Evolution of Fisheries and Aquaculture in India

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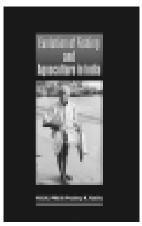

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Published by

Prof. (Dr.) Mohan Joseph Modayil
Director
Central Marine Fisheries Research Institute, Kochi - 682 018

Pillai, N.G.K and Pradeep K. Katiha 2004. *Evolution of Fisheries and Aquaculture in India*, p 240. Central Marine Fisheries Research Institute, Kochi - 18, India

ISBN : 81-901219-4-4

Printed at
Niseema Printers and Publishers
Kochi - 18

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* authorship in alphabetical order

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Profile of marine fishing practices, mariculture and post-harvest technologies

Marine Fishing Practices

The methods of capturing marine fish resources depend largely upon the habit and habitat of the species constituting the resources. Based on these criteria, marine fisheries resources are grouped under three categories, namely (1) sessile resources, (2) pelagic resources and (3) demersal resources. The organisms which are attached to some hard substratum during the exploitable phase of their life may be termed as sessile resources, such as seaweeds, oysters, mussels, etc. The free resources living in the water masses specifically, at the surface and subsurface waters are called pelagic resources and those found at the benthic realm are called demersal resources. The pelagic and demersal groups may be further subdivided into coastal/neritic-pelagic and offshore/oceanic-pelagic as well as coastal/inshore demersal and offshore/oceanic demersal resources. The inshore or neritic region is usually termed for the area upto the edge of the continental shelf and the offshore or oceanic region is outside this limit.

Fishing craft technologies

Marine fisheries operations prior to 1950 was mainly a subsistence activity which remained restricted to operations by only the artisanal craft and gear in the nearshore waters but considering the importance of fisheries as a source of protein, employment and foreign exchange, large scale R&D efforts were initiated by the central and state governments aimed at developing the fisheries sector. Fisheries which became a focal theme of Five Year Plans of the government resulted in the introduction and popularization of mechanized fishing vessels and modern gear materials during I and II Five Year Plans (1951-1960) ; increase in the use of synthetic gear materials during the III Five Year Plan (1974-1978) ; introduction of purseseining during V Five Year Plan (1974-1978); motorization of artisanal craft in 1979 ; rapid popularisation of ring seine gear operations by motorised artisanal fleet during 1985-1996 (Devaraj *et al.,* 1997). This resulted in a phenomenal growth in the annual marine fish production from 0.6 million t in the fifties to 2.7 million t in the nineties (Fig. 34).

The details of fishing crafts employed along the coast of India are given below:

Artisanal crafts

Catamarans: The simplest type of fishing craft made by a few curved logs of wood joined together forming a kind of floating raft, such as the ones used along the east coast of India (Fig. 37.2A). There are two types of catamarans, ' 3-log' and '4-log'. They are mainly operated along the south-west and south-east Indian peninsula. These 10-25 feet long units operate monofilament gill nets (12-50 mm), traps, cast nets, hooks and line, and also for handpicking of molluscs.

Dugout canoes: A simple type of fishing craft for fishing within short distance from the coast made by scooping logs of wood in the form of a boat (Fig. 37B). Traditionally small dugout canoes less than 18 feet are used to operate gill nets (12-40mm), traps, cast nets, hooks and line, and to handpick molluscs.

Plank- built canoes: This is an enlarged variety of dug-out canoe made of planks on the sides largely used in southeast and southwest coasts. These units are 15-40 feet long. They are used to operate shore seines, gill nets (12-40mm), traps, cast nets, hooks and line, and mussel fishing.

The target groups of traditional craft (Fig. 37.1) fishing include elasmobranchs, perches, sciaenids, mackerel, sardines, anchovies, lobsters, crabs, shrimps, bivalves and gastropods.

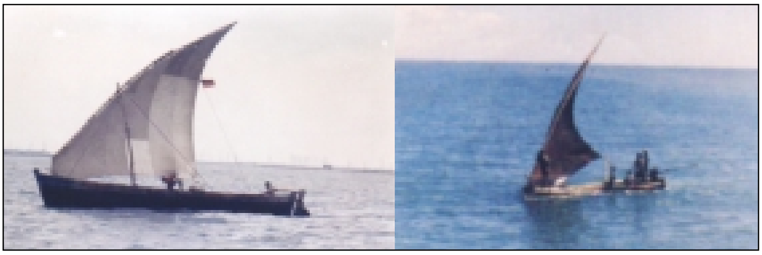


Fig. 37.1. Traditional fishing crafts

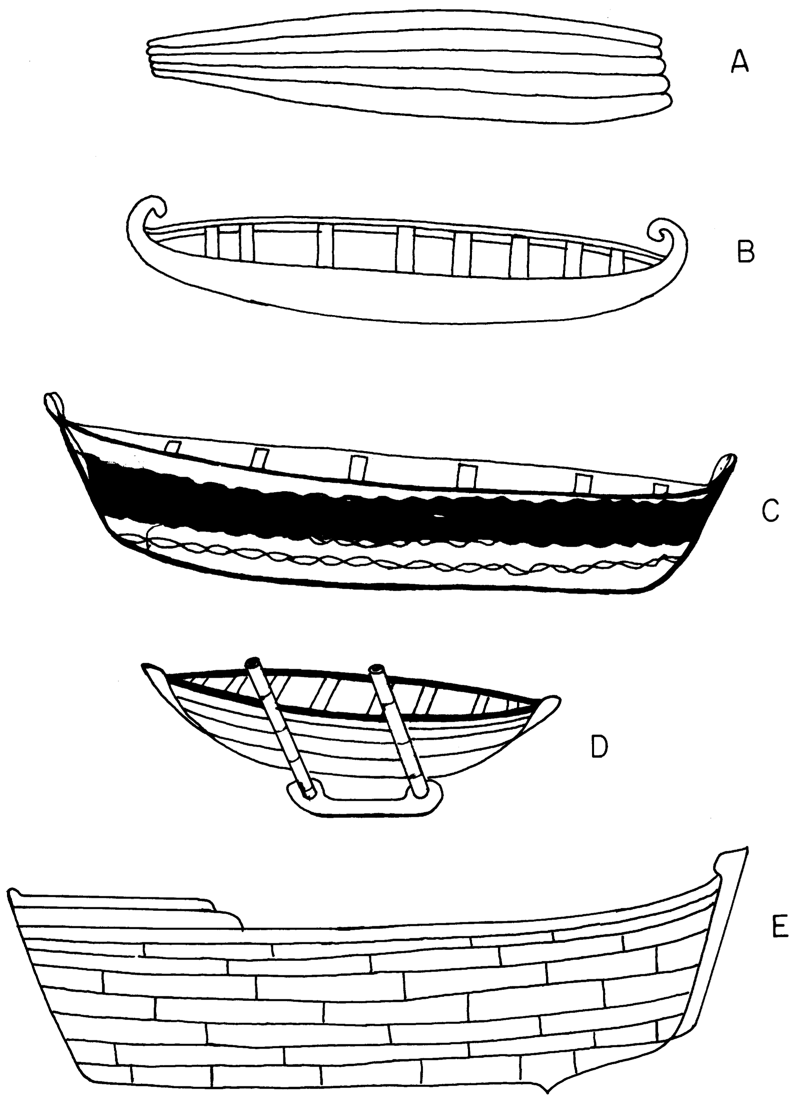


Fig. 37.2. Sketches of some traditional fishing crafts of India
(A) *Catamaran;* (B) Dug-out canoe; (C) *Masula* Boat;
(d) Outrigger canoe; (E) Built-up boat

Motorised crafts

Small outboard crafts (fitted with one outboard (OB) engine)

Catamarans: Motorised catamarans are propelled by 2h.p. outboard engine. They fish using trammel net, hooks and line, boat seines and gillnets (12-40mm) for carangids, sharks, seerfishes and flying fishes.

Dugout canoes: These are powered by 2 - 9.9h.p. OB engines and are 18-30 feet long. Shrimps, sardines, seerfishes, mackerel, sharks etc. are caught while operating gears such as gill nets (12-70 mm mesh), mini-trawl nets and ring seines (12mm mesh).

Plank–built canoes: These 15-40 feet long crafts are powered by 2-25h.p. OB engine. Gears like gillnets (12-70mm), hooks and line etc. are operated from these units to catch sardines, mackerel, anchovies and others.

Plank-built boat: They are 25-30 feet long and propelled by 8-15h.p. OB engine. Gill nets (mesh size 12-70mm) as well as mini-trawl nets (15-20m long; mesh 15-20mm) are operated from these units for catching coastal species like anchovies, sardines, mackerel, sharks, shrimps and others.

