STUDIES ON INLAND FISHING GEARS OF NORTH KERALA

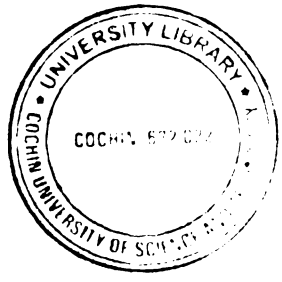
Thesis submitted to the
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

in partial fulfilment of the requirements for
the Degree of

DOCTOR OF PHILOSOPHY

by

REMESAN. M. P



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2006

DECLARATION

I, M.P. Remesan do hereby declare that the thesis entitled "***Studies on Inland Fishing Gears of North Kerala***" is an authentic record of research work carried out by me under the supervision and guidance of Professor (Dr.) A. Ramachandran, Registrar, Cochin University of Science and Technology, Cochin in partial fulfilment of the requirements for the Ph.D. degree and that no part of it has previously formed the basis of the award of any degree, diploma, associateship, fellowship or any other similar title of any University or Institution.

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November, 2006

CERTIFICATE

This is to certify that the thesis entitled "***Studies on Inland Fishing Gears of North Kerala***" is an authentic record of the research work carried out by Shri. **M.P. Remesan** under my supervision and guidance at the School of Industrial Fisheries, Cochin University of Science and Technology, Cochin, in partial fulfilment of the requirements for the degree of Doctor of Philosophy of the Cochin University of Science and Technology, and that no part thereof has been submitted for any other degree

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November, 2006

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ACKNOWLEDGEMENT

I express my sincere gratitude to Prof. (Dr.) A. Ramachandran, Registrar, Cochin University of Science and Technology for his guidance and encouragement as my research supervisor and for providing all facilities for the work.

I am grateful to Prof. (Dr.) Saleena Mathew, Director, School of Industrial Fisheries, for all the help during the study. My sincere thanks are also due to Prof. (Dr.) K. Kunjikrishnan, former Registrar of CUSAT, Prof. (Dr.) C. Hridayanathan, and Prof. (Dr.) Ramakrishnan Korakandy former Directors, School of Industrial Fisheries, Prof. (Dr.) B. Madhusoodana Kurup, Prof (Dr.) K. T. Thomson, School of Industrial Fisheries, for their help in the selection of the topic.

I am very thankful to Dr. K. Devadasan, Director, Central Institute of Fisheries Technology for granting study leave, providing necessary facilities and constant encouragement for the work. The encouragement and support rendered by Dr. B. Meenakumari, Head, Fishing Technology Division, CIFT is gratefully acknowledged.

I am extremely thankful to Dr. M.R. Boopendranath, Principal Scientist and Dr. P. Pravin, Senior Scientist, CIFT, Cochin for the immense co-operation, support and guidance throughout the study as well as for the preparation of the thesis. I also express my sincere thanks to Shri. H. Krishna Iyer, Principal Scientist (Rtd.) and Dr. V. Geethalakshmi, Senior Scientist, CIFT for the help in statistical analysis. I am thankful to Shri. P. George Mathai, Principal Scientist (Rtd), Dr. Leela Edwin, Senior Scientist and Dr. Saly N. Thomas, Senior Scientist for their help during the preparation of the thesis.

I wish to record the technical support extended by Dr. M. Baiju, Shri. P.N. Sudhakaran, Shri. P.S. Nobi, Shri. A. S. Kalangutkar, Shri. K.B. Baskaran, Shri. A.R. John and Shri.Vishnudas for field data collection as well as the fabrication of collapsible fish traps.

I am thankful to Shri. George Joseph, former Scientist-in-Charge of Calicut RC of CIFT for the help rendered in the field work. I express my thanks to Shri. Balakrishnan (Driver) and Shri. Nakulan (Driver) for their co-operation during the survey work. I am thankful to Mr. T. R. Gibinkumar and Mr. E. Gipson, SRFs, CIFT for the help in data collection and testing of fish traps.

I remember with thanks Shri. Bhaskran, Poyil (Taliparamba), Shri. Koran, Podothuruthy (Nileswaram), Shri. Khadar, Pampuruthy (Valapatanam) and Shri. Ahamad, Mannatampara (Malapuram) for the assistance in the field trials of collapsible fish trap developed during the study.

I express my thanks to Shri. Damodaran Thaikadapuram, Ussinika Kattampally, Rajan Ezhome, Remesan Patuvam and Sudhakaran Kavvayi for their support during the study.

I am very thankful to all the inland fishermen in Kozhikode, Kannur, Kasargod and Mahe for their patience, sincere co-operation and providing valuable information during the data collection, without which this work would not have been completed. Thanks are also due Mr. P. K. Pramod, Mr. Suresh Thampy and K.V. Radhakrishnan, Research Scholars of School of Industrial Fisheries for their sincere support and co-operation during the study.

I am thankful to my friends Mr. P.C. Remesan, C.K. Satheesan, E. Pavanananandan, Panneri Dinesan, Raghu Kanai, Sajeevan Kanai and Mohanan Kotakeel for their moral support.

I am indebted to my mother and to my in-laws for their support throughout the study. I express my thanks to my brothers and sisters for their encouragement.

I am very thankful to my wife Ms. Rajina and my sons Mr. Rathul and Mr. Rithik for their immense patience, sacrifice, love and affection during the study.

M.P. Remesan

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Chapter 1

INTRODUCTION

Chapter 1

1. INTRODUCTION

Total world fish production from capture fisheries amounts to about 93 million tones of which 84 million tones are marine fish and 8.7 million tones are freshwater. Globally, in seven countries, inland fisheries provided the only source of fish while in 20 additional countries they accounted for 81 to 99 % of total fish production from all sources. Inland capture fisheries production in Asia was 5.8 million tonnes followed by Africa (2.1 million tonnes) and North America (0.2 mt). In Asia, China dominates in inland capture fisheries followed by India and Bangladesh. Globally Nile perch and Nile tilapia are the two leading species and in Asia Hilsa dominated in the capture fisheries (FAO, 2004).

Although the net contribution of inland fisheries to total World fish production is small in comparison to marine capture fisheries and aquaculture, it has sustained a growing trend of about 2% per annum world wide (FAO, 2004). Development of inland fisheries has assumed great significance in recent years in the context of stagnating growth rate of marine capture fisheries and the growing uncertainties about the resource potential. Catch from the natural water bodies is declining drastically throughout the World due to the negative impact of human activities on aquatic resources. Since marine fisheries is approaching fast to the stagnating stage, most of the shortfall in fish production is to be met from the inland sector (Sugunan, 1995).

1.1. Inland Aquatic Resources of India

India is blessed with rich water resources in the form of rivers, ponds, lakes, reservoirs, flood plain wetlands and innumerable other small water bodies. The major resources include 29,000 km of rivers, 3,56,000 ha of mangroves, 3,00,000 ha of estuaries, 39,000 ha of estuarine wetlands (bheries), 1,90,500 ha of backwaters/lagoons, 31,53,366 ha of reservoirs, 2,02,213 ha of flood plain wetlands and 7,20,000 ha of upland lakes (Sugunan and Sinha, 2001). Potentially

the vast and varied inland fishery resources of India are one of the richest in the World. They pertain to two types of water bodies namely the freshwater and the brackish water.

The total Inland fish production in India was 3.5 million tones in 2004-2005 (Anon, 2005). Although breakup of the catch from rivers, lakes, flood plain wet lands and reservoirs are not recorded, it is generally believed that capture fisheries from rivers and estuaries contribute very little to the total inland catch. Information on the capture fisheries of upland lakes is scanty. Since mangroves are protected and the fishing activities are carried out only on a subsistence basis, details of fish production from these water bodies are also not available.

The river systems of the country are classified into five groups namely Ganga, Brahmaputa, Indus, Peninsular east coast river systems and west coast river systems. It comprises of 14 major rivers, 44 medium rivers and innumerable small rivers and streams.

1.2. Inland Fishery Resources of India

Several reports are available on the distribution of inland fishes in India. Day (1958 and 1889) listed the inland and marine fishes of India and Ceylon. Other notable studies include Beven (1877), Jayaram (1981, 1999), Dutta Munshi and Srivastava (1988), Jhingran (1991) and Talwar (1991). Check-list of freshwater fishes of India is given by Menon (1999).

NBFGR, Lucknow recently listed 758 fish species from the inland waters of India, of these 154 cold water species. 433 species inhabit in warm waters of these 67 fishes are common to warm and brackish waters. Another 171 species inhabit in the brackish water bodies of these 16 are found only in brackish waters, 73 are common to warm, brackish and marine waters and another 82 are common to brackish and marine waters.

Indian rivers provide one of the richest genetic resources in the World. The Gangetic system alone harbours more than 265 species of fish followed by

Brahmaputra river system with 126 fish species. Over 76 fish species are reported from the peninsular rivers. Average fish production from Ganga, Brahmaputra, Narmada, Tapti, Godavari and Krishna has been estimated to be only 0.64 $t.km^{-1}.yr^{-1}$ to 1.64 $t.km^{-1}.yr^{-1}$ with an average of 1.0 $t.km^{-1}.yr^{-1}$ (Nath, 2005). Data on the average catch of other river systems are not available. Carps, catfishes, feather backs, hilsa and prawns are the dominant groups in almost all major rivers.

There are several reports on the dwindling nature of fish catch from all the river systems in the country. Water abstraction and dam construction are the main reasons cited for declining of fish production from Indian rivers (Sugunan and Sinha, 2001). Sand mining, siltation, water pollution and unscientific fishing methods are also leading to the reduction in fish production. Management options include mesh size regulation, banning of catching juvenile fishes, observing closed season during July-August and discouraging use of mosquito nets for fishing purpose (Nath, 2005).

The fisheries of estuaries are above subsistence level and the average yield is estimated to vary from 45 to 75 kg. ha^{-1} (Jhingran, 1991). Hoogly-Matlah in West Bengal is the largest estuarine system in the country covering an area of 2,34,000 ha. Godavari estuary, Mahanadi estuary, Narmada estuary, Peninsular estuaries, Chilka lagoon, Loktak lake, Kolleru lake, Wular lake, Tal lake, Pulicat lake and Vembanad lake are the other major water bodies in this category.

Backwaters and lagoons also constitute an important inland fishery resource. Chilka and Pulicat lake in the east coast and Vembanad lake in the west coast are the major brackish water lakes in India. Hilsa, sea bass, mullets, tilapia, sciaenids, clupeids, threadfins, perches, cichilids, snappers, prawns, crabs, clams and oysters form the major resources in the estuary and backwaters. Siltation, profuse weed infestation, pollution, construction of barricades and fishing with small mesh nets are the problems cited for the declining fish stocks in these water bodies (Sugunan and Sinha, 2001).

Mangroves are another sensitive ecosystem, which forms the nursery ground for several river and marine fishes. More than 80% of the mangrove forest in India is in Sundarban and the forest area is decreasing due to human activities. Several creeks in this ecosystem are utilized for large scale prawn seed collection for aquaculture, which is affecting the fish production in all the associated water bodies (Jhingran, 1991).

Reservoirs are the single largest inland aquatic resources in terms of resource size and production potential. India has 19,134 small reservoirs (1,4,85,557 ha), 180 medium reservoirs (5,27,541 ha) and 56 large reservoirs (3,153,366 ha). Hirakud, Rihand, Bhakra, Tungabadra and Mettur are some the larger reservoirs of the country.

Large reservoirs of our country harbor 60 fish species, of which at least 40 contribute to the commercial fisheries (Jhingran, 1991). The average national yield from small reservoirs in India is nearly 50 $kg.ha^{-1}$ (Sugunan, 1995). Production can be enhanced further by stock enhancement provided the stocked fishes are able to breed and propagate themselves. Mesh size regulation, moderate CPUE, following closing seasons in breeding period of fishes and regular stocking with fingerlings of Indian major carps of more than 1000 mm size are some management norms for increasing fish production from such water bodies (Nath, 2005).

The flood plain wetlands, *beels*, *jheels* or *choran* are either permanent or temporary water bodies associated with rivers that constantly shift their beds. *Beels* form important fishery resources in Assam, West Bengal and Bihar. Culture based capture technique can be practiced in *beels* to increase the production, since they are very rich in nutrients.

Upland lakes situated in the colder region of India are suitable for the development of cold water fishes. These water bodies support a lucrative indigenous and exotic species comprising mahseers, trouts, crucian carps, mirror carps and schizothoracids. On the account of their remoteness and the low

temperature profile, it is believed that drastic increase in fish production from these water bodies is difficult.

Rivers, estuaries and backwaters in our country are exploited to the maximum and it is not possible to further increase the production. Adoption of conservation and management measures is required for sustaining the present level of fish production in these water bodies.

Small reservoirs and flood plain lakes, coupled with the stock and species enhancement in large reservoirs, hold the key for the future inland fisheries development in India (Sugunan and Sinha, 2001).

1.3. Inland Aquatic Resource of Kerala

The total inland water spread area in Kerala is about 3,55,037 ha. There are 44 rivers in Kerala with a total catchment area of 37,884 km^2 (Annon, 1995). The 41 rivers are west flowing, most of them having their origin in the Western Ghats and draining into the Arabian Sea. The other three rivers, Kabini, Bhavani and the Pambar also originate in the Western Ghats but are east flowing. In addition to these, there exist a much larger number of smaller rivulets and streams. After their rapid flow through the mountain, the west flowing rivers continue their meandering course along the undulating mid-land. When they enter the flat coastal belt, they become sluggish and some of them, instead of flowing straight into the sea, drain into a system of backwaters or lakes. Most of these rivers are influenced by the tides at their lower reaches. Some of the lakes are connected to the sea only during monsoon when these water bodies get flooded due to heavy fresh water discharge. Rest of the period the connection may be cut off due to the formation of sand bars along the coast by the action of littoral currents and waves (Nair, 1971).

Other inland water resources include 2, 42,800 ha of brackish water area and 30 reservoirs with a total water spread area of 29,635 ha, 3300 ha of tanks and ponds and 2,43,000 ha of wet and marsh lands (Ghosh, 1993).

1.4. Inland Fishery Resource of Kerala

The fish and fisheries play a crucial role in the Kerala's economy, particularly among the communities along the coastal belt. Inland fish production in Kerala during 2004-2005 has been estimated to about 76,000 t (Anon, 2005). Total fish production from the reservoirs of Kerala is not known. More than half of the reservoirs in Kerala remain unutilized or under utilized as far as fisheries are concerned. Indo-German Reservoir Fisheries Development Project has estimated an annual potential fish supply of 1700 t from all reservoirs in Kerala (Sugunan, 1995).

Literatures reveal that freshwater fishes of Southern India is reported by Jerdon (1849). Day (1878) discovered 1340 species of fishes of which 395 are freshwater. He described 66 freshwater fishes which are common to all rivers and adjacent freshwater bodies of Malabar region. Status of fish fauna of Kerala is reported by several workers of which Remadevi *et al.,* (1996), Gopi and Radhakrishnan (1998), Shaji *et al.,* (2000), Ramachandran (2002), Ramachandran *et al.,* (2004) and Kurup *et al.,* (2004) are relevant to the present study. Kurup, (2002) reported that the rivers and streams in the Western Ghats alone harbour about 170 fresh water fish species of which 66 species belong to potential food fish category, while the rest can be considered as potential ornamental varieties. Ninety four species of fish and shellfish were identified from the major backwaters in Kerala of which 63 species are already reported from the marine environment by several workers (Anon, 2005). John (1936) reported the freshwater fishes and fisheries of Travancore.

1.5. Inland Fisheries of North Kerala

Out of the 44 rivers, 21 (including Mahe river) are located in the three Northern districts of Kerala namely, Kozhikode, Kannur and Kasargod (Table 1). Mahe river is a part of Pondicherry Union Territory but it is geographically situated between Kannur and Kozhikode district. About 10,096 ha of backwaters and 13,354 ha of brackishwater areas are also available. Two reservoirs, Pazhassi

and Kuttiadi, with a total water spread area of about 1700 ha are located in Kannur and Kozhikode districts respectively.

Major fishery resources contributing to the fishery of these water bodies are given in Tables 3, 4 and 5. Major carps, catfishes and tilapia form the main catch component in reservoirs. Upper reaches of some of these rivers harbour carps, coldwater fishes like trouts, mahaseer and various exotic carps (John *et al.*, 2002). Several species of ornamental fishes are also identified from these water bodies.

1.6. Inland Fishermen Population

Fishery activities in backwaters of Kerala support about 2,00,000 fisher folk and provide full time employment to about 20,000 fishermen. As per the statistics, inland fishermen population of the region is about 20,197 of which about 12,000 fishermen are active (Anon, 2005). Some marine fishermen venture in inland fishing in the lower reaches when the sea becomes rough during monsoon. On the other hand some of the inland fishermen go onboard marine vessels during peak season (Remesan *et al.*, 2005f). Only a few fishermen are engaged in fishing in the Pazhassi and Kuttiadi reservoirs since the fish production is very low. In Kuttiadi reservoir the fishery is managed by the SC/ST co-operative society. Due to financial constraints, the carp hatchery is not functioning and hence the fish production from the reservoir is completely dependent on the natural stock.

Two types of migrant fishermen community are engaged in fishing in North Kerala. First group forms the fishermen who migrated mainly from Kollam, Kottayam and Ernakulam districts in Kerala. They are settled in some colonies around selected water bodies in the region. These fishermen are engaged in seine net and stake net operation.

The second group is the fisherfolk from the border districts of Karnataka state. They engage in agriculture during monsoon and by the month of September begin to migrate towards inland water bodies in Kerala. They operate gill nets from coracle. These fishermen usually stay here with their families and return to

their native place by the end of May every year (Remesan and Ramachandran, 2005a).

Nair (1989) reported that the fisheries department of Kerala has no data base on the inland fisheries, fishing industry, etc. worth while to evolve any development on management policies. The condition is more or less same even today. Sugunan and Sinha (2001) reported that riverine scene is a complex mix of artisanal, subsistence and traditional fisheries with highly dispersed and unauthorized marketing system, which makes the collection of data on fish yield a difficult process. Reservoir fisheries of India is described by Sugunan (1995) and riverine and reservoir fisheries by Sinha (2002).

1.7. Review of Literature

The inland aquatic resources of the country are vast and scattered in nature. Though the fishery resources are exploited continuously from all part of the country, due to the absence of an organized accounting and marketing system in the sector, the quantity of catch is often underestimated. The fishery resources of the inland waters are still exploited by traditional fishing methods and gears. Since the fishing opportunities vary at different areas, in species, fishing ground, weather, currents and other hydro biological conditions and local availability of materials and skills, a variety of traditional fishing gear have been developed over the centuries. With the advent of new fishing techniques, many of the fishing techniques that were efficient in the past have become non-remunerative and hence they are being phased out (George, 1991).

India is the second largest producer of inland fish in the World and the aquatic resources are harvested from different water bodies using a variety of gears. But the information available on the existing gears and methods is incomplete, as many of them have only a brief description on the fishing methods as the emphasis was always on the qualitative and quantitative aspects of fish landings.

Review of available literature on inland fishing shows that the first report on the freshwater fish and fisheries of Eastern Bengal and Assam is by Day (1910). Traditional fishing gears of East Pakistan is described by Ahamad (1956). A brief account on the operation of different fishing gears in Japan is given by Anon (1960). Hickling (1961) described some fishing gears associated with the tropical inland fisheries. Detailed work on various fish catching methods of the World is published by Brandt (1972). Fishing implements and methods of fishing in Nepal is reported by Shrestha (1979 and 1994). Welcomme (1985) gave a comprehensive report on the fisheries of the major river systems in the World. Anon (1995) reported the brackish water fishing gears of Sri Lanka.

Inland fisheries in India is reported by Kamal (1991) and Tyagi (1998). A brief account on the fishing methods of prawns and crabs in India is given by Chopra (1936 and 1939). Subramanyam, (1987) reported some aspects of the fishery of the prawns from the Godavari estuarine system and in Mahanadi by Job *et al.,* (1995) and Premkumar and Meenakumari (2003).

The first report available on the inland fishing is probably the work done by Wallinger (1907) in Konkan region, West Coast of India. Fishing gears of Eastern Bengal and Assam is reported by De (1910). A brief account of fishing gears of Nilgiris is given by Wilson (1920). Comprehensive study on the fishing gears of different parts of World in general and India in particular is carried out by Hornell (1924, 1925, 1938 and 1950). Inland fishing gears of some parts of Punjab are reported by Hora (1926 and 1935), Mysore (Bhimachar, 1942), Uttar Pradesh (Faruqui and Sahai, 1943); Ganga river (Saxena 1964 and 1993) and Brahmaputra river (Joseph and Narayanan, 1965). *Roak* fishing and its probable effects on the capture fishery of river Yamuna has been reported by Wishard (1976) and in Padma river by Pandey, (1993).

Various fishing methods and gears employed to catch Indian shad in Narmada river is given by Kulkarni (1951) and throughout India by Jones (1959 a & b). Kurian (1965) reported the trends in the prawn fishing techniques in India. Lal (1969) has described some of the inland and marine fishing gear in India. An

account of inland fishing methods in India is given by George, (1971). Fishing methods of Himachal Pradesh (Sehgal, 1973 & Tandon and Sharma, 1984). A brief account on the indigenous gear of Andhra coast is given by Rama Rao *et al.,* (1985).

Banas fishing in *beels* of Assam is described by Yadava and Choudhury (1986). Studies on the fishing craft and gears of rivers in Rajasthan is reported by Kulshreshtha (1986) and Karnataka by Sathyanarayanappa *et al.*, (1987). Sharma *et al.,* (1993) reported the fishing methods of North Eastern India. Relative efficiency of fish capturing devices in Kachodhara *beel* in Assam is given by Sharma and Ahmed (1998). Kar *et al.,* (2000) gave an account of fishing implements used in Assam.

Status of estuarine fishery resources and their exploitation in India is described by Skene, (1908) and Saigal and Mukhopadhyay, (1988). Fishing in the rivers of the Central Province is reported by Trevenen (1930) and Indian rivers by Sreekrishna and Shenoy, (1987) and Saxena (1988). Catfish fishing methods is described by Seth and Katiha (2000 and 2003). George (2002) gave a note on the present status of fishing techniques of riverine and reservoir system.

Fishing methods of flood plain lakes in North Eastern region, North Bihar, West Bengal and Eastern Uttar Pradesh are reported by Yadava *et al.*, (1981); Bhagavati and Kalita (1987) and Choudhury (1992). Thakur and Banerjee, (1980) reported "*Chhoh*"- a special fishing method employed to catch air breathing fishes in North Bihar. Sinha and Pandit (1984) reported *Kumar jal,* a catfish fishing method of the estuary. Mitra *et al.*, (1987) reported the fishing gears in the upper and middle Hoogly estuary. Das (1993) reported the low energy fishing operation in sewage fed Bheries at Kulti, West Bengal. Fishing method employed in lentic and lotic environment of Jammu province of Jammu and Kashmir state is given by Dutta *et al.,* (2000).

Gulbadamov (1962) gave a report to the Govt. of India on the modifications required in the traditional gill nets in the Indian reservoirs and gill

nets are further modified by Znamensky (1976). Fishing methods in reservoirs of India is described by (Kurian, 1971) and Khan *et al.*, (1991). Mesh optimization studies for *Catla catla* was carried out by Sulochanan, *et al.*, (1968), George (1979) for *Cirrhinus mrigala* and *Labeo rohita* (Kartha and Rao, 1991). Comparative operations of trammel net and framed nets were carried out by Naidu, *et al.*, (1976). Varghese *et al.*, (1982) tried small meshed seine nets for weed fish eradication in reservoirs. Trawling in reservoir was attempted by George (1982), George *et al.*, (1986) and Kartha and Rao (1991). Khan (1993) reported the changes in the netting materials used in reservoirs.

Devasundaram (1951) reported the fishing methods for Chilka mullets. Jones and Singani (1952) reported the *mani-jal,* a special net for beloniform fishes of the lake. Jhingran and Patnaik (1954) mentioned about some interesting methods of fishing of *Sparus* spp. In the lake. Roy and Banerjee (1980) and Nayak *et al.*, (2000) reported the fishing craft, gears and method of fishing in Chilka lake. Krishnamurthy and Rao (1970) and Thomas (1971) reported the fishing methods of Pulicat lake. Raina and Joshi (2006) reported the fisheries and aquaculture in Indus river region.

1.8. Inland fishing methods of Kerala

Different types of fishing gears are in use in the inland water bodies scattered in Kerala state. Fishing gears of backwaters of Kerala are given by Panikkar (1937) and Shetty (1965). Destructive methods of fishing in the rivers of the hill ranges of Travancore are given by Jones (1946). Some interesting methods of fishing in the backwaters of Travancore are given by Gopinath (1953). Prawn fishery of Cochin backwaters with special reference to stake net catches is reported by Menon and Raman, (1961). Prawn fishing methods in the inland waters of the state are reported by Ramamurthy and Muthu (1969) and Kurian and Sebastian (1986). Fishing methods of *Macrobrachium rosenbergii* are reported by Raman (1975), Kurup *et al.*, (1993) and Harikrishnan and Kurup (1998). Mud crab fishery of Cochin backwater is given by Devasia and Balakrishnan (1985) and its exploitation in Korapuzha estuary is given by Sarada (1997). Study on gill nets,

stake net and Chinese lift nets of Vembanad lake are carried out by Pauly (1991). A brief description of fishing gears and methods of 18 rivers and Vembanad lake is given by Kurup *et al.*, (1993). Baiju and Hridayanathan (2002) gave an outline of the fishing gears of Muvattupuzha river. Lakshmilatha and Appukuttan (2002) described the black clam fishing in Vembanad lake. Jose (2002) gave a report on the inland fishermen and inland fishing at Neelamperoor village. An account of inland fishing method in North Kerala is reported by Remesan *et al.*, (2005).

Compared to the marine fishing gears, a greater variety of devices are in vogue for prawn fishing in the estuaries, backwaters and creeks (Ramamurthy and Muthu, 1969). But works related to fishing gears and methods of fishing in inland waters are less when compared to that of marine sector. The literature available on inland capture fisheries of Kerala is based on the study carried out in and around the central Kerala. No effort has been made in the past to study and document the existing fishing gear and methods of North Kerala, except the work carried out by Hornell (1938).

In this context, it is necessary to have a detailed study on the various inland fishing methods, craft and gears of this region. In the present study, an attempt is made to document complete details on the design, operation of various gears and methods adopted by the traditional fishermen and also to see the changes that have taken place after 1938. The information on the existing fishing methods will also help the R and D organizations to develop more selective and efficient fishing craft and gear for the upgradation of inland fishing systems and finally the policy makers in conserving the resources and ensuring profitability to the fishermen as envisaged in the Code of Conduct for Responsible Fisheries of FAO (FAO, 1995).

A weaker section of the fishermen community in North Kerala is operating various kinds of fish traps to earn their livelihood. There are several problems associated with the fabrication and operation of traditional fish traps. These traps are mainly made using split bamboo lashed together with coir twines and hence their service life is short. Moreover, because of the huge size handling and transportation is also difficult.

The box type fish trap operated in the rivers of Kannur and Kasargod districts are also made of bamboo. Catch is very poor in this trap because it is operated without bait and hence the soaking time is also very long.

To tackle some of the problems faced by the fishermen operating box traps a study on the improvements of this trap was taken as the second part of the present study.

1.9. Main objectives of the study are:

1. To document major fishery resources and different craft and gear combinations operating in inland water bodies in selected districts of North Kerala.
2. To identify the existing fishing gears and methods, prepare design drawings and classify the gears based on design, structure, operation and target species.
3. To identify the technical problems and suggest improvements in the existing fishing craft, gears and methods of operation to increase their efficiency and selectivity.
4. To design and develop a collapsible, durable and cost-effective fish trap for riverine fishing and evaluate the performance in comparison with the traditional traps.

Table 1. Inland water resources in Kerala state

No.	Resources	Number	Area (ha)
1	Rivers	44	85000
2	Reservoirs	53	42890
3	Check dams	80	259
4	Bund/Barrier/Anicut/Shutter water holds	70	879
5	Brackishwater area	-	65213
6	Backwaters	53	46129
7	Prawn filtration fields	234	12873
8	Estuaries (Azhi/Pozhi)	84	-
9	Mangrove area	-	1924
10	Freshwater lakes	9	1620
11	Irrigation tanks	853	2835
12	Ponds	46376	24875
Total		**47856**	**284497**

Table 2. Details of rivers in the selected districts/UT

No.	Rivers	Length (km)	Catchment area in Kerala (km^2)	Total Catchment area (km^2)
1	Manjeswar	16	90	90
2	Uppala	50	76	250
3	Shiriya	67	290	587
4	Mogral	34	132	132
5	Chandragiri	105	570	1406
6	Chithari	25	145	145
7	Nileswar	46	190	190
8	Kariangode	64	429	561
9	Kavvayi	31	143	143
10	Peruvamba	51	300	300
11	Ramapuram	19	52	52
12	Kuppam	82	469	539
13	Valapatanam	110	1321	1867
14	Anjarakandy	48	412	412
15	Tellicherry	28	132	132
16	Kuttiadi	74	583	583
17	Korapuzha	40	624	624
18	Kallai	22	96	96
19	Chaliyar	169	2535	2923
20	Kadalundi	130	1122	1122
21	Mahe	54	394	394
Total		**1265**	**10105**	**12548**

Table 3. Other inland water resources in the selected districts

No.	District	Reservoir (ha)	Brackish water (ha)	Backwater (ha)	Prawn filtration field (ha)	Ponds and tanks (ha)
1	Kozhikode	1052	4162	2764.90	7.57	3.21
2	Kannur	648	5944	4157.42	69.69	187.14
3	Kasargod	-	3248	3174.04	0.02	1270.22
Total		**1700**	**13354**	**10096.36**	**77.28**	**1460.57**

Table 4. Major Crustacean and Molluscan resources

No.	Common name	Local name	Scientific name
1	White prawn	Vella chemmeen	*Fenneropenaeus indicus*
2	Tiger prawn	Karim chemmeen	*Penaeus monodon*
3	Brown shrimp	Thelly chemmeen	*Metapenaeus dobsoni*
4	Brown shrimp	Kuzhi chemmeen	*Metapenaeus monoceros*
5	Giant freshwater prawn	Kaalan chemmeen	*Macrobrachium rosenbergii*
6	Freshwater prawn	Mutta chemmeen	*Macrobrachium idella*
7	Mud crab	Puzha nande	*Scylla serrata*
8	Sea crab	Kadal nande	*Portunus pelagicus*
9	Sea crab	Kadal nande	*Portunus sanguinolentus*
10	Sea crab	Kadal nande	*Charybdis cruciata*
11	Clam	Koorka/ Erunthe	*Meretrix meretrix*
12	Clam	Koorka/ Elambakka	*Meretrix casta*
13	Black clam	Elambakka/ Elayakka	*Villorita cyprinoides*
14	Blood clam	-	*Anadara granosa*
15	Edible oyster	Muru	*Crassostrea madrasensis*

Table 5. Major finfish resources of the region

No.	Common Name	Local name	Scientific Name
1	Mullet	Maalan/thirutha/kayyan	*Mugil cephalus*
2	Mullet	Maalan	*Liza tade*
3	Mullet	Maalan	*Liza parsia*
4	Mullet	Maalan	*Valamugil speigleri*
5	Catfish	Etta	*Mystus armatus*
6	Catfish	Etta	*Mystus gulio*
7	Catfish	Etta	*Arius platystomus*
8	Pearl spot	Irumeen/Karimeen	*Etroplus suratensis*
9	Orange chromide	Choottachy/Pallathy	*Etroplus maculatus*
10	Whiting	Nongol	*Sillago sihama*
11	Sea bass	Kolon/Narimeen	*Lates calcarifer*
12	Perch	Murumeen	*Epinephelus tauvina*
13	Perch	Murumeen	*Epinephelus malabaricus*
14	Milkfish	Poomeen	*Chanos chanos*
15	Tarpon	Palankanni/Valaathan	*Megalops cyprinoides*
16	Silver biddi	Pranjil	*Gerres filamentosus*
17	Silver biddi	Pranjil	*Gerres oyena*
18	Silver biddi	Pranjil	*Gerres limbatus*
19	Glassy perchlet	Nanthan	*Ambasis gymnocephalus*
20	Commerson's anchovy	Kozhuva	*Stolephorus commersonnii*
21	Crescent tiger perch	Kotha	*Therapon jarbua*
22	Sole	Nanke	*Cynoglossus cynoglossus*
23	Sole	Nanke	*Cynoglossus punticeps*
24	Pipe fish	Koyala	*Hyporamphus limbatus*
25	Pipe fish	Koyala	*Hemiramphus cantori*
26	Pipe fish	Koyala	*Hemiramphus far*

No.	Common Name	Local name	*Scientific Name*
27	Pipe fish	Koyala	*Xenentodon cancila*
28	Snapper	Chempally	*Lutjanus argentimaculatus*
29	Bar eyed gobi	Payathan/ Pottan	*Glossogobius giuris*
30	Scat	Kachai	*Scatophagus argus*
31	Pony fish	Mullan	*Leiognathus equulus*
32	Pony fish	Mullan	*Leiognathus splendens*
33	Silver belly	Mullan	*Secutor insidiator*
34	Indian pellona	Kannathi	*Pellona ditchella*
35	Moustached thryssa	Manange	*Thryssa mystax*
36	Flat head	Eriyan	*Platycephalus indicus*
37	Thread fin bream	Bammeen	*Eleutheronema tetradactylum*
38	Malabar trevally	Kaduva	*Carangoides* sp.
39	Big eyed trevally	Kaduva	*Caranx sexafasciatus*
40	Croaker	Kallan keeran/ kora/katla	*Daysciaena albida*
41	Croaker	Kallan keeran/ kora	*Johnius* sp.
42	Sneak head	Kaichal/Cheermeen	*Channa marulius*
43	Sneak head	Varal/Bral	*Channa striatus*
44	Catfish	Mussu	*Clarius batrachus*
45	Catfish	Kadu/ Kaari	*Heteropneustes fossilis*
46	Tilapia	Filoppy/ thiloppy	*Oreochromis mossambicus*
47	Barracuda	Seelave	*Shyraena jello*
48	Carps	Catla	*Catla catla*
49	Carps	Mrigal	*Cirrhinus mrigala*
50	Carps	Pullan	*Cyprinus carpio*
51	Carps	Rohu	*Labio rohita*
52	Gobi	Pottan	*Awaous gutum*
53	Tire track eel	Aral/Arakan	*Mastacembalus armatus*
54	Ray	Therandi	*Rhinobatus halavi*

Chapter 2

MATERIALS AND METHODS

Chapter 2

2. MATERIALS AND METHODS

The study on the inland fishing gears of three districts viz. Kozhikode, Kannur, Kasargod and Mahe, UT of Pondicherry state in North Kerala was undertaken during March 2003 to June 2005. The study required primary and secondary data. The primary data relates to (i) field experiments and (ii) and the data on the existing resources, fishing craft and gears. Secondary data was collected from various Central Government agencies like Central Institute of Fisheries Technology, Cochin, Central Inland Fisheries Research Institute, Calcutta, Central Marine Fisheries Research Institute, Cochin and State Government Agencies like Directorate of Fisheries, Kerala, Matsyafed, Kerala, and other orgainsations like Cochin University of Science and Technology, Cochin, and Fishermen co-operative societies in the selected districts in North Kerala.

Initially the State Fisheries Department offices at Kozhikode, Kannur and Kasargod districts were contacted to collect available information on inland fishing, fishermen population, number of fishing villages, etc. Tentative lists of sampling stations were prepared based on the length of the river and the area of other water bodies in each districts. The study started from the mouth of every river and proceeded towards the other end and stations were identified based on the information given by the fishermen in the previous station. Studies were carried out from 234 stations covering 21 rivers and associated backwaters of 3 districts and Mahe. Studies were also carried out in Pazhassi, Kuttiadi and Kakkayam reservoirs with the help of fishermen Co-operative Societies and Forest Department.

2.1. Location of the study area

Three districts namely Kasargod, Kannur and Kozhikode and Mahe in North Kerala were selected for the study (Fig.1). They were selected based on the density of inland water bodies as well as fishing activities.

2.1.1. Kasaragod district

The Kasaragod district was formed during 1984 and is situated between 11° 48' North latitude and 74° 52' East longitude. The district is bound Karnataka state in the North East, Kannur district in the South and Arabian Sea in the West. Total area of the district is 1961 km^2.

There are nine rivers namely Manjeshwar, Uppala, Shiriya, Mogral, Chandragiri, Chittari, Nileshwar, Kariangode and Kavvayi. Chandragiri is the longest river in the district. Active fishing was noticed in the lower reaches of Chandragiri and Kariangode rivers. Other details of the rivers are given in Table 2.

2.1.2. Kannur district

Kannur district is bound by the Kodagu district of Karnataka, (Western Ghats) in the East Kozhikode and Wayanad district in the South, Lakshadweep Sea in the West and Kasaragod district in the North. It is located between latitudes 11° 40' and 12° 48' towards North and between longitude 75° 10' and 75° 57' towards East. Total area of the district is 2967.97 km^2.

There are six rivers in Kannur district. They are Ramapuram river, Kuppam river, Peruvamba river, Valapatanam river, Ancharakandy river, Thalassery river. Valapatanam is the longest river having a length of 110 Kms. Active fishing was observed in all rivers, except Ramapuram and Peruvamba rivers. Variety of fishing gears is seen in Kuppam and Valapatanam rivers.

Pazhassi is the only reservoir in the district with a water area of 648 ha. Mahe river flows through the border area of Kannur district and Mahe.

2.1.3. Kozhikode district

Kozhikode district is situated between North latitudes 11° 08' and 11° 50' and East, longitudes 75° 30' and 76° 08'. The district is bounded on the North by Kannur district, on the East by Wayanad district, on the South by

Malapuram district and on the West by the Arabian Sea. The total area of the district is 2344 km^2.

There are five rivers in the district namely Kuttiadi, Korapuzha, Kallai, Chaliyar and Kadalundi. Kuttiadi is the only reservoir in the district with a water spread area of 1052 ha.

2.1.4. Mahe

Mahe is situated geographically in Kerala and politically forming part of Pondicherry union territory. Mahe is bounded on the South West by the Arabian sea, on the North by river Ponniyar and on the other side by stretches of calcareous hills of medium height, which are linked to Ghats by series of wooden hillocks. Total area of the region is 9 km^2. The river Mahe, which flows towards the West, divides the region into two distinct parts. Mahe town is situated between Kozhikode and Kannur districts of Kerala.

2.2. Inland water resources and sampling centers

2.2.1. Manjeswar River

Manjeswar river is the Northern most river in the state. It originates from Balepuni hills lying along the Northern border of Kerala. The river flows through Vorkadi, Pavuru and Badaje villages before it falls into the backwaters of Uppala river. It is a small river with a length of 16 km of which the navigable area is only 3.2 km and the drainage area is 90 km^2. Fishing activities is very less in the river and is confined to the river mouth. Manjeswaram and Bengara Manjewsaram are the fishing centers in the river (Fig.2)

2.2.2. Uppala River

This river originates at Virakamba hills in Karnataka state and enters Kerala in Kasargod taluk. It flows through the villages Minja, Kuluru, Bekuru and Kodibail before it drains into the Arabian Sea at Uppala. The river has a length of 50 km with a drainage area of 250 km^2. Out of the 50 km only about 23 km are in Kerala and the

navigable length is only 4.8 km. Fishing activities is less and it is seasonal in nature. Five centers selected for the study are shown in the Fig.2. During summer season the river becomes very narrow and above the check dam fishing activities is negligible.

2.2.3. Shiriya River

The river originates from the Anekundi forest in Karnataka. This inter state river flows through Puttige, Mugu, Angadimogaru, Badoor, Maire, Kudlamerkala, Arikadi, Ujar, Ulvar Kayyur, Ichilangode and Bombrane villages before joining the sea through the Kumbla backwaters. The Kumbla is a small stream originating in Edanad and also empties into the same backwater. Important tributaries are Pallatadka hole, Kallaje thode, Kanyana thode and Eramatti hole. The length of the river is 67 km with a total catchment area of 587 km^2. Eight centers were selected for the present study is shown in the Fig.2. Fishing activities are comparatively low in this river and active fishing is limited between Shiriya bridge and Kumbla.

2.2.4. Mogral River

This river originates in Kanathur in Karadka reserve forest in Kasargod. It flows through Bettipadi, Muliya, where it joins with other streams, Yedhir, Madhur and Patla and forms a backwater of about 5 km stretch. The river has a length of 34 km of which a distance of 20 km from the sea mouth is tidal. Total drainage area of the river is 132 km^2. Total number of sampling stations in the river is 8 (Fig. 3).

2.2.5. Chandragiri River

Chandragiri is one of the major rivers in Kasargod district. Payaswini and Chandragiri are the two major tributaries. The river originates from Patti Ghat reserve forest in Coorg district. Total length of the river is 105 km having a drainage area of 1406 km^2 of which 836 km^2 lie in the Karnataka state. The river is tidal for a length of 16 km from mouth. Eight centers were selected for the study (Fig.3).

2.2.6. Chithari River

This river includes the water sheds of Kalanad, the Bekkal and Chithari. Kalanad originates from Chettianchal hillocks and it has a length of only 8 km. River is tidal about 2.5 km from mouth. Drainage area of the basin is only 16 km. Bekkal river is formed by the confluence of two main tributaries originating from Kaniyadka and Maladka. The Bekkal river is about 10 km in length of which 3 km from the mouth is tidal. Total catchment area is only 32 km^2. Chithari river is having a length of 25 km with a catchment area of 97 km^2. The river has tidal influence for about 6 km from the sea mouth. Total catchment area of Chithari basin is 145 km^2. Four centers were identified for the present study (Fig.3).

2.2.7. Nileswar River

The river originates from Kinanur in Hosdurg taluk, Kasargod district. The two main tributaries are Aryangal thode and Baigote hole. The river flows through extensive paddy lands and joins the Kariangode river at Kottapuram near Achanthuruthu. Length of the river is 46 km of which 10-11 km from the mouth is tidal. Navigable length of the river is 11.2 km and the drainage area is 190 km^2. Three centers were selected from the river for the gear study (Fig.4).

2.2.8. Kariangode River

The river originates from Padinalkad Ghat in Coorg district. Two main tributaries are Mundore and the Padiamala hole. At Pulingom another stream *viz.* the Mundroth hole joins the river. After passing through the villages of Cheemeni, Karidalam and Kilayiakote the river flows and joined by the Nileswar river. The river then splits up into several branches before falling into the Arabian sea near Thuruthi about 2 km. North-west of Cheruvathur. The common estuary of the Kariangode and Nileswar rivers extends along the coast forming a long stretch of backwaters into which the Kavvayi and Peruvamba rivers also discharge. The river has a length of 64 km with a catchment area of 561 km^2. Navigable length of the river is 24 km. Seventeen centers were selected from the river for the present study (Fig.4).

Active fishing is noticed in the lower reaches of this river. In contrary seine nets are not seen in operation in this river. It is one of the river where mini-trawls are in operation.

2.2.9. Kavvayi River

This river originates in Cheemeni village in Kasargod and flows through Alapadampa and Vadasseri, before emptying into Kavvayi backwaters at Udamanthai. Three streams coming from the North join the main stream. Length of the river is 31 km with a catchment area of 143 km^2. Eight centers were selected from the river for the study (Fig.4).

2.2.10. Peruvamba River

The river originates near Pekkunnu in Vayakkara village. The river flows through Peringom, Kuttur, Mathamangalam and Kunjimangalam. At Ezhimala the river bifurcates and one branch falls into Kavvayi backwaters while the other branch falls into the Arabian sea at Palakode. The main tributary of the river are Macharuthode, Challachal, Mukkuttenkarachal and Nitaringapuzha. The river has a drainage area of 300 km^2 and a length of 51 km of which 16 km are navigable. Active fishing is restricted between Peruvamba and Palakode. Names of the 10 centers selected for the study are given in Fig. 4

2.2.11. Ramapuram River

The river originates at Iringal and flows through Pariyaram, Kolaparam, Cheruthazham and Madai before it drains into Kavvayi backwater. This is also a small river with a length of 19 km and a drainage area 52 km^2. The length of river suitable for navigation is only 6.4 km. Four centers were selected from the river for the study (Fig.4). Due to the non availability of adequate quantity of fish in the river, the fishing activity is very less.

2.2.12. Kuppam River:

Kuppam river originates in Coorg district of Karnataka. It flows through Kannur and Taliparamba taluks. Before it exit into the Arabian sea, it is joined by the Valapattanam river at Azheekal. Total drainage area of the river is 539 km^2 of which 70 km^2 is in Karnataka. Main tributaries are Pakkattupuzha, Alakuttathode, Kuttikolpuzha, Mukkathode and Chiriyathode. Total length of the river is 82 km and the navigable length is only 24 km. Total number of sampling stations from Kuppam river is 25 (Fig. 5)

2.2.13. Valapatanam River

The river originates in Brahmagiri Ghat in Coorg district, Karnataka. This river drains into Arabian sea along with Kuppam river at Azheekal. After flowing through Karnataka for about 19 km, it passes through Iritty Irrikur, Kalliasseri and Valapatanam villages. Major tributaries of the river are Sreekandapuram river, Valiyapuzha, Barapole, Venipuzha and the Aralampuzha. Total drainage area of the river basin is 1867 km^2 of which 564 km^2 lie in Karnataka. The river has a length of 110 km of which 44.8 km are suitable for navigation. Study has been carried out from 25 stations through out the length of the river (Fig. 6).

2.2.14. Anjarakandy River

The river originates at Kannoth reserve forest. Two main tributaries are Kapputhode and Idumba thode. The river branches into two at Orikkara. One branch, turns South and joins at Arabian sea at Moithupalam, about 5 km north of Thalasseri town. Other branch, known as Dharmadam puzha, falls into Arabian sea near Meethale peedika, 3 km north of Thalasseri town. The basin has an area of 412 km^2 with a length of 48 km of which 27.2 km are navigable. Active fishing is restricted between the river mouth and Mambaram, about 20 km from the mouth. Migratory fishermen from Karnataka seasonally operate gill nets beyond this area. Five centers were selected along the course of the river for the study (Fig. 7).

2.2.15. Tellicherry River

The river is also known as Ponniumpuzha or Eranjolipuzha. It originates in the Kannoth forest of the Western Ghats. The only tributary joins the main river about 14 km away from its mouth near Koduvally, about 3 km. north of Thalasseri town. The river flows through the villages of Cheruvancheri, Mudiyanga, Patyam, Mokeri and Padakkal. This is one of the smallest rivers in Kerala having a length of 28 km with a drainage area of 132 km^2. Navigable length of the river is about 21.6 km. Six centers were selected from the river for the study (Fig.7)

2.2.16. Kuttiadi River

This river is also known as Moorad river and it originates from Narikota ranges on the western slopes of Wayanad hills at an elevation of 1220 m MSL. The major tributaries of the river are Onipuzha, Vannathipuzha and the Madappally puzha. The river has a length of 74 km with a catchment area of 583 km^2. The river flows through Badagara, Quilandy and Kozhikode taluks. It falls into the Arabian sea at Kottakal, 7 km South of Badagara. The river passes through Oorakuzhi, Kuttiadi, Thiruvalur, Muyipot, Maniyur and Kuruvancheri before it joins into the sea. Total navigable area of the river is only 9.6 km. Two reservoirs associated with the river are Kuttiadi and Kakkayam. Study on the existing fishing gear and methods have been carried out from 22 centers including reservoirs. Name of the centers are given in Fig. 8.

2.2.17. Korapuzha River

The river is formed by the confluence of the Agalapuzha with the Punnurpuzha. It originates at Arikkankunni and joins in the Arabian sea at Elathur after flowing 40 km towards Southwest direction. The catchments area of the river is 624 km^2 and total navigable length of the river is 24.8 km. 25 centers were selected from the river as given in Fig. 9.

2.2.18. Kallai River

The river has its origin in Cherukulathur village. It is connected with the Chaliyar river on the south by a man made canal. The river passes through Cherukulathur, Kovur, Olavanna, Manava and Kallai before it joining the sea. Length of the river is 22 km with a drainage area of 96 km^2. Kallai is one of the world's largest timber trading center. River is polluted mainly by the timber industry especially in the lower reaches and hence the fishing activities are negligible in the river. Sampling was carried out from 7 centers (Fig. 9).

2.2.19. Chaliyar River

The river originates from the Ilambileri Hills and joins the sea at Beypore (Fig.9). The important tributaries of the river are the Chalipuzha, Punnapuzha, Pandiyar, Karimpuzha, Cherupuzha, Kanjirapuzha, Kurumbanpuzha, Vadapurampuzha, Iringipuzha and the Iruthillypuzha. The total drainage area of the river is 2923 km^2 out of which 2535 km^2 lie in Kerala and rest is in Tamil Nadu. Length of the river is 169 km. It flows through Nilambur, Mambad, Edavanna, Arecode, Vazhakad, Feroke and Beypore. The Rayon industry situated on the bank of this river at Mavoor polluted the river and damaged the fishery till the plant completely stopped its activities. The river is slowly returning to the normal state at present. Navigable length of the river is 68.4 km. A total of 24 centers were identified and studied from the river.

2.2.20. Kadalundi River

The river is formed by the confluence of its two main tributaries, the Olipuzha and the Veliyar. The Veliyar originates in Erattakombanmala and the river joins in the sea at Kadalundi. Total length of the river is 130 km with a drainage area of 1099 km^2. The Pooraparamba is a small stream is also included in the basin as its length is only 8 km with a catchments area of 29 km^2. Navigable length of the river is 43.2 km. Study has been carried out from 7 centers as given in Fig. 10.

2.2.21. Mahe River

The river is located in Mahe belonging to Pondicherry UT. Mahe river or Mayyazhipuzha originates from the western slopes of Wayanad hills. It flows through Naripetta, Vanimel, Iyyancode, Bhekiyad, Iringannore, Tripangathur, Peringalam, Edacherry, Kacheri, Eramala, Kariyad, Olavilam, Kunnumakkara, Azhiyoor and Mahe before falling into Arabian sea about 6 km south of Thalasseri. The river has a length of about 54 km and it drains an area of 394 km^2. 13 centers were selected from the river for the study (Fig. 7).

Inland fishing craft

Major dimension, type of wood used, cost particulars, service life and details of maintenance of fishing craft used in different centers were collected by checking samples and interviewing the craft owners. Description on the inland fishing crafts of the region is given as Chapter 3.1.

Fishing gear survey

For the study on fishing gear 20 % of the fishermen from each center (Pauly, 1991 and Baiju, 2005) were identified and the total number of nets and other equipments were quantified. Representative samples of each group were calculated from the total number. The method of survey was based on the schedule prepared by Miyamoto (1962). Main tools used for the collection of data were the questionnaires prepared for this purpose. Basically 3 types of questionnaires were prepared for the study viz. (i) Questionnaire for gill net (ii) for seine net and (iii) for cast net. Design details, material specification, mesh size; details of accessories, their distribution and rigging patterns were observed. Common gears were surveyed randomly at each station and full details of new gears, if any, were collected by checking representative samples. Data collected were further supplemented by interviewing fishermen and net makers and observations at the fishing sites.

Design drawings of different gears were prepared as per the FAO catalogue of small-scale fishing gears (Nedlec, 1975). The designs drawings of the nets are not

to scale. Twine size of monofilament were measured using micrometer. Since denier and diameter are the common designations followed for multifilament and monofilament respectively, these are used frequently in the tables, designs and text.

Metric system is followed, metre (m) and millimeter (mm) are used in the length, width, thickness of gear and accessories. Weight is given in kilogram (kg) and gram (g). Hanging coefficient is denoted as E.

Information regarding crew size, fishing time, fishing days, season, depth of operation and catch details were collected by directly interviewing the fishermen. Catch details were collected on weekly basis for one year from a seine net unit operating in Anjarakandy river and economics of gill net operation were collected from a fisherman in Kavvayi river. The data was cross-checked from the purchase register maintained by the local fishermen Co-operative societies. Basic details on the species landed, quantity per day, seasonal average and price variation were also collected for different group of gears. Materials and methods for the development of collapsible trap are given in Chapter – 4.

Analysis of variance (ANOVA) technique as per Snedecor and Cochran (1956) was used in analyzing the significance of observations.

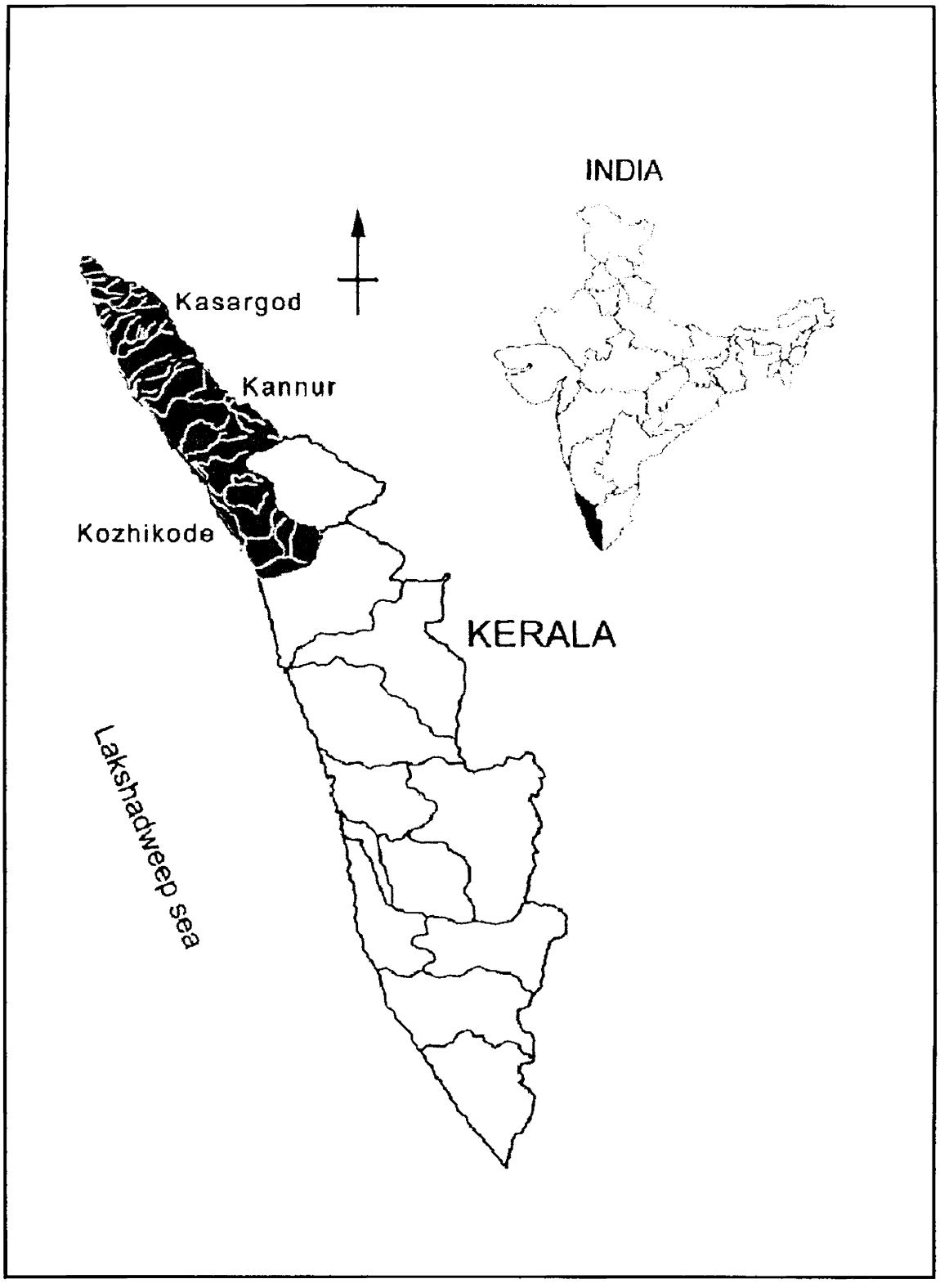
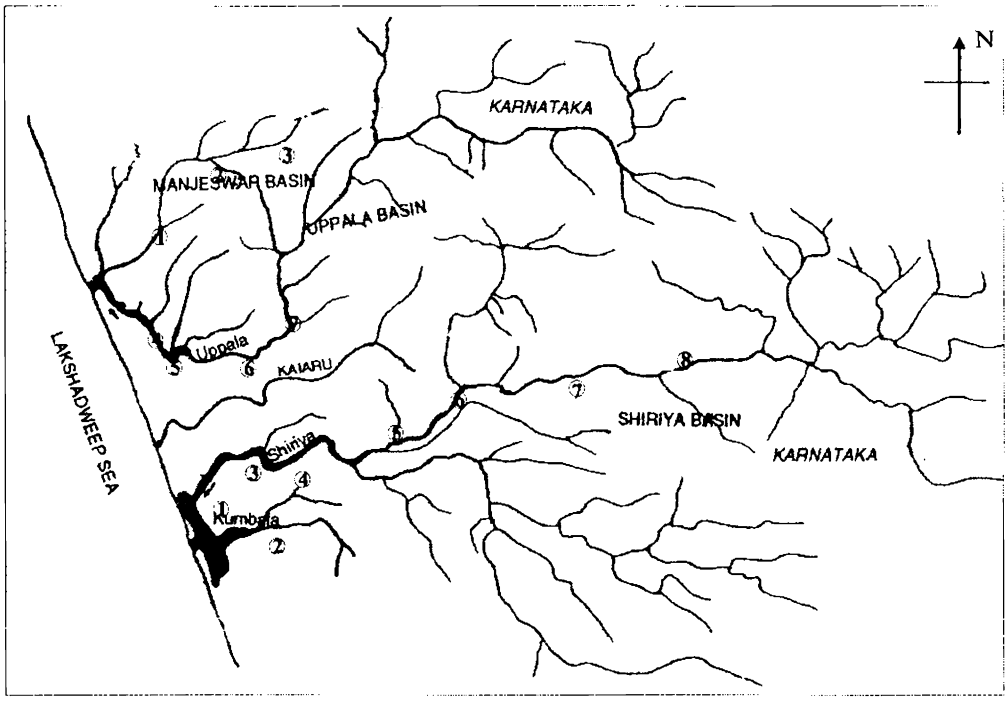


Fig. 1 Map of Kerala showing the location of the study area



Manjeswar

1.Manjeswaram 2. Bengara Manjeswaram

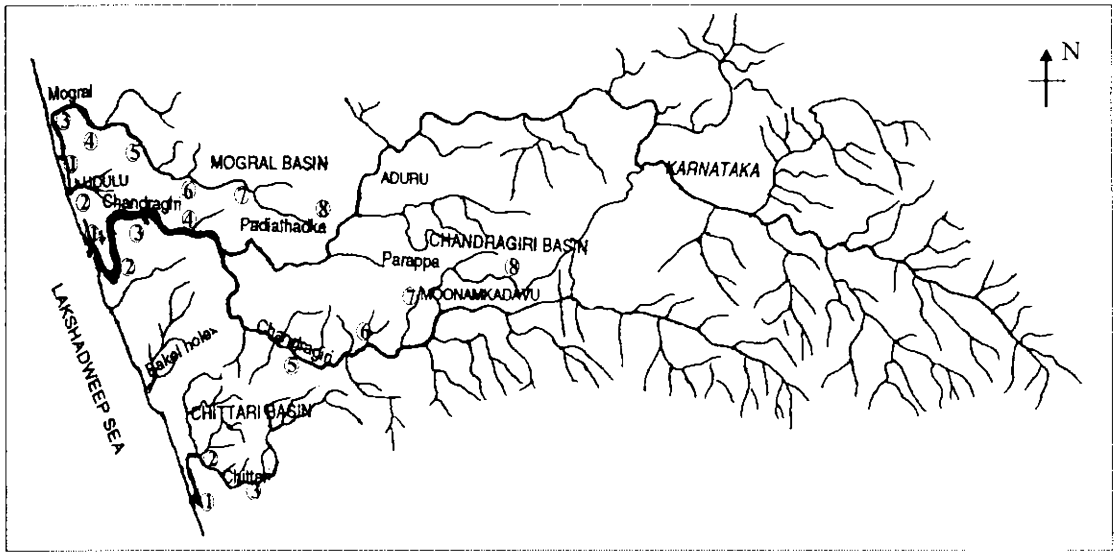
Uppala:

1.Uppala bridge 2.Uppala dam 3.Uppala moosode 4.Machampadithode 5.Puthur

Shiriya:

1.Kumbla 2.Koipadi kadapuram 3.Thangalavede 4.Arecady kadave 5.Muttam 6.Olayum 7.Bendiyode 8.Ichylangode

Fig. 2 Manjeswar, Uppala and Shiriya rivers showing sampling stations

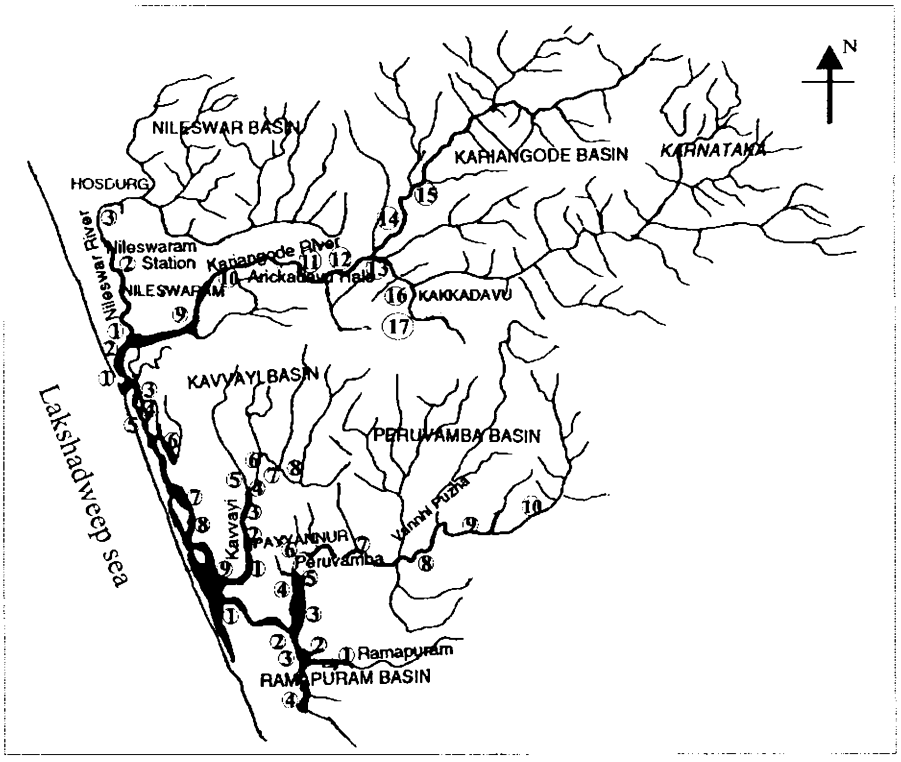


Mogral:
1.Kallamkai 2.Kudlu 3.Azad Nagar 4.Mogral Puthur 5.Kannur 6.Chowki 7.Kopalam 8.Kottakunne

