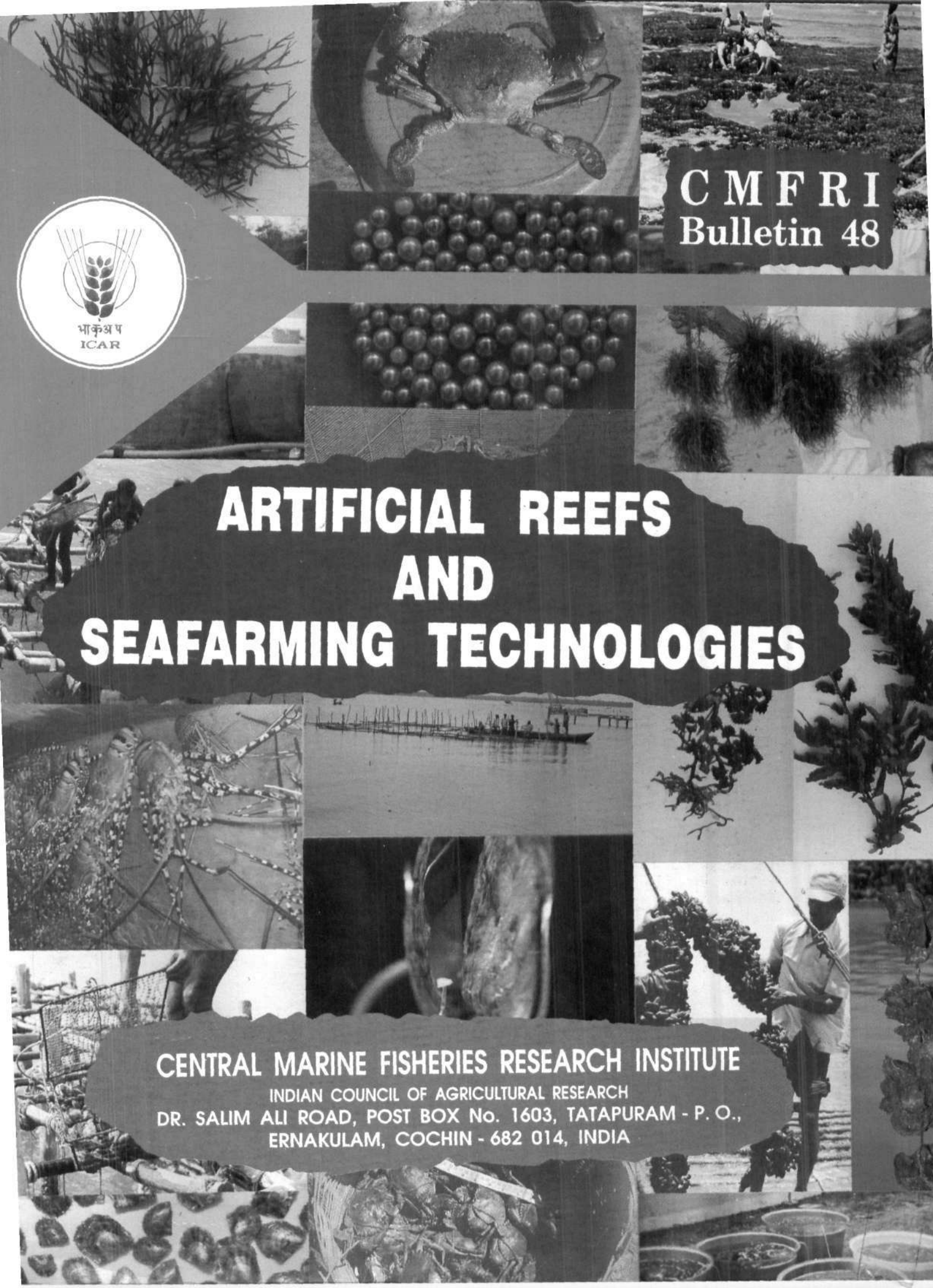

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CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
DR. SALIM ALI ROAD, POST BOX No. 1603, TATAPURAM - P. O.,
ERNAKULAM, COCHIN - 682 014, INDIA

C M F R I
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ARTIFICIAL REEFS AND SEAFARMING TECHNOLOGIES

Dr. K. Rengarajan

Editor

January 1996

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9

ARTIFICIAL FISH HABITATS*

A COMMUNITY PROGRAMME FOR BIO-DIVERSITY CONSERVATION

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Introduction

It has been generally recognised in India that artisanal fishermen are still the masters in traditional gear technology. Artisanal fishermen are continuously involved in innovating new fishing technologies and adapting them to their local marine environment. Technical capability of artisanal fishermen was kept in low profile and was confined and known mostly to regions of origin. The statements given in the note on the National Workshop on Technology for Small Scale Fishworkers are highly relevant in respect of technology developments in artisanal sector.

Technical changes in the small scale marine and inland fisheries sectors of India have always been fairly localised and rarely taken on a high profile. There are two important reasons for that:

i. the vast diversity of these sectors necessarily restricted a technical change to a particular region.

ii. the fact that in recent history most of the changes have been largely fishing gear related tended to keep them outside public vision.

Through continuous interaction with the ocean and fish, the artisanal fishermen accumulated trans-generationally a treasure of scientific knowledge on diverse marine ecosystems and fish behaviour. The technical capability of artisanal fishermen is based on this knowledge, the application of which has proven their worth by enduring for thousands of years like the *"Ayurveda"*, the indigenous form of medicine and health systems. Rejecting this as traditional and primitive, modern fishing technologies developed in the temperate waters like trawling, purse-seining and mechanised fishing were introduced in the mid 60's. The end results of these are overfishing, destruction of marine ecosystems and fall of fish production, particularly the share of the traditional fishermen.

The formal R&D institutions neglected almost totally the traditional sector. It was the commercial interests and profit motive together with government support that made them concentrate on the newly imported modern technologies especially for shrimps for a quarter of a century.

The dawn of 1980 witnessed explosive social unrest among fishing communities. It was a turning point for both the traditional fishermen and the state government. The state was forced to rethink its earlier policy on fisheries and the traditional fisherworkers turned to more dynamic alternative technologies. Since 1980, fishermen took active interest in constructing AFHs as a means of fish aggregating and regenerating and sustaining natural marine habitat greatly damaged by bottom trawling and overfishing.