Plank – transom canoes (Mini/ pelagic trawl units): Plank-transom units were introduced in the 1980s, which were initially made by cutting transversely into two, in the middle of a large plank built boat. Mini trawl net is operated from this craft for catching coastal shrimps, flat fishes, croakers etc.

Small plywood boats: These are late introductions to the marine fishing sector. They are up to 40 feet long, propelled by an OB engine of 8-5h.p. They are used to operate drift nets (60-70mm), hooks and line, mini-trawl etc. Pomfrets, carangids, seerfishes, tunas, perches, mackerel, sardines and shrimps are caught.

Large outboard crafts (fitted with more than one outboard engine)

Ring seine units (Fig. 38) : Plank-built canoes with a length range of 25-70 feet use multiple OB engine units to get a collective power of 34.9(25+9.9) – 120(40x3) h.p. They are mainly used for ring seine

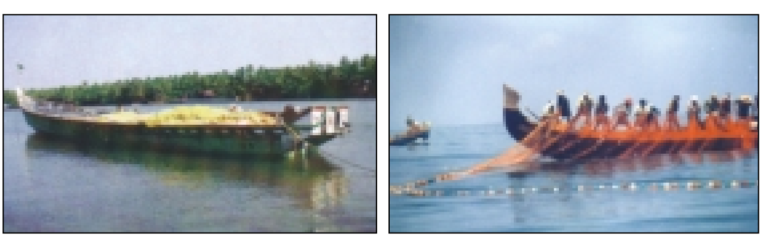


Fig. 38. Motorised ring seine units

(18-22mm mesh) operations for fishing anchovies, sardines, mackerel, carangids, shrimps and others.

Large plywood boats: These large boats of 30-40 feet and 40-57 feet length, are normally fitted with two OB engine units with a propelling power of 40 (25+15) to 65 (25+40) h.p. and are mainly used for ring seine (18-22mm mesh) operations for fishing anchovies, sardines, mackerel, shrimps etc. The smaller boats among these also function as carrier boats for ring seine units. Some plank-built as well as plywood units fitted with either inboard or outboard engines have started using mechanical winches for their operations.

Beach landing crafts (BLC)

BLC are mostly carrying out fishing operations in the inshore at 50-70 m depths with only a few operating in the outer reaches of the continental shelf. They are targetting high unit value fishes like sharks (using drift / bottom longlines) and seerfishes (using large mesh HDPE drift gill nets). The access to good fishing grounds where high unit value fishes occur, access to basic shore infrastructure like repair and marketing facilities and the skills of the fishermen in operating and maintaining the craft and employing diverse fishing methods are critical factors in determining earnings from BLC. The cost of the most popular version of BLC, the IND-20 including gears like drift net and longline was Rupees 190,000 – 200,000 (in 1993) and introduction of the craft was carried out through various state-sponsored schemes like the Hire Purchase Scheme (HPS), National Co-operative Development Corporation Scheme (NCDC) and District Rural Development Agency (DRDA) during 1985-89. The BOBP advocated that the target beneficiary of a BLC should be an enterprising small-scale fisherman as this would ensure the upward mobility of the selected fisherman as well as ensure full time employment to several small-scale fishermen as crew in this efficiently operated BLC. The BOBP experience in India as well as other countries in the Bay of Bengal region was that 'collective ownership and operation of this type of fishing craft is unworkable.' It also recommended that while introducing BLC it should be borne in mind that to be economically viable the craft had to achieve high levels of productivity and earnings as their capital and operating costs were higher than the craft they were replacing. Thus innovative fishermen who had the capacity to operate in more distant fishing grounds should be target beneficiaries and the fishing centres where these crafts are to be introduced should have repair facilities especially for engines so that loss of fishing days will be minimum and does not affect the economic viability of the craft.

A substantial spin-off from the beachcraft development has been the proliferation of FRP craft construction technology on the east coast. Prior to 1979, there was no FRP construction of small marine fishing craft but since then nine boatyards on the east coast took up FRP craft construction and some of these even took initiative to produce other small fishing crafts like FRP *nava* and FRP *teppa*. The idea of using motorized craft also spread among fishermen as a direct result of Beachlanding craft development (BCD) trial operations and subsequent commercial introduction of the BLC. It also became practical with the availability of small marine diesel engines that were originally developed for BLC. Thus motorisation of the dinghy in Orissa and the *nava* in Andhra Pradesh was carried out. Other spin-off from the BCD programme has been the location of less-exploited off-shore resources of larger flying fishes, sharks, tunas and billfishes; increasing use of drift longlines for shark fishing and emergence of new production centres catering to the demand for salted shark meat (in Kerala), seerfish (in Delhi) and shark fins for export to southeast Asian countries.

It is reported that there is no conflicts of operators of BLC and traditional crafts along the east coast. As regards the impact of the BLC operations on the resources, the targetted fishes are mostly sharks and seerfishes. Sharks especially due to their longevity and low and delayed reproductive behaviour are vulnerable to excessive fishing pressure. The rising catches especially of high unit value fishes like sharks by BLCs has increased their popularity and it is certain that more of these crafts will be introduced. Along the Andhra Pradesh and Tamilnadu coast, main investment in these crafts has been through government-sponsored institutional credit schemes. In Orissa it was by individual affluent traditional fishermen supplemented in some cases with informal credit and subsequently from the high earnings generated by BLC (BOBP, 1993). It has therefore become very important to monitor these fishing operations. Unfortunately, the mechanisms to do so are not yet adequate.

Mechanised crafts

Dol netters: *Dol* netting is mainly done along the northwest coast of India at depths 15-35m. Length of *Dol* net varies from 40-80m with a mesh size of 20mm at the cod end. The fishing crafts used for *Dol* netting are of 10-15m length. Earlier fishermen use sailboats, but now 20-88 h.p. inboard engines propel the boats. Some use mechanical winches for operations. Based on the net carried by a single craft, *Dol* netters are classified into two-net, three-net and four-net units. The catches include Bombay duck, pomfrets, catfishes, sciaenids, ribbonfishes, clupeids, *Acetes* spp. and others.

Trawlers: Trawlers are 9.6-40m long crafts fitted with an inboard engine (Fig. 39). Trawl nets are 37-46m long with a cod end mesh size of 15-30 mm according to the species caught. Mechanical winches are used to haul trawl nets. Two types of trawl in practice are beam and otter trawl, the latter being most popular. Stern trawling and pair trawling are later introductions in the technique. Species caught include shrimps, threadfin breams, sciaenids, flatfishes, mackerel and others. The mini trawler is shown in Fig. 40.

Fig. 39. Trawler

Fig. 40. Mini trawler

Ring seine units with inboard engine: These units are innovations in late 90s. These 30-70 feet long large plank-built boats use 85-120 h.p. in-board Leyland diesel engines. They operate ring seines (18-22mm) and are known to have mechanical winches. The catches include sardines, mackerel, shrimps, anchovies, whitefish, sciaenids and others.

Mechanised gill-netter: The crafts are 7-10.5m long and use mechanical haulers to haul gill nets of 800-1000m lengths, with a mesh size of 70-130mm. Target species include sharks, seerfishes and tunas.

Purse seiner: Purse seines are 600m long with a mesh of 8-33mm. They are operated by vessels of OAL 11.5-15m (Fig. 41). Incorporation of purse winch, and use of brailer and synthetic gear material have increased the efficiency of these units. They fish tunas, sardines, mackerel, catfishes, shrimps and others.

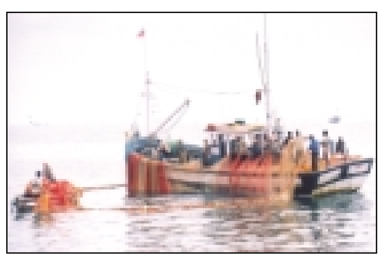


Fig. 41. Purse seiner

Pole and liner: Pole and line (Fig. 42) fishing is widely practised in Lakshadweep waters for tuna fishing. 3-4.5m long bamboo or fibre poles and a line of equal length with barbless hooks are used for fishing. Prior to fishing live baits are collected and kept alive in the bait-wells of the craft. Crafts are plank built boats with a stern platform and an in-board engine up to 120 h.p. Once tuna shoals are sighted, live-baits are thrown into the water to attract the shoal and bring them to a feeding frenzy. Simultaneously, water is either splashed with sticks or with the help of a pump and lines with barbless hooks are dropped into the shoal. Once the fish is hooked, it is lifted and thrown into the boat at brisk pace.


Fig. 42. Pole and line fishing

Long liner: Long lining is done from mechanised (Fig. 43) or non-mechanised (Fig. 44N) vessels. Length of main line varies with the type of operation planned. Branch line is about 20-25m. Each branch line carries a baited hook. Recently, vessels are known to use mechanical haulers. Long liners catch sharks, perches, tunas, bill fishes, barracudas and others.

