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DEVELOPMENT OF FISHING INDUSTRY IN INDIA

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Abstract: This paper presents an overview of the development of fishing industry in India. Marine fish production of India which was only 0.5 million tonnes (mt) in 1950, increased to 3.07 mt in 2010, contributing 38% of the total fish production and 79% of the capture fish production. Total fisheries production of India has increased from 739,817 t in 1950 to 9,348,063 t in 2010, recording 1263.56% growth. During the financial year 2011-12, for the first time in the history of Marine product exports, the export earnings from India have crossed USD 3.5 billion. This growth was primarily due to the introduction of various improved fish harvesting systems in India. In the marine fisheries sector, there are 194,490 crafts out of which 37% were mechanized, 37% were motorized and 26% were non-motorized. The introduction of outboard motors has transformed the face of traditional fishing activities and has brought about changes in the existing craft and gears operated in this sector. Motorisation of country craft in Kerala began only in the early 80s even though experimental projects on motorisation were tried much earlier. Purse seining experiments were conducted in India by the erstwhile Indo-Norwegian Project as early as 1954. Currently many fishing vessels process the catch onboard and are equipped with fish finding equipment and sophisticated navigational aids. From the efficient catchability of fishing gear, selectivity and responsible fishing has emerged the viable solution for fishing in the inshore region. Adoption of the Code of Conduct for Responsible Fisheries by FAO has set out the principles and international standards of behaviour for responsible practices in order to ensure long-term sustainability of the aquatic fishery resources, protection of biodiversity, energy conservation and environmental safety. Approaches in responsible fishing practices include prevention of excess fishing capacity and destructive fishing practices and adoption of scientific management in order to ensure long-term sustainability of the resources; development and promotion of selective fishing gear and methods which would minimise fishing mortality of non-target species and protected species and ensure biodiversity; development and promotion of eco-friendly fishing gears which would minimise negative impacts on environment; energy conservation in harvesting operations; and enhancement of resources by introduction of artificial reefs and fish aggregating devices, and restoration of coastal fishing grounds from negative impacts of environmental pollution and eutrophication. With the assistance from R&D organizations the fishers in India are in a constant quest for improvements in their day-to-day fishing activities that lead to their economic empowerment. This paper also highlights the contribution of Central Institute of Fisheries Technology in fish harvesting in India.

Key words: Fishing industry, craft design, trawling, purse seining, FAD, fishing craft, navigation, fish finder, CIFT, CCRF, TED

INTRODUCTION

Global capture fishery production has been plateauing and has more or less stabilized at around 80 million t (FAO, 2012a). Marine fish production of India which was only 0.5 million t in 1950, increased to 3.07 million t in 2010 (CMFRI, 2011), contributing 38% of the total fish production and 79% of the capture fish production. Total fisheries production of India has increased from 739,817 t in 1950 to 9,348,063 t in 2010 which is 1263.5642% growth (FAO, 2012b; FAO, 2012c). This could be attained due to the introduction of various improved fish harvesting systems in India. Fig.1 depicts the trend in total fisheries production of India from 1950 to 2010.

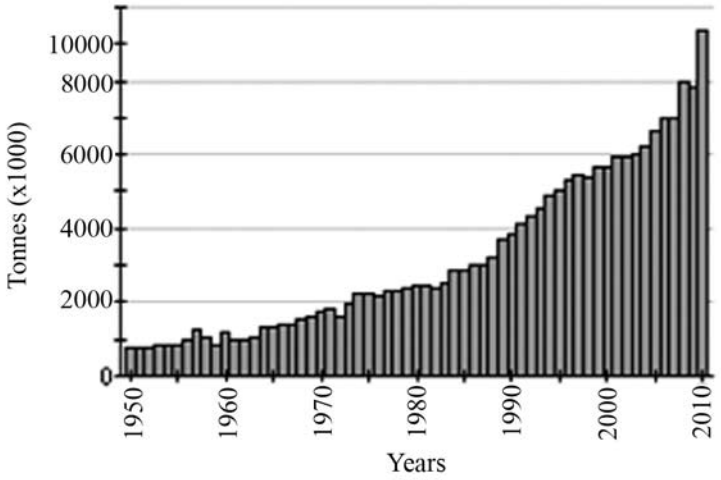

Fig.1: Total fisheries production of India from 1950 to 2010
Source: FAO (2012c)

When comparing with 2008 data (FAO 2010), India has improved its ranking from 6th position to 2nd position in terms of total fish production during 2010 (FAO 2012d). In 2010, India is the second largest producer from aquaculture and third largest producer from capture fisheries (FAO, 2012d). Agriculture, forestry and fishing sector in India during 2011-12 has shown a growth rate of 2.8 per cent (Ministry of Statistics and Programme Implementation, 2012).

During the financial year 2011-12, for the first time in the history of marine product exports, the export earnings from India have crossed USD 3.5 billion. This is also first time export has crossed all previous records in quantity, rupee value and US $ terms. India's exports of marine fish and fish products during 1950-51 were worth only Rs. 2.5 crores. Currently exports aggregated to 862021 tonnes valued at Rs. 16597.23 crores and USD 3508.45 million MPEDA (2012). The Marine Products Export Growth in US $ for the last decade is shown in Fig. 2.

