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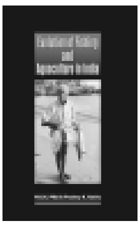

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8

Evolution of marine fishing practices

Prior to and immediately after independence, the marine fishing activity was carried out at subsistence level with the indigenous craft employing gears such as cast nets, small seines and traps operated close to the shore. In fifties, small mechanised boats with bottom trawl nets were introduced. With the inception of First Five Year Plan (1951-56) mechanisation of fishing craft was encouraged by Govt. of India with a view to render assistance to the traditional fishermen to get better return of their effort by extending their range of operation.The Food and Agriculture Organisation (FAO) also played a critical role in R and D activities of the fisheries sector in India. In 1953, an agreement was accorded between the Government of India and FAO regarding technical assistance in small craft mechanisation and gear technology, which led to the appointment of Mr. P.B. Zeiner a naval architect with the following terms of reference:

- to advise on improvements to available boats with regard to design, construction, safety rules and engineering,
- to advise on mechanisation of available boats, and
- to design new, improved types of fishing boats.

Thus between 1954 and 1958, FAO experts in India tried to develop three prototypes of mechanised surf boats for India with partial success only in 1963, reasons which were partly technical and partly economic (Table 42). This was because, these surf boats, in addition to higher initial costs, could operate only gill nets while an open mechanised boat could operate gillnets and trawling/longlining.

Table 42. Details of surf-boats constructed between 1959 and 1963 by FAO

Boat	Length	Material	Engine specification			Remarks
			h.p.	Fuel	Cooling mechanism	
INP-1	25 ft	Wood	10	Petrol	Freshwater cooled	INP design
Surf-2	24 ft	Wood	10	Diesel	Air-Cooled	FAO design built by INP, direct drive
Madras Boat	24 ft	Wood	10	Diesel	Air-Cooled	Government of India design 2:1 rev./reduction gear
Fish Tech.-3	24 ft and fibre glass	Plywood	10	Diesel	Air-Cooled	FAO design, built in Bombay, direct drive

Source: FAO, Third Report to the Government of India on Fishing Boats. Based on the work of Peter Gurtner, Report No. 1535, (FAO, Rome, 1963), p.8.

Indo-Norwegian Project (INP) and its impact on fishing

The INP was set up in 1953 at Quilon (Kerala state) following a tripartite agreement signed by the Governments of Norway, India and the United Nations in October, 1952, with the objective of mechanizing the Indian fisheries sector. Initially the Project attempted mechanization of the existing traditional craft along the Kerala coast, which was a failure. In 1954, the project started concentrating on developing new designs. The first 22 feet boats, with a 4 h.p. semi-diesel engines built between 1956-58 did not find much acceptance as the craft showed no outright superiority over traditional crafts nor were there adequate landing facilities available for these crafts. As a result, in 1958, it introduced a 25 feet boat with 8-10 h.p. diesel engine capable of using larger quantities of traditional gear as well as fishing at greater distance. This was followed by a 23.5 feet craft with an 8-10 h.p. diesel engine in 1961, which yielded better results than the 25 feet craft. In 1962, the project introduced a new 25 feet boat with 16 h.p. diesel engine capable of using a small shrimp trawl. Korakandy (1994) reports that with this, there was some appreciation for mechanised fishing not only because of the comparative 'efficiency' of these crafts *vis-a-vis* traditional crafts in terms of mobility and smaller crew requirement but also because their introduction coincided with the location of rich shrimp grounds in the Indian EEZ and the development of an export oriented industry for shrimps. The state-wise trends of mechanisation of fishing craft is given in Table 43.

Table 43. State-wise trends of fishing craft mechanization

State/UT	Approx. Coastline (km)	Conti-nental shelf (km)	Landing centres	Fishing villages	Fishing crafts 1985-86		Fishing crafts 1994-95		% change	
					Mech-anised	Non-mech-anised*	Mech-anised	Non-mech-anised*	Mech-anised	Non-mech-anised
Andhra Pradesh	974	31	379	409	1009	57458	8911	57269	783	000
Goa	104	10	87	91	1551	2445	850	2000	-45	-18
Gujarat	1600	164	854	851	2772	7795	8365	12653	202	62
Karnataka	300	27	28	204	3153	12103	3655	13141	16	9
Kerala	590	40	226	222	3343	27104	4206	40786	26	50
Maharashtra	720	112	184	395	5563	18415	7930	9988	43	-46
Orissa	480	24	63	329	674	10550	1665	10249	147	-3
Tamilnadu	1000	41	362	442	2514	37969	8230	32077	227	-16
West Bengal	157	17	47	652	1582	4361	1880	4361	19	000
Andaman & Nicobar	1912	35	57	45	88	1082	230	1340	161	24
Daman & Diu	27	0	7	31			870	524		
Lakshadweep	132	4	11	10	309	726	443	1078	43	48
Pondicherry	45	1	28	45	348	3387	553	6265	59	85
Total	8041	506	2333	3726	22906	183395	47788	191731	168.1	195

Source: modified from Vijayakumaran and Bhargava, 2001

* includes motorised crafts

The project also tried to popularize diversified methods of fishing such as purse seining and pole-and-line fishing. Although the operational aspects of purseseining trials were reported to be good, it was not successful as the purse seine catches consisting mainly of small pelagic fishes like the oil sardine and mackerel commanded much less prices than the exportable shrimp targeted and caught in plenty by trawlers. Fisheries technological research in India did not receive much attention until the establishment of Central Institute of Fisheries Technology (CIFT) during 1954, which gave a foundation for research in the aspects of design of various fishing crafts, gears, fishing techniques, methods of handling and post-harvest processing and utilization. Since 1963, the activities of INP were directed to exploratory and experimental fishing while Central Institute of Fisheries Technology (CIFT) took up research work on designing of new craft types.