AFHs construction is one of the methods developed by traditional fishermen to fight for the sustenance of marine life. In the process of ecological destruction, it is in the tropics that the battle to preserve *"bio-diversity"* will be won or lost. AFHs is a great step forward in the march for 'eco-technology .

This book is based on the study on the innovation, adaptation and diffusion of artificial fish habitats technologies developed by artisanal fishermen of Kanyakumari and Trivandrum districts of the south-west coast of India. The study aimed to highlight (a) the technological capability of artisanal fishermen (b) the science and technology of artisanal fishermen and to show it is not at all inferior to modern science and technology but based on their intricate knowledge of the oceanography and fish behaviour (c) the need for formal R&D to study thoroughly and recognise the artifacts of artisanal fisheries sector in order to develop technologies appropriate to tropical waters.

Sources of information

i. Author's learning and experience as a community organiser with artisanal fishing community in Trivandrum district of Kerala State.

ii. Author's continuous interaction with artisanal fishermen during the information sharing sessions of "Dissemination of Scientific and technical information to fishworkers in Kerala", a three year fishermen's training programme by PCO sponsored and financed by Council for Advancement of People's Action and Rural Technology (CAPART, New Delhi).

iii. Participation in the artificial fish habitats building process from planning to execution and evaluation. Observation of fishing in the artificial fish habitats and discussion with fishermen while fishing in the artificial fish habitats and in the 'Gramakoottom' meetings.

iv. Artisanal fishermen involved in the construction of the 22 artificial fish habitats (49 artificial fish habitats fishermen were interviewed) and fishermen participated at various stages of the development of artificial baits (48 hook and line fishermen were interviewed)

"Preview of the study" held at FCO on 9th April 1989. Respondents (artificial fish habitats builders and bait innovators) were fed back all information collected from them and others and checked the facts with them. A few fisheries and social scientists were also present.

Evolution of Artificial Fish Habitats

1. Background

India is the seventh largest fish producing country in the world. It has a coastline of 7517 km. Gujarat, Maharashtra, Goa, Karnataka and Kerala on the West Coast and Tamil Nadu, Andhra Pradesh, Orissa and West Bengal on the East Coast are the maritime states of India. The union territory of Pondicherry and Islands (Andaman & Nichobar in the Bay of Bengal and Lakshwadweep in the Arabian Sea) also covered in the coast line in India. The major share of marine production in India is still being contributed by the small-scale fishermen, using mostly traditional fishing craft and gear. In the small-scale fisheries, hook & line fishing is the oldest sustaining fishing method. Trivandrum and Kanyakumari districts of Kerala and Tamil Nadu respectively have the largest concentration of hook & line fishermen in India.

2. Fishery Situation in Trivandrum & Kanyakumari

Kerala and Tamil Nadu lie in the humid tropical zone (See Map I). The coastal fish habitats in this tropical waters are among the biologically richest and most diverse eco-systems of earth. Kerala has the highest pressure of fishing in the inshore waters, having only 10 ha per fisherman in 1980 as against 37 ha per fisherman for India as a whole[1]. Among the marine fishermen in India, 27% are in Kerala. Even though Kerala's land area is small comparatively, it enjoys 8% of India's coastline. Sixty five percent of the marine production of Kerala is still landed by traditional crafts. Kerala had 26,271 traditional fishing crafts in 1980, of which 11,480 were kattumarams[2]. In 1990 there were 30,459 traditional fishing crafts, of which kattumarams accounting for 15,090[3].

The state of Tamil Nadu with a coastline of 1,000 Km and continental shelf of 61,200 sqkm upto 200 m depth accounts for 13% of the coastline and 14% of the shelf region of India[4]. It varies from 40-60 Km, and more than 63% of this is no deeper than 50m. The fishing fleet consists of about 46,000 craft of which over 80% are traditional crafts. Traditional crafts are responsible for about 70% of the marine landings. The majority of the crafts are kattumarams. Propelled by oar and sail, kattumarams are still the predominant fishing craft in the state.

Fishing is the sole economic activity of the coastal people of Trivandrum in Kerala and Kanyakumari in Tamilnadu. Hook & line fishing from kattumarams at sea is one of the predominant fishing methods. Constructed entirely of wood and made with the simplest of tools the kattumaram represents the longest sustaining sea-going craft. The advantages are many: unsinkability, easy construction, low cost, relative stability, maneuverability and best suited for beach launching and landing in the surf-ridden sandy beaches of the region.

The continental shelf of the South West coast is as wide as 68 Km in North Kerala and as narrow as 40 Km in Kanyakumari. The narrowest continental shelf in Kanyakumari gets wider as it goes towards the North. The continental shelf of Trivandrum and Kanyakumari is so narrow that it makes the inshore sea steep, sloped and surf-ridden. While the sub-stratum of the inshore sea North of Quilon is mostly slushy or muddy due to a large number of rivers emptying into the sea. Trivandrum and Kanyakumari have sandy substratum due to the lack of muddy inflow into sea. The coastline of Trivandrum is regular sandy beach except in Kovalam (The International Tourist Beach Resort) and Vizhinjam. It has rocky outgrowth in the inshore sea in the depth range 18-40 fathoms (32 to 72 m) in Kanyakumari, the coastline is largely irregular with patches of rocky outgrowth extending from the shore to deep sea.

Compelled by these oceanographic features, fishermen of Kanyakumari and Trivandrum developed highly skilful hook & line fishing and kattumaram rowing and sailing. Trivandrum in 1980 had the largest number (90%) of the kattumarams and hook & line units in the state, ie. 10,302 out of 11,480 kattumarams and 2,133 out of 2,949 hook & line units[5]. In Trivandrum the Kattumarams figured 13,527 in 1990[6]. The fish habitats in Trivandrum and Kanyakumari present a large variety of colourful reef fishes.

3. Development of AFH

Natural fish habitats are the result of biological or geological processes taking place in the sea bottom.

> *"A fish habitat develops when benthic organism build a rigid, wave resistant structure on the sea bottom. The fish habitat provide a shallow water environment favourable to many organisms, where nutrients are readily recycled. Barnacles, algae, mussels and other sessile organisms for instance colonise a artificial fish habitats as they do any firm surface in shallow water. The processes by which organisms invade a previously uninhabited area is known as Ecological Succession" or fouling. It begins with an accumulation of bacterial slime. Benthic diatoms and protozoans appear next. They multiply rapidly utilizing absorbed organic compounds and products of bacterial decomposition. Hydroid and multicellular algae follow and then come the planktonic larvae of barnacles, mussels and snails. Eventually the ecosystem reaches a balanced state or climax community in which no further colonisation occurs and ecological succession ceases unless a disturbance of the system causes the process to start afresh."* [7]

What is an Artificial Fish Habitat ?

