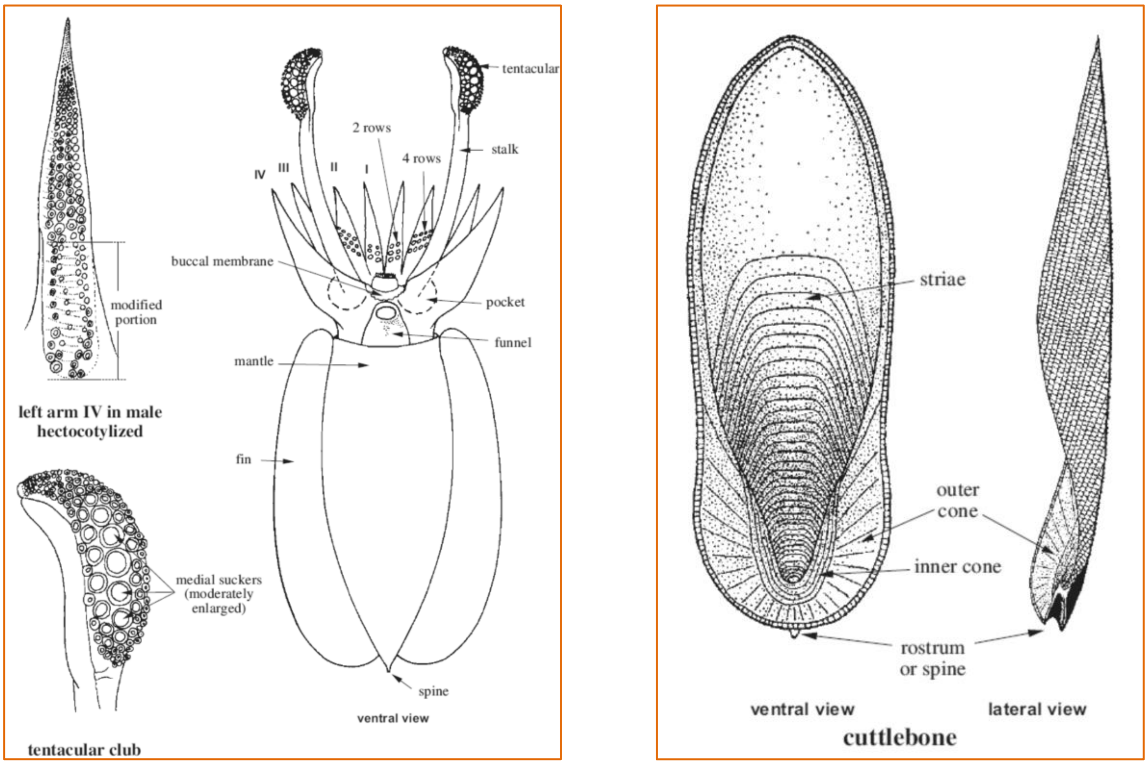
The Class Cephalopoda comprising of squids, cuttlefishes and octopus includes the largest known living invertebrates within the animal Kingdom. Cephalopods have well developed head and a body consisting of a muscular mantle and mantle cavity. Head bears circumoral appendages (arms, tentacles), a feature that reflects the origin of the name ‘Cephalopoda’, which is derived from the union of the two Greek words: ‘kefale’, head, and ‘pous’, feet. These soft-bodied bilaterally symmetrical groups are commercially important fishery resources occurring in all marine habitats in depth ranging from intertidal to over 5,000 m. Salinity is considered as the limiting factor restricting their distribution between 27 and 37 psu, with few exceptions.

The cuttlefishes belonging to the family Sepiidae are of significant commercial value to artisanal and industrial fisheries. 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. Large species such as *Sepia latimanus*, *S. officinalis* and *S. pharaonis* are restricted to much shallower depths and show very different septal spacing and sutures than the deeper water species. Some species migrate seasonally in response to temperature changes and aggregate, usually in shallow water, at spawning time.

Cuttlefishes have broad sac-like bodies with lateral fins that are narrow and extend along the length of the mantle; posterior lobes of the fins free (subterminal) and separated by the posterior end of the mantle; 10 circumoral appendages, the longest 2 (tentacles) are retractile into pockets on the ventrolateral sides of the head; the 8 remaining arms frequently with 4 series of stalked suckers with chitinous rings; eyes are covered with a transparent membrane and eyelids are present. They are characterized by the presence of a dorsally placed internal calcareous shell known as the cuttlebone, which is a finely chambered shell, thick, and chalky.



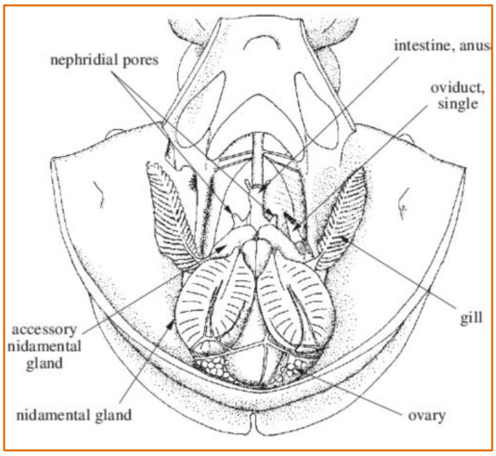


Basic cuttlefish features (Reid *et al*., 2005)

Mantle: The multifunctional mantle cavity is important for cuttlefish locomotion, giving the animal its characteristic jet propulsion ability. To move away from a predator, the cuttlefish sucks water into the mantle cavity and then uses its strong mantle muscles to expel water with great force, forcing the cuttlefish in the opposite direction. Water exits through a movable part called the funnel, which controls the angle of the spray. The mantle cavity also aids in respiration by bringing water to the animal's gills, which in turn filter oxygen into its bloodstream.

Fin: While the cuttlefish uses its mantle cavity for jet propulsion, it relies on its specialized fins for basic mobility and maintaining consistent speeds. The muscular fin can manoeuvre the cuttlefish in nearly any direction: backward, forward, even in circles, with such movement being more energetically efficient than jetting.

Gills, Hearts and Blood: The cuttlefish has three hearts, with two hearts pumping blood to its large gills and one circulating the oxygenated blood to the rest of its body. The blood itself is blue-green in colour because of hemocyanin, a copper-containing protein that transports oxygen throughout their bodies.



Reproduction: Gonads form a single mass at the posterior end of the mantle cavity. Reproductive systems are highly complex structures with ducts, glands and storage organs. In males, the sperms are 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 this organ the sperm 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 and stored until copulation. Female reproductive system consist of a single ovary, the single oviduct having thin walled as well as glandular portions, the paired nidamental glands and the 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 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 contains thick white gelatinous material which 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 different batches.

During mating, the male uses a modified arm, the hectocotylized arm, 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 female uses the arms to wipe the stored spermatophores onto each egg.

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 disguised among many encrusting organisms.

Food and Feeding: All cuttlefish are active carnivores feeding on live prey during their entire life cycle. They are opportunistic feeders, switching easily from one prey to another. Preferred diet of cuttlefish is crabs and fish; they feed on small shrimp soon after hatching. They use their camouflage to hunt their prey. They swim at the bottom, where shrimp and crabs are found and shoot out a jet of water to uncover the prey buried in the sand. Then when the prey are trying to get away, the cuttlefish open their eight arms and shoot out two long feeding tentacles to grab them. The tentacular club suckers grab the prey. The captured prey is brought to the mouth by the arms where it is killed. The dorsal beak or the ‘upper’ beak is inserted within the ‘lower’ (ventral) beak to tear tissue of the prey with a scissors-like cutting action. The gut has spontaneous peristaltic activity. The chopped food passes from the buccal cavity through the oesophagus to the stomach, where most of the digestion takes place. The digestive tract except for glandular area is chitin lined from the buccal mass to the stomach. The cuticular ridges in the stomach aid in grinding food. The food is broken down with enzymes in the stomach from the digestive gland. The stomach may be greatly expandable in size and serve as a storage area until food can be fully processed.

Cuttlefishes along Indian coast

Species	Common name	Distribution
Sepia pharaonis	Pharaoh cuttlefish	Indian coast
Sepia aculeata	Needle cuttlefish	Indian coast
Sepia elliptica	Golden cuttlefish	Indian coast
Sepia prashadi	Hooded cuttlefish	Indian coast
Sepia brevimana	Short-club cuttlefish	East coast
Sepiella inermis	Spineless cuttlefish	Indian coast

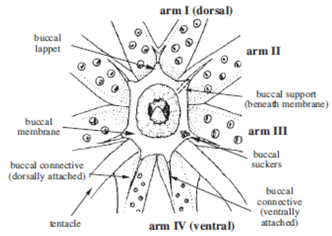
Technical terms

Accessory nidamental glands : Glands consisting of tubules containing symbiotic bacteria.

Beak : Two chitinous jaws of cephalopods, bound in powerful muscles.

Buccal : Pertaining to the mouth.

Buccal connective : Thin muscular band that attaches the buccal support of the buccal membrane to the base of the adjacent arm. The position of attachment of the connective on the fourth arms was recognized in the early twentieth century as an important character for phylogenetic relationships among decapodiformes.



Buccal membrane : The muscular membrane that encircles the mouth like an umbrella. It connects to the buccal supports to form the buccal crown. The pigmentation of the buccal membrane often differs from that of the adjacent oral surfaces of the arms.

Hectocotylus : One (or more) modified arm in male cephalopods used to transfer spermatophores to the female; modifications may involve suckers, sucker stalks, protective membranes, trabeculae .

Ink sac : The structure that manufactures and stores the ink of cephalopods; it lies parallel with the intestine and empties via a duct into the rectum.

Mantle cavity : Space enclosed by the mantle. In cephalopods the mantle cavity contains the visceral sac, gills, anus, openings of the gonoducts, nephridial pores and various muscles and septa.

Needham's sac (**spermatophore/ spermatophoric sac**) – : The elongate, membranous organ of males where completed, functional spermatophores are stored. It opens into the mantle cavity or directly into the water through the penis.

Nidamental glands : Large glandular structures in females of most decapods and nautiluses that lie in and open directly into the mantle cavity. The glands are composed of numerous lamellae that are involved in secretion of egg cases or the jelly of egg masses.

Oviduct : Female gonoduct(s). The oviduct conducts eggs from the visceropericardial coelom, which encompasses the ovary, to the mantle cavity and often is used to store eggs. In some argonautid octopods eggs are fertilized and undergo either partial (*Argonauta*) or complete (*Ocythoe*) embryonic development within the oviduct.

Oviducal gland : Glandular structure that surrounds the anterior end of the primary oviduct and secrets some of the external coatings around spawned eggs.

Sperm duct (=**seminal duct**)	:	The duct of males which joins the testis with the spermatophoric organ
Sperm mass	:	The mass of sperm held within the spermatangia of everted spermatophores.
Sperm receptacle	:	A bulbous structure in the buccal region or at the openings of the oviducts in females of certain cephalopods for deposition of spermatangia.
Spermatangium (pl. **spermatangia**)	:	Extruded, exploded, evaginated spermatophore/s, often in the form of a round bulb.
Spermathecae	:	Specialized sperm-storage structures found in the skin of some female decapodiformes or as pockets of the oviducal gland in octopods.
Spermatophore	:	A tubular structure manufactured by male cephalopods for packaging sperm; capable of holding millions of sperm, it is transferred and attached to the female until fertilization begins. It forms a spermatangium after the spermatophoric reaction occurs and the spermatophore has everted.
Spermatophoric complex	:	The unit formed by the sperm duct, the spermatophoric organ, the spermatophoric sac, the spermatophoric duct and the penis.
Spermatophoric duct	:	The duct of males through which the spermatophores, once formed, pass from the spermatophoric organ to the spermatophoric sac.
Spermatophoric organ	:	Male organ where the spermatophores are formed.
Spermatophoric reaction	:	The evagination of a spermatophore with the extrusion of the sperm mass, caused by the penetration of water inside the spermatophoric cavity, where the osmotic pressure is higher.

Pharaoh cuttlefish (*Sepia pharaonis)* catch – Mangalore FH

Fishery and biology of pharaoh cuttlefish *Sepia pharaonis*

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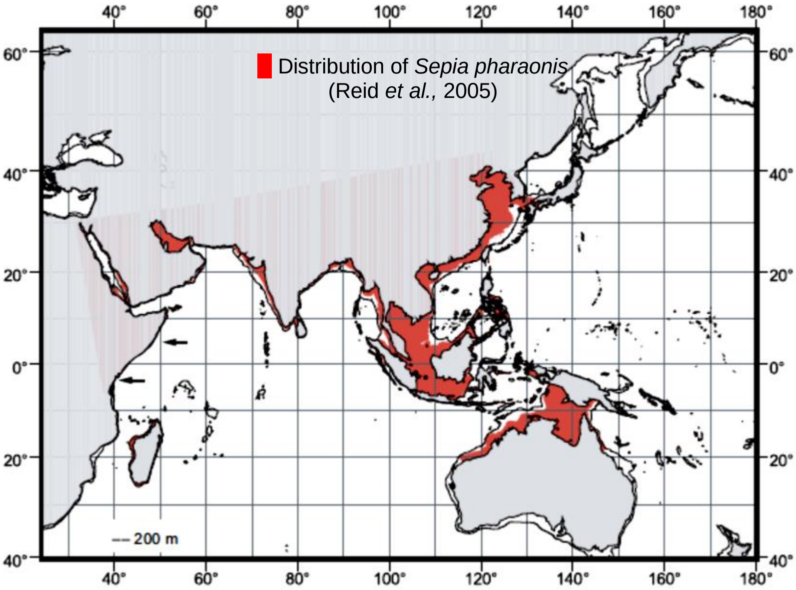
Distribution

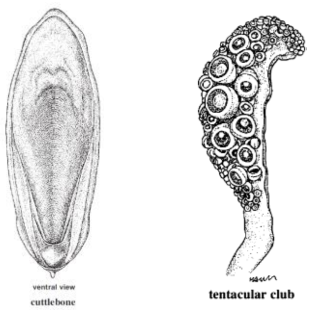
The pharaoh cuttlefish *Sepia pharaonis* Ehrenberg, 1831, is one of the most important species exploited along the Arabian Sea. It is a neritic demersal species endemic to the tropical waters of the Indo-Pacific region including Red Sea, Arabian Sea, Andaman Sea to South China Sea, East China Sea, Japan and Eastern Indonesia to Southern Australia including Gulf of Carpentaria.

Phylogenetic analyses of *S. pharaonis* in its distributional range revealed five distinct clades within the *S. pharaonis* species complex. Accordingly, the Clade C of the *S. pharaonis* population confined to Arabian Sea, Bay of Bengal and Andaman Sea (Andaman Sea coast of Thailand) is exploited in the Eastern Arabian Sea. Commercial catches of *S. pharaonis* are reported from coastal waters up to a depth of 130 m. The species is known to undertake seasonal migrations between the continental shelf waters and shallow coastal waters for feeding and spawning (Reid *et al.* 2005).



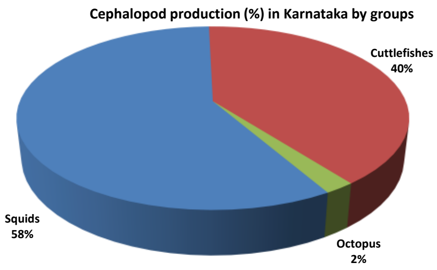
Distinguishing characters

In *Sepia pharaonis*, the tentacular clubs are with suckers of unequal size. Five to six suckers in the middle row of manus are greatly enlarged. The mantle, head and arms are with transverse stripes. Cuttlebone broad, thick and with a mid-ventral groove flattening anteriorly in striated area; striae '^' shaped; inner cone forms a conspicuous yellowish flat ledge; a sharp thick spine present.



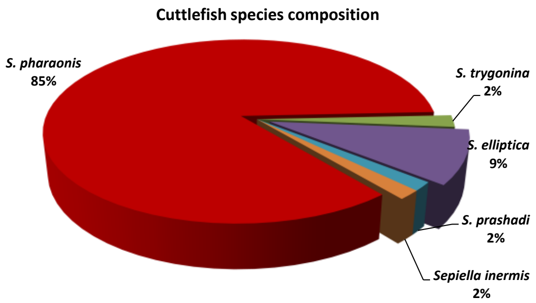
Cuttlefish fishery in Karnataka

Along the Indian coast, cephalopods constitute a fishery of commercial significance, where the production exhibited a quantum leap in the past few decades. The cephalopods fishery production reached 1,90,322t in 2012 from 94t in 1961. During 2010-12, the exploited cuttlefishes formed 43-46% of total cephalopod catches, fluctuating between 71,922 and 88,320t in India. In the State of Karnataka, the cephalopod fishery is characterized by considerable inter-annual variability in production. Cephalopods were landed as by-catch in shrimp trawl in the eighties. They emerged as valuable targeted resource, during the past two decades, due to the tremendous export potential. The group comprising of squids, cuttlefishes and octopus are currently exploited commercially in the State and their production increased from 246t in 1985 to 26,051t in 2012 contributing 13.7% to the national cephalopod production. While the cephalopod production constitutes only 5.5% (2012) to the total marine landings in quantity, it contributed about one quarter to the proceeds from marine fish production for the State. The cephalopod fishery was centered around the neretic squids when the fishing efforts were focused on the post-monsoon congregations in inshore waters and the ensuing recruits. Later, the increased demand coupled with expansion in fishing grounds lead to the increase in the share of cuttlefishes and octopus in the cephalopod production. The major share of cuttlefish catches was formed of *Sepia pharaonis*. Catches of *S. pharaonis* in the State have increased substantially from 3t in 1980 to 8,996t in 2012.



Fishing gears

Sepia pharaonis is a neritic demersal species, targeted almost throughout the year, excluding the mechanized fishing ban period, by bottom trawl in the commercial trawling ground of MDF. Other gears that exploit cuttlefishes in the region are hooks & lines associated with Fish Aggregating Devices (FADs).



The commercial trawl fleet of Karnataka consists of two types of fleets, the single-day fleet (SDF) comprising of smaller trawlers (<9m overall length) and the multi-day fleet (MDF) of medium sized (<20m overall length) trawlers. SDF undertake daily fishing operations in the inshore waters up to 25m depth zone whereas, MDF carry out longer voyages and operate beyond 25 m. Cuttlefishes are targeted by MDF, catching more than 98% of the resource.

Trawling ground

Commercial fishing ground extends from 10^{0}30'N-75^{0}45'E in South to 17^{0}20'N-72^{0}42'E in the North. This included the area lying in the depth zone of the *Bassas-de-Pedro Bank/ Padua Bank* (13^{0}07'N-72^{0}25'E) and around the Netrani Islands, (14^{0}08'N-74^{0}47'E) which are known for their abundance in cephalopods, yielding higher catch rates. Depth of operation of MDF increased over the years from 50m in1986 to 70m in 1991. In 1995, the trawling depth increased beyond 70m when cephalopods were targeted reaching 100 m and continued to increase further, reaching depths of 150m since 2001.

Fishing season

Subsequent to the fishing ban in the monsoon season, the commercial fishing operations in the region commences from August. The major fishing season for cuttlefish is during May-November, when monthly catches (1.67-13.02 kg/h) in trawl are several times higher than those in December-April (0.03-0.85 kg/h). In the post-monsoon season, higher catch rates (4.16-13.02 kg/h) in cuttlefish landings occurs in the beginning of the fishing season, from August to October. The cuttlefish become progressively less abundant from December onwards.

Size distribution

The monthly length distribution of *S. pharaonis* in the commercial fishery range from 4 to 41 cm in Dorsal Mantle Length (DML) with size groups 12-25 cm dominating the trawl catch. Smaller size group in the range of 4-8 cm are represented from January to June. Monthly length distribution of males and females shows a bimodal distribution from October to March, with larger size groups evident during the post-monsoon months. Females are less numerous than males among the larger individuals above size group 27cm and are not present above size group 35 cm. Recruitment to the fishery occurs in two spells with a major one in May/June before the onset of monsoon and subsequently in January/February. The proportion of smaller individuals in the fishery is above 50% in January and in May/June, consequent to the recruitments. Two distinct age groups or cohorts are apparent in the population.

Food and feeding

Sepia pharaonis is an active predators, and their gut generally contain macerated and partly digested fishes, scales, eye balls, otoliths and bones of fishes and appendages of crustaceans, prawns, crabs and stomatopods. Cannibalism is observed in these animals mainly during the post-monsoon period.

Reproduction

Cuttlefishes are gonochoristic. Left ventral arm is hectocotylized in males which are less broader than females that are more muscular and robust. The conspicuous stripes across the dorsal side of mantle, fins, head and arms are more prominent in males than in females. Peak spawning of *S. pharaonis* is reported in October/November ($Lm_{50\%}$-214mm) and in February/March ($Lm_{50\%}$-121mm) (Sasikumar 2011) along the west coast.

Maturity stages

Stages	Female	Male
Immature-Stage I	Ovary very small, occupying the posterior mantle as a whitish patch in cuttlefish. Nidamental glands appear as very fine transparent strip, small in size, accessory nidamental gland not apparent. Oviduct not visible.	Testis small and triangular. Needham's sac small with not visible vas deferens. Spermatophores absent.
Maturing/ Developing-Stage II	Ovary occupies nearly half of posterior body cavity. Individual ova visible. Ovary with uniform sized developing white oocytes. This stage is very brief. Nidamental glands larger, thicker, pearl-shaped; accessory nidamental gland small and creamy white in cuttlefish.	Needham's sac with visible vas deferens and few spermatophores. Testis larger and thicker. Hectocotylization is apparent.
Mature - Stage III	Ovary very prominent with plenty of translucent eggs in oviducts and occupies entire posterior mantle cavity. Oviduct with mature ova. Nidamental glands large, thick, white, with distant anterior pore; yellowish to orange accessory nidamental glands. Proximal oviduct with smooth transparent mature eggs, distal part of ovary with striated eggs and small eggs.	Needham's sac completely packed with plenty of well-developed spermatophores; spermatophores occur in the penis. Testis large and fully developed.
Spawning/ spent-Stage IV	Decrease in gonad volume/ degenerating eggs in oviduct/ or ova absent. Nidamental glands flaccid or diminished. Ovary with few striated loose eggs and few medium to small eggs attached to the connective tissue core of the ovary, nidamental glands flabby, accessory nidamental glands orange red.	Spermatophores in gonoduct. Needham's sac flaccid with degenerating spermatophores. Testis small.

FAD based cuttlefish catch - Mangalore

Aggregation based Cuttlefish fishery

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Cephalopods are actively sought in artisanal fisheries with highly selective gears and fishing techniques based on knowledge of their biology and behaviour (Reid *et al*., 2005). Such techniques use substrates for egg deposition or use live sexually mature females as lures for attracting males while targeting spawning cuttlefishes.

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 employed around Inland Sea in Japan, Atlantic coast in Europe and by countries around the Mediterranean Sea for cuttlefish. Most benthic trapping and potting is carried out in reefy areas, where fish and other animals are concentrated by the sheltered nature of the bottom, either for protection or for feeding purpose. Japanese fishermen have been using cuttlefish trap for *Sepia esculenta* as early as 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 Korean Peninsula.