Chandragiri:
1. Kesaba 2.Kundil 3.Thalangara 4.Chandragiri Palam 5.Balamthode 6.Panathadi 7.Peruthadi 8.Pookayam

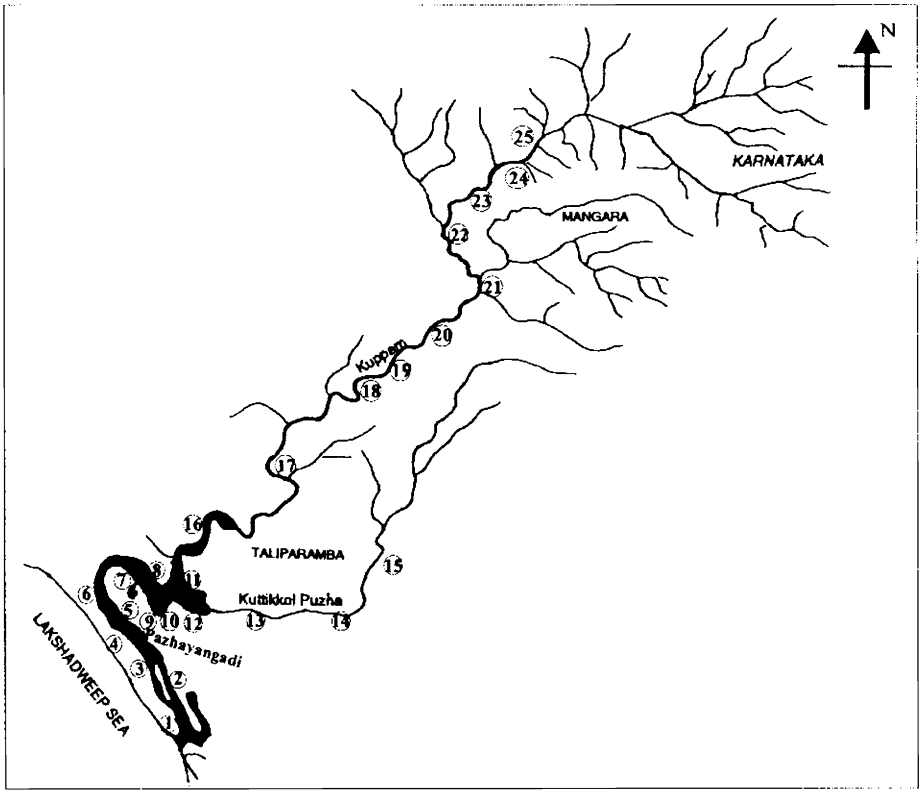
Chithari:
1.Kadapuram 2.Pallikara 3. Chithari 4.Bekkal

Fig. 3 Mogral, Chandragiri and Chithari rivers showing stations



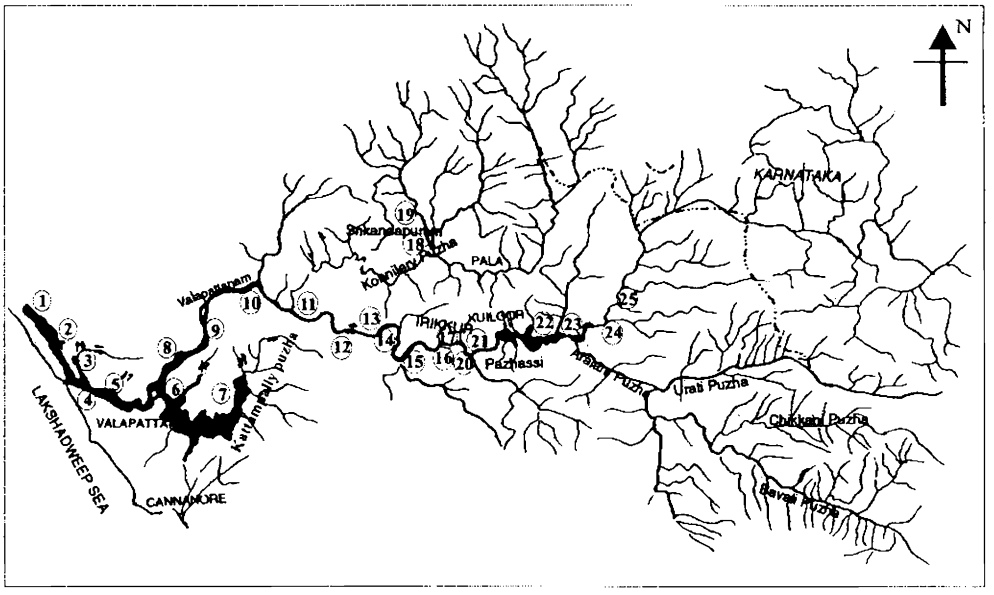
Nileswar:
1.Kadinjimoola 2.Purathekkai 3.Kottapuram
Kariangode:
1.Azhithala 2. Thaikadapuram 3. Mayilakadapuram 4.Ochenthuruthe 5.Maddakara 6.Mundayamade 7.Valiyaparambe 8.Mailadam 9.Padanna 10.Mayicha 11.Pedothuruthy 12.Pazhayakadave 13.Palai 14.Chathothe 15.Cheemeni 16.Kayyur 17.Kakkadave.
Kavvayi:
1.Madakka 2.Kuttichi 3.Gopalankadave 4.Pottanpathare 5.Olavarapalam 6.Oliyathe kadave 7.Kara 8.Anavalave
Peruvamba:
1.Palakode 2.Chempallykunde 3.Kunjimangalam 4.Kunneru 5.Puthiya puzha 6.Perumba 7.Maniyara 8. Mathamangalam9.Peruvamba 10.Pedena
Ramapuram:
1.Paiyaram 2.Kolapram 3.Cheruthazham 4.Maday

Fig. 4 Nileswar, Kariangode, Kavvayi, Peruvamba & Ramapuram rivers showing stations



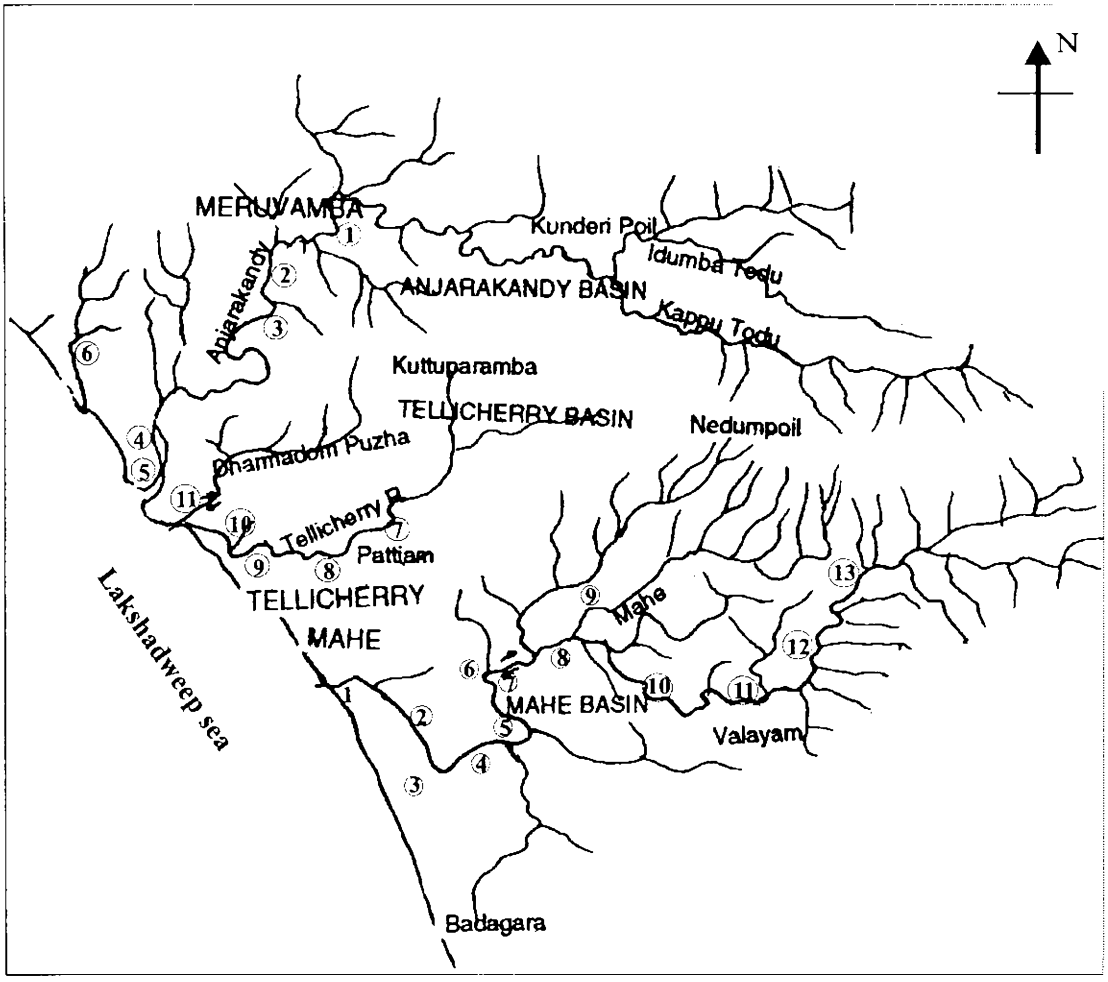
1.Mattool 2.Madakkara 3.Payangadi 4.Thavam 5. Irinave dam 6.Paadi 7.Kavinmunambe 8.Purathekkay 9.Pattuvam 10.Kotakkeel 11.Ezhome 12.Muthukuda 13.Chera 14.Vellikeel 15.Kuttikol 16.Kottila puzha 17. Narikode 18. Kuppam 19.Mukkunne 20.Kuttieri 21.Pacheni 22.Vayade 23.Poonangode 24.Kooveri 25.Chaparapadave

Fig. 5 Kuppam river showing the sampling stations



1.Azheeka 2.Port 3.Boat Palam 5.Kappakadave 6.Valapatanam 7.Kattampally 8.Kambil kadave 9.Pappinisseri 10.Parassini kadave 11.Mayyil 12. Narath 13.Parakkal 14.Mankadave 15.Kalloori kadave 16.Irrikur 17.Kattave 18.Chooliyade 19.Perumpara kadave 20.Kandakai 21.Kurumathur 22.Mullakodi 24.Irritty 25.Kootumukam 26.Sreekandapuram.

Fig. 6 Valapatanam river showing sampling stations



Anjarakandy

1.Anjarakandy 2.Mambaram 3.Pinarai 5.Moidu palam

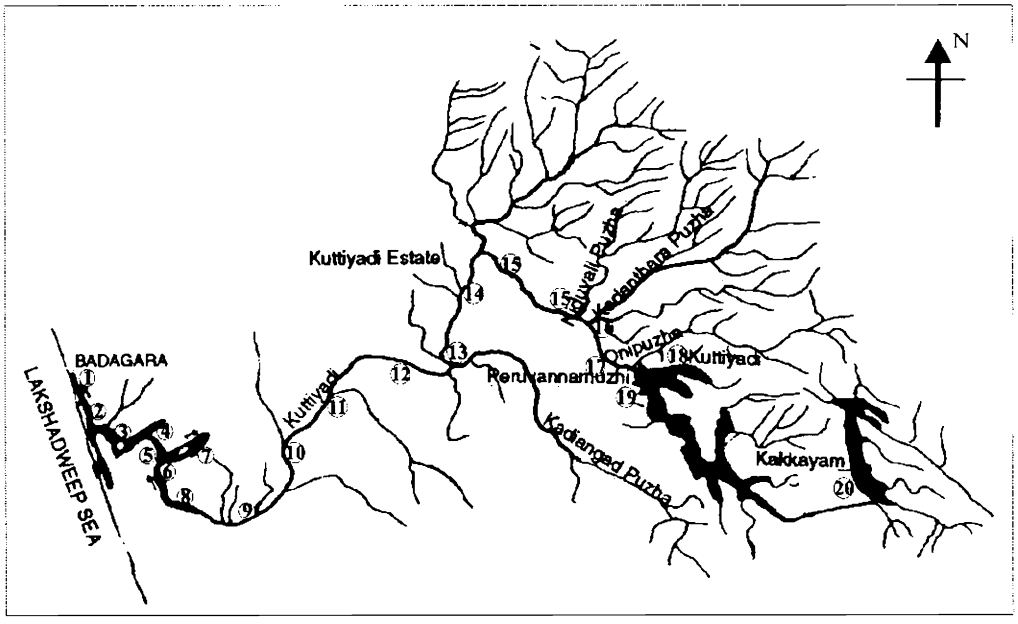
Tellicherry

1.Dharmadam 2.Edakkad 2.Eranjoli 3.Thiruvangad 4.Kuyyali 5.Meethale pedika 6.Koduvally

Mahe

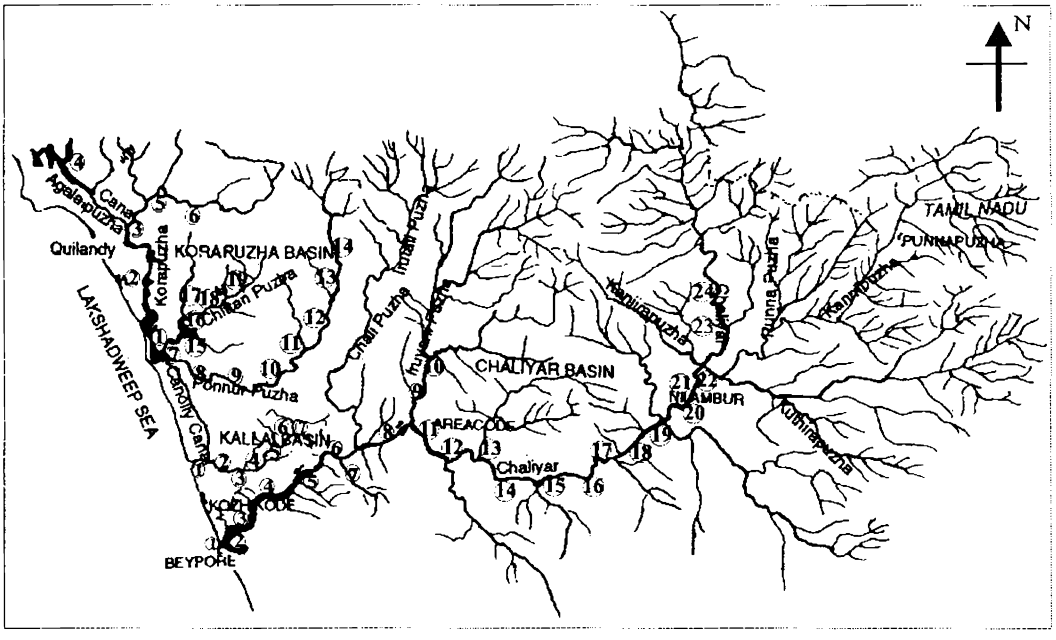
1.Mahe palam 2.Paathikkal 3.Monthal 4.Kariangode 5.Thuruthymukke 6.Peringathoore 7.Parakkadave 8.Kanjirakadave 9.Kurichikkara 10.Olavilam 11.Azhiyoor 12.Edacherry 13.Peringalam

Fig. 7 Anjarakandy, Tellicherry and Mahe river basin showing sampling stations



1. Azhithala 2.Valyalappe 3.Moorad 4.Kottakal 5.Kakkattil 6.Kuruvayil 7.Kolaipalam 8.Gurupeedam 9.Kottathuruthy 10.Kannakadave 11.Payyolicheep 12.Nelliyadi 13.Chittarikadave 14.Idinjakadave 16.Chaniyamkadave 17.Gulikapuzha 18.Kuttiadi 19.Peruvannamoozhi 20.Kakkayam

Fig. 8 Kuttiadi river showing the sampling stations

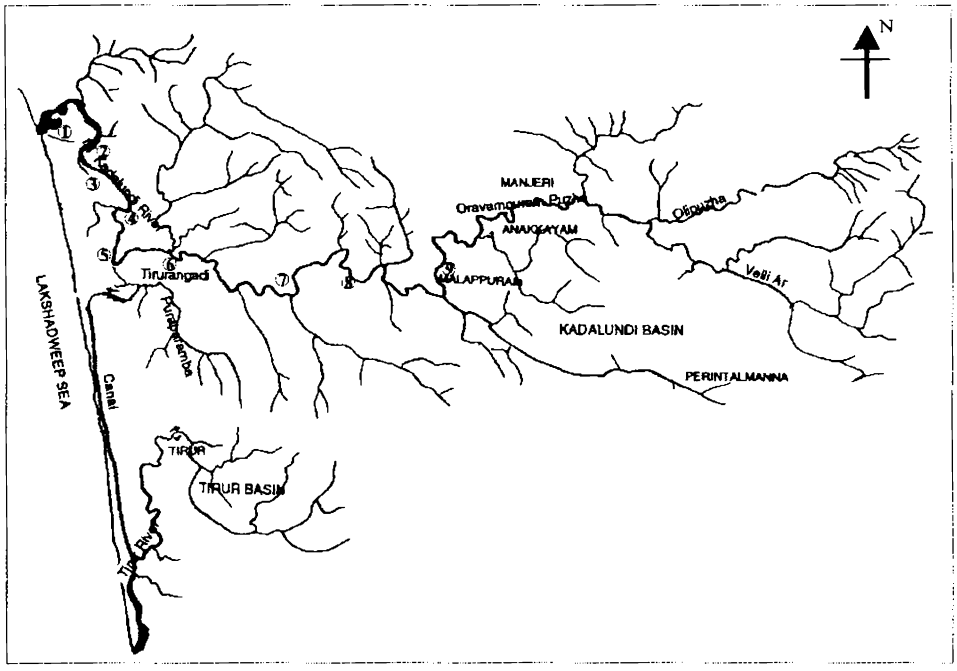


Korapuzha :
1.Elathur 2.Estuary 3.Payyoli cheep 4.Akalapuzha. 5.Anelakadave 6.Ullorkadave 7.Vellorkkadave 8.Eranjikal 9.Kanoore 10.Porakkatari 11.Perumthuruthy 12.Kanayangode 13.Kuneelakadave 14.Poothapara 15.Pulikeel kadave 16.Atholi 17.Vellikeel 18.Pavolicheep 19.Anappara 20.Kuneelakadave 21.Chathanadathe 22.Thorai 23.Puthancherry 24.Nelliadipuzha 25.Muthampy

Kallai :
Kallai 2.Chakumkadave 3.Anamade 4.Mankave 5.Olavanna 6.Mooriade 7.Puthiyakadave

Chaliyar:
1.Beypore 2.Chaliyam 3.Ferroke 4.Azhijilam 5.Arapuzha 6.Mankadave 7.Vellaikode 8.Peruvanna 9.Akkode 10.Chungapally 11.Oorkadave 12.Kavanakalle 13.Elamaram 14.Keezhuparambe 15.Areekode 16.Mulapuram 17.Vazhakade 18.Edvanna 19.Kunnathparambe 20.Karuvanthuruthy 21.Chanthakadave 22.Kodampuzha 23. Nilambur 24.Mapram

Fig. 9 Korapuzha, Kallai & Chaliyar rivers showing sampling stations



1.Kadalundi 2.Porakattary 3.Mukkath kadave 4.Mannur 5.Irimbothingal kadve
6.Kottakadave 7.Olipuram kadave 8.Chali 9.Mannatampara

Fig. 10 Kadalundi river showing sampling stations

Chapter 3

INLAND FISHING CRAFT AND GEARS OF NORTH KERALA

Chapter 3

3. INLAND FISHING CRAFT AND GEARS OF NORTH KERALA

3.1. Inland fishing craft of North Kerala

The floating and movable platform on which the fishermen operate the gear is known as fishing craft. It may be a simple wooden piece, inflated hide or a raft made of few banana stems to large vessels. Artisanal fishermen operating simple gears may not require any craft as they operate the gear along the shore. The nature of inland fishing crafts varies from place to place and it mainly depends on the geographical and hydrological features of the region.

Six types of fishing crafts were identified from the region and their dimensions vary from place to place.

3.1.1. Dug-out canoes

As the name indicates it is constructed by carving the tree trunk of required size. Canoes made of Mango wood, *Mangifera indica,* were very popular in the rivers and backwaters of Kerala. But due to the scarcity of full length tree trunk, this type of canoe is not being constructed at present. Medium and smaller sized dug-outs, with a size ranging from 3-4 m, known as *thoni* or *paathi*, are used for fishing, especially for lining and gill netting. Plate 1 shows dug-out canoes with flat bottom used for shore seining in Anjarakandy river and bamboo canoe used in Korapuzha river.

3.1.2. Plank-built canoes

The present generation canoes are plank built type and they are popular in all parts of Kerala. Wooden planks are joined with coir ropes and a layer of pitch/tar is applied along the joining to make it water tight. A variety of woods are used for this type of construction. Commonly used wood are Mango wood, Sal wood, Anjili, Ven teak and Maruthe. Length ranges from 3 – 7 m and width from 0.6 – 0.85 m with a

depth of about 0.5 m. Bottom is usually rounded or keeled. Traditional preservatives like fish oil, cashewnut shell oil, tar, etc are used for the preservation. Total cost of a medium sized canoe ranges from Rs.17, 000 to 20,000. Plank built boats are used for all types of fishing. A coracle from the middle reaches of Kadalundi river and a typical plank built canoe used by the stake net fisherman in Kuppam river are shown in Plate 2.

3.1.3. FRP canoes

Fiberglass re-inforced plastic canoes are seen in the estuarine parts of the river. Some of these canoes are sea going and seasonally they ply in the rivers. Wooden canoes coated with FRP sheathing are also seen in some places (Remesan *et al.*, 2005g). Plate 3 shows fishermen doing FRP sheathing on wooden canoe near Feroke in Chaliyar river.

3.1.4. Coracle

Coracles are known as "*Haragola*" in Kannada and "*Vatta thoni*" (circular canoe) or "*Kotta thoni*" in Malayalam (Plate 2). Coracles are exclusively used in all rivers in Kerala by the migratory fishermen from Karnataka (Remesan & Ramachandran, 2005 a). Traditionally it is fabricated with bamboo strips and palm leaves. A concave skeleton with 15–25 cm depth and 2 – 2.5 m dia is fabricated and is covered with either palmyra leaves or synthetic sheets. Outer edge of the craft is strengthened using several layers of bamboo strips and cloths or plastic sheet. One or two coats of coal tar is given to the outer surface to make the craft waterproof. Weight of a coracle ranges from 8-15 kg and cost ranges from Rs. 500 – 1000/-. Usually two fishermen carry out fishing from a coracle. Like other canoes, oars are used for propulsion. Fishermen from Karnataka operate bottom set gill nets using coracle.

3.1.5. Bamboo canoe

Canoe made of splinters of bamboo is a new technology and such canoes are seen in operation in Korapuzha river (Remesan & Ramachandran, 2005d). In India,

a bamboo boat having 3.65 m OAL was constructed on an experimental basis at IIT Kharagpur (Sahoo *et al.*, 1988) but it is not suitable for fishing. There is no other report available on a canoe made of bamboo splinters. Three fishing canoes were constructed by two fishermen at Muthampy using *Bambusa arundinacea* (Plate 1). The size of the canoes ranged from 3.5 to 4.5 m OAL having a maximum beam width of 65 -70 cm.

Two bamboos of approximate 25 m length were used for the construction of each canoe. Construction was done when the bamboo was in fresh condition. First the bamboo is split into strips having about 5 cm width. Then a pit having the shape of the canoe is made in the ground. Strips are placed inside the pit and about 15 ribs are made to support the shape of the canoe. 3 to 4 wooden partitions are kept above the strips. After that the strips are bent by heating so as to get the required shape of the canoe. Then they are held tightly together, using polypropylene twine of 2.0 mm dia to make the skeleton of the canoe.

The canoe frame, thus prepared is covered with polyethylene sheets and placed in water to test the balance. If the test is satisfactory, the frame is taken out and the polyethylene sheet is removed. Then the canoe frame is sun dried for a week by keeping heavy stones inside the frame to prevent distortion of shape.

Plastic gunny bags used for packing chicken feed are cut into sheets and these sheets are joined lengthwise using twine, to get sufficient length. The sheet is wrapped over the canoe after applying a coat of tar on the outer surface of the frame. A total of 6 sheets alternating with coal tar are applied to the canoe. After the third coat of tar, a polythene sheet is used to make the canoe watertight. The canoes are allowed to dry for 2-3 days on completion of construction. Inner surface of the canoes was not covered to allow easy drying after fishing.

All the 3 canoes constructed have been engaged in gill netting in Korapuzha river for the past 2 to 3 years. Only a coat of tar is applied once in a year on the outer surface of the canoe for its maintenance.

Bamboo canoes are comparatively light in weight and therefore there could be some problem of stability. However, this can be rectified to some extent by adding sufficient ballast in the keel. Inland fishing gears like gill nets, hook and line, and baited ring nets are often operated by single fisherman and for such fishing methods bamboo canoes are ideal. The details of the construction cost of a bamboo canoe of OAL 3.5 m is given in Table. 6.

3.1.6. Plastic cans

Fishermen from Karnataka and Andhra Pradesh use empty oil cans or ordinary plastic cans with 5-10 liter capacity, for floating during fishing (Remesan & Ramachandran, 2005a). Two such cans are tied together using a piece of rope or cloth, leaving about one feet distance between. During fishing the cans are placed between legs, one in the front and other in the back. Since the upper part of the body remains above water, fishermen are able to operate the net and paddle some distance.

Table 6 Construction cost of a bamboo fishing canoe of 3.5 m OAL

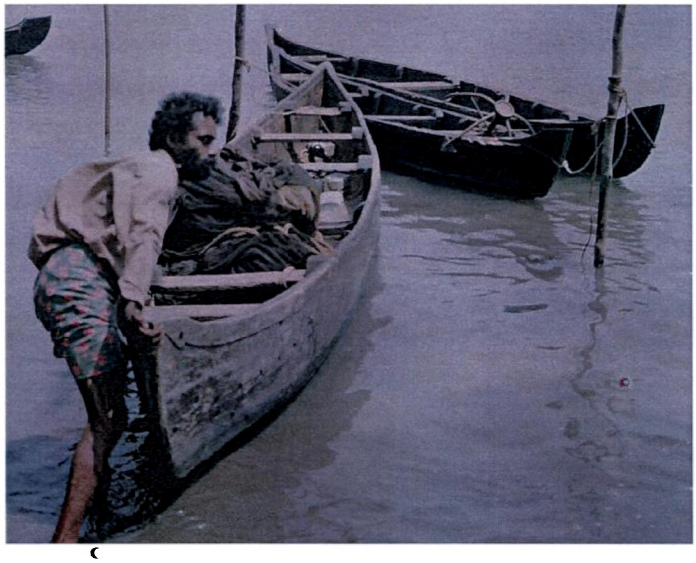
No	Item	Quantity	Rate (Rs)	Cost (Rs.)
1	Bamboo	40 m	150.00/pole	300.00
2	Plastic bag	40 nos	3.00	120.00
3	Polythene sheet	5 x 2.5 m	240.00	240.00
4	Polypropylene twine	1.5 kg	100.00	150.00
5	Tar	20 kg	30.00	600.00
6	Labour	15 days	250.00	3750.00
7	Miscellaneous			250.00
Total				**5410.00**

Dugout canoes in Anjarakandy river

Split bamboo canoe in Korapuzha river

Plate-1 Inland fishing craft of North Kerala

Coracle from the middle reaches of Kadalundi river



Plank built canoes in Kuppam river

Plate -2 Inland fishing craft of North Kerala

FRP coating of wooden canoe

Plastic cans used as fishing craft

Plate - 3 FRP coated canoes and plastic cans as fishing craft

3.2. Inland fishing gears of North Kerala

In North Kerala, majority of the inland waters are in the form of rivers and brackish water areas. In rivers, fishing activities are concentrated in the lower reaches and their intensity decreases along the middle and upper reaches. This is because, in the lower reaches of the rivers estuarine condition prevails and species abundance and quantity is relatively better in the estuarine areas. Several species of fish and shellfish from the sea and river visit this area during their life spans. More over due to the action of strong water current the bottom is smooth and almost flat in the estuarine areas facilitating the operation of towed and dragged gears. Strong current is a pre-requisite for stake net and usually they are set in the lower reaches. Fishermen belonging to the lower reaches are active and their full time occupation is fishing. Some of these people also carry out fishing in the middle reaches of rivers depending on the season and catch.

Several types of fishing gears are in operation in the rivers, estuaries, backwaters, reservoirs and other water bodies in North Kerala. Some of the fishing gears are unique and are not reported by anybody in the past. Traditional way of fishing in this region varies from fishing without any gear like hand picking to gill netting, seine netting and mini-trawling using modern netting materials like Polyamide monofilament and Polyethylene twisted monofilament. Wounding gears, stupefying methods, falling gears, drive-in-gears, lines and different types of traps are also in operation.

Table 7 shows the distribution of major types of fishing gears and methods in the region. Mainly 37 types fishing gears and methods were identified from the region. Fishing gears are classified as per FAO system of classification (Nedelec, 1975). Gears which are not coming directly in the classification are grouped as Miscellaneous gears. Gill nets and hand line are the two fishing gears seen in all water bodies in the region. Cast nets are also seen in all the water bodies except in the two reservoirs.

Seine nets are operated in the estuarine parts of several rivers (Table 7) but they are not operated in the reservoirs. Uneven bottom profile and the absence of target resources may be the main reasons for the absence of seine net and cast net in the reservoirs. Seine nets operated in the inland waters of the region is mainly grouped into three and the details are given in the Chapter 3.2.1.

Box traps were seen in the rivers of Kannur and Kasargod district but they were not seen in Kozhikode district. This type of traps were operated in areas with rocky bottom and such water bodies are more in the first two districts. Filter traps and aproned traps were seen only in some pockets in Kannur and Kasargod district and at present very few fishermen fabricate and operate these traps. Bamboo screen barrier were seen in the tributaries of Kuppam river and in all other places bamboo screens are replaced with HDPE net screens. Screen barriers are not seen in operation in Kasargod district. A unique aerial trap was seen in Pazhassi reservoir for catching large fishes during monsoon.

Lines are common in all water bodies of the region. Baited line was seasonally operated in the traditional prawn culture ponds in Kannur district. Multiple hook and line was seen only in Pazhassi reservoir to catch fishes during monsoon. Multiple baited lines without hook were operated in Kuppam and Valapatanam river for *Scylla serrata*. Vertical line was seen in operation in the weed infested backwaters at Akalapuzha, Kuttiadi river. Long lines for fish were common but exclusive operation for catching eels were seen only in Mahe river.

Mini-trawl operation from non-motorised canoe in the estuarine parts of Chandragiri and Kariangode rivers in Kasargod district is reported for the first time.

Four boat lift net is an interesting fishing method seen only in the lower reaches of Chaliyar river and the same is reported for the first time. *Maade valayal* fishing (surrouding) in Valapatanam river is another unique fishing method reported for the first time.

Drive-in-nets were seen only in the middle reaches of Kuppam river. Scare line fishing was seen in the estuarine waters of Kasargod and Kozhikode districts but

not in Kannur district. Baited lift net operation for mud crab were common along the backwaters and rivers of the region and this fishing method picked up when the export of live crab started.

Cross-bow was seen only at one place in Valapatanam river and the gear was operated by a fisherman migrated from Cochin. Other wounding gears like spears were operated seasonally in selected pockets for catching mainly *Macrobrachium rosenbergii* and *Scylla serrata*

Hand held dredges were operated for clams in the estuarine parts of some rivers shown in the Table 7. Hand picking was mainly carried out by ladies. All these fishing methods are discussed in details in the respective chapters.

Table 7. Distribution of fishing gears in the inland waters of North Kerala

		Manjeswar	Uppala	Shiriya	Mogral	Chandragiri	Chithari	Nileshwar	Kariangode	Kavvayi	Peruvamba	Ramapuram	Kuppam	Valapatanam	Anjarakandy	Tellicherry	Kutiadi	Korapuzha	Kallai	Chaliyar	Kadalundi	Mahe*	Pazhassi reservoir	Kutiadi reservoir
1	Seine net			☑	☑	☑	☑			☑			☑	☑	☑	☑	☑	☑		☑				
2	Gill net	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
3	Trammel net												☑	☑										
4	Plunge basket									☑			☑	☑										
5	Box trap				☑			☑	☑		☑		☑	☑										
6	Filter trap												☑											
7	Aproned trap												☑											
8	Screen barrier				☑						☑		☑		☑	☑		☑		☑	☑			
9	Aerial trap							☑															☑	
10	Hand line	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
11	Multiple hook & line												☑										☑	
12	Baited line												☑	☑										
13	Multiple baited line												☑	☑										
14	Vertical line																	☑						
15	Long line			☑	☑				☑				☑	☑			☑	☑		☑	☑	☑		
16	Mini-trawl					☑			☑															
17	Hand dredge								☑		☑		☑	☑			☑							
18	Four boat lift net																			☑				
19	Cast net	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		
20	Stake net										☑		☑	☑	☑		☑	☑	☑			☑		
21	Surrounding net													☑										
22	Drive-in-net												☑											
23	Scare line								☑	☑							☑	☑		☑				
24	Drag net													☑			☑							
25	Scoop net												☑	☑										
26	Light fishing						☑						☑	☑				☑						
27	Baited lift net				☑	☑							☑	☑			☑	☑	☑	☑	☑			
28	Cross bow													☑										
29	Spear																☑							
30	Bent hook												☑											
31	Poisoning																☑							
32	Explossives				☑																			
33	Electrical fishing															☑								
34	Sluice net												☑	☑			☑							
35	Hand picking	☑		☑	☑	☑			☑	☑	☑		☑	☑		☑				☑				
36	Edible oyster fish.												☑		☑	☑								
37	FAD								☑				☑	☑			☑	☑						

3.2.1. Shore seines

Seine net is a long wall of netting with or without bag, supported by floats and sinkers, which are operated by surrounding areas of water with potential catch (Hameed, 2002). They are typical gear for bulk fishery in the sea, rivers, reservoirs, estuaries and lakes where the water is not so deep. They have a strong center for holding the fish, long wings on both sides and mostly very long hauling lines attached on the wings. The wings and the hauling ropes attached to the wing ends through the short poles on either side serve to drive the fish together. The effect of the warp lines for frightening fish can be increased by attaching twigs, leaves and straw on to them (Brandt, 1972).

A shore seine may be defined as a long length of netting shot from a boat as it is paddled or rowed from the beach and beach again in a semicircle having the shore as the chord of its arc, in the endeavor to enclose any fishes that may be in the area within the semi-circular course taken by the boat (Hornell, 1924). It is an active fishing gear operated in all types of water bodies including aquaculture ponds. It is used where there is a smooth and fairly leveled shore on to which it can be drawn and where the water to be fished is clear of snags. Since the net extends from the surface to the bottom, it can therefore be effectively operated at the depths appropriate to the height of the net from head rope to foot rope (Hickling, 1961). Though seine nets with bags are used in fresh water fisheries in other parts of the country, in Kerala seine nets are fabricated without a bag in the centre.

Review of literature reveal that Hickling (1961) has explained the use of *chilimila,* an open water seine for the fishery of tilapia from the lake Nyasa in Africa. Saxena (1964 and 1988) described the *maha jal* in Ganga and other rivers. Different types of seine net prevalent in Brahmaputra river are given by Joseph and Narayanan (1965). A review of seines operated for catching prawns in inland and marine systems in India is given by Ramamurthy and Muthu (1969) and Kurian and Sebastian (1986). *Karia jal* and *dewari* of Allahabad are big and small meshed editions of *maha jal* (George, 1971). Operation of *kontivala,* a large seine net in the backwaters and estuarine creeks along the Andhra coast is reported by Rama Rao *et*

al., (1985). Seine nets in the rivers of Rajasthan is described by Kulshreshtha (1986). Mitra *et al.*, (1987) and De (1987) reported the seine nets in Hooghly estuarine system of West Bengal. Operation of *Hole Rampani* (seine net with peripheral pocket) and *Sigadi Rampani* (seine net without pockets) in the estuaries of Karnataka is reported by Sathyanarayanappa *et al.*, (1987). *Maha jal* or *bar jal* is a shore seine operated in the beels of Assam and in Rihand and Keetham reservoirs of Uttar Pradesh and is similar to the *alvi* net used in Tungabadra reservoir of Karnataka (Sugunan, 1995). Operation of seine net called *ber jal*, using plank built boats in the Kachodhara beel in Assam is reported by Sharma and Ahmed (1998).

Seines nets in reservoir fishing is detailed by Jones (1959), Kurian (1971), Brandt (1972), George (1983 a, b), Varghes, *et al.* (1982), Khan, *et al.*, (1991) and Ninan and Swamikumar (2003). Znamensky (1967) stressed the significance of shore seine in exploiting the reservoir fishery resources in large scale. Krishnamurthy and Rao (1970) described the operation of seine net in Pulicat lake. Roy and Banerjee (1980) briefly mentioned the occurrence of *Bhida jal*, a large seine in Chilka Lake.

In Kerala shore seines are mainly seen in the central and North Kerala. The first work on the shore seines in Kerala is by Hornell (1938). Shetty (1965) reported the operation of *pattukannyvala* and *telikannivala*, seine nets with smaller and larger mesh size in Vembanad lake. Kurup and Samuel (1985) and Kurup *et al.*, (1993) also reported the occurrence of seines in Central Kerala.

3.2.1.1. Results and Discussion

Approximately 10 % of the inland fishermen operate seine net in North Kerala. In Kozhikode district, it is operated in Kuttiyadi, Korapuzha and Kadalundi rivers. In Kuttiyadi it is mainly operated in Kolaipalam near Payyoli. Only a few units are in operation in and around Kanayangode and Kuneela kadavu areas in Korapuzha. In Kadalundi river it is operated in Kottakadavu and Olipuram Kadavu.

In Kannur district, seine nets are operated in Kuppam, Valapatanam, Anjarakandi and Kavvayi rivers. In Kuppam river the net is usually operated in

Mattool, Payangadi, Cherukkunne and Pattuvam areas. In Valapatanam, only a few fishermen operate this net as the suitable area is limited to about 3 km near the river mouth. In Anjarakandi, seine netters are basically from Pinarai and they operate in between Pinarai to Dharmadam. They also operate the net in prawn farms as and when required. In Kavvayi, only the migrant fishermen operate the seines.

In Kasargod district seine net are mainly operated in the estuarine areas of Chandragiri and Chithari rivers.

The length and breadth of the seine net show considerable variation and are mainly dependent on the area of operation. Based on the target species, 17 types of seines are identified from the rivers and lakes of central Kerala (Kurup, 1993). According to the shape and mode of operation mainly three types of seines are found in different parts of North Kerala (Table 8).

3.2.1.2. Koruvala - Encircling seine

The *Koruvala* or *Valappe vala* is a small encircling seine net, which is operated by the fishermen migrated from South Kerala and settled in Kannur and Kasargod districts. They are settled in colonies near the water bodies in Kavvayi, in Kasargod district, Pazhayangadi, Mattool, Cherukkune and Chempallykunde in Kannur district. Such fishermen are allowed to fish only in some places. According to Kurup *et al.*, (1993) fishermen from Quilon district migrate along the entire stretches of backwaters of Kerala and the fishing operation coincides with the ingression of penaeid prawns.

The net is rectangular in shape with 40-50 m length and 2.4 to 5 m depth, made of PA multifilament of 210Dx1x2 having 10-18 mm mesh size (Fig.11). Prior to fabrication of the net the netting is dipped in black dye to extend the service life. PP rope of about 10 mm dia. is used as head rope and coir with 10 to 20 mm dia. is used as foot rope. Head rope is having PVC floats and foot rope is with or without lead sinkers. Net without sinker is used in areas were the current is weak and bottom is muddy. Krishnamurthy and Rao (1970) also reported that no sinkers are used in the *badivalai*, a shore seine with bag, in Pulicat Lake. Joseph and Narayanan (1965)

reported that the absence of sinkers is often compensated by a much thicker foot rope. Wallinger (1907), while describing the fishing gear of Konkan region, reported that use of sinkers is not compulsory in seine nets. They also reduce the number of floats from the net in areas with strong current, to keep the net at the bottom as well as to prevent drifting. Selvedge, known as *alle* is 1-1.5 mesh depth and is usually made of PA 210Dx8x3 with 50-60 mm mesh size. Coir is used as foot rope because it sinks to the bottom in wet condition and also provide better grip while hauling the net. In *koruvala,* both ends were made tapering by lacing about 70 % of the meshes in the edges with twine to form bags at both ends. In a net with 500 mesh in depth about 350 meshes are laced to make the bags known as *konda.* Most part of the catch is collected in these bags. Approximate cost of a net of 40 m length is Rs.5000/- and the life of the net is 3-4 years.

Operation

Two fishermen operate the net using a canoe of 4-5 m length. In some places they join two units before operation. Both end of the net is connected to poles having 2.5-3 m length leaving about 30 cm between net and poles. Besides keeping the mouth open, they serve as grip for the two men who haul the net to the shore after shooting it in as deep water as they are able to reach by wading (Hornell, 1938). Net is operated throughout the season preferably during night, irrespective of the tide. According to the fishermen, catch of *Metapenaeus monoceros* is always better during night as they may avoid the net in the daylight. Some fishermen go in the evening and come back by midnight. Others go in the midnight and return by early morning depending on the season. Net is operated in areas were the depth is 2-2.5 m. One end is handed over to a fisherman standing in water and the other fisherman release the net in a circular fashion from the canoe along the direction of water flow to spread the net properly. Some times one of the poles is fixed to the bottom close to the shore and the other end is dragged through water for shooting. Hauling is done immediately by pulling the head rope and foot rope together from one end. Simultaneously, the other end of the net is taken inside the circle by the second person and he moves in a circular manner to collect the catch into the pocket in the other side of the net. After hauling and washing the net, catch is removed and

the process is repeated in another place. Depending on the catch, 8-12 hauls could be made during a trip.

During March to May catch is dominated with white prawn and income per head goes up to Rs.500/day. November to January is lean season and income per head comes down to Rs.50-100/day. During the beginning of monsoon catch is mainly *Ambassis commersonii*. In the beginning of summer *M. monceros* dominate the catch whereas *M. dobsoni* is available throughout the season. Fishing is done 4-6 days in a week depending on the catch. During off-season in the sea they get better price for their catch.

3.2.1.3. Chavittuvala-I : Seine net without wings

Chavittuvala is also a rectangular type of seine net operated in the lower reaches of Kuppam, Valapatanam, Kadalundi, Chithari and Chandragiri rivers. Seine nets in the middle reaches of Kadalundi river are known as *Adakkamkolli vala.*

The seine net operated at Pattuvam, in Kuppam river was having a total length of 160 m. It is made up of 7-8 rectangular pieces of different lengths having 3.5 m hung depth (Fig.12). Tandon and Sharma (1984) reported that 5-10 pieces each having 7-10 m length and 4-8 m width are connected to one another to cover maximum area of water. PA knotless netting with 7.5 mm mesh size is used for the fabrication. Selvedge of one mesh depth on both sides is made of PA multi filament with 210Dx4x3 or 210Dx5x3 with 60 mm mesh size. The selvedge is loose netting, generally twice the length of the main netting, which permits the mud and trash to pass through and allows sufficient freedom to the main netting to retain its shape when the net is dragged (Saxena, 1964). 8-10 mm dia. PP rope is used as head rope whereas 12-15 mm dia. coir rope is preferred as foot rope because coir rope in wet condition sinks fast to the bottom. 2-3 mm dia. PP twine is used as float line which is attached to the head rope 80-100 g lead sinkers are used at about 1.3 m distance intervals.

At the time of operation head rope and foot rope on either end of the net is tied to two wooden poles of about 0.8-1 m size leaving about one meter distance

between. 25 mm dia. coir rope, each having about 50 m length is attached to these poles, which serves for herding and hauling of rope. Seine net having dimension up to 250 x 13 m is operated in the lower reaches of Chandragiri river. Ramamurthy and Muthu (1969) reported that *Kairamapani*, a smaller drag net with lesser number of pieces is operated in the estuaries of Kanara region.

Operation

The net is operated throughout the season and usually it is operated early in the morning. 6-7 fishermen and two canoes are required for the operation. Depth of operation varies from 2.5 to 3 m. Net is loaded in a canoe and on reaching the ground, the rope connected to one end of the net is given to the fishermen in the second canoe. Both canoes move apart, simultaneously releasing the net and rope in a semi-circular form. While shooting the canoes come back to shore holding the other end of the rope. The net is released from a canoe at around 2-2.5 m depths, and after making a circle the rope in the other end is brought near the shore about 5-6 m away from the starting point. Meanwhile, one or two fishermen standing outside the circle press the foot rope into the bottom with their feet and hence the name *chavittuvala*.

Hauling is done from both ends by dragging the head rope and foot rope together. Hauling is done in such a way that the foot rope comes up faster than the head rope and at the end the net reaches the surface in a nearly horizontal position with a deep sag in which the fishes are held (Hickling, 1961). When at last they are brought together, the catch of fish is concentrated in a more or less definite pocket at the center of the net (Hornell, 1938). According to Joseph and Narayanan (1965) catch is collected at the middle part of the net which is kept slackened during hauling by manipulating the head rope and foot rope. After removing the catch and cleaning the net they move to another place and the process is repeated. The operation takes about 1-2 hours and they make 4-5 hauls a day and return by around 11.30 a.m. Prawns, Ambassids and other small fishes are the major components of the catch.

Total income is divided into equal shares and the owner of the craft and gear get one additional share. During March to May income per head varies from Rs. 200- 300/- per day. This is mainly due to the catch of white prawns when the salinity increases in the estuarine region. The average income estimated for the seine net unit in Kuppam river during 2003-2004 is Rs.1200/- and the average income per head per day is Rs.200/-. The performance of the gear during 2003-2004 is given in Fig. 14.

3.2.1.4. Chavittuvala-II : Seine net with wings

The nets operated in Pinarai in Ancharakandy river are also known as *chavittuvala* but the main difference is the tapering wings on either side of the net. Saxena (1988) and George (1971) reported that maximum height of the net in rivers is always the middle region, which tapers towards the two arms. Total length of a unit is 90-100 m with nine meter hung depth at the central part. Each unit consists of about eight pieces of different dimensions (Fig.13). Dimensions of the middle units are about 14 x 9 m and end piece is 5.5 x 4.5 m. George (1971) reported that landing part is differentiated from the wings by a great fishing height and a smaller mesh. Net is made of PA multifilament of size 210Dx1x3 with 10 mm mesh size. PA knotless netting is also used for fabrication of the same. According to the fishermen multifilament netting is better for seine net targeting prawn whereas knotless netting is suitable for Ambassids as the fish will not be gilled or enmeshed in the net. Hence depending on the catch they change the netting in the net.

Operation

Six fishermen and two canoes are required for the operation. Mode of operation is similar to that of *chavittuvala*-I described above (Plate 4). When they operated the net in shallow waters close to the shore and in prawn culture farms, the long ropes on either end of the net not used. Operation usually starts by 4 a.m. and by 6 a.m. they come back to the shore to dispose the catch. Two to three hauls are made after the break and fishing stops by around 9 a.m. Different species of fishes and prawns are caught in the net. Catch data has been collected during 2003-2004

from a seine net unit operating in Anjarakandy river and the monthly average income has been worked out, which is given in Fig.14.

3.2.1.5. Other seines

Rankevala (net is shot in the form of Malayalam alphabet "*ra*" and hence the name) is a seine net operated in the backwaters in Kolaipalam, in Kozhikode. Main body of the net is made of PA 210Dx1x2 whereas the lower 30-40 cm portion of the net is made PA 210Dx1x3 to make it heavier. Length of a unit is about 50 m and landing bags are made on either end of the net by joining the meshes in the edge. No sinkers are used and a thicker coir rope is used for sinking.

A seine net with trapezoidal shape is found in operation in the middle stretches of Korapuzha. The net is about 75 m in length with a hung depth of 4 m on one side and 8.5 m on the other side. Saxena (1964) while describing the seine nets of Ganga river reported that the side or the wing of the net put in water first is generally bigger. Mode of operation is almost similar to that of *chavittuvala*. While operating the net the shorter end is put near the shore and the other end is dragged through the deeper area.

Fishermen are slowly shifting from PA knotted to PA knotless multifilament netting. The main reason behind this shifting is the net made of knotless netting is less bulky. Further the removal of smaller sized fishes like *Ambassis commersonii* from the net can be easily done by jerking the netting. Shore seines in North Kerala are with very small mesh size, irrespective of the material and design, resulting in the large scale landings of juveniles. Fishermen should restrict the use of this net at least during the breeding period of economically important fishes. George (1983) reported that in order to avoid the capture of juveniles of carps, the operation of the net has to be restricted to particular season and area.

Weekly data on the total catch during April 2003 to April 2004 has been collected from a seine net unit at Pinarai, Anjarakandy river. Average catch per day was about 31 kg with a CPUE 7.8 kg/hr. Initial investment, labour requirement and maintenance cost is relatively more in seine net fishing. Returns are better during

summer season, when they get prawns. During this period the average income per head varies from Rs.150/- to 400/-day. Average daily income of a *chavittuvala*-I at Pattuvam in Kuppam river and *chavittuvala*-II at Pinarai, in Anjarakandy river during 2003-2004 is given in Fig.14

Table 8 Technical specifications of seine nets in North Kerala

Local name	*Chavittevala - I*	*Chavittevala-II*	*Koruvala*	*Adakkam- kolli*	*Rankevala*	*Koruvala*
Place/River	All places	Anjarakandi	Kuppam/ Kavvayi	Korapuzha	Korapuzha	Korapuzha
Main netting material	PA multi	PA multi/ PA knotless	PA multi	PA multi	PA multi	PA multi
Mesh size (mm)	7.5-30	10	10-18	20	10-16	10-20
Twine size	210Dx1x2, 210Dx1x3	210Dx4x3, 210Dx5x3	210Dx1x2	210Dx2x2	210Dx1x2 & 210Dx1x3 (bottom)	210Dx1x2
Length/unit (m)	60-160	90-100	40-55*	75	35-45	75
Mounted depth (m)	6-7	8-9	2.4-5.5	9	7.5-8.25 (1.5-2m after lacing)	4 (2m after lacing) 8.5 on the other end
No.of meshes in depth	100-625	520-900 (middle)	250-600	800	825-850	800-850
Shape	Rectangular	Tapering wings	Rectangular**	Rectangular	Tapering	Trapezoidal
Hanging coeffi. (E)	0.4-0.45	0.50	0.4-0.5	0.55	0.5-0.7	0.5
Head Rope	Coir/PP	PP	PP	PP	PP	PP
Diameter(mm)	8-10	10	15	8	8	8
Foot rope	Coir	Coir	Coir	Coir	Coir	Coir
Diameter(mm)	10-12	10-12	10-15	10	10-12	10
Selvedge	PAmulti	PAmulti	PA multi	PA multi	PA multi	PA multi
Mesh size(mm)	30	30 & 40(2nd)	50-60	35	40	30
Twine size	210Dx2x3, 210Dx3x3	210Dx3x3	210Dx8x3	210Dx16x3	210Dx12x3& 210Dx12x4	210Dx12/3
Floats	PVC/Wood	PVC	PVC	PVC	PVC	PVC
Size(mm)	50x20/50x40 Spherical/	50x40, 50x50	50x15/50x20	40-50x20	60x20	50x20
Shape	Cylndrical	Cylindrical	Disc	Disc	Disc	Disc
Floats/unit (Nos.)	200-450	240-250	55-75	185-200	64-125	180-190
Sinkers	Lead	Lead	Lead***	Lead	Nil	Clay
Size(mm)	50-70x20	70x20	NA	60	NA	40
Shape	Rectangular/ Cylindrical	Rectangular	NA	Rectangular	NA	Oval
Weight(g)	50-100	80-100	NA	30-40	NA	150
Sinkers/unit (Nos.)	125-205	230-240	NA	75-80	NA	80
Approximate cost (Rs)	30,000/-	30,000/-	5000/-	25,000/-	18,000/-	20,000/-
Target species	Prawn, mullet, Ambassids	Prawn, Mullet, Ambassids, etc	Small fishes & prawns	Fishes & prawns	Mostly prawn	All

*Two units are laced together before operation ** Bag is made by lacing together half of the meshes in both edges ***Sinkers are very few or totally absent in places where current is mild

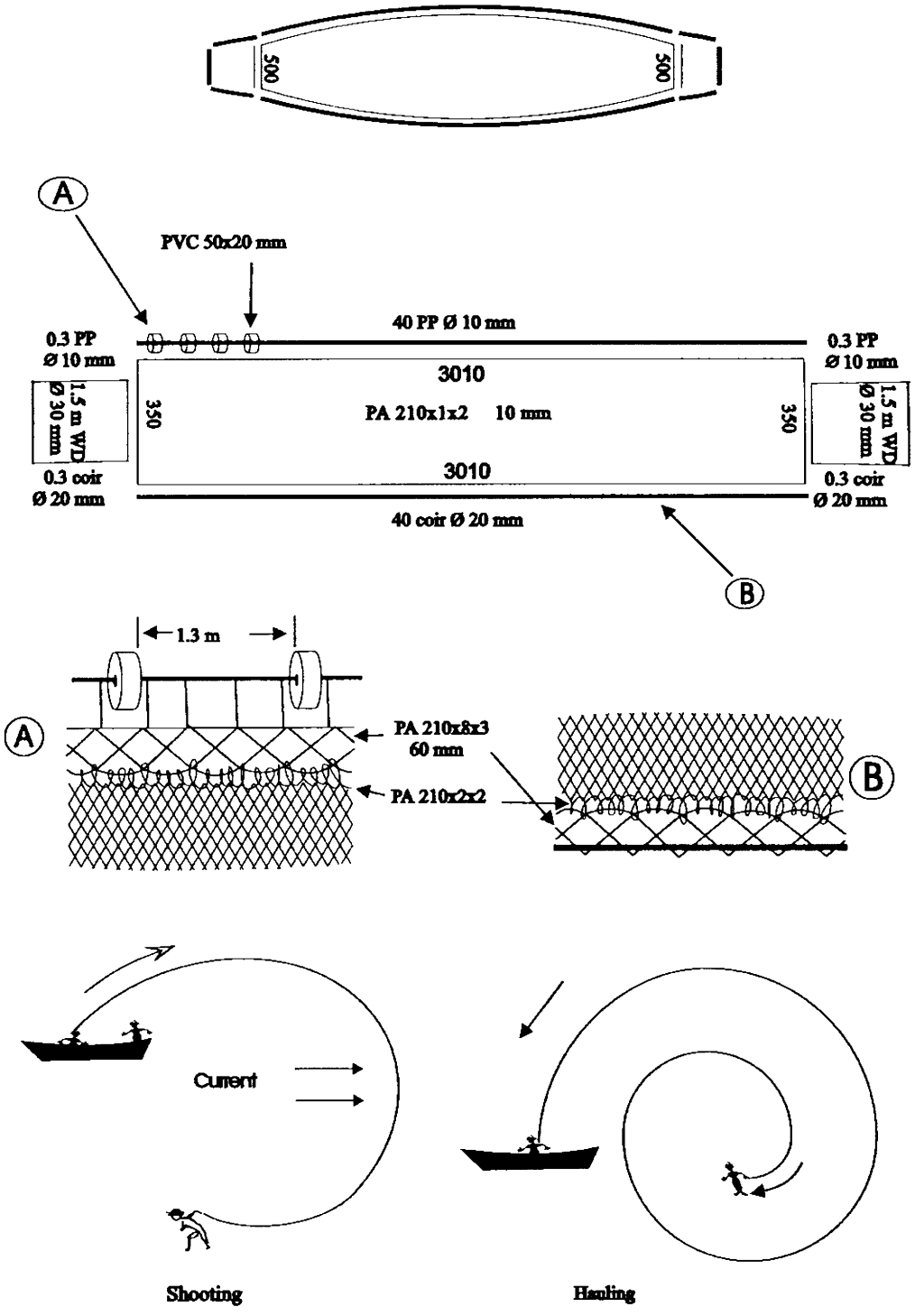


Fig. 11 Shore seine operated by the migratory fishermen

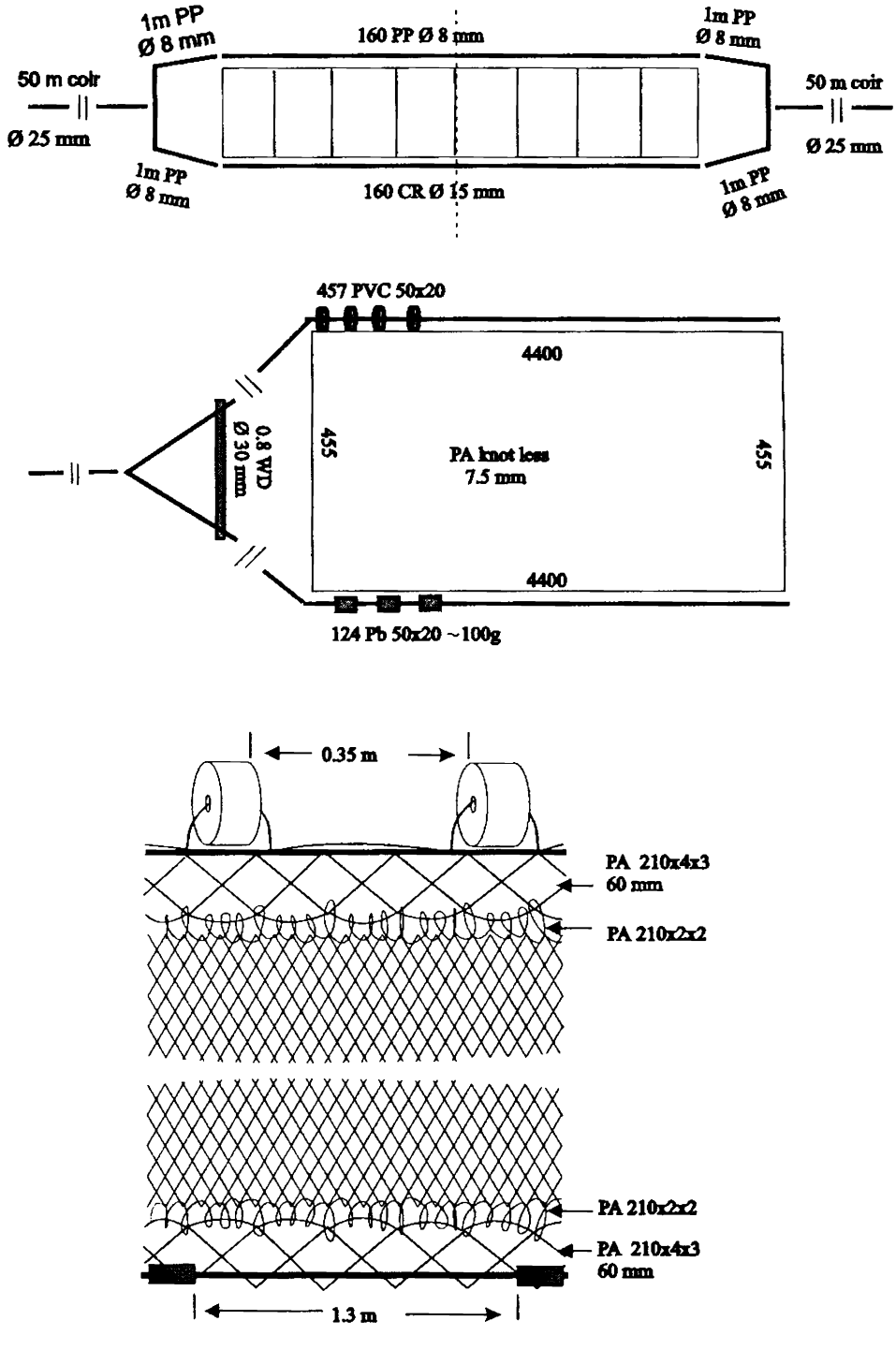
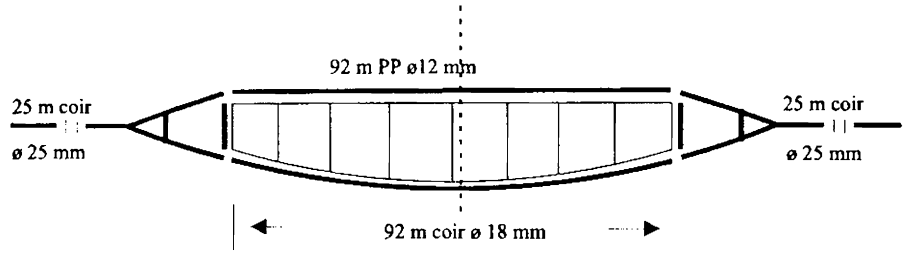
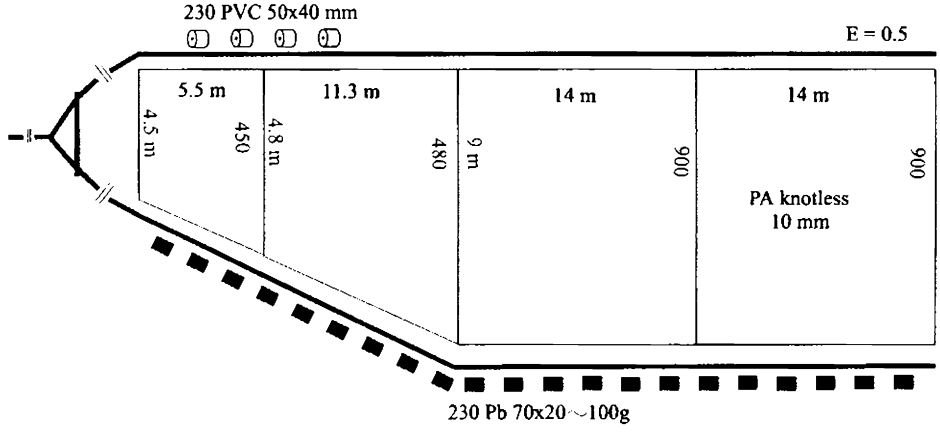


Fig. 12 Design of a shore seine unit from Kuppam river





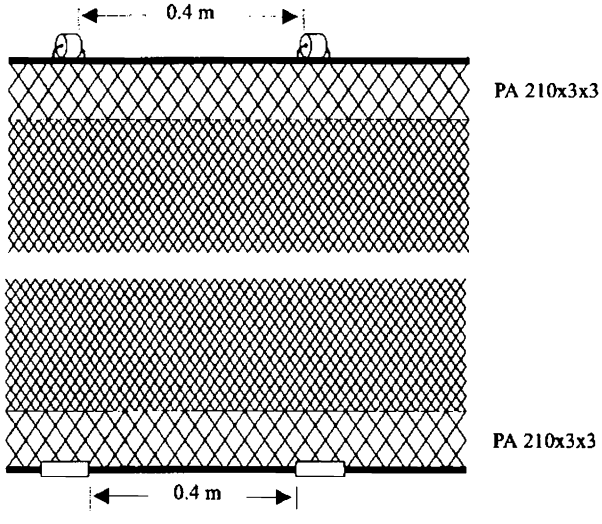
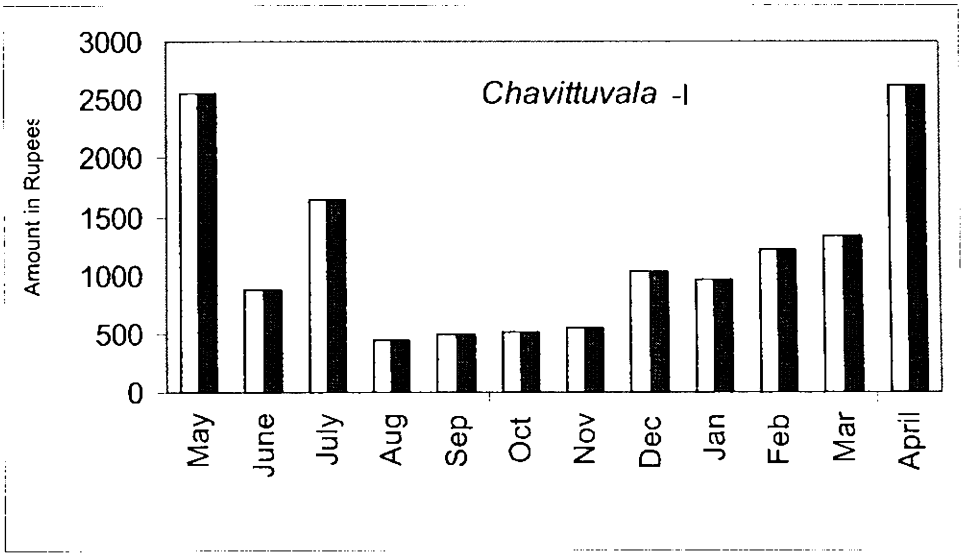


Fig. 13 Design details of a shore seine from Anjarakandy river



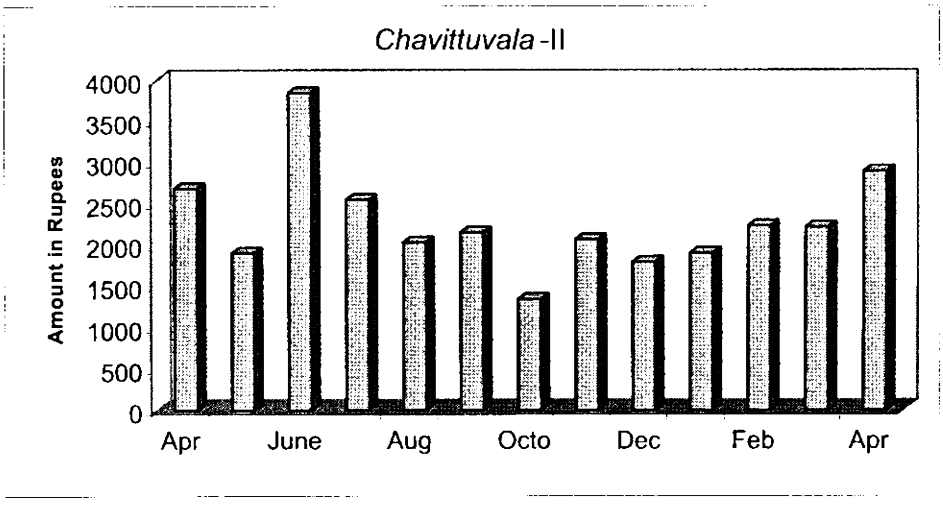


Fig.14 Average income of *Chavittuvala*-I and *Chavittuvala*-II during 2003-2004

Operation of *Chavittuvala* in Kuppam river

Operation of *Chavittuvala* in Anjarakandy river

Plate 4. Operation of seine nets

3.2.2. Gill nets

Brandt (1972) classified gill nets as single walled nets whose lower edge is weighted by sinkers and upper edge is raised by floats, and with a mesh opening of suitable size in which fish of the required size group can gill themselves in the netting. It is a highly selective and passive gear. The net is rectangular in shape and the upper and lower edges are strengthened with selvedges of thicker twines. Net is with uniform mesh size, which allows only the head of the target fish to pass through and subsequently get gilled when the fish tries to pull back. Hickling (1961) reported that a fish can thrust its head no further than the hinder end of the gill covers, where the body becomes thick, will not be able to escape for the two reasons, that the gill covers may, by opening in the normal respiratory movements hold the mesh, and secondly because a fish can usually swim backwards only weakly. Since the fishes are mostly caught in mesh bars behind the gills, these nets came to be popularly known as gill nets.