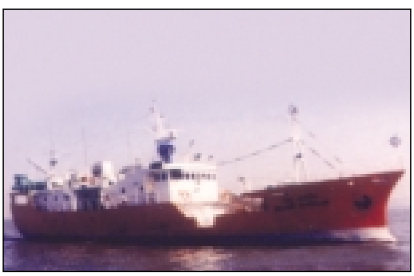


Fig. 43. Long liner

Recent advances in the marine fishing sector include fibreglass fishing crafts for inshore fishing, fuel-efficient propellers for medium- sized fishing vessels and 15.5m multi-purpose craft with steel hull for deep-sea fishing. Development of technologies for proper maintenance and preservation of crafts and gear are also making rapid advance. Some of these innovative technologies have originated within the fishing community itself. With the assistance from R&D organizations the fishers are in a constant quest for improvements in their day-to-day fishing activities that may lead to their economic empowerment.

Fishing gear technologies

For sessile organisms: Perhaps, the most primitive method of fishing was with hand for gathering edible oysters, mussels and clams as well as for picking shrimps, which is practiced in backwaters and estuaries even today (Fig. 44A). In modern times, hoes, dredges, chisel, knives, shovels etc. are also used for collecting oysters, mussels, clams, etc.

Coastal pelagic fishing gears : Usually, fishing nets are used, which are made of cotton yarn for smaller nets and hemp or other special yarns for larger nets. With the advent of nonrotting synthetic fibres, nets made up of synthetic twines, which are more durable than cotton yarn and easier to maintain, have become popular. Coastal pelagic fishing gears are of different types, as dealt with below.

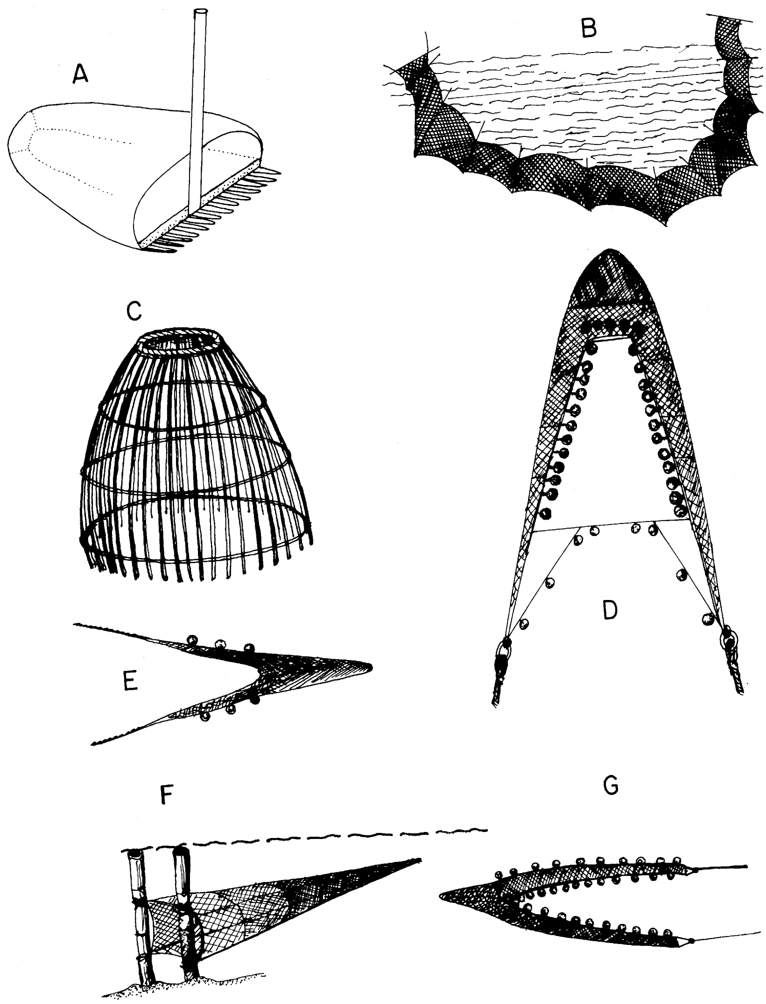


Fig. 44. Some common traditional fishing gears
(A) Mussel collecting rake with bag net; (B) One kind of stationary net, *Kalam-katti vala*; (C) Cover pot trap called *Ootha*; (D) Boat-seine, *Kollivala*; (E) Bag net, *Thoori valai* ; (F) *Dol* net; (G) Shore-seine

(i) **Fixed Nets:** These are usually rectangular or conical in shape and have a wide variety of sizes. They are fixed in the tidal regions of inshore waters during low tide with stakes, floats and sinkers. The high tide brings fish into the net; and when the tide recedes, they are trapped inside. *Kalam Kattivalai* of Tamil Nadu (Fig. 44B), *Pattabela* of Andhra Pradesh, Chinese dip nets and stake nets of Kerala, etc are included in this category.

(ii) **Traps:** Different types of traps are used to trap perches, lobsters, mullets, shrimps, etc. The simplest type is a dome-shaped or conical one made of split bamboo used in many parts of the world (Fig. 44C).

(iii) **Boat seines:** Boat seines are usually simple, conical nets without wings, the meshes increasing in size from the bag region to the flanks, such as the *thuri valai* of Tamil Nadu (Fig. 44E). These are dragged in water like trawls for capturing shoals. The well known boat seines are *Kollivala (Arakolli)* of Malabar coast used for capturing oil sardine, mackerel, etc (Fig. 44D). A specially made boat-seine is *Mathikollivala* used for the *Kollivala* capture of oil sardine under a panic impulse by beating the sides of boats.

(iv) **Bag nets:** Bag nets are operated either from 2 or 4 boats. After encircling a fish shoal, they are operated like a purse seine. *Eda valai* of Tamil Nadu is a good example of bag net. Fixed bag nets such as *Dol* net are used in Maharashtra and Gujarat (Fig. 44F).

(v) **Shore-seines and inshore dragnets:** These are used to capture fishes in the shore areas. These nets contain a bag with two wings as exemplified by *Karavalai* or *Olavalai* of Tamil Nadu and Kerala coasts (Fig. 44G).

(vi) **Cast nets:** Used almost universally, the conical cast nets are either stringed or unstringed and are spread out while thrown over the fish, trapping them (Fig. 44H).

(vii) **Drift nets and Gill nets:** These are vertical wall-like nets of various sizes and meshes, made of cotton, hemp or synthetic twine and provided with sinkers and floats (Fig. 44 I). Fishes which swim across the net are entangled and gilled in the meshes. Certain entangling nets (without gilling) have three layers (two outer layers with larger mesh and an inner layer with smaller mesh) called trammel nets, for capturing shrimps.

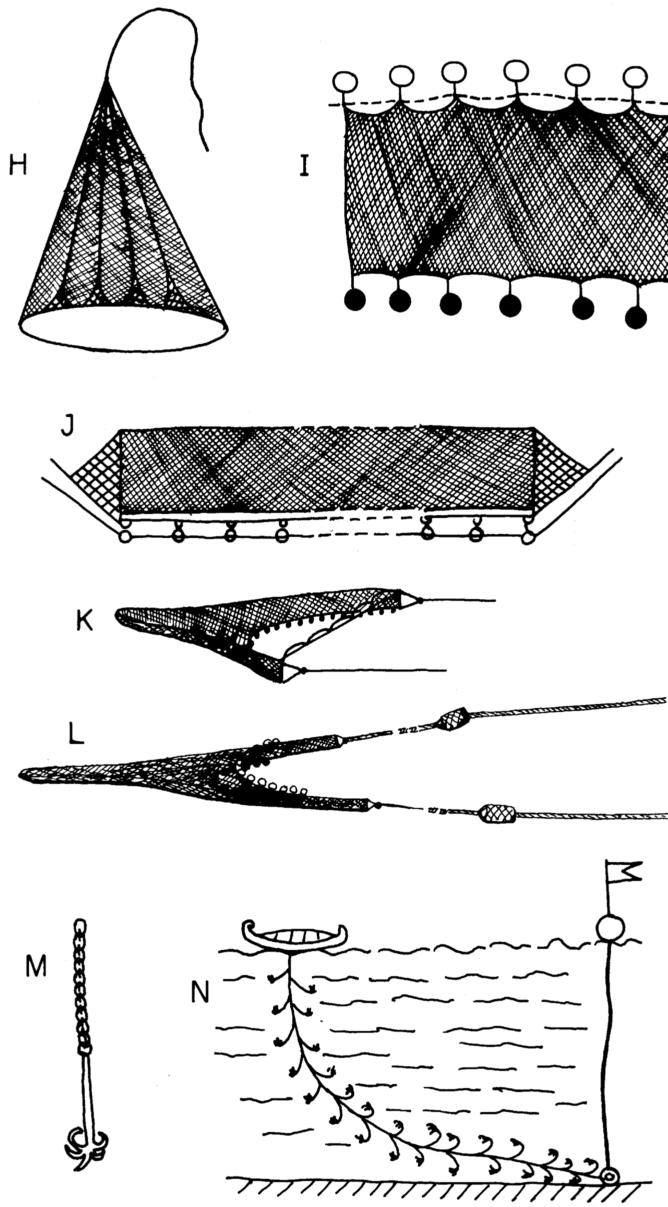


Fig. 44. Some traditional and modern fishing gears
(H) Cast net; (I) A simple gill/drift net; (J) Diagram of a simple purse-seine net;
(K) A simple beam trawl net; (L) A bottom trawl net using otter boards;
(M) Baited hook for lobsters; (N) A simple long-line system of hooks.