Besides traps, bundled twigs as spawning nests for squids were also used in Japan. These traps were placed with stone sinkers for luring egg laying squids and were targeted by various types of gears including the boat seines. A simple but very efficient mid-water FAD made of rope, in combination with natural plant material/ artificial discarded material is 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 the simplest sand filled bags or stone-and-rope arrangement. Hand-jigs are operated with these traditional FADs in cuttlefish fishery. Along the southern Indian coast, artificial reefs 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 lay their eggs (Philipose, 1996). Cuttlefish and squids deposit voluminous egg-masses amidst these concrete modules. At present, the natural plant materials are increasingly replaced by plastic pet bottles and discarded synthetic fishnets in cuttlefish FADs.

As part of their life cycle cuttlefish exhibit onshore migrations to favoured breeding grounds for maturation and spawning. Coastal species of squids and cuttlefishes congregate in annual spawning congregations for facilitating one-to-one transfer of spermatophores. The availability of suitable substrate in the inshore areas and the suitability of the bottom substrate conditions for spawning 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, coelenterates etc. for attaching their eggs. This behaviour of cuttlefishes to migrate to inshore areas in search of spawning substrate for laying of eggs on submerged substratum makes them attractive targets for fishery, and they are effectively caught in FADs. FADs consisting of natural or artificial substrates 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 cuttlefishes.

The cuttlefish FADs has the advantage of being moored on these uneven sea beds, which are preferred spawning areas of cuttlefishes, where trawl nets cannot be used. The female cuttlefishes are first attracted to the FADs and are followed by the males. Immature cuttlefishes are rarely encountered near the FADs.

The biological attributes of the target species are exploited in the traditional and artisanal fishing methods for cephalopods. This tendency of mature females finding a sheltered place for spawning near FADs results in cuttlefish aggregation, which in turn increases their vulnerability to the moving jig. The universal habit of the cephalopod to attach also lures them towards moving jigs, leading to entanglement with 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 aggregation method in Karnataka

In Karnataka, cephalopods comprising of squids, cuttlefishes and octopus are predominantly exploited by trawlers and to a lesser extent by other gears. In 2004, fishing operations for cuttlefishes using fish aggregating devices (FADs) became prevalent in Karnataka waters by fishermen from southern coastal Districts of Kerala (Sasikumar *et. al.,* 2006). FADs are placed in uneven rocky areas where gillnets and trawlnets are difficult to operate. 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, migrates seasonally to north for fishing when the weather in their traditional home grounds becomes unfavorable 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 were characterised by enormous presence of fibre boats operating in the southern coast to shift northwards, temporarily during the cuttlefish fishing season. Apart from coconut spadix, locally available casuarina plants that are ideal spawning materials having firm and slender leaves and bushy branches were also introduced for FAD construction. Of late, FADs were constructed using non-biodegradable materials such as discarded fish nets and plastic bottles.

The operational area for the fishery extends off Manjeshwara in south (north Kerala) to Karwar in north (Karnataka). Prior to the commencement of actual fishing operation, few trips are made 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) to fix the areas with rocky substratum for fishing. 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 varying from 25 to 45 m.

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

FADs are positioned on the sea bottom 4-5 days prior to the commencement of fishing. The materials are transported to the site in traditional crafts. On reaching the site, which is previously marked, the modules are dropped overboard at predetermined locations. Each unit sets about 100 numbers of such FADs at

500 m interval, on rocky sea bottom, in east-west direction along the coast, so as to provide shelter and maximum protection to the shelter-seeking organisms. The modules are installed on the seabed at depth ranging from 25 to 45 m; 25-40 km away from the seashore and their positions are marked using GPS.

The cephalopods, which get aggregated near the FADs, are caught using hand jigs. They are fabricated with barbless steel hooks. Four hooks (# 9) are wound around lead-weights of 5-6 inches of length in a row, using wire-rope. Each jig is attached to a monofilament line of 3 mm diameter. Each fisherman uses one line with a single jig at a time.

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

Crew consisting of five members sets out for fishing by 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 fishermen use cotton gloves to protect their hands during the operation. The craft remain anchored throughout the jigging operation. Fishing is done at 30-35 FADs on a day so that each FAD is fished once in three days. Operation 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 consisted only of the pharaoh cuttlefish, *Sepia pharaonis*. Cuttlefishes are sorted based on their size and sold.

The crew operating the jigs is migrants and generally belongs to Kerala and Tamil Nadu. Locals involved with this activity finance the fishing unit. They provide advance for the craft. These locals are also engaged in the marketing of the catch and get back their advance with profit in the ensuing fishing season. Cuttlefishes caught by jigs are taken by the processing plants.

The FADs set using natural materials like coconut fronds are biodegradable as they decay in a very short period time. Hence, they are eco-friendly, at the same time, because of their short-life, it warrants recurring costs for the fishermen. In spite of their small size, it is observed that they act as good habitat enhancement units and help in aggregating large numbers of spawning cuttlefish. Therefore, in spite of increased catch rates with high profits in certain months, such fishing practices, targeting ripe cuttlefishes should be done with prudence.

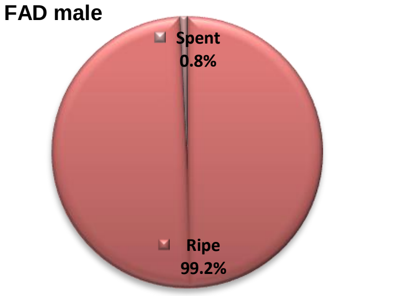
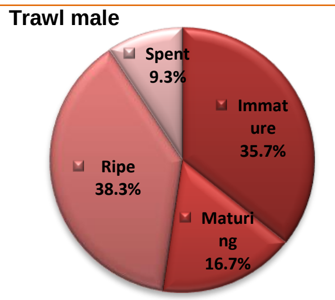
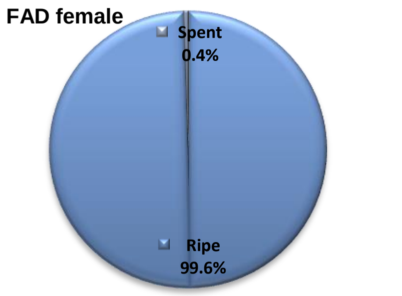
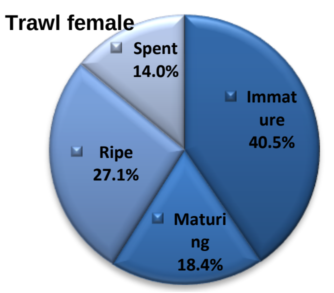
There are concerns that relate mainly to issues of resource sustainability. The use of FADs increases the vulnerability of the spawners to exploitation resulting in increased catch rates. This leads to rapid depletion of resources and hence such practices are discouraged in many countries. In this regard, there are also concerns on the number of FADs used as well as attempts to reduce the fishing effort on the FADs in some countries.

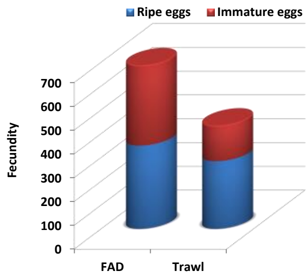
Apart from the biological threat caused by such fishing practices, social problems too have emerged in this area due to gear interaction and access to resource. The high profit rate for the fishermen engaged in this fishery, and the fact that such activity is carried out only by the migrant fisher-folk from Tamil Nadu and Kerala have resulted in discontent among the locals. Further, the FADs get entangled in the trawl nets of single- day boats which, also operate in the same area leading to conflict between trawl and jig-operators. This may even lead to the destruction of the eggs attached to the FADs. The FAD fishery was restricted in certain areas during October 2005 to April 2006 because of conflicts between local and migrant fishermen, but was later resumed from September 2006.

Comparison of FAD associated & unassociated cuttlefishes

The FAD associated hook and line fishery is a selective fishing technique for *S. pharaonis*, whereas, the trawl fishery is non-selective and the catches were composed of *S. 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 ca. 50% of the mean total production of *S. pharaonis* during 2006-2012 periods.

From 2008-09 onwards both the FAD associated fishery and the trawl fishery registered a declining trend in total production and CPUE. Clear differences existed in the abundance of cuttlefish near FADs, where, mean catch rates was initially ca.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 kg/h. Prices of cuttlefishes have been on the rise for the past ten years, although there have been ups and downs. 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.

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		
Reproductive status of Female cuttlefish		

Parameters	FAD fishery	Free schools
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
Nidamental Gland 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
Proportions of ripe to immature eggs		

Management options

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. 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. Over the years the loss in recruitment due to FAD based fishery was estimated to be ranging from 6.3 to 12.3 million in the region. In addition, introduction of torn and worn out net material, plastic pet bottles and other artificial materials as a replacement to the biodegradable material of plant origin can lead to significant environmental consequences. The ecological consequences of the abandoned net material acting as ghost nets, trapping, entangling and killing fishes and shellfishes also requires serious considerations.

The spawning stocks of cuttlefishes exhibit a strong association with the egg laying substrates available in the spawning ground. This increases the vulnerability of the spawners to FAD based fishing gears. Given the higher commercial value of the cuttlefish, it is economically short-sighted to target spawning stock for a short-term benefit. Therefore in the management context, the fabrication and deployment of all materials for cuttlefish aggregation during spawning period need to be prohibited.

Though FADs can be an effective fisheries enhancement tool, there are few negative aspects in their deployment. In the current observation, the presence of only spawning individuals in FAD assemblages indicates that the cuttlefishes are attracted towards the submerged substratum for attaching the spawned eggs. In the process, the spawning individual aggregate and therefore increases their susceptibility to exploitation. Despite the fact that, fish aggregation may be highly adaptive, imparting several advantages to group members such as decreasing the risk of predation, increasing foraging efficiency and increasing reproductive success, such methods that are targeting spawners should be discouraged considering the long-term sustainability of the resource.

References

Kurien J. 1996. Collective action for common property resource rejuvenation: the case of people's artificial reefs in Kerala State, India. Bull. *Cent. Mar. Fish. Res. Inst.* 48: 24-36.

Reid, A., Jereb, P., Roper, C.F.E., 2005. Family Sepiidae. *In* P. Jereb C.F.E. Roper, Eds. *Cephalopods of the world. An annotated and illustrated catalogue of species known to date. Volume 1. Chambered nautiluses and sepioids (Nautilidae, Sepiidae, Sepiolidae, Sepiadariidae, Idiosepiidae and Spirulidae)*. FAO Species Catalogue for Fishery Purposes 4(1). FAO Rome, pp. 57-152.

Samuel, V. D., R. R. Kumar and J. Patterson 2005. FADs and their effectiveness in cephalopod fisheries. Proceedings of the national seminar on Reef Ecosystem Remediation. J.K Patterson Edward, A. Murugan and Jamila Patterson (Eds.). SDMRI Res. Publ., 9 (2005) : 148-153.

Sasikumar, G. 2011. Mantle length and maturation in exploited stock of pharaoh cuttlefish *Sepia pharaonis* along Karnataka coast, p. 68-69. *In* A. Gopalakrishnan *et al.* (eds). Renaissance in Fisheries: Outlook and Strategies-Book of Abstracts, 9th Indian Fisheries Forum, Central Marine Fisheries Research Institute, Kochi and Asian Fisheries Society, Indian Branch, 19-23 December 2011, Chennai, India, 381 pp.

Sasikumar, G., Rohit, P., Nagaraja, D., Lingappa, Naik, R.A., 2006. Fish aggregating devices used for cephalopod fishery along the Karnataka coast. Mar. Fish. Inf. Serv., Tech. Ext. Ser. 189, 9-13.

Sasikumar, G., K.S. Mohamed and D. Nagaraja 2009. Comparison of biological characteristics of FAD-assisted and unassisted fishing methods. In: *Marine Ecosystems Challenges and Opportunities*, Book of Abstracts (Ed. E. Vivekanandan *et al*), Marine Biological Association of India, February 9-12, 2009, Cochin, p 64-65.

Thomas, J.V., Deepu A. V., Afsal V. V, A. Kuriachan and Mustafa 2010. 'Kolachil' Fishing-A destructive fishing method prevails in Kerala waters

Watanuki N and Kawamura G 1999 A Review of cuttlefish Basket Trap Fishery. South Pacific Study 19: 1-2, 31-48.

Captive behaviour of cephalopods

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Introduction

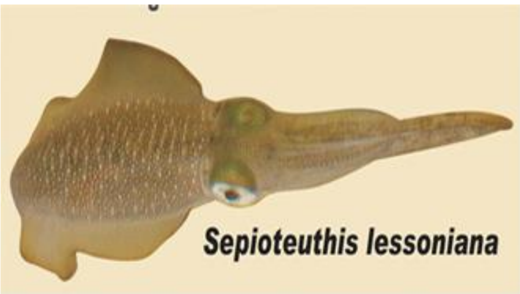
Cephalopods are the largest and most active invertebrates. India exports frozen cuttlefish and frozen squid to countries such as Japan, USA and the European Union. Cephalopods are unique because they have 85% protein by dry weight (16-21% by wet weight) and are considered a delicacy in seafood restaurants. Recent years have witnessed a significant amount of research interest in cephalopod culture and behaviour, in order to develop technology for commercial farming as well as to produce multiple laboratory generations for research in neurobiology and also to gather information for fishery management. In India, first major success in captive rearing studies of Cephalopod was achieved in 1999 with the cuttlefish *Sepiella inermis* at Tuticiorin Research Centre of CMFRI. Since then CMFRI has been working on squids, *Uroteuthis (Photololigo) duvaucelii*, *Sepioteuthis lessoniana*; cuttlefish, *Sepia pharaonis*, and octopus *Octopus dollfusi*. However, research was mainly focused on the cuttlefish *S. pharaonis* and squid, *S. lessoniana*.

Egg Collection

Normally egg mass of *S. pharaonis* is deposited in offshore waters from 15 to 35 m depth along the Vizhinjam coast. Egg deposition of this species is only rarely noticed in near shore waters. For egg collection, coconut spadix is submerged in deeper waters 15-30m. Egg deposition peaks during post monsoon months from September to January and extends till April. These egg collectors are recovered using GPS.

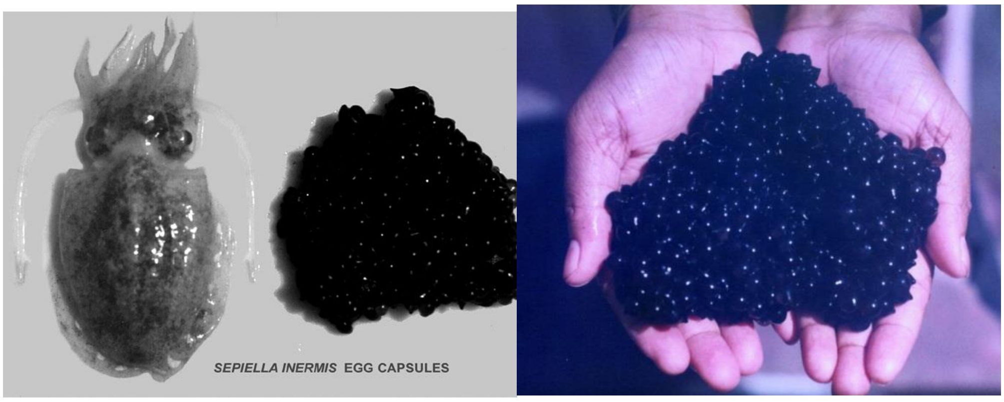
Egg mass of *S. pharaonis*

In the case of *S. lessoniana* spawning congregations are found in inshore waters also. For the collection of egg capsules different collectors such as old net, coconut spadix and nylon ropes are used from a raft or coconut spadix tied together are submerged at selected areas during the breeding season. Squids attached up to 40 clusters of egg capsules in a single spadix with each cluster consisted of 17-19 finger shaped egg capsules containing 6 to 8 embryos. Egg deposition was observed during the months from March to September with peak in August.

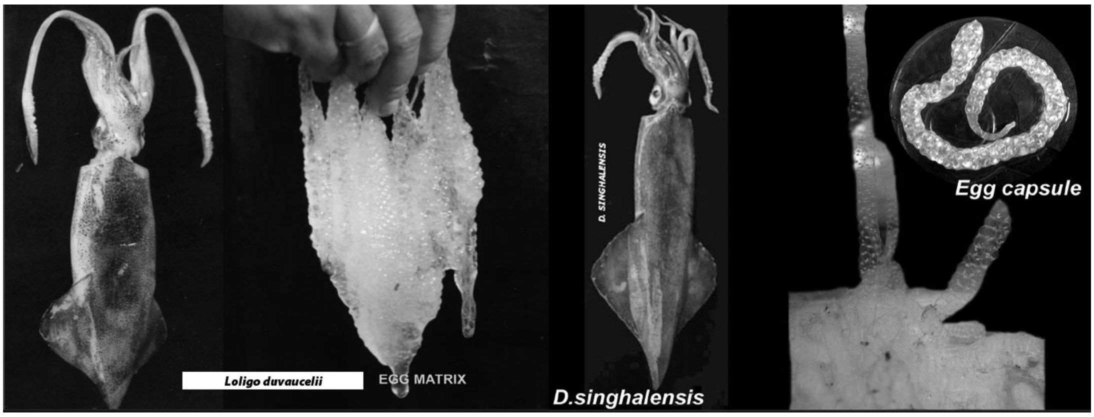


Sepioteuthis lessoniana eggs on coconut spadix

Egg mass of *S. lessoniana*

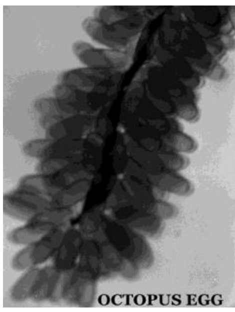


Egg mass of *S. inermis*



Egg mass of *U. (P.) duvaucelii*   Egg mass of *D. singhalensis*

Egg matrices of *U. (P.) duvaucelii* and *D. singhalensis* are found attached to the sandy sea bottom even in near shore waters and can be obtained from shore seines. Octopus keep and incubate eggs among sea bottom structures and rocky areas and guards the eggs till hatching and the incubating female usually dies after hatching due to the starvation during incubation period.



Egg mass of *O. dollfusi*

Captive behaviour of pharaoh cuttlefish (*S. pharaonis*), spineless cuttlefish (*S. inermis)* and palk bay squid *(Sepioteuthis lessoniana)*

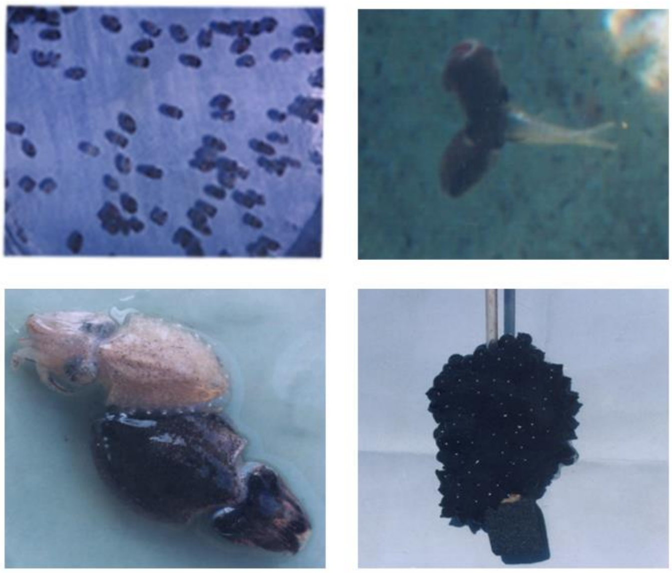
For hatching, the egg masses are placed in an incubation tank and aeration is provided through air stones. The eggs are kept suspended above the aeration point in a smooth nylon net bag of 10 mm mesh size. Development of embryo is clearly visible through the egg membrane. The fully formed embryo with arms clinging to the spherical yolk material and the ink sac of the animal are visible. They showed jerking movements inside the capsule and even released ink inside the egg capsule when mechanical shocks were given.

Food and feeding behaviour

The limitation in cephalopods rearing is that they are carnivorous and selective feeders; they require live feed with a specific size, shape and movement. Feed without these characteristics will be ignored and the cephalopods will starve to death. The degree of selectivity is higher in the early stages compared to the adults. After a stage they can be trained to accept dead fish.

They were observed not feeding on mysids during day time in the first 2 days of rearing but there was noticeable reduction in the live feed available in the rearing containers when observed in the morning. From the third day onwards they were found actively feeding on mysids by striking them with ejection of tentacles even during day time.

From the third day onwards they were found actively feeding on mysids by striking them with ejection of tentacles during day time. Other feed items such as meat suspension, brine shrimp (*Artemia salina)* nauplii and rotifer *Brachionus plicatilis* did not attract the attention of hatchlings. During second week they can be fed with mysids of all sizes and shrimp post larvae and *Artemia*. They readily accepted *Artemia* (6-10 mm size). Shrimp post larvae (*Penaeus indicus* and *Metapenaeus dobsoni*) though accepted by the squid, could not be given in any significant amount due to their non-availability in sufficient quantities. From the 4th week onwards they were fed mostly with small fishes and caridian shrimps.

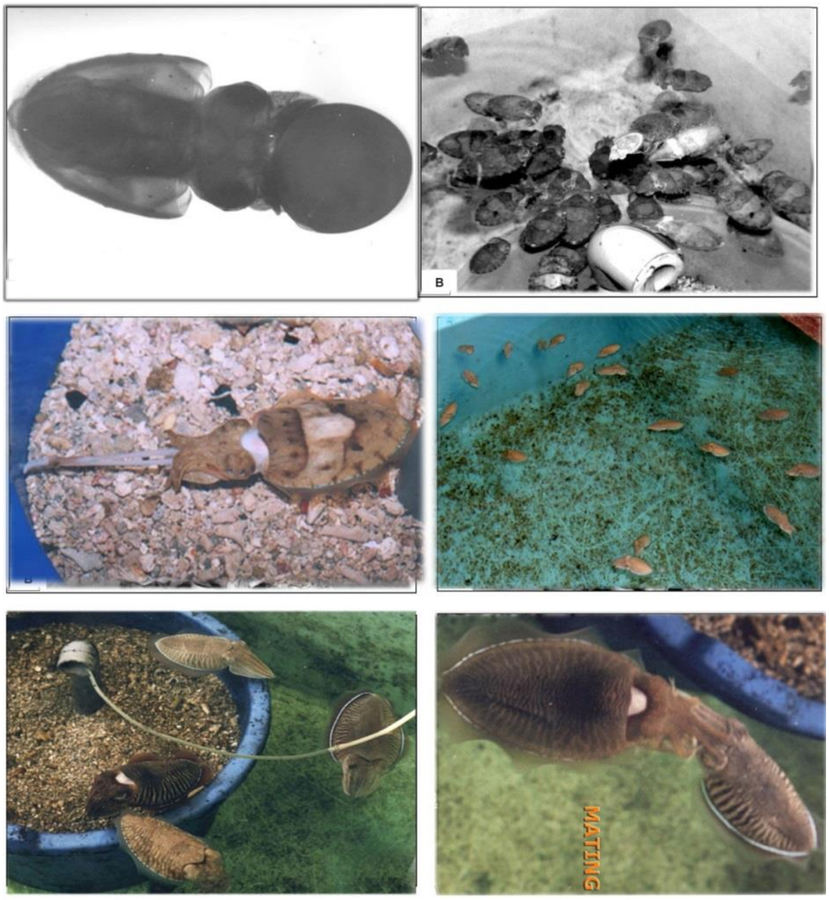


Captive development of spineless cuttlefish *Sepiella inermis*

The young squid were seen capturing animals more than its size. During feeding, even the small squid showed the three stage attack sequence of fixating the prey, positioning itself in attacking position and striking the prey with ejection of tentacles. From 8th week onwards they were slowly acquainted with dead fish (anchovies) and *Acetes* procured from locally and the quantity of live feed given was slowly reduced. Squid *S. lessoniana* acquired most of adult behaviour such as locomotion, capture of prey , ejection of ink and sudden changes of colour associated with excitement and escape bid even in the hatchling size of

5mm ML. These animals frequently changed colour from pale yellowish brown to dark brown and back. During the first two months they showed aggregation behaviour. For training the animals to feed on dead fishes, anchovies of the size 45-50 mm were taken in sticks with pointed ends and presented to the animals. Within 2-3 days most of them started taking the feed. Fish pieces were accepted even from the hand or taken from the bottom after one week training. At Karwar Research Centre of CMFRI, spineless cuttlefish *S. inermis* was successfully reared from the egg mass collected from wild. They mated under captivity and spawned on 86th day at a size of 60 mm mantle length producing 214 viable eggs. Only live food organisms, consisting of mysids, shrimp post larvae and juvenile fishes formed the diet of these animals in different stages. The initial average size of hatchling was 4mm ML (0.02g) that increased to on 110th days respectively. Average survival was 43, 37 and 28% at the end of first, second and third months.