Gill nets are size selective and for a given mesh size, catch decreases sharply on either side of the length of the fish most frequently caught by it (Boopendranath, 2000). Pauly (1991) reported that other than mesh size, the most important characteristics of a gill net are its visibility and stretchability of meshes. Nets of different colour show differences in catches and usually less visible nets are more successful. Nets made of thinner twine can catch more fish, as it is less visible, easier to stretch and more flexible.

When a sheet of similar netting is hung more loosely fewer fishes are taken by the gills and more fishes are captured by entangling or completely wrapped in the netting. Such nets are called tangle or entangling nets. It is estimated that gill netting constitutes 20 % of the different fishing methods employed all over the World. In India they contribute around 25 % of the total fish catch. The simplicity of its design, fabrication and low manpower and energy requirement for operation make the gear very popular especially in the traditional sector (Thomas, 2002). Gill nets can be operated in waters, which are unsuitable for gears such as trawls and seines.

Simple gill net is the most common fishing net used in the inland fishing sectors of our country. The efficiency of the present day gill net has increased several times by replacement of natural fibres to synthetic fibres, especially by Polyamide transparent monofilament (Vijayan *et al.*, 1993). Monofilament gill nets can be used to fish in clear water during day time as they meet the condition of contrasting as little as possible with the surroundings. The nets are operated in the surface, column or bottom layers of water as set, drift or encircling depending on the availability of fish and other conditions. It is an ideal gear in catching sparsely distributed fishes in large water bodies like rivers, reservoirs and lakes.

Different types of gill nets operated in inland waters of India have been described by several workers. Wallinger (1907) mentioned about the operation of wall nets in the Konkan region, Western India. Hornell (1924), Saxena (1964) and Seth and Katiha (2003) described the Gangetic gill nets. Kulkarni (1951) reported the operation of sunken drift nets for *Hilsa ilisha* in Narbada river, in Gujarat. Jones (1959 a, b) while reporting the fishing methods for the *Hilsa ilisha,* described gill nets for the fish in the Indian region and gill nets of River Brahmaputra have been given by Joseph and Narayanan (1965). *Phasla jal*, a gill net, for catching Hilsa in the Ganga and Yamuna is reported by Saxena and Chandra (1968). Kurian and Sebastian (1986) mentioned different types of gill nets operated for the capture of prawns in India. George (1972 and 2002) has given an account of gill nets from different parts of India. Gill nets of Sunderban is described by Banerjee and Chakravarthy (1972) and Hoogly-Matlah estuarine system by Dutta (1973). Tandon and Sharma (1984) have mentioned about gill nets operated in the Kangra and Hamirpur districts in Himachal Pradesh. Gill nets in Rajasthan are reported by Kulshreshtha (1986). Different types of gill nets operated in Indian rivers are reported by Sreekrishna and Shenoy (1987), Saxena (1988).

Baranov (1948, 1977) and Fridman (1986) have worked out the ratio of twine dia. to mesh size for fishing in lakes and rivers. Gill nets for reservoir fishing are described by Gulbadamov (1962) and Khan *et al.,* (1991). Comparative fishing with simple gill nets, vertical line nets and framed net in Hirakud reservoir is carried out by Kurian (1971). Comparative catch efficiency of nylon over cotton gill nets in

reservoir fishing is worked out by Mathai and George (1972). George (2002) studied the efficiency and selective action of gill nets in Gobindasagar reservoir. Khan *et al.*, (1975) studied the comparative fishing power of monofilament and multifilament gill nets and conducted comparative fishing experiments with frame nets for *Catla catla*. Design and operation of *sleeping net*, a type of bottom set net without floats, in Nethravati-Gurupur estuary in Karnataka are given by Ahamad and Sheshappa (1991). Sharma and Ahamad (1998) reported several types of gill nets used for fishing in Kachodhara *beel* in Assam.

Details of different types of gill nets operated in the rivers and backwaters of Kerala are reported by Hornell (1938) and gill nets of inland waters in North Kerala by Remesan and Ramachandran (2005c). Gill nets operated in Vembanad lake were reported by Shetty (1965) and Kurup and Samuel (1985). Vijayan *et al.*, (1993) studied the changes taken place in the costal gill nets of Kerala during 1958 to 1991. Gill nets of 18 rivers and Vembanad lake of Kerala have been studied by Kurup *et al.*, (1993). Details of gill nets operated in coastal waters of Kerala are described by Thomas (2002). Gill nets of Muvattupuzha river (Baiju and Hridayanathan, 2002) and in the seven rivers of Central Kerala are described by Baiju (2005).

3.2.2.1. Results and Discussion

Study reveals that about 70% of the fishermen in this region operate gill nets. More than 95% of the gill nets operated in the selected districts are made of PA monofilament (Fig. 15). The only other material seen is PA multifilament, which is rarely used at present. Khan *et al.*, (1975) indicated that PA monofilament gill nets are 1.5 times more efficient in inland waters and 2.5 times more efficient in marine waters. According to George, (2002) there is a gradual shift from PA multifilament to PA monofilament as gill net material. Vijayan *et al.*, (1993) and Baiju and Hridayanathan (2002) reported similar findings.

3.2.2.2. Classification of gill nets

Saxena (1964 and 1988), Roy and Banerjee (1980) and Biswas (1995) have classified riverine gill nets into two groups, namely gill nets with foot rope and

without foot rope. Pauly (1991) classified the gill nets operated in Vembanad Lake into three major classes namely, the set gill nets, drift gill nets and encircling gill nets and Baiju (2005) also followed same classification while dealing with gill nets of rivers of central Kerala. Kurup and Samuel (1985) have broadly classified gill nets of Vembanad lake into drift and set gill nets. Kurup *et al.,* (1993) reported the occurrence of 28 types of gill nets in Vembanad lake. Based on the construction, area of operation and target species gill nets of north Kerala can be classified as given in Table 9. Surface drift gill net is also operated as encircling gill net by joining few units and most probably with two fishermen and two canoes.

Details of major types of gill nets that are operated in the inland waters of north Kerala are given in Table 9. Length of the net depends on the width of the area of operation and normally it varies from 50 to 300 m with a depth range of 2.4 to 8 m. According to Jones (1959) the length of gill nets for *Hilsa ilisha* varies from about 60 to over 300 m and the depth from about 5 to 8 m depending on the area and depth of the water body. Hung depth of the bottom gill nets generally ranges from 1-2 m, while for pelagic gill nets, it may exceed even 8 m (Boopendranath, 2000). George (1971) reported that nets with minimum fishing height are noticed in riverine gill nets while lacustrine gill nets have maximum height. Depending on the area and type of operation they adjust the fleet length by joining or removing units of nets.

PA multifilament gill nets were almost completely replaced by PA monofilament nets in all three districts. George (2002) and Baiju and Hridayanathan (2002) also reported similar changes in the gill nets fabricated elsewhere in the country. Multifilament nets were very few in numbers and were seen only in three places of Kozhikode district for catching bigger fishes like carps, murrels and sea bass. Relatively better catching efficiency made this material very popular for gill net fabrication. Most of the monofilament gill nets are made with material of 0.16 mm dia, popularly known as *zero*. Mesh size of the gillnet varies from 12 to 300 mm in which the lowest case is for the *M. dobsoni* net in Kannur district and highest for the *Catla catla* gill net in Kuttiadi reservoir.

Hanging coefficient normally varies from 0.4 to 0.7 except for the entangling nets for crabs, flat fishes, spotted scat, pear spot, etc. where it varies from 0.3 to 0.5 Mounted height of the net covered under the study varies from 2.8-8 m with an average height of 4-6 m. Lowest depth is noticed in the drift gill net for *Metapenaeus dobsoni* operated in Valapatanam river and highest in the case of surface drift net in Kadalundi river. Fishermen usually use the machine made netting as such for fabrication of a net. However, depending on the type of net, depth of operation and target group, they cut the netting horizontally and make 2-3 nets. In such cases selvedges of half to one mesh depth is made by hand braiding using PA multifilament of 210Dx2x2 or 210Dx2x3.

Polypropylene multifilament (PP) with 2-4 mm dia. is the most common material used as head rope and foot rope. Polyethylene monofilament twisted or braided and PA multifilament are also used. Entangling nets operated for pearl spot, spotted scat and catfishes in Kavvayi river use old hand twisted PA multifilament netting as foot rope. The netting absorbs water and sinks to the bottom without the help of sinkers. PA multifilament gill nets without foot rope and sinkers are operated in Kuttiyadi reservoir where current is insignificant.

Disc shaped PVC floats are predominantly used for gill nets in all places. Size of these floats varies from 30x10 mm to 150x15 mm. Plastic floats and thermocole pieces are also used in few nets. Fishermen split or cut larger disc floats into 2-3 pieces and use in bottom gill nets, where the buoyancy requirement is less. Floats made of reeds (*Ochalandra* sp.) collected from nearby areas are used as floats by the migrant fishermen from Karnataka. In Andhra vala, a popular type of gill net in the rivers of central Kerala, stem pieces (*peely*) of a reed is used as floats (Baiju, 2005). They cut the reed into 50-60 mm long pieces and sundry it for making it durable. Distribution of floats in the head rope depends on the size of the float as well as mode of operation. While mounting the net the foot rope is inserted through the floats at regular interval and fixed later. Some fishermen use a separate float line, usually thinner than the head rope, which is attached to the head rope.

Lead is the common sinker in all the gill nets studied. The size, shape and weight varies according to the type, size of net and mode of operation. Some fishermen use burnt clay, concrete discs, stones and pieces of earthen tiles according to the availability of the material. Depending on the season and availability of fish, fishermen add or remove sinkers from the net to keep it near the surface or bottom.

3.2.2.3. Surface drift gill nets

As the name indicated it is operated in the surface layers. Same net is either set or allowed to drift depending on the area, season and catch. When the net is set in shallow areas adjacent to the shore the foot rope may be touching the bottom. Fishermen add or reduce the number of floats from the head rope to keep it in the surface or close to the bottom. Similarly they adjust the weight of the net by adding or reducing the number of sinkers in the foot rope depending on the type of operation. Brandt (1972) reported that drift nets are not much used in fresh water fishing because the areas are so limited and only in very large lakes floating gill nets are allowed to drift. In rivers, fishermen use only very small drift nets with one end fixed on a boat and the other on a big float and the whole system is allowed to drift along the current. Details of major types of surface drift gill nets are given in Table 10. Fabrication and operation of PA gill nets is given in Plate 5.

Maalanvala

Mullets are popularly known as *maalan* in several parts of Kerala and *maalanvala* is the most common gill net operated in North Kerala (Fig.17). In Kannur and Kasargod districts the net is made of PA monofilament of 0.16 or 0.20 mm dia. with 35-50 mm mesh size. Thomas (2001) reported the use of *maalanvala* with a mesh size of 36-40 mm in the near shore waters of Cochin. Kurup *et al.*, (1993) reported the operation of *maalanvala* made of PA 210Dx1x2 with 30-34 mm mesh size in Vembanad Lake. In Kozhikode district the mesh size increased up to 60 mm and such nets are made of material with 0.20 or 0.23 mm dia. This is because the same net is operated as bottoms set or drift after adjusting the number of floats and sinkers in the net. Hanging coefficient of the net is between 0.5-7 in all cases

observed with a mounted depth between 3.5 – 4.3 m. The net is operated as surface drift during all season when the current is moderate. One or two fishermen operate the net using a canoe of OAL 3-6 m. Depending on the availability of clear area and tidal intensity the drifting time varies. *Mugil cephalus*, *Liza parsia*, *L. tade* and *Valamugil sp*, sciaenids, carangids and other small fishes are caught.

Maalanvala is also operated as encircling with the help of two canoes and two to four fishermen. After lacing few nets together to increase the length the canoes stay together and half of the net is taken into each canoe. Then the canoes move in opposite direction simultaneously releasing the net in the form of a circle. The fishermen enter inside the circle to splash water with the oar to scare the fish and drive them into the net. Some times they beat the sides of the canoe with a pole to make noise. After encircling, the water in the center is splashed with oars and sticks and the frightened fish trying to escape get entangled in the net (Anon, 1995). Hickling, (1961) reported that the catching performance of the gill net could be increased by beating the water. Hauling is also carried out from the two canoes without giving any chance for escaping the fishes inside the circle.

Narimeen kandadi

It is a large mesh gill net exclusively operated for bigger sized *Lates calcarifer* in the middle reaches of Chaliyar (Remesan and Ramachandran, 2005c). Net is fabricated with PA multifilament of 210Dx24x3 with 220 mm mesh size (Fig.18). Shetty (1965) reported the operation of *Narimeenvala* having 150 mm mesh size during February to April at nights for catching *Lates calcarifer* in Vembanad lake. Wallinger (1907) and Jones (1946) have mentioned about *Lates calcarifer* gill net. Length of the net varies from 100–150 m with 2.5-3 m depth. Light wooden sticks of about 600x20 mm size collected locally are used as floats in the net.

During monsoon the net is allowed to drift in turbid waters with the help of a canoe. During post monsoon the net is set across the river at night. Then two canoes positioned away from the net, drag a scare line against current simultaneously

beating the sides of these canoes to make sound to scare the fish and drive them into the net. Hornell (1924) reported that the crew make all the uproar possible, shouting their loudest and beating the water with poles and paddles to scare sea bass, which rush blindly and ultimately get entangled in the net. *Lates calcarifer* weighing above 20 kg are often caught. Krishnamurthy and Rao (1970) reported that a gill net named, *Koduvala* is exclusively operated for sea bass in Pulicat lake. Biswas (1995) reported that large gill nets made of synthetic netting is operated in the deeper part of Chilka lake to catch sea bass.

Thiruthavala

Large *Mugil cephalus* is locally called *thirutha* and the net targeting this fish is mostly fabricated with PA monofilament having 0.23-0.32 mm dia. (Fig.19). Length of the net varies from 80 to 300 m with 0.4-0.7 horizontal hanging coefficient and 3.4-5 m mounted depth. Mesh size of the net in all the places surveyed varies from 70 to 115 mm. Other details are given in the Table 10.

It is operated as surface drift mainly during post monsoon season. One or two fishermen operate the net using a canoe. A thermocole piece or empty oilcan is attached to one end of the head rope and is allowed to drift, subsequently releasing the complete net across the current in river or associated water bodies. The fisherman sitting in the canoe holds the rope attached to the other end of the net. Net is allowed to drift along the current for 30 – 40 minutes depending on the area and velocity of the current. Pauly (1991) reported that the drifting time for the drift net for *Mugil cephalus* in Vembanad lake ranges between 45 minutes to 2 hours depending on the distance available and tidal intensity. Experienced fishermen can feel the vibration in the rope when a large fish strike the net. The net is hauled by taking the head rope and foot rope together. The process is repeated after coming back to the same area or in another place depending on the catch. *Lates calcarifer, Eleutheronema tetradactylum* and *Daysciaena albida* are also caught in this net. Shetty (1965) reported the operation of *thiruthavala* or *paithuvala,* a stationary gill net for catching *Mugil cephalus* in Vembanad lake.

Surface nets are also operated occasionally in some places for the capture of other fishes like Sciaenids, and Polynemids. In the lower reaches of Anjarakandy river drift net made of PA monofilament of 0.28 mm with 80 mm mesh size, locally known as *Bameenvala* is operated for catching Polynemids. *Kala valai* is a gill net with a mesh size of 75 mm operated in Pulicat lake to capture polynemids (Hornell, 1924). Another net made of PA multifilament of 210Dx1x2 size with 30 mm mesh size locally known as *Veloorivala* was found at Kappakadave in Valapatanam river for Ambassids. Column set gill nets are mainly operated in Kuttiadi reservoir for the fishery of carps. Buoy lines are attached on either end of the head rope to mark the location as well as for easy hauling.

3.2.2.4. Bottom set gill nets

Some of the surface drift gill nets are also used as bottom drift or set net by adjusting the floats and sinkers of the net. Gill nets are set across the current and in the swimming layer of fish. The soaking time for the set nets varies from 1 h to 12 h. In set gill net, both ends of the gears are secured to bottom by means of stone sinkers. In north Kerala fishermen set the gill net usually late in the evening and haul back by next morning. A draw back of this type of fishing is that a portion of the catch is some times eaten or destroyed by the crabs or puffer fishes.

Nandevala

It is an entangling net operated in estuaries and backwaters of all the three districts for catching *Scylla serrata*. Net is usually made of 0.32 or 0.34 mm dia. PA monofilament with a mesh size ranging from 90-160 mm (Fig.20). Length of the net varies from 100-200 m with 3-4 m depth. Thermocole pieces are used as floats at an interval of 23-30 m in Valapatanam river, whereas it is only 5-10 m in all other places. Lead, stones and cement discs are used as sinkers and depending on the current they adjust the quantity. Net is operated through out the season except during heavy monsoon period. Usually it is set along the shore or across the channel in the evening and is hauled by next morning. Jones and Sujansingani (1952) reported the operation of mud crab gill net, popularly known as *Noli-jal* in Chilka lake. *Portunus*

pelagicus, P. sanguinolentus and *Charibdis cruciata* are also captured using crab gill net during summer months. *Kakula dela* is a bottom set gill net with a mesh size of 120-130 mm, which is operated, in brackish water lagoons in Sri Lanka for catching crabs (Anon, 1995).

Chemmeenvala

Gill net for major species of prawn like *Fenneropenaeus indicus* (white prawn), *Penaeus monodon* (tiger prawn), *Metapenaeus monoceros* and *M. dobsoni* are operated in different places in north Kerala. Prawn gill nets are made of PA monofilament with 0.16 mm dia. Mesh size of gill net for white and tiger prawn varies from 32-45 mm whereas for *M. monoceros* and smaller sized white prawn, it is between 28-32 mm. Thomas (2001) reported that mesh size for currently used prawn gill net in Kerala coast are 34, 36, 38, 50 and 52. According to Pravin (2003) gill nets with mesh sizes ranging from 24-36 mm are generally used to harvest *F. indicus* whereas larger mesh sizes of 36 mm onwards are used to harvest *P. monodon.* Kurup *et al.,* (1993) reported that gill nets with mesh sizes of 20, 25, 32 and 40 mm are used for the prawn fishing in the Korapuzha estuary.

Gill net for *M. dobsoni* is unique and very rare but it is operated at Kattampally in Valapatanam river and in Kavvayi river (Fig.21). Mesh size for this gill net operated in Valapatanam is 12 and it is 20 mm in Kavvayi river. As per Kurup *et al.,* (1993) the size of male *M. dobsoni* caught in the gill nets of Korapuzha estuary varies from 52 to 110 mm and that of females from 52 to 125 mm. These gill nets are operated mainly during summer season when the water salinity in the estuarine areas of river increases and the prawns start migrating into the river systems. According to Kurup *et al.,* (1993) the prawn fishing in the estuary is very active during the pre-monsoon periods of March-May and post monsoon period of October-December. The net is operated as bottom set or bottom drift depending on the area. *Chemmenvala* are extensively used not only in rivers, estuaries and backwaters but also in shrimp culture farms (Kuriyan and Sebastian, 1986, Pauly, 1991, Pravin, 2003).

3.2.2.5. Other bottom gill nets

Though pearl spot is caught in gill nets operated for other fishes at some places they use gill nets exclusively for this fish. *Etroplus suratensis* is known as *karimeen* or *erumeen* in different parts of Kerala. Kurup and Samuel (1985) and Pauly (1991) described the design and operation of *karimeen vala* in Vembanad lake. It is made of PA multifilament with a mesh size varying from 50-80 mm. Pauly (1991) reported that the mesh size of this net varies from 40-90 mm. Other details of the net are given in Table 11.

Usually one or two fishermen operate the net using a canoe. This fish is seen associated with submerged rocks, wooden structures or among the decomposing vegetation adjacent to the shore, which is partially submerged. The fishermen encircle such area with the net and make the fish to come out of the hiding place by disturbing the objects or splashing water. This fish generally get entangled in the net while trying to escape. In shallow waters the fishermen are able to see the entangled fish in the net. In slightly deeper waters they search for the fish in the net with their feet or hands and immediately capture the fish. *Lutjanus argentimaculatus* are also captured in the net. Bottom set gill nets are also operated for *Sillago sihama*, *Gerres* spp, catfish, sciaenids, carangids, clupeids, flat fishes, polynemids, murrels and carps.

3.2.2.6. Trammel net

A net whose inner fine-meshed layer is carried by the fish through the coarse-meshed outer layer, and encloses it in a pocket is known as trammel net. It is a multiwalled gill net with inner core netting usually of smaller mesh size which is boarded on each side by tightly hung walls of large open meshes. The outer walls are always with less hung depth whereas the hung depths of inner walls are more. This arrangement facilitates the formation of pockets by the force exerted by the encountered fish (Vijayan *et al.*, 1993). The fish becomes trapped in the resulting pockets that are formed. The outer meshes on one side of the net must be a mirror image of the outer meshes on the opposite side (Thomas, 2001). Trammel nets are

generally operated in sea for capturing prawns. Use of trammel nets in rivers of Kerala and Tamil Nadu has been reported by Kurian and Sebastian (1986).

A few trammel nets, locally known as *saarivala,* are found in operation in Valapatanam river for fish. Outer layer of this net is made of either PA monofilament of 0.4 mm dia or multifilament (210Dx1x3, 210Dx2x3) with mesh size ranging from 145-280 mm. Middle layer is also made of PA monofilament with 0.20 or 0.23 mm dia. or PA multifilament (210Dx1x3) with 50-70 mm mesh size. According to Kurup *et al.,* (1993) *disco vala* is a trammel net for prawn, in Korapuzha estuary, made of PA monofilament with 20 to 25 mm mesh size inner netting and 125 mm mesh size for the outer netting. Operation of *disco net,* trammel net with 40 mm inner mesh size and 127-152 mm mesh size for the outer walls in the brackish water areas for prawns in Sri Lanka has been reported by Anon (1995). Hanging coefficient of the outer layer ranges from 0.5 to 0.64 and that of inner between 0.3 and 0.4. This net is operated as surface set or drift net for catching mullets, sea bass, sciaenids, polynemids, carangids, lutjanids and megalops mainly during monsoon and post monsoon season.

3.2.2.7. Gill nets of migrant fishermen

The migrant fisher folk from Karnataka are operating gill nets in almost all inland waters of Kerala. They operate bottom set gill nets made of PA monofilament of size 0.16-0.25 dia. with 30-90 mm mesh size. Length of the net varies from 40-100 m. Mounted depth usually ranges from 1.5 –2.5m with a hanging coefficient of 0.3-0.6. Most of them use reed having 50-60 mm lengths as floats. Spherical or spindle shaped bunt clay sinkers each weighing 30-60 g are used in the foot rope. Other details are given in Table 12.

Operation

The net is operated from wooden canoes of size ranging from 3 to 6 m. A few fishermen use wooden canoes coated with fiberglass. Gill nets are operated throughout the length of the river, with more concentration in the lower reaches. It is operated during day and night throughout the season. During the onset of high tide

fishes start moving in shoals in upstream areas. Gill net is usually operated as drift or set either in the surface or at the bottom, depending on the season, by one or two fishermen. Depending on the season and catch it is also operated as encircling net as reported by George (1971). Set net is mostly operated during the interface between tides and it is hauled back within 15 to 30 minutes. Otherwise they attach heavy stones at bottom corners of the net to prevent drifting. All types of gill nets are having one or two large floats *viz.* thermocole or plastic cans attached on either end of the net to locate the same. Bottom set gill nets are anchored to the ground using two stones, weighing approximately 5 kg each, attached to the bottom corners of the net. Fishermen often keep surface and bottom gill nets in their canoes and depending on the resource availability and area they select the net.

Surface set net in Kuppam river is often set in the form of an arc with both ends coiled inside. According to fishermen, 50-60% of the catch is obtained from the coiled end. The central part of the net might be acting as leader wall to drive the fish into the coiled ends and gilled there. Anon (1960) reported that both ends of the set net operated in estuaries in Japan is turned round at the place 200 to 400 m from the shore, so as to prevent the enclosed fish from escaping.

In Kuttiadi reservoir, gill nets are set by tying the HR of the net to branches of trees adjacent to the area. Faruqui and Sahi (1943) reported that some times gill nets are fixed across the two banks with the help of bamboo poles.

The migrant fishermen from Karnataka operate the net from coracle. Ladies and children also assist the male members of their family in fishing. Net is operated as bottom set and is set in a zig-zag fashion. Net is hauled back within 30 minutes to one hour. While hauling the net, the upper edge is threaded upon a short pointed stick carried for this purpose as reported by Hornell (1924). Fishes like mullets, silver biddies, whiting, sciaenids, carangids, pearl spot, crab, etc. are usually caught.

There are minor variations in the construction and operation of gill nets from place to place due to the difference in topography of the area, current, depth of water, target species and mode of operation. Monofilament gill net is very efficient

but the problem is that it does not last for more than few months. Nobody is interested in mending the damaged net, as it is very tedious and time consuming.

Weekly landings from a gill net units operating in Kavvayi river has been collected from April 2003 to April 2005. Mesh size of the gill nets operated varies from 20 mm 160 mm. The frequency of operation of gill nets by the selected fisherman and the catch contribution by different gill net is given in Fig.22. It is evident from the figure, that most of the time they operate prawn gill nets. The gill net with 20 mm mesh size is highly selective as the main catch from this net is *M. dobsoni*. Similarly, net with 30 and 40 mm mesh size landed only fish. Net with more than 100 mm mesh size is exclusively operated to catch *Scylla serrata*. Total landings during the period was 392 kg expending 308 h. Average catch/day was 5.1 kg and the average income per day was Rs 251/- per fisherman.

According to some fishermen returns are better during summer season as they get white prawns in bottom drift gill nets. During peak period income per head increases upto Rs. 400/- per day. During monsoon they get better price for their catch, when the marine fish availability in the local markets becomes less.

Table 9. Details of major types of gill nets operated in inland waters of North Kerala

District/River	Local name of the net	Type of operation	Material	Length of net (m)	Mesh size (mm)	Material size (mm)	Mesh in depth (No)	Hanging coefficient	Mounted height(m)	Target species
Kasargod										
Manjeswaram	*Nandevala*	Bottom set	PA mono-filament	100 - 200	100-160	0.32	30 - 35	0.5 - 0.7	4.00**	*Scylla serrata*
Chandragiri										
Kariangode	*Thiruthavala*	Surface drift	-do-	150-300	75-100	0.23-0.28	50	0.4 - 0.6	4.00**	*Mugil cephalus*
Chithari										
Mogral	*Chemmeen vala*	Bottom drift	-do-	130-150	28-32	0.16	100	0.5	2.80	*M.monoceros*
Bekkal										*F.indicus*
Kumbala	*Maalanvala*	Surface drift	-do-	100-150	35-40	0.16-0.20	100	0.5	3.50	*Liza* spp., *Valamugil* sp.
Shiriya										*Mugil cephalus*
Muttampozhi										
Kannur	*Nandevala*	Bottom set	-do-	90-100	100-150	0.32 & 0.34	25	0.7	3.00	*Scylla serrata*
Tallicherry	*Thiruthavala*	Surface drift	-do-	80-160	80-115	0.23 -0.32	35 - 42	0.45-0.7	3.40**	*Mugil cephalus*
Valapatanam			PA mul.							
Kavvayi	*Maalanvala*	Surface drift	PA mono.	50-150	25-40	0.16 & 0.20	100 & 150	0.4-0.7	4.30**	*Liza* spp., *Valamugil* sp.
Kuppam										*Mugil cephalus*
Perumba	*Chemmeen vala*	Bottom drift/set	-do-	60-225	12-40	0.16	100-200	0.5-0.6	6.40**	*F.indicus, P.monodon*
Mahe										*M.monoceros, M.dobsoni*
Kuttikol	*Nongolvala/*	-do-	-do-	50-200	50-80	0.16-0.30	30-100	0.4-0.5	7.00	*Sillago sihama*
Ancharakandy	*Ettavala*									*Catfish, Cynoglossus* spp.
										Etroplus suratensis
										Eleutheronema tetradactylum
Kozhikode	*Nandevala*	Bottom set	-do-	100-150	90-160	0.32	9-25	0.3-0.7	3.00**	*Scylla serrata*
Kuttiyadi/	*Thiruthavala*	Surface drift	-do-	100-150	70-110	0.28-0.32	40-50	0.4-0.5	5.00**	*Mugil cephalus*
Korapuzha										
Chaliyar	*Maalanvala*	Surface drift	-do-	100-200	50-60	0.16-0.23	40-150	0.5	8.00	*Liza* spp., *Valamugil* sp.
Kadalundi										*Mugil cephalus*
	Chemmeen vala	Bottom drift/set	-do-	90-625	24-45	0.16	25-200	0.5-0.74	6.10**	*F.indicus, P.monodon*
										M.monoceros, M.dobsoni
	Ganessevala/	Bottom	-do-	100-750*	60-70	0.20&0.23	20-50	0.3-0.5	3.00**	*Sillago sihama*
	Thandadivala	Column set	-do-	40-100	155	0.32	14-18	0.5	2.40	*Labeio rohita, Cirrhinus mrigala*
	Thandadivala	Column set	-do-	50-100	70	0.20 &0.23	100	0.7	5.00	*Oreochromis mossambicus*
	Kandadivala	drift/set	PA mul	50-100	200	210Dx1x2& 210Dx2x3	20-30	0.5-0.6	5.20	*Catla catla*

*net is operated in sea also

**largest mesh size and highest hanging ratio is taken for calculation

Table 10. Technical specifications of surface drift gill nets in the region

Local name	***Thiruthavala***	***Maalanvala***	***Bameenvala***	***Ozhukuvala***	***Veloorivala***
Place/River	All places	All places	Dharmadam	All places	Valapatanam
Material	PA mono	PA mono	PA mono	PA mono	PA multi
Mesh size (mm)	70-115	25-50	80	40-75	30
Twine size	0.20-0.32	0.16	0.28	0.16-0.23	210D/1/2
Length/unit (m)	100-200	40-100	120	100-200	150
Depth/uint (m)	2.5-4	1.5-3	7.5	2.5-3	3
Hang.coeffi.(E)	0.4-0.7	0.58-0.7	0.5	0.5	0.4
Selvedge	PA multi	PA multi	PA multi	PA multi	PA multi
Mesh size (mm)	75-110	25-40	80	65	30
Twine size	210D/1/3, 210D/ 2/3	210D/1/3, 210D/2/2	210D/2/3	210D/2/2	210D/1/2 (double)
Meshes in depth (Nos)	1	1	1	1	1
Head Rope	PP	PP	PP	PP, PE braided	PP
Diameter (mm)	2-4	2	5	2	2- 3
Foot rope	PP twisted/ braided	PP	PP	PP, *Chana*	PP
Diameter (mm)	3	3-4	5	2	2- 3
Floats	PVC/ Plastic	PVC/ Plastic/ thermocole	Plastic	PVC	PVC
Size (mm)	50-90x20	40-60x20	80	55x15	40x15
Shape	Disc	Spherical, disc	Spherical	Disc	Disc
Floats/unit (Nos)	65-150	30-95	80	11-133	120
Dist.betw.floats (m)	1.5-2.5	1-1.5	1.5	1.5-9	1.25
Sinkers	Lead	Burnt clay, lead	Lead	Lead	Lead
Size (mm)	30-70	30-40	40-50	45x15	40-50
Weight (g)	20-30	30-40	30	30	50-60
Sinkers/unit (Nos)	64-265	95-200	200-210D	105-130	120
Dist.bet.sinkers (m)	0.75-2.5	0.3-0.5	0.3-0.5	1.5	1.25
Target species	Big *Mugil cephalus*	Mullet	Polynemids	Mullet, Carangids, Pearl spot, Catfish	Ambassids

Table 11. Technical specifications of bottom set and drift gill nets

Local name	*Meenvala/ Adivala/ Athalvala*	*Nanduvala*	*Thellyvala*	*Chemeenvala*	*Mukkuvala*	*Chemeenvala*
Place of operation	All places	All places	Kattampally, Kavvayi	All places	All places	All places
Type	Bottom set	Bottom set	Bottom set/drift	Bottom set	Bottom set	Bottom drift
Material	PA mono	PA mono	PA mono	PA mono	PA multi or PA mono	PA mono
Mesh size (mm)	40-60	90-160	12-20	32-50	45-80	30-45
Twine size	0.16-0.2	0.28-0.32	0.16	0.16	0.20, 0.23	0.16
Length/unit (m)	50-200	90-350	90.00	90-150	50-90	50-225
Hung depth (m)	1.3-2	1.75-3	2.40	2.6-5.5	4-6	3-4
Hanging coeffi. (E)	0.4-0.66	0.3-0.7	0.4-0.6	0.5-0.6	0.5	0.4-0.6
Selvedge	PA multi	PA multi	PA multi	PA multi	PA multi	PA multi
Mesh size (mm)	40-50	110-150	12-20	32-40	45-80	30-40
Twine size	210D/1/3	210D/2/3	210D/I/3 or 0.25	210D/2/3	210D/2/3	
Meshes in depth (Nos)	1	1	1	1	1	1
Head Rope	PA, PP	PP	PP	PA braided	PP	PP
Diameter (mm)	2-3	2-3	1.5-3	2-3	3	2-3
Foot rope	PP braided, old PA multi netting*	PP	PP	PP	PP	PP
Diameter (mm)	2, 8-10*	3	2-3	2-3	3	2-3
Floats	PVC, Plastic	Thermocole, PVC	PVC	PVC	PVC	PVC, Plastic
Size (mm)	40-80x20	50-150x20	55x20	30-60x20	35-40x20	35-40x21
Shape	Spherical, disc	Disc	Disc	Disc	Disc	Disc
Floats/unit (Nos)	33-65	15-18	24-30	90-160	30-35	20-30
Dist.betw.floats (m)	3-6	5-12	1.7-3	0.9-1.7	3-4	1-10
Sinkers	Lead, Concrete	Concrete, Lead	Lead	Lead	Lead	Lead
Size (mm)	3-10	10	15-25	40-70	60x10	40-50
Shape	Rectangular, disc	Disc	Rectangular	Rectangular	Rectangular	Rectangular/ spherical
Weight(g)	30-Oct	40-350	30	30-40	20-25	15-40
Sinkers/unit (Nos)	40-330	60-400	40-60	130-200	100-128	100-150
Dist.bet.sinkers (m)	0.18-3.5	1-4.5	0.40-0.50	0.5-0.9	0.5-0.7	0.3-2.7
Target species	All fishes	Mud crab	*M.dobsoni*	White prawn	Pearl spot, catfish,mullet, flat fish, Carangids, whiting,	White prawn

Table 12. Details of gill nets operated by fishermen from Karnataka

Type of operation	Material	Twine size(mm)	Length (m)	Mesh size (mm)	No. meshes in depth	Hanging coefficient	Type of Float	Type of sinker	Target spp.
Bottom set	Nylon mono-filamet	0.16-0.23	50 - 100	55-70	14	0.4 - 0.6	reed	lead/ burnt clay	Small fish & crab
Bottom set	-do-	0.16-0.20	50 - 80	30-40	26	0.5-0.6	reed	-do-	Prawn and small fishes
Bottom set	-do-	0.20-0.23	50-100	40-60	17	0.3-0.4	reed	burnt clay	small fishes
Encircling/ bottom set	-do-	0.16-0.23	80-100	70-80	16	0.4-0.5	reed	burnt clay	*Etroplus* sp, *Gerres* sp, etc.
Bottom set	-do-	0.20-0.25	80-100	60-90	30	0.4-0.5	PVC	lead	Catfish, Scianeids, *Gerres* sp, Sand-whiting, *Etroplus* sp Crab

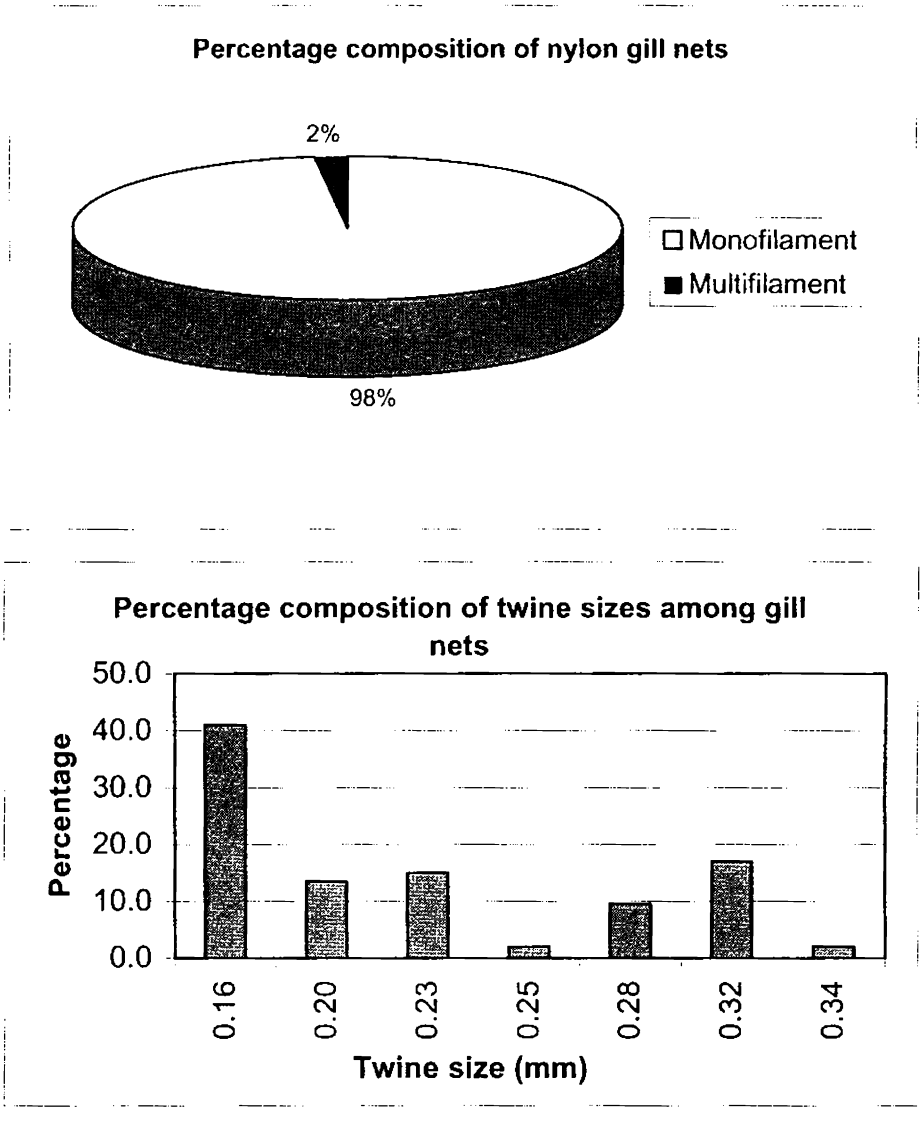


Fig. 15 Percentage composition of different types of nylon gill nets

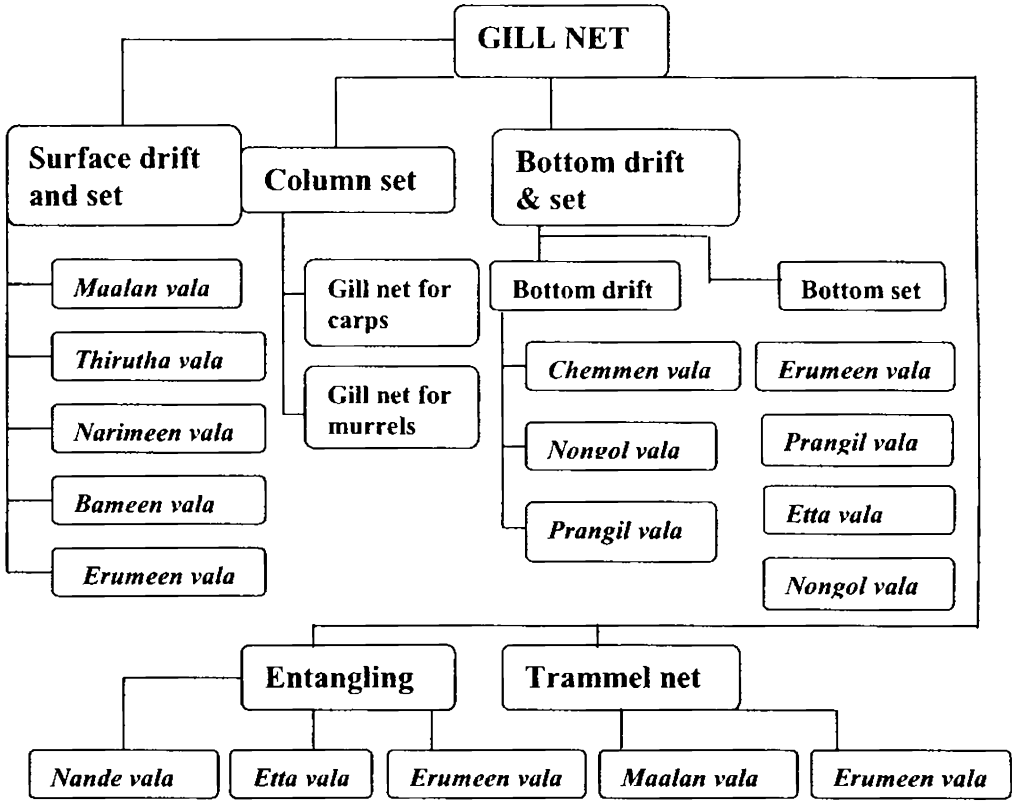


Fig. 16 Classification of major types of gill nets operated in North Kerala

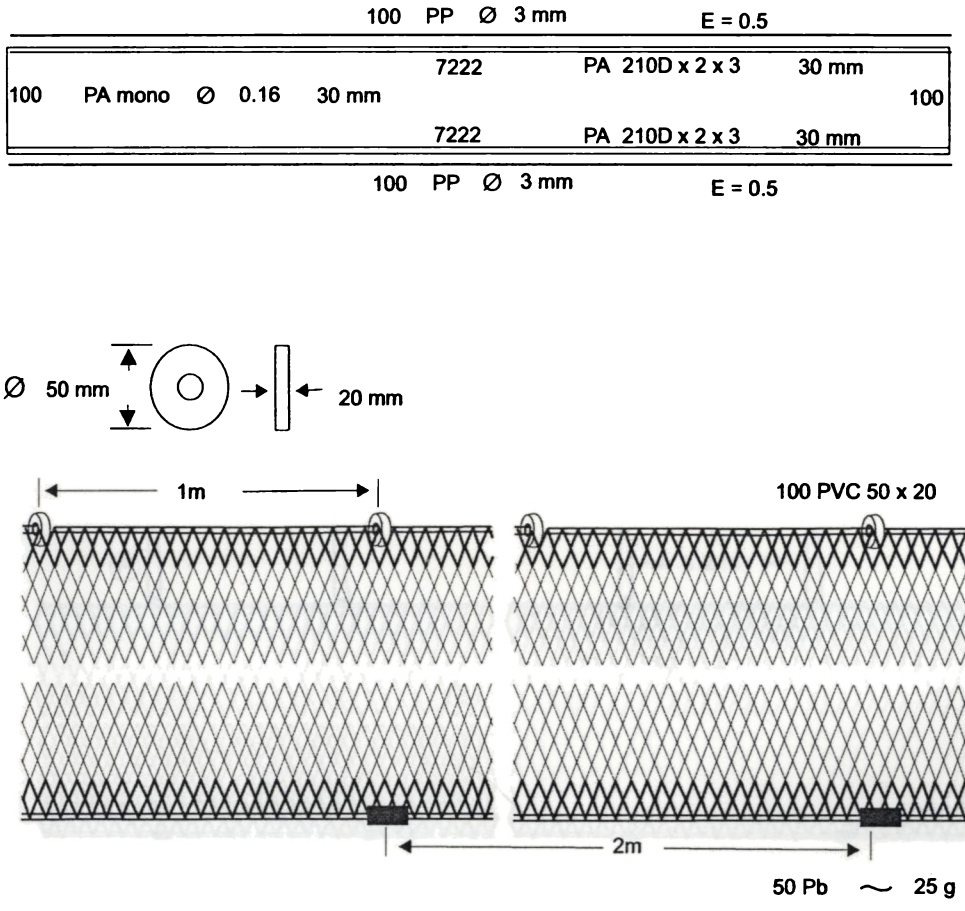


Fig. 17 Design details of a PA monofilament gill net for mullets

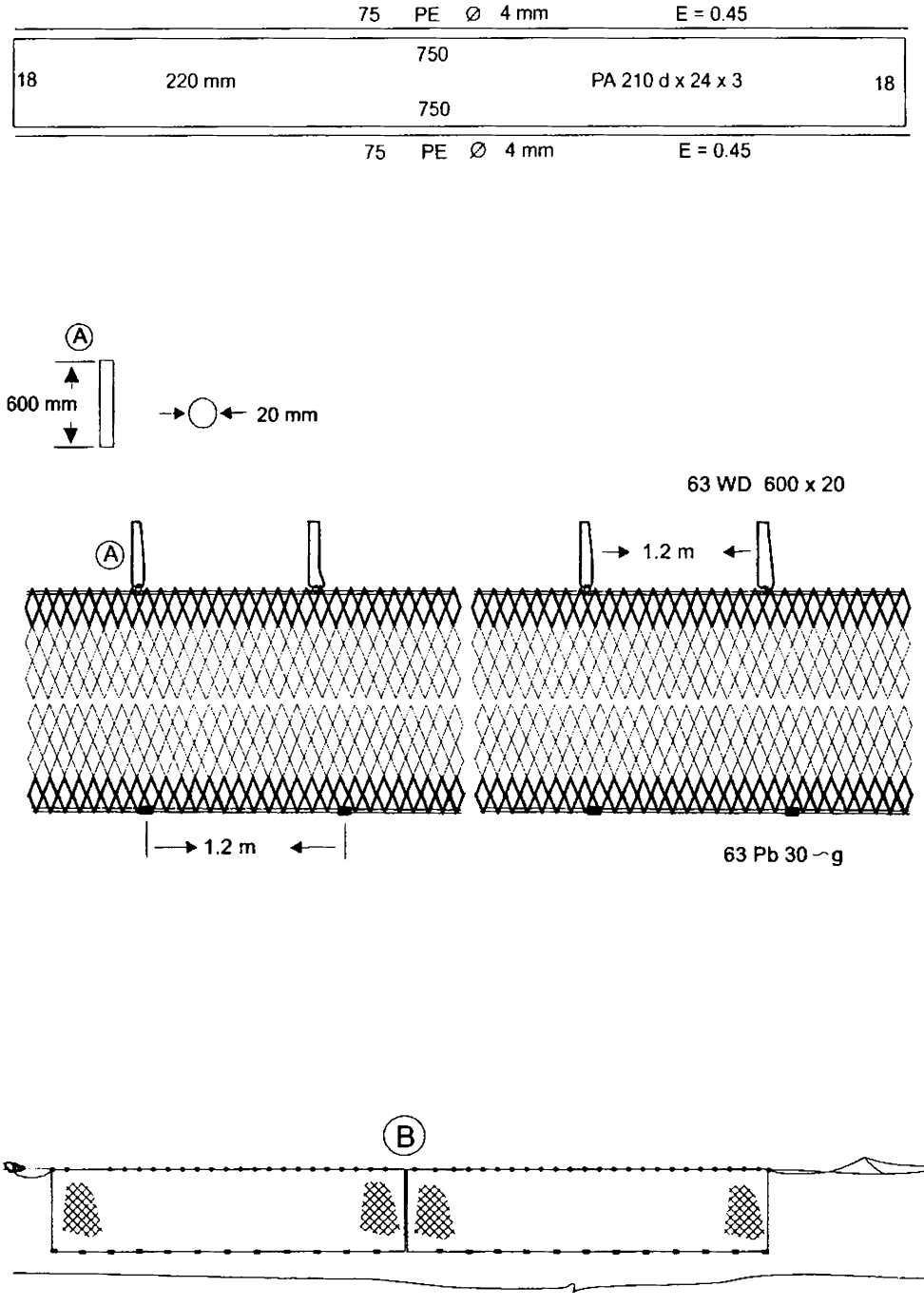


Fig. 18 Design details of *Lates calcarifer* gill net in Chaliyar river

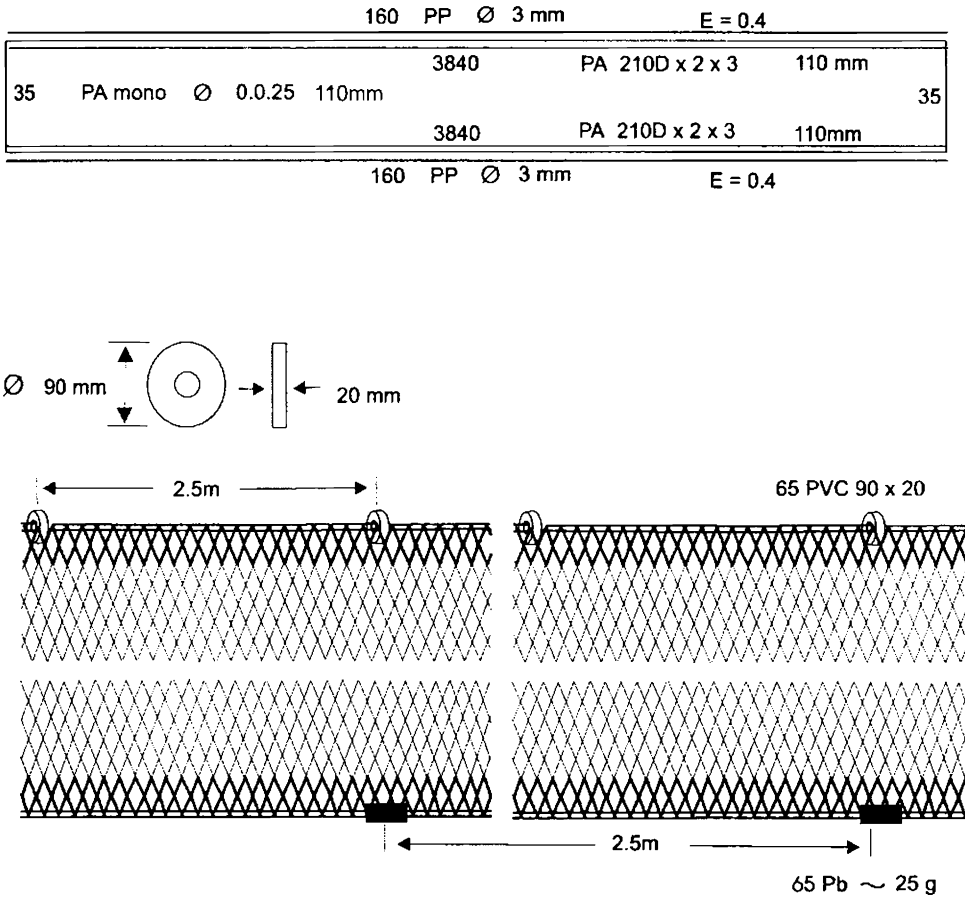


Fig. 19 Design details of gill nets for *Mugil cephalus*

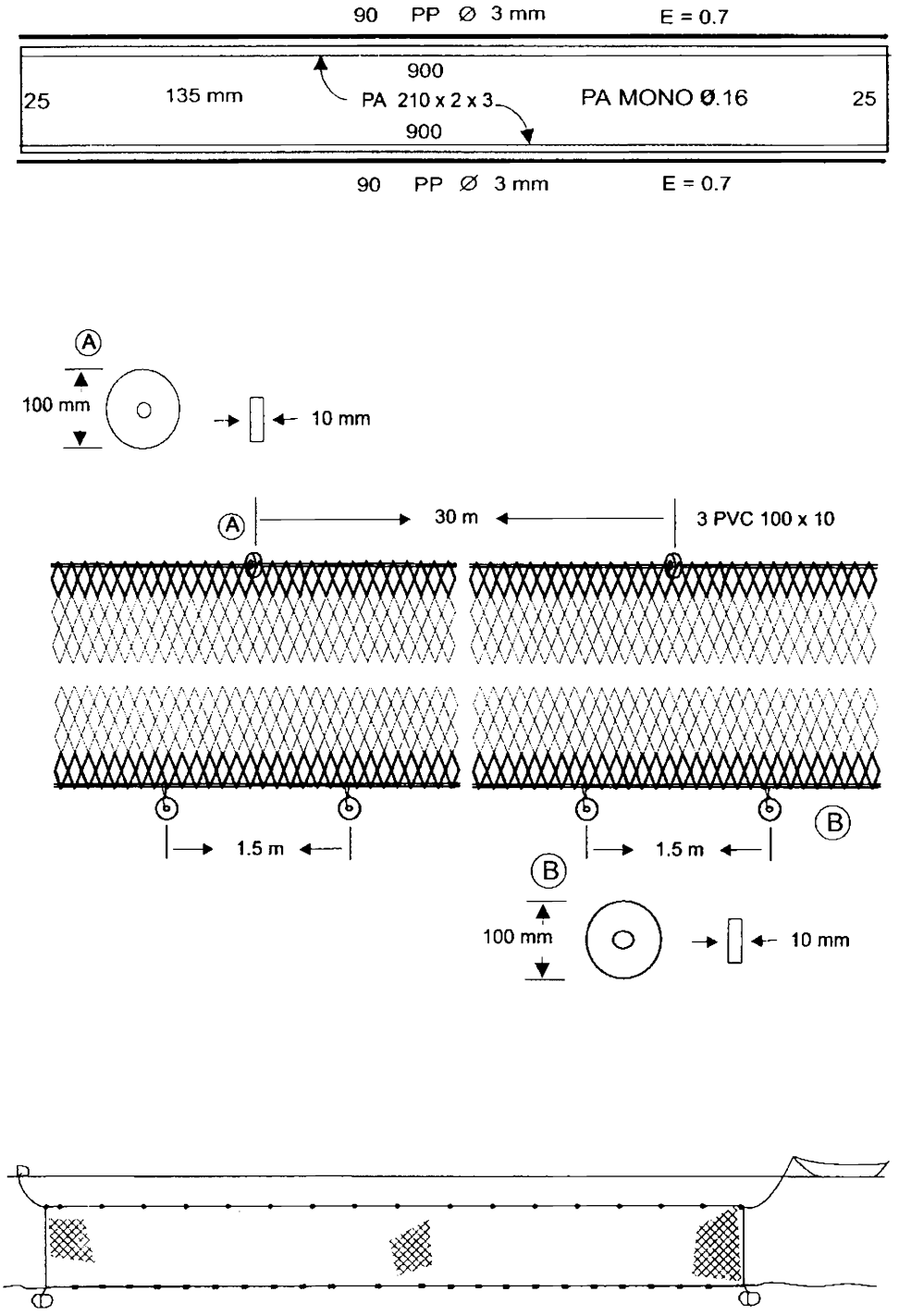


Fig. 20 Design details of Scylla serrata gill net operated in Tellicherry river

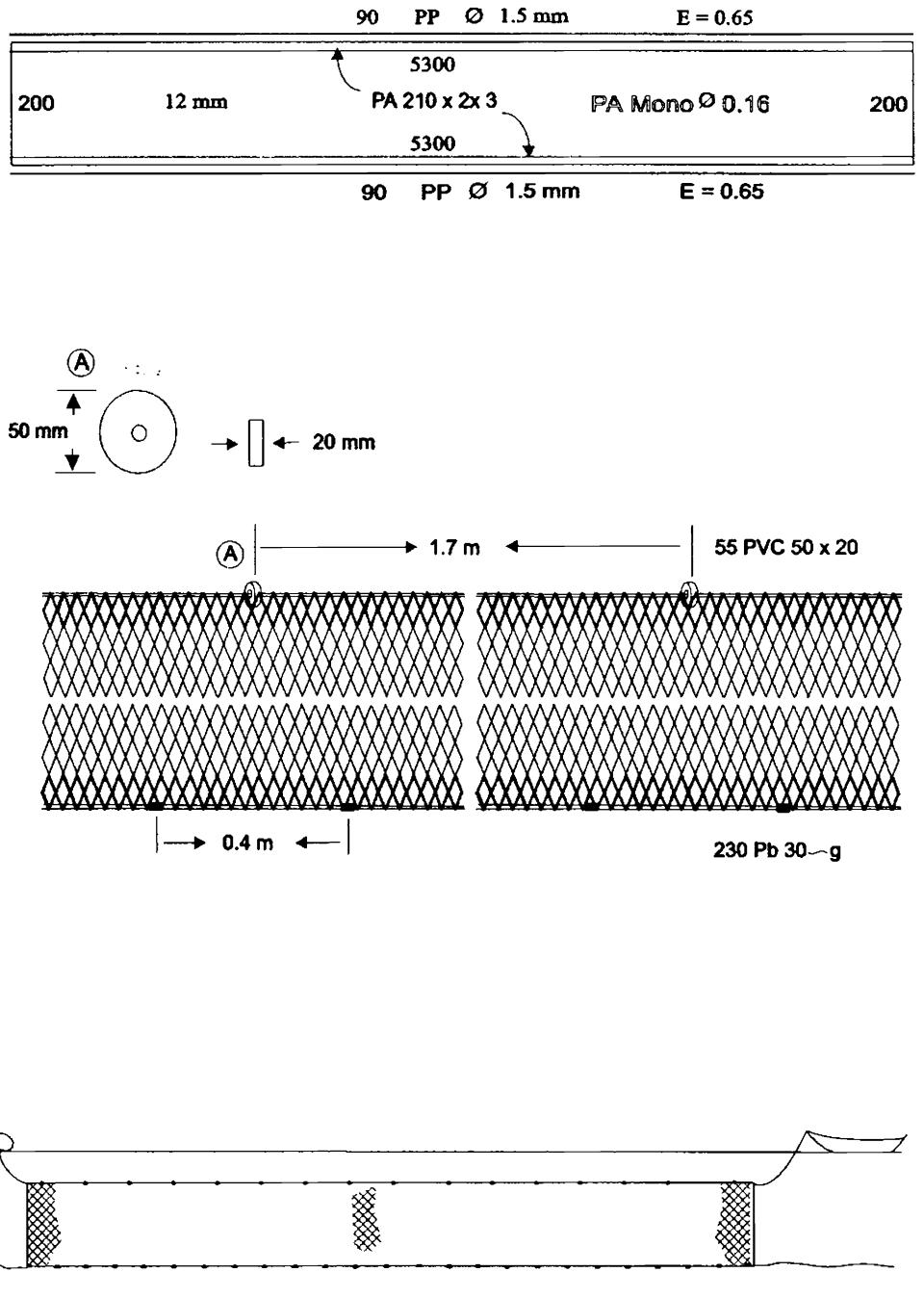
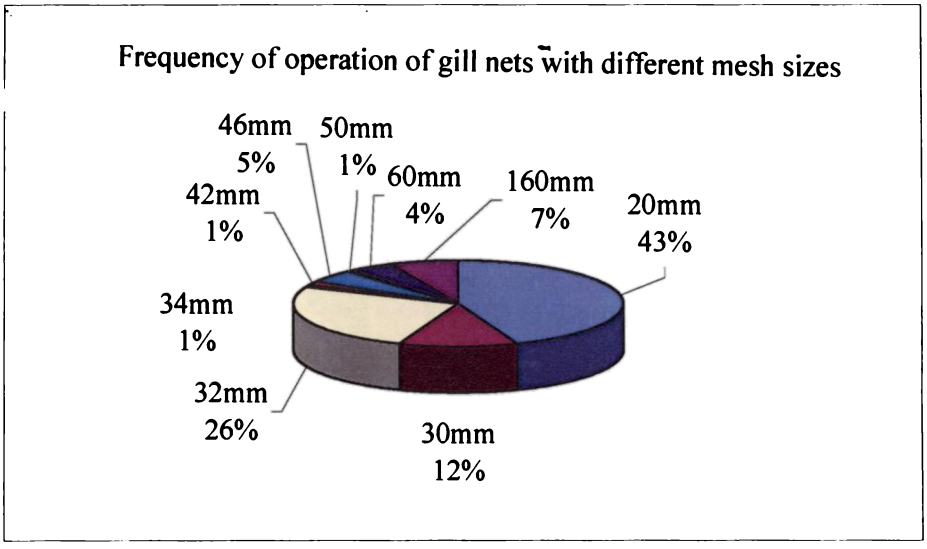


Fig. 21 Design details of *M. dobsoni* gill net in Valapatnam river



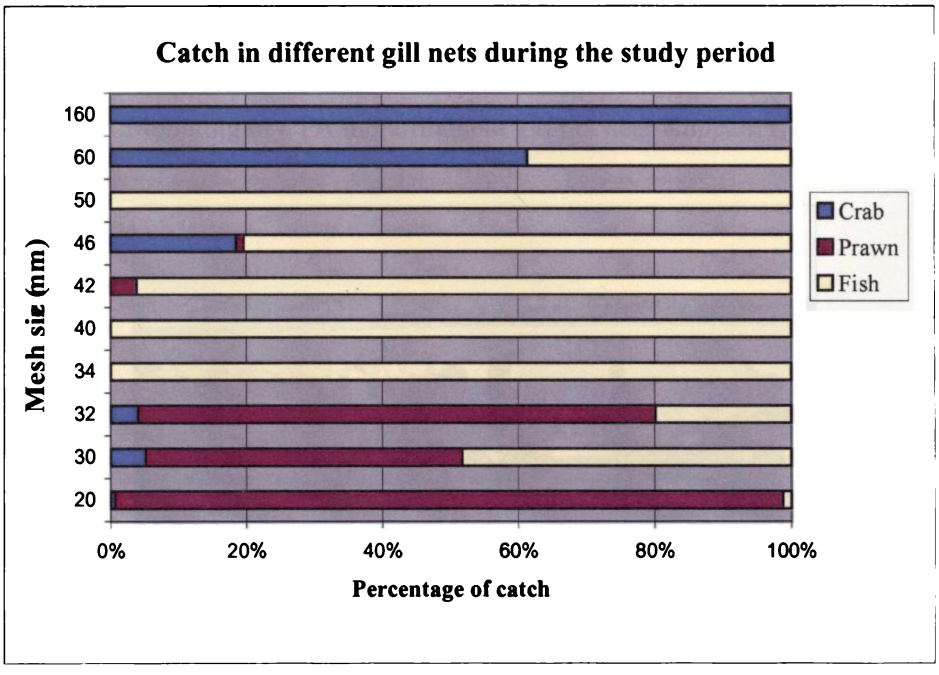


Fig. 22 Freqency of operation and catch details in different gill nets

Mounting of a PA monofilament gill net near Kuppam river

Plate 5. Fabrication and operation of PA monofilament gill nets

3.2.3. Traps

Traps are impounding devices into which an organism is lured and from which escape is made difficult because of the non-return device fixed at the entrance. According to Job and Pantulu (1953) traps being fixed engines do not require continuity of attention and vigilance on the part of the operator but can be left to function themselves and secure a catch while the owner is engaged in other occupation. Trapping was probably the earliest method that man ever resorted for fish catching. They are highly fuel efficient both in terms of returns and biomass per unit of fuel consumed (Willimovski and Alverson, 1971). Mohan Rajan (1993) reported that trap fisheries have economic and energy related advantages over active search and capture fisheries. Nair (1993) mentioned that they require modest investment and due to their simplicity, efficiency and the quality of catch obtained, this method is widely used in all water bodies. Moreover most of the traps retain the fish caught in live or in good condition for long time. Being an eco-friendly fishing method, fish traps are operated in inland and marine waters through out the country. The artisanal fishermen in inland waters operate primitive types of traps whereas the sea fishermen operate the most modern traps from mechanized boats. Mechanical traps are wickerwork cages with trap doors which are tripped when a fish enters. They work on identical principles, similar to that of land traps, they have the great advantage that the fish cannot escape, yet is protected from predators (Hickling, 1961). Traps are used to catch fishes, crustaceans and molluscs.