An artificial fish habitat (AFH) is any external object or stable structure placed in the sea to attract, aggregate and regenerate pelagic, demersal, migratory and residential fishes.

AFHs - Origin and development of the idea

As an age old practice, traditional fishermen of Trivandrum operating shore seine used to dump rocks fastened with coconut fronds into sea bottom to attract fish closer to the shore. Fish which got aggregated over the bottom structures were caught by shore seine locally named *"karamadi "*('kara'=land, 'madi'=seine), a gear pulled from beach from two sides by about ten fishermen on each side. This practice was based on their knowledge that fish tend to congregate over bottom structures.

It may be generally stated that alien objects of virtually any kind placed in the water would cause some form of fish congregation. A well known example is the large number of Japanese warships sunk during Second World War still serving as excellent AFHs.

During the second world war a ship was sunk off Anjengo fishing village 45 Km north of Trivandrum at 25 fm (45m) depth. Local

fishermen rescued nine crew members from the sinking ship. Efforts made by authorities to locate the wreck became futile. After nine years in 1949 a hook and line fisherman alias Sukkurappan discovered the wreck while engaged in hook and line fishing. The wreck measured 50 m long and 45 m wide and 7 fathom depth from the top of the ship. The wreck matured into a rich AFH which attracted line fishermen who fished from the AFH using artificial bait (see Fernandez. J, 1994, 'A Bait to Dazzle the Fish'). Artificial bait hooked more fish than natural bait used by local fishermen. Infuriated by this the locals chased the 8 southern fishermen out of the wreck. They justified their action on the basis of their belief that it was morally unjust to catch fish without giving food and artificial bait would chase the fish away from the wreck. But the southerners achieved the fishing right by getting women of Anjengo married and settling down there. This was possible because of the "matrilineal" and "matrilocal" systems prevalent in the fishing communities of Trivandrum and Kanyakumari districts. A folk song in Anjengo stands testimony to this story:

Vernacular: *"Sukkurappan kandupidicha kappalparu*
Irayillathe meen pidichu thekkenmaru"

Translation: *It is Sukkurappan who discovered the ship wreck*
but fished without bait by southerners.

Almost simultaneously two anchors were lost and sunk at about 12 fm from the ships berthed at the Valiathura Pier, 5 Km west of Trivandrum City. One anchor was taken from sea bottom by skin diving by a local fisherman late Mr. John. He was not able to find the second one. About 10 years later line fishermen located the anchor spot which by that time became a rich fishing spot. These were the earliest known examples of external bodies attracting fish and maturing into rich fishing spots. Of recent there were many such wrecks in the inshore waters of south west coast. An oil tanker sank in about 1970 at 31.5 Fathom off Sangumughom beach. Two boat wrecks occurred in the early 80's, one at Vizhinjam at 14 Fm and another at Chouvara at 12 Fm. Hundreds of rocket noses which fell into the inshore water from the weather testing space rockets launched from Indian Space Research Organisation and Vikram Sarabhai Space Centre, established near Thumba fishing village are serving as good fishing spots, Enayamputhenthura has a boat wreck too (See Table I)

An examination of the evolution of AFHs in the South West Coast of India reveals that three factors have simultaneously contributed to the origin and development of th idea of AFHs and there were four phases in its evolution.

i. The age old practice of dumping rocks fastened with coconut fronds into sea bottom by shore seine operators to attract fish closer to shore.

ii. Anjengo ship wreck which not only aggregated pelagic fishes but also attracted deep sea reef fishes like *"kalava"*

iii. Anchor lost from ships berthed in Valiathura pier and became a rich fishing spot (See Map - II).

Four phases of the evolution of AFH

(i) Origin phase

According to well informed fishermen of Puthiyathura and Eraviputhenthura, artificial fish habitats were setup in Puthiathura of Trivandrum in 1953 and in Eraviputhenthura village of Kanyakumari in 1957. Line fishing is the predominant fishing method in Puthiathura, fishing mostly in natural reefs. Among them one rocky reef is at 12 fm and 2.5 km off the coast. Since they found that the nearby rocky reef in Karimkulam which was higher than theirs was more productive, they decided to enhance the productivity of their reef by heightening the reef. Two lorry loads of rocks packed in bags were dumped on the top of the reef making it 0.5 m taller. Productivity substantially increased after six months of the dump. This was the first known attempt to enhance productivity through artificial means.

In 1957 the Panchayat (local government) authorities built a community well in Eraviputhenthura with concrete rings. One ring of the size off 3 m diametre and 0.5 m height was left over after the completion of the well. The ring was taken by some fishermen and dumped at 11 Fm depth and 1.5 km off the coast on a clay substratum, which was already being used as a fishing ground by line fishermen. This was the first time in the village of Eraviputhenthura an external structure was dropped on the sea bottom which soon became an artificial fish habitat known as *"Vattuparu" ("Vattu" = ring, "paru" = reef)*. These were the two early attempts to create artificial fish habitats in the 50's.

(ii) Dormant phase

The origin phase was followed by a period of 25 years of dormancy in the AFH construction. Between 1957 and 1980 no effort was generally made by fishermen either to create new AFH or to service the existing ones. In the words of fishermen of Puthiathura and Eraviputhenthura, "Nobody took interest to maintain them or create new ones". This can be due to the introduction of synthetic gear materials like nylon nets (Polyester), synthetic line (Polyamide) and ropes (Polyethylene) in the second half of the 60's which revolutionised the fishing gear technology. The change from cotton to synthetic gear materials increased productivity per unit effort. Resources were not fished to the optimum leaving room for steady increase in production. Also trawlers and purse-seiners were not yet introduced in the region. Hence no compulsion on the part of the fishermen to go in for AFHs making.