(viii) Ring nets and Purse-seines: These are used to encircle fish shoals and are hung vertically by a pair of vessels. When a shoal is sighted, one vessel encircles it by paying out the net and the two crafts tow the net forward with the shoal inside. After fully encircling, the bottom of the net is closed as in a stringed purse by messenger ropes (Fig. 44J).

(ix) Hooks and Lines: Baited hooks attached to poles, lines, hand lines and long lines are used to capture sharks, perches, carangids, tunas, seerfishes, mackerel, lobsters etc. (Fig. 44M).

(x) Troll lines: These are operated from catamarans or plank-built boats fitted with or without OB engines. Cotton or nylon monofilament of 40-50m length and 1.5 mm diameter with barbed hooks are used for trolling. Hooks are baited and covered by silk, coconut or synthetic fibres at the time of fishing. Usually three lines are released at a time. Trolling targets species like tunas, seerfishes, barracuda, dolphin fish and others.

Coastal Demersal Fishing Gear: Coastal demersal fishing gears are designed to scrap at the bottom for fish populations present at the substratum. The chief types are given below :

(i) Beam trawls: Beam trawls are operated from small boats in inshore fisheries. It is a tapering bag of netting with the mouth of the bag held open by a long beam supported above the sea bed by a pair of metal runners. The hind part of the trawl net tapers to the cod end (Fig. 44K).

(ii) Otter trawls: This is the chief method employed for demersal fishing. It resembles the beam trawl in all features, but the beam is absent here and the sides of a bag are extended outwards and attached to large rectangular wooden boards called "otter boards". The otter boards are towed by a pair of steel cables from the vessel, causing water to diverge and keeping the mouth of the net wide open (Fig. 44L).

(iii) Mini trawls : Mini trawl net, introduced recently is a seasonal gear mainly operated by the dugout canoes as well as the plank-built boats fitted with outboard engines of 8-9.5 h.p. They are nylon nets with two otter boards mainly intended to harvest the shrimps available in shallow waters. In the mini trawl operation, capture is effected by filtering the passive prey by the actively moving gear. Manpower employed in each unit is 2-4 persons and usually the net is operated for 1 to 1½ hours per haul. Important resources caught by this gear are penaeid shrimps, flatfishes, carangids, silverbellies, stomatopods, croakers and crabs.

Offshore Pelagic Fishing Gears: For capturing pelagic fishes such as sharks, tunas, seerfishes, billfishes etc, driftnets are used. These are usually shot before dusk and the fishes get entangled or gilled to the meshes as they attempt to swim through. The net is hauled up before dawn. For capturing pelagic shoals in offshore waters large sized purse seines may be used. Baited hooks and lines and long lines with baited hooks are also used (Fig. 44N); and sometimes multiple towing of hooks and line gear called "trolling" is also used. Besides, mid-water trawling operations are also undertaken.

Miscellaneous Fishing Gears: A number of miscellaneous methods of fishing such as harpooning, spearing, roping etc. are used in certain areas depending upon local conditions.

Mechanisation of fishing craft stimulated the development of suitable net-making materials that are stronger than cotton and also helped evolution of suitable nets for various types/sizes of boats. The advent of synthetic fibres was a land-mark in fishing gear development in the country. The non-rotting characteristic of the synthetic fibres resulted in an increase in the life-span of the nets to about three years, compared to one or two years for the traditional cotton nets. It also helped the fishermen in dispensing with the laborious and expensive process of rot-proofing. The synthetic twines also possess some of the essential properties required for nets such as the fineness, pliability, elasticity, durability and invisibility for gillnets (Fig. 45) and fineness for trawl nets to minimise hydraulic resistance. Choice of fishing gear based on biological, behavioural and distribution characteristics of the target species are given in Table 61.

Fig. 45. Gill net units

Table 61. Choice of fishing gear based on biological, behavioral and distribution characteristics of the target species

Biological, behavioural and distribution characteristics of fishes	Choice of fishing gear
Large demersal/ pelagic fishes with sparse and scattered distribution (sharks, rays, groupers)	Bottom set longline, gill nets, hand lines, traps and bottom/ mid-water trawls
Small demersal fishes (breams, snappers, croakers, soles and flatfishes, lobsters, shrimps etc.)	Gill nets, traps, trawls
Small pelagic schooling fishes (sardines, mackerel, carangids, coastal tunas)	Purse seines, ring seines and mid-water trawls
Large pelagics (tunas and sharks)	Troll lines, longlines, drift gill nets
Light attracted finfishes and cephalopods	Light attracted dipnets, purse seines and squid jigging
Fish aggregated by FADs	Purseseines, handlines and gill nets

Source: CMFRI, 1997a

Initially, mechanised boats were using indigenous gears. The manufacture of multifilament nylon yarn (polyamide group of fibres) in India started only in 1962. Manufacturing of polyethylene and nylon mono-filaments for making fishing nets started later. By 1977 four net-making plants had been set up in the public sector with a capacity to manufacture over 400 tonnes of twine from nylon yarn per year. Besides, there were four small units in the private sector and four licenced firms (large units) manufacturing nylon nets (Korakkandy, 1994).

Today, the entire fisheries sector uses only synthetic fibres for gears as twisted netting yarns and braided netting yarns of different sizes are available in the country. Combination rope of Polyethylene and Polypropylene (Danline) and Polyamide monofilament is being extensively used as an import substitute for tuna and shark longlines. Fishing hooks and snood wires of international standards are also available in the market which are either made by SSI units or under technical collaboration with foreign manufacturers (George, 1998).

Another technology that has become highly popular among traditional lobster fishermen especially along the southwest coast of India is the new CIFT designed lobster trap which is 70 x 55 x 40 cm size fabricated out of MS rod frame coated with plastic to prevent corrosion and mounted with a 2.5 cm square welded mesh. Earlier the traditional fishermen were catching lobsters (a highly valued export commodity) using traditional traps made of easily biodegradable vegetable fibres that lasted only for 2-3 weeks. In comparison the new traps are 2.5 times more efficient than the traditional traps in terms of catches and also they last for 3-4 fishing seasons (Devadasan, 2002).

Techniques of fish finding

Fish Finder

In modern times, the most important electronic device is the Echo-sounder popularly called "Fish Finder", originally invented for use in naval warfare (Fig. 46). It has a voice box called transducer from which ultrasonic sound waves are sent out at a speed of 15000m/sec which get reflected from the sea bottom back to the transducer. This is then fed on to the pen of a recorder; and depending upon the time taken for the transmission of sound and its echo to reach back, markings are made in the recording paper. The recording gives correct position of the shoals and at what depth these are present. In this case, usually the fish that are right below the vessel can be detected. However, transducers are also designed in such a way as to locate fishes at any depth or angle from the ship. This type of Fish Finders are called Sonar.

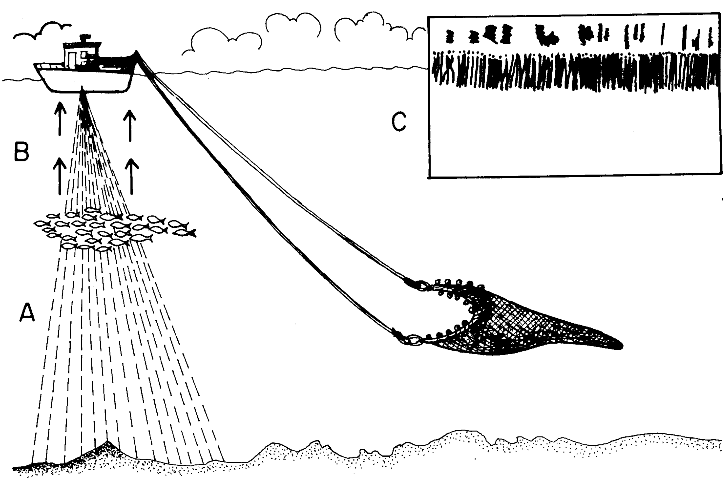


Fig. 46. Diagram to show the working of an echo-sounder.
(A) Echo search beam; (B) Echo reflecting back to the vessel;
(C) Markings made in the recording paper on the vessel

Netsonde

A new type of equipment called Netsonde, widely used in bottom trawling is attached to the head rope of the trawl net; and it gives an estimation of the quantity of fish actually entering the net.