During 1963-1979, the Craft and Gear Division of CIFT carried out research and development activity in craft/gear technology on the following aspects:

- new designs for mechanised crafts;
- indigenous engines;
- alternative materials for boat building;
- new materials and designs of nets; and
- new methods of fishing.

Table 44. Details of major craft-types standardized by the CIFT

Craft particulars	Size of the craft [a]									
	25 ft	30 ft	32 ft[b]	36 ft	38 ft	40 ft	42 ft	45 ft[c]	49 ft[d]	50 ft
Breadth	2.19	2.75	2.90	NA	2.51	3.81	3.96	4.26	NA	4.40
Tonnage	3.90	6.20	8.30	12.20	14.85	17.40	22.30	NA	25.00	30.00
Fishhold capacity (cu. Ft)	No fish hold	150	175	NA	240	260	NA	NA	520	600
Free-running speed (knots)	5-6	6.5-7	7-7.5	NA	7-7.8	NA	NA	NA	7-8	8
Horse power of engine	10-15	30-35	40-45	50-60	60-70	80-90	80-90	90-100	90-100	150-160
Fuel capacity (litres)	75	90	620	NA	990	NA	NA	NA	2000	2700
Fuel used(litres/hr)	NA	5	7.5	NA	15	NA	NA	NA	NA	30
Crew size	5	6	6	5-6	6	5	6	6	7	8
Endurance at sea	10-12 hrs	20-22 hrs	1 day	NA	3 days	3 days	NA	4 days	5 days	5 days
Depth range of operation (fathoms)	0-10	0-15	0-20	NA	0-25	0-25	NA	0-30	NA	0-35
Freshwater storage capacity (litres)	20	40	130	NA	270	NA	NA	NA	675	NA
Crew	NA	NA	NA	NA	6	5	6	6	7	8

Source: Korakandy, 1994

a: All these designs were developed prior to 1967.

b: The particulars are common to both the fishing boat and the trawler of this size.

c: A slightly different version of this craft was developed

d: This design was originally developed by the FAO naval architects.

NA: Information not available

It resulted in 12 standard designs capable of trawling as well as hand lining, gillnetting and purseseining. A notable feature of the craft types developed by the Institute during this period was that they could be used simultaneously for trawling as well as for other kinds of fishing with suitable modifications in the deck layout (Tables 44 and 45). Some important vessel modifications included the introduction of 'gantry' on the deck of a trawler which deviated the need for a mast and the boom, the stay of the mast and the boom and trawl gallows; introduction of a 'net drum' useful in handling the net and otter board and the tiltable drum winch which was self winding and eliminated possibilities of wire getting sharp bends and also saved on manual work. It also developed cheaper and suitable boat building materials as well as engine designs for better performance (Korakandy, 1994).

Table 45. Comparative costs of major craft types standardized by the CIFT

		Cost of parts (in Rs.)				
Size of the craft	Type of craft	Hull*	Engine	Gear	Navigational and life saving equipments	Total cost @ (in Rs.)
25 ft	Open fishing	12000	20000	5000	400	37400
30 ft	Fishing boat	29000	22000-30000	15000	2700	68700-76700
32 ft	Trawler	45000	22000-40000	16000	3200	86000-104200
32 ft	Fishing boat	45000	22000-50000	16000	3200	86000-104200
36 ft	Trawler	59000	62000-70000	20000	4000	145000-153000
40 ft	Trawler	60000	75000	25000	4500	164500
45 ft	Drifter/Trawler	71500	90000	30000	4500	196000
50 ft	Combination vessel	150000	140000	35000	15000	340000

Source: Korakandy, 1994
*includes the cost of sheathing the hull. The wood used for hull is teak.
@ at 1977 prices

Thus initially motorization of indigenous crafts was taken up as first step of mechanized fishing. Subsequently, various designs and sizes of mechanized crafts were introduced besides specialized fishing vessels like trawling-cum-fish carrying, trawler-cum-purse-seiner, boats for long line fishing and trolling, etc. While various new types of mechanised crafts were introduced through various government policy initiatives, most of these have confined themselves to fishing in shallow waters for various reasons, thereby competing with the traditional sector for the dwindling fish resources and creating conflicts (Srivastava *et al.*, 1986). A trend apparent among Indian commercial vessel owners is the preference for small trawlers and 'Sona' boats of 13-17 m OAL to larger vessels. CIFT is engaged in design of vessels in the size range of 18-24 m OAL with improved hull form and propulsion (Ravindran and Baiju, 1998).

The use of synthetic fibre in fishing gears was yet another significant achievement for the development of fisheries due to its non-rotting character. Gear designing was given greater emphasis for enhancing the production from the mechanized vessels and also due to the diverse fishing methods. This led to development of different gears, and methods introduced were stern trawling, out-rigger trawling, mid-water trawling, purse-seining and long-lining. Introduction of gears like four-seam trawl and bulged-belly trawl could increase the catching efficiency by about 30% and specialized gill nets were fabricated for lobster fishing. Fish detection facilities were introduced in large boats with facilities for proper gear handling for enhancing their efficiencies. Of late, the use of mechanical fishing accessories, ancillary fishing equipment and electronic testing devices of practical value in fishing operation have also added a new dimension for enhancing the catch per unit effort of specific gear and craft (Ayyappan and Jena, 2003).