In some traditional traps the fish is made to enter voluntarily into a trap and the escape is prevented by arranging twigs inside the trap. Baits are not always required to lure the fish as some fishes voluntarily enter into the trap. Nair (1993) reported that at present traps are made using plastics, having separate parts, which can be assembled and dismantled easily.

Diverse types of traps are in operation in the inland water bodies of India. Traps of Hooghly-Matla estuarine system in West Bengal has been reported by Hornell (1924); De (1987) and Mitra *et al.*, (1987). Fishing gears of Chilka lake including traps are described by Devasundaram (1951) and Roy and Banerjee

(1980). Job and Pantulu (1953) reported fish traps of India. The *thatta-khonda*, a screen trap of the Chilka lake is given by Mohapatra (1955). Saxena (1964, 1988 and1993) listed fish traps operated in the middle stretch Ganga river. Fish traps of the east and west coast of India is reported by Ramamurthy and Muthu (1969). George (1971) has given an account of fish traps operated in the inland waters of India. Sehgal *et al.*, (1971) mentioned few fish traps while describing the fisheries of Kangra valley and adjacent areas in Punjab. Day (1873) reported the fish traps in Bengal. Fish traps in Kangra and Hamirpur districts of Himachal Pradesh is reported by Tandon and Sharma (1984). Traps operated for the capture of prawns in India is reported by Kurian and Sebastian (1986). Kulshreshtha (1986) mentioned about traps and barriers while describing the traditional fishing methods of Rajasthan. Fish trapping devices and methods of Southern India has been described by Mohan Rajan (1993) and from North Eastern India by Sharma *et al.*, (1993). Traps from the Khachodhara beel in Assam is given by Sharma and Ahamed (1998).

Traps made of twigs and palmyra leaf and bamboo splinters are operated in Tamil Nadu, Kerala, Lakshadweep and Andaman. Details of various traps operated in Malabar coast are given by Hornell (1938). Kurup and Samuel (1985) and Kurup *et al.*, (1993) described the indigenous fish traps of Vembanad lake. Different types of traps are in operation in the rivers, backwaters and reservoirs of north Kerala and several fishermen are depending on this fishing method for their lively hood.

3.2.3.1. Results and Discussion

Traps are mainly operated in rivers and backwaters with more concentrations in the middle and upper stretches where the operation of other fishing gears like gill nets and seines is difficult. Traps are popular in Kannur and Kozhikode districts but it is rarely seen in Kasargod district. Fishermen operating other kind of gears also operate fish traps for an additional income. People living near the river or backwaters operate fish traps for catching fish for their own use. In this case often they purchase the trap from fishermen who regularly make and operate the traps. Traps are not seen in operation in the reservoirs covered under the study, except the

aerial traps operated in Pazhassi Reservoir, near the shutters, during monsoon. Details of all kinds of traps operated in north Kerala is given below.

3.2.3.2. Plunge basket

Different types of traps operated in North Kerala is given in Plate 6. Cover pots or plunge baskets, popularly known as *ottal or kuthu koodu,* is a conical trap open at both ends. Common size of plunge basket operated in Kerala varies from 50-70 cm height, 40-50 cm width at the lower end and about 15 cm at the top. It is constructed with closely set ribs made of sticks or bamboo splinters of about 10 mm width. To keep the ribs in position the trap is hooped at 3-4 places with split cane or other similar materials. The free ends of the splinters at the wide mouth are usually sharpened, so that the device could be pushed down and fixed temporarily in mud (Job and Pantulu, 1953). The sides of the narrow opening at the top is covered with old cotton cloth and stitched with cotton or other soft material to prevent the hand being hurt while handling and operation.

The *ottal* is operated in Kannur and Kasargod district to catch fish from knee-deep waters like inundated paddy fields, backwaters and other small water bodies where the bottom is soft. Fishermen plunge the basket almost every one meter intervals and press it to fix the projecting ribs into the bottom to prevent the escapement of fish. Then one hand is put inside through the opening at the top to search and catch the trapped fish. Fishermen puts this basket quickly on slow moving fish and pulls it out of the upper opening (Faruqui and Sahai, 1943). *Ottal* is very useful in weed infested waters where the operation of other gears is almost impossible. Immediately after the onset of monsoon fishes like *Channa* spp. and *Clarius* sp. migrate into the adjacent paddy fields and canals for breeding and such fishes can be easily caught using plunge basket. Some times a group of fishermen stand in a line across the channel and operate the traps from one end to other end to drive the fish in shallow areas. In shallow waters fishermen operate the basket during night with the help of a torch light. Plunge baskets are also operated with scare lines in Kozhikode district to capture pearl spot, silver biddies and other estuarine fishes. Job and Pantulu (1953) reported that in certain parts of South

Kanara district the cover basket is often used in conjunction with the scare line. Operation of *ottal* in some parts of India is reported by other workers like John (1936), Lal (1969), Kurian and Sebastian (1986) and Mohan Rajan (1993). Hickling (1961) reported the operation of conical wicker basket with a hole in the top by ladies in Sudan. *Polui* is a plunge basket operated in the Rarh region in West Bengal (Sen, 1972). *Ottal* operation for catching *Macrobrachium rosenbergii* in backwaters of Kerala is reported by Raman (1975). Anon (1995) reported that due to the introduction of other effective gears the use of the cover pot has been reduced greatly.

3.2.3.3. Box trap

Fish traps is defined as cages made of split bamboo or wire in which the fishes usually enters through a small opening with or without any bait (Lal, 1969). Box traps having "D"shape in cross section is known as *Chempally koode* in north Kerala, because major share of the catch is constituted by *Lutjanus argentimaculatus,* locally known as *chempally.* Box traps are very common in the upper reaches of Kuppam, Valapatanam and Peruvamba river in Kannur (Plate 4). It is also seen in the upper reaches of Kariangode, Chandragiri and Mogral rivers in Kasargod district where as these types of traps are not seen in Kozhikode district. It is made of split bamboo or areca nut tree with an approximate dimension of 1.4 x 0.6 x 0.6 m. The bottom piece is rectangular in shape and is fabricated using 10-15 strips having 1.4 m length and 30-35 pieces of 0.6 m length kept perpendicular to the first set. The strips are joined together using 3-4 mm dia coir twines. The curved roof portion of the trap is constructed using about 30-35 strips having 1.4 m length held together using coir. There are two funnel shaped valve fitted on either end of the trap. The non-returnable valves are constructed using 15-18 number areca nut tree splinters each having 0.35-0.4 m length. One end of each piece is cylindrical in shape having 2-2.5 cm in dia. and the thickness gradually reduce to a sharp point in the other end. According to Hickling (1961) the sharpened splinters at the hole may project into the trap in such a way that a fish in the trap will tend to jab itself against these sharp inwardly projecting point. Jones and Sujansingani (1952) stated that the opening of the box trap for crab is secured by means of a *Chevaux de fries* of

bamboo splinters, which project inside the trap and form a V-shaped wedge. The entrance funnel is about 30- 35 cm long having 25-30 cm dia. in the upper side. The lower side of the funnel is oval in shape and is about 20 – 22 cm long and about 15 cm wide in the middle, just enough for a big fish to enter inside. The lower part of the funnel opens at about 45° angle and the distance between the lower opening and the base of the trap is kept minimum to reduce the chance of a trapped fish escaping through the funnel by swimming back. Fixing the entrance funnel is the most crucial thing in any type of trap since any defect in the alignment will reduce fish catch. There is an openable lid at one side, towards the base of the trap to take out the trapped fish. The operation of *Konkra-kharia*, a box trap mad of bamboo splinters, in Chilka lake for *Scylla serrata* is reported by Jones and Sujansingani (1952) and Roy and Banerjee (1980). The details of cost of fabrication of a box trap from Kuppam river is given in Table. 13.

Operation

These traps are usually operated in rivers through out the season except during June- July, when the current is strong. However in some places it is operated during August to December, when almost fresh water condition exists in the upper regions of the rivers. This is because during summer season when the salinity of the water increases the degradation of the materials is very fast. More over the settlement of organisms are also on the higher side during summer. It is operated in the middle and upper reaches of the river where other types fishing methods are not viable. Two fishermen using a canoe operate the trap during night to keep the location of the trap secret. No baits are required for the traps and the fishes seeking shelter under submerged objects becomes the prey. Two stones weighing about 5 kg each are attached on either side of the trap to prevent it from drifting. One end of a piece of rope having 5-6 m length is tied to the trap and to the other end a small stone is attached. Traps are set in 4- 10 m and while putting the trap the attached line stretched to its full length to facilitate retrieving. Hauling is also carried out at night, every alternate day. Grappling hook (an iron piece having 3 hooks) locally known as *chempally koka* or *Kollai* (Plate 7) attached to one end of a 10-15 m PP rope is used to retrieve the trap. On reaching the area of the trap fishermen release the line in the

water to hook the rope connected to the trap. As the canoe moves up and down the hook is also being dragged along the bottom. Once the line is hooked it is hauled back and the trap is taken onboard. Catch is taken out through the window provided in the lower corner. *Etroplus suratensis, Scylla serrata* and *Epinephelus* sp. are the other components of the catch. After removing the catch the trap is again set in another place.

Very few people are fabricating the trap and other fishermen purchase traps from those people. Traps are sold @ Rs.1000-1500/piece. Service life of the trap is approximately one year in case of continuous operation. If it is operated only during monsoon, it may remain up to 3 years.

3.2.3.4. Filter traps

Filter trap, locally known as *padal* in Kannur, is a cylindrical device made of midrib slivers (*irkal*) of the coconut palm leaves or bamboo splinters. Various workers used different names for this trap like *kannillatha kuruthi,* cone cage or simple cone cage. It is about 0.6 m in length with a circular mouth of about 0.4 m dia. at one end and other end of the slivers are bunched and tied so as to close it. Few bamboo or creeper stem hoops are fixed inside the trap to give a cylindrical shape (Plate 5). To prevent the slivers from opening 6-7 encircling lacings using coir are also given. Some fishermen make a carrying handle on one side of the trap using a piece of coir rope. Hornell (1938) reported the operation of filter traps in the backwaters of Kerala.

Operation

When contour of the land permits a bunded area to be emptied at will by draining the water through small openings, it facilitates the placing of filter traps in these miniature sluices (Mohan Rajan, 1993). Filter traps are set against the receding current in shallow rivulets and *pokkali* fields. Job and Pantulu (1953) reported that these traps are set where the current is rapid as in openings made in bunds or at inlet and outlet passages in inundated paddy fields. Sen (1972) reported that *pata,* a kind of filter trap in West Bengal, is set at a place where the flowing water gets a fall to a

lower depth in such a way that the water can pass through the mat and all the fish get strained and slide along the slope of the mat to the pouch. Some times the fishermen make small bunds in a V form using mud, boulders and vegetations to block the water and the entire flow is diverted through an opening made at the bottom of V in which the trap is set. Along with current fishes and other organisms are washed into the trap. Since the interstices in these traps are quite small and as the water pass through the traps, fish and other organisms remain inside. Because of the intensity of current and limited space in the trap the fishes cannot escape by swimming backward. Trap is lifted periodically to remove small fishes and prawns brought by the current.

Therakkal is a fishing method practiced by single or two fisherwomen in shallow brackish water areas and *pokkali* field of Kannur district, using one or two filter traps. First they fix the *padals* at one side of the water area. A bund like structure is created at both sides of the trap to divert the water flow through the traps. After fixing the trap, the fisherwoman moves to the opposite side about 10- 20 m away from the trap. Then a bund is made across the water body using mud and aquatic grass collected from the place. The bund is slowly pushed towards the trap along the bottom and during this process the bund turn over several times and hence the name *therakkal.* On reaching the traps the muddy water is drained into the traps along with small prawns and fishes. Trap is taken out to collect the catch and the process is repeated in another suitable place. Nayak *et al.*, (2000) mentioned about *therakkal* in Kannur district.

3.2.3.5. Aproned filter traps

This is an improved filter trap and is popularly known as *tharapadal* in north Kerala. Job and Pantulu (1953) described this trap as modification of the simple cone cage for similar purposes. It is effected by the addition of a detachable fan shaped apron, one end of which is inserted into the open mouth of the cone. The traps observed during the study consist of cylinder made of coconut palm leaf slivers with a non-returnable funnel permanently fixed inside the trap. The mouth of the apron exactly meets the inner edge of the trap mouth and the converging funnel has

an opening in the middle. Length of the cylinder varies from 70-90 cm with about 40 cm dia. at the mouth. The converging mouthpiece, made using several pieces of coconut leaf midrib slivers of about 15 cm size is fixed to further minimize the chance of escapement fishes from the trap. Hornell (1924) reported that the out going water flows on to the apron and any small fish and prawns that come with it are led by the converging sides of the apron into the cylinder behind, where they are trapped. The tail end of the cylinder is tied temporarily, unlike in simple cone cage, and can be loosened to remove the catch. The *kumni* of Hoshangabad described by George (1971) is an aproned cone cage made of bamboo splinters.

3.2.3.6. Screen barriers

Long leaders of converging screens erected in shallow waters to lead the fishes into the chambers fixed in the end is known as fish fences or screen barriers. This type of trap is fixed during high tide and removed during the next low tide and the fish actively swim up into the barrier. Impoundments erected with the help of split bamboo in shallow waters of Chilka lake is known as *Janos* (Jhingran and Natarajan, 1969; Roy and Banerjee, 1980). Crude dams are the probable fore runners of present day barriers. Jones (1946) reported that these types of dams are constructed across the streams with the help of stones, leaves and reeds from one bank to other so that water would flow only through crevices. One or two places towards the middle are kept open where large basket traps kept with their open ends facing the lower side of the streams so that all the fish that ascend the streams and rivers are trapped. Hickling (1961) reported that barriers are constructed with earth, brushwood or they may be substantial dams of planks stuffed with clay. The barriers made of stones in the intertidal areas of Kachchh, in Gujarat is known as *vada* fishing (Remesan *et al.*, 2002). They may be fixed or movable screens, which can be advanced so as to compress the trapped fish into a smaller and smaller space for ease of capture. Fences made of non-textile materials is known as *weirs* and pound nets or set net if made of netting (Brandt, 1972). Based on the materials used for the construction two types of barriers are seen in Kannur and Kozhikode districts. Cost particulars of a screen barrier unit in Telicherry river is given Table. 14.

3.2.3.6.1. Bamboo screen barrier

These are large enclosures with retarding devices erected in shallow waters where an extensive tract of flooded land is in the process of draining. Fish *kraals* are set traps constructed across tidal rivers and shallow estuaries using walls made of strip of bamboo tied by coir rope with narrow space between for the flow of water (Anon, 1995). Such structures are popularly known as *vesa* in Kozhikode and *Cheve* or *Thadave* in Kannur district (Plate 8). Screen barriers are common in rivulets and backwaters of Kuppam, Pervamba, Tellicherry, Chaliyar, Korapuzha and Kuttiadi rivers but they are not seen in Kasargod district. Length of a screen barrier varies from 100 m to more than one kilometer, which depends on the area of operation and availability of the screen. Individual screens measuring 1.5 to 2.5 m length and 0.9 to 1.8 m height are made using bamboo splinters which are held together with coir or 2 mm dia. PP twine at four to six transverse rows depending on the height of splinters. Hickling (1961) reported that barriers are made from split bamboo, reeds or strong grasses, fastened together with three or more lines of twine. They are made in convenient lengths so that they can be joined end to end to make a barrier long enough for their requirement. Several such screens (*chern*) are arranged as vertical walls along the shore line to enclose an area. *Banas* are set barriers erected bank to bank in the channel connecting the *beel* to its riverine source (Yadava and Choudhury, 1986; Choudhury, 1992). Since it is costly to build and difficult to maintain, bamboo screen barriers are being replaced by net barriers. Life of bamboo screen is about one year whereas screen made of netting may last for several years.

3.2.3.6.2. Net barrier

Traditionally the screen barriers are made of bamboo splinters but as cheaper and easily pliable materials like synthetic nettings became common people started using netting for making screens. Mohapatra (1955) stated that *Khonda,* popularly known as *disco* net is a recently introduced modified net made of nylon twine which has replaced the traditional *thatta khonda* made of split bamboo and cotton twine. In Kuppam, Tellicherry, Kuttiadi, Chaliyar and Kadalundi rivers and adjacent backwaters screens made of HDPE webbing has almost totally replaced bamboo

screens. HDPE netting having a twine size of 0.5 mm dia. and 25-30 mm mesh size is commonly used in all these places (Plate 9). A long piece of netting of varying length with 1.5–2 m height is cut and is mounted using 4-6 mm dia. PP rope of approximately equal length. Some fishermen use lead sinkers for the foot rope to keep the lower edge close to the bottom.

The heart shaped fish aggregating chambers of the above traps are always made using bamboo screen. One or two such chambers are set towards both ends of a unit, depending on the length of the screen and topography of the area. The barriers are interrupted at intervals by gaps, into which basket traps, fitted with non-return valves, are put (Hickling, 1961). Each chamber is having two compartments and is constructed using four screens each having about 2 m length. First two screens are pressed into the bottom in the shape of heart leaving about 10 cm gap in the front just enough for a big fish to enter and 4-5 cm exit space in the back. These screens are tied together using ropes and two wooden poles are erected adjacent to the screen for support. The second circular chamber is also built in the same fashion accommodating the exit hole of the first chamber. Mohapatra (1955) reported that the free end of the valve screens points towards the trap chamber, leaving small vertical opening for the one-sided passage of fish. There is no opening in the back for the second chamber. Job and Pantulu (1953) reported that trap chamber is made by arranging a length of screen in such a way that the middle part of its length forms a circle and the ends are brought together to form a narrow passage through which it is difficult for the fish to escape once they enter the chamber. Another two screens are set in the front of first chamber in such a manner that the converging end exactly meet the entrance of the front chamber and the other end is connected to the leader screen. For a screen having 2 m height the first chamber is made with 2 screens having 2.2 m height and the second chamber (second from the screen) is made with another 2 screens having 2.5 m height.

Operation

Peak season is during December to May. Two canoes, with 2-5 fishermen are required for the operation. The chambers are set during low tide near the shore

where the depth is less than the height of trap during high tide. Screens are arranged either to block the entrance of a blind creek having tidal influence or in a semicircular area. The top of the chamber is covered properly using PE netting to prevent the entry of birds, poaching and also leaping of fishes from the chamber. Then the remaining poles are also erected in the front part of the chamber along the course of river at about 2.5 m intervals. During high tide the area between trap and shore get inundated. Just before the commencement of the next low tide the leader screens walls are set by fixing the foot rope into the bottom and tying the head rope to the poles already erected. Wishard (1976) reported that the *roak*, barrier net, is first fixed across the river, from one bank to other, with the help of two rows of bamboo poles. In the case of barrier net operated in Hooghly river only the foot rope is first fixed to the poles and the whole net is left flush with the ground. At peak of the high tide the fishermen go about in boats and raise the head rope and fix it on the poles above the water line (Jones, 1946).

Remesan *et al.*, (2002) reported that net barriers in Kachchh, Gujarat are fixed in a semi circular form using wooden poles with opening facing towards the land. The net barrier is fixed and the mouth of the trap is always set in the direction of current during low tide so that the fishes moving against the current will be lead into the chamber by the leader walls. Das (1993) while describing the operation of *Bitti* or *Atol,* bamboo cage traps, in West Bengal stated that as the ingress water enters the bheri, *P. monodon* and other species of shellfishes move against the current and get entrapped in these traps. As the tide falls the fishes within the area enclosed are forced to pass into these chambers and finally a fisherman enters into the chamber and collects the fishes using a small scoop net.

Anon (1995) reported that fishes and prawns encountering this palisade are directed along the walls into a varying number of traps. Mullets, catfish, prawns and other medium and small sized fishes are captured. The traps and leader walls are removed, loaded in the canoe and made ready for the next tide. Single operation is possible in a day, since the capture process is entirely depends on tide. Hornell (1924); Kurian and Sebastian (1986) and Mohan Rajan (1993) reported that screen barriers are extensively used in the backwaters of Malabar. *Suthuvalai* is a type of

net barrier operated to trap prawns in Pulicat lake (Krishnamurthy and Rao, 1970). Stone barriers and net barriers, known as *vada*, are common in the inter-tidal zones of Kachchh areas in Gujarat (Remesan *et al.*, 2002).

Operational expenditure of a sreen barrier unit is given in Table 15. Income varies from Rs. 200 to Rs. 3000/day. Two shares of the total income is given to the owner of craft and gear. Balance amount is equally divided among the number of fishermen. According to the fishermen catch is declining and the operation is becoming uneconomical. Wilson and Davis (1973) reported that high cost of labour and materials plus scarcity of younger men in the fishery are the chief reasons for declining pound net effort in Virginia.

3.2.3.7. Thottil vala-Aerial trap

Thottil vala is an aerial trap operated in Pazhassi reservoir during monsoon to catch mainly carps. Usually bigger sized carps and sea bass are seen in shoals near the dam in the lower side and they jump against the water flow when one or two shutters are open to release the excess water in the reservoir. It consists of a trapezoidal frame made of 6-8 mm dia. MS rod with a top open box at the base (Plate 10). PE netting made of 1 mm dia twine with 50 mm mesh size is used to cover the frame and the conical box at the base. A few steel strings are attached to the top of the box to prevent the escapement of fishes jumped into the box.

Two PP ropes of 8-10 mm dia., each having about 50 m length are attached to the top frame on either side and is lowered to the side of water flow. The other ends of the ropes are tied to any rigid structure on the dam. One or two such traps are kept on either side of the flow and the trap is always kept above the water level in such a way that when a fish jumps it should fall into the trap. When a fish fall into the trap the man on watch immediately haul the ropes and removes the fish. During peak period 10-15 fishes each weighing 4-10 kg are caught within 1-2 hours.

Table 13. Approximate cost of fabrication of a box trap

No	Material	Rate (Rs.)	Quantity	Cost
1	Bamboo	100/piece	2 nos. (about 24')	200.0
2	Coir twine	15/coil	7 coils	105.0
3	PP rope	1.7/m	35 m	60.0
4	Areca nut tree	-	4 m	50.0
5	Labour	200/day	4 days	800.0
Total				**1215.0**

Table 14. Cost particulars of a screen barrier unit in Tellicherry river.

No.	Material	Rate (Rs.)	No. of units	Cost (Rs.)
1	Bamboo	110/peice	18 nos.	1980.00
2	Coir twine	10/coil	85 coils	850.00
3	Labour for 6 pieces of screen	250	7 days	1750.00
4	Transportation of bamboo	-	-	1000.00
5	PE netting	280/kg	30 kg	8400.00
6	Labour for net making	180/day	14 days	2520.00
7	PP rope	110/kg	15kg	1650.00
8	Lead sinker	80/kg	15	1200.00
9	Areca nut tree trunk	150/tree	4 tree (384 poles)	600.00
10	Labour for poles	180/day	6	1080.00
Total				**21,030.00**

Table 15. Operational expenditures of a screen barrier unit

No.	Expenditure	Amount (Rs.)
1	Rent for canoe of 6 m LOA	100/day.
2	Rent for smaller canoe	60/day.
3	Auto fare	30/day
4	Cost of 1 block of ice	45.00
5	Tea/liquor/cigarette	100.00
Total		**335.00**

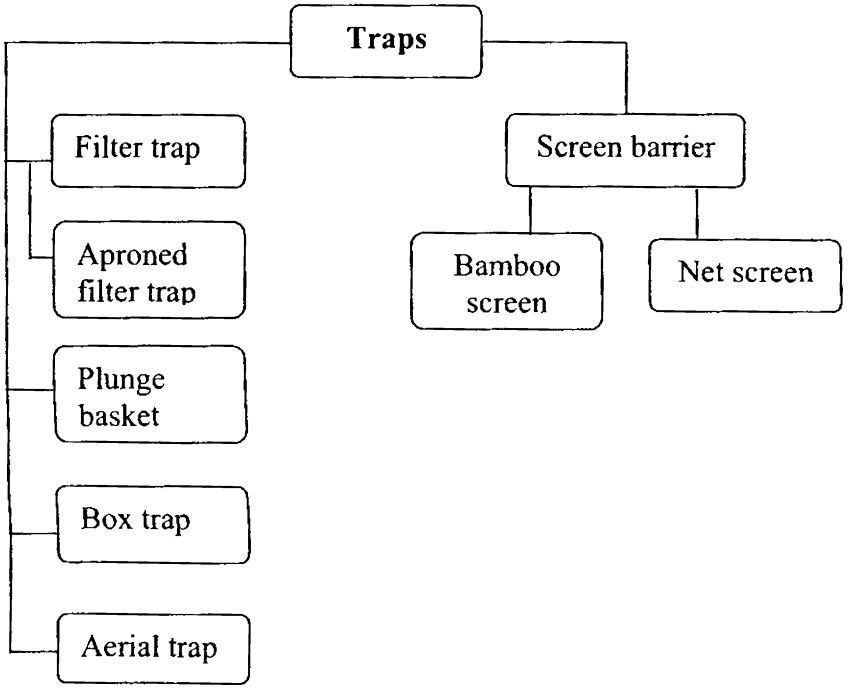
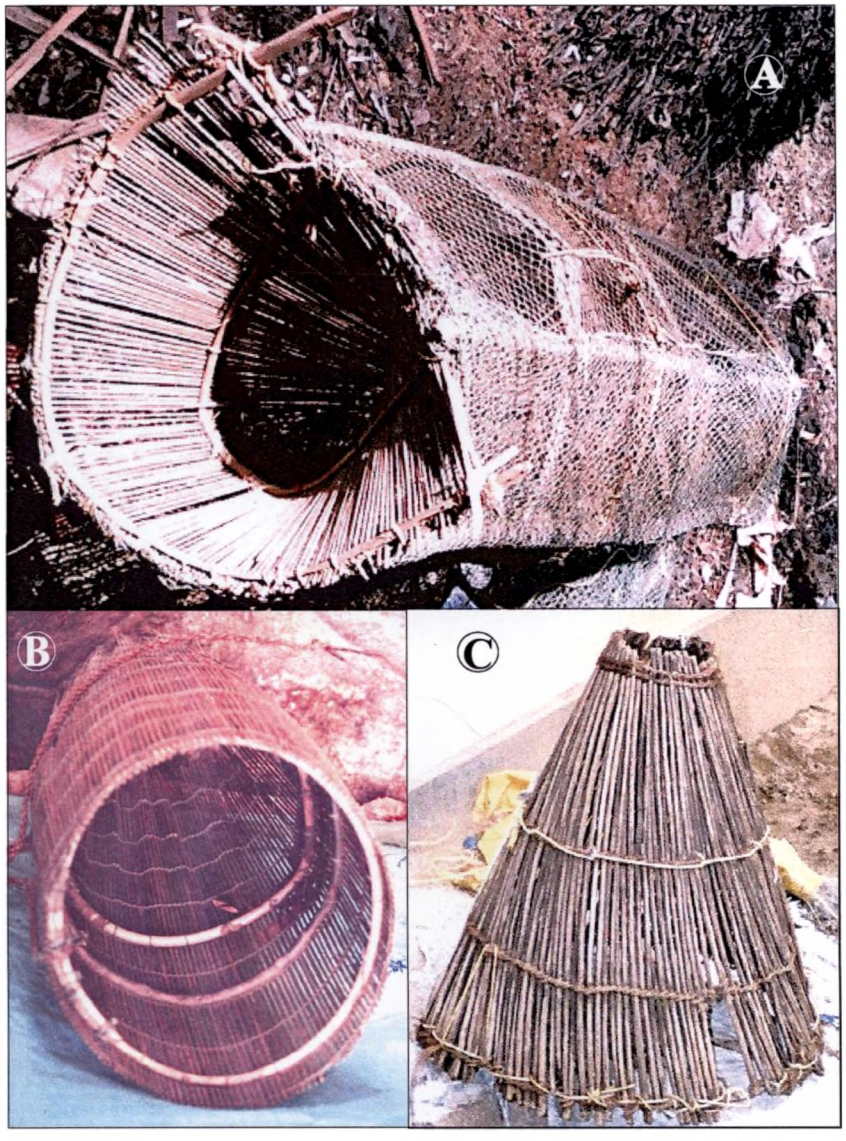
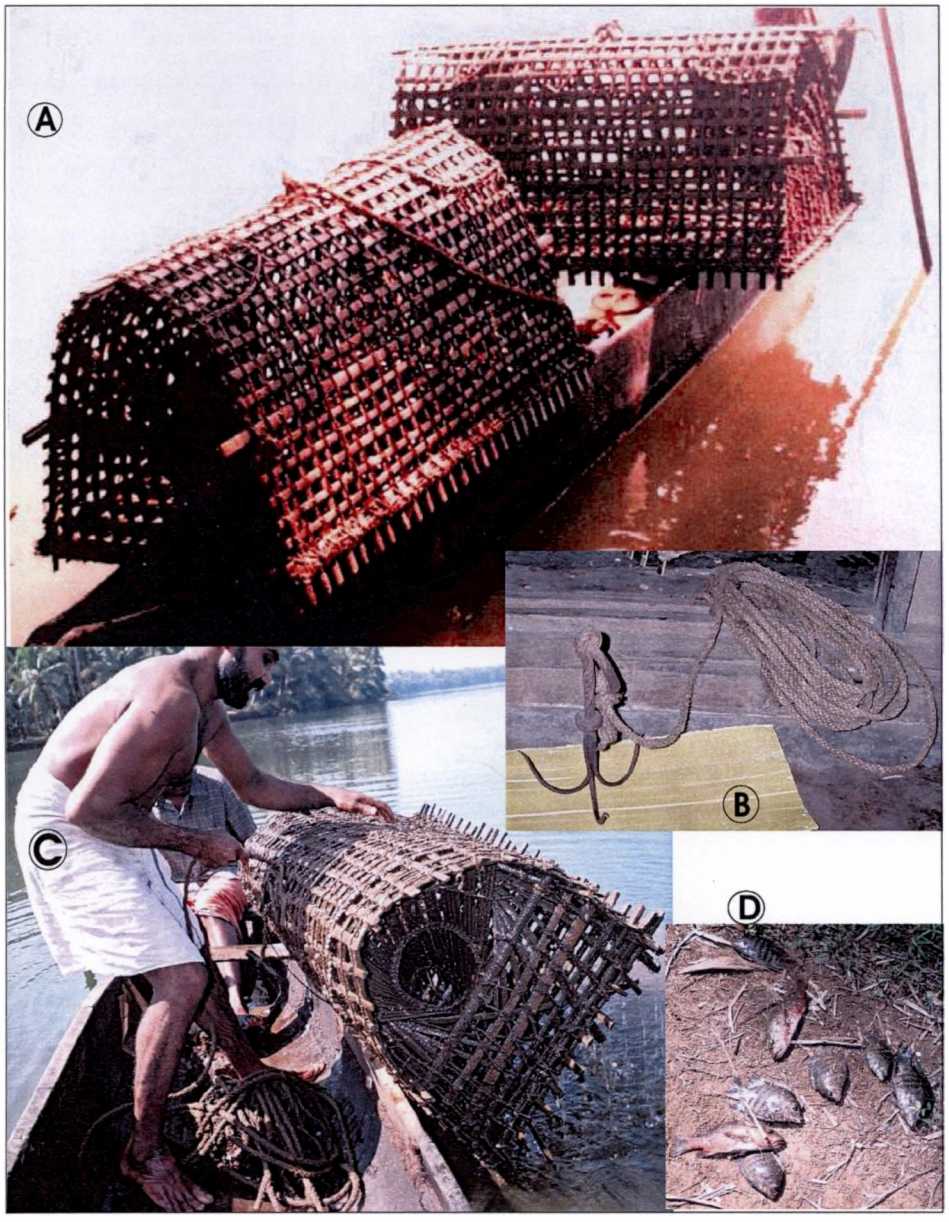


Fig. 23 Classification of traps operated in North Kerala



Ⓐ - Aproned filter trap Ⓑ –Filter trap Ⓒ - Plunge basket

Plate 6. Different types of traps in North Kerala



Ⓐ - Traditional fish trap

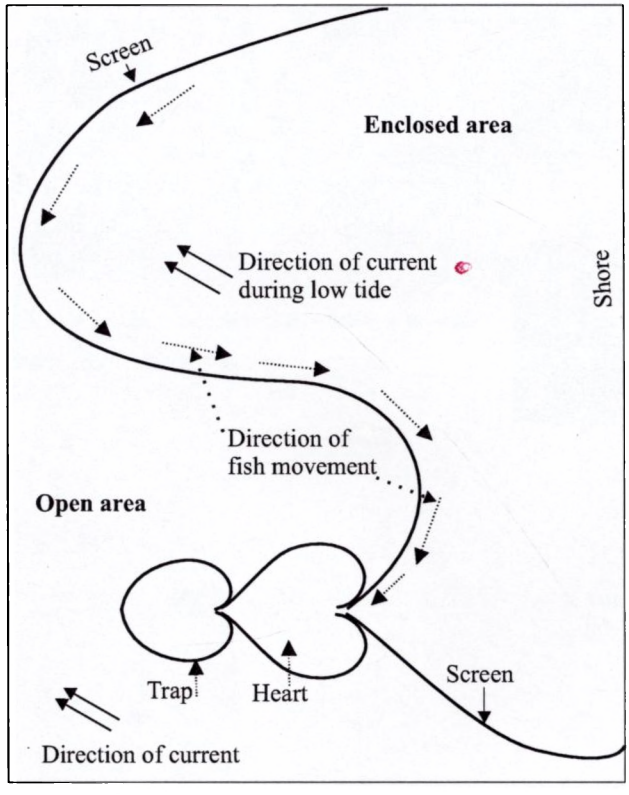
Ⓑ -Grappling hook and line

Ⓒ -Trap being hauled in Kariangode river

Ⓓ - Catch from a trap

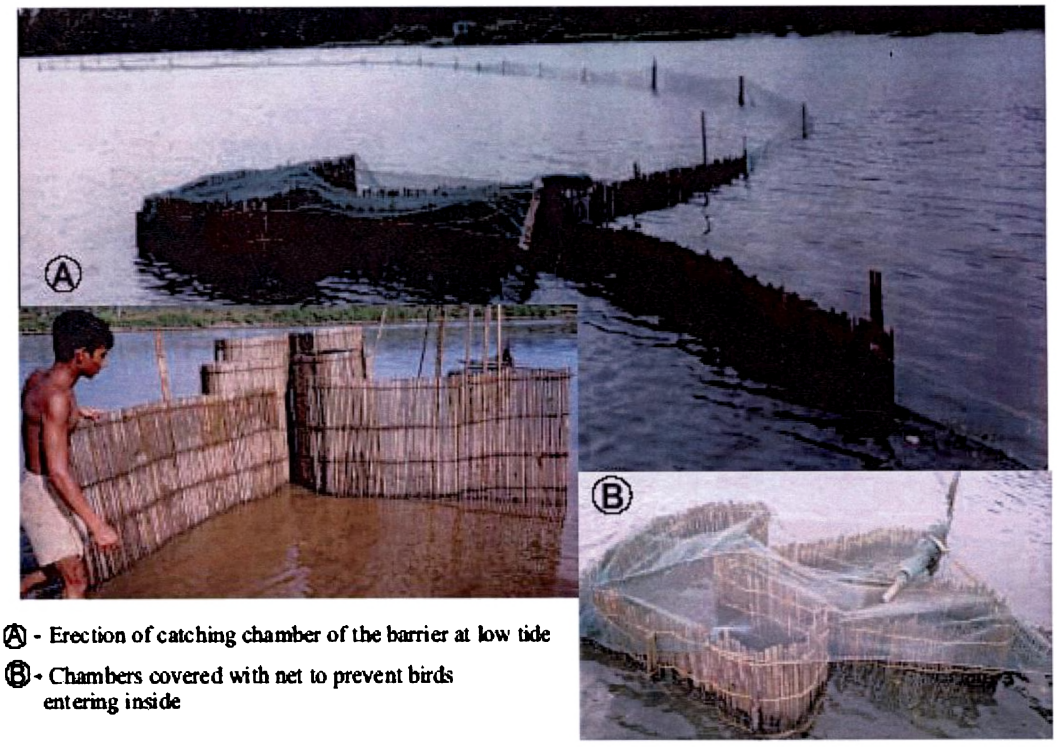
Plate 7. Fish trap operation in Kariangode river

A-Bamboo screen trap in Kuppam river B- closer view the trap



Principle of screen barrier fishing

Plate 8. Bamboo screen barrier in Tellicherry river



Ⓐ - Erection of catching chamber of the barrier at low tide

Ⓑ - Chambers covered with net to prevent birds entering inside

Plate 9. Net screen barrier in Kadalundi river

Aerial trap operated in Pazhassi reservoir

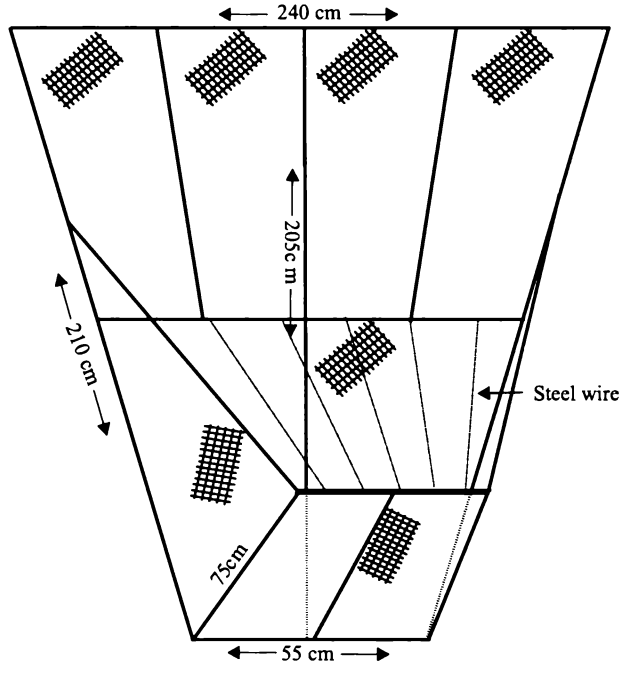


Plate 10. Design of an Aerial Trap operated in Pazhassi reservoir

3.2.4. Line fishing

In its simplest form the gear consists of a line and bait with or without a hook. The principle of line fishing is to offer bait and entice the fish or any other aquatic organism so that it can be lifted from the water together with the bait. In the primitive fisheries there existed curved hooks made of various perishable materials of plant and animal origin like thorns, bones, tortoise shell, oyster shell and whale bone. Hooks with long shanks are designed to prevent a fish from biting the line after swallowing the hook completely. The bend and crook of the hook is usually round or angular. The most important characteristic of hooks are their gap and their spread. The purpose is to ensure that fish shall be unable to spit the hook out with the bait after swallowing it. It should penetrate the mouth of the fish when the bait is taken or the line is pulled so that the fish becomes fast. To improve the fastening the point of the hook is often barbed. The fish hook also serves the function of holding the bait and for this purpose the barbed hook is useful (Brandt, 1972). Lines can be operated with or without hook or bait. The bait can be of plant or animal origin or even any artificial material.

Various types of lines are in operation all over the world, which includes simple line for catching single fish at a time to complicated tackles capable of catching several fishes at the same time.

Chopra (1939) reported the operation of lines for the fishery of crabs in India. Hickling (1961) has explained the use of different types of lines in lake and flood plain fisheries in Africa. Saxena (1964 and 1988) mentioned the use of line in Ganga river and Tandon and Sharma (1984) briefly mentioned the use of lines in Himachal Pradesh. Line fishing in the rivers of Rajasthan has been reported by Kulshreshtha (1986). Mitra *et al.*, (1987) and De (1987) reported the line fishing in Hooghly estuarine system of West Bengal. Operation of different types of lines in the estuaries of Karnataka by Sathyanarayanappa *et al.*, (1987). Nandi and Pramanik (1994) have described in detail the crab fishing lines in Sundarban.

Line for reservoir fishing have been reported by Jones (1959). Natarajan and Banerjee, (1967) described the rod and line technique used for mullets in Chilka lake. Krishnamurthy and Rao (1970) described the operation of lines in Pulicat lake. Brandt (1972), Roy and Banerjee (1980) have briefly mentioned the use of lines in Chilka Lake. Ninan and Kumar (2003) reported the line operation in the reservoirs of Madhya Pradesh.

Line fishing is the most simple and popular fishing method practiced in the inland waters of Kerala. A brief description on line fishing in the inland waters of Kerala is given by Hornell (1938). Kurup and Samuel (1985) and Kurup *et al.*, (1993) also reported the operation of lines in rivers and backwaters of central Kerala.

3.2.4.1. Results and Discussion

Lines are operated in all water bodies in North Kerala and they can be classified as give below.

3.2.4.2. Hand lines

Hand line may be defined as the simplest form of hook and line gear consisting of a hand held single line weighted and with one or more hooks spaced along the far end of the line. Hand lines are popularly known as *Choonda or kaichoonda* and are operated in all types of water bodies. According to Baiju (2005) hand line with single hook or multiple hooks were prevalent in riverine sector. In North Kerala, PA monofilament of size ranging from 0.3-1 mm dia. are in operation, depending on the target species. Length of the line also varies from 2 to 50 m, depending on the depth of operation. Hand lines can be operated very easily. Fishermen operate lines from shore, canoe or any elevated platforms like bridges and dams. They are dropped into the water at places where the fishes are expected and fishermen feels usually with hands when fish bites.

Baited lines having a length of about 20-30 m are thrown from the shore and is retrieved after the fish takes the bait. A piece of lead or a stone is also attached to

the line about 10-15 cm above the hook to facilitate throwing. Small prawns, earthworms, cut pieces of sardine or similar fishes and meat wastes are used as bait. Such lines are known as *Eeru kayar* (Eeru = throw and kayar = line) in Kannur, which requires smooth bottom to prevent the hook from entangling to submerged objects. All carnivorous bottom fishes of the rivers are caught.

Technical specifications of the lines operated in the region is given in Table 16. Round barbed or kirby bent hook of size ranging from Nos. 20-6 are generally used. Single hook is tied to one end of the line and other end is attached to a wooden pole or a wooden piece. A piece of lead weighing 15-20 g is also attached to the line about 15 cm above the hook to prevent the bait floating in the current. Palm ribs of about 2-2.5 m are used as poles by fishermen targeting air-breathing fishes in ponds and other small water bodies. The dried midrib of the Kitul palm leaf is used as the rod by the fishermen operating in brackish waters in Sri Lanka (Anon, 1995). Small frogs, earthworms and fishes are used as bait. Most preferred bait for bigger murrels is live *Channa gachua* popularily known as *kuppa kadan* as it is usually associated with the marginal weeds in paddy fields and other wet lands. Fishermen hook the fish on its dorsal side and release the line in water areas where murrels are usually spotted. Murrels and magur quickly respond to moving baits.

Hand lines, known as *Kaalam,* in Mogral river in Kasargod district use bamboo poles of about 5 m length to attach the line. They usually fix 2 to 3 pieces of feather stalk towards the lower part of the line of which the one close to the hook is having about 30 to 35 mm in length and the second one is about 50 mm length. Their position in the line can be adjusted depending on the requirement and the bait can be suspended at correct depth. Since they float on the water surface they also act as markers. When the fish takes the bait these markers disappear in water and on seeing this fisherman pull the line to catch the fish. The fishermen often suspend a pot, made of coconut shell, on their neck to carry the bait.

In rivers and other deeper areas hand lining is carried out using small wooden canoes of 2.5- 3.5 m lengths. Such fishermen operate two to three lines at a time. Before the actual fishing, they operate cast net or scoop net to collect live

prawns. Others purchase prawns from stake netters and seine net fishermen. The canoes carry some water inside and the prawns are released in this water to keep them alive. Line fishermen in Valapatanam river targeting large *Lates calcarifer* keep prawns in a plastic can having several holes. The can is attached to the canoe using a small rope and is released in water. *Lutjanus argentimaculatus* and carangids are also caught by these fishermen. Earthworms, polychaetes, prawns, sardine pieces and chicken viscera are used as bait. Polychaetes are locally known as *Chettira* (Cher = mud and ira = bait) *or chena,* in Kasargod. It is collected by scooping saline soils adjacent to small canals and mangrove soils (Plate 11). Polychaete is the most preferred bait for *Sillago sihama.* According to Krishnamurthy and Rao (1970) in Pulicat lake hand lines are used with polychaetes as bait extensively for the capture of *Sillago sihama* and *Gerres* spp. Live fiddler crabs are also used as bait by the line fishermen operating near the river mouth in Chandragiri in Kasargod, to catch perches, lutjanids, sea bass and sciaenids. Baits of plant origin like ripe fruits of banyan tree and *maida* balls are also used. *Maida* is mixed with water and the preparation is made into small balls after boiling. This preparation is used to catch mullet, lutjanids, pearl spot and silver biddies. Fishermen in the middle reaches of Kuppam river mix *maida* and little turmeric powder in water and cook in frying pan. Piece of this preparation is used as bait for capturing *Etroplus surantensis.*

3.2.4.3. Multiple hook and lines

Lines with multiple hooks are operated in Pazhassi dam when shutters are opened to release water during monsoon. Fishes usually aggregate near the water flow and try to move against the current by jumping. During this period fishermen operate a type of jigging line with 20 to 30 branches on one end. The main line is made of PA monofilament having 1.2-1.4 mm dia. and about 80 m length. 20-30 branches each having a hook with a size ranging from 1-6 are used (Plate 12). Length of the branch line is about 10 cm and it is tied to the main line at 10-15 cm intervals. A lead piece weighing 150-200 g is attached to the end of the line to keep the line under the current. This type of lines without bait is dropped from the dam and it is continuously pulled and released. During this process the hooks pierce the

body of fishes and the line is hauled back. Bigger sized carps, sea bass and mangrove red snappers are caught. This fishing method is locally known as *chottal.*

Another type of multiple hook and line without bait is operated in the bar mouth region of Valapatanam river. The gear is constructed using 4 round hooks of size ranging from 2-6. Two hooks are attached to one end of a PA monofilament of 1-12 mm dia. Then a rectangular piece of lead about 100 g is pressed around the line close to the hook. The lure is covered using white cloth and the other two hooks are attached to the base of the lead (Plate 13). The hooks are fixed in such a way that they always face in the opposite direction. The line is operated during sunny days by throwing from the shore and pulling back. Attracted by the moving lure carnivorous fish attack the line and during the process it get hooked in any one of the hook.

Multiple hook and line with bait is operated in the estuarine parts of Chithari river, in Kasargod. The main line 0.2 mm – 0.35 mm dia. and the length of which depends on the depth of operation. Usually three branch lines made of same material or with less thicker twine is used for branch line construction. Length of the branch line and distance between branch lines is about 15 cm. A lead weight is attached to the far end of the line to keep it down. Hand line with an end-lead may have several hooks on smaller branch lines so that vertical long lines are formed and such lines are operated in fresh water as well as sea fishing (Brandt, 1972). Polychaete worms and prawns are used as bait. This type of lines are usually operated from bridges or such elevated platforms. Whiting, silver biddies, mullets and mangrove red snappers are the main constituents of the catch.

3.2.4.4. Baited line without hook

It is a type of pole and line without hook operated to capture *Scylla serrata* from prawn filtration fields and backwaters. Babu *et al.*, (2005) reported that mud crabs are trapped using baited lines during high tide in the Godavari estuary. The line can be coir, polypropylene twine or nylon monofilament of 1.5-2.5 m length. One end of the line is attached to a meter long pole and to the other end baits like pieces of dry shark, frog legs or eel pieces are tied. The pole is driven into the

embankment to prevent the crab taking away the line and the line is thrown into the water. Several such lines are fixed at a time in a row at an interval of 2-5 m. The crab after taking the bait tries to pull the line away which make the line strait and on seeing this the fisherman remove the pole from the bund by his left hand and slowly lift the line to the surface. The crab usually clings on to the line when it takes the bait. The final capturing is by using a small stick held scoop net held in his right hand. Krishnamurthy and Rao (1970) reported that baited lines without hooks, known as *chalang,* are operated for crabs in Pulicat lake which are removed by hand net. *Kaabey* is a baited line without hook operated for crabs in shallow waters of Maharashtra (Chhapgar, 1961).

3.2.4.5. Multiple baited line without hooks

This is a kind of bottom set line without hook operated in Kuppam river, in Kannur district for catching *Scylla serrata.* The crab long line popularly known as *nande beppe* is fabricated using 500 to 800 m long PP twines with 2-3 mm dia. Branch line having 100-120 mm length are also made of same material and are attached to the main line at 2.5-3 m intervals (Fig. 25). Two stones are attached to both end of the main line to keep it close to the bottom. Two thermocole pieces or empty oil cans are also attached to both end of the line with ropes, the length of which is adjusted depending on the depth. This float line is to mark the position of the line. Hooks are not used and the bait is tied to the end of branch line by means of slip noose. Eel, slaughter waste, fish and dry fish are used as bait.

The lines are operated through out the season, except during heavy monsoon. Usually two fishermen operate the line from a canoe during daytime. Babu *et al.,* (2005) reported that green crabs hide in shady places or the muddy bottom, during low tide and during high tide they swim freely and hunt for the prey. During high tide they set baited long lines across the mangrove creeks to harvest them. After setting the lines checking is carried out at every 15 to 30 minutes intervals. Devasia and Balakrishnan (1985) reported that maximum number of crabs are caught in the long lines in 3 or 4 days before and after full moon and new moon and catches are more in the morning and evening in turbid and calm waters. Crabs are attracted to

the bait and cling to it with their strong claws (Nandini and Pramanik, 1994). While one of them slowly paddle the canoe close to the line the other man lifts the main line with his left hand and using a small scoop net held in the right hand take the crab inside. Chhapgar (1961) while describing the *pagavali*, the multiple baited lines, stated that the line is lifted by one hand and a net known as *aankha* is slipped under, and the crab is jerked into it. This type of multiple baited lines operated in Sunderban is known as *don*. Hora (1935) and Chopra (1939) reported the operation of long lines for crab at Uttarbhag and Krishnamurthy and Rao (1970) in Pulicat lake.

3.2.4.6. Vertical line

In enclosed water bodies the fishing lines can be allowed to drift freely attached to a float. It can be a tackle with a single hook or a vertical or horizontal long line with several hooks (Brandt, 1972). A kind of vertical line, popularily known as *kenichi,* is operated in weed infested canals and fields of Akalapuzha, in the middle stretch of Kuttiadi river. One end of a PA monofilament line of about1mm dia. and 2-3 m length is tied to a piece of banana stem or wooden piece and to the other end a medium sized hook is tied. The length of the line is either equal to or more than the depth of fishing area. The length of the drop line used in the Hirakud reservoir is adjusted by winding the extra length of the line on the float so that the bunch of hooks remains just above the bottom during operation (Khan *et al.*, 1992). Raman (1975) reported that tapioca or coconut kernal is tied to one end of a rope and the other end to a float or *ponthu* (usually cut pieces of banana stem) and the line is allowed to drift in Vembanad lake for catching fresh water prawn. Live prawns or small fishes are used as bait. The line with live bait is released in weed-infested waters and usually keep it over night (Fig. 26). Brandt, (1972) mentioned that in enclosed waters like lakes, the fishing lines can be allowed to drift freely attached to a float. If the fish takes the bait the float act as a break to tire the fish and prevent its possible escape. Since the entire area is weed infested the fish cannot take the line away after taking the bait. Murrels, magur, sea bass, tortoise are usually caught.

3.2.4.7. Long lines

Long lines popularly known as *beppe* is operated in all places for fish and eel. Mainline is 200-800 m long and is made of PP twine of 2 to 3 mm dia. or PA monofilament of 1 to1.2 mm dia. Long lines for eel are fabricated with cotton twine having 1.5-2 mm dia. Branch lines having 30- 40 cm length are also fabricated with PP twine of 2-3 mm dia or PA mono of 0.6 to 0.8 mm dia (Fig. 26). Distance between branch lines varies from 0.6 m to 1.5 m. Generally round barbed hook of size ranging from number 8-12 are used depending on the target species. Prawns and cut pieces of fish are used as bait. Technical specifications of long lines in north Kerala are given in Table 16.

Two thermocole pieces are tied to both ends of the mainline with the help of two pieces of twines, the length of which depends on the depth of the ground. Two stones are also attached to both ends of the line to prevent the line from drifting. Chopra (1939) reported that the line is weighted with pieces of brick tied to it at regular intervals, and in between, pieces of dead fish are suspended as bait. The most commonly used baits for the long lines in Rajasthan are earthworm, bread, wheat flour paste, small fish, frogs and insect. Usually the lines are set in the evening and hauled back by next morning. Krishnamurthy and Rao (1970) reported the long line operation in Pulicat lake. Operation of *borsi*, bottom set line and *daman*, surface set line in Hoshangabad has been reported by George (1972). Sathyanarayanappa *et al.*, (1987) reported that set long line, *bepu,* is operated during day and night through out the year *in* estuaries of Karnataka and in Hoogly estuary by De (1987). This type of lines are operated in all the three districts throughout the season to capture carnivorous fishes.

In Mahe river long lines made of cotton twine are exclusively operated for catching eels and the line is known as *eel beppu*. Mainline is constructed with 1.5- 2 mm dia cotton twine and branch lines are fabricated using 1.5 mm dia cotton twine. Prior to construction the twines are dipped in a traditional preservative to increase the strength. Main line is about 200 m long and the branch line is approximately 20 cm in length, attached to the line at 2 m apart. Sardines are used bait. *Unagi*

haenawa is an eel long line constructed with cotton twines and is operated in rivers and lakes in Japan (Anon, 1960). To keep captured eels alive, they are put in bamboo basket kept in water. Live eels are sold to the sea fishermen operating long lines for shark.