Aerial survey

Aerial survey is helpful in locating pelagic shoals, but fish finders are more useful in demersal and mid-water fisheries. Technological research is being undertaken to visually see the fish shoals on television with the aid of under-water cameras.

Artificial Fish Habitat (AFH) Technology

In India, fish aggregating devices (FADs) have been traditionally in use but modified versions are becoming increasingly popular among artisanal fishers, to get better catches and save fishing time in the light of increased competition from mechanised craft, operating in the in-shore waters. Materials used are old tyres, concrete structures of different shapes, FRP and HDPE pipes and weighted logs. The first generation AFHs used concrete rings with suspended coconut fronds and stumps which attract both big and small fishes, including highly priced cuttle fishes. Along the south-east and south-west coast of India very efficient mid water and surface AFHs have been installed and operated successfully. A FAD to augment tuna production from Lakshadweep waters and benefit the local tuna based economy of the Island is being implemented currently by CMFRI.

Economic evaluation

The gross capital investment on fishing equipments such as the craft and gears in the non-mechanised, motorised and mechanised sectors at the 1995 price level is around Rs. 41170 million (Table 62). The estimated total first sale value of the marine fish landings is about Rs. 102000 million, which indicates a good profit ratio for the fishing industry (CMFRI, 1997a).

The contribution of the fisheries (marine and inland) sector to the net domestic product increased 8 fold during 1980-81 to 1993-94, while that of the agriculture sector increased only 4 fold during the same period.

The economic feasibility of each fishing unit in the fishing industry, which is operating under nearly perfect competitive conditions depends on several factors like input and output prices, level of production and its functions (type and size of the vessel, age of the vessel, crew size and its skill, fishing time, fishing effort and other inputs like fuel, food, insurance etc.) and above all, the marketing avenues and prospects (Sathiadas *et al*., 1994).

Table 62. Capital investments, fixed cost and annual operating costs (Rupees in million) of the Indian marine fishing fleet during 1995

Fishing Fleet	Invest ment	Fixed cost	Operating				Total cost	Fishing cost (Indian Rs/kg)
			Fuel cost	Labour	Others	Total		
1. Mechanized Sector								
(i) Medium trawlers (14-17m OAL)	8500	2550	2220	2330	1070	5620	8170	22.56
(ii) Small trawlers (10-13m OAL)	15000	4500	6250	4100	2450	12800	17300	22.56
(iii) *Dol* netters	300	90	60	120	40	220	310	2.95
(iv) Purseseiners	900	270	140	170	110	420	690	4.42
(v) Pablo & plank built boats	43.40	1090	1050	2420	500	3970	5060	32.65
(vi) Others	200	60	30	60	20	110	170	3.40
Total	29240	8560	9750	9200	4190	23140	31700	19.87
2. Motorized Sector								
(i) Canoes								
(ii) Catamarans	3750	750	470	1870	780	3120	3870	12.29
	310	90	40	210	90	340	430	10.75
Total	4060	840	510	2080	870	3460	4300	12.11
3. **Artisanal sector**								
(i) Canoes	830	220	-	430	190	620	840	33.60
(ii) Catamarans	3350	840	-	3140	1330	4470	5310	32.18
(iii) Plankbuilt Boats	3690	920	-	1550	660	2210	3130	33.65
Total	7870	1980	-	5120	2180	7300	9280	32.79
Grand Total	41170	11380	10260	16400	7240	33900	45280	20.28

Source : CMFRI, 1997a

Mariculture

Intensive researches during the last two decades by the CMFRI have led to the development of several viable technologies for seed production and culture of finfishes, shellfishes and seaweeds.

Molluscan culture

Culture of filter feeding bivalves, which are low in food chain, is a low energy input aquaculture activity which can be successfully adopted by small traditional fishermen in the numerous coastal waterbodies of India. Molluscan culture (mussels and oyster) technology has been extensively adopted and are successful along the southwest coast while the pearl culture technology has been adopted on the east coast. The molluscan culture technologies and economics are given in Table 64.

Table 64. Molluscan culture technologies and economics

Technology	Edible oyster farming	Mussel farming	Pearl oyster culture
Species	*Crassostrea madrasensis*	*Perna viridis, P. indica*	*Pinctada fucata*
Farming method	Rack and Ren (30 x 10 m)	Raft/Rack (8 x 8 m)	Cages suspended from rafts/ racks
Culture period	8 months	5-7 months	12-15 months
Unit area *Economic in (US$)*	300 sq.m.	64 sq.m.	Open sea; 6 rafts and 600 box cages
Fixed cost	371	203	10000
Recurring cost	139	357	4419
Total Cost	510	560	
Production	5.83 tonnes shell on	0.8 t shell on	
Revenue	736	934	depends on percentage pearl production and market value of pearls
Profit	226 (44.4%)	303 (40%)	30% (at 25% pearl production)

Source : ICAR, 2000

Edible oyster farming

The first attempt to develop oyster culture in India dates back to 1910 by James Hornell. Since 1970 the CMFRI has taken up R&D programmes on all aspects of oyster (*Crassostrea madrasensis*) culture (Fig. 47) and has produced a complete package of technology, which is presently being widely adopted by small scale farmers in shallow estuaries, bays and backwaters all along the coast.

In the rack and ren method, a series of vertical poles are driven into the bottom in rows, on top of which horizontal bars are placed. Spat collection is either from the wild or produced in hatcheries on suitable cultch materials. Spat collectors consist of clean oyster shells (5-6 nos.) suspended on a 3 mm nylon rope at intervals of 15-20 cm and suspended from racks, close to natural oyster beds. Spat collection and further rearing is carried out in the same farm site and harvestable size of 80 mm is

Fig. 47. (a) Edible oyster farm (b) Edible oyster, *Crassostrea madrasensis*

reached in 8-10 months. Harvesting is done manually with a production rate of 8-10 tonnes/ha. Oyster shells are also in demand from local cement and lime industries and culture production has increased to 800 tonnes in 2000. Edible oyster farming techniques are transferred to coastal fishers through demonstration programmes. So far along the southwest coast over 500 farmers have set up commercial farms and the oyster meat is now an acceptable product in many coastal cities. Shri Vincent Mukkadan, the first oyster farmer from Kollam, Kerala was awarded the best oyster farmer by CMFRI.

Mussel (Perna viridis, Perna indica) farming

Raft method (in bays, inshore waters), rack method (in brackishwater, estuaries) or long line method (open sea) is commonly adopted. Mussel seed of 15-25 mm size collected from intertidal and subtidal beds are attached to coir/nylon ropes of 1-6 m length and enveloped by mosquito or cotton netting. Seeds get attached to rope within a few days while the netting disintegrates. The seeded ropes are hung from rafts, racks or longlines. A harvestable size of 70-80 mm is reached in 5-7 months and production of 12-14 kg mussel (shell on) per metre of rope can be obtained. In Kerala attempts to demonstrate the economic feasibility of mussel farming has led to the development of group farming activities in the coastal communities (especially rural women groups) with active support from local administration and developmental agencies like Brackishwater Fish Farmers Development Agency (BFFDA) and State Fisheries Department. Cultured mussel (Fig. 48) production increased from 20 t (1996) to 2000 t (2003) mainly through the rack system in estuarine areas. Mussel farming has been adopted by over 50 women groups in coastal areas of north Kerala with financial assistance from Development of Women and Children in Rural Areas (DWCRA) and Training of Rural Youth in Self –Employment (TRYSEM). The Aquaculture Development Agency in Kerala (ADAK) initiated a new programme on mussel farming with scientific support from CMFRI. Under this, sites for mussel farming were selected and training programmes were conducted. Fifteen groups

Fig. 48. **(a)** Mussel farm and farmed green mussel (inset) **(b)** Harvesting of farmed mussel, *Perna viridis*

were selected by ADAK and they were given free materials such as bamboo poles (25 nos.), nylon rope (13 kg) and other necessary items for setting up mussel farms. It is also being increasingly adopted along the Karnataka, Goa and Maharashtra coast where CMFRI is actively involved in transferring the technology. The National Bank for Agriculture and Rural Development (NABARD) has accepted the mussel and oyster culture technology developed by CMFRI for refinance.