The pelagic finfishes constituted 55%, demersal fishes 26%, crustaceans 14% and molluscs 5% of the total landings. The sector-wise contributions during the year 2010 were mechanized 73%, motorized 25% and artisanal 2%. The west coast accounted for 55% of the total landings and east coast 45% (CMFRI, 2011)

Oil sardine *(Sardinella longiceps)* remained as the most important single species contributing 13.1% to the total marine fish landings in the country. The estimated landings of oil sardine for 2010 is 4,03,932 tonnes against 4,14,767 tonnes in 2009. The second important resource in terms of contribution towards total landings is Indian mackerel *(Rastrelliger kanagurta)* accounting for 7.9% of total landings, the estimate for 2010 being 2,43,154 tonnes compared to 1,85,932 tonnes in 2009. The estimated landings of other important resources are penaeid prawns 2,17,858 tonnes (7.1%), croakers 1,66,967 tonnes (5.4%), cephalopods 1,66,886 tonnes (5.4%), ribbonfishes 1,50,166 tonnes (4.9%), non-penaeid prawns 1,28,876 tonnes (4.2%), threadfin breams 1,24,248 tonnes (4.0%), lesser sardines 1,03,059 tonnes (3.4%) and Bombayduck 94,942 tonnes (3.1%) (CMFRI, 2011).

The Ministry of Agriculture and CMFRI, Kochi (2012) has classified fishing crafts in India into mechanized crafts (trawler, gillnetter, purseseiner, dolnetter, ringseiner, liner and others), motorized crafts (catamaran, dugout canoe, plank built boat, plywood boat, fibre glass boat, ferro cement boat, carrier boat, *teppa* and others) and non-motorized crafts (dugout canoe, catamaran, plank built, ferro cement, thermocol, outrigger canoe, masula boat and others) and fishing gears

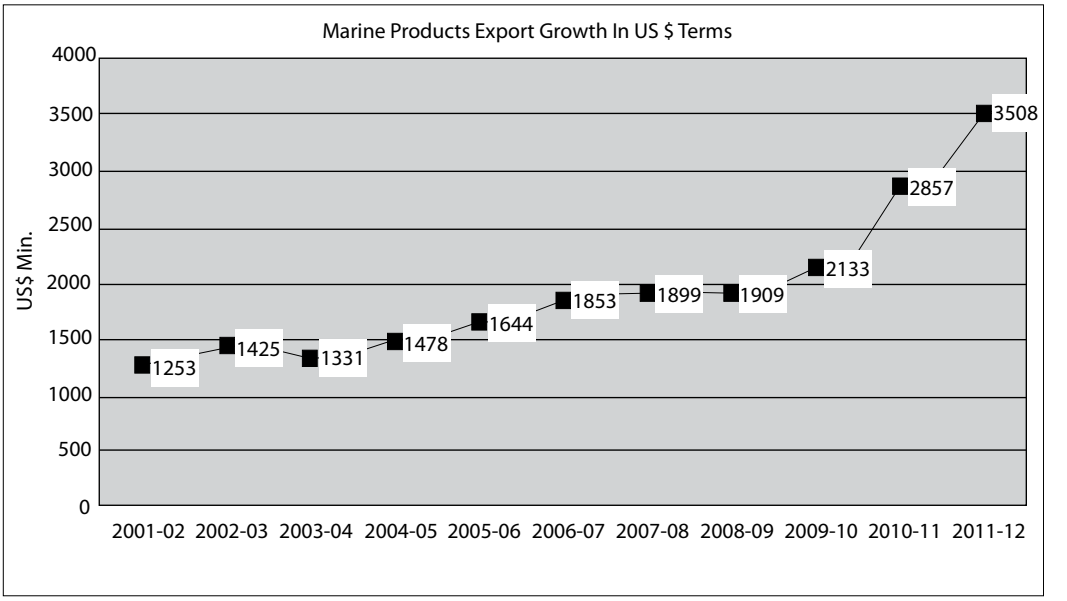

Fig. 2: Marine products export growth in US $ terms
(Source: MPEDA, 2012)

into trawl net, gillnet, driftnet, ringseine, purse seine, boatseine, bagnet, shoreseine, castnet, hooks and lines, troll lines, fixed nets (chinese dipnets/stakenets), traps, scoopnet and others.

Fishing is an ancient occupation which contributes significantly to the foreign exchange earnings of India. Fish harvesting systems include the components of fishing vessel and fishing gear. A wide array of fishing gears and practices ranging from small-scale artisanal to large-scale industrial systems are used for fish capture. Over the years, traditional fishing gears have been upgraded and newer more efficient fishing systems have been introduced. Most important among these fish harvesting systems are trawls, purse seines, lines, gillnets and entangling nets and traps. The basic criterion used for the classification of fishery vessels is the gear used for catching fish or other aquatic organisms. The characteristics used to distinguish the various types and classes of fishing vessels are the general arrangement and deck layout, position of the bridge or wheelhouse, the fishing equipment used and the method of fish preservation and processing used in the vessel (Meenakumari, 2011).The establishment of Indo-Norwegian Project (INP) in the south-west coast of India, opened a new chapter in the fish production history of India.