Table 16. Technical specifications of long lines in North Kerala

Specifications	River/Place		
	Anjarakandi/ Kuppam/ Valapatanam	Kuppam	Kuttiadi
Local name	*Meen beppe*	*Nande beppe*	*Aaral beppe*
Main line	PP/PA mono	PP	Cotton/PA mono
Length(m)	200-800	400-600	100-200
Diameter (mm)	2 to 3, 1.2	2 to 3	1.5-2
Branch line	PA mono	PP	Cotton*/PA mono
Length(m)	0.3-0.7	0.10 - 0.15	0.15-0.25
Diameter (mm)	0.50-1.0	2 - 3	(1.5-2)* / 0.8
No.branches	25-200	260-400	70-100
Distance betw.(m)	0.65 - 1.5	1-2	1-2
Hook Size (No)	8-18	No hook	8-10
Shape	Round/ Kirby bent	NA	Round/ Kirby bent
Floats (mat.)	Plastic/ Thermocole/ PVC	Plastic	Plastic
Floats/unit (Nos)	2	2	2
Float line mat.	PP	PP	PP
Length of float line(m)	1-2	2	Depends on the depth
Diameter(mm)	2 - 3	2 - 3	3
Anchor	Stones at both end	Stones	stones
Bait	Squilla, puffer fish, mussel, ambassis, live prawn, squid, mullet & sardine pieces	Dry shark, chicken parts, eel, slaughter waste,	Sardine, mackerel, flatfish, live prawn
Target species	*Lutjanus* sp, breams, catfish, *Platycephalus* sp, sciaenids, ray, sea bass, carangids, etc.	Mud crab	Eel

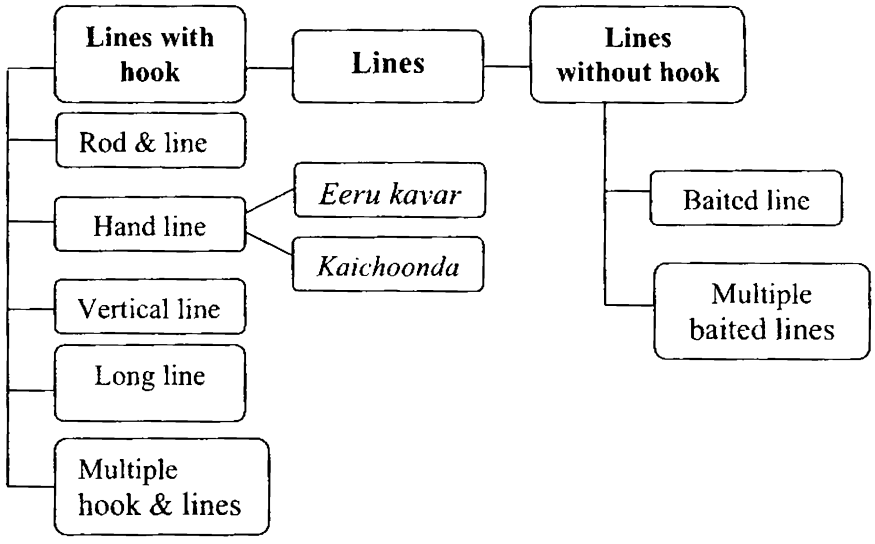


Fig. 24 Classification of lines operated in inland waters of North Kerala

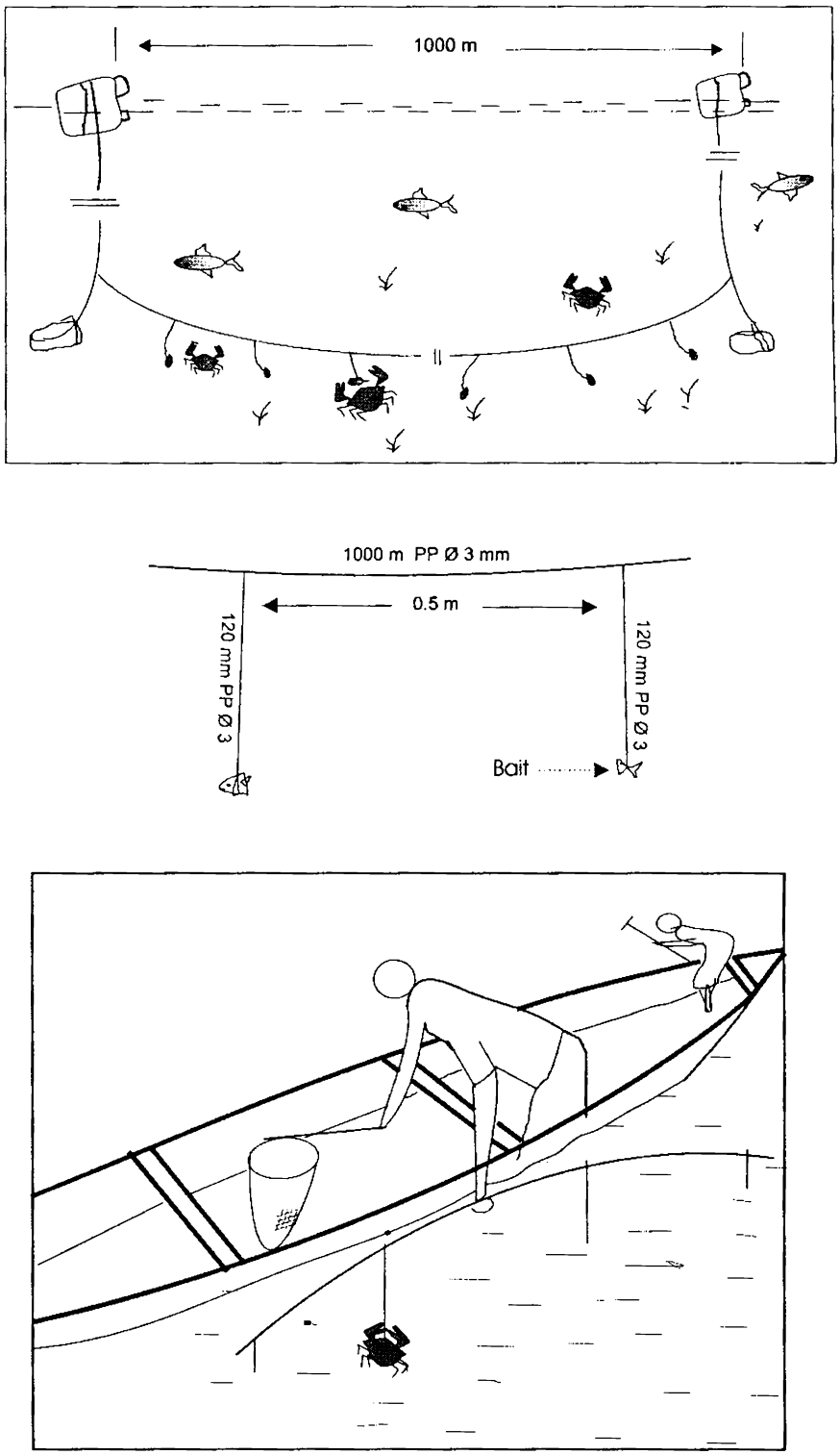
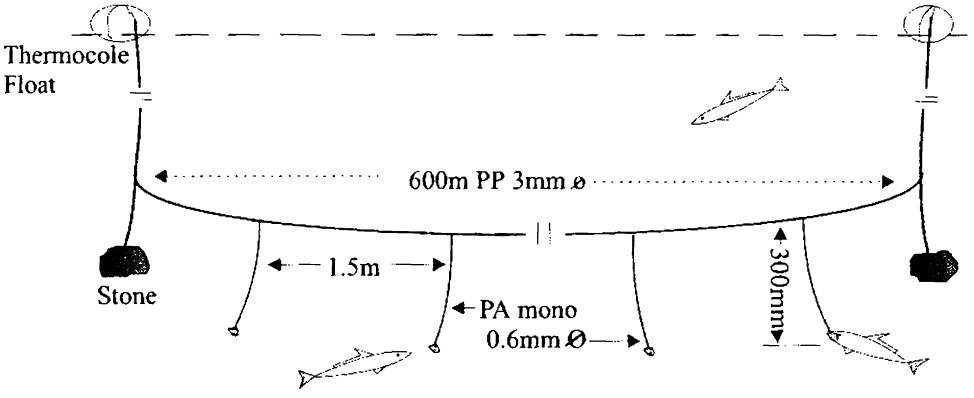
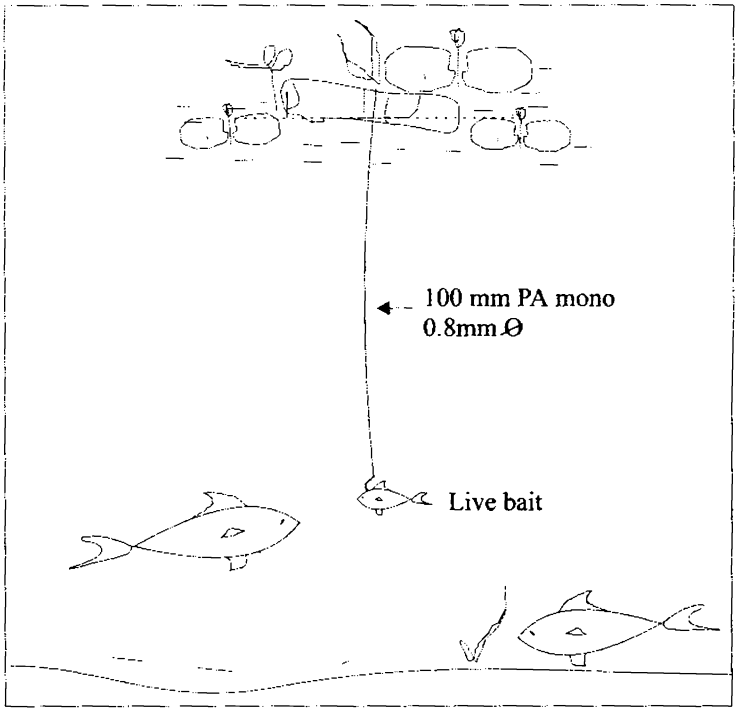


Fig. 25 Multiple baited line without hooks for *Scylla serrata* in Kuppam river



Long line for fish in Valapatanam river



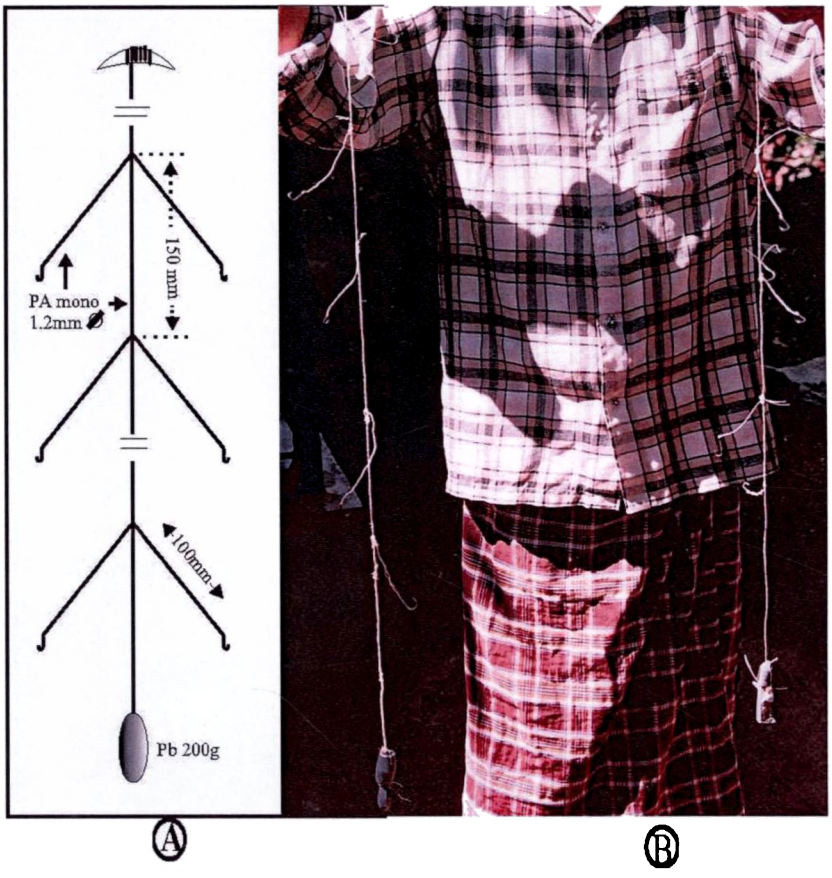
Vertical line at Akalapuzha, Kozhikode

Fig. 26 Long line and vertical line for fish

A - Scooping saline soil for Polychaete collection at Kumbala

B - Live Polychaete worms baits for line fishing

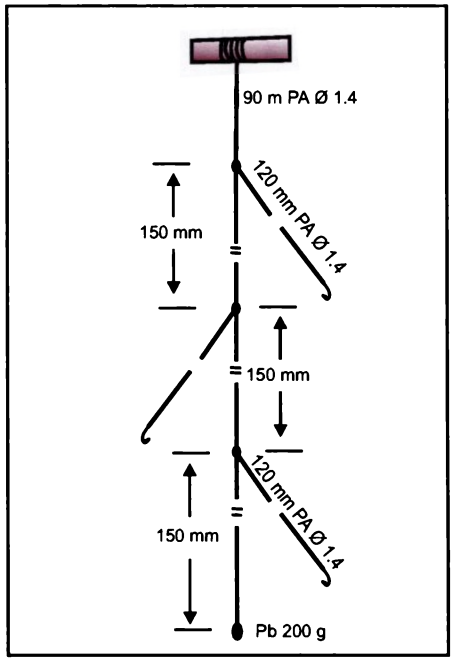
Plate 11. Live bait collection for line fishing



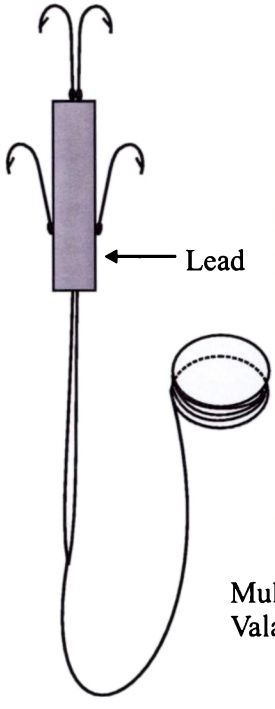
A - Multiple hook and line without bait operated in Pazhassi reservoir

B - Multiple hook and line with bait from Kariangode river

Plate 12. Two types of vertical line operated in North Kerala



Multiple hook and line in Kuttiadi River



Multiple hook hand line operated in the barmouth of Valapatanam river

Plate 13. Multiple hook and line

3.2.5. Other fishing gears and methods

There are several traditional gears operated in inland water bodies of Northern Kerala, which are unknown to other parts. Such gears are location specific and are originated based on the speciality of the existing aquatic environment of the region. The differences noticed in the fishing activity of various regions have a direct bearing on the dissimilarity observed in the resources (Kurup *et al.*, 1993). Similarly the design and nature of the conventional gear also varies from place to place. Different gears encountered during the study are described in this chapter.

3.2.5.1. Mini-trawls

Trawls are bag like nets, towed through water from mechanized or motorized boat, the mouth of which is kept open usually by otter boards, floats and sinkers. Trawls are active fishing gears operated in the sea to capture bottom as well as off bottom fishes. Several workers have reported operation of smaller sized trawls using motorised canoes in the inshore waters of Kerala. Trawling has been carried out in reservoirs and lakes of India and other countries. Meschat (1956), Ellis and Pickering (1973) and Hopson (1975) reported the application of of this fishing technique in reservoirs and lakes of many countries. Hickling (1961) reported that trawling in Tangayika lake landed several hundred kilograms of fish at the cost of heavy loss and damage to the gear. George *et al.*, (1982) reported experimental trawling in Hirakud reservoir in Orissa.

Shetty (1965) reported that one kind of trawl net called *konchivala* is operated in the middle stretches of Vembanad lake for catching big prawns and fish. In some parts of Kerala and Karnataka, otter trawls are operated from dug-outs, close to the shore by two men (Ramamurthy and Muthu, 1969). Design and operational efficiency of a mini-trawl net for capturing demersal fishes and prawns in Netravati-Gurpur estuary at Mangalore has been described by Sheshappa (1978). Kurup and Samuel (1985) reported the operation of mini-trawls from Azheekode in Vembanad lake. Sathyanarayanappa *et al.*, (1987) described the design and operation of mini trawls for estuarine fishing in Karnataka. Jhingran (1991) also

reported the operation of mini-trawls in estuarine waters. Trawling in estuary has also been reported by Liggins and Kennelly (1996). Broadhurst, (1996) reported that in New South Wales, Australia, estuarine prawn trawling occurs in five locations and is valued at approximately Australian $ $7x10^6$ per annum. Trawling in Ashtamudi estuary is reported by Muralikrishna and Onishi (2002).

Mini-trawls are usually operated in the near shore waters by the traditional fishermen from motorized craft. Otter trawling from a 55 feet stern trawler with 110 hp in the Hooghly estuary of West Bengal has been reported by Chakrabarty and Banerjee (1967). Cody and Fuls (1986) have compared the catches in 4.3 m and 12.2 m shrimp trawls in the Gulf of Mexico. Vijayan *et al.*, (1990) field-tested a 12.77 m two-seam trawl net designed for operation from 8.4 m OAL dugout canoe with 11 hp outboard engine. Kuipers *et al.,* (1992) reported the use of small trawls in juvenile flatfish research.

Details of mini-trawl operation in the estuarine systems of Kerala using non-motorised craft was reported for the first time by Remesan and Ramachandran (2005b). About 30 fishermen are engaged in mini-trawl operation throughout the year in Kariangode and Chandragiri rivers in Kasargod district. During monsoon season, when the sea becomes rough, more number of fishermen venture in trawling. Thaikadappuram, Azhithala, Madakara, Mayila kadapuram, Ochanthuruthe and Purathekkai are the main centers of mini-trawl operation in Kariangode. In Chandragiri river, Thalagara, Kadapuram and Kesaba are the centers of mini-trawl operation.

3.2.5.2. Results and Discussion

Based on the target group, three types of trawls are in operation namely fish, shrimp and crab trawl. The head rope length of fish trawls ranges from 3.5 to 7 m, whereas in case of shrimp and crab trawls it ranges from 3 to 6 m. Ramamurthy and Muthu (1969) reported the operation of trawl nets with head line length of 7-27 m. Mesh size in the fore parts of fish trawl is 30 mm and 22 mm and 40 mm for shrimp and crab trawls respectively. Codend mesh size for all the three

trawls ranges from 10 to 18 mm. Details of these nets are given in Fig. 27, 28 and 29. PE netting with 0.5 mm twine size is generally used for fish and shellfish trawls. A few fishermen use PA multifilament made of 210Dx1x2 twines for shrimp trawls. Usually 6 mm dia. Polypropylene rope is used as head rope and footrope. Four to seven PVC floats having 50x20 mm size or spherical plastic floats of about 50 mm dia. is used in the head rope. Some fishermen use a larger plastic float (80-100 mm dia.) in the center. Total weight of sinkers in the footrope ranges from 2 to 4.0 kg. 60-80 small spherical sinkers of 15-20 mm size, each having a hole in the center and weighing 30-50 g are used. A twine is inserted through the hole and it is tied to the footrope at about 10 cm intervals, except in the middle of the rope, where the sinkers are closely arranged to have sufficient bottom contact.

The net is rigged to flat wooden rectangular otter boards of size 40x20 cm, each weighing 5 to 6.5 kg (Plate 14). Rings are fixed either on the edge or backside of the boards. Head rope and footrope is extended to 50 to 70 cm, on either side, which serves as legs. 20 to 30 m long, 6 to 8 mm dia PP rope are used as warps. Vijayan *et al.*, (1990) reported that PP ropes of size ranging from 8 to 12 mm dia are used in place of warps for trawls operated from motorized craft. One end of the bridle is attached to the bracket and the other end to the end beam of the canoe.

Operation

Net is operated from wooden canoes of OAL ranging from 4 to 5 m. Two fishermen are required for the operation. It is operated in all season and more units are seen during monsoon. Crab trawls are operated mainly during December and January, which coincide with the migration of seawater crabs in the estuarine areas. *Neptunus pelagicus* is extensively fished in Chilka lake where it is accustomed to living in fresh water condition (Chopra, 1939). Net is operated usually during low tide and maximum fishermen operate the net during early morning. 120-150 m long PP rope having 10 to 15 mm dia. is used for the propulsion of the canoe. One end of the rope is tied to the front beam of the canoe and the other end to a 15-18 kg anchor.

On reaching the ground the anchor is thrown in the water and the canoe move away from the anchor, along the direction of current, till the rope is released completely. The gear is shot, dropping the codend first, followed by the main body and wings of the net. As the second person starts hauling the anchor rope from the other end, the boards are released (Sheshappa, 1978). They know the approximate depth of water in all areas and it varies from 5 to15 m. Warp line released varies from 5 – 10 m more than the depth of water. When the net mouth is opened properly the boat is kept moving, in order to keep the gear in the fishing position. Propulsion of the canoe towards the direction of anchor while dragging the net against the current is shown in Fig.30. The *cycle vala* described by Kurup and Samuel (1985) is hauled with the help of two canoes by pulling the net quickly towards the fixed anchor. On reaching the anchor the canoe is stopped and the net is hauled. After retrieving the anchor the catch is removed and the process is repeated. Each haul requires 20 to 25 minutes and they spend 4 to 5 h per day. Depending on the catch they shift the ground.

Some times the net is operated without using a canoe. Two men wading in shallow waters parallel to the shore drag the net by pulling the ropes. *Kalapu* is a mini- trawl with 3- 4 m long wings and 6-7 m long trawl body operated in brackish waters in Sri Lanka by dragging it along the shallow waters by two men (Anon, 1995)

Maximum catch is obtained during summer when the sea crabs, *Portunus* spp. and *Charibdis cruciata* starts migrating to the estuarine areas. During peak season catch varies from 10 to 30 kg, which is mainly constituted by crabs. Rest of the period catch is constituted by prawns like *Metapenaeus dobsoni, M. monoceros, Fenneropenaeus indicus* and finfish like *Cyanoglossus* sp., *Glossogobius giuris, Platycephalus indicus Scatophagus argus*. and *Mystus* spp. Mud crab, *Scylla serrata* and clams, *Villorita cyprinoides* and *Meretrix* spp. also contribute to the catch. On an average 20-30 kg of sea crabs are landed per canoe per day during season. Sea crabs fetch Rs.20 to 30/kg and income per day varies from Rs.50/- to 350/- per head.

According to the trawl fishermen in Kasargod, catch is declining due to various anthropogenic activities. Total number of fishing units has increased in the lower reaches of the river. Sand mining, aquatic pollution and fishing using small meshed nets are some of the reasons cited. During summer season the river mouth becomes partially cut off due to erosion sand deposition, which is also adversely affecting the migration of several fishes to the estuarine area.

George *et al.*, (1982) suggested that trawling can be successfully carried out in the silted area of the reservoir bed and in the river course. Sheshappa (1978) suggested to popularise this gear in other estuaries and also to motorise the craft to cover large areas per unit time, but operation of motorized canoes in river mouths and estuaries may lead to conflict between motorised and non-motorised group. Fish production can be improved by introducing proven designs of mini-trawl nets. But the impact of this type of fishing method in estuarine areas needs to be studied to evolve management practices like closed seasons, closed areas and mesh size regulations.

3.2.5.3. Kuthi varal-Hand operated dredge

Hand dredge for clams are operated in the estuarine areas of Kuppam, Valapatanam and Kariangode rivers. Nasser and Noble (1993) reported the operation of hand held dredge in Azhikode backwaters for the fishery of *Meretrix casta* and *Villorita cyprinoides*. The fishing implement used is a dredge made of slightly inwardly curved horizontal plate of about 50 cm length. There are about 40 spikes pointing downward at the lower edge of the plate. The 4-5 cm wide plate is having 5-6 holes to tie the net. To this curved plate an arch shaped frame made of creeper or split bamboo having about 30 cm height at the center is attached. A small bag net of about to 50 cm length is attached to this frame. The net is made of PA multifilament of 210Dx16x3 with 40 to 50 mm mesh size. Mouth of the net is roughly semi circular with an approximate dimension of 15x30 cm. The net and the dredge are attached to a 1-1.5 m long wooden pole which in turn is tied to a wooden pole of approximately 10 m length. PP ropes having 1.5 to 2 m lengths and 4-5 mm dia are attached to either edges of the iron piece and the other end is joined together and

connected to the hauling rope. 20-25 m coir rope of about 18 mm dia is used for hauling the dredge. Operation of hand operated dredge for clams in Vembanad lake is locally known as *Kolli* or *Varandi* (Kurup *et al.*, 1993; and Lakshmilatha and Appukuttan, 2002).

Operation

Two canoes of 4-6 m OAL and 2-3 fishermen are required for operation. Ladies also carry out fishing especially in the Azheekal, Maddikara and Mattol area where the Kuppam and Valapatanam river joins. Operation is usually carried out during early morning when the tide is receding. On reaching the ground the fishermen check the presence of clams by putting a pole into the bottom. After confirming the presence, one of the canoes is anchored across to the direction of current using a 100 to 120 m long rope and a fisherman is boarded. The other canoe is kept parallel to the current direction, about 10 –15 m away from the first canoe. The fisherman in the first canoe hold the pole and the hauling rope is given to the second canoe. The toothed part of the rake is pushed to the bottom with the attached pole. Then the rope is pulled to about 2 to 3 m from the second canoe simultaneously releasing the pole towards the direction of pull along the bottom (Fig. 31). During this process the bottom is scooped and is collected in the net. The fishermen operate these devices like some dragged scoop nets by means of long handles, which enable them to push the rake or scratcher into the bottom as far as it can be reached from the beach or from an anchored boat (Brandt, 1972). Net is taken out and washed to separate clams from sand and mud. The process is repeated, after changing the scooped area, till he reaches the other end of the canoe. On reaching the other end, the anchors are removed and canoes move to adjacent areas.

Nasser and Noble (1993) reported that catch per haul of clams in the backwaters at Azhikode varies from 2.6 to 10 kg with an average catch per month of about 7.26 tonnes/unit and the net profit per annum is about Rs.19,052/-.

3.2.5.4. Peru vala - Four boat dip net

Peruvala is a type of lift net operated in the lower reaches of Chaliyar river in Kozhikode district (Remesan and Ramachandran, 2005e). Four boat lift nets are used in fresh water and sea fishing in Scandinavia, East and South Asia (Brandt, 1972). Net is introduced in Chaliyar by the fishermen from Paravoor, Ernakulam district. The design and operation of the net have some resemblance to the *Madavala* described by Hornell, (1938), lure and lift net fishing at Coromandal coast (George, 1991) and *Shiso Hari Ami,* the Japanese four-boat riverine lift net (Flores and Shibata, 1988).

Shape of the net is trapezoidal and is made of nylon multifilament of different twine sizes. Main body of the net in the middle is made of PA 210Dx2x3 with 20 mm mesh size. Piece of netting having six meshes in depth made of PA 210Dx4x3 twine with 60 mm mesh size is laced to all sides of the middle piece to strengthen it. This is further expanded by joining another piece of net having eight meshes in depth. This outer panel is made of PA 210Dx6x3 twine having 90 mm mesh size (Fig. 32). Coir ropes, with 10-15 mm dia, in double are used for mounting the net. Loops are provided on four corners of the net for connecting ropes during fishing. Approximate cost of the net is Rs. 30,000/-. Since the tidal flow influence the success of operation, fishing is restricted to 20- 22 days in a month. Season commence two days before every full moon and new moon and extend up to nine days. Turbulent and muddy water during monsoon is not suitable for this fishing because of poor visibility to see the fish shoal.

Operation

Fishing is carried out both at low and high tide during day and night. About 14 fishermen and six canoes of lengths 4-5 m are usually engaged in the fishing operation. On reaching a suitable place all the four canoes assemble at one place and front part of the net is loaded in the first two canoes. These two canoes also carry an anchor, weighing approximately 18 kg each and 50 m coir ropes of about 15 mm dia

tied to the anchor. The anchor is also tied to the net with a special knot in such a way that the former can be released from the net when pulled with jerk.

Of the 12 fishermen, three each board in the two canoes carrying anchor and front portion of the net. Two fishermen each board in the other two canoes having the back portion of the net. They usually wait for a fish shoal and canoes stay together till the shoal arrives within the reach. Remaining four fishermen board in two canoes to operate the scare line (Fig. 33).

On seeing a shoal, the four canoes with the net disperse and moves in four directions so as to spread the net properly. The simplest way to achieve this is for sheets of square net to be held at each corner by a boat so that they can be lowered or lifted in combination (Brandt, 1972). Some times the net is released first and fishermen waits for a shoal to pass over the net. As soon as the front portion of net is spread completely, the anchor is thrown from both canoes, which goes to the bottom along with the net. The ropes from four corners of the net are released in such a way that the net takes a gradual upward slope in the back. Mohapatra (1956) reported that during the operating of *marala*, a sink net used in the backwaters of Ganjam, the net is sunk to the bottom, about a dozen fishermen in four dug-outs diverge in opposite directions, at the same time releasing the ropes connected to the corners of the net. Shooting is always done against the current in order to spread the net properly. The four canoes remain idle till the fish shoal completely moves above the net. It may take few minutes to 2-3 h to get the shoal inside.

During day fishing a scare line is used to drive the fish inside the net. Scare line is prepared by inserting coconut leaves with out slivers or polythene ribbons between the twists of an 80-100 m long coir rope of about 10 mm thickness. After putting the net two canoes with the scare line take position in the front, about one km away from the mouth of the net. The canoes drag the scare line towards the mouth of the net by holding the two ends of the line. Similar type of scare line operation has been reported in connection with drive-in-net in the lagoons of Lakshadweep (Vijay Anand, 1996).

During night fishing a petromax light is used to attract and guide the shoal into the net. Two fishermen get into a canoe, one of them keep the petromax light on the head and take position about 500 m away from the mouth of the net. The canoe slowly moves towards the net and finally moves over the net. The Chinese torch net for sardines is kept stationary in the current by two boats while the third boat at first concentrates the fish by means of lights and then guides them into the net (Brandt, 1972).

Once the shoal moves above the net the ropes connecting anchor and net and is pulled with a jerk so as to free the net from anchor. Then the net is hauled up by pulling the ropes simultaneously from all corners. Later the anchor is retrieved by pulling the anchor rope. The canoe carrying light then moves out from the net. Hauling continues from four corners and during the process the canoes get closer and closer. Finally the trapped fishes are scooped out from the net using scoop nets. Operation takes 0.5-3 h depending on the availability of shoal in the vicinity.

Mullets constitute major share of the catch followed by catfish and Lethrinids. Crustaceans are also landed by this net. Maximum catch per haul obtained in 2003 to a fishing unit operating near Ferroke was 2817.0 kg of catfish, which fetched Rs.84,500/- @ Rs.30/- per kg.

In some areas of Chaliyar river, operation of *peruvala* is prohibited by the fishermen operating other types of gear. According to them use of petromax will scare fishes which will affect all other types of fishing.

Compared to other inland fishing methods, *peruvala* fishing is lucrative and that may be one of the reasons for the resistance from fishermen operating other gears. However the scientific rationale behind this allegation need to be verified to reduce the clash among the community.

3.2.5.5. Cast net

Cast nets are circular nets weighted around its perimeter, which are thrown to cover the fish and hauled using the long cord connected to the apex. It is a popular

and simple net, which is in operation in all types of water bodies through out the country. Brandt (1972) reported that cast nets were originally developed in India. The cast net can only be effectively operated in waters that have no hidden obstacles. In uneven grounds the fishes covered by the net can escape sidewise. Description of cast net for inland waters in the country have been given by several workers like Hornell (1938), Jones (1946), Hickling (1961), Joseph and Narayanan (1965), George, (1971) and Saxena (1988). Operation of *kheshwa jali*, cast net, in the Kachodhara beels of Assam by Sharma and Ahamad (1998).

Size of the cast net operated in Kerala varies from 3.5- 6 m in depth and 8-14 m in circumference. Usually this net is fabricated with PA multifilament of size 210Dx1x2 or 210Dx1x3. Recently cast nets are also made using PA monofilament netting with 0.20 or 0.23 mm dia. material. In case of hand braiding, the net is brought to shape by either baiting or creasing at appropriate intervals. In case of machine made netting the nettings are joined together following appropriate take up ratios. Half to one mesh selvedge made of PA multifilament of 210Dx3x3 or above is provided in the apex and bottom edge of the net. Mesh size of a shrimp cast net in North Kerala varies from 15-20 mm where as it varies from 25-35 mm for fishes. At present most of the nets are made using machine nettings since hand braiding is a time consuming process. PP rope having 4-6 mm dia and 6-10 m length is fixed to the apex of the net, which is used for hauling the net. According to the construction 3 types cast nets are in operation namely (i) string less cast net without pocket (ii) string less cast net with pocket and (iii) stringed cast net.

3.2.5.5.1. String less cast net without pocket

Cast net without strings, peripheral pockets and hauling rope are seen at Kattampally in Valapatanam river. The net was brought and operated by a fisherman migrated from Ernakulam. The net is hand made using PA 210Dx3x3 with 50-60 mm mesh size having 125 meshes at the apex and 1078 meshes at the periphery (Fig. 34). The same twine is used to make the foot rope after hand twisting 13-15 number of twines. Tubular lead sinkers each having 10-12 mm length and each weighing approximately 50 g are used in a single net. Same twine in double is

inserted through the peripheral meshes and the same is tied to the foot rope at fixed intervals.

It is operated through out the year preferably during night. In turbid waters the net is operated during daytime also. It is operated maily in areas with underwater obstructions like rocks and wooden structures. Net is folded and is cast from a canoe like the other type of cast nets. Once it is cast it totally disappears, as there is no hauling rope attached. Then the fisherman dives into the water and spread the peripheral part of the net properly to prevent the escape of fish from the net. Then he checks for the fish and periodically dives to capture the fish. After that the net is carefully removed from the obstructions and the process is repeated in another place. Pearl spot constitutes major share of the catch.

3.2.5.5.2. Stringless cast net with pocket

Pockets are made along the peripheral parts of the net by turning inward the weighted lower edge of the net and fixing it to the netting at regular intervals. These pockets, known as *palee* in some parts of Kannur, are made by tying the foot rope to the netting using 10-12 cm long PA or cotton twine known as *thooke kayar*. Sathyanarayana *et al.,* (1987) while describing the cast net, *thool bale,* of Gurupur-Netravati estuary, reported that there about 115 pockets in cat net having 1800 peripheral meshes. Cotton twine is preferred over PA as the chance for knot slipping is minimum. The particular mesh or all the meshes in the row to which the foot rope is attached to the netting is reinforced with one more twine to withstand the strain caused by the load during operation. Details of a stringless cast net is shown in Fig. 36

PA mutiflament of size 210Dx6x3 to 210Dx24x3 is the common material for foot rope (*polam kayar*) as it firmly holds the sinkers and in wet condition it sinks fast to the bottom. PP or PE braided twines of 1.5- 3 mm dia. are also used in some areas. The meshes are spread uniformly over on the FR after inserting the same through them, along with sinkers, and it is fixed using the *thooke kayar* at regular intervals. 4-5 kg of lead sinkers is required for medium sized cast

net and it proportionately increase with the size of the net as well as the twine size. As the PA monofilament is light in weight, sinker requirement is less. PA monofilament cast net is more efficient than PA multifilament net but the former is more bulky. Operation of a stringless cast net along with catch is shown in the Plate 15.

Shape, size and weight of sinkers vary from place to place. Sheet type sinkers of about 60 x 30 cm are common in Kannur and Kasargod. Foot rope is placed in the center of this sheet and after adjusting the number of meshes and distance, sinkers are folded and fixed by beating using a hammer. Details of all types of cast net in the region are given in Table 1.

3.2.5.5.3. Stringed cast net

Stringed cast net popularly known as *churukke vala* in some parts of Kozhikode district and are less in number compared to string less cast net and are totally absent in inland waters of Kannur district. As the name indicates 16-25 number of strings (known as *Nedumkal* in some places) are provided in the net (Fig. 37). The ends of these strings are joined together and connected to the hauling rope through the metallic ring to which the top selvedge is tied. Each string usually branches (*Kurumkal*) into three towards the lower end and these branches are attached to the foot rope leaving about 15- 40 cm distance. Strings are made of PA multifilament of 210Dx16x3, PP or PE braided twines of about 1.5 mm dia. and the total length is equal to the length of net. *Kurumkal* is made using thinner twine and the length varies from 0.4 to 0.9 m. Operation of stringed cast net using shoe *dhoni* or *kettumaram* in the estuarine creeks and back waters of Andhra coast has been reported by Rama Rao *et al.*, (1985)

Operation

Cast net is operated throughout the season during day and night in all types of waters. Usually, single person moving along the shore operates the net. There are several canals in the *pokkali* fields and fishes escape and hide in between the plants when these canals are flooded during high tide. Fishermen prefer to operate the net

during low tide when the fishes return back to the canals. It is also operated in slightly deeper areas using a canoe. The left hand is inserted through the loop made in the free end of hauling rope. Before casting the net the cord and net is coiled and is held in the left hand. The net is piled in loops upon the bent left arm and passes his right fore arm within the mouth of the net. The arms are raised, body turned to the left and then, with a quick dexterous motion, the body swung to right and the net is given such an impetus that it whirls outwards from the arms in a rapidly widening expanse, ending in the fall of the net spread to its full extent on the surface of water (Hornell, 1924).

Operation of a cast net is shown in Plate 15. The weights carry it down to the bottom, and the fish inside are enclosed when the net is withdrawn by its cord. In the case of string less net, while hauling, the net collapse and bunch together and it is usually dragged along the bottom to collect fishes inside the circle. As the net is hauled in imprisoned fishes either finding their way into the pockets or being gilled in the meshes of the upper part of the net (Hickling, 1961). Finally net is taken to the shore and unfolds the net to separate fishes and rubbish. After washing the net the process is repeated. The correct method of casting the net can only be acquired through practical experience.

In the case of stringed cast net fishes are collected in the cavity of the net formed by pulling the strings from the top through the ring. Then the net is quickly hauled aboard the canoe or shore. By slackening the hauling cord the bunched-up net is loosened and the catch is liberated (Hornell, 1938). Stringed cast nets can be operated in slight uneven grounds, as it is not dragged along the bottom unlike the stringless net. Main disadvantage of this net is its inability to catch fishes and crustaceans, which are close to the ground or partially buried.

Though smooth and clear bottom is usually preferred for cast net operation, it is also operated in rocky areas and grounds with submerged wooden structures particularly to capture fishes hiding under these obstructions. In the latter case after casting the net, fishermen get into the water and put the net in the right position at the bottom of the water to prevent the fish from escaping. Then with his hands

fisherman check for fishes along the periphery of the net. Finally the net is carefully removed from the obstacles after capturing the trapped fishes. In Kannur district, fisherman operating cast net usually tie a bag, *kotta,* made of coconut palm leaves, to his waist to carry the catch (Plate 15). If a second person is available he keeps the bag and also assists in cleaning the net.

Valange veessal

Valange veessal (*valange* = surrounding, *veessal* = casting) is an interesting type of cast net operation noticed in the middle stretches of Korapuzha river, practiced by joining 8-10 fishermen using 4-5 canoes. These canoes chase the fish shoal in comparatively wider areas and finally surround the shoal from all sides leaving about 10- 15 m dia circle in the middle. On a given signal all fishermen cast the net simultaneously into the circle in such a way that the foot rope of the adjacent net nearly touches each other and there is no chance for the fishes inside the circle to escape. Brandt (1972) reported that in Columbia 10 or more boats encircle a shoal of fish frightening them together by noise with the oars during the process of narrowing the circle and operate the net simultaneously. A sort of community fishing has been reported by Anon (1995) in Sri Lanka, in which shrimp cast nets are operated by a group of fishermen, some times numbering up to 75 persons and standing in a row and forming an arc across a channel.

Drifting of cast net

Apart from the routine operation, there are a few interesting fishing methods with cast net, practiced in some places. Drifting of cast net from a canoe is one such method noticed at Pulikeel kadave in Korapuzha river. Two fishermen board on either end of a 3.5 – 4 m long canoe and pass the foot rope over the gunwale to keep it open. The fishermen sitting on the edge of boat lowers half of the net into the water and places the other half on the gunwale (Brandt, 1972). Remaining part of the net except the apex cord is released in water so that it takes a bag shape. The canoe is held perpendicular to the shore and is allowed to drift along the current in such a way that the net mouth is towards the direction of water current. In this way the net

is drifted for 15-30 minutes with its lower edge sliding over the bottom and driving the fish forward and finally the foot rope is released from the canoe so as to close the net to trap the fishes inside the net. Joseph and Narayanan (1965) reported almost similar type of operation using cast net locally known as *Octal jal* in Brahmaputra river. Similar type of cast net drifting known as *Nagashi ami* is reported from the Tone river in Japan.

Cast net as drive-in-net

Cast net is operated as a drive-in-net in the Manakkadave, Mulapram and adjacent areas of Chaliyar river. First one or two fishermen set a cast net, like a stake net, against current using two wooden poles erected in the bottom at about 2-4 m depth. The upper part of the net mouth is held above water while sinker line in the lower part is pushed into the bottom. One or two biscuit tins or basket made of rubber tubes of old tyres are also placed inside the net. One end of the scare line, prepared by inserting tender coconut leaves without midribs into a 200-250 m long coir rope, is tied to the pole, which is away from the shore. The scare line also has stones attached at intervals to keep it close to the bottom. The other end of the scare line is dragged towards the net in the form of a circle and during this process frightened fishes are driven towards the mouth of the net. The scared fishes looking for a hiding place usually take shelter in the baskets and tins placed inside the net.

Karamchandani and Pandit (1967) reported *sheer* fishing in the rivers in Hoshangabad in which a composite cast net made by joining two cast nets is held open by two fishermen and the other two fishermen drag a scare line, made of date palm leaves, towards the net. Once the scare line reaches near the mouth of the net, the portion of the foot rope held back is removed from the poles and is quickly released to trap all the fishes herded by the line. George (1971) reported that in *dhor* fishing at Hoshangabad 2-3 nets are employed in this type of scare line fishing. Biswas (1995) reported that in Chilka lake 10-12 large cast nets are spread in an acute angle from the shore and the fish driven to this area by other fishermen in boats. Fishes like pearl spot, sea bass, mullets and lutjanids are the target groups.

Cast nets are operated through out the season in all parts of North Kerala. Though there are no changes in the traditional design, fishermen have used monofilament for the net fabrication to increase the catching efficiency. Only very few people in the lower reaches of the main rivers operate cast net for their livelihood. Since the returns are poor, they operate other type of nets or search for alternate jobs during lean periods. For some members in the riparian community cast net fishing is a recreation.

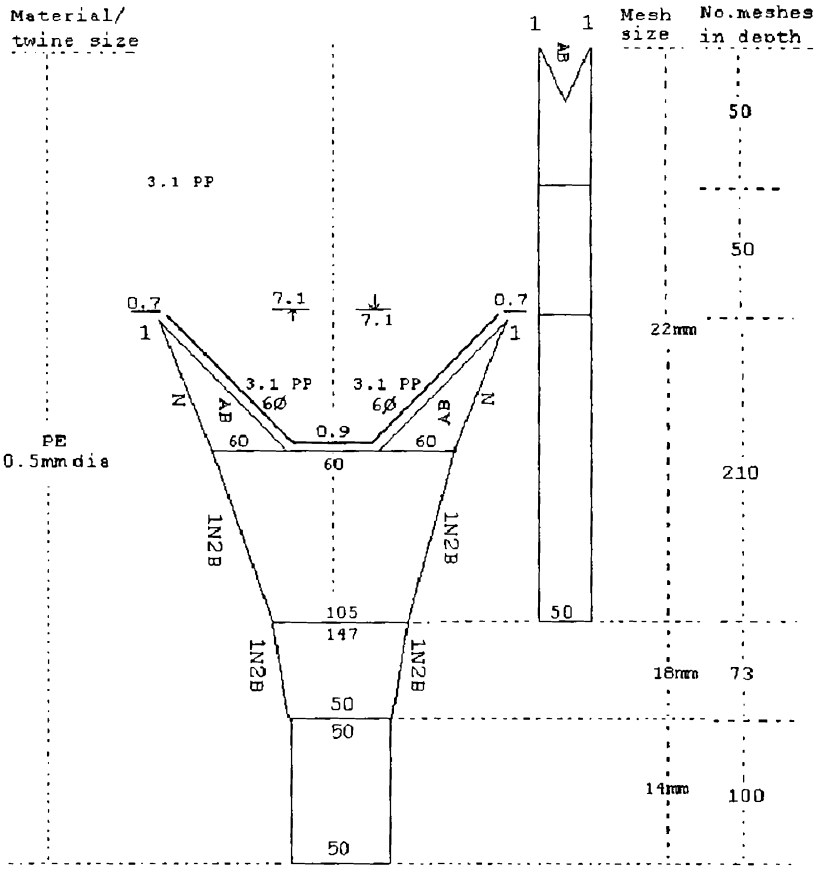


Fig. 27 Design of a 7.1 m shrimp trawl from Kariangode river

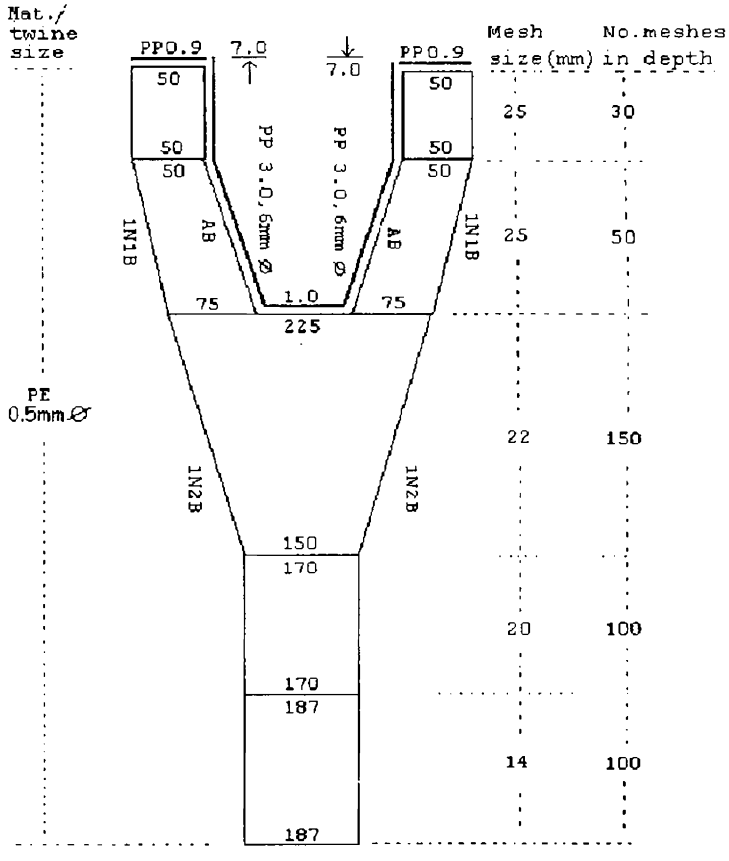


Fig. 28 7.0 m fish trawl from Chandragiri river

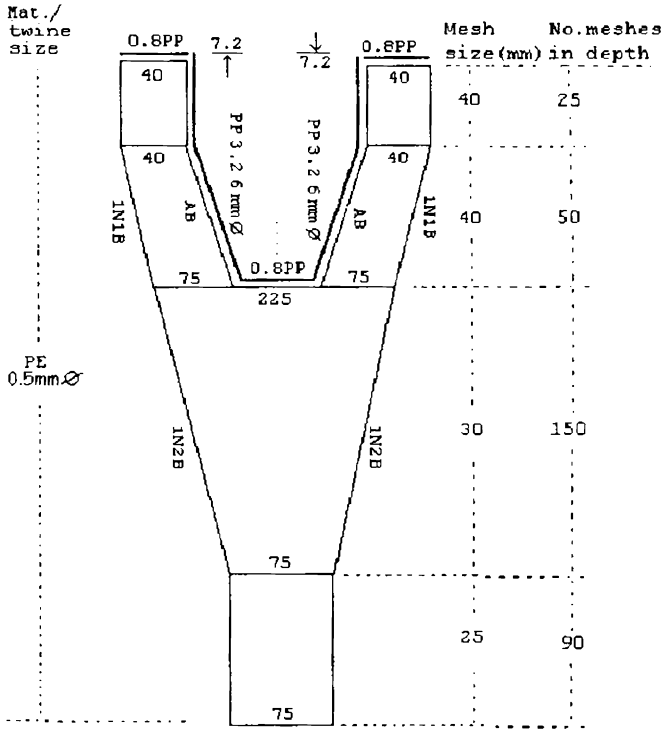


Fig. 29 7.2 m two-seam crab trawl from Mayilakadapuram

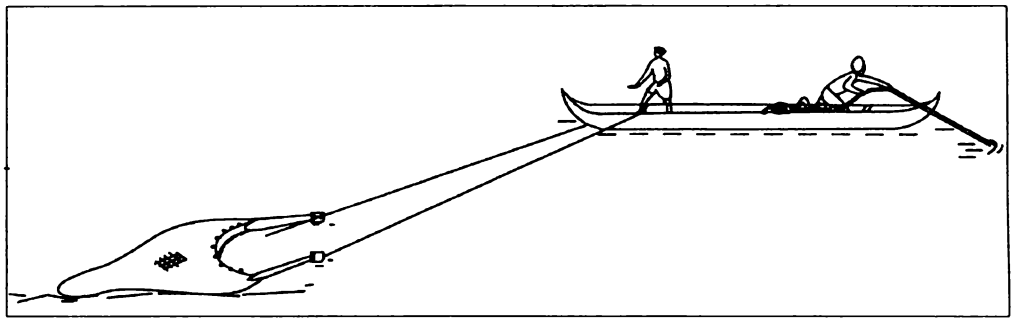


Illustration of trawl operation using rope and anchor

Fig. 30 Trawling in Kariangode river

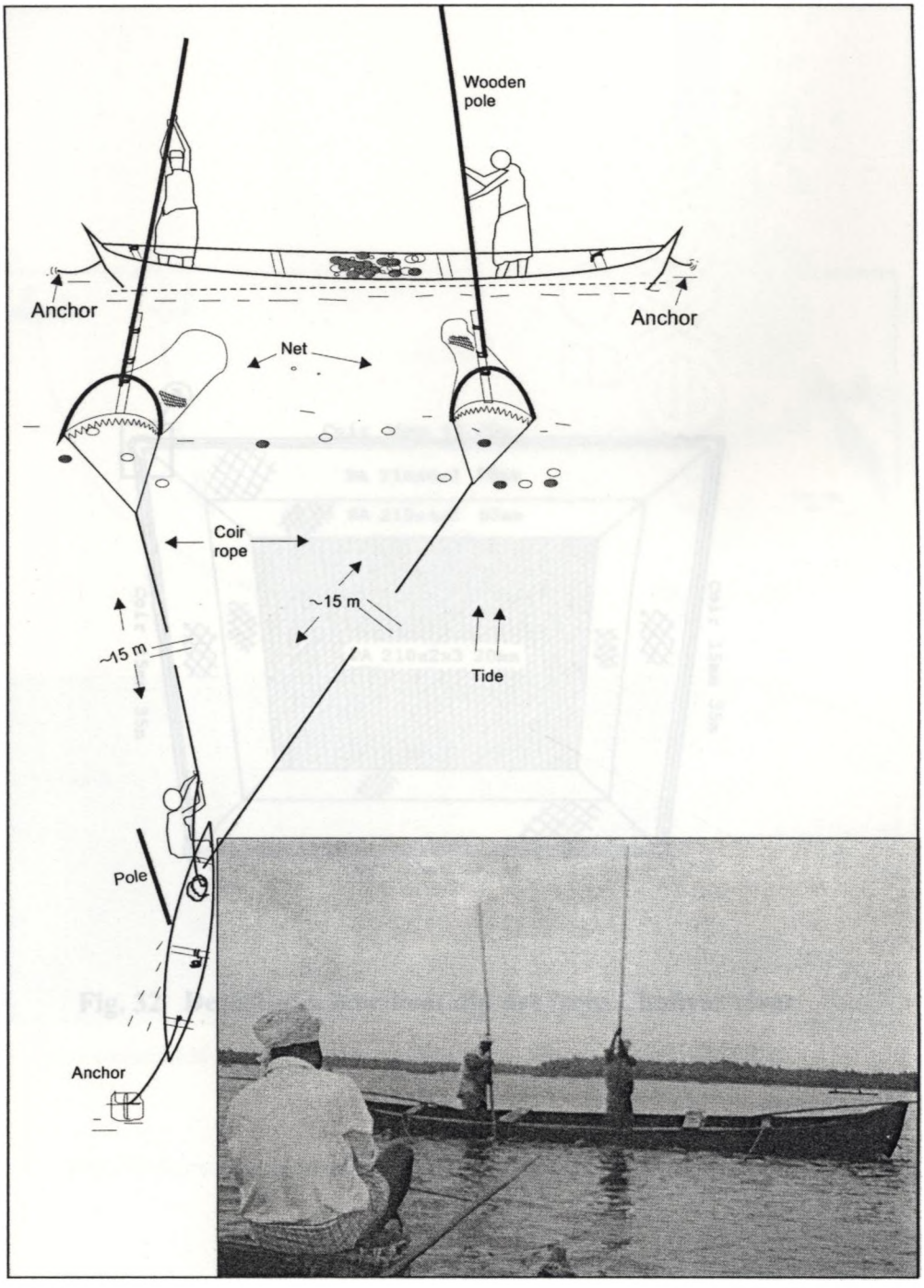


Fig. 31 Hand operated dredge at Thaikadapuram in Kariangode river

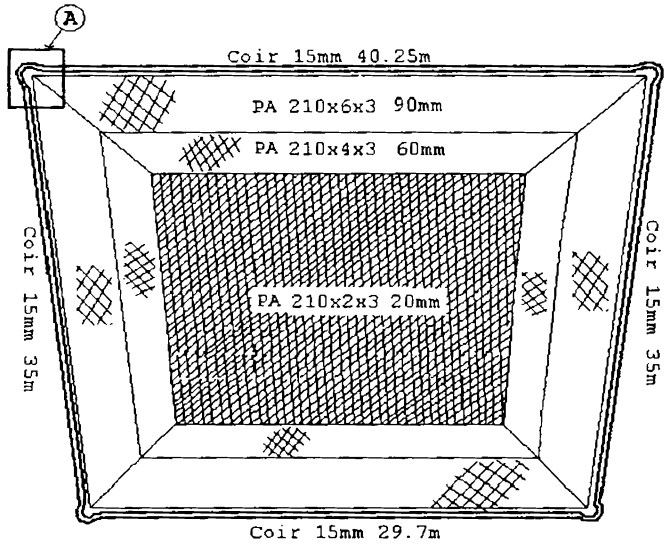
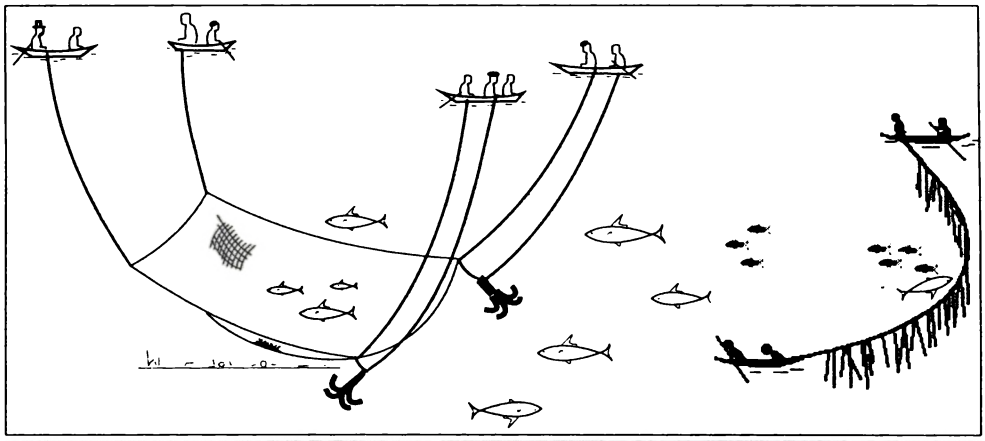


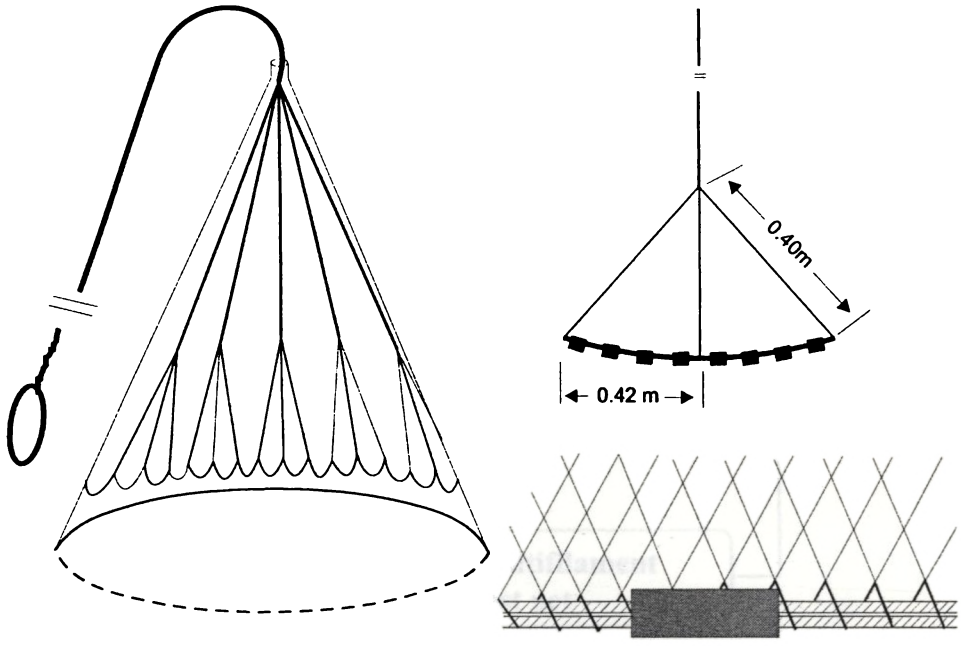
Fig. 32 Design of a four boat dip net from Chaliyar river



All canoes assembled to shoot the net

Fisherman showing dip net at Ferroke

Fig. 33 *Peruvala* operation with scare line in Chaliyar river



Design details of a stringed cast net

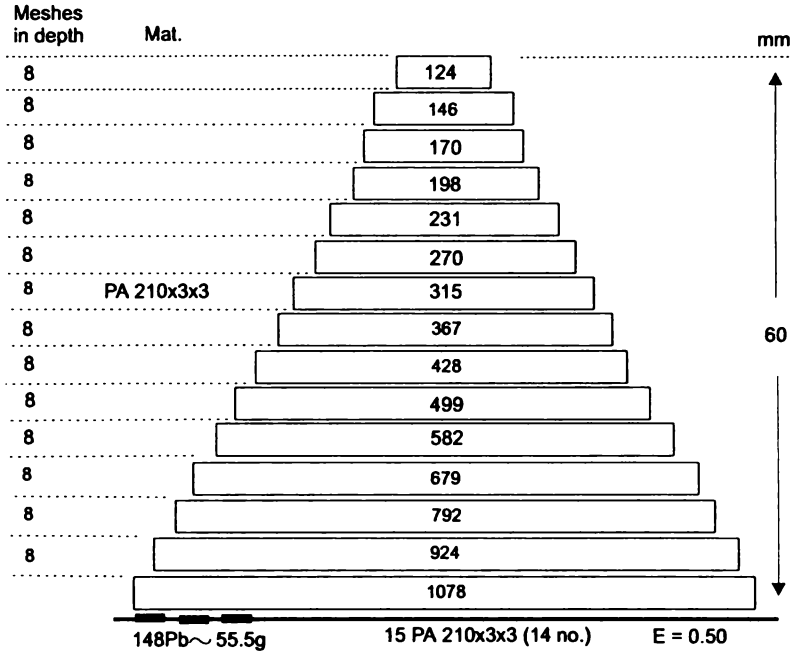


Fig. 34 Technical specification of a cast net without pocket and strings

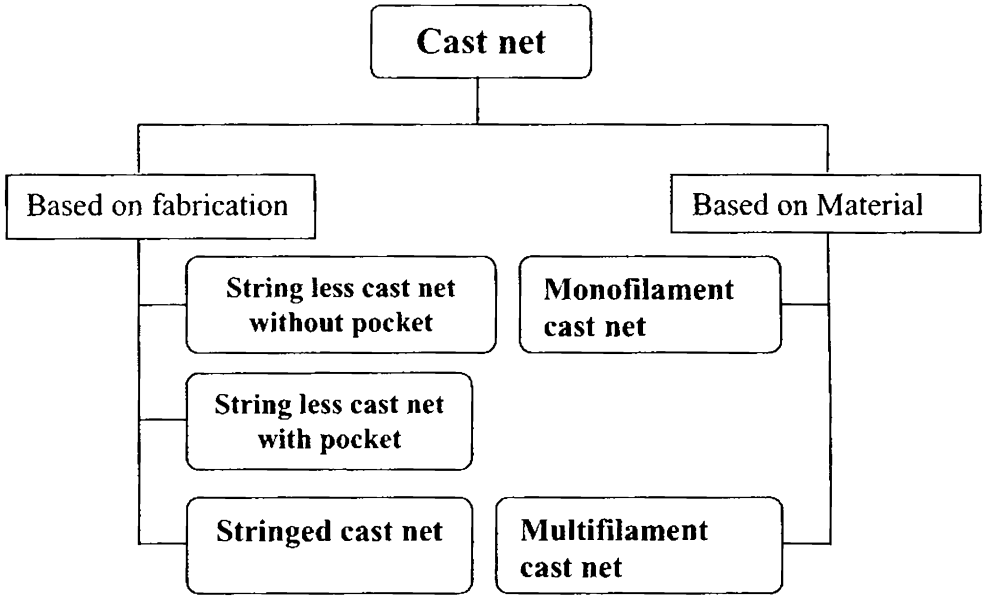
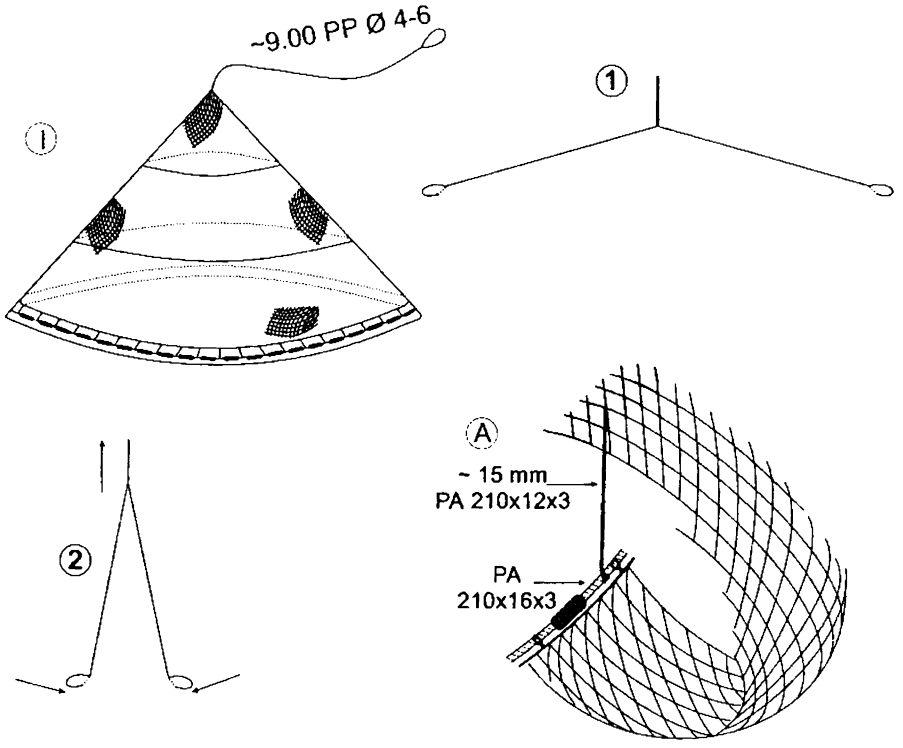


Fig. 35 Classification of cast nets operated in North Kerala



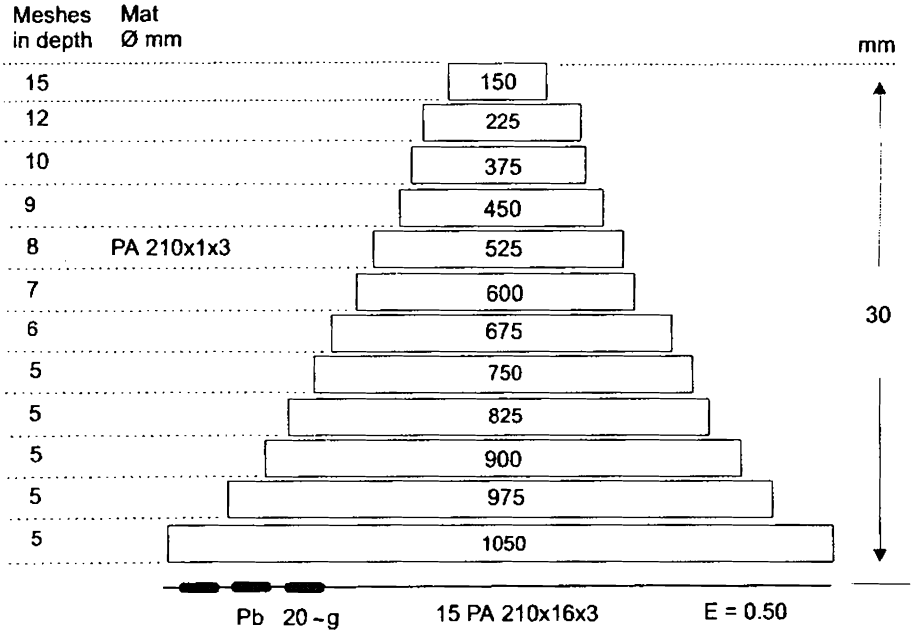


Fig. 36 Design details of a stringless cast net

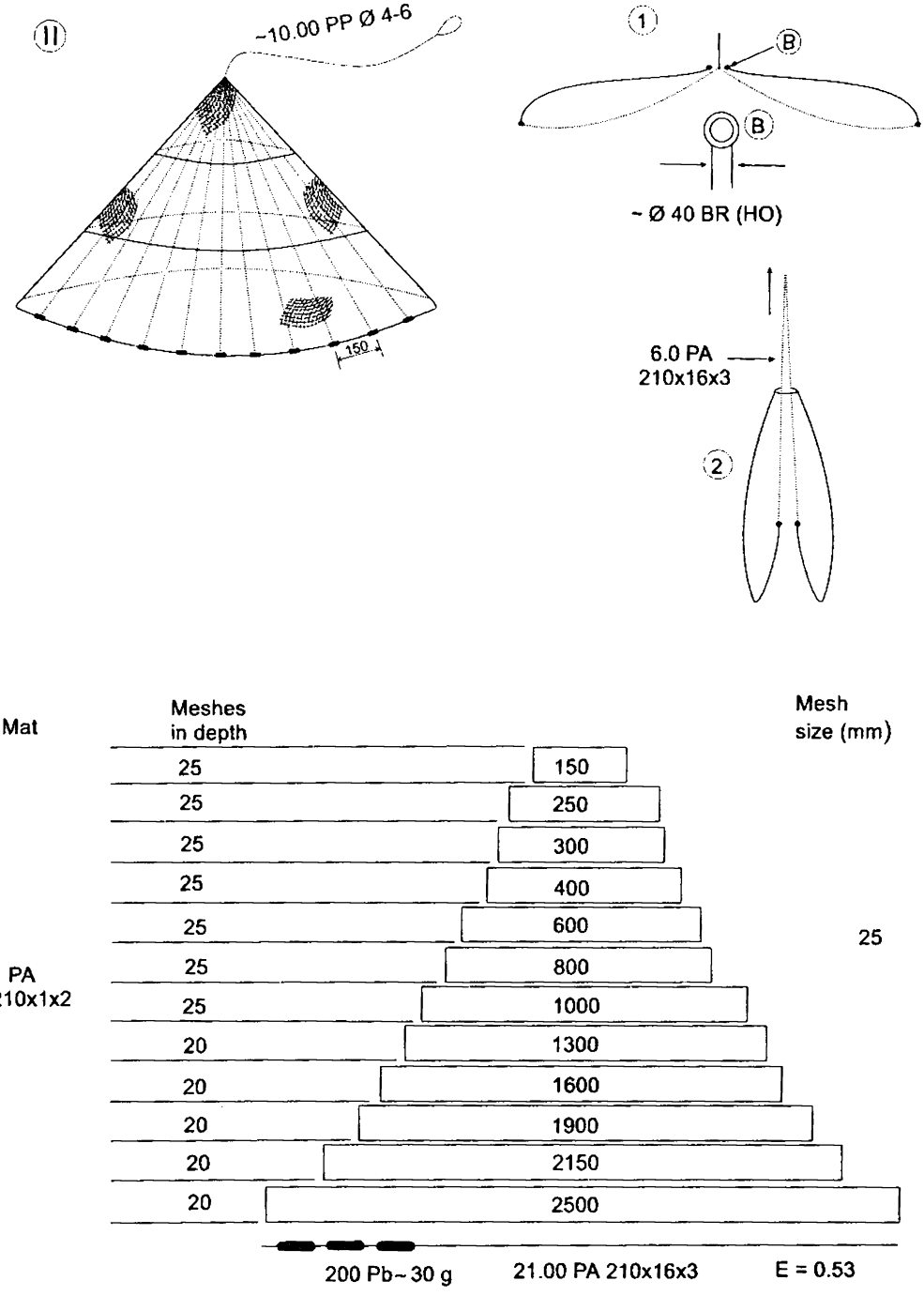


Fig. 37 Design of a stringed cast net from Korapuzha, Kozhikode

Trawl accessories - Otterbords, anchor and hauling rope

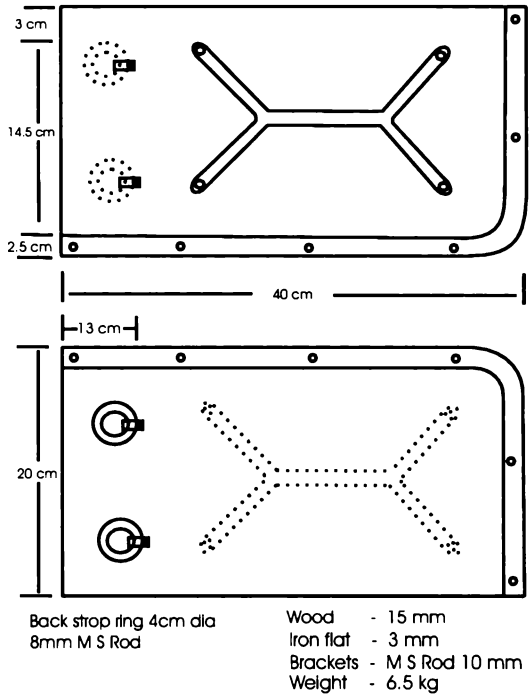


Plate 14. Specification of wooden flat rectangular otter boards

A- Monofilament cast net with a good catch in Chandragiri river
B- Cast net operation in the backwaters of Anjarakandy river
C- Cast net fisherman with a bag made of Coconut Palm leaves for carrying the catch

Plate 15. Operation of stringless cast net

3.2.6. Miscellaneous fishing gears

As already stated some fishing gears and methods are unique and location specific. Such gears are evolved depending on the geographical, hydrological and other conditions of the region. There are some fishing gears and methods in North Kerala, which are not directly coming under the FAO system of classification. Such gears are grouped and presented below as miscellaneous fishing gears.