Shri Gul Mohamed, the first mussel farmer in Kerala, who was encouraged to start mussel farming by CMFRI was awarded '*Karshaka siromony*' for the year 2002 by the Minister of Agriculture, Govt. of India. Integrated fish and bivalve culture in brackishwater ponds whereby fishes like pearl spot *Etroplus suratensis* having very good domestic market can be cultured in cages between mussel or oyster seeded ropes on racks has also been experimented with success.

Research is being continued to further improve the technology by way of introducing alternate materials such as Flexible Plastic Strips (FPS) for seeding mussels instead of coir or nylon ropes and pre-stitched cotton nets to put mussel seeds for attachment as means of achieving higher profits (Mohamed *et al*., 2003).

A mussel seeder developed by CMFRI has provision for seeding two ropes simultaneously thereby reducing time and labour. The seeder has the added advantage that it can be dismantled and easily transported to the farm site. After successful field trials at Kollam, the seeder was introduced to mussel farmers at Korapuzha and Vallikunnu in North Kerala. The cost of a single unit of mussel seeder made of *mahogany* wood is Rs. 2500. The seeder can be used as a common facility by the mussel farmers. Refinements made in mussel farming technology will reduce the recurring expenditure and the physical strain during mussel seeding especially for women farmers.

Pearl oyster farming and pearl production

Among several species of cultivable bivalves, pearl oysters stands unique by viritue of the high returns. The marine pearls in India are obtained from the pearl oyster *Pinctada fucata* (Fig. 49). Success on production of cultured pearls was achieved for the first time in 1973 by CMFRI. Raft culture and rack culture in near-shore areas are the two methods commonly adopted for rearing pearl oysters and recently attempts are being made to develop onshore culture methods.

Shell bead nucleus (3-8 mm) implantation is done in the gonads of the oyster through surgical incision while graft tissue are prepared from donor oysters of same size and age group. Implanted oysters are kept under observation for 3-4 days in the laboratory, under flow through system and

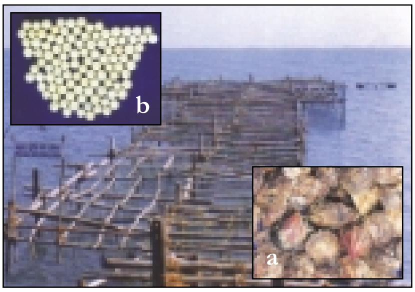


Fig. 49. Pearl oyster farm **(a)** pearl oyster, *Pinctada fucata* **(b)** cultured pearls (inset)

Dr. M.S. Swaminathan examining the implanted pearl oysters at the grow-out site

then shifted to the farm in suitable cages for rearing. Periodic monitoring is done and harvest is carried out after 3-12 months. Pearls are categorized into A, B and C depending on colour, lustre and iridescence. 25% pearl production has been successfully demonstrated in a series of farm trials at various locations along the Indian coast. Research is also directed towards development of a technology for *in vitro* pearl production using mantle tissue culture of pearl oyster.

The technology for mass production of pearl oyster seed and pearl production has paved the way for its emergence as a profitable coastal aquaculture activity at certain selected centres along the coast. Village level pearl oyster farming and pearl production, through direct involvement of small-scale fishermen has been carried out successfully as part of technology transfer programme of CMFRI along the Valinokkam Bay on the east coast (Table 65).

Table 65. Economics of pearl culture programme at Valinokkam Bay – a group farming success

Number of oysters implanted	9414
Total expenditure incurred	US$ 1571
Rate of Return	56.7%
Total pearls harvested	1849
Revenue earned from sale of pearls	US$ 2178
Pearls distributed to fishermen	250

Expenditure incurred (as percentage of total)

Raft	Cages	Pearl oyster implantation	for pearl oyster graft tissue	for shellbead nuclei	Labour	Miscellaneous
24	18	24	2	17	6	9

Source: APAARI, 2000

Pearl oyster farming has already generated income worth US$ 26000 and several young women who are trained in pearl surgery in pearl farms are finding ready employment in this developing industry. The CMFR

Institute also imparts training on pearl culture to trainees in neighbouring Asian countries, and various Memorandum of Understanding (MoU) have been signed with entrepreneurs, desirous of pearl culture since 1996. From the Valinokkam experience pearl oyster farming and pearl production can be propagated as a group farming venture of the coastal fishermen community. Recently Dr. M.S. Swaminathan Foundation, Chennai initiated a pearl culture programme jointly with CMFRI to supply nucleated pearl oysters to fishermen community (as a community programme) along the Gulf of Mannar coast to undertake pearl oyster farming and pearl production as an alternate livelihood.

Crustacean culture

Lobster farming/fattening

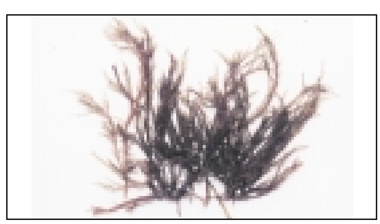
There is high demand for live and whole cooked lobsters in the international market. The price difference between a low priced smaller grade (< 100g) to a larger one (>100g) is three fold. Lobster fattening in inter-tidal pits provided with numerous shelters at a stocking density of 5 numbers/m^2 using undersized lobster caught along with the commercial size lobsters from capture fisheries has been successful along the Gujarat coast. Molluscan meat and trash fish are used as feed to grow the lobsters until they attain 125 g weight. Value addition to undersized lobsters by fattening in indoor grow out system has shown high profitability. Attempts are on to develop a hatchery technology for spiny lobsters (*Panulirus* spp.).

Seaweed culture

Around 60 species of commercially important seaweeds (Fig. 50) with a standing crop of 100,000 t occur along the Indian coast from which, nearly 880 t dry agarophytes and 3600 t dry alginophytes are exploited annually from the wild (Kaladharan and Kaliaperumal, 1999) (Table 66).

Seaweed products like agar, algin, carragenan and liquid fertiliser are in demand in global markets and economically viable seaweed cultivation technologies in India have been developed by CMFRI and Central Salt

Fig. 50. (a) Seaweed culture by women fisherfolk



(b) Seaweed, *Gracilaria edulis*

and Marine Chemical Research Institute (CSMCRI). CMFRI has developed technology to culture seaweeds either by vegetative propagation using fragments of seaweeds collected from natural beds or by spores (tetraspores/carpospores). It has the potential to develop in large productive coastal belts and also in onshore culture tanks, ponds and raceways.

Table 66. Commercially important Indian seaweeds and their standing crop

Group	Species	Standing crop (t)
Agarophytes	*Gracilaria edulis, G. corticata, G. crassa, G. folifera, G.verrucosa, Gelidiella acerosa, Gelidium spp., Pterocladia spp.*	6,000
Alginophytes	*Sargassum spp., Turbinaria spp., Laminaria spp.,Undaria spp., Dictyota spp., Hormophysa spp.*	16,000
Carageenophytes	*Hypnea spp., Chondrus spp., Eucheuma spp.*	8,000
Edible	*Ulva sp., Enteromorpha, Caulerpa spp., Codium spp. Laurencia spp., Acanthophora spp.*	70,000

Culture of agar and agarose yielding seaweeds

Culture is carried out either in the sea or saline ponds. Fragments of the seaweed (*Gracilaria edulis* or *Gelidiella acerosa*) are inserted into the twists of the coir ropes or mesh intersections of HDP ropes (3mm thickness) with the help of a nylon twine (no.6) which are fabricated in the form of 5x2 m size nets floated at subsurface levels with the help of sinkers and buoys. *Gracilaria edulis* and *Gelidiella acerosa* reach harvestable size after 2 and 2.5 months respectively. Problems like grazing by fish and sedimentation can be minimised by carrying out the operation in 4-5 m deep areas. The culture technology of agar yielding red alga, *Gracilaria edulis* by vegetative propagation on coir rope nets has been successfully transferred to the fisherfolk in coastal areas of Palk Bay and Gulf of Mannar by CMFRI.

Carageenan yielding seaweed culture and processing

The growth of the highly valued carageenan yielding seaweed, *Eucheuma* in experimental longline culture along the southwest coast of India was very good with a growth rate of 12 g per day (CMFRI, 2002) and large scale culture can be taken up after proper environment impact studies. Carrageenan yielding seaweed, *Kappaphycus striatus* was introduced from the Philippines by CSMCRI (Mairh *et al.*, 1995), and presently this species is acclimatized and cultivated extensively along the Mandapam coast. If facilities for processing the yield and buy-back agreements with the farmers are taken care of, this technology has tremendous potential to improve the living standards of the poor artisanal fishermen.