The oldest established Department of Fisheries in India is in the State of Madras, formed in 1905 (Agarwal, 2006). The Union Ministry of Agriculture established Central Fisheries Research Station in the year 1947. Central Institute of Fisheries Technology, Central Marine Fisheries Research Institute, Central Inland Fisheries Research Institute, Central Institute for Fishery Education, National Institute of Fisheries Post Harvest Technology and Training, Fisheries Survey of India, Central Institute of Fisheries Nautical and Engineering Training, Bay of Bengal Programme of FAO, School of Industrial Fisheries of Cochin University of Science and Technology, Fisheries colleges of Agricultural Universities of maritime states, Ministry of Earth Science, the Indo-Danish Project and all Government agencies like SIFFS have contributed to the development of fishing techniques in India in one way or other.

Most significant among the technological developments which supported the evolution of fish harvest technology are (i) developments in

craft technology and mechanization of propulsion, gear and catch handling; (ii) introduction of synthetic gear materials; (iii) developments in acoustic fish detection and satellite based remote sensing techniques; (iv) advances in electronic navigation and position fixing equipment; and (v) awareness of the need for responsible fishing to ensure sustainability of the resources, protection of the biodiversity and environment safety and energy efficiency (Hameed and Boopendranath, 2000).

In the marine fisheries sector, there are 194,490 crafts out of which 37% were mechanized, 37% were motorized and 26% were non-motorized (Ministry of Agriculture and CMFRI, 2012).

FISHING CRAFT DESIGN AND DEVELOPMENT

Fishing craft mechanisation in India progressed through four stages, beginning with motorisation of some of the existing designs of traditional crafts, followed by introduction of mechanised craft, introduction of more specialised crafts, broadening to a full-fledged fishing fleet (Gurtner, 1958). The first attempt to motorise traditional fishing craft in Kerala, was made by Indo-Norwegian Project in 1955 (Gulbrandsen & Anderson, 1992; Vivekanandan, 1993; Alagaraja *et al.,* 1994). During 1970-73, Indo-Belgian Fisheries Project made an attempt to motorise log crafts (kattamaram) at Muttam in the Kanyakumari District with 25 hp outboard motors. The mechanization of indigenous craft has enabled the fishermen to fish in distant off-shore waters, that were previously inaccessible to them (Chidambaram, 1956). Lodhia, machuwa, kotia and Satpati-Versova type are built up canoes that have been found to be fit for mechanization (Zeiner *et al.,* 1958; Edwin, 2009). The traditional fishing craft and the modern factory vessel represent two phases of development of the fishing vessel (Edwin, 2009). Although some exploratory fishing surveys have been carried out using large vessels for locating resources and introducing fishing technique in the pre independence period, commercial fleet where not introduced till the last forties.

The introduction of outboard motors has transformed the face of traditional fishing activities and has brought about changes in the existing craft and gears operated in this sector. Motorisation of country craft in Kerala began only in the early 80s eventhough experimental projects on motorisation were tried much earlier (Jacob *et al.,* 1987; Pillai *et al.,* 1992). One of the significant outcome is the facility to drag a mini version of trawl net from the small traditional craft which was modified with transom to facilitate the fitting of an outboard motor. Ravindran (1998) discussed the trends in fishing craft development in India.

Paucity of traditional craft designs which are amenable to motorisation, led to the introduction of new designs. It was thought that the mechanisation need to be a gradual process allowing enough time for the traditional fishermen to take to more advanced craft designs. Initial attempts to evolve appropriate designs of beach landing crafts as suitable replacement for traditional catamarans and canoes were done by Gurtner (1960). Further developmental work in this direction was pursued under FAO/SIDA Bay of Bengal Programme for Small-scale Fisheries Development (Gulbrandsen, 1984; Ravikumar, 1985; Gulbrandsen and Andersen, 1992; Lehtonen and Lund, 1990). A substantial spin-off from the beach craft developed has been the proliferation of FRP craft construction technology on the east cost (Pillai and Katiha, 2004). During the eighties, the Bay of Bengal Programme of FAO has developed beach-landing crafts made of fiberglass for operating from surf-beaten coasts of Tamilnadu and Andhra Pradesh. Simultaneous with the evolution of beach landing craft, introduction of small mechanised crafts which operated from harbours and sheltered bays received attention. Many designs of small and medium fishing crafts belonging to this category were introduced into the Indian Fishing industry since 1953. Indo-Norwegian Project introduced some designs in Kerala State. FAO Naval Architects and later Central Institute of Fisheries Technology introduced several standard designs of fishing crafts for different types of fishing operations. The outcome of this mechanisation programme was the design popularly known as Pablo. Twelve standard designs of wooden fishing boats in the size range of 7.67 to 15.24 m were developed and

introduced by CIFT, Cochin which gave a major fillip to the mechanization programme of Indian fisheries. It is estimated that over 80% of the nearly 54,000 mechanised wooden fishing crafts in the Indian fishing fleet conform to the popular CIFT designs or its later adaptations. A steel fishing trawler (15.5 m) has also been designed and is in commercial operation today. Designs for boats for fishing in rivers and reservoirs, pole and line fishing vessel, trawler-cum-carrier vessel, steel trawler-cum purse seiner, gillnetter were also developed by CIFT (Anon, 1977; CIFT, 1982). FRP boats made of a composite material of fibreglass and a polyster resin has gained wide acceptability as they are of light weight and having longevity and strength. During the past couple of decades the fishing fleet in the country underwent an explosive increase in terms of both numbers of vessels and their efficiency. The light, powerful diesel engine and hydraulic winch allow the use of reasonably large trawl nets on a vessel that is relatively small and inexpensive to run. Tremendous progress has been made in new vessel design and construction and operations of modern fishing vessels. Hydraulic power is used on many vessels to operate most deck gear. Mechanical cooling and freezing equipments are common on vessels under taking longer trips.