3.2.6.1. Stake net

The stake nets are conical bag nets set against current with the help of poles erected to the bottom. Brandt (1972) reported that these are stow nets or bag nets set in rows, side by side, between stakes in running waters particularly in the estuaries of large rivers. The net is known as *oonni vala* in most part of the Kerala. It is a fixed bag net operated in places where the tidal amplitude is strong so as to filter the small prawns and fishes swept by the current. The stakes usually occur in linear sets or series, each set being locally known as *oonnipadu* as seen in Plate 16. The number and units in each *oonnipadu* vary considerably depending on the width of backwaters and nature of bottom (Pauly, 1991). In some places instead of poles floats and anchors are used to suspend the net.

Similar type of nets is operated in several parts of our country and is reported by several workers in the past. Fixed bag net is known as *behundi jal* or *thor jal* in Bengal and it is set against the current in the estuaries by fastening the wings using wooden anchors and empty oil barrels (Jones, 1946 ; Pillai and Ghosh, 1962). Bag nets are known as *dol* or *bokshi jal* in Gujarat and Maharashtra coast (Ghokhale, 1957; Ramamurthy and Muthu, 1969; Kurian and Sebastian, 1986; Sehara and Karbhari, 1987). Hickling (1961) reported the operation of a moored stow net in Mekong river of Cambodia. Bag nets are known as *kona jal,* in the river Brahmaputra (Joseph and Narayanan, 1965). It is also known as *been jal* (De 1987 and Mitra *et al.*, 1987).

In the Rann of Kutch region fixed bag nets, *gunja net,* is operated for the fishery of *Metapenenaeus kutchensis* (Pillai and Gopalakrishnan, 1984; Khan 1986

and Remesan *et al.*, 2002). *Dol* net in the creeks and estuaries of Konkan region is reported by Sankoli *et al.*, (1993). Investigations with improved design of *dol* net in Gujarat coast is carried out by Kunjipalu and Boopendranath (1993). Preliminary investigation with improved stake nets around Kakinada is carried out by Rama Rao *et al.*, (1993). The net is known as *thokavala* or *gidasavala* in the deltaic region of Krishna and Godhavari (Sreedhar *et al.*, 2005).

Hornell (1938) and Lal (1969) Kurian and Sebastian (1986) described the operation of stake nets in the backwaters of Kerala. Krishna Menon and Raman (1961) reported the stake net operation with reference to prawn fishery of Vembanad lake. Kurup and Samuel (1985) and Kurup *et al.*, (1993) mentioned about *oonni* or *kutti vala* in the rivers and Vembanad lake in central Kerala. Detailed description of the stake nets in Vembanad lake is reported by Pauly (1991). Kurup *et al.*, (1993) mentioned the stake net operation in Korapuzha estuary for prawn fishing and that of Kerala by Hridayanathan and Pauly (1993).

Stake net is generally known as *oonnivala* or *kutti vala* in north Kerala. It is also known as *kochi vala* in some parts of Kannur district because it is introduced in north Kerala by the fishermen migrated from Kochi. It is known as *vaale vala* (*vaale* = tail) in some parts of Kannur, because of the long bag. Net is operated in all the three districts in the estuarine areas. Net is tied to two main stakes, vertically driven into the bottom, supported by two other poles placed obliquely and tied to the main poles (Fig.38). Pauly (1991) reported that this type of base system is usually seen in places where the current is relatively weak. Areca nut tree, cassurina or vengana (*Carellia brachiata*) poles are mainly used. In some parts of Korapuzha bamboo poles are also used to fix the net.

3.2.6.2. Results and Discussion

The dimension of square mouthed nets varies from 2.5- 3.2 m, whereas the net with rectangular mouth the horizontal spread varies from 2.5- 3 m with a vertical span of 3- 3.8 m. Net with square mouth are relatively more in number in all the three districts The length of the bag varies 8-16 m in all types of nets. Number of

rectangular panels used in the constriction of the net as shown in the Fig. 38. The meshes at the periphery of these pieces are hung on to a rope, which is made into a loop at the four corners. Fore part of the net is usually fabricated using 3 mm dia. PP twine with 230- 250 mm mesh size. Middle part of the net is fabricated using PA multifilament with different mesh and twine size. Last part of the net is fabricated with PA mutifilament or knotless netting with 8-10 mm mesh size. Total cost of the net varies from Rs. 10,000 to 30,000.

Operation

Two fishermen are required for setting the net and they carry the net in the canoe and proceed to the stakes at the beginning of the low tide. After closing the codend a float is attached to it using a line for easy location. The bottom pair of loops is first tied to the poles with a pair of ropes. These hauling lines are pushed down with a pole forked at one end. The knot employed is such that one end of the line runs along the stake upward, passes through the upper loop and is used for tying the same to the stake a the top. The net is set in position just before or soon after the ebb tide has set in and is usually hauled up when the tide reverses. The time of operation is usually in the evenings extending into the early hours of daybreak. Both during full moon phase and new moon phase of a month, fishing is restricted to about half the period commencing on the 10^{th} or 11^{th} day and ending on the 4^{th} or 5^{th} day after the new and full moon. On some days when there is a good catch and when tides are favorable, fishing is done both in the evenings and early mornings of the same day. To haul the net fishermen untie the lower loops by pulling the hauling line at the surface and lift the lower edge of the net mouth to the surface by hauling the same rope. After removing the upper loops the whole net is hauled into the canoe and return to the shore. The catch is removed from the net by releasing the codend rope. Juveniles of prawns like *M. dobsoni, M. monoceros and F. indicus* and small fishes constitute the major share of the catch.

In Kallai river stake net fishermen practice a sort of quota system because the suitable area for stake net operation is limited. Net is operated only in the narrow channel, of about 30 m length and 20 m width at low tide, connecting the river and

sea. The stake netters in the region formed six groups, each group having 6-10 fishermen. Each group will get an opportunity to fish minimum one day in a week. Six nets are operated at time in two rows. The group operated net in the front row (towards river) will move to the back row during the second day and the new group will occupy the front row. Smaller sized nets are used in the region using bamboo stakes. Stakes are fixed temporarily and after each operation fishermen removes the poles and the next party will put their pole in the same day.

3.2.6.3. Maade valayal - Surrounding net

Encircling shallow areas temporarily using net walls with the help poles fixed at regular intervals is known as *Maade valayal* (*Maade* = mudflat and *valayal* = surrounding (Fig.39). The principle is to surround an area probably having fish shoal and later capture them during low tide by reducing the enclosed area. The only report available on this type of fishing method is by Remesan and Ramachandran (2004). It is an unique and ancient fishing method practiced by the members of a Muslim family living at the Port area of Valapatanam River in Kannur district. The net, also known as *thadave vala* (*thadave* = arrest) is similar to a rectangular shore seine in its construction and rigging.

The net is rectangular in shape and the length varies from 400- 500 m, which include 12-15 pieces, each having a length ranging from 25-35 m and 2.5-3.0 m height. It is made of PA multi filament of different twine sizes (210Dx1x2, 210Dx1x3, 210Dx2x2 or 210Dx2x3) with 20-30 mm mesh size. Usually old ring seine net is purchased from the sea fishermen and fabricate the net after cutting and shaping. However, new net of approximately 30 m length is used for the fabrication of the portion of net where the fishes are collected while hauling. After cutting and preparing the required pieces, the net is dipped in *Cutch* water for 24 hrs to strengthen the net. *Cutch* is the resin obtained from a tree, *Acacia catechu* and is available in local shops @Rs.80/-kg. The material is powdered and about 2 kg of powder is boiled with approximately 500 liters of water and 200 g of salt. Netting is dipped in the solution after cooling.

Wooden floats made of *Erythrina indica*, are also dipped in *Cutch* water. Branches having about 50 mm dia. are cut into 6-7 cm long pieces and boil in this preparation. Soft tissue in the middle of the cut pieces is removed using a thin stick, after cooling and the pieces are sun dried for about 24 hr before using as floats.

Coir ropes having 10-15 mm dia. are used as head rope and foot rope. According to the fishermen coir ropes are easy to handle, less strains to the hands, remain at the bottom and twisting is also less. Head rope and foot rope are extended to 2 to 2.5 m at both ends, beyond the length of the net. After three wooden floats one PVC float of 60x20 mm size is used to give sufficient buoyancy. Total cost for a new net is approximately Rs. 25,000. Other details of the net are given in Fig. 39.

Prior to the fishing trip all piece of nets are laced together and make two sets of about 200-250 m length, and load in two canoes. HR and FR at one end of each set are tied to about one meter long wooden pole. Then 100 - 120 m long coir ropes having 10-15 mm dia are tied to these poles, like a shore seine. Poles are used to prevent the net from twisting while dragging the net before setting.

Operation

Fishing season is restricted to only 4 months and it starts by the end of February extending up to the end of May every year. During these period water level is comparatively low in the estuarine areas of the river. During fishing season male members of the family living in distant place also assemble at their ancestral house at Valapatanam port and stay there till the end of the season.

Fishing is carried out for 14 –15 days in a month and it starts two days after the full and new moon, extending up to 6 to 7 days. During these period tidal amplitude is strong and water level in the estuarine parts of the river is minimum at low tide. 12 –18 fishermen operate the net using four canoes of OAL ranging from 4 to 6 m. Net is always set at night during high tide. They form four groups with four fishermen each and board in four canoes. Two canoes move together keeping about one km distance from the other two canoes. On reaching the ground with depth less than 2.5 m, four fishermen get into the water and take one end of the net. The canoe

with the net and other four fishermen moves from the place while releasing the net and rope. Other two canoes also repeat the process simultaneously. After releasing the net completely they drag the net by pulling the ropes against each other. The four fishermen standing in water on either end also moves toward each other while dragging the net. The purpose of using long ropes and dragging is to aggregate fishes towards the center. When they reach together the two sets of the net are joined. From other end also they join the net after removing the long ropes so as to form a circle and is then fixed enclosing a shallow area inside. FR is pressed into the bottom from all side to prevent the escape of fish. The HR is held straight above the water level with the help of 50 to 60 cassurina poles, of about 3.5 m lengths, driven into the bottom. The net is tied to these poles erected about 5-8 m interval using tender coconut tree leaves. It requires about two hours to complete the enclosing operation.

Hauling starts at about 6 a.m. in the next day when the tide is receding. They start the process only when the bottom inside the enclosure is visible to see the fish. 5-6 fishermen first enter into the enclosure while one of them starts removing the poles from one side. The fishermen inside the net drag the FR from the same side simultaneously, while the HR is being held above the water level. The process is continued till the distance between two walls of the net reduces to about 5 m. They fix the net using the same poles and a bag like structure having about 5 m length is created on the other end by tying the FR of folded net using coconut leaves. Then all fishermen move to the opposite end. The fishermen inside the net grab the foot ropes from adjacent sides, bring together and move back wards by sitting on their knee (Plate 17). They also catch fishes hiding in the bottom while dragging the net. Other fishermen remove the remaining poles and also help to hold the HR above water while moving.

On reaching the landing part HR and FR is lifted thus collecting the fishes inside the bag. *Chaundi jal* of Allahabad is released in a circular fashion in shallow water, later the area of the circle is reduced and the enclosed fishes are captured (George, 1971). In the operation of *wachchal*, encircling net, in Sri Lanka, after encircling an area fishermen start moving to the center of the circle holding the ends

of the adjacent nets together. When they reach the center the fish are trapped inside and the area inside the circle is reduced by gathering the nets gradually to collect the fish (Anon, 1995). Catch is emptied into the canoe by lifting the net. The remaining poles are also removed and the net is washed and taken into the canoes.

If they enclose the net in shallow areas, some areas of the bottom may get partially exposed during high tide. In that case, the fishermen catch the fish by hand after reducing the area of the enclosure. Then the net is washed and taken to the shore for sun drying. After disposing the catch, fishermen disperse and again assemble in the afternoon for the mending the net. The net is some times operated as shore seine after reducing the length.

Major share of the catch is constituted by *Mystus* spp. followed by *Sillago sihama* and *Gerres* spp. Sciaenids, (*Otolithus* sp. and *Johnius* sp.), rays, *Scylla serrata* and clupeids also constitute a portion of the catch. Catch usually varies from 10 to 100 kg. Highest catch obtained during the last few years was one full canoe of catfish.

Two family members own generally the craft and gear. The total income is divided into equal shares and the owners get two additional shares. However the total amount is shared equally when the catch is poor. Average income per day varies from Rs 50/- to 300/- per head. The new generation is not interested in this fishing method, since the catch is declining year after year. Proliferation of other types of gear fishing units, sand mining and aquatic pollution are the reasons cited for declining the catch. More labour requirement also makes this fishing method uneconomical.

3.2.6.4. Beppe vala - Drive-in-net

Scare lines are known as *beppe* and *beppe vala* is a drive-in-net operated in the middle reaches of Kuppam river in Kannur district. It is rectangular in shape, about 30 m long and 3 –3.5 m wide. Net is made of PA multifilament of 210Dx1x3 or 210Dx2x2 with 20-25 mm mesh size. Coir rope having 10-12 mm dia is used as head rope and foot rope whereas PP rope of about 6-8 mm is also seen in some

places. Head rope and foot rope rigging are similar to a seine net as shown in the Fig. 40.

One end of the net is attached to a 15 mm dia coir rope of approximately 800 m length. About half of the rope adjacent to the net is made as scare line by inserting fresh coconut leaves without slivers or polythene ribbons into the rope. Dried coconut tree leaves are used to make scare line for the drive-in-net operated in the lagoons of Lakshadweep (Vjay Anand, 1996). Anon (1995) reported that the drive in device of *viduvalai* operated in Sri Lanka consists of two 10 to12 mm dia coir ropes each of which is about 50 m long on to which the coconut leaves or Palmyra leaves are attached as streamers (Plate 18). Stones weighing 2-3 kg are attached to the scare line at about 10 m intervals.

Net is operated during all season irrespective of the condition of the tide where the bottom is clear. One or two fishermen operate the net with the help of a small canoe. Head rope, foot rope and few meshes in the center of the free end of the net are tied to a wooden pole of about 2 m lengths which is driven into the bottom close to the shore. The canoe carries the remaining portion of the net and scare line and it moves in a circular manner while releasing the net and scare line. The net takes an arc shape with sagging in the center as it is held against tidal current. As soon as the canoe comes back to the shore about 150 m away form the pole, fisherman starts hauling the rope. While hauling he moves along the shore towards the net. On seeing the approaching line, scared fishes in the circle rush towards the opposite side where the net is kept.

According to Krishnamurthy and Rao (1970) *kalavalai* is fixed in Pulicat lake and a scare line of thick coir rope is operated by two fishermen, who stand opposite to the net. George (1971) reported that the *Gopal jal* of Allahabad is put in the form of 'U' and the fishes are driven into by scare line. Finally the line and the net are hauled and trapped fishes are removed. After changing the area the process is repeated. Fishes like pearl spot, mullet, silver biddies and catfish usually constitute the catch.

3.2.6.5. Vellavali / Verppe – Scare lines

It is basically a scare line with a median loop and two long arms held in the form of 'V'. (*Vella* = white and *vali* = dragging). The line is made by inserting fresh coconut leaves without mid ribs or white polythene ribbons into a 100 to120 m long coir rope having 8 -10 mm dia. This type fishing is prevalent in Kuttiadi, Korapuzha and Chaliyar in Kozhikode; Kavvayi and Kariangode rivers in Kasargod districts.

In Kariangode river 3 to 4 fishermen operate the line at low tide using a canoe of 4 to 5 m OAL. They make a long burrow at about 1.5 to 2 m depth, parallel to the shore, with their feet. The length of the burrow ranges from 0.5 to 1.2 km depending on the area. Two wooden poles each having about 3m size are erected at the beginning and end of the burrow to indicate its position. Usually fishing starts by early morning and continues up to midday. Two persons standing on either side of the burrow hold the ends of the scare line and starts walking about 5-6 m apart. If depth is more then the fisherman on the deeper side moves with the help of a wooden or bamboo pole. Third man who is standing in the middle inserts his right leg through the median loop of the rope and he moves on his left knee. He always moves behind the other two along the burrow so that the line takes a "V" shape (Plate 19). The scare line is dragged along the direction of the current to trap the fish moving against the current. Disturbed by the trampling men and probably frightened by the vibrating rope the fish comes and crowed at the apex. At frequent intervals the diver dives down and actually grabs the fish by hand (Gopinath, 1953).

Fishes, which is scared by these lines usually, takes shelter in the burrow. Hornell (1938) reported that the fishes swim towards the apex of the triangle formed by the diverging warps, while trying to escape. The person pulling the canoe and walking through the burrow feel the presence of fish with his feet. In clear and shallow waters the burrowing fishes can be seen by the presence of muddy patches on the water surface as the fish churn the bottom while burrowing. Periodically he crawls in his knee, put his head under water and watch for the fish. *Etroplus suratensis* forms the major share of the catch. Other fishes including crustaceans are also caught. After reaching the other end of the burrow they shift the ground and

repeat the process. The poles are often left in the same position and after few days lines are again operated in the same place.

Slight variations occur in the operation of these lines from place to place. Lines are operated without making a burrow in all places except at Padanna in Kariangode river. In some places one or two stones of about 2-4 kg are attached to the middle of the scare line to make it "V" shape. In such cases the third and fourth fishermen catch the fish either operating a plunge basket behind scare line or by hand picking. John (1936) reported the use of cast net in conjunction with the scare line in fresh water fisheries of Travancore. Some fishermen continuously drag the scare line from one place to other along the shore without making burrows in the bottom. In *Vallikodi* fishing of Pulicat lake (Hornell, 1938, Krishnamurthy and Rao, 1970) fishes and prawns are captured by hand, after they are scared towards the fishing party by a scare line of Palmyra leaves. According to George (1971), *Chir* fishing at Hoshangabad is similar type of fishing in which Palmyra leave threaded to ropes are used to congregate the fish. Encircling an area with the scare line and capturing the fish by hand after reducing the areas of enclosure is also exist.

Kayam valakkal (*Kayam* = depth and *valakkal* = surrounding) at Palai to Kayyur area in Kariangode is an interesting variation in scare line fishing. It practiced during August to September when the water becomes clear to see the fish. 5-6 fishermen operated the gear using a canoe and a scare line of about 150 m length. Gear is operated with 1-2 plunge baskets, irrespective of the condition of tide. The person standing in the shore or on a mud flat holds one end of the line. Rest of the line is released in a circular fashion from the canoe and it returns to the other side of the mud flat. When the fishermen holding the ends of the line moves closer and haul the line, the other two fishermen standing in water just out side the scare line watch for the fishes in the circle, which are coming closer to the line. Karamchandini and Pandit (1967) reported that one end of the scare line is tied to the free leg of one of the two fishermen holding the net, the rest of the scare line is laid in water in semi-circle fashion and dragged towards the river bank in Narbada. They also move along with the line and operate plunge basket to catch the fish, which are coming closer to the line.

Another type of scare line fishing, known as *verpe,* is also practiced in this area during summer season. 4-5 fishermen, one cast net and two pieces of scare lines, each having about 15 m length is required for the operation. First two fishermen keep a cast net or a bag net open by holding its mouth at about 1.5m depths. They also hold one end of the two scare lines. Anon (1995) while explaining the operation of *vidu valai* in Sri Lanka reported that two fishermen set the net in the water and hold it to facilitate the proper opening of the mouth of the net, while the bottom rope is kept under their feet. Another two people standing on either side of the net hold the other ends of the line. While dragging the net and line, they start moving towards the mud flat to drive the fish forward. Those holding the free ends of the line reach the shore first thereby spreading the line in a circular form. When these two starts walking along the shore, against each other the other two in the water also drags the net towards the shore. Finally, the area or the circle is reduced and the net is brought to the shore while driving all the fishes into the net. Hornell (1924) while describing *ola vala* stated that the holders of the scare line advances slowly converging upon the crescent of the net to drive them towards the net. Pearl spot forms the major share of the catch and catch is better in the beginning of the post monsoon season.

3.2.6.6. Thande vala/ vadi vala - Stick held drag net

It is a bag net with rectangular mouth, which is held open with the help of two sticks attached to both sides. Use of this net in shallow waters is reported by Ramamurthy and Muthu (1969). A number of similar drag nets are operated in Pulicat lake with little variations in mesh size, length of netting and mode of operation to suit the target fishes (Krishnamurthy and Rao, 1970). Kurien and Sebastian (1986) also reported this type fishing method. The drag net operated in the backwaters of Cochin is bag shaped and has a fixed mouth opening of about 4x1m and is about 6 m long (Pravin, 2003). Fore part of the net about two meters from the mouth is made of PA 210D x 2x2 and rest with 210Dx2x3 with a uniform mesh size of 15-20 mm. Selvedge is two mesh depth and is made of PA 210Dx14x3 having 30 mm mesh size. Net is mounted with PP rope of 4 mm dia. About 40 sinkers, each weighing approximately 15g, are attached to the rope in the lower part

of the net mouth at 10 cm intervals. Two wooden sticks, each having about two meter length are attached to either side of the net to facilitate dragging (Plate 20).

Dragnets are operated in rivulets and backwaters of Kozhikode and Kannur district. Two fishermen wading in shallow waters drag the net by holding the sticks. Periodically the net is lifted to wash and remove the catch. Catch is mainly small prawns, mud crab and fishes.

3.2.6.7. Koruvala – Multiple stick held drag net

Koruvala is a multiple stick held drag net having 7-9 m length and three meter height. Net is similar to the *vadi vala* operated in Kerala (Hornell, 1938, Shetty, 1965 and Ramamurthy and Muthu, 1969). Krishnamurthy and Rao (1970) reported the operation of *Kondavavalai* in Pulicat lake. George (1971) reported *konda vala* or *kondala* from Wijayawada. Operation of *koruvala* in estuaries and backwaters of Kerala for prawn fishery is reported by Kurian and Sebastian (1986). It is made using PA multi filament of size 210Dx1x3 with a mesh size ranging from 10 – 22 mm. PP ropes with 5 mm dia. are used to mount the net. Seven poles, each having one meter length are used to keep the net mouth open. Poles are placed vertically between the opposite margins and tied at equal distance so as to take a rectangular shape with a shallow bag when dragged against current. Ramamurthy and Muthu (1969) reported that the mouth of the net is kept open by sticks tied at intervals.

Koruvala is seen in Chithari river, in Kasargod and its operation is similar to that of a simple drag net. Two fishermen hold both side of the net mouth and the third person from the center. The net is dragged in shallow waters keeping the ground rope at the bottom with the help of the foot. The ends of the net are lifted and the men come close together gathering the sticks quickly such that the catch is collected in the center of the bag. Periodically they lift the net and wash the content to collect fishes. Prawns and small varieties of fishes form the major shares of the catch.

3.2.6.8. Scoop net

Scoop nets are small bag nets with a circular mouth, which is mounted on a creeper stem. The bag is about 1.5 m long with 0.7 m dia at the mouth. It is made of PA 210Dx1x2 or 210Dx1x3 with 20 to 25 mm mesh size. The dia meter of the bag reduces to about 0.2 m at the codend. The posterior end of the codend is closed with a piece of twine.

Fisherman wading in knee-deep water operates the net. He holds the net by both hands and keeps it close to bottom by bending his body. Then the net is dragged along the bottom for 4-5 m by moving backward. Net is lifted periodically and washed and the catch is removed. The process is repeated till the commencement of high tide. *E. maculatus, Etroplus suratensis, Glossogobius giuris*, mullets, prawns and crabs are the target species. Presently this type of fishing is almost stopped because of the poor landings of *E. maculatus*, which forms the major share of the catch. Small types of scoop nets having circular or oval shape is used to catch the fish from the chambers of screen barriers.

3.2.6.9. Stick held scoop net

Stick held scoop net (Plate 21) with a shallow bag is operated in the upper reaches of Kuppam and Valapatanam rivers. The oval shaped frame of the net is made using 1-3 mm dia. mild steel rods and its size ranges from 20-35 cm dia. Net is made of PA mono or multi filament with 20-40 mm mesh size. Net is attached to a 1-1.5m long and 10-15mm dia bamboo or other light wooden poles.

Two fishermen operate the net from a canoe during moonless nights with the help of a powerful torchlight. Vijay Anand (1996) reported the use of lights at night in Lakshadweep either to attract fish or stun them and make them vulnerable to capture. Fisherman standing near the bow holds the net in the right hand and torchlight in the left hand. During operation one fisherman slowly paddles the canoe along the shore without disturbing the water, while the other man look for fish from the front. When a fish is sighted in the striking range it is scooped out with a quick motion. This type of fishing is known as *aru nokkal* (*aru*= shoreline, *nokkal*=

watching) in Kuppam river. Some times birds sitting on the shoreline vegetation are also captured by beating with the handle of the net. Kurup *et al.*, (1993) reported that *ottipiditham* is carried out during new moon phases when fishes are attracted towards the light emitted from the bamboo torch/petromax while they are bailed out with the help of a scoop net.

Stick held scoop net of about 1.2 m length and 0.5 m dia. at the mouth made of mosquito net is used to catch attentive carplets (*Amblypharyngodon melettinus*) in Chaliyar (Plate 22). This fish usually comes in large shoals near the check dam at Kavanakkalle where the salinity of the water is almost zero due to the overflowing water from the upper side of the check dam. Shoals are seen as dark patches near the surface adjacent the dam. Fishermen scoop out the shoal with a quick motion and 2-3 kg of fishes are caught in a single haul.

3.2.6.10. Scoop net for clams

Scoop nets are used in Kavvayi, Valiaparambe, Padanna and Mundayamade of Kariangode river and Puthiyapuzha and Kunneru area of Peruvamba river mainly by fishermen from south Kerala. The length of the net varies from 1-3 m and is made of PE having 0.5 - 0.75 mm twine dia. PA multifilament of 210Dx2x3 is also used in some places. Mesh size varies from 20-30 mm stretched. Mouth of the net is mounted to a rectangular steel frame of about 35x15 cm. The upper and lower part of the frame is 35x1.5 cm and is made of steel plate of about 5 mm dia. It is welded to the two steel pipes on either side at about 45° to facilitate scooping. Net is mounted to the frame through the holes on the upper and lower part of the frame. Oval shaped or circular frames made of creeper stem are used to mount the net in Peruvamba river (Plate 22)

One or two fishermen carry out clam fishing using a canoe. Operation starts during early morning and it extend up to 12 pm. They dives up to 3 - 5 m depths by holding the net and the bottom is scooped. Before diving he make a heap at the bottom using his feet, if the depth is less than the height of the person. Lakshmilatha and Appukuttan (2002) reported that in Vembanad lake women feel and detect the

clam bed by their feet and remove the clay over the clams to a particular spot and guide the collected clams to their baskets. Some people keep the net in the bottom using the left leg and with the right leg they sweep the bottom and put in the net. Clams are also collected by hand picking or using a small bamboo basket. Clams are washed and after several attempts the content of the net is emptied to the canoe. Ladies engaged in hand picking of clams in the mouth of Kavvayi river put 5-6 kg of sand in a piece of cloth and make a bundle. While diving they carry these bundles on their head to counteract the upward thrust of water.

A fishermen in Kariangode river collects about 5 basket of clams per day which is sold to the vendors, or middleman @ 35/basket. Ladies prepare clam meat after boiling fresh clams and the meet is supplied to the nearby houses @ Rs.10 per 0.25 kg.

3.2.6.11. Ring-Baited lift net

It consists of an iron ring of 0.5-0.6 m dia made of M. S rod of 4-6 mm dia to which a basket like net is fastened as to form a shallow scoop net with 15 – 20 cm depth. Baited lift nets are very popular in almost all rivers and backwaters of Kerala and it started when the trade of live export of *Scylla serrata* picked up. Since live crabs with intact legs are only suitable for export, use of other types of gear such as seine net or gill net is not suitable for harvesting of crabs. Babu *et al.*, (2005) reported that basket trap (a kind of baited lift net) is the ideal gear for crab harvesting. This gear is operated round the clock and through out the year as well in all most all parts in north Kerala due to the high demand of live *Scylla serrata* in the export market. The fishermen in the upper reaches of Korapuzha use old cycle tyre rum for mounting the net.

PE netting made of 1- 1.5 mm dia having 20-40 mm mesh size is used for the fabrication of the net. This type of net is known as *phuck* in Bombay, which is let down and hauled up by a long cord attached to the hoop by three bridles (Chhapgar, 1961). A PVC float, plastic bottle or thermocole piece is attached to the free end of

the rope to indicate location and facilitate retrieving. Two cross pieces of thicker twine, tied tightly across the ring hold the bait (Plate 23).

Eel pieces, chicken parts and beef intestine are used as bait in the net and it is attached to the ropes running across the frame. *Kakulu thati* is a baited lift net operated for lagoon crabs in Sri Lanka in which cut pieces of skates are used as bait (Anon, 1995). Sathyanarayanappa *et al.*, (1987) reported that shark gut contents, frogs and flesh of cat fishes are tied to the netting and the *yedi bale*, ring net, is kept in turbid waters. Fishermen carry 15-20 numbers of rings at a time and it is dropped in waters at about 5 m intervals. The length of rope is roughly adjusted according to the depth of the water body.

Net is hauled periodically from the canoe and crab holding on to the bait is released into the canoe by a slight jerk. The ring is released back after taking the crab and the process continues till evening. The *uri-vala*, float net described by John (1936) used for catching *Etroplus maculatus* in backwaters of Travancore is similar to baited net. A similar contrivance with minor adaptations is used for catching lobsters in South Africa (Chopra, 1936) and crabs in California (Lahr, 1939). *Kawahagi ami* is a baited lift net operated in Japan for filefish (Anon, 1960). According to Devasia and Balakrishnan (1985) round net (*nandu vala*) is operated in shallow regions of Cochin backwater with salted eel or catfish head as bait. The chelate legs are tied together and the crabs are stored in bamboo basket. Crabs are sold to the merchants @ Rs.40-250/kg depending on the size and condition of the crab.

3.2.6.12. Cross bow

It is employed to shoot the fish in the streams and quiet backwaters, which occupy extensive areas in the coastal region (Hornell, 1938). Cross bow known as *thettali* is operated in Valapatanam river by a fisherman migrated from Ernakulam district. The bow is made of 3 thin areca nut tree strips, of varying lengths and rectangular shape in cross section, arranged in the same way as the leaves of a carriage spring. The longest strip in the front is about 1.5 m long. At intervals the

component leaves are secured using coir yarn. The second and third strips are having 130 cm and 110cm respectively. A rectangular hole is made in the distal portion of the stock, *kai*, through this the bow part is passed half way and is locked using thin wooden strips. The stock is made of teak and is about 60 cm in length with a downward bent in the backside for holding the bow while shooting. The trigger and the wheel nut are made of buffalo horn to reduce the wear and tare. A shallow groove runs length wise along the upper side of the stock forward of the butt region, in which the arrow, *koore*, lies before shooting. The bowstring is also about 150 cm long and is made of 4 mm dia. PP rope. The 90 cm long barbed arrow is made of 4 mm dia. SS rod. The base part of the arrow is flat and is conical in shape. One end of a 3 m long PA monofilament of 0.8 mm dia. is tied to the base of the arrow and the other end to the middle of the bow.

It is operated close to the shore or from a canoe during night. Clear and calm water is a pre requisite for this fishing method. Two people are required for operation from a canoe. The person standing in the bow part of the canoe holds the cross bow and lookout for the fish. The second person paddles the canoe without much disturbance. The fishes attracted to the light during night are shot from the canoe and the line is pulled to retrieve the fish.

3.2.6.13. Spear and trident

Spear is simple metallic rod with a pointed tip operated to catch shellfish in shallow waters. Though it is a primitive hunting tool, people in some parts of the country are still using it. Spears operated in Kadalundi and Kuttiadi rivers are made by fixing a sharp iron piece to one end of two meter long narrow wooden pole. Three pronged iron spear attached to three meter long bamboo poles are used during dark night with the help of a lamp to capture large mullets in Chilka lake (Biswas, 1995). Barbed spears are operated in the upper reaches of Kadalundi river for fresh water prawns.

Tridents (three pronged spear) are used for catching *Macrobrachium rosenbergii* at Payyoli in Kuttiadi river and Kattampally in Valapatanam river during

monsoon. To increase their efficiency fish spears are provided with several prongs (Brandt, 1972). The trident operated in Kattampally is made of 6 mm dia. steel rod of about 50 cm length. One end of the rod is pointed and it is fixed to a 1.5 m long and 15mm dia Areca nut tree pole. The other end of the trident is made 3 mm dia. steel rod having about15 cm length. It is operated mainly during night with the help of a lamp. The fisherman walk along the shore on seeing the prawn or crab the spear is pushed to pierces its body.

3.2.6.14. Kambi - Hook for crabs

It is a simple straight iron rod with one end slightly curved in the form of 'J'. Steel rod having 1.5 - 2 m length and 3 - 4 mm dia. is used for making the rod known as *kambi*. The curved end is pointed for easily hooking the crab and the other end is also sharpened in order to pierce the body of crabs. It is used in backwater and inter-tidal areas to pull out mud crab from their burrows. Hora (1935) described the use of a blunt iron hook, lashed to a piece of split bamboo to catch crabs living in burrows.

Operation is usually carried out during low tide when the crab burrows get exposed. The hooked end is thrust into the hole for the detection of the crab before actual fishing. It is moved up and down to feel the location of the crab in the burrow and maneuvered in such a way that the crab is hooked. When the crab is agitated it firmly clings to the rod with the help of its strong *chela*. Crabs are dragged out of the hole using hooked rods known as *sik* in Sundarban (Nandini and Pramanik, 1994). The blunt iron hook at the lower end of the bamboo stick is used for hooking the crab in its burrow at Uttarbhag (Chopra, 1939). *Dharkan* and *aankdi* are similar curved hooks used for catching crabs in Bombay (Chhapgar, 1961). The other side of the *kambi* used in Chithari river is pointed like a spear and is used to pierce and catch the crab with the help of a torch light.

3.2.6.15. Nanje kalakkal- Icthyotoxins

Although it is a prohibited method, toxins of plant origin are used to catch fishes in small water bodies. An account of destructive methods of Nilgiri district is reported by Wilson (1907) and fishing in rivers of hill ranges of Travancore is reported by Jones (1946). Indigenous plant piscicides used in Northeastern India has been reported by Sharma *et al.*, (2005).

Stem of *Kareencha* (*Acacia pennata*) and seeds of *Mullukuru* (*Anamirta cocculus*), *Kutappnakuru* (*Corpha umbraculifera*), *Veli avanakku* (*Jatropha curcas)*, *Neervalam* (*Croton tiglium*) and *Sapium indicum* are crushed and used. Leaves of *Nanchumaram* (*Croton kloteschianus*), *Poothakarandavalli* (*Derris brevipes*), etc are crushed and used (Jones, 1946). According to Brandt (1972) toxic plant parts are crushed, cut to pieces or pulverized and sprinkled on the water or added to the bait. In Rajasthan, rotenone obtained from the roots of the plants *Derris elliptica, D. uligmosa* and *D. lagensis* is used as fish poison (Kulshreshtha, 1986). This type of fishing is generally known as *nanje kalakkal* in north Kerala.

In Korapuzha fishing using toxins are practiced in some pockets in the middle stretches. First they set a bag net facing the water flow in the lower side of the stream with the help of sinkers and floats (Fig. 41). The poison is mixed with water and is sprayed in the upper side of the stream. The affected fishes are washed into the net by water current. Sharma *et al.,* (2005) reported that stems of cactus are cut into small pieces and are thrown into pools of streams. Within minutes, fishes are stupefied and start gasping and are easily caught by hands or using simple fishing gears At Akalapuzha, in Kuttiadi river, fishermen encircle an area with gill net. Then the *Croton tiglium* made as a paste is mixed with water and sprayed inside the enclosure. Affected fishes accumulates inside the net wall towards the direction of water flow which are easily caught by hand

3.2.6.16. Explosives

Dynamiting, even though prohibited is rarely practiced in some parts of the region. In Kerala, local made bombs, *thotta*, is used in upstream of rivers. The fishes

come up due to shock and those that die sink down immediately. Affected fishes are usually captured by diving.

3.2.6.17. Electrical fishing

Electrical current is applied to kill the fish or just to give a shock so that it can be captured easily. It is practiced in smaller water bodies like ponds and canals very rarely. Electrical wire is coiled and the bundle is immersed in water, after tying to a long coir rope. Fisherman on the shore holds the other end of the rope. Electricity is taken from near by electrical post and passed in the water through the coiled wire. The fishermen apply electricity to all parts of the pond by dragging the immersed wire by pulling the rope. The fish is stunned, loses its ability to swim and it goes from the cathode to the anode with its tail ahead (Lal, 1969). According to Brandt (1972), one advantage of electrical fishing is the fishes can be guided to a desired spot.

3.2.6.18. Sluice net

Sluice net is a stationary conical shaped filtering device which is attached to a wooden or metal frame, fitted into slots on the sluice gate (Pravin, 2003). The net is used for harvesting shrimps from the traditional prawn farms. Size of the net varies depending on the size of the pond as well as the sluice gate. Length usually varies from 5-8 m with a mesh size of 10-25 mm. The net is fabricated similar to a stake net in which a number of rectangular panels are joined together. PA multifilament netting made of 210Dx1x2 and 210Dx1x3 twines are commonly used for making the net. Mesh size reduces from 25 to 10 mm in the codend. Selvedge is one mesh in depth and is made using PA 210Dx2x3.

Sluice nets are widely used in the prawn filtration fields (Panikkar, 1937; George *et al.*, 1968 and Kathirvel, 1978). Filtration starts 3-4 days before the full or new moon days and it extends another 3-4 days after the full or new moon. Usually it is carried out after dusk or before dawn during low tide. Maximum quantity of incoming spring tide is kept inside the pond with the help of shutters of the sluice and when the water starts receding, the net is fixed to the sluice and the shutter

planks are removed (Plate 24). When the water rushes into the net prawns and small fishes are filtered. The man on watch from the canoe kept near the gate periodically lift the codend and empty the catch into the canoe.

3.2.6.19. Cover net

Cover net is operated in Mandankave and Aneelakadave area in Korapuzha river. This gear looks like a small cast net, which is kept open with the help of an iron hoop of about 60 cm dia. It is made of PA multifilament of 210D x 1 x 2 with 30-40 mm mesh size. Spherical lead sinkers are attached to the foot rope. Apex part of the net is attached to a stick of about 1-1.5 m size. Net is operated in shallow areas during night with the help of torchlight. Fishermen hold the stick and cover the fish with the net like a plunge basket. It works well even in uneven grounds since the peripheral part is having sinkers.

3.2.6.20. Hand picking

It is a well known fishing method in shallow inland water bodies and is reported by several workers. Hand picking is practiced in shallow waters in several places for fish and shellfish. Ladies sit in a row across a channel, moves in their knees holding a bag by their teeth to carry the catch (Fig. 42). They feel the bottom by hand and collect the fish burying in the mud. Periodically mud is collected from bottom and throws to their front to frighten the fish and induce them to burry. Hand picking for clams and oysters are also common in the lower reaches of several rivers. Ladies carry a sand bag weighing about 4 kg on their head hand while picking clams in the estuarine area of Peruvamba river. The load on the head helps them to dive fast and remain sufficient time under water to collect clams.

3.2.6.21. Edible oyster fishing

The backwater oyster, *Crassostrea madrasensis,* is known as *muru* in Kannur and Kozhikode districts. Usually it seen as attached to rocks, concrete walls, jetties and other hard submerged substratum Though it is distributed in the rocky areas in the estuarine parts of several rivers, fishing is restricted to few places.

Collection of edible oyster is known as *muru muttal* in Kannur and is carried out by few people from shallow waters at Dharmadam and Pinarai in Ancharakandy river and at Elathur in Korapuzha river. Fishing is carried out through out the season at low tide when the rocky areas get partially exposed. In slightly deeper areas it is collected by skin diving (Plate 25). Ladies are also engaged in oyster fishing at Dharmadam, in Anjarakandy river. They use local made knives for removing oysters from rocks. Fishing usually starts by early morning and return back after 3-5 hours. Meat is separated from the shells using a knife and it is put in a bucket containing water. Meat is sold @ Rs.50-60/100 pieces and they make Rs.200-300 per day.

3.2.6.22. Kaade valayal - FAD

Making artificial fish shelters by planting tree branches in shallow waters and the subsequent capture of fishes, which are sheltered inside is known as *kaade valayal* (*kaade*= forest, *valayal*= surrounding). This type of fishing is extensively practiced in all backwaters making use of the peculiar habit of the fish gathering around any submerged objects. Fish attracting devices like the *acadjas* in West Africa (Welcomme, 1972) or the *kathas* of South Asia (Wahab and Kibria, 1994) establish dense mass of branches in lakes and lagoons. According to Yadava *et al.*, (1981) and Sharma and Ahamad (1998), *Jeng* fishing in the *beels* of Assam is a post monsoon activity whereby a habitat for shelter of fishes is created by dumping tree branches, bamboo shoots and water hyacinth. According to Hasan *et al.*, (1999) brush parks, *komars,* are kinds of FAD made of bamboo and tree branches set in September-October and usually fished every 2-3 months from January-June. Choudhury, (1992) reported that *khatals,* floating fish parks, are set in *beels* of NEH region using tree branches and water hyacinth. A fish aggregating device, *phoomdi,* made of aquatic weeds and grass is used in Loktak lake in Manipur (Suresh, 2000 & 2002).

The branches are planted in the form of a circle with the peripheral part of the circle having branches with maximum height. Welcomme, (1972, 2002) reported that *refuge traps, vegetation parks* or *fish parks* are particularly rich trophically because of the abundance of epiphytic organisms, boring insects and molluscs on the

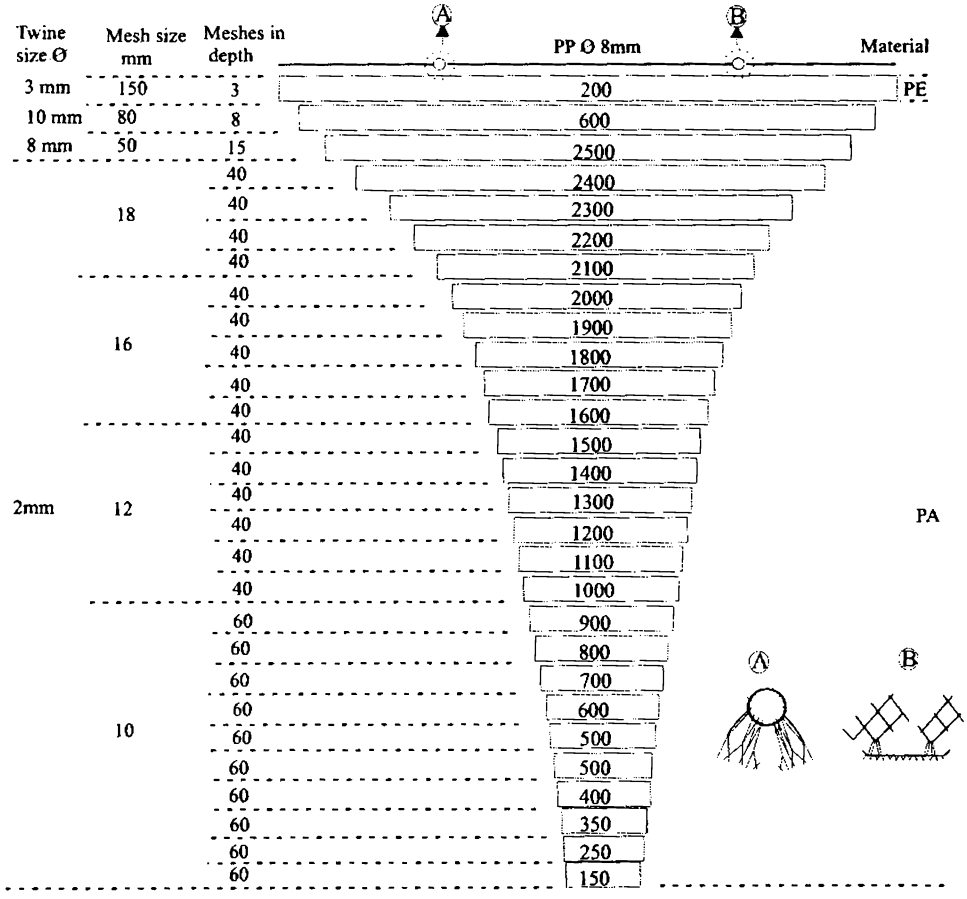
submerged surfaces of the wood and the root systems, and because of the enriched bottom mud caused by decay of the woody material. Total production from *katha* (brush pile) was estimated at 750kg/ha/year in floodplain river *titas* in Bangladesh (Ahamad *et al.*, 2003). In some places tapioca and other food waste are put inside the circle to attract more fishes. After two to three weeks the structure is enclosed with bamboo screens or netting. The brush piles, *kottu*, are left unvisited, in a particular place of the lagoon in Sri Lanka, for 3-4 days when targeting for prawns and for around 30 days when targeting for fish (Anon, 1995).

According to Brandt (1972) large heaps of brushwood are deposited at or between stakes and these heaps are shaken or slightly lifted after the site has been encircled by gill nets or traps in which to catch the fish when they endeavor to escape. The net is held upright by being tied to circle of poles driven securely into the bed of the *jeel* or stream and projecting several feet above the surface of water (Hornell, 1924, 1938). Later they remove all bushes inside the circle and the screen is pushed towards center from all sides to reduce the area inside the circle. Trapped fishes are usually captured using scoop nets or cast net.

This type of FAD is set in the backwaters of several rivers in Kerala (Plate 26). John (1936) reported this type of fishing methods in Kerala. Yield from this kind of parks usually depends on the amount of vegetation, age as well as the location. According to the fishermen branches of trees like *Anacardium occidentale* (cashew) is good in attracting fishes like Pearl spot as the resin comes out of the decomposing branches act as an attractant. Gopinath, (1953) reported that fishes are gathered around the bush park, probably to feed on the organic detritus formed on the leaves or to seek protection from the sun and enemies. Kurup *et al.*, (1993) reported that the principle of thigmotropism has been employed in *padal, kettupadal, nurumpu* in which artificial reef is made on a platform and placed beneath the water along the marginal fringes of the lake. According to Ahamad *et al.*, (2003) locally available feed ingredients are used to attract fishes in brush shelters in the Kaptai reservoir in Bangladesh.

However, fishermen operating other types of gear objects putting vegetation in open waters as the fishing gear may get entangled to these structures. According to Hornell (1938) obstruction to the current caused by the bushes lying for comparatively longer period on the bottom of a channel has a silting effect and therefore this fishing method is prohibited in some areas. However, when properly managed very high yields per unit area can be obtained and the structures can change from simple fish attracting devices to a form of aquaculture whereby net production from a river or lake can be increased (Welcomme, 2002). It is estimated that on an average of 200 - 800 kg of juveniles and sub-adults are caught in a month from the *padals* of Ashtamudi estuary (Thomas and Kurup, 2004). Along with adult fish lot of juveniles also assemble among the vegetation, which need to be spared to while harvesting to have sustainable yield from these water bodies.

Six types of fishing crafts and about 38 types of fishing gears and methods adopted in the inland waters of the region are described. Fishing crafts used and their dimension are almost similar in Kerala. Gill nets are the most popular gear used for inland fishing in all parts of Kerala. Mud crab gill nets are not reported from any other parts of Kerala. Materials used and method of rigging of gill nets and seine nets are same throughout Kerala. Use of locally available materials as floats and sinkers in gill nets are common in all places. Traps like screen barriers and box traps are seen only in North Kerala. The only one cross bow seen in Valapatanam river during the study is actually brought and operated by a migrant fisherman from Ernakulam. Chinese dip nets are not used in north Kerala. The reports available on the inland fishing gears in other parts of Kerala are incomplete and hence a detailed comparative analysis is difficult.



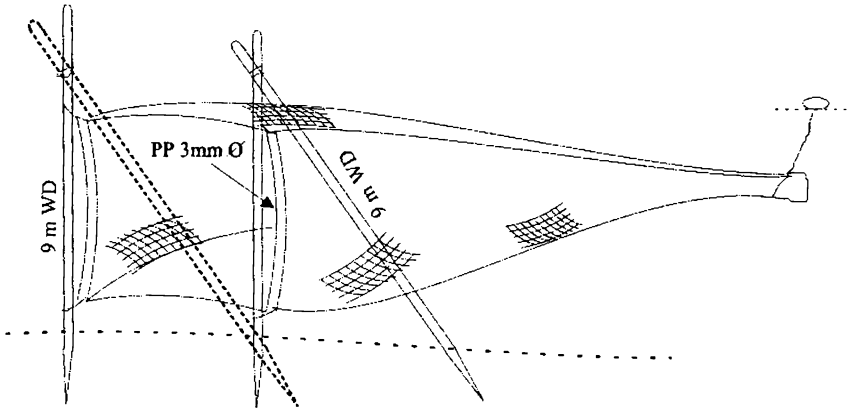
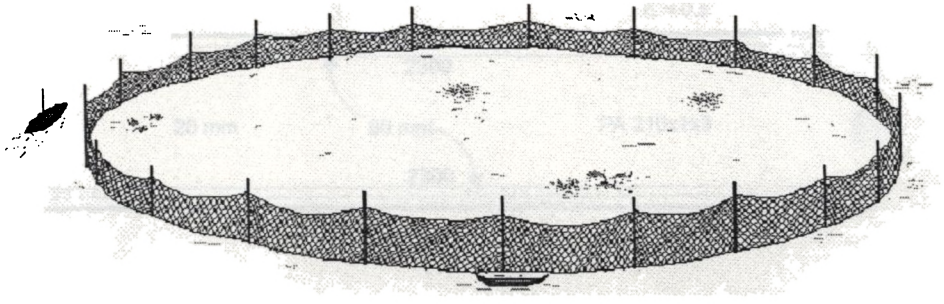


Fig. 38 Design of a stake net from Kuppam river



Net after setting with the help of wooden poles

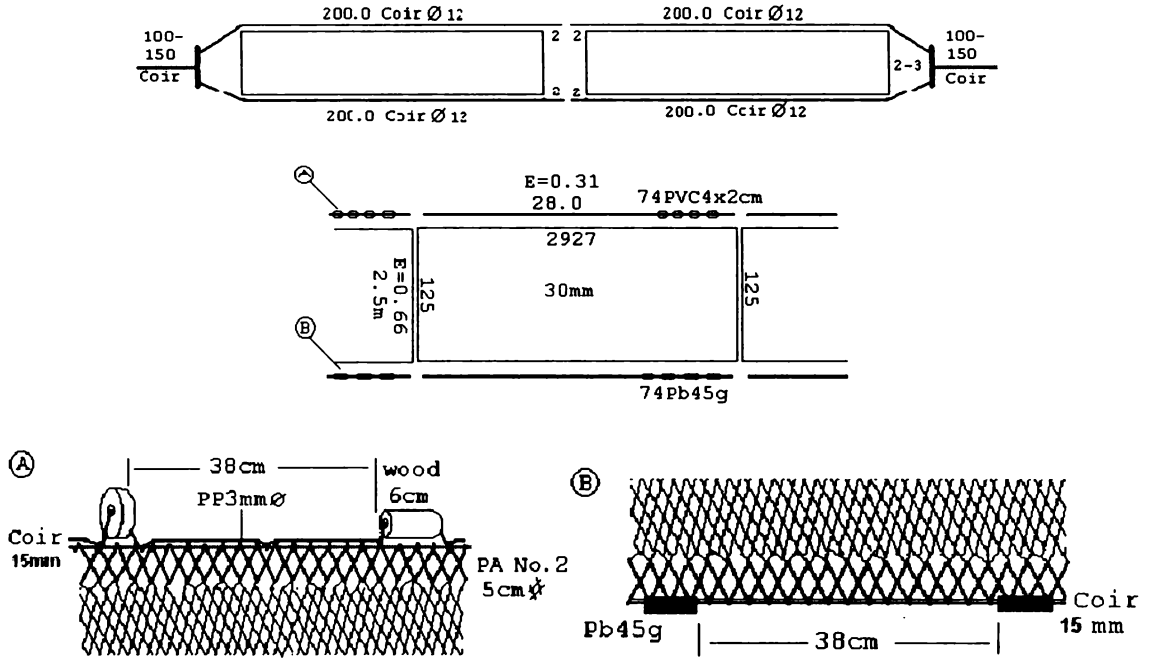
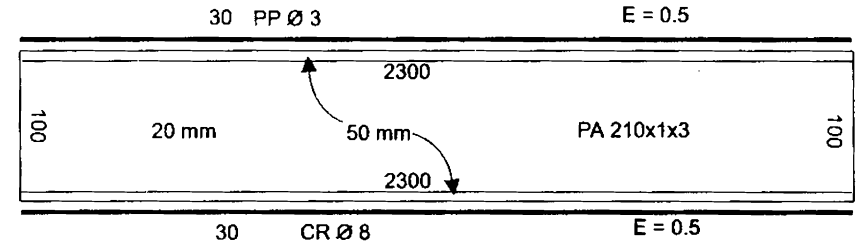
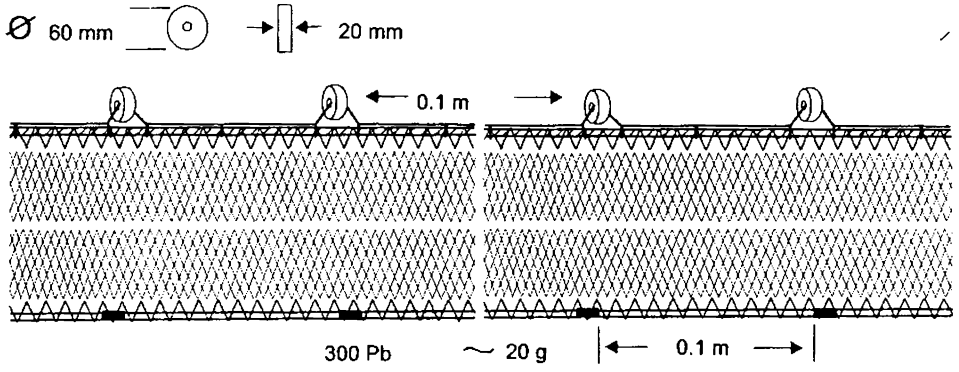


Fig. 39 Design & rigging details of net used for *maadevalayal*





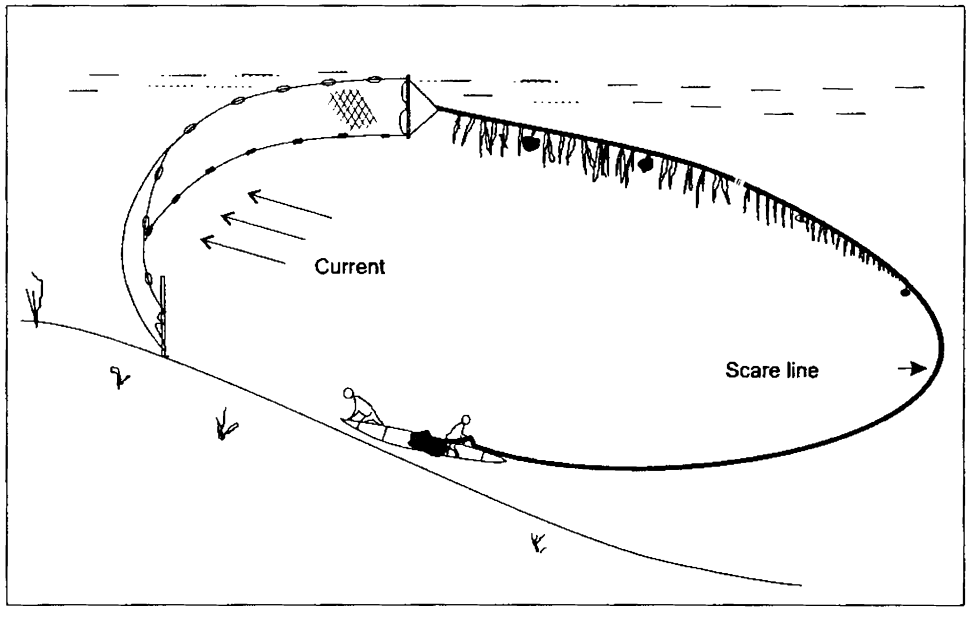


Fig. 40 Technical details of drive-in-net from Kuppam river

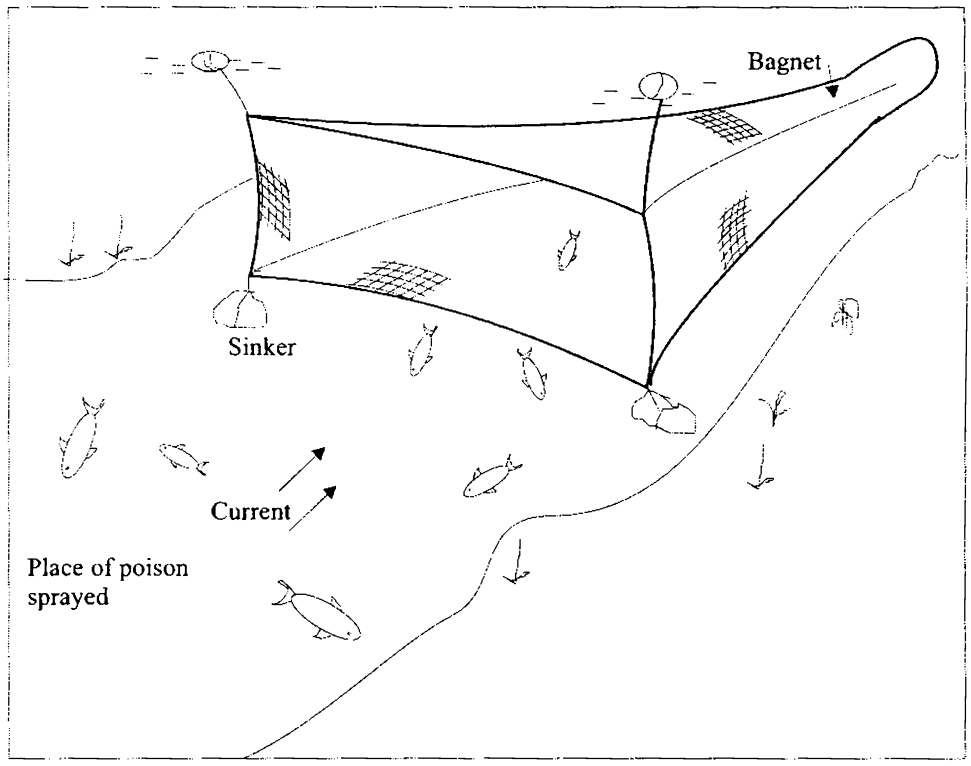
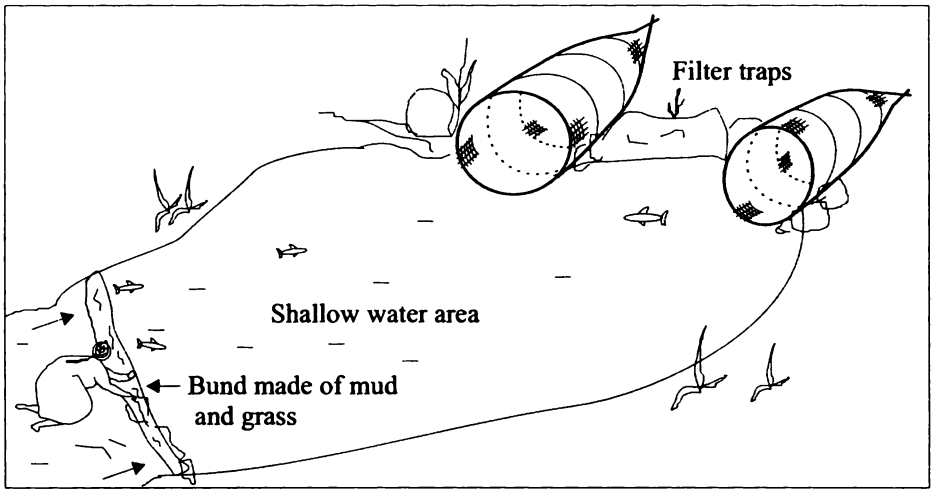


Fig. 41 Fishing using poison in Kurapuzha river

Hand picking



Fishing using filter traps in the backwaters of Kuppam river

Fig. 42 Hand picking and fishing using filter trap

Plate 16. Stake nets near Azheekkal ferry in Valapatanam river

A & B- Hauling of net C- Catch

Plate 17. ***Maadevalyal*** **fishing in Valapatanam river**

Beppevala **fisherman in a tributary of Kuppam river**

Scareline made using polythene ribbons

Plate 18. Drive-in-net and scare line

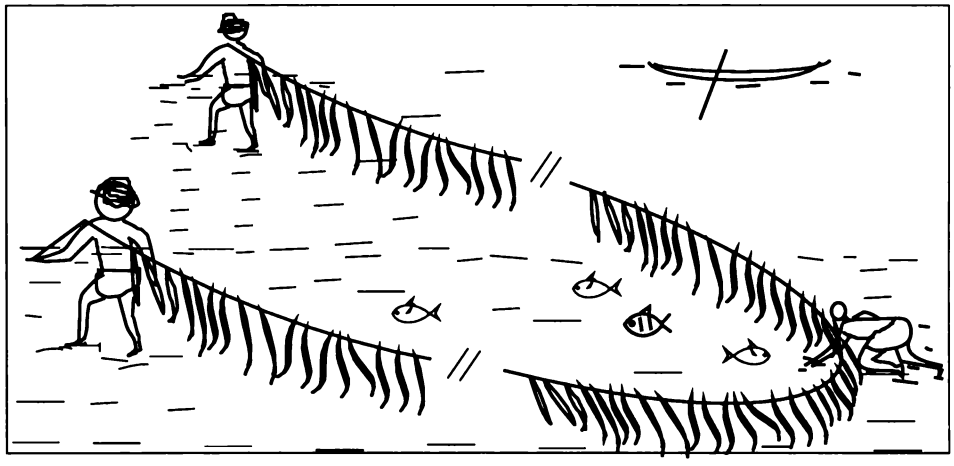


Plate 19. Scare line fishing in Kavvayi river

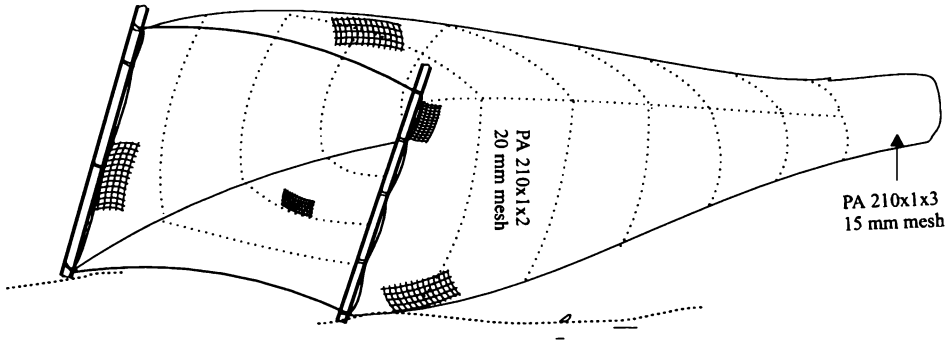


Plate 20. Stick held drag net in the backwaters of Kuttiadi river

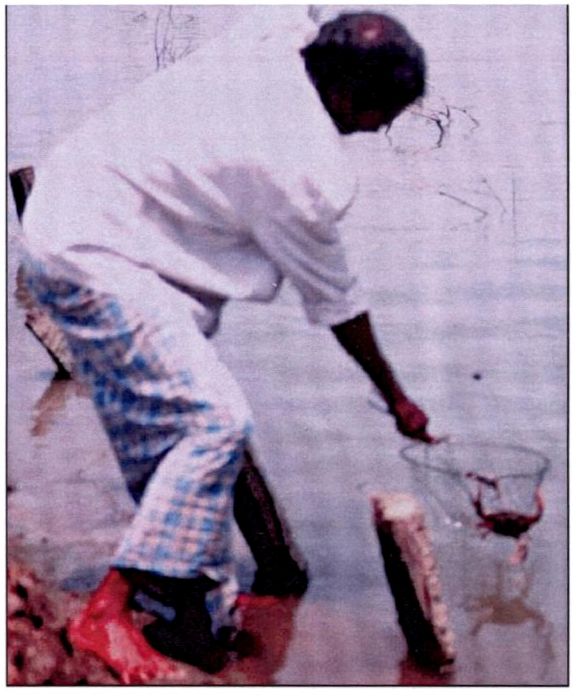
Amblypharyngodon melettinus fishing using stick held scoop net

Plate 21. Stick-held scoop net and catch at Kavanakalle in Chaliyar

A-Stick held scoop net B-Hand operated dredge C- Nylon and Polyethylene Scoop nets

Plate 22. Different types of clam fishing nets

Baited lift net for Mud crab in Kuppam river

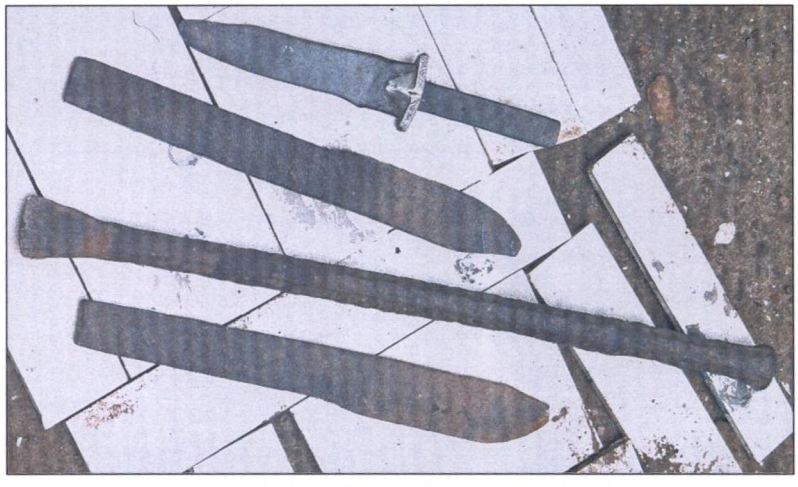


Operation of baited line for crabs near Anjarakandy river

Plate 23. Baited lift net and baited line operation

Plate 24. Sluice net in operation in prawn filtration field

A-Diving for edible oyster in Anjarakandy river B-Heap of shells at Elathur



Tackle used for edible oyster collection in Tellicherry river

Plate 25. Edible oyster fishing in the backwaters of Anjarakandy river

Plate 26. FAD in the upper reaches of Kuppam river

Chapter 4

DEVELOPMENT OF COLLAPSIBLE FISH TRAP

Chapter 4

4. DEVELOPMENT OF COLLAPSIBLE FISH TRAP

4.1. Introduction

Trapping is probably the earliest method of fishing that man ever resorted to. Traps are impounding devices into which an organism is lured and from which escape is made difficult because of the non-return device fixed at the entrance. According to Job and Pantulu (1953) traps being fixed engines do not require continuity of attention and vigilance on the part of the operator but can be left to function themselves and secure a catch while the owner is engaged in other occupation. They are highly fuel efficient in terms of catch per unit of fuel consumed (Willimovski and Alverson, 1971). Mohan Rajan (1993) reported that trap fisheries have economic and energy related advantages over active search and capture fisheries.