At Vizhinjam Research Centre of CMFRI, Pharaoh cuttlefish (*S. pharaonis*) was successfully reared from egg to an average size of 168 mm mantle length (ML) and weight of 521 g in 226 days in the laboratory, using simple biological filtration systems. The period of egg incubation was 15 days at a temperature range of 27-31˚ C. Food items given were live mysids, *Artemia salina*, juveniles of fishes and prawns. Subsequently, the juveniles were slowly acquainted with food items such as dead caridian prawns and small fishes. Hatchlings were reared at a stocking density of one animal/l during the first month, and subsequently stocking density was reduced as the growth proceeded. The study shows that the pharaoh cuttlefish can be reared under captivity with a survival rate of 40% with the use of live feed limited to the initial phase of 50 days.



Sepia pharaonis: embryo, juveniles**,** feeding behavior, subadults, mating behaviour, mating

At Vizhinjam, the PalkBay squid *Sepioteuthis lessoniana* was also successfully bred under captivity.

Captive development of *S. lessoniana*

REFERENCES

Anil M.K. 2003. Laboratory rearing and breeding of spineless cuttlefish *Sepiella inermis* Orbigny (Mollusca: Cephalopoda). *J. Aqua. Trop*., 18 (1): 35-44.

Anil M.K., J. Andrews and C. Unnikrishnan, 2005. Growth, behaviour and mating of pharaoh cuttlefish Sepia *pharaonis* Ehrenberg under captivity. *Israeli Journal of Aquaculture.*

Choe S. 1966. On the eggs, rearing, habits of fry and growth of some cephalopods. *Bull*. *Mar*. *Sci*., 16 (2): 330 – 348.

Choe S. and Y. Oshima, 1963. Rearing of cuttlefishes and squids. *Nature*, Lond., 297:3-7.

Choe S. 1966. On the eggs, rearing, habits of fry and growth of some cephalopods. *Bull*. *Mar*. *Sci*., 16 (2): 330 – 348.

Cole K.S. 1972. Membranes, ions and impulses. Second edition, University of California Press, Berkeley, CA, 569 pp.

Forsythe J.W., Hanlon R.T., Lee P.G. 1987. A synopsis of cephalopod pathology in captivity. *Intern Assoc Aqua Anim Med* 1(4): 130-135.

Forsythe J.W., Hanlon R.T., Lee P.G. 1990. A formulary for treating cephalopod mollusc diseases. *In* F O Perkins& T C Cheng Ed, Pathology in Marine Science. San Diego, Academic Press: 51-63.

Hanley J.S., Shashar N., Smolowitz R., Bullis R.A., Mebane W.N., Gabr H.R. and R.T. Hanlon, 1998. Modified laboratory culture techniques for the European cuttlefish *Sepia officianalis*. *Biol. Bull*. 195: 223-225.

La Roe E.T. 1971. The culture and maintenance of the loliginid squid *Sepioteuthis sepioidea* and *Doryteuthis plei*. *Mar*. *Biol*., 9 (1): 9 –25.

Lee P.G., Turk P.E., Yang W.T. and R.T. Hanlon, 1994. Biological characteristics and biomedical applications of the squid *Sepioteuthis lessoniana* cultured through multiple generations. *Biol. Bull*. (Wood Hole, Mass.) 186: 328-341.

Messenger J.B. 1968. The visual attack of the cuttlefish, *Sepia officinalis. Anim. Behav.* 16: 342 – 357.

Messenger J.B. 1977. Prey-capture and learning in the cuttlefish, *Sepia*. *Symp*. *Zool. Soc*. *Lond.,* 38**:** 347-376.

Minton J.W., Walsh L.S., Lee P.G. and J.W. Forsythe, 2001. First multi-generation culture of the tropical cuttlefish *Sepia pharaonis* Ehreberg, 1831. *Aquaculture International,* 9: 375-392.

Nabhitabhata J. 1978a. Rearing experiment on economic cephalopod –I: Long-finned squid *Sepioteuthis lessoniana.* Technical paper 1978, Rayong Brackish water Fisheries Station, Brackish water Fisheries Divisions, Department of Fisheries. 41 pp.

Nabhitabhata J. 1978b. Rearing experiments on economic cephalopod-II: Cuttlefish *Sepia pharaonis* Ehrenberg. Technical paper 1978, *Ibid*. 62 pp.

Nabhitabhata J., Pitak P. and K. Somnuk, 1984. Culture, growth and behaviour of spineless cuttlefish *Sepiella inermis* Fer. & d'Orb. Technical paper 5/1984, *Ibid*. 48 pp.

Nabhitabbata J. 1994. The culture of cephalopods. *Fishing chimes*, September, 1994, 12 – 16.

Nabhitabhata J. and P. Nilaphat, 1999. Life cycle of cultured pharaoh cuttlefish *Sepia pharaonis* Ehrenberg, 1831. Phuket Marine Biological center special Publication, 19: 25-40.

Nair K.P., Thomas P.A., Gopakumar G., Vincent S.G. and T.A. Omana, (1986). Some observations on the hatching and post-hatching behaviour of the cuttlefish *Sepia pharaonis* Ehreberg. In: (E.G.Silas Ed.) Cephalopod Bionomics, Fisheries and Resource of the Exclusive Economic Zone of India., *Bull*. *Cent*. *Mar. Fish*. *Res. Inst*., 37: 157 – 159.

Rosenberg P. 1973 The giant axon of the squid; a useful preparation for neurochemical and pharmacological studies. In: (R. Fried (Ed.), Methods of Neurochemistry, Vol.4, 97 – 160, Mercel Dekker, Inc., New York, NY.

Silas E.G., Sarvesan R., Nair K.P., Sastri Y.A., Sreenivasan P.V., Meiyappan M.M., Vidyasagar K., Rao K.S. and B.N. Rao, 1986. Some aspects of the biology of cuttlefishes. In: (E.G.Silas Ed.) Cephalopod Bionomics, Fisheries and Resource of the Exclusive Economic Zone of India., *Bull*. *Cent*. *Mar. Fish*. *Res. Inst*., **37:** 49 – 70.

Sivalingam D. 1999. Successful breeding and hatchery experiments of the spineless cuttlefish *Sepiella inermis* at Tuticorin shellfish hatchery. *Mar*. *Fish. Infor. Serv.* T&E Ser., No.161: 11 – 13.

Sivalingam D. and S.K. Pillai, 1983. Preliminary experiments on breeding of Cephalopods. *Proc. Symp*. *Coastal Aquaculture,* Part 2, *Mar. Biol. Assn. India*: 633 – 635.

Sivalingam D. and S.K. Pillai, 1983. Preliminary experiments on breeding of Cephalopods. *Proc. Symp*. *Coastal Aquaculture,* Part 2, *Mar. Biol. Assn. India*: 633 – 635.

Fish aggregating devices (FADs)

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Fish aggregating devices, more commonly called FADs, are anchored or drifting objects that are placed in the ocean to attract fish. They may be a permanent, semi-permanent or temporary structure or device made from any material and used to lure fish. They have been used for thousands of years in various forms. The earliest surface/ midwater FADs were elements from nature such as driftwood and trees. Fishermen from Indonesia and Philippines began building floating rafts of bamboo and other materials to attract fish as early as 1900. Now surface and midwater artificial FADs are systematically used in a large number of countries. Present practices vary considerably, sometimes involving advanced technology.

Traditional FADs, based on long-term fishing experience, are made on-the-spot with local materials and used in shallow coastal waters (depth 50-200 m) by small-scale fishers to catch small pelagic fish and bait, e.g. payaos (Philippines), unjang (Malaysia), rumpon (Indonesia). Modern FADs, the result of imported technology and materials, can be anchored to over 3000 m.

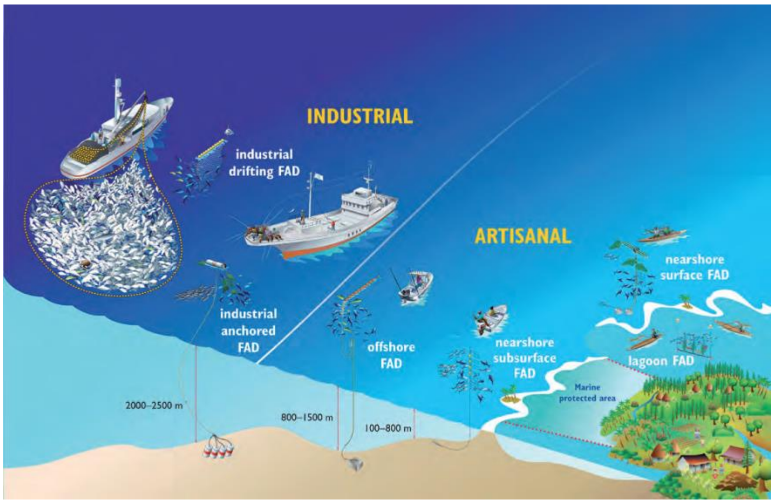
Drifting FADs are not tethered to the bottom and can be natural objects such as logs or man-made. Certain models have large surface dimensions. Moored FADs occupy a fixed location and attach to the sea bottom using a weight such as a concrete block. A rope made of floating synthetics such as polypropylene attaches to the mooring and in turn attaches to a buoy. The buoy can float at the surface (lasting 3–4 years) or lie subsurface (mid water FAD) to avoid detection and surface hazards such as weather and ship traffic. The midwater FADs – where the only surface component is a small marker buoy is less subject to stress from wind and waves and the risk of damage by ships. Subsurface FADs last longer (5–6 years) due to less wear and tear, but can be harder to locate. In some cases the upper section of rope is made from heavier-than-water metal chain so that if the buoy detaches from the rope, the rope sinks and there by avoids damage to passing ships that no longer use the buoy to avoid getting tangled in the rope. *Smart* FADs include sonar and GPS capabilities so that the operator can remotely contact it through satellite to determine the population under the FAD.

FADs can be used in either a single or multiple arrangements. Common practice is to use more than one with enough distance between each. The most suitable distance between each FAD depends on the abundance and type of species targeted; ranging between several hundred and one thousand metres for small pelagic fish in coastal or shallow waters; or 5 to 10 nautical miles for deep-water tuna FADs.

FADs aggregate different fish at different depths. Fish also aggregate under drifting logs and even whales, and rules on fishing around FADs often apply to all objects drifting on or near the sea surface, which attract fish. Various types of FADs in different areas, after a short period, attract and aggregate fish around the structure, irrespective of its design. Fish are fascinated with floating objects. They aggregate in considerable numbers around objects such as drifting flotsam, rafts, jellyfish and floating seaweed. The objects appear to provide a "visual stimulus in an optical void", and offer some protection for juvenile fish from predators. The gathering of juvenile fish, in turn, attracts larger predator fish.

Some FADs are permanent structures while others are moveable. The former are set mainly in deep waters and relocation is virtually impossible. Present experience shows that the expected life of a permanent FAD would be 2 to 3 years. The mobile, lighter structures can be moved to attract fish to a particular point. Still others can be removed from the water during certain seasons when the fish are not in the area or when the weather is rough, e.g. monsoon.

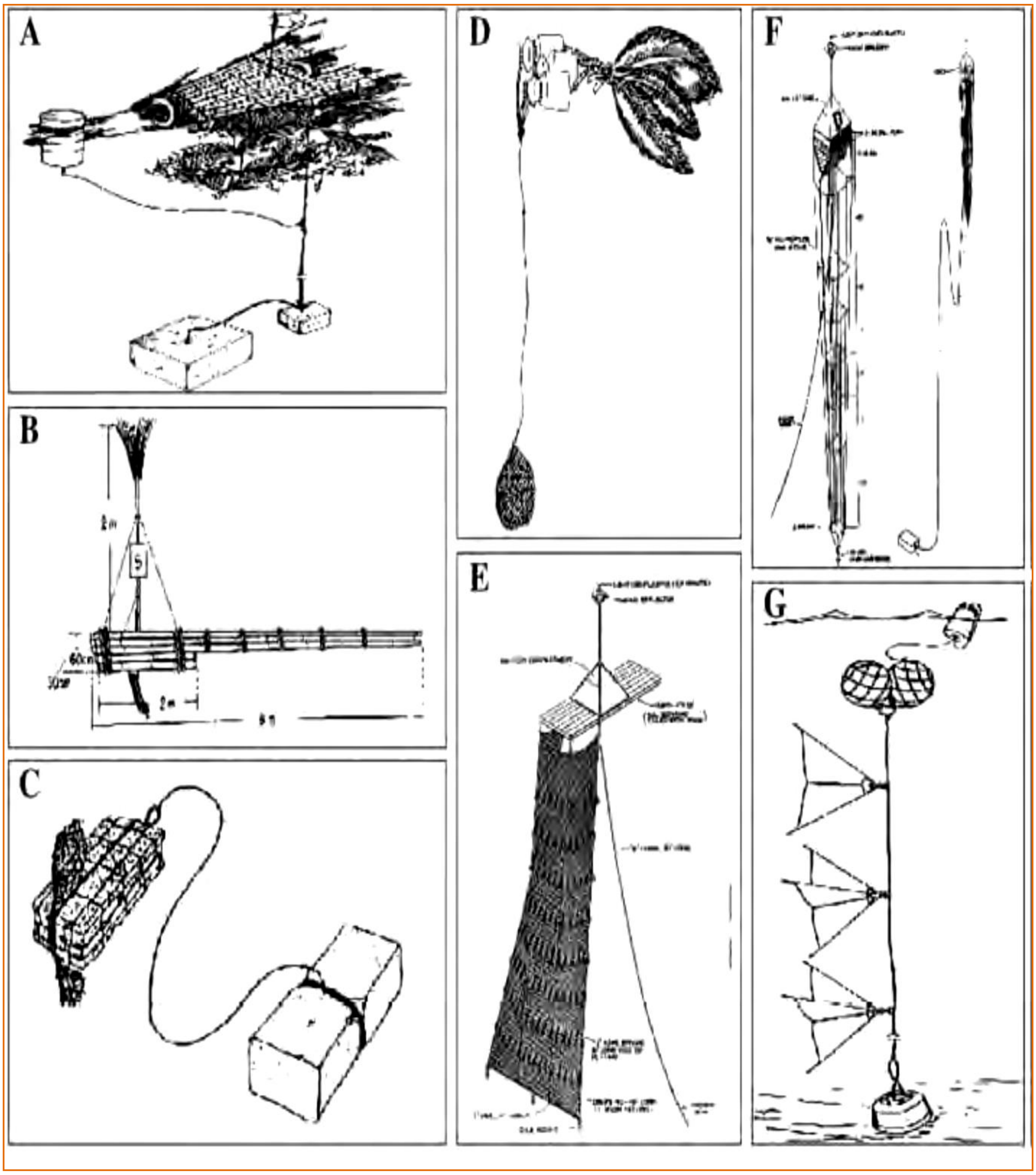
Two major categories of FAD's may be classified into two - Artisanal and Industrial types. Simple or advanced FADs are left drifting in deep waters to help offshore, artisanal and industrial fleets catch big pelagic fish, mainly tuna. Hundreds of simple, traditional types of drifting FADs are used by each large, modern tuna purse seiner operating in certain areas. Before FADs, the commercial purse seiners used to target surface-visible aggregations of birds and dolphins, which were a reliable signal of the presence of tuna schools below. The demand for dolphin-safe tuna was a driving force for FADs. The artisanal FADs are smaller and used by subsistence, artisanal and recreational fishers. These are mostly anchored offshore or near-shore and in lagoon and maybe surface or subsurface. The Industrial FADs are huge structures and may be drifting or anchored. The fishers use purse seine, long line or pole & line type of fishing and cater to fishing companies in support of industrial scale vessels.



Industrial FADs improve the catch rate of purse seine and pole & line vessels that target large schools of tuna. These are commonly drifting rafts, with an electronic beacon so the fishing boat can find the FAD and sometimes sonar equipment that shows the amount of fish under it. Anchored buoys are also used. FADs play an important economic role for industrial fishing fleets and their use has increased greatly in recent years. Most fishing is by purse seine is non-selective and catches all the fish around the FAD. Fish tend to move around FADs in varying orbits, rather than remaining stationary below the buoys. They mostly target tuna schools. Shoals of juvenile bigeye tuna and yellowfin tuna aggregated closest to the devices, 10 to 50m. Further out, 50 to 150m, was a less dense group of larger yellowfin and albacore tuna. Yet further out, to 500m, was a dispersed group of various large adult tuna. The distribution and density of these groups was variable and overlapped. The FADs are also used by other fish, and generally the aggregations disperse when it was dark.

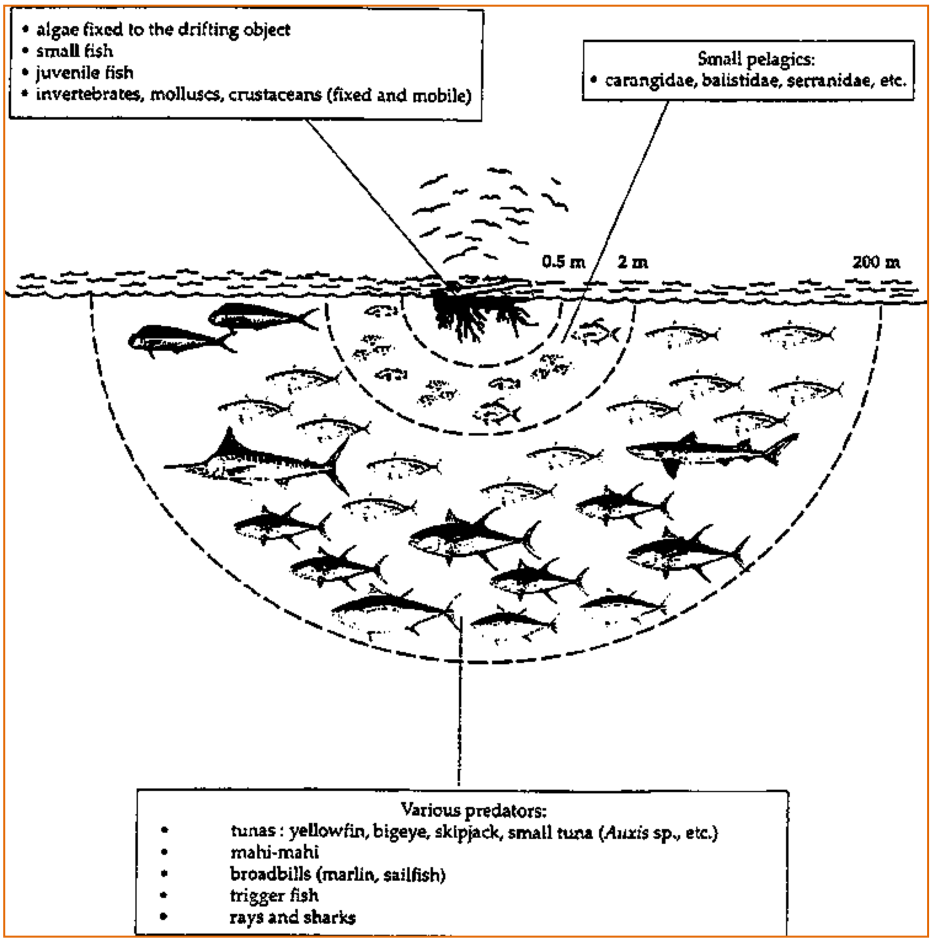
FAD type	Advantages	Disadvantages
Artisanal	• Food security • Vessel efficiency • Coastal resource management • Climate change adaptation • Tourism • Safety at Sea	• Short lifespan • User Conflicts • Budget constraints
Industrial	• Food security • Efficiency • Domestic development • Distribution of effort and license revenue	• Increased catch of big eye tuna though not targeted • Catch of small sized tunas • By-catch (mostly silky sharks and turtles)

The deployment and proliferation of FADs in an extensive way has influenced harvesting practices and become the concern of fisheries managers. The use of FADs by purse seine vessels has come under increased criticism for its impact on tuna stocks and its potential threats to biodiversity, specifically the by-catch of sharks and other marine life. Tropical tuna show a natural behavioural tendency to aggregate around floating objects and the fishermen exploit this behavior using FAD. Technological advances in FAD design have increased fishing efficiency and FADs have contributed to increasing tuna catches especially skipjack and yellowfin tuna.



Diagrams of types of fish aggregating devices used in different parts of the world: **A**. Raft called “payao” used by tuna fishermen off certain islands of the Philippines (by de Sylva, 1982). **B**. Bamboo raft called “tsukegi” used in Japan to fish dolphin fish (by Kojima, 1956). **C**. Fish aggregating device called “capcer” used off the Balearic Islands (the East Mediterranean Sea) (by Massut´ı & Reñones, 1994). **D**. “Cannizzi” made with plastic bottles and palm leaves used by fishermen of Sicily (Italy) (by Potoschi, 1996). **E**. and **F**. Anchored fish aggregating devices used in Hawaiian waters. Raft made of wooden planks filled with polyurethane foam and a nylon net drape hanging from its rear (**E**), and a FAD made with gallon steel oil drums filled with polyurethane foam in a frame of iron and a drape made of polypropylene (**F**). Both FADs have a radar reflector and a navigational warning light (by Matsumoto et al.,1981). Manufactured FAD McIntosh Sea-kites fishing system (by McIntosh Marine, Inc. 621 Idlewyld Drive, Fl, USA).

Studies on FAD fishing showed that the vulnerability to FAD fishing varies with species size and age and FAD contribute sustainability to overfishing risks and as suggested earlier the FAD fishing takes significant levels by by-catch. On the positive side, FADs may trap tunas in unproductive regions. Management of FAD associated fishing is becoming a concern for policy makers. Time-area closures are the predominant method used to limit impacts of fishing on FAD fisheries has been suggested but the effectiveness of time – area closures is uncertain. Management of FAD-based fisheries will need to be assessed on a regional basis. Further, the degree of local impact is uncertain due to uncertainties over stock structure. In general, FADs are not inherently bad; however, these floating objects require additional attention from the scientific and fishing communities. If used correctly, FADs can reduce fuel costs and carbon footprints without jeopardizing the ecosystem or the survival of the target species. And, like all fishing methods, FADs need to be monitored and managed.