Trawling

Trawling as a major fishing method for prawns became popular with the introduction of the mechanised harbour crafts (Miyamoto and Deshpande, 1959; Kurian, 1969). Consequent to the expansion of the shrimp processing industry, interest in the trawling technique increased which resulted in an increase in the mechanised fleet and its capabilities. At the beginning of mechanisation, small mechanised crafts of 9.75 m and 10.97 m were popular and economical for undertaking one day fishing, mainly targeted at shrimp. Later, larger vessels sufficiently powered and equipped to undertake multi-day operations in deeper waters, became popular due to economic advantages. Trawling was first attempted in Indian waters during exploratory surveys conducted from S.T. Premier, off Bombay coast, in 1902 (Hordman, 1903; Malpas, 1926; Chidambaram, 1952,1956) and by Ceylon Company for Pearl Fishing Survey, during 1906-07 (Hornell, 1916). Single boat midwater trawling was developed in the late 1940s to capture pelagic shoaling fishes. Pair trawling operations were conducted from the Japanese trawler Taiyo Maru 17, during 1947-1953 (Chidambaram, 1952). In 1955, an FAO Technical Expert conducted experimental shrimp trawling and obtained consistently impressive catches of shrimp in the shallow coastal waters of 4-18 m depth (Kristjonsson, 1967). This finding gave a major boost to commercial shrimp trawling in India. The introduction of bottom trawling to exploit marine fishery resources beyond the traditional fishing grounds around 1950s was an important event in the capture fishery development of Kerala State. At first most mechanized boats have used trawl nets without winches. However, very soon winches suitable for small boats were developed indigenously and such small trawlers became quite popular. The west coast consortium constructed Jheenga type stern trawler and operated for inshore fishing in the seventies (Hameed and Kurup, 1998). Double rig trawling for shrimp in the upper east coast was a notable advancement in the seventies (Hameed and Kurup, 1998). The banning of trawling by chartered foreign vessels and the speedy motorization of traditional fishing craft in the 1980s led to a quantum jump in marine fish production in the late 1980s. Sampling gear for demersal resource surveys was studied by Boopendranath *et al.* (1996).The introduction of mini trawls, a typical dragger type gear, operated by powered country craft was an innovation along Kerala, Karnataka and Maharashtra coasts (Pillai *et al.,* 2000). Mesh regulation is an important step towards reducing the growth overfishing, rampant in Indian fisheries (Vijayan *et al.,* 2007). By locating cuttle fish, deep sea lobsters and deep sea prawn in the continental shelf and slope, fishing industry has diversified its activities using net divergent devices such as oval slitted otter doors, polyvalent otter doors and V form otter doors (Hameed and Kurup, 1998). Introduction of suberkrub otter boards for one-boat midwater trawling and flat rectangular doors are some of the other otter doors used in Indian commercial fisheries.

The Central Institute of Fisheries Technology (CIFT) was established in 1957 with its

headquarters at Cochin under the Ministry of Agriculture, Government of India. Its administrative control was brought under Indian Council of Agricultural Research, ten years later. The mandate of the Institute is to carry research with a view to develop appropriate technologies in the fields of harvesting and post harvesting for the optimum utilization of aquatic resources and it has played a very important role in the overall development in the fisheries in the country. Research in CIFT on fishing gear has led to innovative concepts and designs for multipurpose gear such as the high opening trawl, bulged belly trawl, high-speed demersal trawl, hybrid trawl, bobbin trawl, large mesh trawl, long wing trawl, rope trawl, large mesh semi-pelagic trawls, semipelagic trawl with flexible headline and lifting devices, CIFT Semi-pelagic trawl (CIFT-SPTS), mini-trawl for traditional motorized crafts, mini-purse seine, improved dol nets, purse seine, long lines, troll lines, gill nets, trammel nets, shore seines, monolines, pots, gill nets and lift net for crabs, etc. These developments played a vital role for capturing fishery resources. All the fishing gears in vogue like gill net, trammel nets, troll lines, seines and trawls have become highly efficient with the incorporation of appropriate techniques based on scientific findings.