Nair (1993) mentioned that they require modest investment and due to their simplicity, efficiency and the quality of catch obtained, this method is widely used in all water bodies. Moreover, most of the traps retain the fish caught in live condition for long time, unlike other fishing gears such as gill nets and trawl. Archdale and Kuwahara (2005) reported that some advantages of pots over other gears are that crabs are easily removed, thus requiring less handling and labour, and that the catch is alive and undamaged, reaching a higher price in the market. Capital investment is relatively low for traps and most of the traps are selective in nature. The costs of setting and hauling traps are usually low and it can be set and hauled from a canoe or a vessel without a motor (Slack Smith, 2001).

Small pots, fyke nets, larger weirs and pound nets come under trap. According to Kara (2001) pots are three-dimensional traps, which are covered except for their entrances and used with baits in them. People in different parts of the world are not always referring to exactly the same things when they use the words "trap" and "pot". In general, traps are large structures fixed to the shore. Pots

are smaller, movable traps, enclosed baskets or boxes that are set from a boat or by hand (Slack Smith, 2001). Disadvantages include the bulky nature which cause difficulty in setting and hauling under rough weather and also high rates of trap loss in marine fishing, which results in ghost fishing.

Catching efficiency of any trap depends on size, soak time, shape and number of entrances, number and volumes of pot chambers, type, length and material of main body, mesh size and dimensions, structure of the bottom, currents and other related factors. Attraction, location, near field behaviour, entrance, behaviour in the trap and escape attempts are the six behavioural phases of fish encountering a trap (Kara, 2001).

Traps are operated in inland and marine waters throughout the world to catch fishes, crustaceans and molluscs. The artisanal fishermen in inland waters operate primitive types of traps whereas the sea fishermen operate the most modern traps from mechanized boats. There are several types of traps and the construction and operation of the same varies from place to place. They may be used on the bottom or in mid water, with or without bait. Fishes are usually attracted to the trap either for feeding, shelter space or for both.

Traditional fish traps are made of split bamboo, areca nut tree, reed, canes, creepers, palmyrah leaf stalk fibers, babul or similar type of wood that can be bent easily. It is reported that in Northeastern Brazil rock lobster pots are traditionally made from mangrove. Traps constructed of sticks and wire mesh is used throughout the Caribbean Island (Munro, 1971). Bamboo is a suitable material as it is easily available, strong, cheap, easy to make splinters, easy to shape and is durable for several months. Meenakumari *et al.*, (2005) reported that high strength weight ratio coupled with its versatility makes it useful in the construction of variety of traps. In some of the traps like screen barriers, where long leader walls are to be made, huge quantity of bamboo is required for the construction. In such traps, of late, the bamboo screens are almost completely replaced by polyethylene netting. Discarded material such as old tyres, plastic and earthenware piping can be used to make effective traps. The traps with hexagonal shaped wire mesh made of galvanized steel

is the most common trap design used in the Barbados commercial fishery (Slack Smith, 2001).

Mechanical traps are wickerwork cages with trap doors, which are tripped when a fish enters. They work on identical principles, similar to that of land traps. They have the great advantage that the fish cannot escape, yet is protected from predators (Hickling, 1961).

Diverse types of indigenous traps operated in the inland water bodies of India is reported by several workers. Being an eco-friendly fishing method many fishers in other parts of the world operate modern types of traps in marine fisheries. The traps for marine waters are made of durable materials like stainless steel, plastic and several other non-corrosive synthetic materials. Prado (1990) reported that traps are made in a wide variety of shapes and sizes using many different materials. The search of cheaper and non-corrosive covering material for the trap fabrication has led to the widespread use of synthetic nets like nylon and polyethylene netting. Molded plastic pots appear to be cheap and easy to stack.

Collapsible fish trap of plexiglass and netting has been developed by Trippel and Crossman (1981). The material used for the fabrication of a trap also play a role in its success as certain species are attracted by principle of thigmotropism. Main factors to be considered for the choice of material are its strength, durability, resistance to corrosion and fouling, availability and cost. Profuse growth of biofilms is noticed on the surface of traditional box traps operated in the river systems of Kerala. Small fishes are attracted to the trap by these films, as they feed on this periphyton, followed by large fishes to prey on the former.

The common types of finfish trap used throughout the world include Caribbean traps, round traps, rectangular traps, "D" shaped traps, collapsible traps, pelagic fish traps, North Atlantic cod pots and plastic multipurpose traps. The "D" shape is preferable to the traditional rectangular fish trap in areas of stronger currents, as it offers less resistance to water flow and is less likely to roll (Slack Smith, 2001). The four most common fish traps in Caribbean Islands include

Antillean "Z" trap, "S" trap, arrow head or chevron trap and rectangular trap (arrowhead, "Z" and "S"). Frames of traps are made from strong materials that prevent the traps and pots from losing their shape during fishing and storing. Frames are often made from steel rods, although timber is also in use. At present, plastic coated wire is used widely to prevent corrosion. In Australia and New Zealand, pots and traps are now being made from steel mesh that does not need a frame to support it.

Like the material, the size and shape of the trap also play a role in its success. If a pot is too crowded with captured fish inside, it will stop catching. The interior volume of a pot must be large enough to avoid this situation. Some type of pots appears to be effective because their shape and size make them attractive shelters for certain species (Prado, 1990). Different types like pot, box type, rectangular, cylindrical, semi-cylindrical, ink-well type, arrow head etc. are available throughout the world. Large size of traps creates problems in handling, transportation and operation in commercial fisheries. Some of the modern traps are collapsible in nature, which facilitates easy handling and transportation of several units at a time.

The critical factor in the success of a trap is the nature, position and number of the entrance funnels. The design of the entrance was shown to be of great importance for the catching efficiency of the pots especially for cod (Furevik and Lokkeborg, 1993). There are several types of entrance funnels in the modern traps and their size and shape depends on the size and behavior of the target species. The funnel should be large enough to allow the entry of adults of target groups without any difficulty. Funnels have usually tapering posterior ends. Horse neck funnel, in which the posterior end is kept downwards, is generally seen in fish traps. The Caribbean trap for snappers and other reef fishes have funnels, which are pointing down. Some lobster pots have "bedroom and parlour" design. This consists of a funnel leading from outside to an initial chamber (parlour) and a second funnel to an inner or holding chamber (the bedroom) (Slack smith, 2001).

The position of the funnel mainly depends on the feeding behaviour of the target fish. The length of the funnel should not be too long. The funnel is kept close

to the bottom in the traps for crabs and lobsters, since they are bottom dwellers. Funnels are seen on the sides in most of the traps. In some pots for prawns and lobsters entrance funnels are also seen on the top. Research has shown that traps with more than one funnel catch more fish than traps with single funnel. Fishing trials with torsk and cod in Norway had shown that pots with a double entrance had a significantly higher catch rate for cod, but not for torsk (Furevik and Lokkeborg, 1993). Easy access through the entrance, low escape rate, and the orientation of the entrance relative to the direction of the water current were regarded as important factors in catching efficiency. Munro (1971) reported that the rate of entry of most species of fish into the trap is substantially depressed at or near neap tides and is approximately 50 percent greater at or around spring tides.

A lid or door is provided towards the bottom corner of the trap body, which can be opened to take out the fish from the trap. This also serves as an escape gap. In many rock lobster fisheries, including Australia, New Zealand and Cuba, escape gaps are compulsory in all pots to allow the escape of juveniles. A zip is provided in place of door in Norwegian traps for crabs and lobsters.

As mentioned traps are selective gear and hence the area and depth of operation depends on the availability of the target species. Traditional traps are usually set in the required depth with the help of additional weights provided on the corners. Metallic traps, in which the entire body is covered with wire mesh, additional weight is not required. In inland waters trap is set in such a way that the funnels always face the water current to trap the fishes moving against the current.

Baits are optional in many of the traps. Meat, fish, molluscs, semi-boiled edible roots like tapioca are used as bait in several traps. No bait is used in the traditional fish trap, *koode* (Plate 27), operated in the rivers of North Kerala. Slack Smith (2001) reported that sometimes the trap itself will lure the fish inside. Maida is mixed with asafoetida and the mixture is boiled with water. The thick paste obtained is made into small balls and is used in the traps operated in Mahanadi for *Macrobrachium rosenbergii* (Premkumar and Meenakumari, 2003). Holothurians are used as bait in the trap operated for perches in south west coast of India.

Fishermen in Tamil Nadu use mussel meat in lobster traps. Plastic containers or net bags are used to keep the bait in traps. Use of bait in fish traps attract non target species like crabs, which prevents the entry of target species, as they often cling to the hind end of the funnel.

The key to successful fishing with traps and other gear is to acquire knowledge on their habits, migrations, movements, feeding habits, etc. This will not only help to find the target fish but also allow for improvements to the traps to augment the catch rate.

Review of literature on studies on modern traps and pots reveals that most of the works on traps carried out in the foreign countries is related to the behavioural aspects of crustaceans like lobsters, crabs and prawns. Some selected publications on these aspects are mentioned here. Details of crab pot construction are reported by (Andrew, 1948). Entry of *Cancer products* to baited traps and design criteria for crab traps is reported by Miller (1979 & 1980). Developmental studies on spiny lobster traps were carried out by Mohan Rajan and Meenakumari (1982) and Mohan Rajan *et. al.,* (1988). Fishing mechanism of pots for crabs is carried out by Ko (1987 & 1990). Studies on materials for traps for spiny lobsters were carried out by Meenakumari and Mohan Rajan (1985). Behaviour of *Portunus pelagicus* at trap entrances is reported by Smith and Sumpton (1989). Comparative fishing efficiency of lobster traps on various factors like, design, shape and material of the trap and bait used is carried out by Balasubramanian *et al.,* (2001). Behavior of *Charybdis japonica* towards two collapsible baited pots is reported by Vazquez Archdale *et al.,* (2003). Effect of two pot types on entrance rate and behaviour of the Japanese swimming crab *Charybdis japonica* is reported by Archdale *et al.,* (2006).

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Effectiveness of three designs of traps for the capture of bottom coral reef fishes off Atlantic coast is carried out by Collins (1990). Preliminary experiment of deep-sea pot fishing in the Andaman sea is reported by Sae Ung *et al.,* (1990). Comparative fishing with O, S and Z shaped traps were conducted on the North West Shelf of Australia by Whitelaw *et al.,* (1991). Effect of increased mesh size on the catch and fishing power of coral reef fish traps is studied by Robichaud *et al.,* (1999). Fish response to pots, advantages and disadvantages of pot fishing is given by Kara (2001).

Review of literature on fish traps in the country shows that most of the available reports are just descriptions on the existing indigenous traps. Day (1873) reported the fish traps in Bengal. Hornell (1924, 1925, 1938 and 1950) and Kurian and Sebastian (1986) reported fish trap operations while describing other types of fishing gears. Fishing gears of Chilka lake including traps are described by Devasundaram (1951), Mohapatra (1955) and Roy and Banerjee (1980). A notable contribution on the indigenous fish traps from all parts of India is made by Job and Pantulu (1953). Saxena (1964, 1988 & 1993) listed fish traps operated in the middle stretch Ganga river. Fish traps of the east and west coast of India is reported by Ramamurthy and Muthu (1969). George (1971) gave an account of fish traps operated in the inland waters of India. Sehgal *et al.,* (1971) mentioned few fish traps while describing the fisheries of Kangra valley and adjacent areas in Punjab.

Menon and Joseph (1969) and Menon *et al.,* (1977) reported the rock-cod fishery of south west coast of the country using traps. Fish traps in Kangra and Hamirpur districts of Himachal Pradesh is reported by Tandon and Sharma (1984). Kulshreshtha (1986) mentioned about traps and barriers while describing the traditional fishing methods of Rajasthan. Traps of Hooghly-Matla estuarine system in West Bengal is reported by De (1987) and Mitra *et al.,* (1987). Trap and trap fishing in South India is given by Mohan Rajan (1993).

Details of various traps operated in Malabar Coast are given by Hornell (1938). Kurup and Samuel (1985) and Kurup *et al.,* (1993) described the indigenous fish traps of Vembanad lake.

Traditional fish traps operated in several river systems of our country are made of split bamboo, reed, cane, babul tree splinters, palmyrah leaf fibers, mid ribs of coconut tree leaves, Areca nut tree splinters, shrubs and stems of creepers and climbers. Coir twines are used to secure them during fabrication. Traps have to be immersed in water continuously, unlike other fishing gear. These structures undergo bio-deterioration and hence the trap will not last for more than one year in the case of continuous operation. To extend its life fishermen stop fishing operation by the commencement of summer season as the rate degradation of material as well as biofouling increases with the rise of salinity.

Different types of traps are in operation in the rivers and backwaters of North Kerala and several fishermen are depending on this fishing method for their lively hood. The box type fish traps operated in the rivers of North Kerala are made of bamboo and the fishermen are also facing the problem of bio-degradation. Because of the huge size, only two traps can be effectively operated from a canoe. Since it is operated without any bait, the catch rate is also poor.

Being an eco-friendly, low-energy and passive fishing gear, several countries in the world are operating modern types of traps for the fishery of fish and shellfish in marine waters. But the works on the development of modern fish traps for marine fishing are very few and that of inland waters are negligible.

A simple, light weight, long lasting collapsible fish trap, which can be transported and operated by single fisherman for inland fishing is designed and developed under the present study. The aim is to improve the economic conditions of the poor fishermen operating traps and also to divert the fishermen towards a selective fishing practice to achieve sustainability.

4.2. Materials and Methods

The collapsible fish trap was made with two rectangular stainless steel frames of 1.1 x 0.75 m size having a supporting rod at the middle of the frame. The upper frame was made of 6 mm dia. stainless (SS) steel rod whereas the lower frame was made of 10 mm dia. SS rod to make it heavy so that the trap maintain bottom

contact. Two square mesh panels of 1.1x 0.75 m were made using polyethylene (HDPE) netting of 1.25 mm dia. twisted monofilament with 60 mm mesh size and the same were laced to the frames with 1.25 mm dia twisted PE filament. The netting laced to 10 mm dia rod was used as the bottom of the trap and the panel attached to 6 mm dia rod was used as the top of the trap. Another two square mesh panels of 1.1x 0.6 m were also made with the same netting for the fabrication of two sides of the trap.

Two inverted horse neck type entrance funnels were made using HDPE netting of 1.5 mm dia twisted filament with 20 mm mesh size. Funnels were made with HDPE netting after shaping and joining as shown in Fig. 43. The wider ends of the funnels were attached to the frames at both ends of the trap and the tapered free ends were put inside. The free ends were kept in position using 3 HDPE filament tied to the funnels, one at the top and the other two at both sides of the free end. The free ends of the filaments were attached the top and both sides of the frame respectively. The size of the opening of the free end was just enough for an adult fish of the target group to enter the trap.

PVC disc floats of 150 x 20 mm size were used to lift the upper body of the trap under water. The buoyancy requirement was assessed by immersing the trap in Periyar river. Four floats were initially attached to the four top corners and immersed the trap in clear water. Another 4 floats, one each at four corners were subsequently attached to lift the upper portion of the trap to achieve a box shape (Plate 28).

The weight of the lower frame was sufficient to keep the trap in the bottom. However four disc shaped cement sinkers weighing 1 kg each were attached to the four bottom corners to keep the trap stationary in areas having strong tidal currents. An openable window was provided at one side, near the bottom corner, to take out the catch. PP rope of 6 mm dia. with 15 m length was attached to the top of the trap. The free end of the trap could be attached to any objects in the shore for easily locating. A stone was attached to the free end of the rope and stretched it to the full length whenever the trap was laid away from the shore.

Kuttieri, a village popular for trap fishing in Kuppam river in Kannur district was selected for the comparative fishing experiment. Collapsible trap was operated along with a traditional trap of same size during December 2004 to January 2006 using a wooden canoe of OAL 4.2 m. Two fishermen operate the trap, one for mainly maneuvering the canoe and he also helps the other while lifting the trap into the canoe. Fishermen leave the shore at around 8 p.m. and reach the fishing ground within 10-20 minutes. Setting and hauling of the traps were carried out during night to keep the location secret. Soaking time for the traditional trap extend up to 48 hours depending on the catch. Traps were usually operated in the depth range of 5-10 m. In the initial experiment bait was not used in traps as fish seeking shelter voluntarily enter the trap while browsing on the trap surface.

To retrieve the trap the grapple hook was throwed from the canoe, near the spot where the trap was set and the attached rope was released. While dragging the hook along the bottom, the rope attached to the trap was usually hooked. Then the line was slowly hauled to see the location of the trap. Then the canoe was taken to the location and the remaining part of the line was also hauled and the trap was lifted into the canoe. The window provided at the side was opened and the trap was jerked to release the catch into the canoe. After closing the lid the trap was again put in another location.

To study the effect of bait on catch rate, peeled and semi-boiled tapioca was tried as bait. About 200g of tapioca were put in a small bag made of PA 210Dx1x3 with 15 mm mesh size and the bag was suspended at the center of the trap, adjacent to the funnel opening. The bait was changed after 3-4 days and fresh bait was again put. 15 observations were made in comparison with another collapsible trap without bait. The result of comparative fishing experiments were analysed separately using ANOVA.

In another experiment chicken waste was tried to increase the catch rate. Chicken waste is the traditional bait used in the lift net (ring net) for mud crab. The trap was operated along with another trap without bait and 40 observations were made during January to October 2005 and the data was analysed using ANOVA.

Economic analysis like cost and earnings, depreciation, rate of return and pay back period was carried out as per the standard methods (Varshney and Maheshwari, 1981).

4.3. Results and Discussion

Balasubramanian *et al.,* (2001) used 10 mm dia MS rod for different types of lobster traps fabricated for comparative trials. The traps were covered with HDPE netting with 60 mm mesh and the funnels were covered using netting with11mm mesh. Similar material and specifications were followed for the present trap also.

The catch from the rivers and backwaters was generally poor in all types of fishing gear operated in the area during the period of study. Results of the comparative operation of traditional and collapsible traps without bait are given in Table 17. In the collapsible trap, species obtained consisted of *Etroplus suratensis* (34.8%), *Lutjanus argentimaculatus* (30%) and *Scylla serrata* (28%). In the traditional fish trap *L. argentimaculatus* (46%) dominated the catch followed by *E. suratensis* (36.4%) and *S. serrata* (16.2%).

Average catch per haul was about 0.94 kg in traditional trap and 0.54 kg in the collapsible trap. Statistical analysis has shown that the effect of trap on total catch was significant at 5% level (Table 18). The reasons for better catch in the traditional trap could be due to better accumulation of periphyton on the trap surface and rigidity of trap mouth configuration. The difference in catching efficiency may be attributed to the variation in shape and stability of the traps (Mohan Rajan and Meenakumari, 1982). More fishes get attracted while browsing on the surface of the trap and the chance for entry of fishes is high.

It is possible that distortion of the trap mouth entrance take place or it may vibrate under strong current in the case of collapsible trap, as it is made of netting, which may scare the fish. Archdale *et al.,* (2006) reported that in the case of crab pots ease at finding entrances is a critical factor when many crabs are in the vicinity of a pot. Miller (1979) documents that they will accumulate around the pot if the entrance is difficult to locate or go through, fight, and many will flee from the pot;

consequently reducing the capture efficiency. However this problem could be rectified using two circular rings of 160 and 140 mm dia fixed inside the funnel.

Miller (1979) and Archdale (2006) reported that the entrance parallel to the current is the most effective orientation of the trap for catching *Cancer products.* There was no statistically significant difference in the species wise landings between the experimental and traditional traps.

4.3.1. Field trials with bait

Baits are optional in fish traps whereas traps targeting crabs and lobsters use baits of animal origin. Munro (1971) reported that chopped fish bait was ineffective in increasing Antillean fish trap catches. Baits are not used in traditional fish traps operated in North Kerala. To attract fishes into the traditional fish aggregating devices like bush parks or *padals*, fishermen keep half boiled tapioca or tapioca wastes. Semi-boiled tapioca is also used as bait in hand lines for *E. suratensis.* Field trials were carried out using semi-boiled tapioca as bait. According to Ahmed *et al.*, (2003) locally available feed ingredients are used to attract fishes in brush shelters in the Kaptai reservoir in Bangladesh.

Result of the experiment is given in the Table 19. Interaction of different species with tapioca bait is given in Fig. 44. Species composition and average catch was almost same in the two traps and ANOVA shows that there is no significant difference in catches between experimental traps with and without bait.

Result of the comparative operation of traps with chicken waste and trap without bait are given in the Table 20. In the total catch in trap with chicken bait *S. serrata* dominated (63.29%), followed by *L. argentimaculatus* (16.28%), *E. suratensis* (13.49%) and *Lates calcarifer* (6.9%). Average catch per haul was 0.85 kg and 0.45kg in the trap with bait and without bait respectively. The average catch of trap with bait was comparable with the catch of traditional trap. In trap without bait *E. suratensis* (47.1%) dominated the catch followed by *L. argentimaculatus* (33.88%) and *S. serrata* (19%).

ANOVA shows that there is significant difference in the total catch ($p<0.01$) between traps with and without bait (Table. 21). ANOVA on the effects of bait on species wise catch is given in Table 22. This is due to the increase in the catch of *S. serrata* as evident in the average mean catch of different species (Fig. 45) Charley Cyr and Marie (1994) established a positive correlation with bait weight and catch in crab pots. Setting of the trap is also important for a successful haul. Vanquez Archdale *et al.*, (2003) observed that crabs approached the pots from the down stream direction by following the bait odour trails. Representation of carnivorous fishes like *L. calcarifer* was better in traps when chicken waste was used as bait. The catch of *E. suratensis* and *L. argentimaculatus* was less in the trap operated with bait indicating lack of preference of these fishes for chicken waste as bait.

The new collapsible fish trap is highly selective and species specific in nature. Mesh size of 60 mm in cover netting allow for escapement of juveniles that could have entered the trap. Balasubramanian *et al.*, (2001) used polyethylene webbing having 60 mm mesh size and 1 mm twine size as external cover the experimental lobster traps. Traps are eco-friendly, compared to other fishing gear such as small meshed gill nets and all towed gears. Major advantage of the new trap is its collapsibility, which enables the fisherman to carry about 10-15 traps at a time and operate them in a single fishing trip. Moreover soaking time can be considerably reduced when it is operated with bait.

4.3.2. Economics of Collapsible fish trap

The fish trap operation in inland waters of North Kerala is an ancient and subsistence fishing method in which the investment and returns are minimum. To increase the daily income of this poor group, the study on the development collapsible and durable fish trap was carried out. It is the profitability that is the primary criterion of choice of technology in fisheries. A technology can be considered appropriate and successful only if it lowers production cost per unit catch or increase productivity (Thomas, 2001). Consequently the economic analysis become imperative for any kind of technology developed. In order to evaluate the

economic efficiency, performance of the two traps in terms of cost and earning for one year were worked out.

Economic analysis of different fishing systems in different parts of the country have been discussed by several workers. Noble and Narayanan Kutty (1978) calculated the economics of the indigenous fishing units of Cochin. Economics of artisanal and mechanised fisheries in Kerala is worked out by Kurian and Wilmann (1982). Supanga and Smith (1982) reported the costs and returns of cabusao stationery gears. Economics of different craft gear combination in Orissa coast is reported by Dutta *et al., (*1989). Sahara, and Karbhari, have given the economics of gill net fishing by OBM units at selected centers in North West Coast.

Results of economic analysis of traditional and collapsible trap fishing are given below. Craft and gear are the two basic components of the investment cost. The traps were operated from a wooden canoe of 4.2 m OAL, which costs Rs. 15000/-. Cost of fabrication of traditional trap and collapsible trap is given in Tables 26 and 27 respectively. A fishing unit includes two traps in traditional. However, more than 10 traps could be carried in the case of collapsible trap fishing units. Capital investment is Rs. 27550/- and Rs. 17430/- for collapsible trap fishing unit carrying 10 trap and traditional trap fishing unit respectively. About 45.5 % of the capital investment of collapsible trap fishing unit is for the gear and 54.5 % for the craft. Capital investment for the gear component was only 14 % in the case of traditional traps and the remaining 86 % was for the craft. The approximate cost of fabrication of traditional fish trap and collapsible trap is given in Table 23 and Table 24 respectively.

4.3.2.1. Fixed cost

Fixed cost includes depreciation on capital investment on craft and gear and interest on capital. Life of the craft was taken as 8 years for calculating depreciation. Average life span was one year for traditional traps and 3 years for collapsible traps. Scrape value is zero for craft and gear. Annual interest on capital was calculated at 6 %. Total fixed cost of Rs. 5350/- for traditional traps was

calculated by depreciation craft (19.55 %), depreciation on gear (45.42 % and interest on capital (19.55 %). Total cost of Rs. 7711/- for collapsible trap unit was constituted by depreciation on craft (24.32 %), depreciation on gear (54.25 %) and interest on capital (21.44 %).

4.3.2.2. Variable cost

The variable cost includes cost of maintenance of craft and gear as well as the labour cost. Cost of labour is Rs. 10,000/- for traditional traps and Rs. 15, 000/- for collapsible traps, since the number of traps is more in the latter case. Two fishermen are required for trap fishing, one for controlling the canoe and also helping to lift the trap into the canoe to empty the catch. The second person usually hauls the trap from the stern of the canoe. They spent nearly two hours in the night and the labour charge is calculated on hourly basis. Maintenance cost on craft is uniform for both types of fishing. Maintenance cost in each case includes the labour and material cost.

4.3.2.3. Total cost

Total cost for trap fishing includes fixed cost and variable costs. It is Rs. 17,150/- for traditional trap fishing unit and Rs. 24661/- for collapsible trap fishing unit.

4.3.2.4. Gross and Net profit

Traditional traps are usually set at night and hauled after 24h. Average catch obtained in the traditional trap during the study was 0.94 kg/haul and that of collapsible trap without bait was 0.54 kg/haul. Average price realized for fish is Rs. 100/kg. Though the average catch obtained in collapsible trap with chicken bait was better, the catch of trap without bait was taken for economic analysis, since traditional traps were operated without bait in North Kerala. 10 collapsible traps can be easily operated from a canoe with two fishermen against two traps in the traditional operation and can earn approximately Rs. 540/- per day. Daily income of

fishermen operating two traditional fish trap is about Rs.188/-. Average catch and income from comparative trap operation is given in Table 25.

4.3.2.5. Profitability ratios

Details of cost and earnings of two types of traps are given in Table 26. Total earnings is Rs. 37,600/- for traditional trap fishing unit and Rs. 1,08,000/- for collapsible trap fishing unit. Net profit is Rs. 21,495/- and Rs. 84,992/- for traditional and collapsible trap units respectively. It is clear that the net profit of collapsible traps is nearly four times higher to the traditional traps. The returns on capital investment, total cost and variable cost were 117.32 %, 119.24 % and 173.30 % respectively for traditional trap fishing unit. These values are over 2.5 times higher in the case of collapsible trap fishing unit indicating significantly high profitability in operation of collapsible trap fishing units.

4.3.2.6. Pay back period

Pay back period refers to the number of years required to cover the investment cost by earnings from fish harvest. The pay back period of collapsible trap is only 0.33 years, which is much less than the life period of the technology. This indicates that the traps will continue to be functional for long period after the investment cost is recovered. The pay back period of traditional trap is 0.85 years, which indicated that the trap would be functional for only few months after the repayment of capital investment. The trap should be utilized properly to increase the production using chicken waste as bait, which can make the operations more economically viable.

Profitability analysis shows that return on capital investment, total cost and variable cost are significantly better in collapsible trap fishing unit compared to the traditional trap unit. Though cost of fabrication of the traditional and collapsible trap is almost same, traditional trap will not last for more than a year, if operated continuously. Since bio-deterioration is nil, the collapsible trap will last up to 3 years with minimum maintenance.

Catch rate of collapsible trap unit can be further improved by standardizing all other parameters. As evident from the bait preference studies, the net profit in collapsible trap operation can be increased further by increasing the number of traps per trip and also by using chicken waste as bait. Since the time requirement is less than 2 h at night and continuous attention is not required, fishermen can operate other type of fishing gears or engage in other economic activities after setting the traps.

Table 17. Results of comparative operation of collapsible and traditional fish traps without bait

No. of haul	Species	Collapsible (Kg)	Traditional (Kg)	Collapsible (Total)	Traditional (Total)
1	*E. suratensis*	0.00	0.45		0.45
2	*E. suratensis*	0.00	0.50		
	S. serrata	0.60	0.00	0.60	0.50
3	*E. suratensis*	0.10	0.00	0.10	
4	*E. suratensis*	0.00	0.70		
	S. serrata	0.35	0.40	0.35	0.70
5	*E. suratensis*	0.40	0.00		
	S. serrata	0.50	0.00		
	L. argentimaculatus	0.00	0.80	0.90	0.80
6	*L. argentimaculatus*	0.00	0.60		0.60
7	*L. argentimaculatus*	0.75	0.50	0.75	0.50
8	*E. suratensis*	0.00	1.00		
	S. serrata	0.25	0.60	0.25	1.60
9	*E. suratensis*	0.80	0.70		
	L. argentimaculatus	0.00	1.10	0.80	1.80
10	*E. suratensis*	0.00	0.50		0.50
11	*S. serrata*	0.45	0.70	0.45	0.70
12	*L. argentimaculatus*	0.30	0.50	0.30	0.50
13	*L. argentimaculatus*	0.65	0.30	0.65	0.30
14	*E. suratensis*	0.00	0.50		
	S. serrata	0.40	0.00		
	L. argentimaculatus	0.00	0.60	0.40	11.00
15	*E. suratensis*	0.30	0.90	0.7	1.60
	L. argentimaculatus	0.40	0.70	0.40	0.70

No. of haul	Species	Collapsible (Kg)	Traditional (Kg)	Collapsible (Total)	Traditional (Total)
16	*E. suratensis*	0.00	0.45		0.45
17	*L. argentimaculatus*	0.00	1.00		1.00
18	*L. argentimaculatus*	0.40	0.60	0.40	0.60
19	*E. suratensis*	0.00	0.80		0.80
20	*L. argentimaculatus*	0.00	0.40		
	S. serrata	0.80	0.30	0.80	0.70
21	*E. suratensis*	0.00	0.50		0.50
22	*E. suratensis*	0.50	0.00		
	S. serrata	0.00	0.25	0.50	0.25
23	*E. suratensis*	0.65	0.00		
	L. argentimaculatus	0.30	0.80	0.95	0.80
24	*E. suratensis*	0.00	0.30		0.30
25	*E. suratensis*	0.00	0.90		
	L. argentimaculatus	0.25	0.00	0.25	0.90
26	*L. argentimaculatus*	0.00	0.65		0.65
27	*L. argentimaculatus*	0.40	0.50	0.40	0.50
28	*E. suratensis*	0.35	0.00		
	S. serrata	0.00	0.35	0.35	0.35
29	*L. argentimaculatus*	0.00	0.50		
	E. suratensis	0.00	0.30		0.8
30	*S. serrata*	0.45	0.00		
	L. argentimaculatus	0.00	0.40	0.45	0.40

Table 18. Analysis of variance between traps and total catch

Source of variation	SS	df	MS	F	Sig.
Trap	5.332	1	5.332	5.210	0.024

Table 19. Results of field trial of collapsible trap with tapioca bait

No	Species	Species wise catch (kg)		Total catch (kg)	
		with bait	without bait	with bait	without bait
1	*L. argentimaculatus*	0.7	0.6	0.7	0.6
2	*S. serrata*	0.3	0.5	0.3	0.5
3	*L. argentimaculatus*	0	1	0	1
4	*E. suratensis*	0.5	0.52	0.5	0.52
5	*E. suratensis*	0.3	0.75	0.3	0.75
6	*L. argentimaculatus*	0	0.65		
	S. serrata	0	0.4	0	1.05
7	*L. argentimaculatus*	0.3	0.7	0.3	0.7
8	*L. argentimaculatus*	0	0.6	0	0.6
9	*E. suratensis*	0.32	0.5	0.32	0.5
10	*S. serrata*	0.5	0.65		
	E. suratensis	1	0	1.5	0.65
11	*E. suratensis*	0.6	0.55	0.6	0.55
12	*S. serrata*	0.4	0	0.4	0
13	*L. argentimaculatus*	0.9	0.6	0.9	0.6
14	*L. argentimaculatus*	0.8	1.6		
	S. serrata	0.4	0.6	1.2	2.2
15	*E. suratensis*	0.5	0.95		
	L. argentimaculatus	0.4	0.8	0.9	1.75

Table 20. Results of field trial of collapsible trap with chicken waste

No.	Species caught	with bait	without bait	No	Species caught	with bait	without bait
1	*E. suratensis*	0.4	1	19	*S. serrata*	1.1	0.5
	L. argentimaculatus	0	0.35		*L. argentimaculatus*	0	0.9
	S. serrata	0.8	0	20	*L. argentimaculatus*	0.35	1.2
2	*L.calcarifer*	1.3	0		*S. serrata*	0.65	0
	S. serrata	0.6	0.25	21	*L. argentimaculatus*	0	0.75
2	*E. suratensis*	0	0.8		*E. suratensis*	0.3	0.4
	L. argentimaculatus	0.6	0.5	22	*S. serrata*	0.65	0.5
	S. serrata	1.2	0	23	*L. argentimaculatus*	0.65	0.3
4	*E. suratensis*	0.3	6	24	*E. suratensis*	0.45	0.5
	L. argentimaculatus	0	0.6		*S. serrata*	0.7	0.35
	S. serrata	0.9	0.7		*L. argentimaculatus*	0	0.6
5	*S. serrata*	0.6	0	25	*E. suratensis*	0.3	0.9
6	*S. serrata*	0.75	0.3		*L. argentimaculatus*	0.4	0.7
	E. suratensis	0	0.4	26	*E. suratensis*	0	0.45
	L. argentimaculatus	0	0.6	27	*S. serrata*	1	0.25
7	*L. argentimaculatus*	0.32	0	28	*L. argentimaculatus*	0.4	0.6
	S. serrata	0.5	0.6	29	*E. suratensis*	0	0.8
8	*E. suratensis*	0	0.4	30	*L. argentimaculatus*	0	0.4
	L. argentimaculatus	0	0.5		*S. serrata*	0.8	0.3
9	*L. argentimaculatus*	0.6	0	31	*E. suratensis*	0	0.5
	S. serrata	1.5	0.4	32	*E. suratensis*	0.5	0
10	*L. argentimaculatus*	0	0.6		*S. serrata*	1.4	0.25
11	*S. serrata*	0.7	0	33	*E. suratensis*	0.65	0
	L. argentimaculatus	0	0		*L. argentimaculatus*	0.3	0.8
12	*L.calcarifer*	1	0	34	*E. suratensis*	0	0.3
	E. suratensis	0	0.6	35	*S. serrata*	0.9	0.4
	S. serrata	0.7	0.2		*L. argentimaculatus*	0.25	0
13	*E. suratensis*	0.35	0.7	36	*L. argentimaculatus*	0	0.65
14	*L. argentimaculatus*	0	0.4		*S. serrata*	0.75	0.3
	S. serrata	0.65	0	37	*L. argentimaculatus*	0.4	0.5
15	*L.calcarifer*	0	0.75	38	*E. suratensis*	0.35	0
	S. serrata	1	0.2		*S. serrata*	1	0.6
16	*L. argentimaculatus*	0.9	0	39	*L. argentimaculatus*	0	0.5
	S. serrata	0.5	0.25		*E. suratensis*	0	0.3
17	*S. serrata*	0.7	0	40	*S. serrata*	0.8	0
	E. suratensis	0	1.5		*L. argentimaculatus*	0	0.4
18	*E. suratensis*	0.85	0.4				
	L. argentimaculatus	0.2	0.7				

Table 21. ANOVA of effect of chicken waste on the total catch

Source	SS	df	MS	F	Sig.
Bait	25.796	8	3.225	7.072	.000

Table 22. ANOVA of effect of bait on species wise catch

Source	SS	df	MS	F	Sig.
Species	4.537	3	1.512	0.027	0.994
Bait	0.230	2	0.115	0.210	0.818
Species and bait	1.331	4	0.333	0.584	0.674

Table 23. Approximate cost of fabrication of traditional fish trap

No	Material/ labour	Rate (Rs.)	Quantity	Cost (Rs)
1	Bamboo	100/piece	2 nos. (about 24')	200.00
2	Coir twine	15/coil	7 coils	105.00
3	PP rope	1.7/m	35 m	60.00
4	Areca nut tree	-	4 m	50.00
5	Labour	200/day	4 days	800.00
Total				**1215.00**

Table 24. Cost of fabrication of a collapsible trap

No	**Material/ labour**	**Rate (Rs.)**	**Quantity (kg)**	**Cost (Rs.)**
1	Cost of SS frames	245/kg	3.2	785.0
3	PE netting	270/kg	0.35	100.0
4	PVC floats	Rs.15/piece	8 nos	120.0
5	Fabrication	250/trap	-	250.0
Total				**1255.0**

Table 25. Average catch and income from comparative trap operation

No.	**Trap**	**Average catch/haul (kg)**	**No. of traps**	**Income/ day (Rs.)**
1	Traditional	0.94	2	188.00
2	New trap	0.54	10	540.00

Table 26. Cost and earnings per unit of Collapsible and Traditional traps

Items	Traditional	Collapsible
I. Capital investment (Rs.)		
i) Cost of fishing craft	15000	15000
ii) Cost of gear (Traditional-2, Collapsible-10 units)	2430	12550
Total	**17430**	**27550**
2. Fixed cost (Rs.)		
2.1.Depreciation on capital investment on craft (Life of vessel- 8y, scrap value-nil, Bank interest rate @ 12.5 %)	1875	1875
2.2. Depreciation on capital investment on gear (Life-1y-traditional, 3-y for collapsible)	2430	4183
2.3. Interest on capital @ 6 % per annum	1045	1653
Total	5350	7711
3. Variable cost (Rs.)		
3.1 Maintenance of craft	1300	1300
3.2 Maintenance of gear	500	650
3.3 Labour cost	10,000	15,000
Total	11800	16950
4. Total cost for one year (Rs.)	**17150**	**24661**
5. Earnings (Rs.) (Rs.100/kg of fish, Catch- @ 0.94 kg/day for traditional & @ 0.54 kg for collapsible)	37600	1,08,000
6. Net Profit (Rs.)	**21495**	**84992**
7. Profitability ratio (%)		
7.1 Return on capital	117.32	302.50
7.2 Return on total cost	119.24	337.93
7.3 Return on variable cost	173.30	491.67
7.4 Pay back period on capital investment (yr)	0.85	0.33

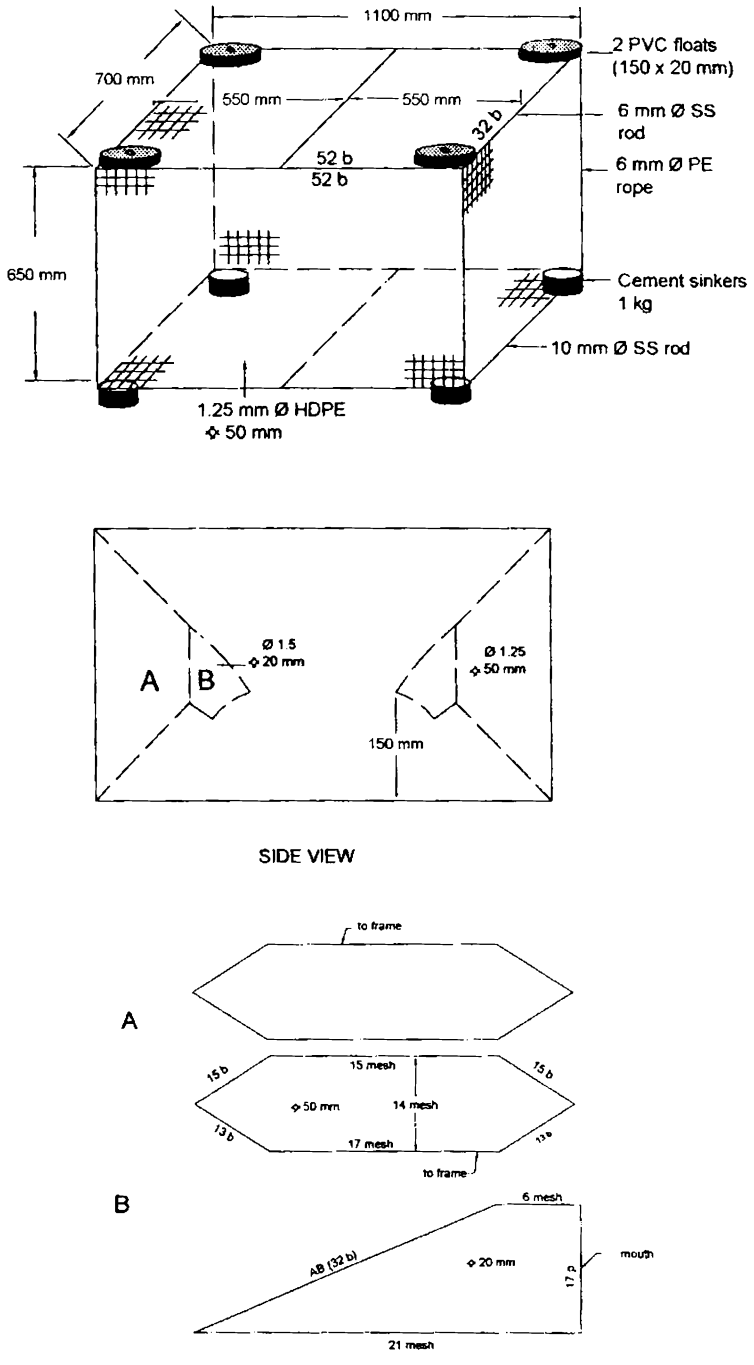


Fig. 43 Design details of collapsible fish trap and shaping funnels

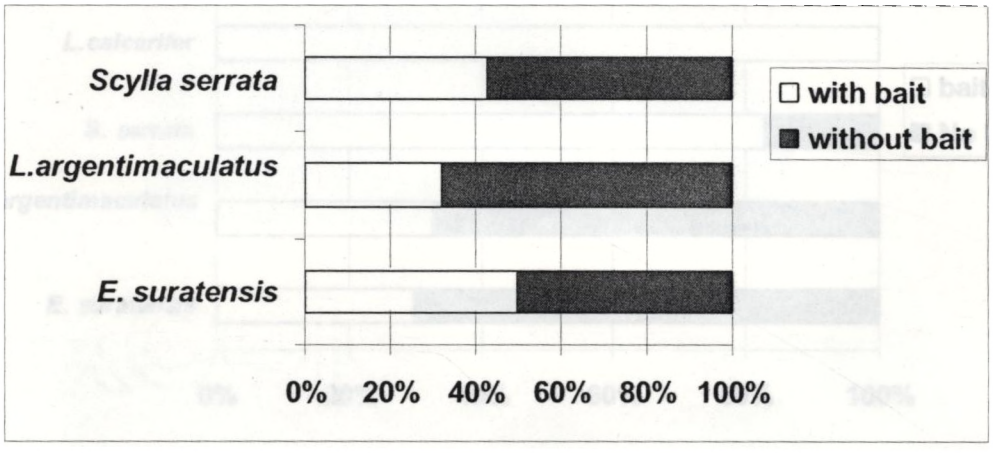


Fig. 44 Percentage of catch with tapioca bait

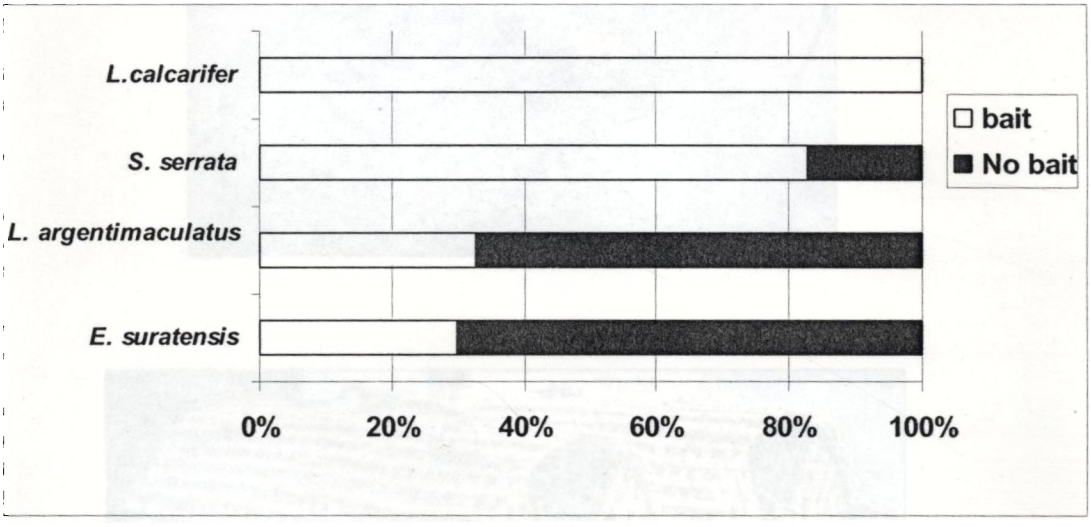


Fig. 45 Percentage of catch with chicken bait

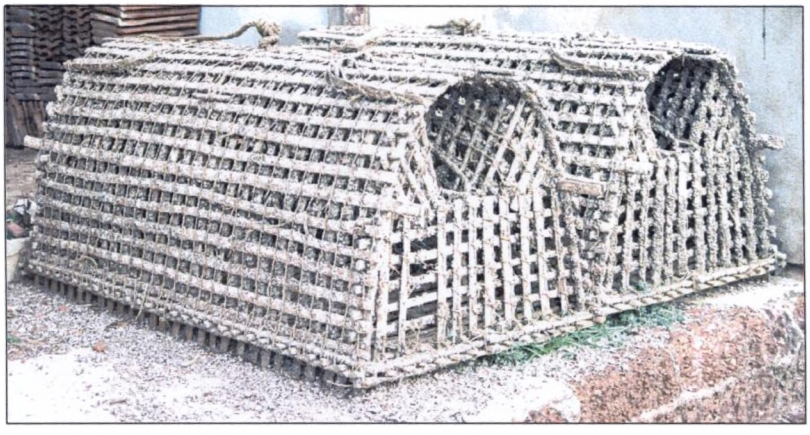
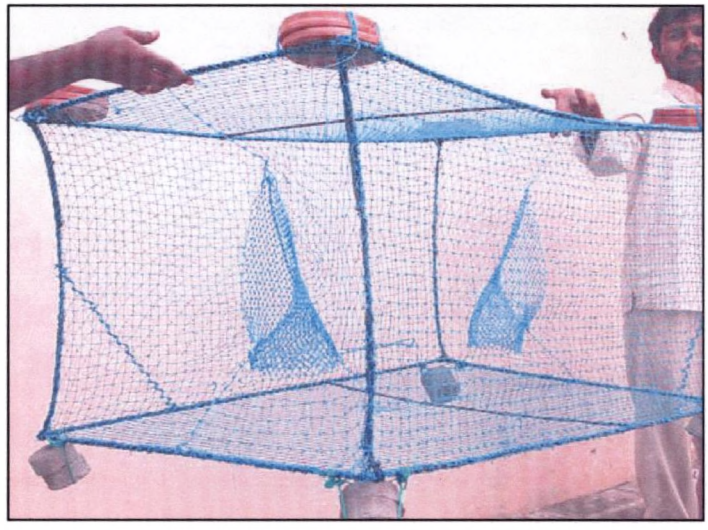


Plate 27. Traditional fish trap in North Kerala



Collapsible trap showing the position of funnels

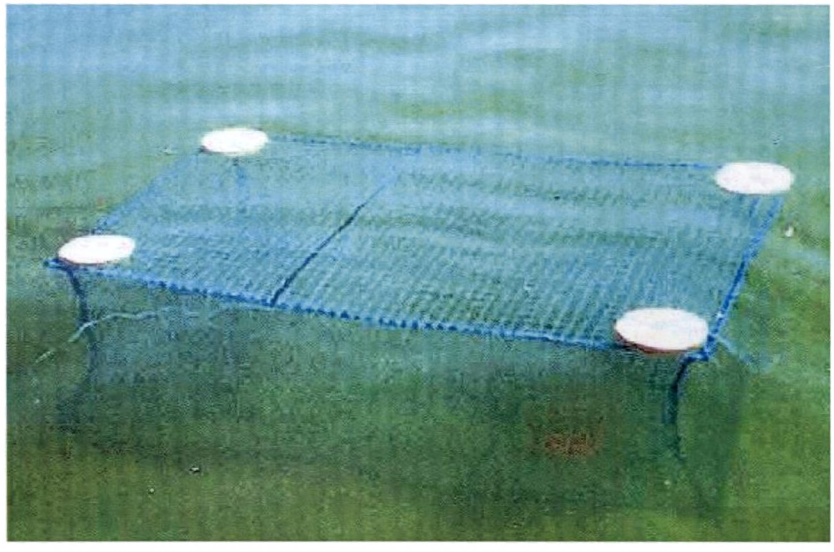


Plate 29. Collapsible fish trap before and after setting

Chapter 5

SUMMARY AND RECOMMENDATIONS

Chapter 5

5. SUMMARY AND RECOMMENDATIONS

India is blessed with abundant water resources in the form of rivers, ponds, lakes, reservoirs, flood plain wetlands and innumerable small water bodies. The inland fish habitat in India harboures 587 fish species in the freshwater systems and 171 fish species in the estuarine waters.

The total inland water spread area in Kerala is about 3,55,000 ha. There are 44 rivers in Kerala with a total catchment area of 37,884 km^2. Out of the 44 rivers, 21 rivers (including Mahe river) are located in the three Northern districts of Kerala *viz.*, Kozhikode, Kannur and Kasargod. About 10,096 ha of backwaters and 13,354 ha of brackishwater areas are also available. Two reservoirs, Pazhassi (Kannur) and Kuttiadi (Kozhikode) with a total water spread area of about 1700 ha are located in North Kerala. The rivers and streams in the Western Ghats alone harbour about 170 freshwater fish species of which 66 species belongs to food fish category. Major backwaters in Kerala harboures about 95 species of fish and shellfish.

The fish and fisheries play a crucial role in the Kerala's economy, particularly among the communities along the coastal belt. Inland fish production in Kerala during 2004-05 has been estimated to be about 76,000 t. Fishery activities in the backwaters of Kerala support about 0.2 million fisher folk and provide full time employment to more than 50,000 fishermen.

Fisheries activities of the inland sector of India are traditional in nature and fishermen generally carry out the fishing operations without any consideration to sustainability of the resources, which is leading to dwindling catches and poor returns. Reduction in landings can be further attributed to habitat degradation, land reclamation, sand mining and aquatic pollution.

The literature available on inland capture fisheries of Kerala is based on the study carried out in and around the Central Kerala. No effort is made in the past to

study and document the design and operation of existing fishing gear in North Kerala, where almost half of the total numbers of rivers in Kerala are located.

In the present study, results of investigations conducted during 2003-2005 on the craft and gears in the inland waters of North Kerala and performance evaluation of collapsible fish trap for riverine waters are presented. The content of the thesis is organized into five chapters.

Chapter I

In this chapter, an introduction to the topic of study, highlighting its relevance, objectives of the study and a review on the inland fisheries sector of the World, in general, and India and Kerala, in particular, are presented. Inland aquatic and fishery resources of different categories of water bodies in India and Kerala are presented.

Inland aquatic and fishery resources of the selected districts are listed separately. 54 species of fish and shellfishes constituting the catch from the region were identified. Literatures on the inland fisheries and fishing methods of World, India and Kerala are reviewed and documented.

The objectives of the study were (i) To document major fishery resources and different craft and gear combinations operating in inland water bodies in selected districts of North Kerala. (ii) To identify the existing fishing gears and methods, prepare design drawings and classify the gears based on design, operation, mesh size, target species, etc. (iii) To identify the technical problems and suggest improvements in the existing fishing crafts, gears and methods of operation to increase their efficiency and selectivity. (iv) To design and develop a collapsible, durable and cost-effective fish trap for riverine fishing and evaluate the performance in comparison with the traditional traps.

Chapter II

This chapter deals with the materials and methods used for the conduct of the investigations. Details of study area and all water bodies in the selected districts are described. Figures of 21 rivers in the three districts indicating the location of sampling centers and other water bodies are also given. Methodologies followed for the survey of fishing crafts and gears are described. Methodology followed for the performance evaluation of collapsible fish trap is given separately in the respective chapter.

Chapter III

Chapter III is divided into two sections. The first section deals with the details of inland fishing crafts of the region. Wooden canoes of LOA ranging from 3-6 m are the major fishing craft. Dug-out canoes are almost totally replaced with plank-built canoes. FRP coated canoes are seen in the estuarine areas of a few rivers. Coracles are exclusively operated by the migrant fishermen from Karnataka. Migrant fishermen carry out fishing using two plastic cans tied with a piece of cloth.

Canoe constructed using split bamboo covered with polythene bags and coal tar is an innovative cost effective fishing craft seen at Muthampy, in Kuttiadi river and is reported for the first time from India.

The second part deals with various types fishing gears operated in the inland waters of the region.

Seine net

Seine nets in North Kerala are grouped mainly into 3 categories. They are *Koruvala* (encircling seine), *Chavittuvala-I* (seine without wings) and *Chavittuvala-II* (seine net with wings). Design and operation of these seines and other types of seine nets are discussed. Approximately 10 % of the inland fishermen operate seine net. Net is usually made of PA multifilament of 210Dx1x2 having 10-18 mm mesh size. Polyamide (PA) knotless netting is widely used for seine net fabrication.

Average catch and monthly variation of income of the major category of seines are also discussed.

Average catch per day of a seine net in Anjarakandy river is about 31 kg with a CPUE 7.8 kg/h. Catch is mainly constituted by juveniles and other small fishes and prawns. Closed area and season is recommended for seine nets to conserve the resources.

Gill net & Trammel net

Important categories like surface gill nets, bottom gill nets, their design, technical specifications and operational details are discussed. Gill net is the most common gear and more than 95% of the gill nets are made of PA monofilament and most predominant material size is 0.16 mm dia. Mesh size of the gillnet varies from 12 to 300 mm in which the lowest case is for the *Metapenaeus dobsoni* net in Kannur district and highest for the *Catla catla* gill net in Kuttiadi reservoir. Mud crab entangling nets are made of PA monofilament having 0.32 mm dia with 90-160 mm mesh size. *Lates calcarifer* gill nets in Chaliyar river is made of PA 210Dx24x3 with 220 mm mesh size. Trammel nets for fish are operated in Valapatanam river for fish. Economics of gill net unit in Kavvayi river shows that average catch/ day was 5.1kg and the average daily income was Rs. 251/-.

Selectivity studies are required to optimize the mesh size for different species. Resource specific gill nets are recommended to reduce the landings of juveniles. Gill net for *M. dobsoni* is unique and is reported for the first time.

Traps

Traps are operated in the rivers and backwaters. No traps are found in reservoirs, except the aerial traps operated in Pazhassi Reservoir. Box trap of about 1.5x0.6 m size having a "D" shape in cross section, made of split bamboo fastened using coir twines are popular in Kannur district. This trap is operated in rocky areas without any bait to catch *Etroplus suratensis* and *Lutjanus argentimaculatus.* Service life of the trap is one year.