(iii) Active phase

With the dawn of 1980, efforts were made by fishermen to reactivate the existing AFHs and construct new AFHs especially in Trivandrum district. Fishermen started feeling the pinch of resource depletion which started with the middle of the 70's. To quote Achari T.R.T, "since the middle of the seventies, Kerala has been passing through a fisheries crisis. The characteristics of the crisis are broadly indicated below:

1. The demersal fishery wealth of inshore sea of Kerala started diminishing on account of indiscriminate fishing leading to over exploitation. Several bottom species are on the wane. The striking example is prawns.

2. Production has been lagging behind since the middle of the seventies in spite of the fact that high and intermediate technology inputs have been fast increasing.

3. The monsoon upwellings in the inshore sea (chakara), a manifestation of rich fishery of Kerala, have become a rare occurrence in recent years, indicating certain changes in the environmental and ecological condition.

4. While the off-shore resources remain virtually unexploited the inshore water is over capitalised with more and more investment on production inputs."[9]

Moreover the impact of the introduction of bottom trawling in the 60's began to be felt severely towards the end of 70's. By ploughing the sea floor with fine-meshed trawling nets, the bottom trawlers caused heavy damages to the benthic vegetation, the food chain, juveniles and the natural habitats of a wide variety of inshore life, the most productive zone of the ocean.

As a measure of rehabilitation or enhancement of areas impacted by overfishing and bottom trawling, fishermen built 19 AFHs since 1980 in Trivandrum and Kanyakumari (See Table II & Chart I). During the same period the two AFHs created in the 50's and remained dormant for nearly 25 years were revived, serviced and enlarged.

(iv) Cooperative and collaborative phase

In 1988 two research institutions, The Central Marine Fisheries Research Institute, Cochin and Department of Aquatic Biology and Fisheries, University of Kerala have cooperated in the study of the biological aspects of AFH development in the AFHs, which fishermen of Valiathura created in 1988 with the financial assistance of Intermediate Technology Development Group, London through South Indian Federation of Fishermen Societies, Trivandrum. This is the first AFHs construction where fishermen and an outside agency collaborated in financing, planning and constructing a AFH. The CMFRI researchers placed 12 specimen materials in the newly created AFH to study the bio-mass growth to understand the best suitable materials for AFHs building. The total cost of the AFHs was Rs. 10,000. This AFHs was supposed to be larger than the previous one built by the same fishermen measuring 30 m length, 15 m width and 0.75 m height. A structure was built for the first time by fastening worn out tires with concrete rings. While transporting these structures on Kattamarans from the shore to the AFHs site, the rings ripped apart and therefore attempts to place them in the water failed initially.The author has participated in the process of this AFHs building right from planning to execution and evaluation.

(v) Present Trends

Three trends are visible in AFHs programmes around the world. In Japan, where the AFHs technology is the most advanced, AFHs is one of the biggest governemnt financed research project. These huge AFHs are also used for large scale commercial fishing. Since the most advanced technologies are used for the AFHs Programme in Japan, the Government's annual budget for AFHs run into billions of Yen. The Europian and North American AFHs Programmes reveal a trend towards using AFHs for tourism promotion and academic research. Tourism industry is showing strong interest to invest in AFHs to use them for angling, diving and 'Fish Watch'. Marine Science Department of many universities in USA and Europe are involved in small and big AFHs research projects. The third category of AFHs were those developed as a survival technology by traditional and artisanal fish workers in the third world countries especially in Africa and Asia. This has become imperative because of loss of aquatic habitat both in the marine as well as fresh waters. In India efforts were taken by coastal fishing communities during the 80's to construct FADs (Fish Aggregating Devices) mainly in the south east coast in the Bay of Bengal and bottom reef structures (Artificial Reefs) in the south west coast in the Arabian Sea. The artisanal fishermen with the help of NGOs like ICO and SIFFS over the last ten years made many AFHs. They made improvements in design, size, location and placement. The AFHs (bottom structures) created by the artisanal fish workers function not only as fish aggregating devices but also started functioning as habitats. Under water photographs taken recently from the AFHs in Trivandrm show clearly that 'colonisation' or 'ecological succession process' is taking place. Eventually it will contribute to the productivity. The Govenment of Kerala recently implemented the same AFHs programme using ferro-cement triangular structures in Pozhiyoor village. "The community built, community managed" AFHs could be used as a rallying point for village fishing communities to manage the inshore resources sustainably.

Formation of Artificial Fish Habitats

In our analysis of the factors influencing the formation of artificial fish habitats, we found the fishermen have considered several aspects. Over the years their thinking process got improved on better scientific lines. These factors are discussed below:

i. Site selection

Selection of site for constructing AFHs is an important decision in the entire AFHs building process. The failure or success of an AFH depends primarily on the site. The parameters used by fishermen in selecting sites for most of the AFHs were wave damage, shore-seine operating range, gillnet operating range, easy accessibility, live-bottom, and poaching. All but two of the 22 AFHs were built in the 9 to 18 fm depth range (See Chart I). As the sea is surf-ridden the waves are quite strong and in order to avoid damages from the waves the AFHs were placed far enough from the shore. Shore seiners operate from beach to 9 to 11 fm, and hence to keep these away from shore seine obstruction. Most part of the productive seasons gillnet operates beyond 18 fm. Only occasionally they do operate in inshore sea. As users of the AFHs are mainly aged fishermen and children the AFHs must be easily accessible by manual oaring. AFHs constructed in the locations north of Beemapally which is about 7 km south-west of Trivandrum city are restricted to members only and therefore they were built within sight from the shore in order to avoid poaching by non-members. All these AFHs were sited on or near a live bottom or productive substratum. To them AFHs is a productivity enhancement tool.

ii. Materials used

Materials used in the first generation AFHs were concrete rings, fastened with coconut fronds, coconut stumps, screw pine plants. The basis of the selection of materials was the fishermen's knowledge of sea bottom, its benthic vegetation, natural fish habitats and fish behaviour. From their experience they know that fishes use AFHs for shade, shelter and food. Coconut fronds and stumps help plankton and other biomass to grow on them which attract small fishes which in turn become food for AFHs fishes. High structures like rings provide shade and heaps of stones provide the niches and wholes for shelter and refuge from predators.