Purse seining

Purse seining experiments were conducted in India by the erstwhile Indo-Norwegian Project as early as 1954 (Oommen, 1989). Purse seining was introduced in Goa in 1957 (Sadanandan *et al.,* 1975). Purse seining in the commercial small- scale mechanised sector was started in India in 1974 (Mukundan and Hakkim, 1980). The Central Institute of Fisheries Technology (CIFT), Cochin developed and introduced a mini purse seine which came to be known as ring seine, for operation from the traditional motorized craft, during 1982-83, as an efficient alternative gear for operation from the traditional boat seine craft thangu vallom (Panicker et al., 1985). This gear had an overall dimension of 250 x 33 m and was fabricated of polyamide knotless netting of 18 mm mesh size. This development has offered an efficient alternative gear for operation from the traditional boat seine craft *thangu vallam*. Parallel innovations have taken place in the traditional motorised sector, around this period, leading to the development of a number of variations of ring seines (Rajan, 1993; Edwin and Hridayanathan, 1996; SIFFS, 1997). Widespread operation of purse-seiners along Kerala, Karnataka and Goa coasts especially from the eighties had a profound influence on the marine fish production. Edwin (1997) conducted detailed investigations on the catch and effort, energy utilisation pattern, gear selectivity, economic efficiency and management aspects of ring seine fishery of south Kerala coast. Power block introduced by CIFT in Indian purse seine fisheries in 2012 is a significant development which has made purse seining easily possible by facilitating the hauling of the net with minimum man-power. The introduction of large mesh purse seine to reduce catch of juveniles and also to target large pelagics by CIFT is a success.

[Another technology that has become highly popular among traditional lobster fishermen especially along the southwest coast of India was the new CIFT designed lobster trap which is 2.5 times more efficient than traditional traps in term of catches and also they last for 3-4 fishing seasons (Devadasan, 2002)].

Low energy fishing techniques

Introduction of FAD and fishing around this potential progressed satisfactorily in some of the selected areas on the south west coast of India. In India several groups of fishermen, particularly from villages of Kerala state, have erected reefs in the coastal waters to rejuvenate the depleting fish stocks. Reefs erected in this manner were termed Peoples Artificial Reefs (PARs). Large rocks, packed in monofilament net bags, cement well rings, granite stones and old tyres were installed in coastal waters at 25-50 m depth. Hooks and lines are the main gear to fish over the PARS. The reef became productive after three months (Kurien, 1991). In Andhra Pradesh, Visakhapatanam Research Centre of CIFT initiated a programme to install Fish Aggregating Devices in the coastal waters and later Andhra Pradesh State Fisheries Department had installed FADs at Kakinada, Visakhapatanam, Vijayanagaram and Nellore (Rageswari, 2009). The major species of fish caught in the area near FAD site comprised of

mackerel, seerfishes, carangids, sciaenids, *Upeneus* spp., engraulids and tunas (Rageswari, 2005).

The trammel net or the three-walled gill net, popularly known as disco net has got wide acceptance as an efficient gear along the east coast of India in recent years.

With the introduction of two large long liners namely Prashikshani and Matsya Sugundhi both Central Institute of Fisheries Nautical and Engineering training (CIFNET), and Fishery Survey of India (FSI) conducted extensive tuna exploratory surveys in the EEZ and beyond. Pole and line fishing in Lakshadweep with small mechanised vessel continues to be the main tuna production method in the Indian waters (Hameed and Kurup, 1998).

With the declaration of Exclusive Economic Zone of 200 miles in 1976, the programmes relating to deep sea fishing intensified. In 1981, the Maritime Zone of India Act was promulgated, in the Indian EEZ and to encourage deep sea fishing through licensing of vessel, chartering them and/ or joint venture. Tuna long lining by commercial enterprises and Govt agencies has become an established method. Deployment of vessels under the joint venture programme which began in 1992 have also helped in the exploitation of deeper water (Hameed and Kurup, 1998).

One of the important investigations for fuel saving is introduction of kort nozzle which has given fuel saving of 20% in trawlers. (Hameed and Kurup, 1998; Silas, 2003). Fuel saving concepts in trawl design such as rope trawl and large mesh trawl have been studied by Rao and Narayanappa (1994), Rao *et al.* (1994) and Kunjipalu *et al.* (1989, 1998).

Fishing craft and gear materials

Various cost effective protective measures against bio deterioration of wooden fishing vessels have been developed and are in use. A number of non-timber building materials such as ferro-cement, fibreglass reinforced plastic (FRP) and toxic non-plastic composites have been tested as alternative boat building materials (Silas, 2003). Use of cost timber like rubber and coconut have also been experimented successfully for small canoes.

In India, CIFT which plays a major role in the development of harvest technologies has also developed aluminium alloy sheathing for wooden fishing vessels, cathodic protection against marine corrosion in fishing boats, new substitutes for propeller material for cost savings, marine anti-corrosive paints, marine antifouling paints, chemical wood preservatives, indigenous resin based protective coatings for wooden crafts, ferrocement for boat building, rubber wood canoes, fibreglass reinforced plastic (2002) coated fishing canoes.