The International Indian Ocean Expedition (1959-1965) and the Pelagic Fisheries Project (1971-75) were also initiated with FAO/UNDP collaboration. Between 1977 and 1989, a number of working papers on the small scale and artisanal fisheries of various coastal states and union territories of India were published under an FAO/UNDP executed Bay of Bengal Programme (BOBP) which was financed largely by the Swedish International Development Cooperation Agency (Sida).

Motorization of traditional fishing crafts

In the early 70s mechanised boats (17.5 m stern trawlers operated in coastal waters for shrimp) were preferred, triggered by the booming export market for shrimps. Since 1979, the focus shifted to motorization of the traditional crafts especially along the southwest coast of India. The keen competition from shrimp trawlers in the in-shore waters prompted many traditional fishermen to adopt motorization of crafts to expand their fishing operation area which lead to better financial returns. Simultaneously the declining resources and increasing fuel costs compelled many traditional fishermen to prefer installation of outboard motors rather than adopt mechanised boats. The motorization process was also facilitated by the pioneering efforts of the Kirloskar Oil Engines Ltd., Poona, in the fifties, for manufacturing marine diesel engines indigenously. Until 1966, marine diesel engines were imported but by 1977 there were 9 manufacturers in the country with a capacity to produce engines of even 10,000 h.p. (Korakandy, 1994).

The advantages of motorization of traditional craft are many such as increasing fishing time and labour efficiency, widened operational area and enabling tapping additional resources and better quality (freshness as well as higher unit value offshore varieties) fish landings (Balan *et al.*, 1989). This motorization process has enhanced the mobility of fishermen even during rough monsoon and also increased scope for employment consequent to increase in size of craft and gear. However it has reduced the capability of fishermen to use sail devices and rowing to reach fishing grounds. The development of innovative gears like ring seines and its large-scale adoption by traditional fishermen in Kerala were an offshoot technology from the motorization process.

The BOBP also brought about significant changes in the life of artisanal fishermen of India with its yeoman services in the popularization of beach landing crafts (BLC), motorization of craft and introduction of new net designs, post-harvest technologies like hygienic curing of fish and smoking, introduction of insulated fish boxes for transportation from landing centres to markets and enhanced role of fisherwomen in coastal fishery development. During the same time, the FAO/UNDP/CIFNET/CIFT experiments on fuel saving devices also came up with interesting solutions to improve propeller efficiency and added fuel efficiency.

Diversification of fishing techniques

High opening bottom trawling

Initially, stern trawling aimed at shrimp resources was adopted by the fishermen. The high opening bottom trawling method for the demersal fishery resources (fish and shrimp) was a major technological breakthrough introduced in 1982 by BOBP along Tamil Nadu coast and in 1983 by CIFNET along Gujarat coast.

The Mexican trawlers

Realizing the need for extending the fishing operation to offshore region to enhance the fish/shrimp production, larger fishing vessels (Mexican trawlers) were introduced from mid seventies.

Conversion of small trawlers into deep-sea shrimp fishing

During 1999, medium sized trawlers which are upgraded and fitted with GPS and echosounders ventured into deep sea shrimp fishing along the Kerala coast. Shrimp trawlers based at Quilon, Kochi and Munambam fisheries harbours carried out intensive fishing operation at *Quilon bank* at depths ranging between 175 and 400m.

Multi-day fishing operations

When mechanisation was started in the early 70s, small mechanized craft of 9.75 –10.9 m OAL were very popular and economical for single day shrimp fishing operations. The increasing number of vessels operating in in-shore waters, over the years, led to decreasing catch per unit effort and prompted multi-day fishing operations for economic reasons. Vessels with upgraded engines could operate profitably in off-shore waters during the early nineties. During late 1990s, the fishing industry undertook deck modifications in their idling shrimp trawlers (9-13m OAL) so as to carry out drift gill netting aiming high unit value fishes like tunas and seerfishes (Balasubramaniam, 2000). Modifications included removal of the mast, winch and gallows, reducing the area of the wheelhouse including its height, conversion of part of the rear portion of the deck as storage for ice blocks and fish catch and storage of gear /craft operational material just in front of the gear hold.

Tuna long-lining

During 1983-84, surveys for tuna resources and training programmes for tuna long-lining with technical guidance of Captain E.Haruta of the Japan International Cooperation Agency were conducted with the aim of developing an export oriented tuna fishery in the Indian seas. Further development of suitable technology for sub-surface longlining for oceanic tunas which are an underexploited resource in the Indian seas has to be seriously thought of.

Development of Beach Landing Craft (BLC)

Beach Landing Crafts were specifically designed for the coast of Andhra Pradesh and Orissa by the BOBP and this is a classical example of developing a successful fishing vessel technology. It has replaced the existing traditional boat '*Nava*' of the region as the fishermen view the BLC as a safe and comfortable craft along with its higher mobility, fuel economy and ability to carry more gears. On technical ground, the BLC has proven itself as a surf-crossing and beachlanding craft mainly due to the superior features of its hull like a flat and rounded bottom without keel enabling it to sit upright on the beach and high manoeuvrability achieved by a large rudder directly behind the propeller, complemented by the pivoting engine installation, combined within-built buoyancy and a water-tight deck (BOBP, 1993). Better earnings by crew members of BLC and the fact that crew of traditional fishing boats are eager to shift to BLC are indicators of the success of the technology. The history of Beach landing Craft Development (BCD) project covers two phases. During the first phase (1979-1984) crafts were developed and trials of several prototypes were carried out resulting in two models being deemed suitable for commercial introduction by 1984. In the second phase (1985-92) commercial introduction of the craft was carried out along with considerable refinement of the technology, mainly in respect of the engine and propulsion system and hull details, offshore fishing trials and evaluation of performance of the craft. The development of BLC technology in India is given in Table 46.