iii. AFHs design and placement

The productivity of a AFH is found to be related to the size and shape of the AFHs. The size of the first generation AFHs was about 20 m long, 10 m wide and 0.5 m height. The productivity is also related to height. Taller the AFHs higher the productivity. Initially materials were dropped at random without the help of any equipments hoping that they dropped straight and placed on the in-

tended sea bottom. But this 'random dump and hope method' didn't work well. The result was that the AFHs didn't have desirable shape, size or height. The first generation AFHs materials were actually placed in unoriented piles and mounds. According to the AFH fishermen, productivity was low in these AFHs compared to the Sangumughom AFH with 3 m height and at 18 fm depth, that serves as the most productive AFH. The size of the fish school will increase with the size of the AFHs. The ratio of structural height to water depth has been studied and a minimum ratio of 1:10 is required for good aggregation of pelagic fishes[10]

iv. AFHs Direction

Most of the (14 out of 22) AFHs were placed in the east west direction. The local current in the inshore sea usually flows from north to south and vice versa. Current changes within 24 hours some times. These southerly and northerly current shifts to east and west frequently at the instance of change in temperature, direction of wind etc. The traditional hook and line fishermen using sails have intimate knowledge of flow of current through out the year and its seasonal and even daily changes from their experience. In order to do line fishing in the AFHs the Kattamarams have to stay just above the AFHs so that the lines with hooks and the weight go straight down to the AFHs. By constructing the AFHs in the east-west direction across the northerly and southerly current the Kattamarams could anchor either south or north of the AFHs as the current may be and stay over the AFHs one after the other. In this manner each Kattamarams will get sufficient space over the AFHs.

v. Fish behaviour and AFHs

Shade, shelter and food provided by AFHs are mainly the attractors of fish to AFHs. All the 49 fishermen interviewed agreed to this point. According to them some fishes use AFHs as a dwelling place. They are known generally as reef fishes (Parumeen). Others come, rest in the reef shades and leave. Yet some others use the nooks and crannies of a reef to hide from predators. Classification of this behavioural pattern corresponds to what Robert S Grove and Choule J Sonu (1983) say:

> *"One of the fundamental reasons for the fish to be attracted to AFHs may be related to instinct. Some species may be seeking a dwelling in AFHs. This probably explains the strong tendency of bottom dwellers to flock to AFHs. The mid and upper layer swimmers may be using the AFHs as a resting and or feeding station. Others as a shelter or refuge from predators".*[11]

Fish respond to AFHs horizontally and vertically. There are upper fish and lower fish depending on their vertical response. There are residentially and migratory species which respond to AFHs horizontally.

The behavioural response of fish to AFHs changes with light conditions. The Puthiyathura fishermen are of the opinion that hooking rate is the highest early in the morning and gradually reduces to almost nil at noon and increase gradually to almost half that of the morning in the afternoon. The trend of the hooking rate if drawn on a graph looks like a hook.

This is substantiated by the fact that all hook and line fishermen in this region fix the launching time by calculating the distance to AFHs and the time to reach in such a way that they may be on the AFHs just at the time of sun rise.

AFHs fishing is done from December to March, the fair season in the south west coast. As the marine water is non-turbid and clear sun light goes deep down. To escape from the heat and to search for food, fish get more aggregated in the bottom structures during this season. In the rest of the year inshore is turbid and rich with planktonic organisms due to "monsoon upwelling", which produces also a cooling effect in the sea.

vi. Spawning in AFHs

Whether or not spawning takes place in AFHs is the most debated point among fisheries scientists. However Puthiyathura fishermen confirmed that cuttlefish (Sepia pharonis) spawned in their AFHs. Agreeing to this Thoothoor fishermen informed that cuttle fish hither to not found in the inshore water of the region got aggregated in their artificial AFHs. Cuttle fish caught from their artificial AFHs weighed between 5-6 kg. They were spawning in the AFHs. During clear water the fishermen were able to see juvenile cuttle fish in their AFHs.

> *"Perhaps the most likely near term application for designed AFHs for commercial fishing would be related to their use to create or expand nurseries or spawning grounds. Although most American AFHs researchers continue to debate whether AFHs actually increase productivity or merely attract and concentrate organisms from surrounding areas Japanese Scientists generally have little doubt that AFHs, when properly designed, sited and placed can be used to increase the productivity of desired species"*[12]

According to Sanjeeva Raj[13] who has been experimenting with artificial fish habitat and Fish Aggregating Devices in Madras in the east coast the most encouraging feature was that the fry of about 5 species were collected amidst the coconut fronds so that it is suspected that these species might be breeding at these artificial fish habitats. How ever this point is now being put to investigation and confirmation.

Later experience support the view that fish breeding also take place in artificial fish habitats (see cover page photographs by under water divers)

vii. Fishing methods in AFHs

The only fishing method used in these AFHs is hand lining from Kattamarams. Most popular baits used in the AFHs are artificial baits. Occasionally natural baits are also used particularly to catch AFHs resident species. Active migrating fishes like little tunnies (tunas) are caught by *Thoottavu*, a surface hand lining with only one hook hidden in a live bait usually mackerel or scads that are caught by *Achil* a hand line with 25 to 50 hooks baited with artificial baits. Occasional visitors form the bulk of the fishes caught by *Thumbu*, a hand lining with two hooks baited with natural baits. By means of these three kinds of line fishing AFHs fishermen are able to catch all species related to a AFHs. (For details see Fernandez. J,1994, 'A bait to dazzle the fish').

Latest Developments in AFHs

i. Recreate the complexities and surface of natural fish habitats

Initially, AFHs builders concentrated on recreating the complexities and surface of natural fish habitats. Hence materials selected were similar in sight and substance to those in the natural reefs. Stones often taken from sea walls fastened with coconut fronds, well rings, screw pines and coconut stumps were the materials used in the first generation AFHs. These AFHs

were small in size and short. Average size 17 m long and 10 m wide and 1 m height. They chose what ever materials freely available in their respective localities example Tar roller wheel in Eraviputhenthura, empty iron barrels and telephone post in Valiyathura, Concrete waste from demolished structures in Valiyathope, sea weeds in Vizhinjam etc. These materials were dumped as they were. (Fig A and B)

ii. Modified AFHs materials

From the experience gained from first generation AFHs following modifications were made in the AFHs materials.

(a) Stones packed inside coir and rope nets.

The sandy bottom of inshore sea is subjected to the fury of monsoon waves and upwelling. The cumulative effect of this process exerts heavy siltation and gradual burial of AFHs materials placed in a scattered manner. In order to withstand the siltation and burial the Puthiyathura and Beemapally fishermen packed stones in large coir or rope nets with mesh size big enough for fishes to enter and small enough to retain the stones together(Fig B). Similarly, parts of trees were packed and dumped to create vegetation in the AFHs site for the decay which will enhance the nutrients.