Initially, mechanized boats were using indigenous gear. Major advances in fibre technology, along with the introduction of modern gear materials, have directly influenced and brought about important changes in the design, dimensions and method of handling fishing gears (Meenakumari, 2011). Introduction of synthetic fibres during the 1920s opened a new era in the field of fishing gear development. The manufacture of multifilament nylon yarn (polyamide group of fibers) in India started only in 1962. Manufacturing of polyethylene and nylon mono-filaments for making fishing nets started later. Extensive use of synthetic materials like PA, PE and PP have witnessed in sixtees which created a revolution in fabrication of fishing gears. Today, the entire fisheries sector uses only synthetic fibers for gears. 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. The development of combination wire rope as an import substitute for deep-sea fishing is a recent innovation which has now been commercialised. CIFT has standardised specifications for the use of polypropylene multifilament netting yarn with lower specific gravity and better tenacity than nylon (Silas, 2003).

Contribution of CIFT in fish harvesting in India

CIFT has made significant contributions in the development of fishing gear and methods for the traditional sector, traditional motorised sector, small-scale mechanized sector and large –scale industrial sector in Indian fisheries, which is reflected in the increase in fish production.

Standard designs of mechanized fishing crafts

Twelve standard designs of wooden fishing boats in the size range of 7.67 to 15.24 m were developed and introduced which gave a major fillip to the mechanization programme of Indian fisheries.

Aluminium alloy sheathing for wooden fishing vessels

Aluminium-magnesium alloy sheathing with cathodic protection and prescribed coating system was developed as a cost-effective substitute for copper sheathing for wooden hulls as protection against marine borers. This technology is widely used in the small-scale mechanised vessels.

Cathodic protection

Mercury-free ternary aluminium anodes were developed for cathodic protection of steel fishing vessels against marine corrosion.

New substitutes for propeller material

Epoxy resin based coating developed has improved the life span of cast iron propeller, making it a cost-effective substitute for bronze propeller in fishing boats. Spheroidal graphite cast iron with nickel (21-24 %) material as substitute for conventional manganese-bronze for propellers of fishing boats, resulting in cost savings of 25-30%.

Hull maintenance of fishing vessels

CIFT has developed a package of technologies for protection against bio deterioration, fouling and corrosion for increasing the life span, substantially reducing maintenance coast of fishing vessels.

Marine anti-corrosive paints

Cheaper anticorrosive paints were developed incorporating cashew nut shell liquid resin and zinc chromate.

Marine antifouling paint

Superior cost-effective antifouling paint formulations incorporating cuprous oxide and modified indigenous resins were developed for protection against fouling, in fishing boats.

Chemical wood preservatives

Chemical wood preservatives such as arsenic creosote, copper creosote and creoscor were developed for protection of traditional crafts against bio-deterioration.

CIFT has developed technologies for the chemical preservation and up gradation of low cost timbers to make them more durable. These have extended the service life of fishing crafts and contributed toward the efforts against deforestation.

Technology was evolved for up gradation of cheaper secondary species of wood as substitutes for boat scantling, by impregnation with styrene-polyester monomers, fortification with Creosote/ Tributyl tin oxide (TBTO) and polymerisation with gamma irradiation.

Indigenous resin based protective coatings for wooden crafts

Protective coatings based on indigenously produced natural resins such as Andaman damar (Canarium euphyllum), black damar *(Canarium strictum)*, rock damar *(Hopea robusta)*, white damar *(Vateria indica)* as substitute for imported damar battu (family: Dipterocarpaceae) extensively used for protection of traditional wooden crafts in Maharashtra and Gujarat.

Ferrocement for boat building

Economic feasibility of ferrocement as substitute material for steel and wood for construction of fishing boats of 12-17 m length class.

Rubber wood canoes

The rubber wood, which comes as a waste from rubber plantations, can be efficiently utilized after upgrading by chemical preservative treatment. The Central Institute of Fisheries Technology, Cochin has successfully used treated rubber wood as alternative material for construction of traditional fishing craft. Treated rubber wood canoe can be further protected using fibre glass reinforced plastic (FRP) sheathing

Poma / other low cost wood canoes with FRP sheathing for NEH region

Netting, netting yarn and netting twine for fishing gear fabrication

Standardization of netting, netting yarn, netting twine, floats and hooks for fishery purposes

These developments have led to an increase in the productivity of the fishing gear and increase in net profits due to low maintenance and long service life of the nets.

Combination wire rope

Standardization of combination wire rope for deep sea trawl gear leading to import substitution through indigenous manufacture.

Improved lobster trap

Improved and durable lobster traps in substitute for traditional traps of short life span and low efficiency for harvesting of spiny lobster. Design: 700 x 550 x 400 mm size. It has a mild steel rod frame mounted with 25 mm square welded mesh, plastic coated for corrosion protection

Pots, gill nets and lift net for crabs

Crab pots, gill nets and crab lift net for catching crabs in live and undamaged condition.

Mini-trawl for traditional motorized crafts

A mini-trawl for operation from traditional crafts powered by outboard motors of 8-15 hp, for shallow water shrimp trawling. Design: 12.77 m mini-trawl

Mini-purse seine

A purse seine was introduced and popularised for operation from traditional plank built canoes (Thangu vallom) powered by outboard motors, for efficient harvesting of pelagic shoaling fishes. Since its introduction, the mini-purse seine has become very popular among the fishermen of motorized sector along the coast-line of Kerala, significantly contributing to the landing of pelagic coastal resources such as sardines, mackerel and anchovies.