Motorization of traditional crafts coupled with introduction of innovative gears

Motorization of country crafts in Kerala began only in the early 80s eventhough experimental projects on motorization were tried much earlier

(Jacob *et al.,* 1987). In Kerala, the ringseine or the mini purse seine was introduced in the mid 80s as new pelagic gear for traditional crafts. Adoption and popularisation of this gear in the second half of the eighties (1986) was the most significant development in the post-motorisation phase of fisheries in Kerala. Although this gear is banned under the Kerala Marine Fishing Regulation (KMFR) Act 1980, its numbers have grown rapidly and contribute a considerable portion of the State's total marine fish landings (Leela Edwin and Hridayanathan, 1998).

Table 46. Development of Beach Landing Craft Technology in India

Craft type	Introduction	Construction Material	Model specifications	Comments on technology
IND-10	1980	Timber	7m decked craft diesel air-cooled inboard engines (4.8 hp)	Discarded as too heavy to haul on/off beach
IND-11	1982	Polystyrene blocks encased in a non-watertight framework based on the catamaran principle	7.4m boat diesel air-cooled inboard engines (4.8 hp)	Discarded due to high cost of timber, fasterners and polystyrene
IND-21	1982	Modified version of IND-II based on the buoyancy block principle	7.2m, diesel air-cooled inboard engines (4.8 hp)	
IND-13	1983	Marine plywood	7.4m decked craft, diesel air-cooled inboard engines	Found economically feasible for large mesh drift nets but more space for crew and gear storage required
IND-14	1980	Marine plywood	7.4m twin hull craft with kerosene out-board motors	Inadequate control during beachlanding and hence discarded
IND-18	1981	Marine plywood	8.4 m boat with 8hp diesel air-cooled inboard engines	Commercial introduction craft
IND-20 IND-23 & IND-24	1984 1984	FRP version of IND-18 Design with aluminium hulls		Excellent beachlanding ability but non-availability of correct grade and temper of alluminium alloy led to discard of model
IND-25	1985	FRP	1.7 M	Considered the smallest possible motorized BLC

Source : BOBP, 1993

A modified version of the boatseine, the ringseine can be broadly classified into two major types – the large *thanguvala/ ranivala* (800 x 90 m with 18-22 mm mesh) and the small *choodavala/ discovala/ nanduvala* (400 x 60 m with 8-12mm mesh). Large sized ring seines, varying in size from 800-

1700m length are used from inboard motor (IBM) crafts along the coast of Kerala. During the introductory stage of ringseine in 1988, a study conducted by the South Indian Federation of Fishermens' Societies (SIFFS) estimated the catch/fisherman/month (c/f/m) by this gear as 496 kg but in 1995-96 it was observed to be only 218 kg (Leela Edwin and Hridayanathan, 1998). This decline in CPUE is being attributed to the excess effort being expended in the ringseine sector of Kerala. At the time of introduction, 300 ringseine units were recommended for the Kerala coast (Panicker, 1985) but in course of time the size of gear has increased three times and the number of units went up to 2259 in 1991 (Anon, 1992). To accomodate the larger gear, the size of the plank craft was increased, the number of crew was increased (30-40 nos); and the number of outboard motors (upto 4) and more powerful engines (upto 85 h.p. total) are common now. The proliferation of ringseine has caused two other major gears used by traditional fishermen the '*koruvala*' (scoop net) and '*kollivala*' (boatseine) to become obsolete (Algaraja *et al.*, 1994). Impacts of declining CPUE on the socio-economic conditions of ringseine fishers need further research and documentation.

Panikkar *et al.* (1998) based on the cost and earning data of different craft-gear combinations operating from major fish landing centres of Kerala (Table 47) concluded that after motorization artisanal fishing units have become more profitable and transformed from a subsistence oriented one to the level of cash crop operation but the studies by Leela Edwin and Hridayanathan (1998) contradict this.

Table 47. Economic indicators of motorised units operating in Kerala during the 1992-93 period

Attribute	Ringseine (large)	Ringseine (medium)	Mini trawlers	Gill net	Hooks & Line
Average landings per day of operation					
Quantity (kg)	870	730	27	68	80
Value (Rs.)	6100	5119	964	1085	1188
Fishing days per year	200	200	110	220	220
Value realized (Rs./kg)	7.15	7.00	36	16.5	14.85
Cost of fish production(Rs./kg)	5.82	5.67	30	14.34	14.15
Operating Cost (Rs./kg)	4.70	4.70	25.80	11.86	11.81
Returns to labour (Rs./ labour day)	90	100	120	100	100
Net profit per day (Rs)	1032	974	157	110	56
Rate of Return (%)	43	51	44	31	23

Source: Panikkar *et al.*, 1998

Boat building materials

Teak (*Tectona grandis*) and jungle jack (*Artocarpus hirsuta*) were the most common timbers used in vessel construction until the 60s. Non-availability of quality timbers (Table 48) at reasonable price, difficulties in maintenance of wooden crafts and government policy of forest conservation spurred studies by CIFT and the Bay of Bengal Programme (BOBP) on alternative materials for vessel construction. The BOBP studied the comparative costs of alternative boat-building materials (Table 49) and emphasized the need for development work on FRP and aluminium boats while *venteak* (*Lagerstroemia lanceolata*), fibreglass, ferro-cement, aluminium alloy and steel were identified as alternates by CIFT (Korakandy, 1994). *Venteak* in particular has been recommended as it is available in sufficent quantities in different parts of the country and its prices only one-third of teak and half of jungle jack *Aini* (Balasubramanyam, 1970).