(b) Painted Stones

In Thoothoor, fishermen observed that the natural reef with red colour attracted certain resident reef fishes. Motivated by this, they created AFHs with stones painted with red colour. The fish workers in Thoothoor claim that stones painted with different colours will attract fish with different colours. It is the red sea weeds that create red colour in the natural reef. Fishermen also claim that 'maturing' of an AFHs can be reduced considerably if the materials used are painted with the desired colours.

(c) Tyres fastened with concrete rings to give 'shape' to AFHs materials

A recent development in artificial fish habitats construction in Valiathura is characterised by model making. Discarded tyres were used with rings to give particular shapes to attract resident fishes which use the spaces as hideouts.

(d) Materials modified for protection of AFHs

Drift nets are menaces to the AFHs. The 'sliding wall' effect of drift nets keep away fish from the AFHs. Fishes in shallow waters when exposed to sunlight during fair whether season occupy the bottom zone of the sea. Drift nets are operated over the AFHs to catch these species. Nets may get entangled in the AFHs which may act as a barrier to fish to enter the AFHs. AFHs builders made many modification in the construction to protect the AFHs from entangling and sliding wall effect of drift nets (See Fig C). Modifications made are as follows :

a. Iron hooks over the concrete ring (Poothura).
b. Installation of iron pillars around the AFHs (Thoothoor).
c. Installation of anchors around the AFHs (Valiathura).
(See Table III for Details)

Motivations For Artificial Fish Habitats

i. Loss of natural habitat by over fishing and bottom trawling

The accumulated effect of trawling introduced in the mid 60's resulted in the degradation of marine environment especially natural marine habitats and fragile coral fish habitats systems in the south west coastal waters. In an earlier attempt in 1987 to study the status of natural reefs, the author was told by the late Mr. Arogyam, the then oldest living line fisherman aged more than 90 that in his younger days he used to fish from at least 150 small natural fish habitats in the inshore waters. All of them have been destroyed or rendered unproductive by Norway ships, local name of trawlers as they were introduced with the help of Norway. Its impact on resources began to be felt severally with the beginning of 1980. Line fishermen whose main source of fish were natural fish habitat sites began to build AFHs as enhancement of areas impacted by trawling.

Over fishing, the characteristic feature of Kerala fisheries since the middle of 70's resulted in fall in production particularly the share of traditional fishermen. Over fishing was mainly due to discriminate fishing, bottom trawling and mechanised fishing. Artificial fish habitats are built to regenerate the fish habitat destroyed by overfishing and bottom trawling. They are used as protection grounds for marine living resources and obstruction to trawler operation in inshore waters.

All except one artificial fish habitats were built with in the depth. range of 9-16 fm. This is to bring fish as close as possible to save fuel and labour. The artificial fish habitats can be reached by oars without the help of outboard motors and far enough to avoid wave damage. Though fishing in the outer natural fish habitats is done individually a crew of six fishermen who go in plywood canoe powered by an OBM to reach the natural fish habitats. Maintenance of engine and fuel cost become unbearable for them. An AFH in close waters solves these problems.

ii. Role of formal R&D

The formal scientific R&D institutions and personnel maintained until very recently a don't care attitude towards artisanal fisheries sector. This was because of the fisheries policy followed by state and central governments since the introduction of planned development in the 1950s. Neglecting the knowledge and fishing methods of artisanal fishermen as 'primitive and unscientific' the central Government with the support of the formal R&D went all out for modern technologies like trawling. Attention of formal R&D was concentrated almost completely on modern mechanised sector which caters generally towards international market.

Technology development based on the traditional sector was little cared for. Hence the initiative for this fell on the shoulders of the fishermen themselves and the non-governmental organisations working in support of artisanal fishermen. The much popularised motorisation of country craft in Kerala today had its early experiment at Muttom of Kanyakumari district of Tamil Nadu in 1970 under the Indo-Belgian Fisheries Project, a non-governmental organisation and through Marianad Fishermen Cooperative in Trivandrum District in 1974[14]

In fact the formal fisheries scientist community in Kerala came to know of the construction of artificial fish habitats by artisanal

fishermen when the author informed about this in an all Kerala Fisheries Conference held in Trivandrum in 1987. Initially, the scientists could not believe it. On the same day the Director of CMFRI and a team visited Valiathura and confirmed the author's claim. This is a typical example of the extent of 'negligence' of formal R&D of the technology developments in artisanal fisheries. The Central marine Fisheries Institute, Vizhinjam and Department of Aquatic Biology and Fisheries University of Kerala started collaborating with FCO since 1988 to study the biological process of the AFHs.

Apart from the 1988 Society (SIFFS) AFHs all the 21 AFHs constructed were of the fishermen, by the fishermen and for the fishermen. The only outside help received was a donation of Rs.700 from the village church for the construction of one of the AFHs.

The study reveals that AFHs construction is an area where artisanal fishermen with their intricate knowledge of oceanography and fish behaviour, marine Biologists, with their knowledge of AFHs biology and Marine engineers with their knowledge of structural engineering could join hands to improve productivity of AFHs. The productivity of all but one AFHs is very low because many biological and engineering parameters were not considered seriously in the artificial fish habitats construction. The rate of siltation, time or maturity, materials and structuring of AFHs were not properly assessed before its construction. This is where formal R&D could participate in AFHs construction.

In the case of artificial bait it was entirely innovated, designed, adapted and spread horizontally by fishermen themselves. The formal R&D did not play any role. The most popular artificial bait known as 'minisum' was evolved on the basis of their knowledge acquired through constant interaction between fishermen and fish and observation of fish behaviour to bait.

The ship wrecks of Anjengo and Sangumugham still serving as rich fishing ground a resource of motivation for AFHs construction.

Highly adventurous and innovative nature of Trivandrum and Kanyakumari districts,prompts them to explore new ways of solving their problems. E.g. Kattamaram launching from Valiathura Pier.