Improved dol nets

Improved dol net, which is a fixed bag net operated for Bombay duck *(Harpodon nehereus)* in Gujarat and Maharashtra, with better size selection properties and design permitting fabrication from ready-made netting

Long wing trawl

Specially designed trawl for shrimp trawling with low vertical opening and extra long wings on either side to facilitate sweeping of wider horizontal area along the sea bed to increase the catch.

Designs :17.0 m and 32.0 m long wing trawls.

Bulged belly trawl

Bulged belly trawl has relatively high vertical opening compared to conventional shrimp trawl, to improve the catch of finfishes by about 30 % without compromising on shrimp catching abilities.

Designs: 17.0 m, 20.0 m, 25.0 m, 32.0 m bulged belly trawls.

High opening trawl

In high opening trawls, vertical opening of the trawl is increased by innovative design improvements, facilitating capture of demersal as well as off-bottom resources.

Designs: 17.0 m, 25.0 m and 32.0 m six seam and 25.0 m eight panel high opening trawls.

Large mesh trawl

Relatively large meshes are incorporated in the forepart of trawl resulting in significant reduction in trawl resistance, making use of the herding effect of large meshes on fin fishes. The reduced drag permits greater trawling speed and/or operation of an optimum sized trawl. Designs: 25.0 m, 32.0 m and 40.0 m large mesh trawls

Rope trawl

In rope trawl, the front trawl sections are replaced by ropes which as in the case of large mesh demersal trawl, results in reduction of trawl resistance. Fin fishes are retained due to the herding effect of ropes. The reduced drag permits greater trawling speed and/or operation of a larger trawl with the available installed engine power. Designs: 35.0 m rope trawl.

Sheer devices for trawls

Otter boards

Otter boards are sheer devices used in trawls for keeping the trawl mouth horizontally open. Designs: Different sizes of flat rectangular boards of wood and steel construction, V-form steel otter boards and high aspect ratio vertically cambered otter boards for small mechanized fleet.

Flexible headline lifting devices for trawls

Sail kite and double walled flexible float as advantageous substitutes for traditional hard plastic floats and rigid kites.

Purse seine

Purse seines for catching pelagic shoaling fishes such as sardine and mackerel, from small mechanized vessels.

Long lines

Long line for sharks using indigenous hooks.

Troll lines

Troll lines for predatory fishes such as Spanish mackerel and barracuda, using buffalo horn, stainless steel, spoon and fish head jigs

Gill nets

Marine gill nets optimized for catching sardine, mackerel, Spanish mackerel, pomfret and hilsa, in terms of material and mesh size. Colour- optimized gill nets for hilsa.

Fishing gear for inland fisheries

Gill nets
Trammel nets
Shore seines
Monolines
Trawls

High speed demersal trawls

Deep sea trawls developed for commercial harvesting of fast swimming, low density demersal resources in the depth range of 50 - 500 m depth, in the Indian EEZ.

Designs: 41.0 m HSDT-I, 38.0 m HSDT-II and 38.25 m HSDT-III

Trawls for deep sea operations in Indian EEZ

Bobbin trawl

Two-panel deep sea demersal trawl suitable for operation in the rough bottom conditions, in Indian EEZ.

Design: 32.0 m Bobbin trawl

Hybrid trawl

Multi-purpose hybrid trawl for cephalopod and demersal finfish resources.

Design: 38.0 m multi-purpose hybrid trawl.

High opening trawl

In high opening trawls, vertical opening of the two-panel trawl is increased by innovative design improvements, facilitating capture of demersal as well as off-bottom resources.

Design: 50.0 m high opening trawl.

Large mesh semi-pelagic trawls

Trawls incorporating large meshes for reducing drag and fuel consumption, for harvesting semi-pelagic resources.

Design: 33.7 m. large mesh semi-pelagic trawl,

CIFT Semi-pelagic trawl system (CIFT-SPTS) 18 m.

18 m. CIFT-SPTS with low impact on benthic biota with exchangeable contends for harvesting non-shrimp trawl resources.

Sampling gear for resource assessment studies

The necessity for developing standard and calibrated sampling gears for resource assessment studies has been a long felt need. 38.0 m HSDT-II crustacean and finfish versions have been identified as suitable for adoption for demersal finfish and crustacean sampling, respectively, during stock assessment studies.

Harvesting techniques for Antarctic krill

Acoustic detection and aimed midwater trawling techniques for Antarctic krill *(Euphausia superba)* have been developed, during First Indian Antarctic Krill Expedition (FIKEX) 1995-1996.

Selectivity of fishing gears

Information on fishing gear selectivity is important in biological investigations, fish stock assessment, fisheries management and fishing gear design & development. Selectivity characteristics such as mean selection length, selection range, selection factor and selection curve of square mesh and diamond mesh with respect to demersal catch components have been determined through covered codend experiments.