Screen barriers made of bamboo splinters prevalent in Kannur and Kozhikode districts are almost completely replaced with HDPE net barriers. The later is cheap; handling is easy and is durable. Plunge basket and filter traps are also found in operation at few places.

Thottil vala is the aerial trap operated in Pazhassi reservoir during monsoon to catch big fishes. Trap is lowered from the dam and is set above the water surface, to trap the fishes jumping against the current. Operation of this trap is reported for the first time.

Lines

Hand lining is carried out using small wooden canoes of 2.5- 3.5 m lengths. Lines with multiple hooks without bait are operated in Pazhassi dam to catch jumping fishes, when the shutters are open. Baited line without hook is operated in backwaters to catch *Scylla serrata*. Mutliple baited line without hooks is operated in Kannur district for catching *Scylla serrata*. Vertical line with baited hooks are operated in Kozhikode to catch finfishes. Long lines for fish are seen in several places. In Mahe river, long lines are exclusively operated to catch eels for use as bait in shark long lines.

Mini-trawls

Mini-trawls for fish, shrimp and crab with head rope length ranging from 3-6 m are popular in the estuarine areas of Kariangode and Chandragiri rivers in Kasargod. Net is generally made of HDPE netting of 0.5mm dia with 15-40 mm mesh size. A few shrimp trawls are made of PA 210Dx2x3. Wooden, flat rectangular otter boards of 40x20 cm weighing 5.5 kg each are used. The net is operated from non-motorised canoes using rope and anchor to catch bottom dwelling fishes.

Operation of mini-trawls from non-motorised craft in estuarine waters is not reported by any workers in the past.

Hand dredge

Hand-held dredges are operated in the estuarine areas of Kariangode, Valapatanam and Kuppam rivers by men and women to collect clams. Dredge is a curved iron plate with teeth attached in the mouth of a small scoop net fastened to a 10 m long wooden pole. The canoe held perpendicular to the shore hold the pole and press the dredge into the bottom. Man standing in the second canoe drag the dredge against current by pulling the rope tied to the pole to scoop the bottom.

Four-boat lift net

It is operated in the lower reaches of Chaliyar river to catch shoaling fishes. Net is trapezoidal in shape and is made of nylon PA multifilament. Mesh size in the central part is 20 mm and it is 90 mm in the periphery. It is operated from four boats and another two boats leads the fish into the net by dragging a scare line during day time or a petromax during night. Catch is mainly mullets and catfish. This method is also reported for the first time.

Cast net

String less cast net without pocket, stringed cast net without pocket and string less cast net with pocket are the three types of cast nets in operation. They are made of PA multifilament (210Dx1x2 & 210Dx1x3) and a few nets are made of PA monofilament. Group cast netting is practiced in Kozhikode by joining 4-5 canoes and a group of 8-10 fishermen. They drive the shoal to a central place and simultaneously cast the net from all sides. Drifting of cast net in open condition along the water current from a canoe and cast net as drive-in-net are some innovative type of fishing seen in some parts of Kozhikode.

Stake net

Stake nets made of PA mutifilament knotted or knotless netting with 8-10 mm mesh size is common. Dimension of square mouthed nets varies from 2.5- 3.2 m. The length of the bag varies 8-16 m. Fore part of the net is usually fabricated

using 3 mm dia. PP twine with 230- 250 mm mesh size. Middle part of the net is fabricated using PA multifilament with different mesh and twine size. Last part of the net is fabricated with PA mutifilament or knotless netting with 8-10 mm mesh size. Total cost of the net varies from Rs. 10,000 to 30,000. In Kallai river stake net fishermen practice quota system for the net operation because suitable locations are limited.

Encircling net

Dragging two rectangular nets against each other and encircling shallow areas temporarily using poles erected to the bottom to harvest the trapped fishes during low tide is an unique and ancient fishing method practiced by the members of a muslim family in Valapatanam river. The net is rectangular in shape with 12-15 pieces of size ranging from 25 to 35 m in length and from 2.5 to 3.0 m in height. Fishing is carried out only during from February to May. Fishes are captured by removing the poles, reducing the enclosed area. This fishing method is reported for the first time.

Drive-in nets

It is rectangular net of about 30 m length and 3.5 m width, made of PA multifilament of 210Dx1x3 or 210Dx2x2 twine size and 20-25 mm mesh size. The net is operated by dragging the scare line attached at one end of the net to drive the fishes into the net.

Scare lines

The scare line, made of inserting coconut leaves into a 100 m long coir rope, is held in the form of "V" and is dragged along shallow waters by 3 fishermen to scare the fish to burrow and they are subsequently captured by the fisherman moving at the base of the "V".

Stick held drag net

They are rectangular bag nets made of PA multifilament of 210Dx1x3 twine size with 10 – 22 mm mesh size. Double stick held and multiple sticks held dragnets with shallow bag are operated in shallow areas by 2 to 3 fishermen.

Scoop nets

Scoop nets made PA and HDPE are operated in shallow waters to capture shrimps and small fishes. Stick held scoop nets are also operated in some places.

Baited lift net

It consists of an iron ring of about 0.5 m dia made of MS rod of 4-6 mm dia to which a basket like net is fastened as to form a shallow scoop net with 15 – 20 cm depth. Eel pieces, chicken parts and beef intestine are used as bait in the net and it is attached to the ropes running across the frame. A series of such nets are operated in rivers and backwaters, with the help of thermocole floats, to catch *Scylla serrata.*

Cross bow

It is employed to shoot the fish in the streams and quiet backwaters. Cross bow is operated in Valapatanam river by migrant fishermen from Ernakulam district. It is operated from a canoe during night.

Spear and trident

Spear is simple metallic rod with a pointed tip. Three pronged spears are also operated in shallow waters during night particularly to collect shellfish. Hooked rods are used to capture crabs from burrows.

Miscellaneous fishing methods

Stupefying methods of fish capture includes use of poisons of plant origin, electricity and use of explosives. Although these are prohibited practices a few people do it as a sort of recreational fishing. Other methods are hand picking for

fish, clams and edible oysters. Locally made knives are used to remove oysters from the rocks.

Fish aggregating devices

Artificial fish shelters are made in shallow waters by planting cut branches of trees. The fishes which takes shelter inside such parks are captured after 2-3 weeks by surrounding the FAD using nets and removing the vegetation.

Chapter IV

This chapter deals with design, fabrication and performance evaluation of collapsible fish trap for riverine fishing.

The traditional trap is made of natural materials and hence it is prone to bio-deterioration. Collapsible trap is made of two SS rods of 1.1x 0.75 m size covered with HDPE netting made of 1.25 mm dia twisted monofilament with 50 mm mesh size. Funnel shaped entrances are provided at both ends. Eight disc shaped PVC floats of 150 x 20 mm size, two each at four corners were used to lift the upper portion of the trap to achieve a box shape during operation. Four disc shaped cement sinkers weighing 1 kg each were attached to the four bottom corners to keep the trap at the bottom.

Performance evaluation was conducted during January 2005 to March 2006 at Kuttieri in Kuppam river in comparison with the traditional fish. Average catch per haul was 0.94 kg in the traditional trap and 0.54 kg in collapsible trap when operated without any bait. In collapsible trap the species composition is *Etroplus suratensis* (34.8 %), *Lutjanus argentimaculatus* (30 %), *Scylla serrata* (28 %) and *Lates calcarifer* (7.2 %). In the traditional fish trap *L. argentimaculatus* (46 %) dominated the catch followed by *E. suratensis* (36.4 %) and *S. serrata* (16.2 %).

ANOVA reveals that there is significant difference in catch between these two traps at 5 % level. There is no increase in the catch when operated with tapioca as bait. There is significant difference in total catch when operated with chicken

waste as bait, due to the increase in the catch of *S. serrata*. Catch of collapsible trap was comparable when operated with chicken waste.

10-15 collapsible trap can be operated from a canoe whereas only 2 traditional traps were able to operate at a time because of its huge size. Daily income was Rs. 540/- against Rs.188/- realized from traditional trap fishing. Net annual profit in collapsible trap fishing was Rs. 84,992/- against Rs. 21,495/- Since the fabrication, operation and maintenance cost is low, artisanal fishermen can easily adopt it to earn an additional income.

Chapter V

Conclusion and Recommendations

37 types of fishing gears and methods of fishing are identified from the inland waters of North Kerala. Design drawings of all these gears are prepared and this will form the basis for the gear technologists for efficiency improvements. This will also help the fisheries administrators for formulation of policies for sustainable fisheries development.

1. One new type of fishing craft and four new type of fishing gears are reported for the first time. Split bamboo fishing canoe, design details of four-boat dip net, mini-trawling from non-motorised craft, *Maade valayal* and *thottil vala* are reported for the first time and it is a contribution to the science of fishing technology.
2. The traditional fish traps operated in the region is prone to bio-deterioration and hence its operation is restricted to six months in a year. Service life of the trap is one year. Two fishermen and a canoe are required for its operation.
3. A collapsible, light weight, durable fish trap is developed during the study. A fisherman can operate 10 collapsible traps from a canoe and can earn minimum Rs. 540/- per day. Daily income from the trap operation is approximately Rs. 188/- Total cost of traditional trap fishing is Rs. 17,150/- and that of collapsible trap is Rs. 24,661/-. Net annual profit is only Rs.

21,495/- for traditional trap and it was Rs. 84,992/- for the new trap developed.

4. Catch of *Scylla serrata* in fish trap can be increased, if chicken waste is used as bait. Moreover carnivorous fishes can be lured into the traps, in addition to the normal target species.
5. Details of inland aquatic and fishery resources of the region are made available. The R & D organizations can take up further studies to assess the resources and make appropriate management strategies.
6. Selectivity experiments should be carried out for major species to optimize the mesh size for the most predominant gear, *viz.* gill nets. Further, use of resource specific nets may be encouraged to eliminate juveniles from the catch.
7. Closed season and area may be observed to reduce the landings of juveniles in seine nets.
8. Number of stake nets may be restricted, mesh size regulated and operation during flood tide banned in order to protect the juveniles.
9. Resource enhancement programmes like stocking and ranching may be strengthened in water bodies like reservoirs to increase the productivity and daily income of the dependent fishermen.
10. Large-scale sand mining is noticed in several rivers during the study. It may be restricted to protect the habitat and increase fish production.
11. Passage for migration of fishes may be provided while constructing check dams, barriers and roads across channels and other water bodies.
12. Awareness programmes on responsible fishing may be taken up for the sustainable development of the sector.

REFERENCES

References

Ahmad, M.D., Hossain, M.M. and Akhteruzzaman, M. 2003. Flood plain gears of Bangladesh: A case study of *Titas* flood plain. Abstract submitted to the second *International Symposium on the Management of large Rivers for Fisheries*. Phnom Penh, Cambodia, Mekong River Commission.

Ahmad, N. 1956. Fishing gear of East Pakistan. Directorate of Fisheries, Govt. of East Pakistan. 35p.

Ahmad, S. and Sheshappa. D.S. 1991. Sleeping net: a new method of fishing in Nethravati-Gurupur estuary of Mangalore, Karnataka. *Fishing Chimes* 11(2): 56-58

Andrew, E. 1948. Crab pot construction, *Fishing Leaflet*. No. 262. 4p.

Anon, 1960. Illustration of Japaneese boat and fishing gear. Japan Association for Agriculture and Forestry, Tokyo, Japan: 207p.

Anon, 1995. Fishing craft and gear of Sri Lanka. Dept. of Fisheries and Aquatic Resources. UNDP/FAO/SRL/91/022. Marine Fisheries Management Project. Colombo. Sri Lanka. State Printing Corporation, Colombo: 216p.

Anon, 1995. Water Atlas of Kerala. Center for Water Resource and Management, Kozhikode: 82p.

Anon, 2005. Fisheries and environmental assessment in selected backwaters on the South west coast of India. CIFRI, Barrackpore: 43p.

Anon, 2005. Inland Fisheries Statistics of Kerala 2005. Directorate of Fisheries, Thiruvananathapuram, Kerala. 44p

Archdale, M.V, Kariyazono, L and Anasco, C.P. 2006. The effect of two pot types on entrance rate of and entrance behaviour of the invasive Japanese swimming crab *Charybdis japonica*. *Fish. Res.*77: 271-274.

Archdale, M.V. and Kuwahara, O. 2005. Comparative fishing trials for *Charybdis japonica* using collapsible box-shaped and dome-shaped pots. *Fisheries Science*. 71: 1229-1235.

Babu, D.E., Rama Rao, K., Ratuna Raju, M., Khasheem, S.K. and Jitendra, V. 2005. Harvesting of mud crab and their transportation. In: Boopendranath, M.R., Mathew, P.T., Gupta, S.S., Pravin, P. and Jeeva, J.C., (eds.). Proc. *Sustainable Fisheries Development: Focus on Andhra Pradesh.* Society of Fisheries Technologists (India), Cochin: 82-86.

Baiju, M 2005. Studies on the riverine fishing gears of central Kerala. Ph.D theis. Cochin University of Science and Technology. 215p.

Baiju, M. and Hridayanathan, C. 2002. Fishing gears of Muvattupuzha River system of Kerala. In: Boopendranath, M.R., Meenakumari, B., Joseph, J., Sankar, T.V., Pravin, P. and Edwin, L. (eds.) Proc. *Riverine and Reservoir Fisheries of India.* Society of Fisheries Technologists (India), Cochin : 256-263

Balasubramanian, A, Kathavarayan, E and Neethiselvan, N. 2001. Comparative fishing efficiency of lobster traps. *Fish. Technol.* 38(2): 77-80

Banerjee, S. and Chakravarthy, R.D. 1972. Drift gill nets in Sunderbans, West Bengal. *Indian J. Fish.* 16 (1and2): 75-81.

Baranov, F.I. 1948. Theory and assessment of fishing gear. Theory of fishing with gill nets. Translated from Russian by Ont. Dep. Lands For, Malpe, Ont., 45p.

Baranov, F.I. 1977. Selected works on fishing gear. Volume II: Theory and practice of commercial fishing. Israel Programme for Scientific Translations, Jerusalem. 261p.

Beven, R. 1877. Hand Book of the freshwater fishes of India, London, L Reeve and Co.

Bhagwati, A.K. and Kalita, B. 1987. Studies on traditional fishing in some beels in Kamrup, Assam. In: *Proc. of workshop on dev. beel fisheries,* Assam, held at Guwahati during 21-22, April 1987: 47-69

Bhimachar, B.S. 1942. Report on the survey of the fisheries of Mysore state. Bull. Dept. Agri. Mysore (1): 1-39.

Biswas, K.P. 1995. Ecological and Fisheries Developments in wetlands. A study of Chilka Lagoon. Daya Publishing Home, Delhi, 188 p. Boopendranath, M.R. 2000. Gill Nets. *Technology Advisory Series*. Central Institute of Fisheries Technology, Cochin. 7p.

Boopendranath, M.R. 2000. Gill Nets. *Technology Advisory Series*. Central Institute of Fisheries Technology, Cochin. 7p.

Brahmaputra in Assam. *Fish. Technol.* 2(2): 205-219

Brandt, A. V, 1972. Fish Catching Methods of the World. Fishing News (Books) Ltd. London: 240p.

Broadhurst, M.K., Kennellly, S.J. and Isaken, B.1996. Assessment of modified codends that reduce the by-catch of fish in two estuarine prawn trawl fisheries in New South Wales, Astralia. *Fish. Res.* 27: 89-111.

Butler, T.H. 1953. The Stephenson collapsible traps. Progress Reports of the Pacific coast Stations. No.94, Fisheries Research Board of Canada.16 p

Chakraborty, R. D. and Banerjee, M.K. 1967. Otter trawling in the Hooghly estuary, West Bengal. *Proc. Nat. Acad. Sci. India* . 37(B), IV: 389-400

Charley Cyr and Bernard Sainte-Marie 1995. Catch of Japanese crab traps in relation to bait quantity and shielding *Fish. Res.* 24 (2): 129-139

Chhapgar, B.F.1961. Crab fishing at Bombay. *J. Bombay Nat. Hist. Soc.* 59(1): 306-309

Chopra, B. N. 1939. Some food prawns and crabs of India and their fisheries. *J. Bombay. Nat. Hist. Soc.* (2): 221-234

Chopra, B.1936. The Cape Craw Fish Industry of South Africa with some observations on the prawn and crab fisheries in India. *Curr. Sci.* (7) 4: 529-533

Choudhury, M.1992. Fishing Methods in Flood Plain Lakes. In: Yadava, Y.S and Sugunan, V.V. (eds.) Compendium: *FAO Sponsored Training Programme on Flood Plain Fisheries Management.* 2: 163-166.

Cody, T.J. and Fuls, B.E. 1986. Comparison of catches in 4.3 m and 12.2 m shrimp trawls in the Gulf of Mexico. *Fish. Bull.* 84 (4): 981-990

Collins, M.R. 1990. Comparison of three fish trap designs. Fish. Res. 9(4): 325-332.

Das, C.R. 1993. On the low energy fishing operation in two sewage fed Bheries at Kulti, 24-Paragnas, West Bengal. In: Low Energy Fishing. Fish. Technol. (Spl. Issue) Society of Fisheries Technologists (India), Cochin : 166-167.

Day, F. 1873. Report on the freshwater fish and fisheries of India and Burma, p23, 24 and 66.

Day, F. 1878. The fishes of India, A natural history of the fishes known to inhabit the seas and freshwaters of India, Burma and Ceylon. (Reprinted by Today and Tomorrow Book Agency, New Delhi). 778p.

Day, F. 1958. Fishes of India, A natural history of the fishes known to inhabit in the seas and freshwaters of India, Burma and Ceylon. William Dawson and sons Ltd, London. 1, 708.

Day, F. 1989. The fauna of British India, including Ceylon and Burma. Fishes, 1, Taylor and Francis, London. 548.

De, K.C. 1910 Report on the fisheries of Eastern Bengal and Assam, Govt. printer, Shillong, 36 p

Devasundaram, M.P. 1951. Fishing methods for Chilka mullets. *Indian fmg.*12 (1and2): 22-25

Dutta Munshi, J.S. and Srivastava, M.P. 1988. Natural history of fishes and systematics of freshwater fishes of India. Narendra Publishing House, Delhi: 403 p.

Dutta, K.K., Dan, S.S. and Dutta, A.K.. 1989. Economics of different craft gear combination in Orissa coast. *Seafood Export Journal* , 21 (8):15-26.

Dutta, S.N, 1973. On the gill nets of the Hooghly-Matlah estuarine system (West Bengal) with special reference to their specifications and operation. *J. Inland Fish. Soc. India.* 5: 29-36

Dutta, S.P.S., Bali, J.P.S., Kour, H., Gupta, S.C. and Salaria, S. 2000. Fishing method employed in lentic and lotic environment of Jammu province of Jammu and Kashmir state. Fish and Food security (Abstracts). First Indian Fisheries Science Congress. Indian Society of Fisheries Professionals, Mumbai :21-23.

Ellis, J.E and Pickering. E. N. 1973. Trans. Am. Fish. Soc. 1: 116p

FAO, 1995. Code of Conduct for Responsible Fisheries, FAO, Rome. 41p.

FAO, 2004. Fisheries statistics: Capture production. Yearbook. FAO, Rome. 94/1: 642p.

Faruqui, A.J. and Sahai, R. 1943. On the methods of catching fish in United Provinces and scope of establishing inland fisheries in these provinces. Proc. Natl. Acad. Sci. India 13:198-214.

Flores, E. and Shibata, K. 1988. Survey of small scale fishing gears in the selected areas of Indonesia and Philippines. In: Proc. World Symposium on Fishing Gear and Fishing Vessel Design. Marine Institute, Canada. 221-227.

Friedman, A.L. 1986. Calculation of fishing gear designs, FAO, Fishing Manual, Fishing News Books (Ltd.), Farnham. 264p.

Furevik, D.M. and Lokkenborg, S. 1993. Fishing trials in Norway for torsk (Brosme brosme) and cod (Gadus morhua) using baited commercial pots. Fish. Res. 19(3and4): 219-229

George, M. J. Mohamed, K.H. and Pillai, N.N.1968. Observations on the paddy field prawn filtration of Kerala, India. FAO Fisheries Reports, 57(2): 427-442

George, V. C. 1991. Studies on prawn gill nets of the Kerala coast. Ph.D thesis, Cochin University of Science and Technology, Cochin, 189p.

George, V.C. 1971. An account of inland fishing gear and methods of India, Spl. bull. Central Institute of Fisheries Technology, Cochin 1:68p

George, V.C. 1982. Stick held drag net for shore line fishes of reservoirs. Fish. Technol. 19(2): 121-122.

George, V.C. 1983a. Shore seines for reservoirs. Part-1. Design and Performance. Fish. Technol. 20(1): 5-8

George, V.C. 1983b. Shore seines for reservoirs. Part-2. Fish. Technol. 20(2): 97-100

George, V.C. 2002. Fishing techniques of riverine and reservoir systems - Present status and future challenges. In: Boopendranath, M.R., Meenakumari, B., Joseph, J., Sankar, T.V., Pravin, P. and Edwin, L. (eds.) Riverine and Reservoir Fisheries of India. Society of Fisheries Technologists (India), Cochin. 192-196

George, V.C., Dawson, P., Khan, A.A. and Varghese, M.D. 1982. Experimental trawling in Hirakud reservoir. Fish. Technol. 19 (1):15-18

George, V.C., Dawson, P., Khan, A.A., Varghese, M.D. and Iyer, H.K. 1986. Efficiency of two designs of trawls in Hirakud Reservoir. Fish. Technol. 23(1): 43-44.

Gokhale, S.V.1957. Operation of the dol net off the Saurashtra cost. J. Bombay Nat. Hist. Soc. 54 (3): 714-724

Gopi, K.C. and Radhakrishnan, C. 1998. Freshwater fish diversity in Wetland Kerala, South India- A revised checklist. Zoos'print. J XIII (12), 31.

Gopinath, K. 1953. Some interesting methods of fishing in the backwaters of Travancore. J. Bombay Nat. Hist. Soc. 51:466-471

Gorge, V.C. 1991. The lure and lift net fishing techniques at Coromandal cost off Tamil Nadu. In : Ravindran, K., Unnikrishnan Nair, N., Perigreen, P.A., Madhavan, P., Gopalakrishnan Pillai, A.G., Panickar, P.A. and Mary Thomas (eds.) Harvest and Post-harvest Technology of Fish. Society of Fisheries Technologists (India), Cochin : 241-244.

Gulbadamov, S.B.1962. Report to the Govt. of India on the improvement of fishing techniques in inland reservoirs of India. ETAP/FAO/TA Report FAO, Rome. No.1342: 1-12

Hameed, M.S 2002. Classification of fishing gears. ICAR Winter School Manual on *Advances in Harvest Technology*. Central Institute of Fisheries Technology, Cochin: 82-100

Hameed, M.S. and Boopendranath, M.R. 2000. Modern Fishing Gear Technology, Daya Publishing House, Delhi, 186p.

Harikrishnan, M. and Madusoodana Kurup, B.1998. Fishing methods and gearwise intensity of fishing of Macrobrachium rosenbergi (de Man) in Vembanad

lake. In: Hameed, M.S. and Kurup, B.M. (eds.) Technological Advancements in Fisheries. Publn. No.1. School of Industrial Fisheries, Cochin University of Science and Technology, Cochin. 216-222

Hasan, M.R., Bala, N. and Hossain, M.I. 1999. Gear specific catches in culture based fisheries in Oxbow lakes. In. *Sustainable Inland Fisheries Management in Bangladesh*. ICLARM Conf. Proc. 58, 280p

Hickling, C.F.1961. Tropical inland fisheries. Publ. Longman, Green and Co.Ltd.London.287p

Hopson, A. J. 1975. Afx. J.Trop. Hydrobiol. Fish. 4: 79p.

Hora, S.L. 1926. On a peculiar fishing implement from the Kangra valley, Punjab. Proc. Asiat. Soc. Bengal. 22:81-84

Hora, S.L.1935. Crab fishing at Uttarbhag, Lower Bengal. Curr. Sci. (11) 3: 543-546

Hornell, J.1924. The fishing methods of the Ganges. Mem. Asiat. Soc. Bengal 8(3): 197-237

Hornell, J.1925. The fishing methods of Madras Presidency. Part-1. The Coromandel cost. Madras Fish. Bull.18 (2): 59-110

Hornell, J.1938. The fishing methods of Madras Presidency. Part-II. The Malabar Coast. Madras Fish. Bull. 27(1): 1-69.

Hornell, J.1950. Fishing in many waters.Univ.Press. Cambridge. 210p

Hridayanathan, C. and Pauly, K.V. 1993. Stake nets of Kerala- Their present condition and future prospects. In: Low Energy Fishing, Fish. Technol. (Special Issue) Society of Fisheries Technologists (India), Cochin. p: 229-233

Jayram, K.C. 1981. Freshwater fishes of India, A hand book. Zoological Survey of India, Culcutta. 551p.

Jayram, K.C. 1999. Freshwater Fishes of the Indian Region. Narendra publishing House, New Delhi. 509p.

Jerdon, T.C. 1849. On the freshwater species of Southern India. *Madras J. Lit. Sci.* 15, 302-346

Jhingran, A.G. and Natarajan, A.V. 1969. Study of the fisheries and fish populations of the Chilka Lake during the period 1957-65. *J. inland Fish. Soc. India.* 1: 49-63

Jhingran, V.G. 1991. Fish and fisheries of India, Hindustan Pub. Co., New Delhi. 666p

Jhingran, V.G. and Patnaik, S. 1954. Some interesting methods of fishing of *Sparus* spp. 'Khuranti' in Chilka lake. *J. Bombay Nat. Hist. Soc.* 61(3): 701-703

Job, T.J and Pantelu. V.R. 1953. Fish trapping in India. *J. Asiatic. Soc. Sci.* 19(2): 175-196

Job, T.J. David A. and Das, K.N.1995. Fish and fisheries of the Mahanadi in relation to the Hirakud Dam. *Indian J. Fish.* 11(1): 1-36

John, A.T, Thomas, R. and Raghavan, R. 2002. Optimal use of water resources for fishery related activities in Kerala. *Riverine and Reservoir fisheries of India* In: Boopendranath, M.R., Meenakumar, B., Joseph, J., Sankar, T.V., Pravin, P. and Edwin, L. (eds.) Society of Fisheries Technologists (India), Cochin: 35-42

John, C.C.1936. Freshwater fishes and fisheries of Travancore. *J. Bombay Nat. Hist. Soc.* 38: 702-712

Jones, S. 1946. Destructive methods of fishing in the rivers of the hill ranges of Travancore. *J. Bombay Nat. Hist. Soc.* 46(3): 437-445

Jones, S. and Sujan Singani, K.H. 1952a. Notes on the crab fishery of Chilka lake. *J. Bombay Nat. Hist. Soc.* 51(1): 119-34

Jones, S.1959a. Fishing Methods of Indian Shad, *Hilsa ilisha* (Hamilton) in the Indian region, Part 1, *J. Bom. Nat. Hist. Soc.*54 (3): 714-25

Jones, S.1959b Fishing Methods of Indian Shad, *Hilsa ilisha* (Hamilton) in the Indian region, Part II, *J. Bombay Nat. Hist.* Soc.54 (3): 423-445

Jose, R.V.2002. Inland fishermen and inland fishing: A study at Neelamperoor village, Alappuzha. Discussion Paper Series, Kerala Research Programme on Local Development. Center for Development Studies. Thiruvananthapuram, 40p.

Joseph, K.M. and Narayanan, K.P. 1965. Fishing gear and methods of river

Kamal, M.Y. 1991. Riverine fisheries in India-A retrospect. *J. Inland Fish. Soc. India,* 23 (2): 1-8.

Kar, D., Dey, S.C. and Kar, C. 2000. An account of fishing implements used in bark drainage in Assam with a note on their efficiencies. Fish and Food security (Abstracts). *First Indian Fisheries Science Congress.* Indian Society of fisheries Professionals, Mumbai. 22 p

Kara, A. 2001. Fishing with fish pots. Work shop on Technological developments in fisheries. June 19-21, Izmir, Turkey: 37-40

Karamchandani, S. J. and Pandit, P.K. 1967. A special fishing method for *Mystus (Osteobagrus) seengala* (Sykes) and *Mystus (Osteobagrus) aor* (Hamilton) and certain other interesting fishing methods in River Narbada. *J. Bombay Nat. Hist. Soc.* 64 (3): 455-461

Kartha, K.N. and Rao, K.S.1991. Selectivity of gill nets for *Catla catla* (Ham) *Cirrhinus mrigala* (Day) and *Labeo rohita* (Ham) in Gandhisagar reservoir. *Fish. Technol.* 28(1): 5-10

Kathirvel, M. 1978. Harvesting and marketing of cultured prawns. *Spl. Bull. Cent. Mar. Fish. Res. Inst.* 3: 121-127.

Khan, A. A., Kartha, K.N., Dawson, P. and George, V.C. 1991. Fish Harvesting systems in Indian Reservoirs. *Proc. National Workshop on Low Energy Fishing,* p: 152-155. Fishery Technology (Special Issue) Society of Fisheries Technologists (India), Cochin

Khan, A.A. 1993. Observations on experimental two-boat bottom and midwater trawling in Gandhisagar reservoir *In. Low Energy Fishing, Fish. Technol.* (Special Issue) Society of Fisheries Technologists (India), Cochin: p 116

Khan, M. Z. 1986. Dol net fishery of Nawabandar (Gujarat) *Fish. Technol.* 23(1): 92-99.

Kim, D. Ko, K. 1987. Fishing mechanism of pots and their modification. 2. Behaviour of crab, *Charybdis japonica*, to the pot. Bull. Korean Fish. Soc. 20(4): 348-354.

Kim, D. Ko, K. 1990. fishing mechanism of pots and their modifications. 4. An experiment for modifying the pot of crab, *Charybdis japonica. Bull. Korean Fish. Soc.* 23 (4), 310-314.

Krishna Menon, M. and Raman, K. 1961. Observation on the fishery of the Cochin backwaters with special reference to the stake net catches. *Indian J. Fish.* 8 (1):1-23

Krishnamurthy, K.N. and Rao, A.V.P.1970. Fishing methods of Pulicat lake. *J. Inland Fish. Soc. India.* II: 1-15

Kuipers, B.R., Maccurrin, B., Miller, J.M., Veer, Vander, H.W. and Witte, J.I. 1992. Small trawls in juvenile flat fish research: Their development and efficiency. In: *Proceedings of the first international symposium on flatfish ecology.* Part 2: 29 (1-3): 109-117

Kulkarni, C.V. 1951. Hilsa fisheries in the Narbada River. *J. Bombay Nat. Hist. Soc.* 49(4): 614-623

Kulshreshtha, S.D. 1986. Traditional inland fishing methods in Rajasthan, India. In: Maclean, J.L., Dizon, L. B. and Hosillos, L. V. (eds.) *Proc: First Asian Fish. Soc.*, Manila, Philippines: 413-416.

Kunjipalu, K. K., Boopendranath, M.R., and Khan, M.Z. 1993. Investigation on dol nets of Gujarat coast. In: *Low Energy Fishing, Fish. Technol.* (Special Issue), Society of Fisheries Technologists (India), Cochin: 225-233.

Kurian, C.V. and Sebastian, V.O.1986. Prawns and Prawn Fisheries of India. Hindustan Publishing Corporation (India). New Delhi. 307p.

Kurian, G.K. 1965. Trends in the prawn fishing technique in India-A review. *Fish. Technol.* 2(1): 64-68.

Kurian, G.K. 1971. Fishing methods in fresh water reservoirs of India. All India Co-ordinated research project for ecology and fisheries of freshwater reservoirs, Calcutta

Kurian, J. and Wilmann, R.1982. Economics of Artisanal and Mechanised Fisheries in Kerala: A study of cost and earnings of fishing units. RAS/77/044. FAO/UNDP working paper Madras, India. No. 34: 387-411

Kurup, B. M. 2002. Rivers and streams of Kerala part of Western Ghats-Hotspots of Exceptional fish biodiversity and endemism. In: Boopendranath, M.R., Meenakumar, B., Joseph, J., Sankar, T.V., Pravin, P. and Edwin, L. (eds.) *Riverine and Reservoir Fisheries of India.* Society of Fisheries Technologists (India), Cochin: 204-217

Kurup, B.M. and Samuel, C.T.1985. Fishing gear fishing methods of Vembanad Lake. In: Balachandran, K. K., Iyer, T.S.G., Madhavan, P., Joseph, J., Perigreen, P.A., Ragunath, M.R. and Varghese, M.D. (eds.) *Harvest and*

Post-harvest Technology of Fish. Society of Fisheries Technologists (India), Cochin p: 232-237

Kurup, B.M., Radhkrishnan, K.Vand Manojkumar, T.G. 2004. Biodiversity status of fishes inhabiting in the rivers of Kerala (S.India) with reference to endemism, threats and conservation measures. *Proc. Second International Symposium on the Management of Large Rivers for Fisheries.* 2: 162-163.

Kurup, B.M., Sebastian, M.J., Sankar, T.M. and Ravindranath, P. 1993. An account of Inland fishing gears and fishing methods of Kerala. *In: Low Energy Fishing, Fish. Technol.* (Special issue), Society of Fisheries Technologists (India), Cochin : 145-151.

Kurup, N.S. Sarada, P.T. Menon, K.K. and Lakshmi, S. 1993. Low energy fishing methods for the prawn fishery of Calicut, Kerala. In: *Low Energy Fishing, Fish. Technol.* (Special Issue), Society of Fisheries Technologists (India), Cochin: 130-136.

Lahr, L.E. 1939. The crab industry at Eureka, California fish and Game (4) 25:330-335.

Lakshmilatha, P. and Appukuttan, K.K. 2002. A review of the black clam (*Villorita cyprinoids*) fishery of Vembanad lake. *Indian J. Fish.* 49(1): 85-91

Lal, K.B. 1969. An introduction to the fishing gear technology. Publ. by Metropolitan Book Co. Ltd. Delhi: 229p.

Liggins, G. W. and Kennelly, S. J.1996. By catch from prawn trawling in the Clarance river estuary, New South Wales, Australia. Fisheries Research. 25: 347-367

Mathai, T.J. and George, N.A. 1972. A note on the comparative catch efficiency of nylon over cotton gill nets in reservoir fishing. *Fish. Technol.* 9(1): 81-82

Meenakumari, B. 2002. Traps and their operation. ICAR winter School Manual 410-415.

Meenakumari, B. and Mohan Rajan, K.V. 1985. Studies on materials for traps for spiny lobsters. *Fish. Res.*, 3: 309-321.

Meenakumari, B., Remesan, M.P. and Pravin, P. 2005. Bamboo in the fisheries sector of India. *International Policy Workshop on Bamboo in Fisheries*. Sep 30 – Oct 1, 2004, Goa. CIBART, India: 94-110

Menon, A.G.K. 1999. Checklist-freshwater fishes of India. Occ. Pap., *Rec. Zool. Surv. India*. 175, 243-259.

Menon, M. D. and Joseph, K. M. 1969. Development of '*Kalava*' (Rock-cod) fishery of South West coast of India-prospects. *Seafood Export Jour.* 1(2): 7-28

Menon, M. D., Varghese, C.P. and Haridas 1977. Development of trap fishing for rock–cods of south west coast of India. *Bull.*No.2. IFP Cochin: 96-102.

Meschkat, A.1956. FAO Report to the Government of Yugoslavia, 555, 15.

Miller, R.J. 1978. Entry of Cancer Productus into Baited Traps. J. du Cons. 38(2): 220-225.

Miller, R.J. 1980. Design criteria for crab traps. *J. Cons. Int. Explor. Mer.*, 38: 220-225.

Miller, R.J., 1979. Entry of *Cancer productus* to baited traps. *J. Cons. Int. Explor. Mer.* 38, 220-225.

Mitra, P.M., Ghosh, K.K., Saigal, B.N., Sarkar, N.D., Roy, A.K., Mondal, N.C. and Paul, A.R. 1987. Fishing gears in the upper and middle Hooghly estuary. *Bull.* Central Inland Fisheries Research Institute, Barrackpore, No.49: 1-22.

Miyamoto, H. 1962. A field manual suggested for fishing gear surveys (In Mimeo), CIFT, Cochin.15p

Mohan Rajan, K.V. 1993. Fish trapping devices and methods in Southern India. *Fish. Technol.* 30 (2): 85-93.

Mohan Rajan, K.V. and Meenakumari, B. 1982. Development of lobster traps-Priliminary experiments with three new designs of Rectangular, Australian Pot and Ink-Well traps. Fish. Technol. 19 (2): 83

Mohan Rajan, K.V., Meenakumari, B. and Nair, A.K.K. 1988. Development of an efficient trap for lobster fishing. Fish. Technol. 25(1): 1-4

Mohapatra, P. 1955. The *Thatta-Khonda* - a screen trap of Chilka lake. *J. Bombay Nat. Hist. Soc.* 53: 277-279.

Mohapatra, P. 1956. The *marala*-a sink net used in the backwaters of Ganjam, Orissa. *J. Bombay Nat. Hist. Soc.* 54(3): 773-775.

Munro, 1971. Dynamic factors affecting the performance of the Antillean fish trap. *Proc. Gulf Caribb. Fish. Inst.* 23: 184-194

Muralikrishna, M. and Onishi, Y. 2002. Mussel Muscle: Resource management *Samudra*: 19-21

Naidu, R.M., Khan, A.A. and Narayanappa, G. 1976. Comparative efficiency of frame nets and trammel nets. *Fish. Technol.* 13(1): 59-61

Nair, N. B. 1971. Water wealth of Kerala. *Seafood Export J.,* 3(1): 29-38

Nair, N.B. 1989. Report of the expert committee on marine fishery resource management in Kerala. 116 p

Nair, P. R. 1993. Fishing with traps. In: *Low Energy Fishing. Fish. Technol.* (Special Issue) Society of Fisheries Technologists (India), Cochin: 207-209 p

Nandini, N.C. and Pramanik, S.K. 1994. Crabs and Crab fisheries of Sunderban. Hindustan Publication Corporation, Delhi. 192p.

Naser, A.K.V. and Noble, A. 1993. Economics of Clam exploitation from backwaters at Azhicode - A Case Study. In: *Low Energy Fishing. Fish. Technol.* (Special Issue) Society of Fisheries Technologists (India), Cochin : 50-54

Natarajan, A.V and B.K. Banerjee, 1967 Mullets on Rod and Line in Chilka lake. *J. Bom. Nat. Hist. Soc.*64 (3): 572-574.

Nath, D. 2005. Open water fishery resources of India, Problems and Prospects. Suvenir, National Seminar on Management Challenges in Fisheries of Rivers and Associated Eco-systems-Issues and Strategies. Inland Fisheries Society of India and CIFRI, Barrackpore, West Bengal: 81-87.

Nayak, A.K., Mukhi, S.K., Behera, B.K., Samantray, B., Misra, C. and Koli, M.P.S. 2000. A survey on various gears, crafts, and fishing methods adopted by the fishermen of Chilka Lake. Fish and Food security (Abstracts). *First Indian Fisheries Science Congress*, Indian Society of Fisheries Professionals. 22 p.

Nayak, N., Nandakumar, D., Amruth, A., Unnikrishnan, P. and Padmanabhan, T.P. 2000. Wetland resources of Northern Kerala: A case study of Payangadi and Kunjimangalam in Kannur district. Discussion paper No.15. Centre for Development Studies, Thiruvananthapuram, Kerala.

Nedlec, C. 1975. FAO Catalogue of Small Scale Fishing Gear, Fishing News (Books) Ltd., Farham, Surrey, England: 191p.

Ninan, G. and Samikumar, M. 2003. Types of crafts and gears are in use for exploitation of fishes in small reservoirs of India. *Proc. Workshop on Fishery Mamnagement in Lentic Water System: Stocking of Reservoir with Fish Seed.* CIFRI, Barrackpore, West Bengal: 92-105.

Noble, A. and Narayanan Kutty, V.A. 1978. Economics of the indigenous fishing units of Cochin: A case study, *Spl. Pub.* No.4, CMFRI: 24p.

Okawara, M.1983. Trap fishing. TD/TRB/28, Training Department, SEAFDEC, Thailand: 36p

Pandey, B.L. 1993. A short note on the special catching device for *Clupsoma garua* (Hamilton) in River Ganga around Bhagalpur. *Punjab Fish. Bull.* 27(1): 33-34

Panikkar, N.K. 1937. The prawn industry of Malabar Coast. *J. Bombay Nat. Hist. Soc.* 39: 343-353

Pauly, K.V. 1991. Studies on the commercially important fishing gears of Vembanad lake. Ph.D. Thesis, Cochin University of Science and Technology, Cochin.171p

Pillai, N.S. and Gopalakrishnan, K. 1984. A brief account on the *Gunja net* fishing of the Kutch backwaters (Gujarat). *Fish. Technol.* 21(1): 147-149.

Pillay, T.V.R. and Ghosh, K.K. 1962. The bag net fishery of the Hooghly-Matlah Estuarine System (West Bengal). *Indian. J. Fish.* 9(A): 71-99.

Prado, J. 1990. Fisherman's Workbook.FAO, Fishing News Books, Oxford. 180 p

Pravin, P. 2003. Studies on Shrimp Harvesting Techniques in Aquaculture. Ph. D. Thesis. Central Institute of Fisheries Education, Mumbai. 220p

Pravin, P., Remesan, M.P., Ravishankar, C. N., Asok Kumar, K., Badonia, R. and Solanki, K. K., 1996. Fishery of Surajbari prawn (*Metapenaeus kutchensis*) *Sea Food Export J.* 27 (12): 15-18

Prem Kumar and Meenakumar, B. 2003. Methods of prawn harvesting from the River Mahanadi, Orissa. Paper presented in the *International Symposium on fresh water prawns.* College of Fisheries, Panangad, Kerala (in press).

Raina, H.S. and Joshi, C.B. 2006. In Fisheries and Aquaculture in Indus River Region. In: Singh Koli, M.P. (ed.). Proc. Workshop on Fishing and Aquaculture Development in Indus River Region. Punjab Agricultural University, Ludhiana, 21-22, Dec. 2005. Society of Fisheries Professionals, Mumbai: 27-48

Rama Rao, J.S., Satyanarayana, A.V.V., Naidu, R.M., Rama Rao, S.V.S. and Narayanappa, G. 1985. Indigenous gear of Andhra coast-A brief account. In : Ravindran, K., Unnikrishnan Nair, N., Perigreen, P.A., Madhavan, P., Gopalakrishnan Pillai, A.G., Panickar, P.A. and Mary Thomas (eds.) *Harvest and Post- harvest Technology of Fish.* Society of Fisheries Technologists (India), Cochin: 292-295

Ramachandran, A. 2002. Freshwater indigenous ornamental fish resources in Kerala and their prospects for international marketing, In: Boopendranath, M.R., Meenakumari, B., Joseph. J., Sankar, T. V., Pravin, P. and Edwin, L (eds.). *Riverine and Reservoir Fisheries of India.* Society of Fisheries Technologists India, Cochin: 109-134.

Ramachandran, A., Mini, S., Pramod, P.K. 2004. Resource analysis of potential ornamental fishes of Kerala for the development of market in India and abroad. Final Report, School of Industrial Fisheries, Cochin University of Science and Technology, Cochin. 98p.

Ramamurthy, S and Muthu, M.S. 1969 Prawn fishing methods. In: *Prawn fisheries of India.* Bull. No.14, CMFRI, Cochin: 234-257

Raman, K 1975 Some interesting methods of fishing for the giant freshwater prawn in Kerala. *J. Bom. Nat. Hist. Soc.* (2): 575-579.

Remadevi, K., Indra, T.J. and Emiliyamma, K.G. 1996. On the fish collection from Kerala deposited in Southern Regional Station, Zoological Survey of India by N.R.M. Stockholm. *Rec. Zool. Surv. India. Trop. Fish Hobbyist.* 6: 175-176.

Remesan, M. P. and Ramachandran, A. 2004. *Maadevalayal*-unique fishing method in Valapatanam river. Paper presented in the *7th Asian Fisheries Forum.* Nov.30-Dec.2, 2004, Penang, Malaysia. (in press).

Remesan, M. P. and Ramachandran, A. 2005b. Mini-trawls for estuarine fishing in Kasargod district. *Fish. Technol.* 42 (1): 41-46

Remesan, M. P. and Ramachandran, A. 2005c. Gill nets for inland fishing in North Kerala. *Fish. Technol.* 42 (2): 125-134.

Remesan, M. P. and Ramachandran, A. 2005e. *Koruvala* fishery of Chaliyar river. *Fishing Chimes.* 24 (7): 55and64

Remesan, M. P., Pravin, P. and George Mathai, P. 2002. Indegeneous fishing gear of Saurashtra and Kachch. *Technology Information Series,* CIFT, Cochin, No.9: 15p

Remesan, M.P, Ramachandran, A. and Pravin, P. 2005g. An account of inland fishing methods of North Kerala. Paper presented in the *International Symposium on Improved Sustainability of Fish Production Systems and Appropriate Technologies for Utilization.* 16-18, March 2005. School of Industrial fisheries, CUSAT, Cochin.

Remesan, M.P. and Ramachandran, A. 2005a. *Vattathoni* fishing by migratory fishermen in Kerala. *Fishing Chimes,* 25(2): 42and60

Remesan, M.P. and Ramachandran, A. 2005d. The bamboo canoe – a novel and economical fishing craft. *Infofish International.* 6: 67-69

Remesan, M.P. and Ramachandran, A. 2006. Shore seines for riverine fishing in three districts of Kerala. *Fish. Technol.* Dec. 2006 (In press)

Remesan, M.P., Pravin, P., Meenakumari, B. and Ramachandran, A. 2005f. Riverine fisheries of North Kerala. Paper presented in the *National Seminar on Management Challenges in Fisheries of Rivers and Associated*

Ecosytems-Issues and Strategies. 16-17, April 2005. Inland Fisheries Society, India and CIFRI, Barrackpore, West Bengal.

Robichaud, D., Hunte, W. and Oxenford, H.A. 1999. Effect of increased mesh size on the catch and fishing power of coral reef fish trap. Fish. Res.3993): 275-294.

Roy, B. and Banerjee, B. K.1980. Fishing Methods of Chilka Lake (mimeo) *Summer Institute on Brackish Water Capture and Culture Fisheries*, CIFRI, Barrackpore

Sae Ung, S., Ananpongsuk, S. and Fukui, J. 1990. A preliminary experiment of deep-sea pot fishing in the Andaman Sea. SEAFDEC, TD/RES/27: 1-16p.

Sahara, D.B.S. and Karbhari. J.K. 1989. Economics of gill net fishing by OBM units at selected centers in North West Coast, *Mar.Fish.Infor.Serv.* T& E Ser, 98: 1-8.

Sahoo, N., Mukherjee, C.K. and Mitra, A. 1988. Development of a bamboo boat for small-scale fisheries. In: *Proc. World Symposium on Fishing Gear and Fishing* Vessel Design. The Newfoundland and Labrador Institute of Fisheries and Marine Technology, St. John's, Newfoundland, Canada: 485-487.

Saigal, B.N. and Mukhopadhyay, M.K. 1988. Status of estuarine fisheries Resources and their exploitation in India. In: Jhingran, A. G. and Sugunan, V.V. (eds.) *Conservation and management of Inland capture fisheries resources.* Inland Fisheries Society of India, Barrackpore, West Bengal: 183-188.

Sanjeevaghosh, D. 1993. Brackish water Fishery Resources of Kerala. In: *Low Energy Fishing*. Fishery Technology (Special issue), Society of Fisheries Technologist (India), Cochin: 63-67

Sankoli, K. N., Patil, S.W. and Shenoy, S. 1993. Low energy fishing techniques of the Konkan coast. In: *Low Energy Fishing, Fish. Technol.* (Special issue), Society of Fisheries Technologist, (India), Cochin: 141-144.

Sarada, P.T. 1997. Exploitation of mud crab *Scylla serrata* (Forskal) from Korapuzha estuary, Kerala. *J. Mar. Biol. Ass. India*, 39 (1and2): 113-117.

Sathyanarayanappa, S.N., Hanumanthappa, B., Salian. P.K. and Sheshappa, D.S. 1987. Riverine fishing crafts and gear of Karnataka. *Proc. Symp. impact of current land use pattern and water resources development on riverine fisheries.* Inland Fisheries Society of India. CIFRI, Barrackpore, West Bengal, 68p

Saxena R.K, 1993. Drift in status of Riverine fishing gear- A case study of middle reaches of Ganga river system. In: *Low Energy Fishing, Fish.Technol.* (Special issue), Society of Fisheries Technologist (India), Cochin: 159-162

Saxena, R.K .1964. The fishing nets and traps in a section of the middle reaches of Ganga river system in India. *Indo. Pac. Fish. Coun.* 11(11): 250-271

Saxena, R.K, 1988. Fishing methods in river systems. In: Jhingran, A, G. and Sugunan, V.V. (eds.) Conservation and Management of Inland capture fisheries resources. *Bulletin No. 57*, CIFRI, Barrackpore, India: 161-68

Saxena, R.K. and Chandra, R. 1968. On the introduction of *phasla jal*, a gill net for catching Hilsa in the Ganga and Yamuna, near Allahabad. *J. Bombay Nat. Hist. Soc.* 65(2): 496

Sehara, D.B.S. and Karbhari, J.K. 1987. A study on dol net fishery at selected centers in Northwest cost with special reference to costs and returns *Mar. Fish. Info. Ser.* 78:1-15

Sehgal, K.L, 1973. Fisheries survey of Himachal Pradesh and some adjacent areas with special reference to trout, mahseer and allied species, *J. Bombay Nat. Hist. Soc.*, 70(3): 458-471

Sehgal, K.L., Shukla, J.P. and Shah, K.L.1971. Observations on the fisheries of Kangra valley and adjacent areas with special references to Mahaseer and other indigenous fishers. *J.Inland Fish. Soc.India.*, 3: 63-71

Sen, V. 1972. Methods of fishing in the Rarh region of Bengal. *Indian Museum Bulletin*. 37-52

Seth, R.N. and Katiha, P.K.2000. Present scenario of riverine fishing methods with special reference to large sized *Aorichthys* spp. Fish and Food security (Abstracts). *First Indian Fisheries Science Congress*. Indian Society of Fisheries Professionals, Mumbai: 21-23,

Seth, R.N. and Katiha, P.K.2003. Riverine fishing methods with special reference to catfishes *Aorichthys seengala* (Sykes) and *Aorichthys aor* (Hamilton). *Indian J. Fish.* 50(1): 125-130.

Shaji, C.P., Easa, P.S. and Gopalakrishnan, A. 2000. Freshwater fish diversity of Western Ghats. In: Ponniah, A.G. and Gopalakrishnan, A. (eds.). *Endemic Fish Diversity of Western Ghats*, NBFGR-NATP Publication-1: 33-55. National Bureau of Fish Genetic Resources, Lucknow. 347p

Sharma, K.K., Bhattacharya, B.K., Manna, R.K., Choudhury, M., Barik, N.K., Sarkar, A. and Chandra, G. 2005. Indigenous plant piscicides used in Northeastern India. *National seminar on Management challenges in fisheries of rivers and associated ecosystems-issues and strategies*. 16-17, April 2005. Inland Fisheries Society, India and CIFRI, Barrackpore, West Bengal.

Sharma, P. and Ahamed, S. 1998. Relative efficiency of fish capturing devices in Kachodhara beel of Morigaon dist, Assam. *Environ. Ecol.* 16(1): 123-126.

Sharma, P., Kalita, K. K. and Dutta, O.K. 1993. Low energy fishing techniques of the North eastern India. In: *Low Energy Fishing, Fish. Technol* (Special issue), Society of Fisheries Technologist (India), Cochin: 163-167.

Sheshappa, D.S. 1978. Performance evaluation of a four seam trawl in capturing bottom resources in estuarine areas. *Mysore J. Agri. Sci.* 12: 618-621

Shetty, H.P.C. 1965. Observations on fish and fisheries of Vembanad backwaters, Kerala. *Proc. Nat. Acad. Sci. India*, 35(1): 115-130

Shrestha, T.K. 1979. Techniques of fishing in Nepal: Innovation and development of loop line sharing. *J. Museum of Natural History*, Tribuvan University, Katmandu, 3: 121-138

Shrestha, T.K. 1994. Fishes, fishing implements and methods of Nepal. Gwalior, India, Gupta Publishing. 150p

Sinha, M, 2002. Riverine and Reservoir Fisheries of India- Present status and Future Prospects. In: Boopendranath, M.R., Meenakumari, B., Joseph, J., Sankar, T.V., Pravin, P. and Edwin, L. (eds.). *Riverine and Reservoir fisheries of India,* Society of Fisheries Technologists (India) Cochin: 197-203

Sinha, M. and Pandit, P.K. 1984. *Kumar Jal* – a catfish fishing method of Hooghly-Matla estuary. *Sci. and Cult.* 50(11): 318-319.

Skene, D. 1908. Estuarine fishing in India (Miscellaneous notes). *J. Bombay Nat. Hist. Soc.*18 (2): 691-694

Slack Smith, R.J. 1997. Traps used for finfish fishing in Australia, Report to FAO: 1-13.

Slack Smith, R.J. 2001. Fishing with traps and pots. FAO Training Series No.26.

Smith, P.S. and Sumpton, M.D. 1989. Behaviour of the commercial sand crab Portunus pelagicus at trap entrances. *Asian Fish. Sci.* 3: 101-113.

Snedecor, W.G and Cochran, G.W. 1956. Statistical Methods Applied to Experiments in Agriculture and Biology, The lowa State University Press, Ames, lowa, USA, 534p.

Sreedhar, U., Rajeswari, G. and Raghu Prakash, R. 2005. Artisanal fishing gears of Vishakapatanam. In: Boopendranath, M.R, Mathew, P. T, Gupta, S.S, Pravin, P and Charles Jeeva (eds.). *Sustainable Fisheries Development, Focus on Andhra Pradesh.* Society of Fisheries Technologist (India), Cochin: 101-111

Sreekrishna, Y. and Shenoy, L. 1987. Fish catching methods of Indian rivers. *Proc. Symp. impact of current land use pattern and water resources development on riverine fisheries*. CIFRI, Barrackpore, West Bengal.

Subramanyam, M. 1987. Some aspects of the fishery of the prawns from the Godavari estuarine system. *Proc. Symp. impact of current land use pattern and water resources development on Riverine fisheries*. CIFRI, Barrackpore, West Bengal

Sugunan, V.V. 1995. *Reservoir fisheries of India*. FAO Fish. Tech. Paper No.345, FAO, Rome

Sugunan, V.V. and Sinha, M. 2001. Sustainable capture and culture based fisheries in freshwaters of India. In: Pandian, T. J. (eds.) *Sustainable Indian Fisheries*. National Academy of Agricultural Sciences, New Delhi: 43-70.

Sulochanan, P., George, V.C. and Naidu, R.M. 1968. Experimental fishing in Hirakud reservoir, Orissa (1965-67). *Fish. Technol.* 5(2): 81-95

Sundberg, P. 1985. A model for the relationship between catch and soak time in baited fish traps. *Oceanogr. Trop.* 20 (1): 19-24

Supanga, N.C. and Smith, I.R.1982. Costs and returns of Cabusao stationery gears. In: Smith, I.R. and Mines, A.N. (eds). Small scale fisheries of San Miguel Bay, Philippines: Economics of production and marketing. ICLARM Technical report 8: 45-60

Suresh, V.R. 2000. Floating islands: a unique fish aggregating method. *NAAGA*, The ICLARM Quarterly. 23(1): 11-13

Suresh, V.R. 2002. Fishery resources of Manipur – potential, problems and strategies for development. In: Boopendranath, M.R., Meenakumari, B., Joseph, J., Sankar, T.V., Pravin, P. and Edwin, L. (eds.). *Riverine and Reservoir fisheries of India,* Society of Fisheries Technologists (India) Cochin: 135-140.

Talwar, P.K. and Jhingran, A.G. 1991. Inland Fishes of India and adjacent Countries, Oxford and IBH Publishing Co, Pvt., New Delhi. I and II: 1158p.

Tandon, K.K. and Sharma, V.K.1984. An account of fishing methods in Kangra and Hamirpur districts of Himachal Pradesh. *J. Zool. Soc. India* 36(1/2): 95-100

Thakur, N.K. and Banerjee, S.R. 1980. *Chhoh-* A special fishing method employed to catch air breathing fishes in North Bihar. *J. Inland. Fish. Soc. India.* 2: 92-94.

Thomas, A.J.1971. Crab fishing of the Pulicat lake. *J. Mar. Biol. Ass. India*, 13(2): 278-280

Thomas, J. V. and Kurup, B.M. 2004 *Padal* fishing-A unique fishing method in the Ashtamudi Estuary of Kerala (South India). *NAGA*, World Fish Center, Quarterly, 27(3and4): 1-4

Thomas, S.N. 2001. Gill nets of Kerala: A study on technological and operational aspects. Ph.D. Thesis. Cochin University of Science and Technology. 217p.

Thomas, S.N. 2002. Gill nets and their operation. In: Advances in Harvest Technology. ICAR Winter School Manual, CIFT, Cochin: 371-382

Trevenen, W.B. 1930. Fishing in the rivers of Central Province. *J. Bombay Nat. Hist. Soc.* 34(3): 701-715.

Trippel, E.A. and Crossman, E.J. 1981. Collapsible fish trap of Plexiglass and netting. *Prog. Fish. Cult.* 43(3): 157-158

Tyagi, R.K. 1998. Riverine fisheries in India with special reference to Ganga river system. *Bull.* CIFRI, Barrackpore, West Bengal No.83: 78-82

Varghese, M.D., George, V.C., Khan, A.A. and Krishna Iyer, H. 1982. Shore seines for reservoir. Part-11, Studies on optimal mesh size. *Fish. Technol.* 20(2): 97-100

Varshney, R.L. and Maheshari, K.L. 1981. Managerial Economics, Sultan Chand and Sons, New Delhi, 446p.

Vazquez Archdale, M.F., Anrku, K., Yamamoto, T., Higashitani, N. 2003. behaviour of the Japanese crab "Ishihani" Charybdis japonica (A. Milne Edwards) towards two baited collapsible fish pots: Evaluation of capture effectiveness. *Fish. Sci.* 67, 785-791.

Vijay Anand, P.E. 1996. Fishing Methods in Lakshadweep. *Infofish International*, 3: 57-65

Vijayan, V. Varghese, M.D. and Pillai, S. N. 1990. Evolution of an improved trawl net for artisanal craft. *Fish. Technol.* 27: 83-86

Vijayan, V., Varghese, M.D., Edwin, L., Thomas, S.N. and George, V.C. 1993. Coastal gill nets of Kerala- Changes in three decades. In: *Low Energy Fishing, Fish. Technol.* (Special issue), Society of Fisheries Technologist, (India), Cochin: 170-176

Wahab, M.A. and Kibria, M.G. 1994. *Katha kua* fisheries: unusual fishing methods in Bangladesh. *Aquaculture News*, 18: 24.

Wallinger, W.A, 1907. Estuarine fishing - some remarks on its decadence, as an industry in the Konkan, Western India. *J. Bombay Nat. Hist. Soc.*17 (3): 620-636.

Welcomme, R. L. 1972. An evaluation of *acdaja* method of fishing practiced in the coastal lagoons of Dahomey (West Africa) *J. Fish. Biol.* 4: 39-55

Welcomme, R.L. 1985. River fisheries. FAO Fisheries Technical paper, 262: 330p

Welcomme, R.L. 2002. An evaluation of tropical brush and vegetation park fisheries. *Fisheries Management and Ecology*. 9:175-188

Whitelaw, A.W., Sainsbury, K.J., Dews, G.J. and Campbell, R.A. 1991. Catching characteristics of four fish trap types on the North West Shelf of Australia. *Aust. J. Mar. Freshwat. Res.* 42(4): 369-382

Willimovski, N.J. and Alverson, D.L. 1971. The future fisheries. In: Kristjonsson, H., (ed.). *Modern fishing gear of the World.* Fishing News (Books) London 3: 509-513.

Wilson and Davis 1973. The active pound net fishery in Virginia. *Va. J. Sci.* 24(3): 126p

Wilson, H.C. 1920. Report on the methods of capture and supply of fish in the rivers of the Nilgiri district. *Madras Fish. Bull.*, 12(40):135-56.

Wishard, S.K. 1976. *Roak* fishing and its probable effects on the capture fishery of river Yamuna in Agra district. *Indian J. Fish.* 23(1-2): 213-31.

Yadava, Y.S. and Choudhury, M. 1986. *Banas* fishing in beels of Assam *J. Bombay Nat. Hist. Soc.* 83(2): 452 p

Yadava, Y.S., Choudhury, M. and Kolekar, V.1981. Fishing methods of flood plain lakes in North Eastern region. *J. Inland Fish. Soc. India*, 13(1): 82

Znamensky, Y. A. 1976. FAO Report to Govt. of India. TA 2290. FAO, Rome

LIST OF PUBLICATIONS FROM THE PRESENT STUDY

1. M.P. Remesan and A. Ramachandran. 2005. Mini-trawls for estuarine fishing in Kasargod district. ***Fishery Technology***. Vol.42(1):41-46
2. M.P. Remesan and A. Ramachandran. 2005. Gill nets for inland fishing in North Kerala. ***Fishery Technology***. Vol. 42(2): 125-134
3. M.P.Remesan and A. Ramachandran 2005. The bamboo canoe-a novel and economical fishing craft. ***INFOFISH*** November 6/2005.p 67-69
4. M.P. Remesan and A. Ramachandran. 2005. Koruvala fishery of Chaliyar River. ***Fishing Chimes***. Vol.24 (7): 55and64
5. M.P. Remesan and A. Ramachandran. 2005. *Vattathoni* fishing by migratory fishermen in Kerala. ***Fishing Chimes***. Vol. 25(2) :42and60
6. M.P. Remesan and A. Ramachandran. 2004. *Maadevalayal*-unique fishing method in Valapatanam river. Paper presented in the ***7th Asian Fisheries Forum*** 2004, Nov 30-Dec 4, Penang, Malaysia.
7. M.P.Remesan, A. Ramachandran and P. Pravin. 2005. An account of inland fishing methods of North Kerala. Paper presented in the ***International Symposium on Improved Sustainability of Fish Production Systems and Appropriate Technologies for Utilization***. Organised by School of Industrial fisheries, CUSAT, 16-18, March 2005.
8. M.P. Remesan, P.Pravin, B. Meenakumari and A. Ramachandran 2005. Riverine fisheries of North Kerala. Paper presented in the ***National Seminar on Management Challenges in Fisheries of Rivers and Associated Ecosytems-Issues and Strategies***. Inland Fisheries Society India and Central Inland Fisheries Research Institute, Barrackpore, West Bengal. 16-17, April, 2005
9. M.P. Remesan, A. Ramachandran, P.Pravin and B.Meenakumari. Inland fishing gears of Kannur district (Abstract). ***15th Swadeshi Science Congress*** held at Govt. Brennen College, Thalassery during 5-7, November, 2005.
10. M.P.Remesan and A. Ramachandran. 2006 Shore seines for riverine fishing in three districts of Kerala. ***Fishery Technology,*** Dec. 2006 (In press)