The present concrete pier (213 m long and 7 m wide) built in 1956 for loading and unloading cargoes was declared a dead port for shipment. Taking advantage of this fishermen in Trivandrum are making use of this pier for launching their kattamarams during monsoon when beach launching is extremely difficult owing to the presence of high surfs in the coastal sea. "The way the fishermen of Valiathura and adjacent villages in Trivandrum launch out their kattamarams into sea during the period of north west monsoon (June-August) is an example of over-coming obstacles of nature through innovations and ingenuity. Fishing activity in many parts of the south west coast lying between Cape Comorin and Quilon remains suspended often at many centres in monsoon season mainly because the fishermen find it difficult to negotiate their kattamarams through the unfavourable breakers. On account of this, the fishermen move to certain centres that afford favourable conditions for setting off their craft in the sea. Centres like Colachil, Kollengode, Vizhinjam and Quilon have bays or barriers and hence considered good for fishing operations during monsoon period. The fishermen of the area from Kovalam to Veli where that coast is rather straight, sandy and much exposed to the fury of monsoon waves, solve this problem by taking advantage of Valiathura pier for launching the craft safely into the sea"[15]

Impact of Artificial Fish Habitats

The impact of AFHs is assessed at the micro level and macro level by considering the multi-faceted aspects. At the micro level, costs and earnings, social and ecological sustainability and effect on employment are assessed. Resource management and energy conservation are considered at the macrolevel.

A. Micro-level assessment

(I) Costs and Earnings: From no cost to low cost

Artisanal AFHs constructed with massive support and left open like in the village of Eraviputhenthura cost them nothing as the materials used such as concrete rings, coconut fronds and stones were available freely in their locality. Transportation and labour were contributed freely by the interested fishermen. However, AFHs constructed by and restricted to specific groups and individuals cost them from Rs.900 in 1983 for Valiathura AFHs to Rs.10,000 in 1988 for SIFFS sponsored AFHs. AFHs varied from no cost to low cost depending on the types of materials used and the size. In 1988 the Kochuthope artificial fish habitat was built at the cost of Rs.6,000. Initially 100 fishermen used to fish from this AFH and the membership subsequently rose to 300. About 94% of the AFH fishermen were able to get a daily income of Rs.18 to 50. Around 4% of them had upto Rs.200 per day per fisherman during high catches. An average of Rs.39 was earned by fishermen per fishing day[16]. According to a rough estimate of the SIFFS society fish worth of Rs.10,000 were caught from the AFHs built at the cost of Rs. 6,000 in the first year of operation.

The cost of construction of AFHs is around Rs.2,000 upwards. The average income per day has been Rs.600 but some of the higher incomes have been Rs.2,000 to Rs.3,500 and a single record catch was 10,040 kg of the round scad was sold for Rs.3,500[17].

Moreover AFHs fish landed afresh and just in time for marketing fetches higher prices. The addition of the amount over and above the normal market price is a bonus for bringing the fish fresh. Artisanal AFHs built in the close coastal waters enables fishermen to make more than one trip to artificial fish habitats within a day.

AFHs constructed in the "active phase" earned more than the cost. It is truly a low cost technology. There is tremendous scope for increasing productivity of AFHs. Because of the random dump and hope followed in the construction of all but one AFHs the materials were placed in unoriented piles or mounds. Since they are not structured the height of the majority of the AFHs were between 0.5 m to 1.5 m. They were so short that they get buried by siltation due to soft sandy substratum and monsoon waves. Maintenance and reinforcement of the AFHs become necessary every year soon after the monsoon. Though the initial cost is very low, recurrent costs to maintain them would be high.

(II) Ecological and Social Sustainability

A technological innovation should not only be economically sustainable but also socially and ecologically sustainable. While the formal R&D in fisheries concentrate on harvesting and post- harvesting technologies, AFHs by artisanal fishermen is essentially a pre-harvesting technology in that they are regenerating the benthic vegetation so much devastated by indiscriminate fishing including commercial bottom trawling. It is nourishing the sea or 'nurturing nature'. By creating the marine habitat AFHs preserve what is called the 'bio-diversity'. If knowledge is the mother of all resources, the physical, chemical and biological processes of resources is the father. Only by blending both the mother and father aspects judiciously that we can be able to utilize resources

in sustained manner and leave them without damaging permanently to the posterity.

Traditional fishermen innovate and develop technologies in response to both these aspects. For example the only method used to catch fish from artificial fish habitats is hook and line fishing which does not disturb the artificial fish habitats environment and catch only the targeted fish leaving the juveniles and other species. Selective and passive line fishing keep the ecological succession or food chain undisturbed. Materials used for artificial fish habitats constructions were non-polluting and mostly biodegradable to enhance growth of marine organisms. They provide ecological niches for fish to feed and breed. It is essentially an eco-technology.

(iii) Effect on employment

AFHs make line fishing possible round the year except during monsoon season (June-August) when the sea becomes turbid and turbulent. Earlier line fishermen of Trivandrum and Kanyakumari used to go far beyond 50 fm upto 150 fm for deep water and reef fishes. It took 2 to 3 days to complete the fishing operation including journeys both ways. Using sails powered by wind fishermen often get stuck in the sea for want of appropriate wind. Only daring and adventurous adult fishermen used to take such risks. Deep water line fishing was during the fair weather season (Dec-March). The majority of the line fishermen were depending on natural fish habitats in the range of 16-24 fm depth. As they were all destroyed or rendered unproductive, these fishermen were affected badly particularly the old and the young. After a certain age the sight becomes too poor to see the geographical fixed land markings in necessary details to line up to locate the fishing spots. Either they have to accept the status of a permanent member crew or remain unemployed. The younger ones learning the fundamentals of line fishing need to be in closer sea to be safe. AFHs constructed in close waters not only provided employment opportunities for the fishermen in general put also to the old and young fish workers.

B. Macro-level Assessment

Resource management and energy conservation

At the macro level AFHs may be a resolution of the conflicts between the artisanal fishermen and commercial fishermen. AFHs are built to regenerate the natural fish habitats and used as protection grounds for marine living resources by effectively obstructing bottom trawling in inshore waters.

AFHs built in close coastal waters save fuel which otherwise will be spent for reaching for fishing grounds and searching for specific fishing spots. All catamarans fishing in the AFHs use oars as most of the AFHs are within 45 minutes reach.

The AFHs is now being used by village communities who have the management of the habitats under their common ownership. In Puthiyathura, Adimalathura and Thumba community AFHs were constructed by the fishermen themselves under the guidance of social organisation.