The potential candidate species for mariculture are summarised in Table 67.

Table 67. Candidate species for mariculture in India

Species	Hatchery techniques	Grow-out techniques
Fishes		
Epinephelus tauvina, Sillago sihama and Siganus spp.	X	X
Ornamental Fishes		
Amphriprion sebae	XX	X
Neopomacentrus filamentosus, N.memurus, Pomacentrus caeruleus and *P.pavo*	XX	X
Crustaceans		
Penaeus semisulcatus	XXX	XXX
Portunus pelagicus	XX	XX
Panulirus homarus, P.versicolor and *Thenus orientalis*	XX	XX
Molluscs		
Perna viridis, P. indica, Pinctada fucata, Crassostrea madrasensis	XXX	XXX
Trochus radiatus, Xancus pyrum, Sepia pharaonis S.aculeata, Sepiella inermis and *Loligo duvaucelli*	X	X
Seaweeds		
Gracilaria edulis, Gelidiella acerosa, and *Eucheuma sp.*		XXX
Seacucumbers		
Holothuria scabra	X X	X X
H.spinifera	X X	X

x= Techniques under development; xx= Techniques developed; xxx=Techniques developed and commercialised

Source: CMFRI, 1997a

Hatchery technologies

Hatchery technology has been developed and standardised for pearl oyster, edible oyster, mussel and marine ornamental fishes.

Bivalve hatchery technology

Technology has been perfected for bivalve hatchery and production of seeds of various bivalves like pearl oysters (2 species), edible oyster (1 species) and mussels (2 species) (Fig. 51). The process involves conditioning, induced spawning, larval rearing and spat settlement. Brood stock collected either from the wild or farm is conditioned for 3-4 days prior to inducing them to spawn by thermal stimulus. After fertilization, the larvae are reared in controlled conditions, providing them with mixed algal diet to spat stage when they are ready for settlement. The spat is collected on suitable cultch materials and transported/transplanted for further rearing in grow-out farms (Anon, 2000). Larval rearing up to spat settlement of pearl oysters takes 18-22 days, mussels 15-20 days, edible oyster 18- 20 days and clams 7-17 days. In one larval cycle of 20-30 days, nearly 2 million spat can be produced.

Seed production in abalone *Haliotis varia* has also been successfully achieved, but needs standardisation. Larval stages are lecithotrophic and requires no feeding. After settling, a mat of benthic diatoms is given as food. After 26th day, they are also given chopped seaweeds like *Ulva lactuca* (CMFRI, 2000).

Fig. 51. Bivalve hatchery

Captive breeding of marine ornamental fishes

Clownfish hatchery technology

The pomacentrid fishes (*Amphiprion* and *Premnas* spp.) popularly called clownfishes or anemone fishes are highly priced marine aquarium fishes in the international market (Fig. 52). A successful hatchery technology for large-scale production of young clownfish has been developed at CMFRI (CMFRI, 2000). Fishes collected from the wild are kept along with anemones in one ton tanks fitted with a biological filter. They are fed with minced beef and boiled mussel meat twice daily. Larval hatching period is between 7-8 days with the egg capsules becoming very thin and transparent on the day of hatching. Newly hatched larvae measure 2.5 – 3mm and start feeding the following morning after hatching. They are fed with rotifers and freshly hatched *Artemia* nauplii which are cultured in outdoor tanks. Metamorphosis into juveniles occurs between 12th and 15th

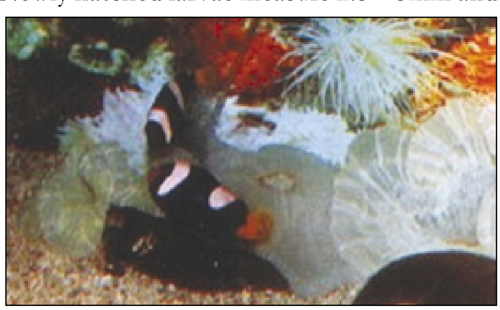


Fig. 52. Clownfish, *Amphiprion sibae*

day of hatching and they are transferred to grow-out tanks with sea anemones.

Seahorse seed production

Highly valued as aquarium fishes and in Chinese traditional medicine practices, seahorse rearing is a low cost and simple technology that can help in enhanced earnings of the coastal fishermen and sustain this limited resource in the coastal seagrass beds. Wild broodstock of pregnant males are reared in well aerated and filtered seawater tanks. Once spawning is over, the young sea horses are fed on a diet of zooplankton consisting of copepods, freshly hatched *Artemia* nauplii and mixed algae. A size of 30-40 mm is attained in 4 weeks (Anil *et al.*, 1999).

Hatchery input technologies

The hatchery technologies such as live feed culture, micro-algal culture, rotifer (*Brachionus* spp.) culture and brine shrimp *(Artemia)* culture are mentioned in detail under brackishwater farming.

Processing and Post-harvest Technologies

Fish is a highly perishable commodity and needs proper care and attention from the time it is caught until it is cooked, processed or exported. The handling of fresh fish in the interim determines to what extent deterioration takes place. For this quality improvements are needed at the points of catching, landing, marketing and export. The main source of deterioration of fish are enzymatic, oxidative and bacterial.

In India, about 65% of the total fish catch is consumed in fresh form, 14% in cured form, 6.6% in frozen form, 8% for reduction purposes and 2% for special processing techniques. The processing industry is mainly export oriented and deals with frozen fish and shellfishes. The growth of frozen seafood industry is quite impressive. Export of frozen shrimp alone contributes more than 60% to the total export earnings. One of the major problems of frozen shrimp trade is drip loss, wherein, the muscle loses its ability to hold water upon thawing, thereby leading to great economic losses. It has been estimated that the annual loss is more than US $ 10 million. Effective intervention has been developed by Central Food Technology Research Institute (CFTRI), Mysore, which will have significant impact in minimizing the economic loss.

The preservation and processing infrastructure in the marine sector includes 372 freezing plants with a capacity of 52.5 t per day, 148 ice making plants with about 1,800 t capacity per day, 450 cold storage having capacity of over 80,000 t and 15 fish meal plants with about 330 t capacity per day. There are also 900 registered prawn peeling sheds with a capacity of 2,684 t, which form the pre-processing centres. The capacity utilization of the processing plants at present is hardly 25%, mainly because of the shortage of raw materials. Most of the processing factories are old and only a few meet the criteria of the European Union Certification for imports to Europe.

Proper care of the harvested fish is still a neglected area, particularly in the traditional sector and also in the mechanized sector. However care is taken while handling the high unit value fishes intended for processing and export, but the by-catch and low valued species are neglected resulting in avoidable loss. Small scale fish processors, the majority of whom are fisher women, incur losses associated with fish processing during the monsoon. The spoilage of harvested fish can be minimized by taking suitable precautionary measures. The transfer of post harvest and processing technologies to poor fishers would be helpful in uplifting their socio-economic status.

Insulated fish boxes

There has been a gradual change in attitudes of consumers towards iced fish and fish quality with prices reflecting the premium quality of iced fish. This has stimulated interest in insulated ice boxes for ice storage and fish marketing purposes even by traditional fishermen. Simple insulated ice boxes made of thermocole and enclosed in tarpaulin have been designed for the catamaran fishermen of the east coast which is very popular (Anon., 1996c). This technology needs to be promoted along the west coast.

Improved method of fish curing and rack drying

In the traditional process where the fish are salted and beach drying is adopted, contamination by sand and red halophilic bacteria create a low priced product which cannot be stored for more than two months. The new method standardised by CIFT for fishes involves evisceration of fish, salting and keeping in clean cement tanks for about 24 hours. It is followed by a dip in saturated brine containing 5% calcium propionate for 2-5 minutes and drying on racks to permitted moisture content. Racks of two decks can be made of locally available materials like bamboo, casuarina with nylon webbing for the base of the racks. The product packed in polythene bags or sacks has a shelf life of more than 6 months.

Recently the CIFT, Cochin has developed and is propagating a simple sun drying device called 'sundrying chamber' to help the fisherfolk. The drying chamber is made of aluminium frame fitted with racks of aluminium mesh and covered by polythene sheets. Polythene cover can absorb and transmit heat quite well, apart from preventing flies, birds and animals. CIFT has adopted the Kasaba fishing village in Kasaragod, Kerala where the women of 80 households are engaged in fish drying under its village adoption and rural empowerment programme.