Migrant labourers in the Primary Sector of Marine Fisheries: A Case study in Karnataka

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Migration is perceived as a way of life, a coping mechanism often providing a means of alternate livelihood to the human population ever since the dawn of civilisation. Migration is a worldwide phenomenon and perceived as the movement of people/ animals/ birds and insects from less endowed areas to greener pastures in search of better income, food, work or even more suitable socio-economic/geographic milieu. One of the popular forms of migration namely the economic migration has resulted from unequal development trajectories (McDowell and De Haan, 1997; Kothari, 2002). This supposedly led to one-way population movements from less endowed areas to well-endowed prosperous areas through the 'push' created by poverty and a lack of work and the 'pull' created by better wages in the destination (Lee, 1966). Theories of urban expansion were in agreement with this analysis of migration. Ideas of seasonal and circular labour migration were first articulated in the 1970s (Nelson, 1976; Rao, 1994) and defined as 'characteristically short term, repetitive or cyclical in nature, and adjusted to the annual agricultural cycle'. Migration occurs at a variety of scales. Intercontinental (between continents), intracontinental (between countries on a given continent), and inter regional (within countries). One of the most significant migration patterns has been rural to urban migration, the movement of people from the countryside to cities in search of opportunities. Migratory behaviour is of two types, outward migration and inward migration. Outward migration is defined as the movement of labourers outside their revenue villages to seek employment opportunities available elsewhere and inward migration is the movement of labourers in to the native villages from any other place, in search of any feasible work according to their capacity/ potential (Lekshmi *et.al,* 2011). The Indian Marine Fisheries Sector is no exception to this. This sector has been witnessing a steady inflow of migrants from less endowed regions to areas of more prosperity and greenery than the native lands. From the status of a subsistence economy using artisanal gears during the pre-independence era, it has attained a colossal status due to its gradual metamorphosis in to an industrial economy by virtue of the rapid technological innovations, changing consumption pattern and emerging market forces.

In India, Coastal Karnataka has been a witness to the steady influx of migrant labourers from two specific districts of Tamil Nadu namely Villupuram and Ramanathapuram. Villupuram district has primarily an agrarian economy with only 19 fishing villages (coastal length of 30 Km) and is having the second least number of fisher folk population (18,124) among the coastal districts of Tamil Nadu. 99.91% of these fisher families are BPL (Below Poverty line) families (Marine Fisheries Census, 2010, Tamil Nadu). Uneven rainfall, fragmented land holdings, heavy downpour in coastal areas than interior areas and occurrence of seasonal rivers are some of the drawbacks of this district. Poor wages of agricultural labourers, frequent droughts leading to crop failure and consequently leading to unemployment have compelled them to migrate to other places outside their native soil in search of better prospects. This case of outward migration wherein, the agricultural labourers from Villupuram district and both agricultural and fishermen from Ramanathapuram district of Tamil Nadu who have migrated to DK in search of employment in the fisheries sector of Karnataka was documented for the present study. The pattern of migration of agricultural labourers from Villupuram to DK can be termed as inter-sectoral migration (*ie* from agrarian to fisheries) and from fisheries sector of Ramanathapuram to DK district can be termed as intra-sectoral migration (within the sector). However, a small percentage of inter-sectoral migration was observed in Ramanthapuram district since this district had a predominantly coastal economy with very few villages having farming. Inter-sectoral migration has probably many a rationale attributed, as is evinced by the following research studies.

(Deshingkar *et.al* 2008) observed that, in India, the growth in non-agricultural wages was higher than that of agricultural wages. The studies conducted by Tietze et al (2000) reveal that, contrary to the popular belief that fisher folk are the poorest group of the rural population in coastal areas, in five out of the six countries studied namely, India, Tanzania, Senegal, Bangladesh, Malaysia and the Philippines in spite of declining catches, the average annual household income of fisher folk households is significantly higher than that of households in neighbouring agricultural villages. The savings rate and the amounts saved were generally higher in fishing villages than in neighbouring agricultural villages. In most of the countries studied, finally, households in agricultural villages were as indebted as or more indebted than households in fishing villages. Overtime, the most frequently heard explanation for migration has been the so called “push-pull theory”, which depicts that some people move because they are pushed out of their former location, whereas others move because they have been pulled or attracted to some place elsewhere. This concept was first given by Revenstoein in 1989 (cited by Rafique, 2003). According to him the living conditions are “push factors” and attractions of better living conditions are “pull factors”. The migration from farming to fisheries sector causes labour displacement in the agrarian sector and on the other, it leads to labour gain in the fisheries sector. This steady inflow of migrants has taken place not only in the primary sector (sector that consists of the active fisher folk) but also in the secondary sector (harbour workers and processing sector). Improvements in technologies in the fisheries sector has led to unbridled capital investment in this sector and has attracted more and more people from the adjacent coastal transects who necessarily do not belong to the fishing community (Sathiadhas et al., 2009).

Ramanathapuram district has a coastal length of 260 Km and has the largest number of fishing villages (178) and largest number of fishermen families (41,048) among the coastal districts of Tamil Nadu. (Figure 5) This district incidentally has one of the largest number of families (33,429 families) under BPL (Marine Fisheries Census, 2010, Tamil Nadu). Ramanathapuram is predominantly a coastal district and its main economy is based on its rich and diverse coastal resources. Inboard “*Vallams*” (Herleser-14hp, 22hp, 24hp, 26hp, 28hp-double cylinder, 20-32 feet length and travelling 40-45 nautical miles) form 54.73% of the mechanised crafts in the district. There are 950 multi-day trawlers in DK district. With an average crew of eight per multi-day trawler, there are a total of 7,600 multi-day trawl labourers in this district. Out of this 70% of labourers are from Tamil Nadu, 20% from Andhra Pradesh and the rest 10% are from Karnataka. Hence it can be deduced that there are approximately 5,320 multi-day trawl labourers who have migrated from Tamil Nadu. Since the major chunk of the migrants were from Tamil Nadu this study was aimed to identify the factors for migration and the push and pull factors for migration in the primary sector. The migration from farming to fisheries sector causes labour displacement in the agrarian sector and on the other, it leads to labour gain in the fisheries sector.

Map of the study area

Methodology:

The migrants in the primary sector of the marine fisheries of DK were found to come from two important districts of Tamil Nadu namely Villupuram and Ramanathapuram. 50 migrants each from Villupuram and Ramanathapuram working in the Multi-day trawlers of Mangalore Fisheries Harbour were randomly selected to form a total sample size of 100 respondents for the study. A well-structured interview schedule was constructed keeping in view the diaspora of the migrants in mind namely those respondents from Villupuram where the main occupation was agriculture and the latter Ramanathapuram district, where the main occupation was fishing. Data was collected using freewheeling interviews and focus group discussions. Apart from 50 sample respondents from each category, 5 Key informants (KI) representing the local leaders of each district were interviewed to form a total of 10 key informants. The key informants were asked to enumerate the factors responsible for migration. They were further asked to name 50 migrants each from Villupuram and Ramanthapuram districts. The farmers identified through the KI of the respective districts of Villupuram and Ramanthapuram were also asked to list out the factors which had caused them to migrate from their native locations. Besides the Push factors and Pull factors in migration pertaining to these two districts were studied. The data collected was tabulated and analysed. The number of respondents who attributed a particular factor for migration was found out. The factors for migration were ranked using the Rank Based Quotient (RBQ) (Sabarathnam, 2002) This was calculated using the formula:

$$R.B.Q = \frac{\sum_{i=1}^{n} (Fi)\,(n+1)\,-i)}{(N_{*}n)} \times 100$$

Wherein Fi = Number of Key informants/ fishermen for the i^{th} rank of the factor for migration, i= i^{th} rank, N=Total no. of Key informants/ Fisherfolk and $n_{=}$no. of ranks/ factors.

Computation of the Spearman's Rank Correlation Coefficient (R)

In order to know the degree off association between the key informants and the fishermen in attributing the main factors for migration, the Spearman's rank correlation was worked out using the formula

$$R= \frac{1- 6\sum di^2}{n^3-n}$$

Where R is the Spearman's Rank Correlation Coefficient, n is the total number of factors for migration di^2 is the difference in the ranks between the Key informants and the fishermen for a particular factor (i). A significant value of R is indicative of a high degree of association for the factors for migration attributed by the key informants and the fishermen.

Results:

Preferential ranking technique was used for the present study in order to identify the factors for migration by the key informants as well as fishermen belonging to the respective districts from where they had migrated. Four main factors of migration were identified namely lack of employment, less wages in the agricultural sector, drought incidence and lack of own land for cultivation. Thus the reliability of the data was established.

The ranking for these factors were given by the key informants and the fishermen, which are presented in Table 1 and Table 2 respectively. A perusal of these tables revealed that the calculated R.B.Q values ranged from 45 to 90 in the case of key informants and 51 to 96 in the case of migrants for Villupuram district. In both cases of key informants and fishermen the highest value of R.B.Q corresponded to the factor namely, lack of employment in their native district. The Spearman's rank correlation was worked out to find out the degree of association between key informants and the fishermen in identifying the key factors for migration (Table 3). The rank correlation value worked out to be 0.80 which was highly significant. In order to arrive at a single value of R.B.Q and preferential ranking, the mean R.B.Q Values were worked out and based on this preferential ranking for the factors was done. (Table 4) Accordingly, lack of employment followed by drought incidence, less wages in the agricultural sector and lack of own land for cultivation were ranked as first, second, third and fourth most important factors for migration. Villupuram has primarily an agrarian economy. The major crops grown in the district are paddy, maize, pearl millet, groundnut, cotton, gingerly, and sugarcane. For most part of the year, the district is ravaged by droughts and failing monsoons. This has led to displacement of thousands of agricultural labourers who depend on farming for a living. This has led to the migration of a substantial section of these labourers to neighbouring States like Karnataka in search of employment. Fewer wages in the agricultural sector was ranked as the third important factor for migration. The wages for men agricultural labourers was found to be Rs. 300/day and for women it was Rs. 100/day for 8 hours of work in a day. The agricultural season in Villupuram district is supposed to last only roughly around 250 days and unskilled workers have no alternative source of income in the remaining parts of the year. (Jacob, 2008) Lack of own land for initiating cultivation was ranked as the fourth important factor for migration.

Table 1: Ranking of factors for migration by key informants Villupuram District

Factors for migration (n=5)	Rank (I)	Rank (II)	Rank (III)	Rank (IV)	Rank Based Quotient (R.B.Q)
Lack of employment	3	2	-	-	90
Less wages in the agricultural sector	2	2	1	-	70
Drought incidence	2	3	-	-	75
Lack of own land for cultivation	-	-	4	1	45

Table 2: Ranking of factors for migration by Fishermen, Villupuram district

Factors for migration (n=50)	Rank (I)	Rank (II)	Rank (III)	Rank (IV)	Rank Based Quotient (R.B.Q)
Lack of employment	45	3	1	1	96
Less wages in the agricultural sector	2	44	2	2	51
Drought incidence	44	3	3	0	95
Lack of own land for cultivation	10	8	7	25	51.5

Table 3: Computation of Spearman's Rank Correlation Co-efficient

Sl.No	Factors for migration	RBQ values (KI)	Rank	RBQ values (Fishermen)	Rank	d	di^2
1.	Lack of employment	90	1	96	1	0	0
2.	Less wages in the agricultural sector	70	3	51	4	-1	1
3.	Drought incidence	75	2	95	2	0	0
4.	Lack of own land for cultivation	45	4	51.5	3	1	1
R=0.80							∑ 2

Table 4: Preferential Ranking based on mean value of R.B.Q

Sl.No	Factors for migration	RBQ values (KI)	RBQ values (Fishermen)	Mean R.B.Q	Preferential Ranking
1.	Lack of employment	90	96	93	I
2.	Less wages in the agricultural sector	70	51	60.5	III
3.	Drought incidence	75	95	85	II
4.	Lack of own land for cultivation	45	51.50	48.25	IV

The push and pull factors for migration are depicted in Fig.1 and Fig. 2. It could be observed that the push factors for migration were the same as the main factors for migration. Under pull factors, it could be observed that, sustained income from fisheries sector, higher wages in fisheries sector, ability to maintain families and ability to save for the families scored high among the migrants from Villupuram district.

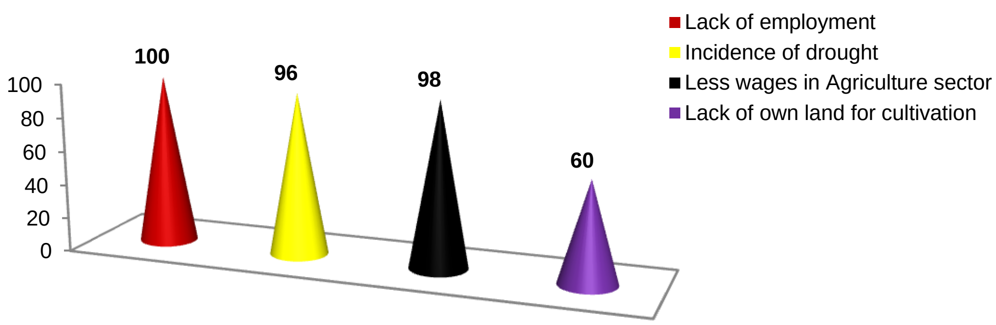

Fig 1. Push factors for migration (%) Villupuram district (n=50)

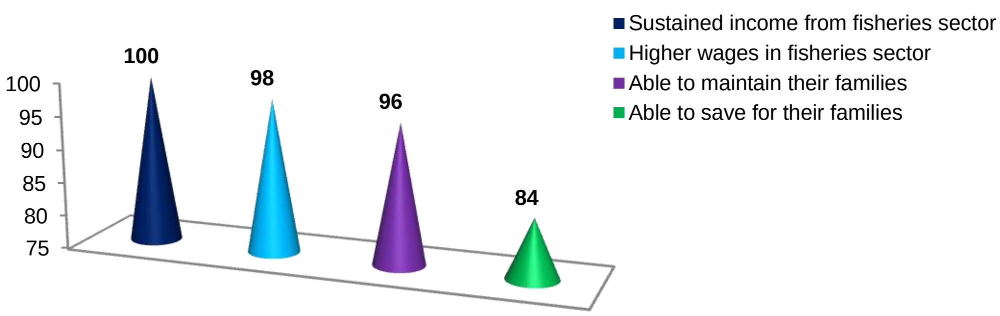

Fig 2. Pull factors for migration (%) Villupuram district (n=50)

The major factors for migration (Ramanthapuram district) as enumerated and ranked by the key informants and fishermen are presented in Table 5 and Table 6. A high degree of association between the key informants and fishermen with respect to ranking of the factors for migration was observed as indicated by the spearman’s rank correlation coefficient value of 0.85 (Table 7)

The mean value of R.B.Q was worked out and the results presented in Table 8 revealed that, lack of employment was ranked as the foremost important factor for migration (Rank I) followed by relatively large family size of the migrants from Ramanathapuram (Rank II). Less income from the primary sector of marine fisheries in Ramanathapuram district was ranked as third in order. Fewer wages in the agricultural sector of Ramanthapuram was ranked as fourth in order of importance. This district is predominantly a coastal district with agriculture being practiced in very few tracts. Agricultural production in these areas is very poor due to irregular rainfall distribution which in turn affected the cropping pattern, income, employment and standard of living of people. In this district, paddy is the main food crop cultivated in more than 63% of the net area sown. Here paddy is raised as a rainfed crop. Apart from this, coconut is the other main crop cultivated. Most of the cultivable lands are kept fallow due to scarcity of inputs and scanty rainfall and majority of the population were living under poverty condition. Majority of the farmers raised crops under rain fed condition, which resulted in economic loss and financial risks to farmers (Nandhini, *et.al*, 2006).

Results of primary data analysis revealed that, in this district, men agricultural labourers are paid Rs. 150-200/day and for women the wages were very less to the tune of Rs. 50-80/day. The push factors for migration are depicted in Fig. 3. All the respondents perceived less employment opportunities in their native district to be the major push factor. A problem caused by crossing the Indo-Srilankan maritime boundary was perceived by 98% of the migrants as yet another major push factor.

A perusal in to the geographical location of this region throws more light on this particular push factor for migration. The Palk Bay separates the coastal regions of Nagapattinam, Thanjavur, Pudukottai and Ramanathapuram from Jaffna and Mannar districts of Srilanka. The rich fishing grounds especially on the Sri Lankan side of the maritime boundary line became a bone of contention between Tamil Nadu fishermen and the Srilankan navy. Tamil Nadu fishermen were intimidated and harassed, their catch was dumped in to sea, some were detained and others fired at. (Suryanarayan, 2005) The Palk Strait is just 22 miles of water and separates the northern coast of Sri Lanka from the South east Coast of India. The International boundary line is close to the shores of both countries. The boundary line is only 6.9 nautical miles from Dhanushkodi and 11.5 nautical miles from Rameswaram.

The maritime agreements between India and Srilanka signed in 1976 which does not permit fishermen from India and Sri Lanka to fish outside their respective maritime boundaries have adversely affected the livelihoods of thousands of Indian fishermen especially from Ramanathapuram district. The Sri Lankan side of the maritime boundary is attractive to the Indian fishermen due to the easy availability and abundant supply of prawns. The ban on fishing imposed by the Srilankan Government has further enriched the marine resources on the Srilankan side. The Rameswaram fishermen say that the prawns in the Sri Lankan waters across the maritime boundaries exert a magnetic pull on them (Suryanarayan, 2005). All these attractions of marine resources lure the Indian fishermen to the Srilankan boundaries and these further results in Indian fishermen being caught by the Sri Lankan coast guard following which they are jailed or shot at. The migrant labourers from Ramanathapuram district quote this as one of the main push factors for migration. The migrants further say that fishery resources have become less in the inshore waters and for getting a good catch they have to fish beyond the Indo-Sri Lankan maritime boundary which itself poses a huge risk. Single Day trawlers are in operation in Ramanathapuram district and there is no multi-day trawl fishing here. The average monthly wages of a single day trawl fishermen in this district amounted to Rs.1191.50. On the other hand the average monthly wages of these migrants employed in a single day trawler and multi-day trawler were Rs.2500 and Rs.9500 respectively, in DK district of Karnataka (Fig. 8). The average monthly earnings from a inboard mechanised "*Vallam"* (the dominant craft in Ramanathapuram district (Fig. 6) was Rs. 702). High levels of unschooled population and fewer wages in the agricultural sector were perceived as the push factors by 98% of the respondents.

It is interesting to observe from figure 7 that among the coastal districts of Tamil Nadu, Ramanathapuram district has the highest number of unschooled population. A virtual lack of formal education leaves these people with very few choices other than migration in search of better prospects. The pull factors for migration (figure 4) as perceived by 98% of migrants were, more employment opportunities and higher wages in the fisheries sector of DK district. Higher wages in the fisheries sector, followed by ability to maintain their families in native districts and ability to save for their families were other pull factors enumerated by 97, 96 and 92% of the migrants respectively. During the 45 days mechanised ban period in Karnataka *ie* from June 15th to August 3rd, they go back to their native districts where they undertake works in carpentry, masonry and farming. Once the ban period is over in Karnataka they return back in the month of August, to work in the boats.

Recommendations

From the forgoing study, it was deduced that there are approximately 5,320 multi-day trawl labourers (primary sector) in DK district who have migrated from Tamil Nadu. The contribution of the migrants to the marine economy of Karnataka is commendable. However, the living conditions of these migrants are deplorable. Almost all the migrants in the primary sector of multi-day trawl fisheries of DK in particular, work on board the fishing vessel, leaving their families in the native districts. They do not have either temporary/permanent shelters/houses in the place of work. They work, rest, eat and sleep on-board the fishing vessels. Only the Tamil migrants who work in the secondary sector (harbour work) have temporary shelters since they bring their families along with them. In such instances, the family labour is utilised in the secondary sector.

The problems encountered by the migrants are numerous and are often not effectively addressed by the government and policy makers. They do not have ration cards or identity cards at the place of work, suffer from lack of hygienic working conditions, long working hours, lack of insurance facilities in instances of physical injuries endured during work, inadequate wage structure and are not eligible for benefits of welfare programmes of the State Fisheries Department.

Social safety nets such as targeted poverty alleviation programmes for migrants, issue of temporary identity cards at place of work, provision of insurance policies and ensuring remunerative wage policy for migrant labourers will give an integrated, multidimensional and holistic approach to enhance their livelihoods and mitigate the negative effects of distress migration.

1. Better monitoring of the movement of migrants is warranted, since it forms a pre-requisite for understanding the issues faced by migrants.

2. The Marine Fisheries Census should undertake documentation of the extent of inward and outward migration taking place in the respective States. Questions on the origin of the migrants, their mobility patterns, period of stay, occupational experience as migrants in a particular State/District, and future migratory plans need to be collected.

3. The invisibility of fishers' mobility in policy decisions reflects that institutions developed to deal with coastal management at the community level may not have sufficient support from legal and policy documents, and may not be developed or equipped to handle the possible conflicts and difficult trade-offs that need to be addressed as a result of fishers' mobility. This happens in the light of migrant fishers from one State illegally encroaching upon the resources or territorial limits of another State.

4. Migration must be perceived in the context of socio-economic and ecological dynamics occurring in sending and receiving communities. The management of migratory flows therefore must target both origin and destination of migrants and should be linked to broader policies about poverty reduction.

5. Any policy decision needs to consider the trade-offs between both benefits and negative effects as perceived by members of communities hosting migrant fishers.