Table 48. Timber used in fishing craft construction along the Indian coast

Craft type	Material
Log raft/ catamarans	Siris (*Albizzia chinensis*), semul (*Bombax ceiba*) Malabar neem (*Meliacomposita*, *M.dubia*), Maharukh (*Alianthus malabarica*), Murrukku (*Erythrinaindica*) and rain tree (*Samanea saman*)
Mechanised boats	Teak (*Tectona grandis*), Jungle jack (*Artocarpus hirsuta*), Chaplash (*A.chaplash*), Sal (*Shorea robusta*) Shisham (*Dalbergia sissoo*), Laurel (*Terminalia alata*)

Source: Leela Edwin, 2002

Table 49. Comparative cost* per square metre of alternative materials used in the construction of an 8.5 m boat

Material	Basic material cost	Thickness (mm)	Weight (kg/sq.m)	Cost (Rs./sq.m)
Jungle jack	Rs.3000/cu.m in log form (40% loss from log to plank)	19	11.5	112
Marine plywood	Rs.120/sq.m	12	9	120
Fibreglass	Rs.55/kg	6	9	500
Aluminium	Rs.40/kg	3	8.4	340

* 1985 prices

Source: Gulbrandsen, 1984

In 2002, the CIFT designed Fibreglass Reinforced Plastic (FRP) coated fishing canoes (5.78 x 0.82 x 0.39 m) each costing about Rs. 23,000 for traditional fishermen and distributed to Chellanam Village SC/ST Co-operative Society under the Special Component Plan of Government of India (Devadasan 2002). Selected persons were trained in canoe construction to meet further demand. Also, the studies initiated in 1997 by CIFT on rubberwood (*Hevea brasiliensis*) gave encouraging results and paved the way for construction of two prototype canoes in 2002 for backwater and marine fishing. The cost of rubberwood is only one-fourth of the conventionally used timber, jungle jack (*Artocarpus hirsuta*) used for traditional craft construction and is worthy of serious consideration as an alternative (Devadasan, 2002). The availability of steel (IS: 226, IS 3039 grade), easier availability of skilled welders compared to skilled boat building carpenters and less wastage of materials during construction have paved the way for a gradual preference for constructing steel vessels of above 15m OAL for offshore fishing (Ravindran and Baiju, 1998).

Protection of fishing boats

Development of a viable chemical treatment for catamarans to protect it from marine borers assumes special significance as the craft is used by the poorest of traditional fishermen in India. Earlier, indigenous preservatives like liquid cashewnut shell extract and fish oils were used which had very little toxic properties and acted as mere water repellents, thus becoming a wasteful expenditure incurred by the traditional sector on craft maintenance. In 1993, the first indigenous chemical preservative called ASCO was formulated and patented by the Forest Research Institute, Dehra Dun. Later, preservatives like arsenic creosote, copper creosote and creoscor have been developed by CIFT. The new treatment besides imparting toxicity to wood against the harmful effects of bacteria, fungi and termites also retards weathering and crack formation on the boats and the frictional resistance to motion of the craft in water. The cost of chemical treatment of a catamaran comprising six logs of maximum size 10 x 0.4x 0.35 m with 75% Copper-Chrome-Arsenic compound (CCA) is reported to be Rs. 2,400 while the increase in life span (normally 5–7 years) of the catamaran would be three-fold (Leela Edwin and Saly Thomas, 2000). Substantial savings is facilitated by the new technology as the treatment procedure costs only 28% of the traditional treatment and needs to be done only once a year compared to twice a year for indigenous preservatives (Leela Edwin, 2002). Recently CIFT has developed a 'dual preservation' treatment using a water borne preservative (CCA) followed by an oil-borne preservative (Creosote) under pressure with an intermittent drying period for crafts in areas of extreme borer hazards (Devadasan, 2002).

The traditional method of protecting the hulls of wooden boats from marine borers and fouling organisms has been by giving copper sheathing which is very costly. CIFT has recommended an alternative cheaper aluminium-magnesium alloy sheathing alongwith G.I.fastenings, cast iron fittings and aluminium alloy tacks and screws (Devadasan, 2002).

Fuel efficiency and energy conservation

Energy conservation and fuel saving are priority areas because of the increasing price of oil which is a major input for motorised/mechanised fishing. Annual fuel consumption by mechanized and motorized fishing fleet of India is estimated at 1219 million l, costing over Rs. 19000 million (Boopendranath, 2002). Trawling is reported to consume 0.8 kg of fuel while longlining and gillnetting consume between 0.15 and 0.25 kg fuel and purseseining requires 0.07 kg of fuel to catch 1 kg of fish (Gulbrandson, 1986). Targeted fishing for shrimp by trawlers, triggered by excellent opportunities for export have resulted in declining resources in the coastal fishing grounds while the other fishing techniques like longlining and gillnetting can yield high unit value fishes like tunas, carangids, seerfishes and sharks.