Solar air heating system for fish drying

Technology has been demonstrated by an NGO, Planters Energy Network (PEN) with funding support from Ministry of Food Processing Industries for the benefit of poor fishermen of Gangavaran fishing hamlet of Visakhapatnam in Andhra Pradesh. The solar drier is reported to have a capacity of 500 kg with a drying time of 7-9 hours and can reduce moisture content of fish from 85% to 15-30%. Project set up on an 149 m^2 area had the capacity to prepare 300-350 kg dried fish per day and 81000-95000 kg dried fish per year (for 270 days operation). Recurring costs included electricity, labour, administration and transportation of raw and dried fish and the profit margin was Rs. 5-7 per kg with a payback period of less than 2 years. Cleaned fish is salted for 8 hours and sent for drying using hot air at a temperature of 45-55^{o}C for 7-9 hours. The trays on which fishes are spread for drying are made of aluminium kept on a mild steel frame trolley each containing 44 trays. Hot air from the roof integrated solar panel is sucked and forced into the drier through two axial flow fans and gravity levers are provided for escape of moisture-laden air. During inclement weather, there is provision to be coupled with the conventional diesel fired heater (Palaniappan, 2001). The quality dried fishes can create a separate niche in the existing domestic dried fish market and also for export to foreign countries and create employment opportunities for rural youth. A package of practices has to be developed and popularised among the primary fish handlers. Value-added products (dried, smoked, pickled fish) have to be developed with the involvement of fisherfolk especially women.

Dried shell-on prawns

The dried shell-on prawns are often made locally by directly exposing the prawns to sun on beach sands under unhygienic conditions with vulnerability to disease-causing microorganisms. Moreover, the product which is neither attractive nor really ready-to-cook is sold unhygienically in bamboo baskets. These deficiencies can be overcome by drying the product in an electric drier under hygienic conditions. The unique feature of the technology is its ready-to-cook qualities and attractive colour retaining all the intrinsic values. It can be used as a base raw material for curry products, either fried or cooked.

Ready-to-fry dried products

Low cost fishes like silverbellies, sciaenids and upenoids which occur as by-catch in shrimp trawl fisheries are used (Khasim and Prasad, 1998). It involves dressing the fish, blanching in 10% boiling brine for 1-1.5 minutes depending on the size of the fish and drying on a drier. The bones are removed, meat mixed with spices, packed in polythene bags and stored for upto five months.

Mas fingers and *Mas* granules

Masmin which is the traditional smoked hard dried tuna (skipjack, *Katsuwonus pelamis*) product from Lakshadweep has a good market in India and abroad. An improved *masmin* production as well as two new convenience products processed from *masmin* by CIFT has received better consumer acceptance in domestic and overseas markets (Antony *et al.*, 2002). Based on the Hazard Analysis and Critical Control Point (HACCP) safety system, the beheaded, gutted and fully bled fish is scored longitudinally along backbone on either side and cooked in 5% boiling brine for 1 hour, followed by cooling and partial drying and then smoked. This is followed by drying to reduce moisture content to 10% after which it is processed into *mas* fingers or *mas* granules by pulverization.

A simple process for a *Masmin*-like product from a comparatively lower priced but abundant tuna species (*Euthynnus affinis*) has also been developed (Nair *et al.,* 1994). It involves cooking the dressed and brined fish under steam pressure followed by cooling, seperation of meat from fillets and alternate drying and smoking.

Fish maw

This is a traditional dried fish product prepared from air-bladders of marine fishes (jewfish, catfish and eels) and is used for purification of wines. The air bladder is cut open, internal membranes removed and washed completely free of blood and beaten against a piece of wood till well flattened and dried in sun till hard. This technology has the advantage of low capital requirements that makes maximum use of local raw materials to make a world-class product and export (ICAR, 2000).

Dehydrated jelly fish

Jelly fish, an abundant but unutilised marine resource in the coastal waters of east and west coast, is frequently landed as by-catch in shore seines operated by traditional fishermen. Umbrella portion alone can be taken, trimmed, cleaned, washed well and treated in four solutions of salt and alum of different concentrations and drained till moisture content is <60%, graded, packed and stored in chilled condition at 0^{o}C.

However, constraints in adoption of this technology is that the jellyfish are highly susceptible to spoilage in hot climatic conditions and have to be processed immediately after catch or kept for a short period in iced condition which may be difficult at many of the landing centres from where the traditional fishermen operate.

Technologies utilizing by-products obtained from fish and shellfish during their processing are also available for,

- Chitin and chitosan from prawn shell waste
- Surgical sutures from fish guts
- Shark cartilage
- Shark fin rays

To capture export markets, improved technologies include

- Individual quick freezing
- Accelerated freeze dried products
- *Surimi* and *Surimi* based products
- Shark fin rays

Ready to serve fish curry

The domestic market demand among the urban upper class for processed fish especially high unit value fishes in the ready-to-serve or ready-to-cook is fast increasing. Technology has been developed by Central Institute of Fisheries Technology to market ready-to-consume fish curry in flexible retort pouches of polyester/aluminium foil/cast polyprophylene using the over pressure autoclave method. The product has a shelf life of over one year at room temperature and it is now replacing metal containers which improves the economy and also increases consumer acceptance (Vijayan *et al.,* 1998).

Seafood Export Scenario

The export of marine products from India is showing an increasing trend during 2002-03 with a 10.1% increase in quantity and 15.5% in value, over the previous year. The average unit value has also increased to US $ 3.05 per kg compared to US $ 2.95 per kg during the preceeding year. The total export of marine products during 2002-03 was 467297 MT, at a value of Rs. 68813.4 million; equivalent to US $ 1424.90 million (Jose Cyriac, 2003). The corresponding figures for 2001-02 was 425596 MT valued at Rs. 66117.8 million; equivalent to US$ 1253.35 million (Table 63).

USA has emerged as the single largest market for Indian marine products during 2002-03, relegating Japan to the second position. USA accounts for 13.21% by volume and 29.79% by value. The share of Indian seafood exports to Japan was 11.75% in volume and 22.3% in value. The export of Indian marine products to EU countries continue to grow, and the members of EU countries together accounted for 20.23% and 20.18% in total quantity and value of Indian seafood exports. China also is an important market for Indian seafood particularly low value fishes. Among the products exported, shrimps constitute the main share with 66.97% of the value and 28.85% by quantity.

The stringent import policies of many importing countries have also influenced the type and quality of products being exported. Out of the total marine fish landings, only about 15%, including cephalopods and crustaceans, is exported. Finfishes constitute the single largest commodity in the seafood export market with major varieties as ribbonfish, pomfrets, seerfishes, mackerel, reef cod, snappers and tunas (Table 63). The *surimi* based products, pasteurized crab meat and live fish (crabs, groupers, lobsters) also offer an immense scope for development. Fresh and frozen farmed mussels and oysters have good demand in domestic market while mussels are also exported to countries like UAE, Germany and Republic of South Africa. Export to European countries requires certification of the water bodies used for mariculture and the appropriate authority issuing such certificate has to be decided. Production of value added fishery products is also being done although it is highly capital intensive and advanced processing and packaging technologies are currently insufficient in India.

Quality assurance in fishery products has been introduced since 1965 with pre-shipment inspection scheme (Export Quality Control and Inspection Act) and the In Process Quality Control (IPQC) was implemented in early 1978, prescribing the minimum requirements for raw materials, manufacturing processes, end product testing, preservation and packaging of final products. The Hazard Analysis Critical Control Point (HACCP) with stress on safety was introduced in 1995, and it is the responsibility of the processors to ensure proper hygienic conditions and observe the prescribed standards for seafood exports.

Table 63. Item-wise exports of marine products from India

	1997-98		2001-02	
Item	Quantity(t)	Value, million Rupees	Quantity (t)	Value, million Rupees
Frozen Shrimp	100720	31341.5	127709	41399.2
Frozen Fish	188029	7267.3	174976	7131.1
Frozen Squid	35095	2708.9	39790	3296.7
Frozen Cuttle Fish	37258	3234.1	30568	2800.7
Frozen Lobsters	1289	477.9	1126	6547.3
Chilled Items	3183	443.1	3284	636.6
Live Items	1700	293.4	1628	405.7
Dried Items	5669	334.5	7020	601.9
Others	12875	874.1	39495	3298.6
Total	385818	46974.8	425596	66117.8

Source: MPEDA, 2002

The steps taken by the Govt. of India to relax the policy on trade and convertibility of Indian rupee into foreign currencies have resulted in an increase of export of fish/fishery products. The Marine Products Export Development Authority (MPEDA) is also conducting numerous promotional efforts which have benefited exporters of fish and fishery products. In view of the rigorous quality requirements of the European countries, the quality vigilance and compliance to attain the required international standards are being stepped up. Irradiation process (Radurization) for the extension of shelf-life of fresh fishery products and improvement in microbial safety have been standardized in many countries, including India and would pave the way for reducing post-harvest losses (Shamsundar, 2001).