Table 5. Ranking of factors for migration by key informants, Ramanathapuram District

Sl.No (n=5)	Rank (I)	Rank (II)	Rank (III)	Rank (IV)	Rank Based Quotient (R.B.Q)
Lack of employment	4	1	-	-	95
Less income from primary sector of marine fisheries	3	2	-	-	90
Less wages in the agricultural sector	-	2	3	-	60
Relatively large family size	4	-	1	-	90

Table 6. Ranking of factors for migration by Fishermen Ramanathapuram District

Sl.No (n=50)	Rank (I)	Rank (II)	Rank (III)	Rank (IV)	Rank Based Quotient (R.B.Q)
Lack of employment	48	1	1	-	98
Less income from primary sector of marine fisheries	40	8	2	2	94
Less wages in the agricultural sector	5	40	5	0	75
Relatively large family size	47	3	0	0	98

Table 7. Computation of Spearman's Rank Correlation Co-efficient

Sl.No		RBQ values (KI)	Rank	RBQ values (Fishermen)	Rank	d	di^2
1.	Lack of employment	95	1	98	1.5	-0.5	0.25
2.	Less income from primary sector of marine fisheries	90	2.5	94	3	-0.5	0.25
3.	Less wages in the agricultural sector	60	4	75	4	0	0
4.	Relatively large family size	90	2.5	98	1.5	1	1
R=0.85							∑ 1.5

Table 8. Preferential Ranking based on mean value of R.B.Q

Sl.No		RBQ values (KI)	RBQ values (Fishermen)	Mean R.B.Q	Preferential Ranking
1.	Lack of employment	95	98	96.5	I
2.	Less income from primary sector of marine fisheries	90	94	92.0	III
3.	Less wages in the agricultural sector	60	75	67.5	IV
4.	Relatively large family size	90	98	94.0	II

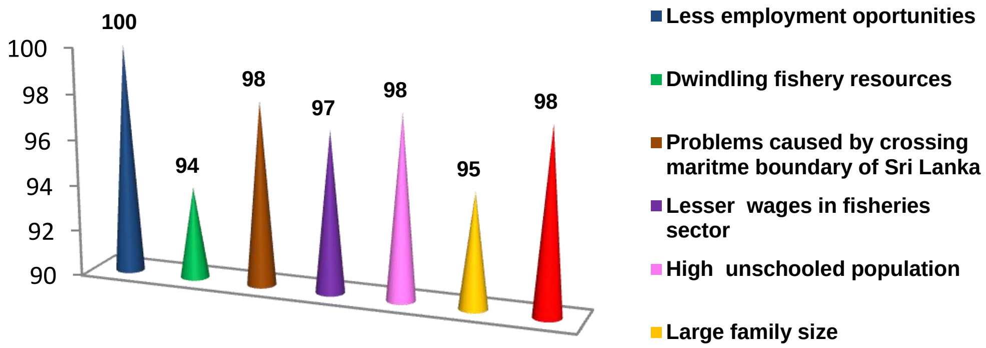

Fig 3. Push factors for migration (%) Ramanathapuram district (n=50)

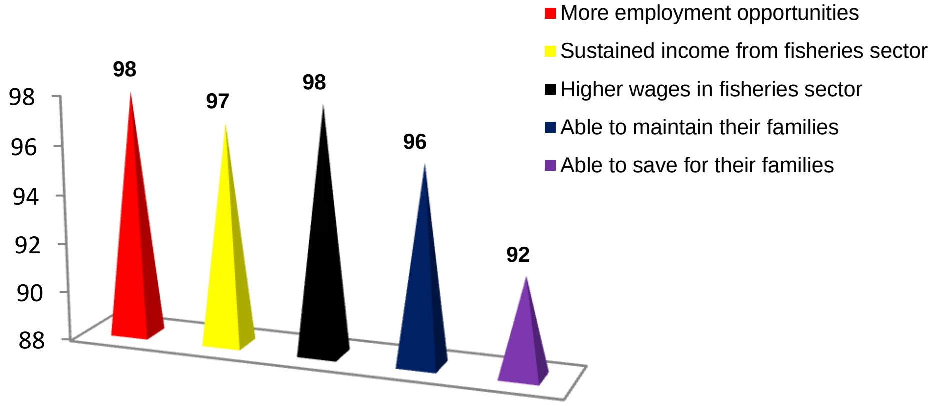

Fig. 4. Pull factors for migration (%) Ramanthapuram district (n=50)

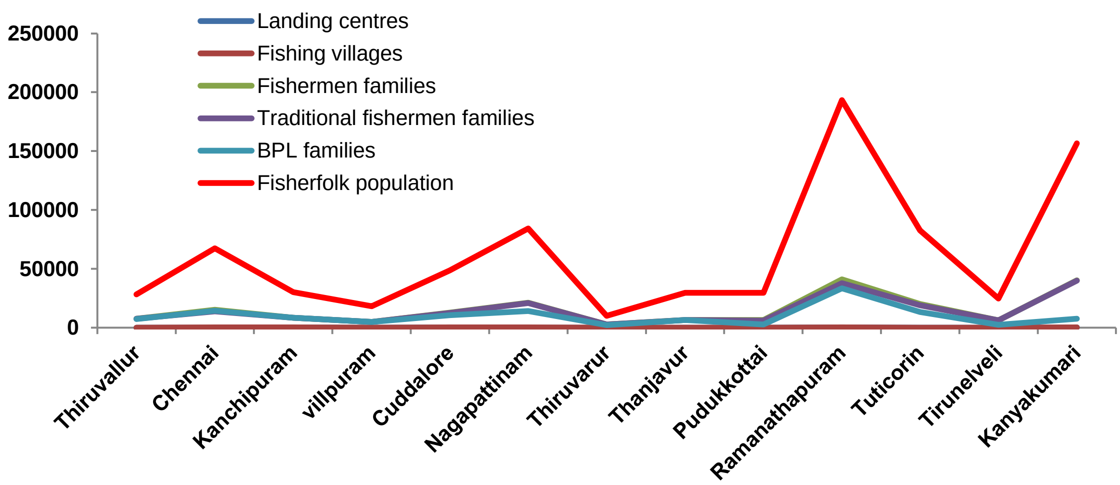

Fig. 5. District Profile, Tamil Nadu Source: Marine Fisheries Census, 2010

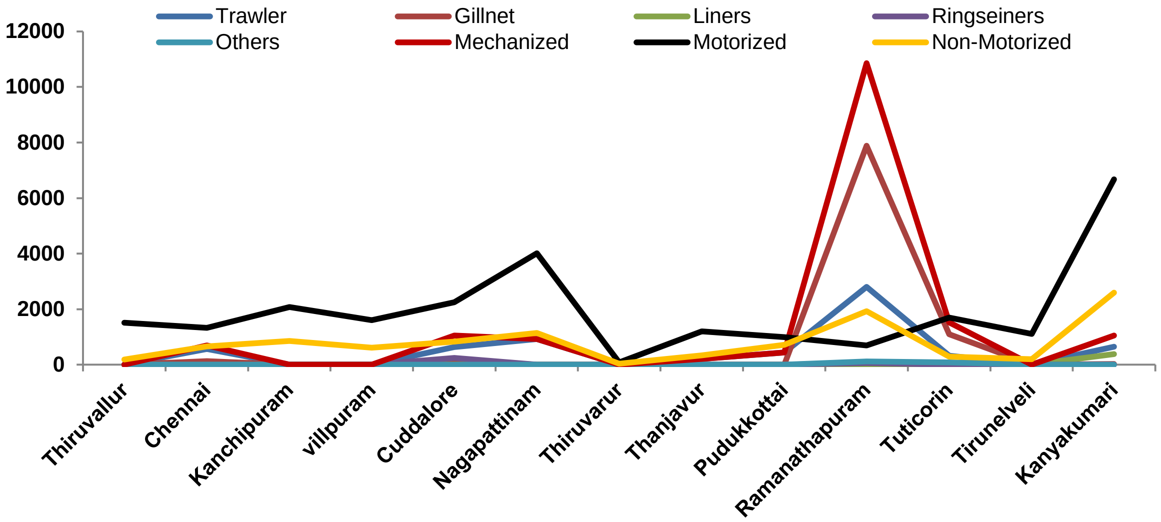

Fig. 6. Fishing Craft in the Fishery, Tamil Nadu. *Source: Marine Fisheries Census, 2010*

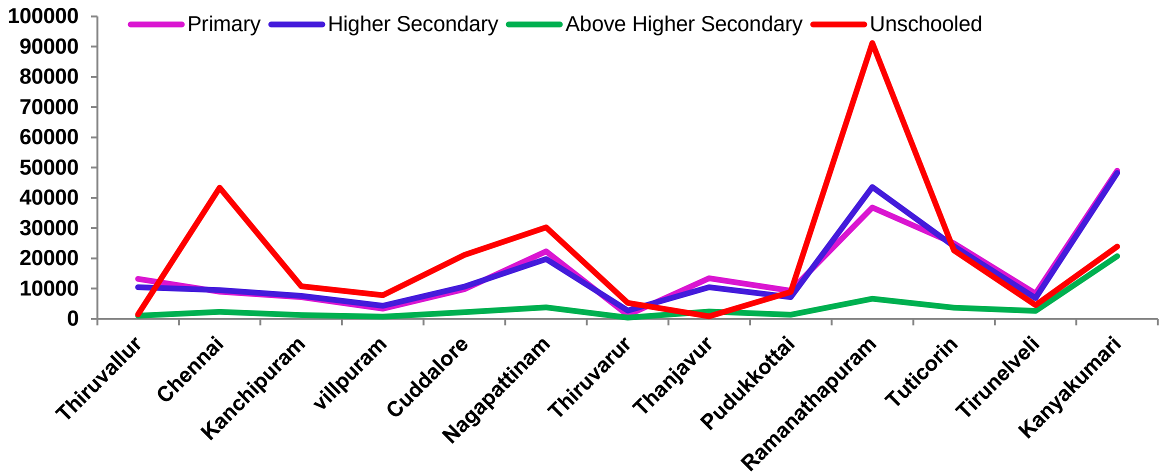

Fig. 7. Educational status of fisher folk, Tamil Nadu *Source: Marine Fisheries Census, 2010*

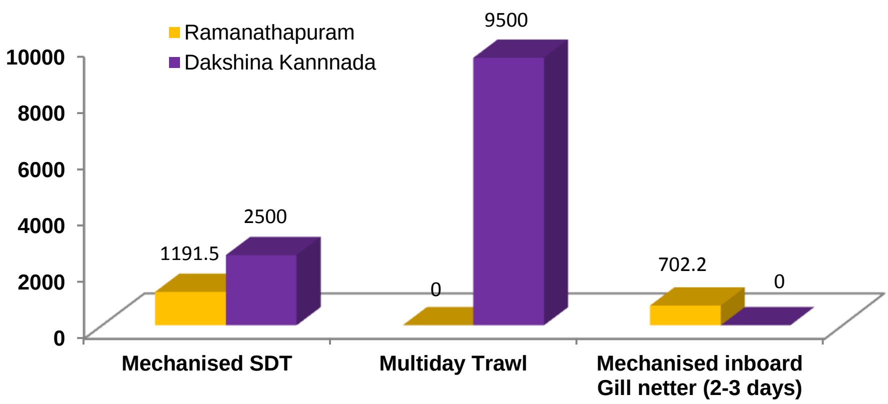

Fig. 8. Average monthly crew wages per fisherman (Rs.)

Reference:

Deshingkar, Priya Sharma Pramod, Kumar Sushil, Akter, Shaheen and Farrington, John (2008) Circular migration in Madhya Pradesh: changing patterns and social protection needs. European Journal of Development Research, 20 (4). pp. 612-628. ISSN 0957-8811

Jacob, Naomi, 2008. The Impact of NREGA on Rural-Urban Migration: Field survey of Villupuram District, Tamil Nadu. CCS Working Paper No. 202 Summer Research Internship Programme Centre for Civil Society. Pp 5.

Kothari U. (2002) ‘Migration and Chronic Poverty’, Working Paper 16, Manchester: Chronic

Lee, E.S. (1966) ‘A Theory of Migration’, Demography 3:1, pp.47–57.

Lekshmi Swathi P.S, A.P. Dineshbabu, H.S. Mahadevaswamy and Lingappa 2011. Migrant labourers in the marine fisheries sector. *Marine Fisheries Information Service T&E Ser*., No. 207, pp. 26-27.

Marine Fisheries Census 2010 Tamil Nadu. Department of Animal Husbandry, Dairying and Fisheries and Central Marine Fisheries Research Institute, Kochi. pp1- 421.

Mc Dowell, C. and De Haan, A. (1997) ‘Migration and Sustainable Livelihoods: a Critical Review of the Literature’, IDS Working Paper 65, Brighton: Institute of Development Studies, University of Sussex. Manchester.

Nandhini, U, Alagumani T and Shibi S.(2006). Economic analysis of Agriculture in the Southern parts of Coastal India. Agricultura Tropica, ET, Subtropica. Vol. 39(4) 2006. Pp. 279.

Nelson, J.M. (1976) ‘Sojourners versus New Urbanites: Causes and Consequences of Temporary versus Permanent City ward Migration in Developing Countries’, Economic Development and Cultural Change, 24:4, pp.721–57.

Rafiq, R., 2003. A Sociological Study of achievement and motivation of rural migrants. A case study in Faisalabad city. *M.Sc. Thesis,* Department of Rural Sociology, University of Agriculture, Faisalabad–Pakistan

Rao, U. (1994) Palamoor Labour: A Study of Migrant Labour in Mahabubnagar District.

Sabarathnam, V.E.2002. R/R/PRA (PLA) for Agriculture. Vamsarvath Publishers, Hyderabad. pp 348-368.

Sathiadhas, R and Prathap, K Sangeetha (2009) Employment Scenario and Labour Migration in Marine Fisheries. Asian Fisheries Science, 22 (2). pp. 713-727.

Suryanarayan, V. 2005. Conflict over Fisheries in the Palk Bay Region. Published by Lancer Publishers and distributors, K-36A, Green park Main, New Delhi.

Tietze, U.; Groenewold, G. & Marcoux, A. 2000. ‘Demographic change in coastal fishing communities and its implications for the coastal environment’, *FAO Fisheries Technical Paper* No. 403. Rome, FAO.

Hand-lining for cuttlefish along Mangalore coast

Prohibition of cuttlefish fishing using unconventional methods: A case study along Karnataka coast

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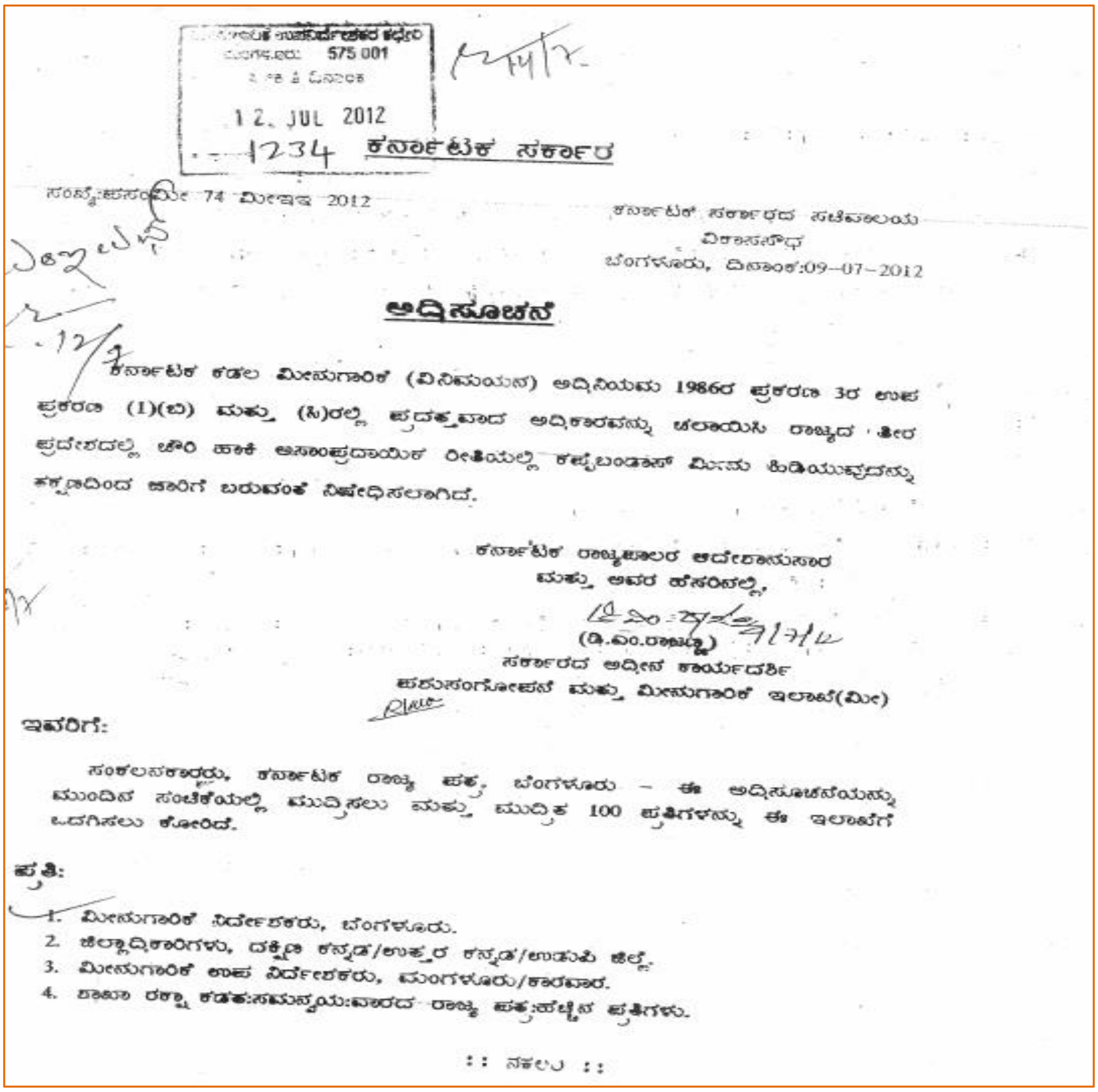
Fish aggregating Devices (FADs) for cuttlefish fishery are moored in areas beyond the territorial waters, which are difficult to monitor from shore-based facilities. Apart from the biological threat caused by FAD based hooks and line fishing practices, social issues emerged at Malpe Fisheries Harbour in Karnataka. The higher value-per-unit-effort for the fishermen engaged in FAD fishery, and the fact that such activities are carried out only by the migrant fisher-folk from south lead to discontent among the local fishermen. Further, the FADs getting entangled in the trawl nets which are operating in the same area, lead to conflict between trawl and FAD-operators.

During 2011-12, based on scientific advice from CMFRI, FAD fishing for cuttlefish was banned by the State administration under **Section 3** of the Karnataka Marine Fishing (Regulation) Act, 1986. To avoid conflict between the trawl and FAD fishermen, detailed discussions were carried out in the District Commissioner's Office. Regulations were enacted by the State Fisheries Department in July, 2012 prohibiting the FAD based cuttlefish fishery in the coastal waters off 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'*

Following the ban, two boats were seized from Mangalore - Malpe and a fine of Rs 2,00,000/- was imposed by the State fisheries officials. Later, two boats carrying cuttlefish caught in hooks and lines near FADs were seized at Malpe. The officials issued notice to 5 country craft owners engaged in cuttlefish fishing using FADs. The implementation of the ban requires extensive maritime surveillance to monitor compliance, which is challenging under the limited manpower/ inadequate infrastructure situation.

Fish aggregating devices fabricated using non-biodegradable materials –
for cuttlefish fishery along Karnataka coast



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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 ಚೌರಿ ಹಾಕಿ ಅಸಾಂಪ್ರದಾಯಿಕ ರೀತಿಯಲ್ಲಿ ಕಟ್ಲ್‌ಬಂಡಾಸ್ ಮೀನು ಹಿಡಿಯುವುದನ್ನು ತಕ್ಷಣದಿಂದ ಜಾರಿಗೆ ಬರುವಂತೆ ನಿಷೇಧಿಸಲಾಗಿದೆ.

ಕರ್ನಾಟಕ ರಾಜ್ಯಪಾಲರ ಆದೇಶಾನುಸಾರ
ಮತ್ತು ಅವರ ಹೆಸರಿನಲ್ಲಿ,

(ಡಿ.ಎಂ.ರಾಜಪ್ಪ)
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:ಶಾಖೆಯ ರಾಜ್ಯ ಪತ್ರ:ಹೆಚ್ಚಿನ ಪ್ರತಿಗಳು.

:: ನಕಲು ::

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

Fisheries Legislation in India

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Fish production in the country has increased from 5.65 million tonnes in 2000-2001 to 8.66 million tonnes in 2011-12, of which inland and marine sectors contributes to 5.29 and 3.25 million tonnes respectively. The growth rate in marine fisheries in recent years has been slow compared to inland fisheries. India is the second largest producer of fish in the world. About 14 million persons depend directly on fisheries sector for their livelihood. India is endowed with vast and varied marine and inland fishery resources, an outline of which is as follows:

Marine Fishery Resources

Coastline	:	8129 km
Exclusive economic zone	:	2.02 million km^2
Inshore area (<50 m depth)	:	0.18 million km^2
Continental shelf	:	0.50 million km^2
Estimated annual production potential	:	3.90 million tonnes

Inland Fishery Resources

Rivers and canals	:	0.20 million km
Area under reservoirs	:	3.15 million ha
Tanks and ponds	:	2.25 million ha
Beels, oxbow lakes and derelict water bodies	:	0.82 million ha
Brackishwater area	:	1.24 million ha
Estimated annual production potential	:	4.5 million tonnes

Indian Fisheries Legislation

The need for fisheries legislation was emphasized as long back as in 1873 when the attention of the then Government of India was drawn towards widespread slaughter of fish, fry and fingerlings and the urgency to adopt legislative measures to conserve the fisheries resources. At that time, the Government of India enacted the Indian Fisheries Act, which came into being in 1897.

The Act highlighted the following:

- Use of destructive methods of fishing such as dynamiting or other substances in inland and coastal waters (up to one marine league) was prohibited. Similarly, poisoning of water with noxious materials was also prohibited.
- Provincial governments were empowered to make rules in selected waters for protection of fish with previous notification, restricting the creation and use of fixed engines (dams, weirs, bar pattas, etc.) for catching fish; to put a limit on mesh size, size of fish and catch, and to ban the fish in certain seasons and certain places for a period of 2 years (declaration of closed season and sanctuaries).

Marine Fishery Legislation in the Maritime States of India

There are 10 maritime states/union territories in India, *viz*. Gujarat, Maharashtra, Karnataka, Goa and Kerala along the west coast, bordering the Arabian Sea; and Tamil Nadu, Pondicherry, Andhra Pradesh, Orissa and West Bengal along the east coast, bordering the Bay of Bengal. The two island union territories, viz. Lakshadweep, and Andaman and Nicobar Islands are situated in the Arabian Sea and Bay of Bengal, respectively.

The introduction of small mechanized boats of 9 to 10 m has rapidly caught on since the 1960s, and at present, about 53,000 such boats are operating in the inshore area, engaged mostly in bottom trawling, gill netting and purse-seining. During the 1970s, purse-seining was introduced for pelagic shoaling fishes like mackerel and sardines. It was in this backdrop that the scope and possibility to safeguard the interests of traditional fishermen were recognized by the 10th Meeting of the Central Board of Fisheries held on 22-23 March, 1976, at New Delhi. Based on its recommendations, the Central Government constituted a committee in May, 1976, for examining the questions of delimiting the areas of fishing for different types of boats. The Committee submitted its report in December, 1978, with a model Marine Fisheries Regulations Bill. The model bill was circulated to all maritime states and union territories in 1979 for enacting suitable legislation.

Various state governments have issued regulations under the Indian Fisheries Act 1897 for regulation and protection of fisheries. The regulations concerning Indian marine fisheries are listed below:

i. The Indian Fisheries Act, No. IV of 1897, Government of India

ii. The Indian Fisheries Act as adopted and applied by the State of Saurashtra, 1897

iii. The Mysore Game and Fish Preservation Act 2 of 1901, Government of Mysore

iv. The Game and Fish Protection Regulation Act 12 of 1914, Government of Travancore (1914) (modified 1921)

v. Cochin Fisheries Act 3 of 1917 (modified 1921), Government of Cochin

vi. Andaman and Nicobar Islands Fisheries Regulation 1 of 1938

vii. The United Provinces Fisheries Act 45 of 1948

viii. Government of Travancore-Cochin Fisheries Act 34 of 1950

ix. The Maharashtra Fisheries Act 1960 (modified 1962), Government of Maharashtra

x. The Indian Fisheries (Pondicherry Amendment) Act 18 of 1965

xi. The Indian Wildlife Act 1972. 2lb-The territorial waters, continental shelf, EEZ and other maritime zones Act 1972

xii. The Marine Products Export Development Authority Act 1972

xiii. The Maritime Zones of India (Regulation of fishing by foreign vessels) Act 1981

xiv. The Kerala Marine Fishing Regulation Act and Rules 1980 (Act 10 of 1981)

xv. The Goa Marine Fishing Regulation Act, 1980

xvi. The Maharashtra Marine Fishing Regulation Act 1981, Government of Maharashtra

xvii. The Orissa Marine Fishing Regulation Act 981 (Orissa Act 10 of 1982) and the Orissa Marine Fishing Regulation Rules 1983

xviii. The Tamil Nadu Marine Fishing Regulation Rules 1983

xix. The Karnataka Marine Fishing Regulation Act, 1986

xx. The Andhra Pradesh Marine Fishing Regulation Act, 1994

xxi. Lakshadweep Marine Fishing Regulation Act, 2000

xxii. The Gujarat Fisheries Act, 2003

xxiii. Andaman and Nicobar Marine Fishing Regulation Act, 2003

The Marine Fishing Regulation Acts (MFRAs) have provision for regulating fishing and conservation measures in the territorial waters. These include regulation of mesh size to avoid catch of juvenile fish; minimum-maximum fish sizes, regulation of gear to avoid over exploitation of certain species; reservation of zones to traditional fishermen and declaration of closed seasons. These Acts demarcate fishing zones in territorial waters for fishing by non-mechanized and mechanized fishing vessels. The distance from the shore earmarked for each category varies from state to state. In general, 5 to 10 km is reserved for operation by artisanal (non-mechanized) vessels.