Energy conservation in fish harvesting can be achieved through

- improved fishing gear and methods;
- fuel efficient vessel technology;
- engine designs and maintenance;
- reduction gear, propeller and nozzle;
- sail assisted propulsion;
- adoption of advanced technologies like GPS and PFZ maps;
- installation of Fish Aggregating Devices (FADs) and sea ranching programmes to increase availability of fish in the fishing grounds;
- fleet management through multiday fishing, mother-ship and carrier-boat operations;
- diversification of idling shrimp trawler fleet for drift gillnetting or longlining; and
- GIS based fishery prediction systems.

Presently, two types of engines are predominantly used in small fishing boats: (1) Outboard petrol and / or kerosene engines and (2) inboard diesel engines. Two-stroke outboard engine has high fuel consumption (0.5–0.6 $l.h.p.^{-1}.h^{-1}$) compared to diesel inboards (0.25 $l.h.p.^{-1}.h^{-1}$). While advantages of outboard engines are their low cost and portability, their disadvantage is high propeller speed and consequent low propeller efficiency. Turbo-charged diesel engines are about 15% more fuel efficient than normally aspirated engines. Petrol 4-stroke outboard engines, which have a much better fuel economy and emission standards, are also being introduced in small-scale fisheries. Direct fuel injection (DFI) petrol outboard engines, which are reported to have still better fuel efficiency, are expected to be introduced in small-scale fisheries. Research towards improved traditional wind propulsion system like fixed aerofoils, magnus rotor devices are also in progress (Boopendranath, 2002).

Smaller engines have multiple benefits of lower investment cost, lesser maintenance and huge reduction in the fuel consumption. Overpowering the vessel is wasteful in terms of energy as the maximum attainable speed of the vessel is dependent on length of the waterline. The installed engine power for a small fishing vessel engaged in passive fishing methods like gillnetting and lining, need not exceed 5-6 h.p. per tonne of displacement with a 10% increase in the tropical conditions (Gulbrandson, 1986). In the case of outboard engines, this should be 7.5 to 9 h.p. per tonne of displacement.

Increasing fuel cost coupled with decreasing catch is fast reducing the economic feasibility of medium sized trawlers (14 -15m) and optimisation of fuel consumption can be achieved either through modifications in hull design or improvement in propellor design. Nasar (1998) found that hull modifications are less likely to succeed compared to propellor improvement as it entails considerable expenses besides loss of fishing days. The new propeller designed by CIFT tested on six trawlers indicated an average 20% saving on fuel and recovery of the additional investment on propeller replacement within 3 months of operation (Table 50).

Table 50. Fuel consumption in vessels with different propellers

		Free running				trawling	
Existing propeller	RPM	1200	1500	1800	1950	2000	1825
	Fuel consumption (l/h)	7.90	12.20	18.5	22.7	24.3	13.70
	Speed (Knots)	5.98	6.89	7.56	7.86	8.00	3.90
Wagenin-gen B type	RPM	1200	1500	1800	1950	2000	1840
	Fuel consumption (l/h)	6.50	10.20	15.5	18.8	20	11.80
	Speed (Knots)	5.98	6.89	7.60	7.90	7.97	3.85
Improved propeller	RPM	1200	1500	1800	1950	2000	1850
	Fuel consumption (l/h)	6.50	10.10	15	18	19.2	11.30
	Speed (Knots)	5.90	6.85	7.62	7.9	7.95	3.90

Source: Nasar, 1998

In India, there is a long tradition of using sail in small fishing vessels and catamarans. If the sail is used as the main propulsion wherever it suits the fishing method adopted, it is possible to reduce the size of the engine to what is required to manoeuvering in harbours and fishing grounds. In low energy fishing methods such as coastal gill netting and long lining, it is definitely a practical alternative energy source. The Beach Landing Craft operated with sail and specifically evolved for the coast of Andhra Pradesh and Orissa by the BOBP that subsequently become very popular is an example (Verghese, 1998).

Energy can also be conserved by optimising fleet management. Multi-day fishing rather than daily fishing; mother ship and carrier boat operations wherever practical are fuel saving practices that can be implemented in fleet operations along the Indian coast.

Use of PFZ advisories, GPS and other electronic gadgets in fishing

Recent advances in technology have provided fishermen with equipment such as Global Positioning Systems (GPS) to reach the potential fishing grounds accurately; detect the presence of fish and monitor the success of capture process acoustically (echo sounder, sonar, gear monitoring systems) thereby minimizing the search time and fishing time and hence saving energy. Intensive validation of Potential Fishing Zone (PFZ) advisories generated by National Remote Sensing Agency (NRSA) based on sea surface temperature (received from NOAA satellite AVHRR imageries) and ocean colour (from OCEANSAT) at many fish landing centres have revealed positive relationship between PFZ and occurrence/abundance of commercially important pelagic fishes (Pillai, 2002). These are being implemented by State Fisheries Departments in collaboration with Research organisations like CMFRI, CIFT and INCOIS. Timely communication of information on PFZ to the fishermen is the most critical factor for the effective implementation of this technology which has good scope to develop fisheries in India.

Development of Geographical Information Systems (GIS) in the marine fisheries sector could provide accurate decision making support for choice of fishing grounds for specific target resources based on spatial relationship of fish stocks in relation to hydrographic and bathymetric parameters.