Bycatch Reduction Devices

BRDs are devices used to minimize the catch of non-targeted organisms during trawling. Benefits of BRDs are

- Reduction in impact of trawling on non-targeted marine resources.
- Reduction in damage to prawns due to absence of large animals in codend.
- Shorter sorting time.
- Longer tow time and
- Lower fuel costs due to reduced net drag. BRDs such as rigid grid devices, fish eye, radial escapementdevice, are being optimized for small-scale mechanised trawling industry.
- Oval rigid grid BRD, Fish eye, Big eye, Sieve net are recommended for shrimp trawls

Juvenile Fish Excluder cum Shrimp Sorting Device (JFE-SSD)

Trawl fishermen in India and other tropical fisheries depend on both finfish catches and shrimp catches to keep the commercial operations economically viable. CIFT has developed a unique solution for this in developing Juvenile Fish Excluder cum Shrimp Sorting Device (JFE-SSD), whcih traps mature shrimp in the bottom portion of the net while allowing juvenile shrimp to swim out of the mesh net unharmed. The device also retains mature finfish in the upper portion of the net while allowing small fish of low commercial value to safely exit the shrimp trawl. The sorting of the shrimp and the finfish between the lower and upper parts of the net enhances profitability because it reduces sorting time on the deck which increases the useful fishing time of the trawler fishermen, and it prevents shrimp from becoming crushed under the weight of fish and bycatch hauled on deck which increases the shrimp's market value.

Turtle Excluder Device

Turtle Excluder Device is a specialized form of BRD designed for saving sea turtles caught incidentally during shrimp trawling. CIFT has developed an efficient indigenous TED design (CIFT-TED) for commercial shrimp trawling which offers 100% protection to sea turtles with minimal catch loss

Advanced technology in fisheries

The Institute endeavors to promote the adoption of advanced technology among small-scale mechanised and traditional fishermen in order to enhance the productivity and profitability and sustainability of fishing operations.

- Acoustic fish detection devices such as fish finder.
- Electronic navigation and position fixing devices such as GPS.
- Satellite based remote sensing for potential fish aggregations.
- Energy conservation measures in fish harvesting.

Fish Aggregating Devices (FADs)

The Institute has developed and standardized low-cost designs of floating FADs and benthic Artificial Reef (AF) modules in order to make the fishing operations energy efficient and cost-effective, for the benefit of traditional fishermen operating low impact fishing gears such as gill nets and lines.

Navigation and Fish Finding

Many fishing vessels process the catch onboard and are equipped with fish finding equipment and sophisticated navigational aids. Small-scale fishing, especially in developed countries, has also undergone technological improvements in boat design and propulsion, navigation aids, fishing gear and methods and onboard preservation of the catch. Sophistication and availability of communication and safety equipment have improved considerably (Meenakumari, 2011). Advances in satellite-based technologies such as global positioning system(GPS) have positively influenced the precision in fishing, and Global Maritime Distress Safety System (GMDSS) based rescue system have facilitated safety of fishermen, who undertake one of the most dangerous occupations in the world. Satellite remote sensing application in Indian Fisheries helped to make maps of Potential Fishing Zones (PFZ), which in turn helped the fishermen to reduce search time and significantly increase in catch per unit effort (Solanki *et al.,* 2003; Zainuddin *et al.,* 2004) Electronic instrument for fishing such as echosounder, sonar, aimed midwater trawling techniques (1995-1996), GPS and netsonde (net monitoring system) have played vital role in increasing fish production.

Responsible fishing

From the efficient catchability of fishing gear, selectivity and responsible fishing has emerged the viable solution for fishing in the inshore region. Adoption of the Code of Conduct for Responsible Fisheries by FAO in 1995, has set out the principles and international standards of behaviour for responsible practices in order to ensure long-term sustainability of the aquatic fishery resources, protection of biodiversity, energy conservation and environmental safety (FAO, 1995). Approaches in responsible fishing practices include prevention of excess fishing capacity and destructive fishing practices and adoption of scientific management in order to ensure long-term sustainability of the resources; development and promotion of selective fishing gear and methods which would minimise fishing mortality of non-target species and protected species and ensure biodiversity; development and promotion of eco-friendly fishing gears which would minimise negative impacts on environment; energy conservation in harvesting operations; and enhancement of resources by introduction of artificial reefs and fish aggregating devices, and restoration of coastal fishing grounds from negative impacts of environmental pollution and eutrophication. CIFT has developed Bycatch Reduction Devices such as rigid grid devices, fish eye, radial escapement device etc., Juvenile Fish Excluder cum Shrimp Sorting Device (JFE-SSD), Turtle Excluder Device (CIFT-TED), for the sustainability of fisheries. Article 8 in the FAO Code of Conduct of Responsible Fisheries (CCRF) (FAO, 1995) is elaborated in FAO

Technical Guidelines for Responsible Fisheries 1: Fishing Operations (FAO, 1996). Directions related to the use and development of fishing gear and practices delineated in the CCRF focus on (i) selective fishing gear and practices, (ii) environment- friendly fishing gears (iii) energy conservation in harvesting and (iv) enhancement of resources (FAO, 1995; 1996; CIFT, 2003; Boopendranath and Pravin 2009; Boopendranath, 2009).

With the increased vessel capabilities, availability of more efficient gear systems, electronic navigation and acoustic fish detection equipment, areas of operations of the mechanised fishing fleet has expanded over the years, resulting in increased fish production in India. With the assistance from R&D organizations the fishers are in a constant quest for improvements in their day-to-day fishing activities that lead to their economic empowerment (Meenakumari *et al.,* 2009).

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