Kerala and Goa were the first to enact the Marine Fisheries Act in 1980 followed by Maharashtra (1981), Orissa (1982), Tamil Nadu (1983), Karnataka (1986), West Bengal (1993) and Andhra Pradesh (1994). Lakshadweep did so in 2000. Gujarat as well as Andaman and Nicobar islands enacted the Act in 2003.

Unlike regulations of fishing areas provided in the Acts, the decision on seasonal closure is taken on a year to year basis normally prior to or during the onset of the south-west monsoon. As per the recent order issued by Department of Animal Husbandry, Dairy and Fisheries, Government of India, dated 9th March, 2011, uniform ban on fishing by all fishing vessels in the Indian Exclusive Economic Zone (EEZ) beyond territorial waters on East Coast including Andaman & Nicobar islands and West coast including Lakshadweep has been imposed for conservation and effective management of fishing resources and for sea safety reasons. Along the east coast, uniform seasonal closure of 47 days is being implemented from 15th April to 31st May, while along the west coast it is from 15th June to 31st July.

Zonation and other fishing regulations in different states are summarized below:

Gujarat

(i) The area up to 9 km from the shore is reserved for non-mechanised vessels and mechanised vessels beyond 9 km.

(ii) In case of trawl net, square mesh of minimum 40 mm size at cod ends need to be used.

(iii) Gill net with mesh size less than 150 mm cannot be operated.

Maharashtra

(i) Operation of trawl net by mechanized fishing vessels is prohibited from the seashore to 5 fathoms and 10 fathoms depth zone in specified areas; Fishing vessels is banned from 15th June to 31st July.

(ii) Operation of trawl gear by mechanized fishing vessels is prohibited between 6 pm and 6 am.

(iii) Fishing by mechanized fishing vessels of any type with more than 6 cylinder engines is prohibited within the territorial waters of Maharashtra up to 22 km.

(iv) Purse-seine shall not be operated by any mechanized fishing vessel within the territorial water of Greater Mumbai, Thane, Raigad, Ratnagiri and Sindhudurg districts.

(v) Mechanized fishing vessels operating purse-seine gear beyond the territorial waters shall not land the catch caught by such gear in any port other than Mirkarwada (Ratnagiri Port).

(vi) No trawl gear having less than 35 mm mesh size shall be operated by any mechanized fishing vessel within territorial waters of Thane, Greater Mumbai, Raigad and Sindhudurg.

(vii) No trawl gear having less than 25 mm mesh size shall be operated by any mechanized fishing vessel within territorial waters of Ratnagiri.

Goa

(i) The area up to 5 km from the coast-line is the specified area and mechanized fishing vessels are prohibited from fishing in the area.

(ii) Restrictions on mesh size of nets, *i.e.* 20 mm for prawn and 24 mm for fish.

Karnataka

(i) The area up to 6 km from the shore or up to 4 fathoms (whichever is farther) is reserved for traditional crafts.

(ii) Mechanized boats (up to 50' length) are allowed to operate beyond 6 km.

(iii) Deep-sea vessels (of 50' and above) are required to operate beyond 20 km.

Kerala

(i) The area from shore up to 30 m line in the sea along the coast from Kollencode in the south to Paravoor (Pozhikkara), a length of 78 km, is called the First Zone.

(ii) The area up to 20 m line in the sea along the coast line from Paravoor in the south to Manjeshwar in the north for a length of 512 km is called the Second Zone.

(iii) Mechanised fishing except fishing by motorized country craft is prohibited in the first and Second zones. Only fishing with country craft and traditional craft is allowed in these zones.

(iv) Small mechanized vessels (<25 GRT) are allowed to operate between 40 and 70 m depth in the first zone and between 20 and 40 m in the second zone.

Tamil Nadu

(i) Areas up to 5 km are reserved for traditional non-mechanised boats.

(ii) Mechanized boats are permitted to use areas beyond 5 km.

(iii) Fishing within 100 m below a river mouth is prohibited.

(iv) No gill net of mesh size less than 25 mm shall be used.

(v) No shrimp trawl net with mesh size less than 37 mm at cod end shall be used.

(vi) No fish trawl net with mesh size less than 40 mm at cod end shall be used.

(vii) The number of mechanized fishing vessels which may be used for fishing in any specified area shall be decided by the Authorized Officer.

Andhra Pradesh

(i) The area upto 8 km from the shore is reserved for traditional craft.

(ii) Mechanised boats are allowed to operate beyond 8 km.

(iii) Mechanised fishing vessels of 25 Gross tonnage and above or 15 m and above of length shall be allowed to operate only beyond 15 km from the coast.

(iv) No vessel to be engaged in fishing using nets with mesh size below 15 mm.

(v) Shrimp trawlers engaged in fishing without Turtle Excluder Device (TED) shall be liable for confiscation of entire catch and impose a fine of Rs. 2,500/-.

Orissa

(i) Non mechanized traditional craft shall be allowed to operate freely without restriction. Waters up to 5 km from the shore have been exclusively reserved for such fishing craft.

(ii) Mechanized fishing vessels up to 15 m in length shall be allowed to operate beyond 5 km from the coast.

(iii) Mechanized fishing vessels of 25 GRT and above or 15 m length shall be allowed to operate beyond 10 km from shore.

West Bengal

(i) The area up to 18 km from the shore is reserved for artisanal fishing craft and craft fitted with engines less than 30 HP.

(ii) Fishing craft fitted with more than 30 HP engine are allowed to operate beyond 18 km.

(iii) No gill net with mesh size less than 25 mm shall be used.

(iv) No bag net/ dol net with mesh size below 37 mm shall be used.

(v) No shore seine/drag net with mesh size below 25 mm to be used.

(vi) Trawl net of standard mesh size fitted with turtle excluder devices to be used.

Andaman and Nicobar islands

(i) Vessels up to 30 HP only are allowed to operate up to 10 km.

(ii) Vessels above 30 HP are allowed to operate beyond 10 km.

(iii) Every year 15 April to 31 May shall be closed season for bottom trawlers and vessels engaged in shark fishing.

(iv) Every year 1 May to 30 September closed season for fishing sea shells.

(v) Fishing nets below 20 mm mesh size are prohibited.

(vi) Trawl nets of standard mesh size fitted with turtle excluder device alone are permitted.

(vii) Only gill nets, shore seines and dragnets with mesh size above 25 mm are allowed to operate.

Lakshadweep

(i) Use of purse seine, ring seine, pelagic, mid water and bottom trawl of less than 20 mm mesh size is prohibited except live bait net;

(ii) Use of draft gill net of less than 50 mm mesh size and shore seine of less than 20 mm mesh size is prohibited.

The Maritime Zones of India (Regulations of fishing by foreign vessels) Act, 1981

This act was introduced to control activities of foreign fishing vessels within Indian Maritime Zone. The Act provides basis for joint ventures and chartered vessels and also for bilateral / multilateral fishing access agreements.

If any foreign vessel is used in contravention of the provision of section 3 of the Act in any area within the territorial waters of India are punishable with imprisonment for a term not exceeding three years or with fine not exceeding rupees fifteen lakhs or with both. If such contravention takes place in any area within the exclusive economic zone of India be punishable with fine not exceeding rupees ten lakhs. The penalty for contravention of license is not exceeding rupees ten lakhs. The penalty for contravention of permit related to area of operation or method of fishing specified in such permit will be not exceeding rupees five lakhs and rupees fifty thousand in other cases. If any person intentionally obstructs any authorized officer in the exercise of any powers conferred under this Act or fails to afford reasonable facilities to the authorized officer or fails to stop the vessel or produce the license permit, log book or other document or any fish, fishing gear or other equipment on board the vessel when required to do so by the authorized officer, shall be punishable with imprisonment for a term which may extend to one year or with fine not exceeding rupees fifty thousand or with both.

The Environment (Protection) Act, 1986

It authorizes the Central Government to protect and improve environmental quality, control and reduce pollution from all sources and prohibit or restrict the setting and or operation of any industrial facility on environmental grounds. It also makes it mandatory to conduct Environmental Impact Assessment (EIA) for specified developmental activities. Public hearings are also made mandatory for all developmental activities that require environmental clearance from the Ministry of Environment.

The Coastal Regulation Zone (CRZ) 1991 notification was issued under the provisions of Environment (Protection) Act, 1986. It outlines a zoning scheme to regulate development in a defined coastal belt. It declares the coastal stretch influenced by tidal action in the landward side up to 500 m from the high tide line (HTL) and the land between the low-tide line (LTL) and the HTL as the CRZ. It imposes restrictions on setting up and expansion of industries, operations or processes etc., in the said CRZ. The CRZ has been classified into four categories for regulation of developmental activities

The CRZ-I includes areas that are ecologically sensitive and important which include national ponds / marine parks, sanctuaries, reserved forests, wild life habitats, mangroves, corals / coral reefs areas close to breeding and sparing grounds of fish and others marine life and areas rich in genetic diversity. The CRZ-I also includes area between the Low Tide Line and the High Tide Line.

The CRZ-II includes the areas that have already been developed up to or close to the shore line.

The CRZ-III includes the areas that are relatively undisturbed and those which do not belong to either CRZ-I or II. These will include coastal zone in the rural areas (developed and undeveloped) and also areas within municipal limits or in others legally designated urban areas which are not substantially built-up.

The CRZ-IV includes coastal stretches in the Andaman and Nicobar, Lakshadweep and small islands except those designated as CRZ-I, CRZ-II or CRZ-III.

New Deep Sea Fishing Policy, 1991

In March 1991, the Indian government announced New Deep Sea Fishing Policy (NDSP) as part of the economic reforms programme. The policy involved three schemes (i) leasing out of foreign fishing vessels to operate in the Indian EEZ; (ii) engaging foreign fishing vessels for test fishing and (iii) forming joint ventures between foreign companies and Indian companies on 49:51 equity basis in deep sea fishing, processing and marketing. Government of India started giving licenses to joint venture, lease and test fishing vessels. There was opposition to the policy by artisanal fishers.

Murari Committee, 1995

The Murari Committee comprising 41 members including bureaucrats, experts, activists and representatives from fishing communities was constituted. It was divided into five groups and went around all the coastal states to collect opinion from all sections of Fisheries Sector. All the five groups unanimously recommended the cancellation of all licenses to foreign vessels and review of the deep sea fishing policy. The committee came up with 21 recommendations, the important ones include:

- No renewal, extension or new licenses be issued in future to joint venture / charter / lease / test fishing vessels.
- The present licenses be cancelled as per going through the legal procedures
- Upgrade the skill of the fishing community to equip them with exploiting the deep sea resources
- Stop pollutions
- Supply of fuel at subsidized rate
- Fishing regulations in the entire EEZ
- A separate ministry to deal with the entire fisheries
- Monsoon trawl ban

- The area already being exploited or which may be exploited in the medium term by fishermen operating traditional craft or mechanized vessels below 20m size should not be permitted for exploitation by any vessels above 20m length except currently operated Indian vessels which may operate in the current areas for only three years.

The Central Government accepted all the recommendations of the committee in September 1997. The Minister of Food Processing Industry nominated a small committee from the National Fisheries Action Committee against Foreign Fishing Vessels to oversee the implementation of Murari Committee recommendations.

Broad Guidelines for the Operation of Indian Deep-Sea Fishing Vessels in Indian EEZ

Outline of broad guidelines circulated by the government for operation of Indian deep sea fishing vessels in the Indian EEZ are given below:

Permission in writing (LOP) is required from the nodal ministry for operating any fishing vessel in Indian EEZ. Presently, permission is accorded only for (i) Long lining for tuna; (ii) tuna purse seining; (iii) squid jigging and squid hand lining and (iv) mid-water/ pelagic trawling and (v) trap fishing

The operation of Indian deep-sea fishing vessels will be governed by the executive orders issued/to be issued from time to time. The area of operation of the deep-sea fishing vessels will be regulated by the instructions/orders issued by the Government of India from time to time. For proper monitoring of the operations of Indian deep sea fishing vessels and sea safety point of view, it is mandatory for all deep-sea fishing vessel operators to report their vessels' position, intended course and speed and area of operation with latitude and longitude to Coast Guard at 08.00 hours daily or any other time specified by the authority. Date of commencement of voyage, likely period, together with crew list should be furnished to Coast Guard and Fishery Survey of India, Mumbai, before each sailing. Intimation on completion of each voyage shall also be furnished to these agencies on return. The operator shall furnish an undertaking to the effect that (a) they will not resort to any type of fishing other than what has been permitted to them, (b) the company will not exploit any endangered species of marine turtles, mammals and fish species and the vessel will not resort to bottom trawling/pair trawling/bull trawling and (c) will not violate the Code of Conduct for Responsible Fisheries (CCRF). The operator should take clearance from the Government for assignment of foreign crew.

Biological Diversity Act, 2002

Main objective of the Act is to protect biological diversity of India. The Act provides for the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and related matters. There is a provision for setting up of National and State Biodiversity Boards. The Act encourages conservation and has a provision to declare a fish stock threatened if it is over exploited.

The Marine Fishing Policy, 2004

The Ministry of Agriculture has been paying due attention in the past decade to the development of deep-sea fishery in the country. On realization that most of the deep sea fishery resources are beyond the conventional fishing limit and fishing capability of the indigenous craft and can be gainfully exploited only if upgraded and sophisticated vessels of adequate size and capabilities are inducted into the fishery, Government addressed this issue in 1981 Charter Policy.

Consequent upon the introduction of the Charter Policy in 1981 which permitted entry of foreign fishing vessels to fish in the Indian EEZ, the Central Government enacted the Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act, 1981 and the Rules there under in 1982. The enforcement of this Act is resting with the Ministry of Agriculture. Subsequent to the Charter Policy of 1981, initiatives were taken by the Government from time to time to enable Indian companies to acquire fishing vessels. After the expiry of five years of operation of this policy the government revised the policy to rectify the deficiencies noticed during its operation and to make it more beneficial to the country. Accordingly a revised 1986 charter policy was pronounced. The charter policy envisaged acquisition of vessels by Indian Companies either through import/construction in India or through joint venture etc. As a result of the above 97 companies were permitted to operate 311 foreign fishing vessels. Having laid the foundation for the Indian deep sea fishing industry, the government went ahead to broad base the initiative through 1991 policy. The New Deep Sea Policy of 1991 permitted Indian companies to enter into Joint Venture arrangements with foreign fishing companies and acquire fishing vessels for fishing in the Indian EEZ, flying the Indian flag.

The other measures for resource conservation include implementation of closed season, ban on destructive methods of fishing and mesh size regulations. The policy also envisages prohibition of catching of juveniles and non-targeted species and discarding less preferred species once they are caught through legislation. Monitoring control and surveillance system (MCS) would be enforced through posting of observers on commercial fishing vessels. Seed production for sea ranching, designation of certain areas as marine sanctuaries and regulating capture of brood stock from these locations would form important components of resource enhancement programme. Open sea cage culture and fish aggregating devices form other important areas of resource management.

The policy highlights ensuring socio-economic security of the fishermen. Artisanal fisheries deploying out Board Motors (OBMs) and small mechanized boats up to 12 m would be treated par with agriculture while small scale fisheries involving mechanized boats under 20 m registered length would be treated at par with small scale industries. Fishing vessels above 20 m and fishing activity involving mother ships or factory vessels would be treated as industrial activity. Further, full time occasional fishermen whose household does not own a boat would be treated at par with landless labourers and would qualify for special care and protection. Housing scheme for fishermen, greater focus by financing institutions and improved safety at sea are the other components of fishermen welfare programmes.

The marine fishing policy 2004 also outlines policy for development of fisheries in the Union Territories of Lakshadweep and Andaman & Nicobar Islands.

Marine Fisheries (Regulation and Management) Bill, 2009

The Union Government proposes to bring fishing vessels of Indian origin in the Indian EEZ, along with other categories, under a legal regime called the Marine Fisheries (Regulation and Management) Bill 2009, through a common legal framework for regulation of fisheries, and conservation and sustainable use of fishery resources in all maritime zones including territorial waters. The scope of the proposed Bill 2009 includes the territorial waters (can be up to 12 nautical miles from the base line), contiguous zone (can be up to 24 nautical miles from the base line), EEZ (can be up to 200 nautical miles from the base line) and the continental shelf (can be up to 350 nautical miles from the base line). It proposes to bring into its ambit Indian fishing vessels constructed in India, owners of such vessels and fishery and fish-workers on board these vessels and their operations, especially in the EEZ.

Fisheries in territorial waters are a state subject, while that of other zones are a Union subject. The regulation of fishing in territorial waters is being legally undertaken by the State Fisheries Departments under marine fishing regulation acts/rules (based on a model bill prepared by the Central Government). In the EEZ, Indian citizens have been given more or less freedom to fish. The Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act 1981 and the Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Rules, 1982 are meant to regulate foreign fishing vessels in the Indian EEZ that are owned and/or operated by both Indian Citizens and foreign nations. Thus there is a legal vacuum in relation to the regulation of Indian fishing vessels of Indian build in the EEZ with no legal responsibility or accountability except the requirement to follow the seasonal monsoon ban and the prohibition on taking certain endangered or protected species under the 1972 wildlife (Protection) Act. This Bill seems to be proposed mainly with the purpose of bringing all Indian and foreign vessels and related interests in the EEZ under a legal mechanism so as to meet India's obligations under 1982 United Nations Law of the sea convention and the 1995 United nations Fish Stocks Agreement and to draw upon relevant sections from the 1995 FAO Code of Conduct for Responsible Fisheries.

International Agreements

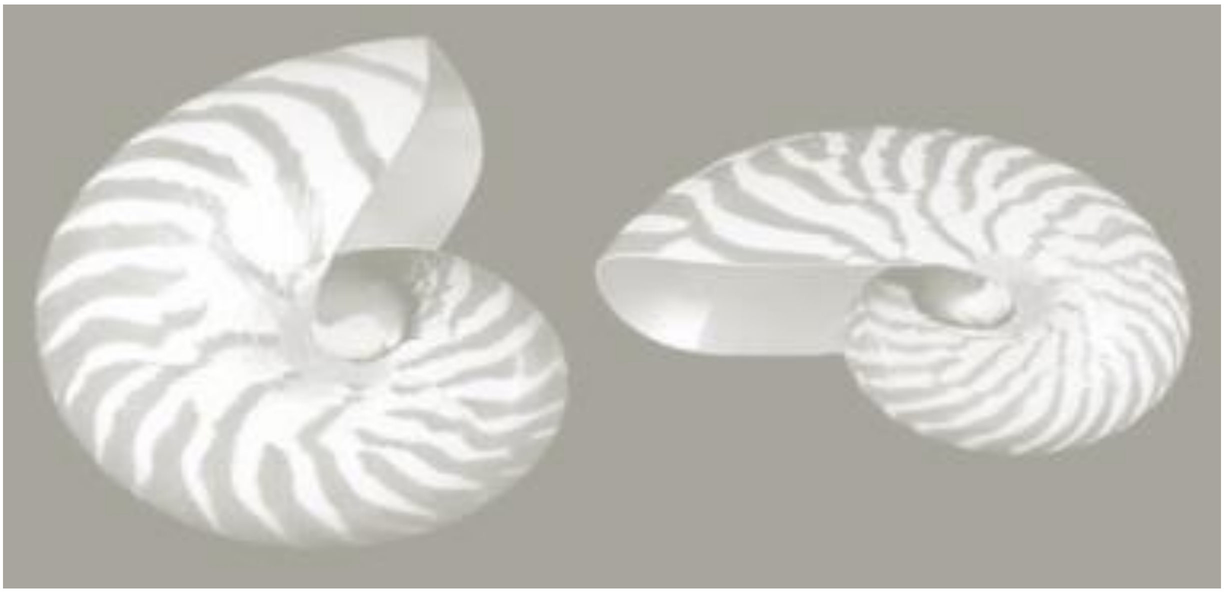
The following four international agreements emerging out of the endorsement of the Code are relevant in this context for incorporation under the relevant laws/legislation proposed in this regard.

(i) Agreement for the implementation of the provisions of the United Nations Convention on the Law of the Sea of 10 December,1982 relating to the Conservation and Management of Straddling Fish Stock and Highly Migratory Fish Stock.

(ii) Agreement to promote compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas.

(iii) International Plan of Action to prevent, deter and eliminate, illegal, unreported and unregulated fishing.

(iv) International Plan of Action for Management of Fishing Capacity, Conservation and Management of Sharks, reducing incidental catch of Sea Birds in long line fishing.



Conservation criteria and Red listed marine resources of India

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Marine conservation, also known as marine resources conservation is the protection and preservation of ecosystems in oceans and seas. Marine conservation focuses on limiting human-caused damage to marine ecosystems and on restoring damaged marine ecosystems. Marine conservation also focuses on preserving vulnerable marine species.

Marine species were thought to be abundant and unlikely to become extinct. Exploitation of the marine resources over the years has caused the decline in many marine species population and recovery found to be much slowly than the previously understood. Studies have shown that many species have restricted distribution which makes it vulnerable to exploitation and extinction. In order to conserve the biodiversity and protect the vulnerable species from extinction an international organization for environment protection was constituted. This is International Union for Conservation of Nature (IUCN) which is the world's oldest and largest global environmental organization. This was formed to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable.

Biodiversity loss is continuing at an unprecedented rate, with many species declining to critical levels and significant numbers going extinct. The IUCN Red List is the most comprehensive information source on the status of wild species and their links to livelihoods. It is the clarion call for fighting the extinction crisis. The overall aim of the Red List is to convey the urgency and scale of conservation problems to the public and policy makers, and to motivate the global community to work together to reduce species extinctions. Marine species are poorly represented on the IUCN Red List, largely because of the lack of information about them. The status of most of the larger species (marine mammals, seabirds and turtles) has been assessed and many are considered globally threatened. Threatened marine fish are currently being assessed and many are being added to the Red List including swordfish, sawfish, all tuna species except yellowfin and skipjack, sharks (38 in the WIO), groupers, seahorses, manta rays and the coelacanth. Very few marine invertebrates are on the IUCN Red List, with the exception of six species of Giant clam

Information on distributions and abundance of marine species in the Western Indian Ocean (WIO) region is still poor, but there are at least 11,000 macrofaunal species (creatures larger than 1-2 mm) of which 10-20% are endemic (i.e. do not occur anywhere else).

Group	Global	WIO
Whales, dolphins	65	29
Marine otters	7	0
Seals	4	0
Manatees/ dugong	4	1
Seabirds	155	17*
Marine turtles	7	5
Marine fish	375	105
Molluscs	93	7
Coelenterates (corals, sea fans, anemones)	3	0
*Known to be an underestimate		

Species are classified into the following eight categories defined by criteria that cover trends in population size, extent of occurrence and extinction risk.