Resource enhancement and conservation

Fish aggregating devices have shown the potential for saving fuel and scouting time, in purse seining, handlining and gillnetting in different parts of the world. In India, fish aggregating devices (FADs) have been traditionally in use but modified versions are becoming increasingly popular among artisanal fishermen as a way of getting better catches and saving fishing time in the face of increased competition from mechanised crafts which are also operating in inshore waters. They can be installed with active cooperation of traditional fishermen communities and State Fisheries Departments. However, this process, being done in an open access water body like the coastal seas, has to be governed by a legislation that shall cover all major issues including placement, use, ownership, fishing rights and navigation. A National Artificial Reef Plan will have to be formulated that will set out geographic, hydrographic, ecologic and socio-economic criteria for setting artificial reefs and methodologies for management.

Sea ranching programmes will also have to be taken up by Fishery Development Agencies with research support from Central Institutes and co-operation from fishermen self-help groups to replenish the heavily exploited resources like shrimps and enhance catches made by traditional / small scale fishermen.

Marine fishing regulations

With the rapid motorization and mechanization of the fishing fleet, fishing activities became highly competitive especially in the inshore waters and conflicts between the artisanal and mechanised sector do occur often. This necessitated promulgation and enforcement of fisheries management measures and Marine Fishing Regulation Acts (MFRA) (Table 51).

Table 51. Marine Fishing Regulation Acts in various maritime states (Provinces) of India

State (Province)	Act & Year	Exclusive Fishing rights
Kerala	MFRA 1980	Traditional fishermen- upto 10 km from shore, Mechanized boats < 25 GRT – beyond 10 km, Mechanized boats > 25 GRT – beyond 23 km
Goa	MFRA 1980	Traditional fishermen- upto 5 km from shore, Mechanized boats – beyond 5 km
Maharashtra	MFRA 1981	Traditional fishermen – upto 5-10 fathoms depth
Orissa	MFRA 1982	Traditional fishermen- upto 5 km from shore, Mechanized boats – beyond 10 km
Tamilnadu	MFRA 1983	Traditional fishermen- upto 3 nautical miles (5.5 km)from shore, Mechanized boats – beyond 3 nautical miles
Andhra Pradesh	Executive Order 1983	Traditional fishermen- upto 10 km from shore, Mechanized boats – beyond 10 km, Mechanized boats > 20m OAL – beyond 23 km
Karnataka	MFRA 1986	Traditional fishermen- upto 6 km from shore, Mechanized boats upto 50 feet OAL – beyond 6 km, Mechanized boats >50 feet OAL – beyond 20 km
West Bengal	MFRA 1993	Non-mechanised vessels < 9m OAL - upto 8 km from shore, Non-mechanised vessels > 9m OAL – beyond 8 km, Mechanized boats upto 15 m OAL – beyond 20 km, Mechanized boats >15 m OAL – beyond 50 km
Gujarat	MFRA 2003	Seasonal closure of fishing

Source: modified from Verghese, 1989

Infrastructure development

The development of fishing harbour projects have played a key role in marine fisheries development in India. In 1954, the Government of India solicited the services of two FAO harbour specialists to study possible locations for fishing harbours in the country. By the sixties, the rapidly growing fleet of small mechanised boats required full fledged fishing harbours (with all facilities like landing jetties, berthing quays, slipways, dredging machines, fuel bunks, ice and water supply, auction halls, transport, repair and maintenance). To accelerate the modernization and expansion of the fishing industry in the country, the work on investigation, formulation and execution of major fishing harbour projects was entrusted to the Port Trust Authorities of the respective regions in 1965. A Central Agency 'Pre-Investment Survey of Fishing Harbour Projects' to study the techno-economic viability of developing a number of minor fishing harbours at the major fish landing centres of the country was also set up in 1968 with technical assistance from FAO/UNDP. Today there are six major and 28 minor fishing harbours in the country.

Credit and support services

Since their nationalisation in 1977, banks have also been playing a major role in transfer of technology in the fisheries sector among which the National Bank for Agriculture and Rural Development (NABARD) has played a key role in the development of infrastructure like hatcheries, feed mills, net making, processing plants, development of landing centres and mechanization of fishing vessels required for fisheries development (Table 52). Since 1992 this Bank has also been paying special attention to gender issues in the credit and support services and are actively promoting women Self-Help Groups.

Table 52. Contribution of NABARD in the development of fisheries sector (in physical terms) till March 1995

Activity	Total units developed	Units supported by NABARD	% share of NABARD
Multi-day fishing vessels (nos.)	34,848	18,425	53
Other boats (nos.)	197,219	59,749	30
Brackishwater aquaculture (in ha)	25,000	2,606	11
Freshwater aquaculture (in ha)	738,000	189,000	26

Source: Palanisamy and Ghosh, 1998

Self-help Groups

The concept of Self-Help Groups (SHGs) has been found to be crucial for sustainable development of human resources as well as livelihoods. The concept was introduced in the 90s with the aim of replacing a subsidy-oriented development with a revolving fund development. The Development of Women and Children in Rural Areas (DWCRA) is the largest programme of its kind in India and has played a key role in enabling adoption of mariculture techniques among women fisherfolk to supplement their incomes.

Marine fisheries research and development

Marine fisheries (Research, HRD, Development and Trade) are administered through three different Central Ministries; the Ministry of Agriculture and its Institutions (IFP, CIFNET, FSI and CICEF), the DARE and the ICAR Institutes, the Ministry of Science and Technology with DST, DOD, DBT and the CSIR with NIO and Ministry of Commerce with MPEDA. At the State level the SAU Fisheries Colleges, some Academic Universities and the Fisheries Departments administer HRD/R&D of marine fisheries sector. All these organizations implement programmes as per their mandate.