Extinct (EX) - A taxon is Extinct when there is no reasonable doubt that the last individual has died.

Extinct in the Wild (EW) - A taxon known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside its past range.

Critically Endangered (CR) - A taxon facing an extremely high risk of extinction in the wild in the immediate future as defined by the criteria. WIO examples are Coelacanth, Southern Bluefin tuna, Hawksbill and Leatherback turtles.

Endangered (EN) - A taxon that is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future as defined by the criteria. WIO examples are Loggerhead, Green and Olive Ridley turtles, several species of saw fish and the Blue whale.

Vulnerable (VU) - A taxon that is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future as defined by the criteria. WIO examples are dugong, Humphead wrasse, Whale shark, Humpback whale, several shark species including Grey Nurse shark and Great White shark.

Lower Risk (LR) - A taxon that has been evaluated but does not satisfy the criteria for any of the above categories. Such taxa are divided into the sub-categories

Near Threatened and Least Concern. WIO examples include many shark and whale species.

Data Deficient (DD) - A taxon for which there is insufficient recent information for assessing threat or a lot of uncertainty about data for widespread but declining species. WIO examples are species of whales, dolphins and fish, including seahorses and sharks.

Not Evaluated (NE) - A taxon that has not yet been assessed against the criteria.

In line with IUCN red list, MINISTRY OF ENVIRONMENT AND FORESTS (MoEF) has brought out the notification of the marine species to be included in scheduled list. Following are the species included in the schedule.

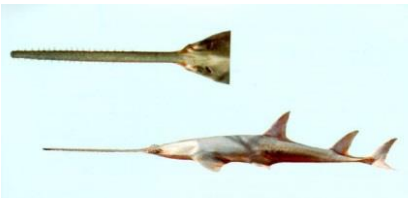
<u>Fishes</u>

Sea Horse
(All Sygnathidians)

Epinephelus lanceolatus
Giant Grouper

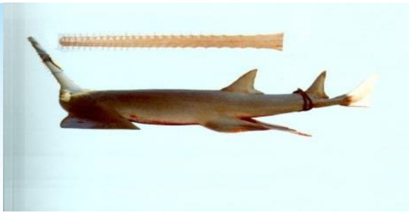
Carcharhinus hemiodon
Pondicherry shark

Anoxypristis cuspidata
Pointed sawfish



Pristis microdon
Largetooth sawfish

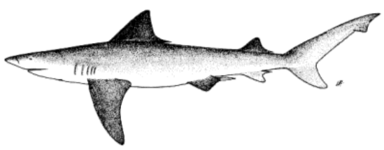
Pristis zijsron
Longcomb sawfish



Urogymnus asperrimus
Porcupine ray

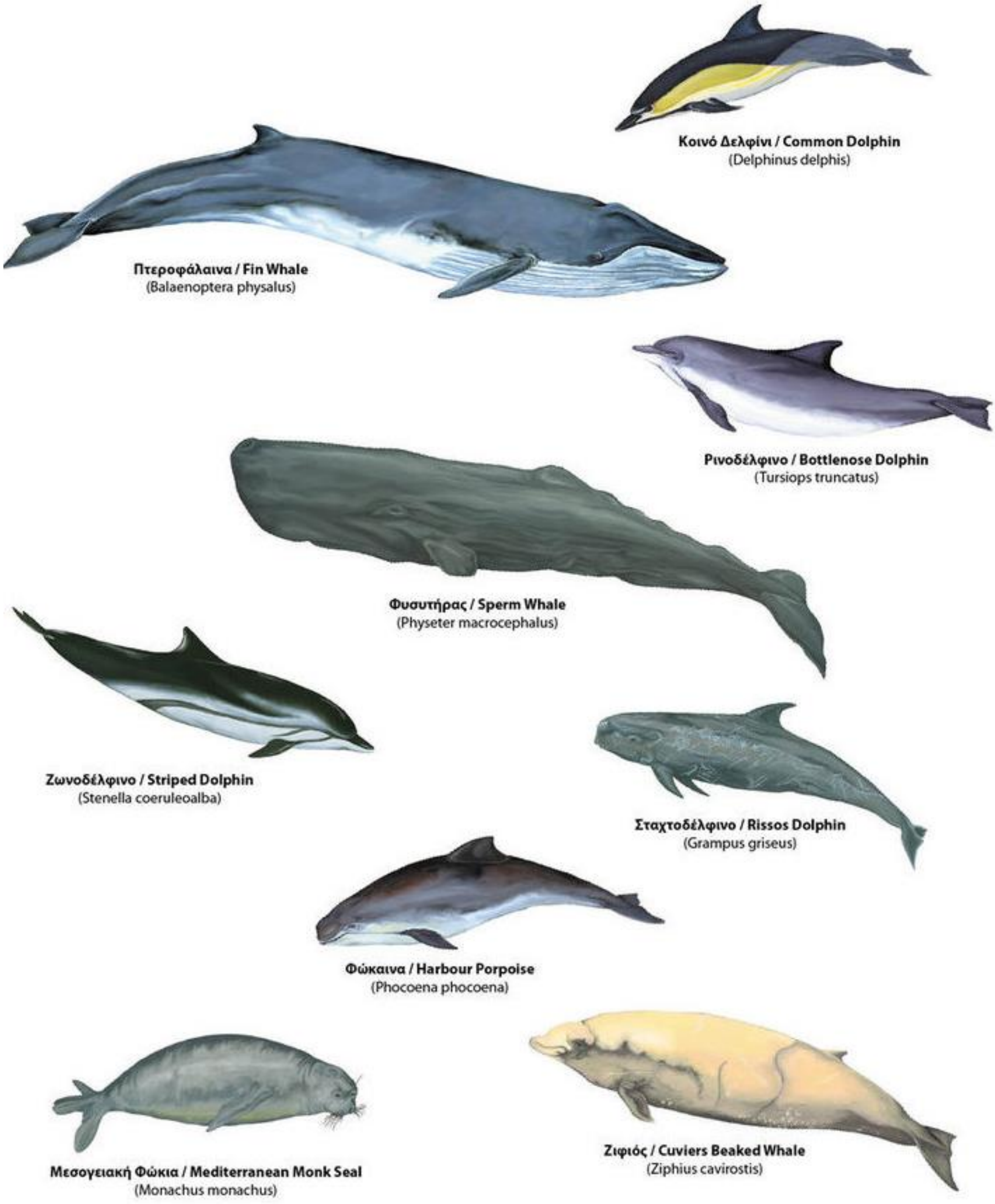
Rhynchobatus djiddensis
Giant guitarfish

Glyphis gangeticus
Ganges shark



Marine Mammals

All marine mammals are included in the schedule by MoEF

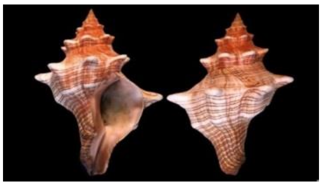


Molluscs

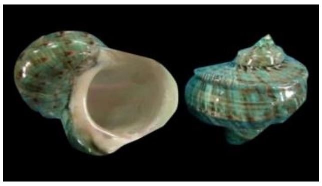
Banned Sea Shells under Wildlife Protection Act, 1972 - SCHEDULE-IV


Cypraea lamacina


Lambis truncata

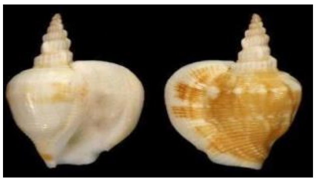

Fasciolaria trapazium

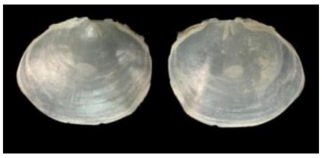

Cypraea mappa

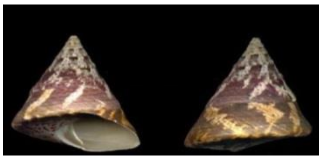

Turbo marmoratus


Harpulina arausiaca


Cypraea talpa

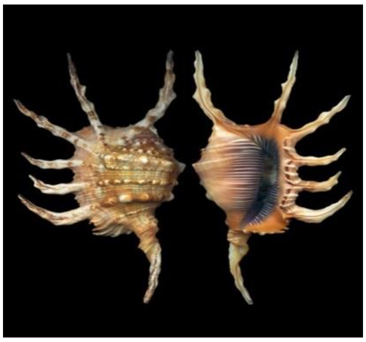

Strombus plicatus sibbaldi


Placenta placenta


Trochus niloticus

Banned Sea Shells under Wildlife Protection Act, 1972 - SCHEDULE-IV


Lambis scorpius


Lambis crocea


Lambis millepeda


Lambis chiragra arthritica


Lambis chiragra

Banned Sea Shells under Wildlife Protection Act, 1972 - SCHEDULE-I PART-IV B

Hippopus hippopus

Cassis cornuta

Cypracasis rufa

Tridacna squamosa

Nautilus pompilius

Charonia tritonis

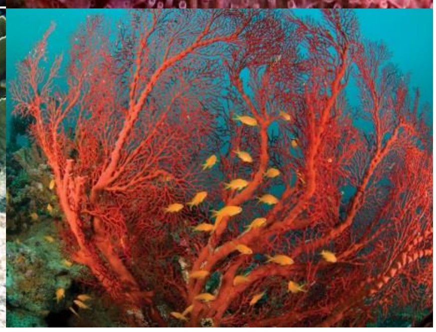
Tudicla spiralis

Tridacna maxima

Conus malneedwardsi

Coelenterates

(i) Reef Building Coral (All Scleractinians)
(ii) Black Coral (All Antipatharians)
(iii) Organ Pipe Coral (*Tubipora musica*)
(iv) Fire Coral (all *Millipora* Species)
(v) Sea Fan (All Gorgonians)



Echinodermata

Sea Cucumber (All Holothurians): There are some marine species which are facing threat, but due to lack of sufficient data on the species those species are not considered. In future there are chances of including more species in the list to protect them from extinction and to conserve the biodiversity of the country.

Mangrove ecosystem and its impact on fisheries

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Introduction

Mangrove formation is a tropical phenomenon confined to tropical coastal areas, and sometimes extends to sub-tropical or slightly beyond. Areas where mangroves occur include estuaries and marine shorelines. In comparison with the tropical rainforest biome which contains thousands of tree species, mangrove forests are less in diversity. But the ecosystem these trees create provides a home for a great variety of other organisms. Mangrove forests form an interface between marine and terrestrial environment.

Mangroves fall into two groups according to their habitats in nature: true mangroves and mangrove associates. True mangroves refer to species that specifically grow in intertidal zones, while mangrove associates are capable of occurring in either littoral or terrestrial habitats. Mangrove formations depend on terrestrial and tidal waters for their nourishment and silt deposits from upland erosion as substrate for support. Mangrove is one of the most productive ecosystems and a natural renewable resource (Kathiresan, 2003). An inventory of the existing mangroves at the global scale indicates a total cover of about 18 million ha, inhabiting in 118 countries and territories in the tropical and subtropical regions (Spalding 1997). Mangroves of South and Southeast Asia are the most extensive and diverse systems comprising 42% of global mangroves. Indian mangroves make up 3.1% of the total global, 3rd largest in Asia (7%), after Indonesia (63%) and Bangladesh (8%). The Indian mangroves are distributed along the east (59.6%) and western (27%) coasts and the Andaman & Nicobar islands (13.3%), covering an area of about 4461 sq. km along the 7,500 km long Indian coastline.

Occurrence of Mangroves in Karnataka

Karnataka coastline extends over a length of 320.km with numerous river mouths, lagoons, bays, creeks, cliffs, sand dunes and long beaches. On account of the Western Ghats there are 14 rivers flowing from east to west. None of them takes its rise as much as 35 km beyond the peak of Western Ghats as these Ghats are not more than 80 km from the sea. The course of the rivers does not exceed 150 to 160 km. The rainfall of south west monsoon combined with the broken nature of the area is responsible for number of rivers and streams and also great volume of water in them during monsoon. Sometimes heavy rains cause flooding of rivers but they also deposit fertilizing silt. There are six estuaries with more than 70,000 ha water spread area and 8,000 ha of brackish water area.

Mangroves in Karnataka coast grow well on silty and clayey muds or mixtures of these soils. Often they form soft muddy substrates under the influence of tidal range where mud is deposited naturally. Under the canopy of mangrovephytes the substrate undergo physico-chemical alterations which determine the formation of zones within the habitat. The factors responsible for zonation are: frequency of flooding by tides, soil types based on structure, salinity, nutrient content, permeability and drainage, plant interaction, iron-influx-efflux regulatory mechanism and animal interaction. Along the Indian coast the estuarine area consists of Mangrove and their associates. There are 14 true Mangrove species of Karnataka belonging to 7 families (Table1).

The important estuarine areas where mangroves are present in Dakshina Kannada are Netravathi-Gurupur, Mulki-Pavanje, Udayavara-Pangala, Swarna-Sita-Kodi, Chakra-Haladi-Kollur, Baindur hole and

Shiroor hole while in Uttarakannda the mangroves are present in the Venkatapur, Sharavathi, Aghanashini, Gangavali and Kali river estuarine complexes. The coverage of mangrove area in Karnataka is reported as 6000 ha (GOI 1997).

Table 1 Mangrove species available in Karnataka

Sl. No.	Family	Species
1	Acanthaceae	*Acanthus ilicifolius*
2	Avicenniaceae	*Avicennia marina Avicennia officinalis*
3	Combretaceae	*Lumnitzera racemosa*
4	Euphorbiaceae	*Excoecaria agallocha*
5	Myrsinaceae	*Aegiceras corniculatum*
6	Rhizophoraceae	*Bruguiera cylindrica* *Bruguiera gymnorrhiza* *Kandelia candel* *Rhizophora apiculata* *Rhizophora mucronata* *Ceriops decandra*
7	Sonneratiaceae	*Sonneratia alba* *Sonneratia caseolaris*

Adaptation of Mangrove plants

Mangrove plants require a number of physiological adaptations to overcome the problems of anoxia, high salinity and frequent tidal inundation. Each species has its own solutions to these problems. Small environmental variations within a mangrove ecosystem may lead to greatly differing methods for coping with the environment. Adaptations concerning above-ground breathing roots are essential for gas exchange in saturated, non-porous soils depleted in oxygen. Roots are also adapted to support above ground mass by growing lateral support structure. Some of the modifications of mangrove plants are as follows

1. Stilt roots: It is an intricate network of branching areal roots up to 3 m above the ground. Their formation is mostly confined to *Rhizophora* species. The main purpose of these roots is to support the tree from severe strain by tides and wind.
2. Aerial roots: The flexible slender roots of uniform thickness descending from the lower branches of the crown of *Rhizophora* sp., they do not take root. These are also observed in *Avicennia* group.

Fig. 1 Root adaptation in *Rhizophora mucronata*

3. Plankbuttress: Columnar trunk of certain mangroves like *Bruguiera* and *Ceriops* have flanged or buttressed with short plate like protuberances, at the basal portion. This increases the surface area at the base of the trunk for increased aeration and also for the support of the trunk.

4. Surface roots: Exposure of roots on the muddy surface is not common among the certain mangrove taxa. In *Ceriops tagal* the plank buttresses, however extend into roots which are vertically flattened irregularly. Their exposure on high ground enables them to absorb sufficient oxygen.
5. Pneumatophores: The vertical outgrowth protruding above the surface from the horizontal cable root system just below the level of the mud. The different types are pencil like, geniculate or knee like, knobby or tuberous.
6. Vivipary–production of live young: This assist is rapid attachment to the muddy substratum.
7. Succulence: This is another common feature which is in response to the presence of chloride.

Importance of mangroves

Mangroves are highly productive components of the food web of coastal ecosystem. Detritus of plant material serves as the basis of food web and contributes to the good quality of mangrove habitat. Many commercial finfish and shell fish species depend on mangrove habitat for part of their life cycle. An analysis of the impact of mangrove plants on marine carbon inventories suggests that the mangroves account for more than 10% of the terrestrially derived dissolved organic carbon transported to the ocean, while they cover only 0.1% of the continents' surface.

The unique ecosystem found in the intricate mesh of mangrove roots offers a region for young organisms. In areas where roots are permanently submerged, the organisms they host include algae, barnacles, oysters, sponges and bryozoans, which all require a hard surface for anchoring while they filter feed. Shrimps and mud lobsters use the muddy bottoms as their home. Mangrove crabs mulch the mangrove leaves, adding nutrients to the soil for other bottom feeders. In at least some cases, export of carbon fixed in mangroves is important in coastal food web.

The dense network of mangroves protects adjacent high lands from erosion and damage. However, mangrove swamps' protective value is sometimes overstated. Wave energy is typically low in areas where mangroves grow, so their effect on erosion can only be measured over long periods (Massel *et al.* 1999). Their capacity to limit high-energy wave erosion is limited to events such as storm surges and tsunamis (Mazda *et al.* 2005). Erosion often occurs on the outer sides of bends in river channels that wind through mangroves, while new stands of mangroves are appearing on the inner sides where sediment is accruing.

The vegetation acts as filter trapping sediments and litter which enter with the run-off from the upland areas (Fig 2). The trapping of sediments helps maintain water clarity, a factor important to clam, oyster and phytoplankton productivity. The mangroves assimilate pollutants and recycle nutrients through various biochemical processes. Sediment meiofauna feed directly on mangrove detritus. The composition of the meiofaunal community changes during the process of litter decay, suggesting that the community is responding to chemical changes in the leaves (Gee and Somerfield, 1997). A number of factors can affect the rate of litter decomposition and rates of nutrient cycling. Litter decomposition rates vary among mangrove species. *Avicennia* leaves are thinner and have fewer types of tannin hence decompose faster than those of other species (Sivakumar and Kathiresan, 1990). *Avicennia* leaves also sink and begin to decompose immediately whereas the leaves of other species (*Sonneratia* and *Rhizophora*) may float for several days (Wafar et al., 1997). Many birds also utilize mangrove habitat for their feeding and breeding. Mangrove habitats have also become important for the purpose of aquaculture.

Impact of destruction of Mangrove habitat

Mangrove habitats of India have been facing tremendous threats due to indiscriminate exploitation of mangrove resources for multiple uses like fodder, fuel wood, timber for building material, alcohol, paper, charcoal and medicine (Upadhyay *et a*l. 2002). It is estimated that about 75% of mangroves in Karnataka state is lost due to expansion of cultivation, deforestation and encroachment activities. The development of ports, sand mining, sewage discharge, construction of bridges, expansion of roads (Fig. 3&4), disposal of non-biodegradable waste all this has taken a heavy toll on our coastal ecosystem and biodiversity. As more mangroves are destroyed the litter transported to the seaward side will increase. The total suspended solids in the estuarine area especially during monsoon will be higher.

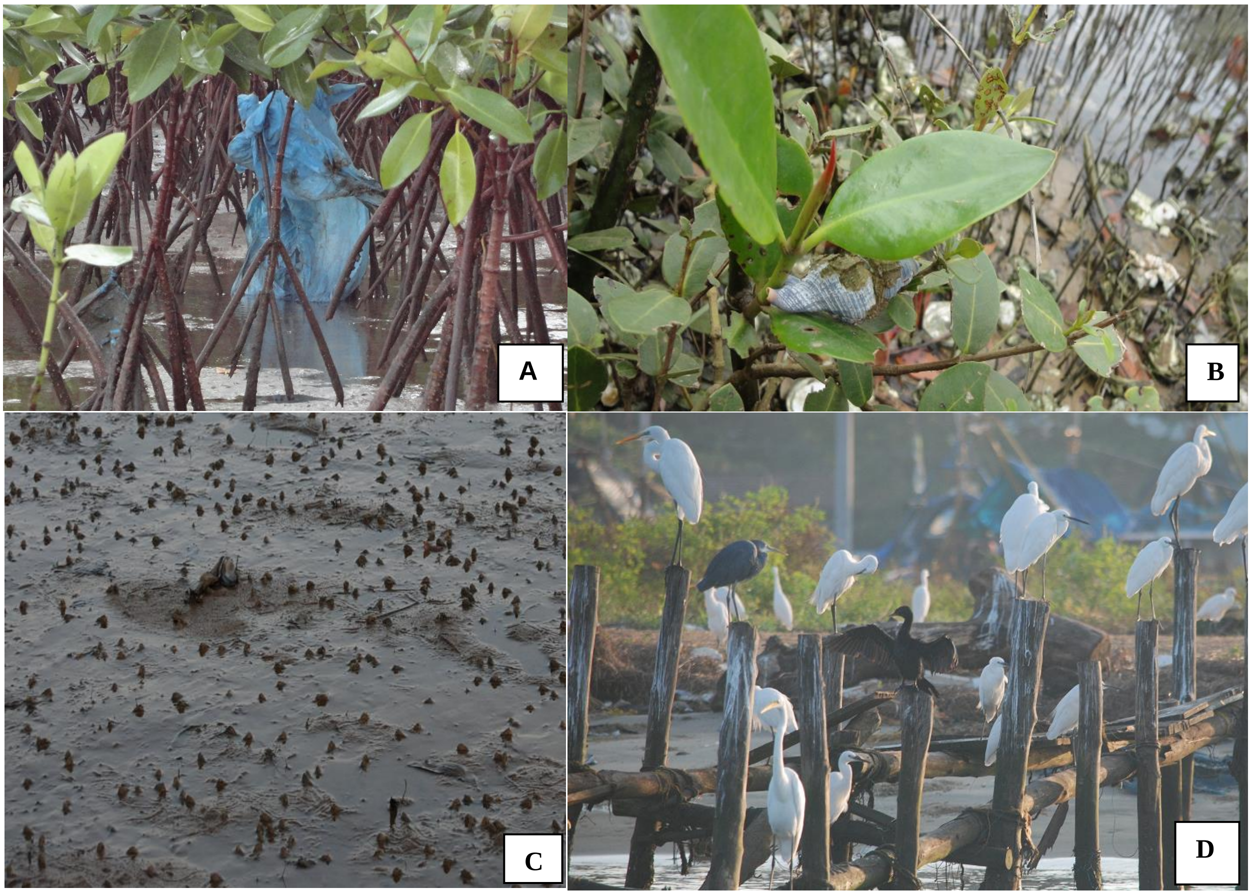

Fig 2. A - Trapping of litter, B - Gastropods and oysters, C - benthic organisms, D - Avian diversity

Fig. 3. Destruction of mangroves in Mulki for cultivation purpose

Lime shells are being removed from mangrove habitat, thereby the bottom becomes deep and the receding tides move faster causing the bank erosion. The soil in mangrove region consists of those washed down from the Ghats as well as by the tidal accumulation from the sea. In texture the soil varies from drift sand to loam and stiff clays. The areas occupied by *Acrostichum aureum* an apparently salt tolerant fresh water fern is an indication of degradation of mangrove ecosystem. The inorganic constituents of Mangrove soils from different estuaries show considerable variability. This is due to topographic erosion and also human activity.

Once established, mangrove roots provide an oyster habitat and slow water flow, thereby enhancing sediment deposition in areas where it is already occurring. The fine, anoxic sediments under mangroves act as sinks for a variety of heavy (trace) metals which colloidal particles in the sediments scavenged from the water. Mangrove removal disturbs these underlying sediments, often creating problems of trace metal contamination of seawater and biota.

Fig 4. Development activities on Western Ghats which could influence erosion rate

Regeneration programme

Regeneration of mangroves has become increasingly important in recent years due to varied development activities. Below are some of the factors which need to be considered for successful regeneration.

1. In *Rhizophora* species November and December are the starting point for flower buds production; propagules start emerging from January and attain maturity in May/June.
2. *Bruguiera* species starts flowering in the months of October and November and the propagules are ready for propogation in the month of April/May. *Ceriops* and *Kandelia* start flowering after the fall of monsoon rains and the propagules mature in the months of April/May.
3. Spacing for various species ranges from 50 cm to 150 cm. *Rhizophora mucronata* is planted at 1.5m x 1.5m.
4. The oviparous fruits of *Sonneratia* reproduce by seeds. At maturity the fruits drop down and the seeds are released by disintegration of fruit wall.
5. Sediment texture, water quality, tidal variation and suitability of the mangrove species to the area selected for planting are to be considered.
6. Initial stages the plant requires fresh water and suitable temperature hence the ideal sowing season will be just before monsoon.

Conclusion

For successful regeneration an understanding of the mangrove soils is essential. The reasons for destruction of natural ecosystem diversity in the areas have to be ascertained. Proper spacing and diversity of mangroves have to be taken into consideration when any regeneration programme is conducted. Curbing deforestation may be more effective than reforestation. In the last decade, a study in Thailand found that the cost of restoring mangroves was US $946 per hectare, while the cost for protecting existing mangroves was only US $189 per hectare (Ramsar Secretariat, 2001). In India, the estimated values for different functions of Bhitarkanika mangrove (Orissa), such as nutrient retention was US$ 865 /ha/year, offshore fishery US$ 37.97/hr, inshore fishery US$ 1.9/hr, fry collection US$ 0.2/ h; and storm abatement US$ 116.28/household (Iftekhar, 2008).

Mangrove forests are increasingly recognized as a valuable source of revenue therefore it should be easier to entice those who benefit from mangroves to make payments for the ecosystem services that they generate (Lavieren *et al*., 2012). As mangrove forests store significant amounts of carbon and are threatened by the economic allure of conversion, they could be ideal targets for carbon financing. Such initiatives and investment funds provide new opportunities to better protect natural capital, benefit communities, and utilize cost-effective green technologies to address the challenges of climate change.

References

Gee, J.M. and Somerfield, P.J. 1997. Do mangrove diversity and leaf litter decay promote meiofaunal d iversity? *Journal of Experimental Marine Biology and Ecology,* 218 (1) : 13-33.

Government of India. 1997. *The State of Forest Report. Forest Survey of India*, p. 5-6, 38. New Delhi, Ministry of Environment and Forests.

Kathiresan K. 2003. How do mangrove forests induce sedimentation? Rev. Biol. Trop. 51: 355-360.

Iftekhar, M.S. 2008. Functions and development of reforested mangrove areas: A review. *International Journal of Biodiversity Science and Management* 4(1) 1-14

Massel, S. R., Furukawa, K. and Brinkman R. M. 1999.Surface wave propagation in mangrove forests. *Fluid Dynamics Research* 24(4): pp. 219–249

Mazda, Y.; Kobashi, D. and Okada, S. 2005 Tidal-scale Hydrodynamics within Mangrove Swamps. *Wetlands Ecology and Management* 13(6): pp. 647-655

Upadhyay, V., Ranjan, R., Singh, J., 2002. Human-mangrove conflicts: The way out. *Curr Sci India* 83, 1328–1336.

Ramsar Secretariat, 2001. Wetland Values and Functions: Climate Change Mitigation. Gland, Switzerland. *http://www.ramsar.org*

Sivakumar, A. and Kathiresan, K. (1990). Phylloplane fungi from mangroves. *Indian Journal of Microbiolo gy*, 30(2) : 229-231

Spalding, M.D, Blasco, E and Field, CD. (Eds). 1997. World Mangrove Atlas. *The International Society for Mangrove Ecosystems*, Okinawa, Japan. 178 pp.

Lavieren, H., Spalding, M., Alongi, D., Kainuma, M., Clüsener-Godt, M., Zafar, A., 2012. Policy Brief: Securing the future of mangroves. United Nations University. Institute for Water, Environment and Health, Canada. http://unesdoc.unesco.org.

Wafar, S., Untawale, A.G. and Wafar, M. (1997). Litter fall and energy flux in a mangrove ecosystem. *Estuarine, Coastal and Shelf Science*, 44: 111-124.

Artificial Reefs

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Artificial reefs (AR) are natural or manmade external objects or stable structures placed in the sea to provide an artificial fish habitat and thereby to attract, aggregate and regenerate fishery resources. Artificial reefs are used worldwide to increase the productivity and fisheries potential of relatively barren or unproductive areas. They are also used as effective fish attracting devices during certain times of the year. Reefs when properly located and structured not only concentrate fishes but also increase the biological productivity of the area. Reefs also often serves as spawning and nursery areas for fishes and shellfishes.

History of Artificial reefs

Maritime countries all over the world has a rapidly increasing interest in artificial aquatic habitat enhancement technologies and 40 countries on 6 continents are using it today (Grove and Sonuj 1983). Artificial reefs and fish aggregating devices have been mainly used for three purposes; commercial fishing in Japan, sport fishing in United states and small scale fishery in a few Asian countries including India. Properly constructed reefs transform itself to convenient fishing grounds in a short span of time. FAD's have proved to be effective in commercial tuna fishing in the South East Asian countries.

Japan leads the world in the development of artificial fish habitat technologies for fisheries. The oldest record of an artificial reef in Japan dates back to 17th century when a reef was developed by dropping rocks into the sea. The declaration of EEZ (Exclusive Economic Zone) brought continuous decline in the fish production from distant fishing grounds. This prompted the country to invest extensively in the AR programme not only to increase the fish production but also to conserve the resources. At present Japan has the most intense and technologically advanced AR programme in the world. The total expenditure during 1988-1993 was in the order of $ 3 billion (Akira 1991).

In the United States, the earliest recorded history of AR construction dates back over 150 years. Reef building in the United States was initially promoted for sport fishing interests. Today AR's are constructed for sport fishing, commercial fishing, resource management, environmental mitigation, waste disposal and recycling, sport diving and tourism (Stone et al 1983). In Thailand AR's deployed adjacent to the coastal villages show increase in biomass and species diversity and substantial increase in the catches of traditional fishermen (Sinanuwong, 1991). In Philippines the use of Payaous increased the tuna catches tremendously. Payaous had improved exports and fishermen's status, reduced conflicts between artisanal and mechanized fishermen and increased local consumption of Tuna. (Apreito 1991). In Srilanka and Maldives use of FAD's are still in the experimental stages only.

Artificial reefs in India

In India artificial reef building technology was conceived and adopted by traditional fishermen. The potential of using AR's to increase the fisheries potential was first realized by NGO's working in the fisheries sector like South Indian Federation of Fishermen's Societies (SIFFS) Trivandrum, Programme for Community Organization (PCO) Trivandrum, Layola Social Service Centre Trivandrum, Murugappa Chettiar Research Centre (MCRC), Chennai and Centre for Research on New international Economic Order (CReNIEO), Chennai. These NGO's were largely responsible for mobilizing the fishermen and launching AR's close to a number of fishing villages in the South west and South east coast of the country in the 90's.Central Marine Research Institute (CMFRI), Kochi was involved in reef building programmes by monitoring the fish catches and assessing the productivity levels of the reefs along the Trivandrum coast. During the early 90's CMFRI installed one AR in Minicoy, Lakshadweep and another one in Tuticorin to study the resource generation in the reefs. Murugappa Chettiar Research Centre during these period installed on Hut shaped reef off Chennai. This reef was made of high density poly ethylene pipes. CReNIEO also installed on AR off Chennai using Concrete rings, Coconut leaves and tree trunks. Coconut leaves are tied to a rope and the rope was tied to the reef module on the bottom and to a marker buoy on the surface. Fishermen used lift nets to catch the fish from the reef area.

During 1996 Trainers Training Centre (TTC) of CMFRI conducted a national workshop on ARs and sea farming technologies at Kochi. This workshop discussed the reef building technology in detail and also recommended to the Central government to increase the allocation for reef building activities along the coast. During the year 1997 CMFRI installed two more artificial reefs off Vizhinjam. One reef was developed for lobster resources. Modules of this reef were developed by placing stoneware pipes arranged in a triangular fashion. Each module was 4’x4’ size and 100 modules were used in one reef. The second reef developed was for the fish resources made of triangular concrete modules. The lobster reef was installed about 500 meters away from the breakwater whereas the fish reef was installed about 1 kilometer away from the breakwater. Both the reefs are performing very well and are abound with fish resources. During 1998 CMFRI with the cooperation of the State fisheries department installed the largest AR (10000 M²) off Poovar in association with Loyola Social Service Centre, Trivandrum. More than 150 modules were used in this reef.

Till 1998 most of the reef building activities were restricted to the southern parts of Kerala and during 1999-2000 CMFRI installed another large reef (10000 m²) off Dharmadom in Kannur district of Kerala.This project was implemented with the involvement of the local bodies and fishermen community. The reef site was selected by them and the installation was completed during March 2001.This reef was considered as one of the Successful reefs as it generated plenty of resources. During 2001-2002 CMFRI developed two AR’s off Moodady and Thikkody in Kozhikode district of Kerala in association with the State fisheries department. Each reef was of 7500 m² areas made of 100 modules each. The Moodady reef was a fish reef whereas the Thikkody reef was a lobster reef of 100 modules made of PVC pipes built in a triangular concrete base. At both the places the fishermen themselves did reef building and the local body authorities provided the necessary support. As a novel exercise reef enrichment materials (Coconut leaves) were dumped in the reef area to attract fishes and shellfishes into the reef. The Thikkody reef built in the traditional lobster fishing grounds showed resurgence in the lobster fishery of the area.

During the year 2002-03 another reef was installed by CMFRI off Muttom in the Kannur district of Kerala. This reef (10,000 m²) was installed off Palakode in Muttom at a depth of about 24 meters close to a recent shipwreck in the area. This reef was also installed by involving the traditional fishermen of the area. Fish reef modules were alone used in this reef. Reef enrichment materials (6000 coconut leaves) were used to increase the biological productivity of the area. The AR building technology in India is an emerging one and needs strong support from the planners in a large way.

Artificial Reefs developed by Central Marine Fisheries Research Institute

Central Marine Fisheries Research Institute has designed and developed 50,000 M² reefs along the Kerala coast over the last 7 years in the following localities.

Reef and Funding Agency	**Year of Installation**	**Area m²**
Vizhinjam I.Trivandrum (CMFRI)	1997	2,500
Vizhinjam II.Trivandrum (CMFRI)	1997	2,500
Poovar, Trivandrum, (Department of Fisheries. Govt. of Kerala.)	1999	10,000
Dharmadom, Kannur, (Department of Fisheries. Govt. of Kerala.)	2000	10,000
Moodady, Kozhikode. (Department of Fisheries. Govt. of Kerala.)	2001-2002	7,500
Thikkody,.Kozhikode, (Department of Fisheries. Govt. of Kerala.)	2001-2002	7,500
Muttom, Kannur, (Department of Fisheries. Govt. of Kerala.)	2003	10,000
Total Area		**50,000**

Artificial reef modules are designed considering the following features of the reef site

- Depth of the water column.
- Nature of sea bottom (Sandy and muddy bottoms require different types of modules)
- Type of resource being targeted

The depth of the water column and the reef height has a direct relationship. It is generally accepted that the reef height should be at least one tenth of the water column height, for example if the depth of the water column is 15 m the height of the reef should be at least 1.5 m. Less than this the effectiveness of the reef decreases.

Muddy bottoms experience drifting of mud during monsoon months and the modules are prone to sink in mud eventually. In such circumstances periodic depositing of reef modules are required to maintain the effectiveness of the reef. Where as in sandy bottom modules are more stable and its effectiveness also remain year after year. Triangular modules of 1.5Mx1.5Mx1.5m with a 0.60x0.60m window on all sides are found more suitable to areas where strong water currents prevail during the monsoon months. Triangular modules maintain its position in the sea bottom irrespective of the way it reaches the bottom. Cubical modules also serve same purpose but are more costly. Concrete pipes, well rings and used tyres are all very cost effective materials in reef building. The following types of modules are designed and used in reef building in India.

- Triangular modules
- Rectangular box type modules
- Circular modules
- Tetra pods
- Concrete rings
- Old tyres fixed on a concrete bed
- Triangular or rectangular modules with PVC or stoneware pipes fitted inside.
- HDPE pipe structures

While designing resource specific reefs modules are designed to fulfill the behavioral requirement of the targeted species, for example while designing lobster reef module stoneware or PVC pipes are used in the module to provide hiding space to the animal. Lobsters normally reside in crevices where an easy escape opening is available. Hence both ends of the pipe are kept open so that it can escape in the event of a predator attacking it. Lobster reef provide new habitats for the juveniles to settle, grow and populate the entire reef. In fish reefs fishes aggregated initially will stay back because of the plentiful food availability and eventually breed and populate the reef and later form fishery resource in the adjoining fishing grounds.

Fabrication of reef modules

Reef modules are fabricated on shore very close to the reef site so as to minimize the cost of transportation. Modules are to be carried from the shore to the transportation platform by the fishermen and hence the weight should be minimal. Modules are fabricated either by reinforced concrete or ferrocement. When concrete is used 4mm weld mesh is used for reinforcement and in the case of Ferro cement chicken mesh is used for reinforcement. To reduce the thickness of the modules to 4-5CM, 0.5" granite jelly is used in the concrete. Each slab of the module is fabricated separately and joined later after completing the curing of the concrete. Curing is normally done for 12 days. Each slab of 1.5Mx1.5m is provided with a middle window of 0.60Mx0.60m.Dried slabs are joined together to form either triangular modules or rectangular box type modules as the case may be. While fabricating the modules care may be taken to maintain the cement, sand, jelly ratio as 1:2:4 for greater strength. While joining the slabs 2 mm tying wire is used for strong corners.

Fabrication of reef modules

Triangular modules ready for transportation (Poovar, Trivandrum)

Specially designed modules for lobster resources

Low cost modules (Old tyres mounted on concrete slabs, Poovar, Trivandrum)

Triangular modules on the beach (Muttom, Kannur)

Fishermen carrying the modules to the raft (Dharmadom, Kannur)

Modules being loaded onboard a catamaran (Vizhinjam I,Trivandrum)

Module loaded Catamaran pushed beyond wave breakers (Vizhinjam II, Trivandrum)

Catamarans with modules being towed to the reef site (Poovar, Trivandrum)

Arranging the catamarans on the raft before towing (Kozhikode)

Modules sliding down to reef site (Thikkody, Kozhikode)

Enriching the reef with materials of plant origin increases the productivity

Coconut leaves being transported to the reef site

Coconut leaves are deposited in the reef site in bundles anchored with stones

Creating awareness among the fishermen is a pre requisite for reef building

Reef building succeeds when it is a community activity

Transportation and Installation

Transportation and installation of the modules are the most important part in the reef building. While building small scale reefs funds are always a constraint and hence heavy machinery is not used at all. Moreover reef building along the Indian coast is nurtured as a community activity. This ensures greater participation of the fishermen community whose livelihood depends on the availability of fish resources. Reefs have a primary function of conserving the resources and hence reef building creates a sense of responsible fisheries among the fishermen.

Reef sites are normally 3-12 km away from the shore and transporting modules on boats has its own limitations. Although catamarans were used extensively in the transportation of modules in the south a major constraint faced was the number of modules a catamaran can carry (Normally only one module was placed onboard a catamaran causing inordinate delay in transportation). Considering these difficulties a bamboo raft was designed for module transportation in the northern Kerala. Eight oil barrels of 200 l capacity was used to float the raft of 3mx3m size and 2 modules were placed on the raft, which was towed to the reef site using a 15 HP outboard motor fitted plywood boat. Bamboo poles are used by 8 people to transport the module from the shore to the raft and then towed to the reef site. After reaching the reef site the modules are either lowered to the bottom by using a strong nylon rope or slided to the bottom from the top. While lowering the modules greater accuracy is achieved in reef building whereas while sliding down the modules are dispersed in the reef in a scattered manner. The earlier method is more costly. Using marker floats on 4 corners of the proposed reef marks the reef area. Marker floats helps the fishermen to locate the reef correctly while installation as well as in the subsequent period. Modules are placed from one end of the marked area to the other end. Reef modules are normally placed on the outer sides of the reef leaving the middle area free for depositing reef enrichment materials subsequently. Reefs require annual maintenance by way of dumping enrichment materials to maintain high productivity in the reef.

Enriching the reef and enrichment materials

Artificial reefs are artificial habitats where large-scale aggregation of the fishes takes place due to the availability of plentiful food organisms in the newly developed habitat however as time progress the size of the population increase and the food availability decreases. This results in decreasing the productivity of the reef. The best way to overcome this problem is by enriching the reef by dumping plant materials like coconut leaves, coconut stumps, palm leaves, freshly cut branches of trees or additional modules into the area. Plant material when decays, especially coconut or palm leaves, exudes a typical smell which attracts the fishes and fish food organisms to the reef area. This sudden availability of food in the reef provides sufficient food to the larvae and fingerlings of many organisms. The fishermen knew this since time immemorial and this is widely practiced both in fresh water as well as marine environments for aggregating fishes. This is also widely practiced by fishermen for catching the cuttlefishes and squids in north Malabar coasts.

Fishing Methods in the AR

The following gears are commonly for exploiting the resources available in the reef area

1. **Hooks &line**

   Hooks and lines used in the reef are mainly three types

a. **Long lining:** Long lining is mainly used for the flat needlefish *Abelennes hians, Carangoides* Spp., *Lethrinids, Snappers, Groupers, triggerfish, Rachycentron canadum* etc. There are three types of long lines *i.e.* Surface long lines, small bottom long lines and big bottom long lines.
b. **Mid-water Hand lines:** This is mostly used for catching small sized mid water fishes. The gear consists of 25-50 hooks tied at intervals to a main line. This gear is mainly used for catching fishes like scads, mackerels, trevellies and small tunas. The bait used is commonly artificial.
c. **Bottom hand jigging:** The gear consists of a lead rod of 300 g over which a silver or golden or multi coloured glittering cloth piece is rolled completely acting as a bait.4-5 hooks are firmly tied at one end of the bait and the main line passes through a hole on the other end. Single fishermen operate many lines at a time to cover a wider area. This gear is exclusively used for catching cuttlefishes.

2. **Gill Nets**

Gill net is a rectangular piece of netting with large mesh size. While in water column the net acts like a barrier and while the fishes, without noticing the barrier, tries to pass through it gets entangled in the gills (gilling). There are different variations of gill nets available all along the coast and depending upon the area in the water column where they are operated or the resource for which they are operated this gear is known in different names at different places. Netholi vala (Anchovy net), Ayila kollivala (Mackerel net), Chala vala (Sardine net), Kanatha vala (Tuna net) etc are all variations of gill nests

3. **Trammel nets**

These are triple layered nets with the outer layers having big mesh size (250mm) and the middle layer having a smaller mesh size (50mm). Locally known as discovala, this gear is commonly used for catching prawns, Skates, rays and flat fishes from the reef area.

4. **Seine nets**

This gear has wings and towing wraps in the front and a bag in the rear end. The wings direct the fishes to the bag as the boat moves forward. Locally known as thattumadi this gear is mostly used for pelagic fishes like anchovies, squids etc.

Fishing Season

Fishing in the AR is normally restricted to a 6-month period starting from October and ending in March. After the post monsoon season there is a gradual decrease in the catches in the inshore waters starting from October, locally known as *Panjamasom (means months of starvation)*. It is during these months that the fishermen depend on the ARs for their livelihood. Fish catches in the reef decreases from February and by March catches will be very poor. Whereas fish catches in the open waters increases from

February onwards and fishermen move from reef area to open waters during these period. Thus the traditional fishermen regulate the exploitation of the resources in the reef area and open waters judiciously throughout the year. This conservation minded exploitation protects the resources to a greater extend. However, when the mechanized fleet invades the coastal waters this balance disappears.

Major resources exploited from the artificial reef area

D'Cruz (1995) reported that *Atule mate* belonging to the family carangidae dominated the species composition of the fish catches from the Valiathura reef (41.25%) followed by *Priacanthus spp* (12.97%), Mackeral (10.30%), Balistids (6.5%) and others forming the rest. Cuttlefish one of the important resource available in the reef formed 0.60%. In reefs where enriching is done, the cuttlefish catches can be increased many times. In general resources from the reef mostly consists of *Atule mate, Priacanthus spp, Rastroliger kanagurta, Abalistes stellatus, Odonus niger, Abalennes hians, Lethrinus nebulosus, L.lentjan, Deccapteres Russellii, D.macrosoma, Carangoides spp, Lutjanus lutjanus, Carangoides gymnostethus, Megalopsis cordyla, sepia pharaonis, Epenepheleus malabaricus, E.tauvina, Acanthurus spp, Dussumeria accuta, Sillago sihama* and others. Although the abundance of these species varies from month to month these are the major resources forming the fishery in the ARs.

Socio economic aspects of ARs

Artificial reefs increase the fish availability in the coastal waters and thereby increase the employment opportunity of the artisanal fishermen. AR's also play a greater role in conserving the resources by preventing mechanized vessels fishing in the inshore waters and depriving the livelihood of small and marginal fishermen. AR's are more significant in areas where traditional fisher folks face resource depletion due to over fishing or mechanized fishing. Reefs provide additional habitat for fishes as well as fish food organisms to attach and grow. Additional food invariably attracts smaller fishes to the reef which will eventually attract larger fishes. These fishes reproduce and populate the reef forming fishery resource to the traditional fishermen using hooks and lines and other minor gears. Artificial reefs are thus required to ensure a stable and dependable livelihood to the traditional fishermen and also to ensure the conservation and management of our valuable coastal fishery resources.

References

Akira Nakamae (1991) Artificial reef and fish aggregating devices in South East Asian fisheries: Management issues. Indo-Pacific fishery commission, Paper presented at the symposium on artificial reefs and fish aggregating devices as tools for the management and enhancement of marine fishery Resources, Colombo, Srilanka 14-17, May 1990. RAPA REPORT: 1991/11,pp 153-161.

Aprieto V.L (1991) Payao, Tuna aggregating devices in the Philippines. Indo-Pacific Fishery commission. Paper presented at the Symposium on artificial reefs and fish aggregating Devices as tools for the management and enhancement of marine fishery resources, Colombo, Srilanka 14-17, May 1990. RAPA REPORT: 1991/11, pp 1-7.

Robert G.S. and Choule S.J. (1983) Artificial fish habitat Technology in the world-Today and Tomorrow. Paper presented at Japan-US Symposium on artificial habitat for fisheries, Proceedings 1991 Tokyo, Japan, pp 3-9.

Sinanuwong Khian (1991). Artificial reefs in Thailand Paper presented at the Symposium on artificial reefs and fish aggregating devices as tools for the management and enhancement of marine fishery resources, Colombo, Srilanka 14-17,May 1990.RAPA REPORT: 1991/11,pp 340-347.

Richard, S.B., G.S. Robert and S.J. Choule (1983). Artificial fish habitat technology in the United States-Today and Tommorow. Paper Presented at Japan-US symposium on artificial habitat for fisheries, Proceedings 1991 Tokyo, Japan, pp 21-27.

D'Cruz Tito. (1995) Artificial fish habitats, Impact on artisanal fisheries Book Published by South Indian Federation of Fishermen Societies, Trivandrum, 1995.

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Awareness program on the '*Impact of the aggregating devices on cuttlefish fishery*'
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