The Central Marine Fisheries Research Institute is the nodal agency in India responsible for research support to the development of marine fisheries in the country. At the CMFRI, initially, research efforts were devoted to estimation of marine fish landing and effort, taxonomy of marine organisms, fishery environment and bio-economic characteristics of exploited finfish and shellfish stocks. In the early 70s, recognizing the need to supplement capture fisheries production with that from sea-farming and coastal mariculture, development of many viable mariculture technologies (shrimp, edible oyster, mussel, clam, pearl oyster and seaweed) was given priority. In the 90s research was concentrated on augmenting marine fisheries production through programmes like sea-ranching (shrimps, clams, pearl oysters) and setting up of Fish Aggregating Devices (FADs) as community programmes in fishing villages. The assessment and refinement of the various technologies generated by CMFRI through Institution-Village Linkage Programme has proved their viability at the field level. The Agricultural Technology Information Centre (ATIC) at CMFRI, Cochin was established in 2001 to provide a single window delivery system for the transfer of these technologies apart from the existing facilities like *Krishi Vigyan Kendra* (KVK) and Trainers' Training Centre (TTC). Besides, development of human resources in mariculture was successfully carried out by CMFRI through Post-graduate Programme in Mariculture (PGPM) offering Master's and Doctoral programmes.

The other Institutes providing R & D support to the marine fisheries sector are the Central Institute of Fisheries Technology, Fishery Survey of India, Integrated Fisheries Project, Central Institute of Coastal Engineering for Fisheries, Centre for Marine Living Resources and Ecology and Marine Products Export Development Authority. Education and training are crucial in improving productivity of the workers and the fisheries sector. The education and training institutes established in the country to meet the trained manpower requirements for management of fisheries projects, for operation of fishing vessels as well as shore activities are the Central Institute of Fisheries Education, Fisheries Colleges under SAUs and Central Institute of Fisheries Nautical and Engineering Training. The fisheries education and training in India have evolved under a four-tier pattern, namely

- Operative technical personnel for the artisanal fisheries (base level);
- Statutorily required personnel for manning ocean going vessels and trained personnel for handling, processing and marketing as well as shore-based personnel for maintenance of vessel and machinery and fabrication of fishing gear etc. (under-graduate level);
- Development and managerial personnel to plan and to be in charge of developmental programmes (graduate and post graduate level) and
- Scientific and technical personnel for stock assessment, aquaculture, harvest and post-harvest, development of new technologies etc. (post-graduate level).

The marine fisheries sector in India has, over the years grown to the level of a major industry with a gross capital investment of around Rs 41,170 million (at 1995 price level). Development thrusts in the marine fisheries sector through the Plan periods from 1957 to 2002 are given in Table 53.

Table 53. Development thrusts in the marine fisheries sector by GOI through the Plan periods

Plan period	Duration	Major developments	Average annual catch (t)
I Five Year Plan	1951 to 1955	1. Mechanization of indigenous artisanal fishing craft	565412
II Five Year Plan	1956 to 1960	2. Introduction of mechanised fishing vessels	730699
		3. Introduction of modern gear materials	
		4. Infrastructure for preservation, processing, storage and transportation	
III Five Year Plan	1961 to 1965	1. Substantial increase in the use of synthetic gear materials	730061
Three annual plans	1966 to 1968	2. Export trade	904355
IV Five Year Plan	1969 to 1973	1. Imports of trawlers for deep-sea fishing	
		2. Indigenous construction of deep-sea trawlers	
		3. Fishing harbours at major & minor ports	1070264
		4. Intensification of exploratory fishery surveys	
		5. Expansion of export trade	

V Five Year Plan	1974 to 1978	1. Diversification of fishing, introduction of Purseseining	1326408
One annual plan	1979	1. Diversification of products 2. Motorization of artisanal craft	1365739
VI Five Year Plan	1980 to 1984	1. Exploratory surveys in offshore grounds 2. Declaration of EEZ in 1977 3. MZI Act 1981 for regulation of foreign fishing vessels 4. Deep-sea fishing through licensing, chartering and joint venture vessels	1434914
VII Five Year Plan	1985 to 1989	1. New chartering policy of 1989 2. Development of deep-sea fishing	1769040
Two annual plans	1990 to 1991	3. Substantial growth in motorized artisanal fleet of ringseiners on west coast 4. Introduction of Beachlanding crafts on east coast 5. Coastal shrimp aquaculture	2182412
VIII Five Year Plan	1992 to 1996	1. Deep-sea fishing by joint venture 2. Development of coastal aquaculture 3. Substantial growth in motorized artisanal fleet of ringseiners 4. Export trade changes from a resource-based to food engineering-based industry	2295889
IX Five Year Plan	1997 -2002	1. Stay-over fishing 2. Growth of motorised sector 3. Resource specific fishing by trawlers and drift gill nets 4. Popularization of bivalve farming 5. Export of finfishes including oceanic tunas 6. Installation of Artificial Reefs/ FADs	2532436
X Five Year Plan (thrust areas identified)	2002 -2007	1. Development of domestic fish marketing network 2. Development of oceanic fisheries and deep-sea resources like shrimps and lobsters 3. Promoting mariculture and cage culture 4. Sea ranching	2662809 (2003)

Source: modified from Devaraj *et al*., 1997.