Learning Process and Constraints

Generally learning takes place through three domains: cognitive, psychomotor and affective domains. Reading and writing are the prerequisites for learning through cognitive domain. As the fishermen in Trivandrum and Kanyakumari are generally illiterate (80% approximate) their learning of fish and their environment takes place through Psychomotor domain requiring very skilful movement of hands and legs and affective domain requiring acute human senses, all the five, work simultaneously to get a 'feel' of fish and the ocean.

> *"Any particular fishing operation in progress is a simultaneous integration of large numbers of discrete thought processes of past experiences with the immediate observation aided by all the human senses. The feel of the sea bottom acquired by touching the plumb line, the smell of the sea, the sight of birds, land marks, stars the colour of the sea and ripples on it, the sound of the shoal movement to mention a few. The coming together of these aspects initiates the response of dropping the hooks, casting the nest or laying the traps. The result: fish is soon caught".* [18]

The sum and substance of artisanal fishermen's science is their intricate knowledge of fish and their environment and the process of inter-relationship, the father aspect of natural resources. Line fishing is an individual operation. Therefore, fishermen in Trivandrum and kanyakumari are always learning to be independent producers. The art of lining up a specific fishing spot of artificial fish habitats is required if a fisherman is to become an independent producer on his own kattamaram. Lining up requires an acute sense of vision. All fishing artificial fish habitats or spots are marked and remembered by individual fishermen using a visual system of triangulation which utilises a series of and marks which can be seen on clear days from most of the fishing grounds. The land marks used by Trivandrum and Kanyakumari districts are steeples of churches, mountains, coconut palm groves, sand bars by the sides of the river mouths etc. By lining up these fixed land marks, they constitute a directional clue to locate the fishing spot. They can distinguish landscapes from sea out to this distance. Distance itself is expressed in terms of depth.

Knowledge of visual triangulation by lining up geographical marks, fishing spots, fish and their behaviour and environment, local wind and current to judge the drift of his cattamaram and lines are learned, accumulated and passed transgenerationally. Though this knowledge is passed from father to son one has to acquire more and more skills and practice fishing regularly to master the art of fishing.

Trivandrum and Kanyakumari fishermen have extensive and detailed knowledge of artificial fish habitats ecology and fish behaviour based on their fishing experience in a limited number of natural reefs. With the plumb line they learn about the length, width and height of a artificial fish habitat with reasonable accuracy. From the pieces of materials entangled in the hooks, like plants, corals and other organisms they learn the biota of artificial fish habitats. These give them the clue to the nature and characteristics of a natural reef.

There are two fish channels in this region. One a monsoon fish channel in 15 fm and the other is fair whether fish channel in 18 fm. The knowledge of this is derived from local fishing experience and is virtually impossible to explain by physical parameters like temperatures and salinity. Thus ecological details, fishing grounds and spots bait materials, fish behaviour, feeding habits, fish channels etc. are common knowledge among fishermen.

Spread of innovations

Knowledge of marine environment and fish behaviour accumulated through generations lead to innovations that get spread horizontally. In the case of AFHs, what one fishing village does on

AFHs construction is observed by the neighbouring villages. South west coast is a long stretch of villages situated very closely (see map. Collection of materials, transportation and dumping are done so openly about artificial fish habitats construction. Within a span of 8 years it has been spread to 17 villages from one end of Kanyakumari to the other end of Trivandrum.

The social factors that help spread the AFHs and bait innovations are reciprocate invitations for church festivals, matrilocal system whereby husband stays in wife's house, standing god father to children of friends in other villages etc. Most of time the talk during these social interactions are like the talks around the artificial fish habitats.

Politics of People's technology

People's technology is the answer for overfishing. International market controlled by multinational companies dictates the technology options to commercial fishermen who operate to fulfil the requirements of multinationals at the cost of artisanal fishermen. Example trawling for prawns an export commodity contributed to a large extent to the destruction of natural fish habitat and over fishing. The politics of commercial technology motivated by multi nationals is to extract maximum resources at minimum time to maximise profit. People's technology is based on 'give and take'. So far fishing has been considered as taking or capturing or hunting only. This has desertified the sea. Artificial fish habitat is reforestation of bottom sea.

Constraints

(i) Transportation of AFHs materials and structures

Most of the AFHs are built with light and small size materials for easy transportation by kattamarams. Heavy structures transported in kattamarams often get lost or broken by strong waves. In the 1988 society AFHs at Valiathura many concrete rings were broken on the way to AFHs site. Transportation was a big problem to be solved. Kattamarams are too small and have uneven surface to carry big structures. In the recent, Pozhiyoor AFHs programme a new method of transportation was tried and it became highly successful.

(ii) Random dump and hope

Placement or dropping the materials was done haphazardly by overturning the kattamaram. The result was unoriented piles on the sea bottom making the AFHs short and unshaped. Also these materials may not have dropped on the desired points. Productivity was low in all except one AFHs because of the random dump and hope method.

(iii) Bottom trawling

Sometimes the AFHs structures were dragged by bottom trawlers. Trawlers hunting for cuttle fish operated over the AFHs and rendered them unproductive for a long time.

(iv) Sliding wall effect of drift nets

Bottom drift nets operated during fair weather season sometimes operate on AFHs. Its net sets entangled in the AFHs making a barrier to fish to enter the AFHs.

(v) Siltation

The high rate of silting due to sandy substratum and monsoon waves, affects adversely the growth of biomass and productivity of AFHs. Moreover maintenance and reinforcements become necessary every year as the AFHs gets buried fast. In the Valiathura society artificial fish habitats 12 specimen materials placed to find ecological succession rate on different materials were all buried. So great a loss that nothing could be learned so far.

Suggestions and Conclusion

i. AFHs could be spread in other parts of the south west coast from Cape Comorin to Alleppey where we have the largest number of Hooks and Line fishermen in India. In future, extension of AFHs construction to other villages of Trivandrum and Kanyakumari are possible. Possibility for building AFHs in Quilon must be explored.

ii. The State and/or Central Government should appoint a task force to study the problems and prospects of AFHs and fully subsidise construction of AFHs as it will be an effective tool for conservation of marine living resource and regeneration of lost habitats,

iii. As it is a people's technology, grass root voluntary organisations working with the fishermen may be involved in the construction of AFHs.

iv. An immediate study must be undertaken to find out the siltation rate and ecological succession rate in order to find out the best material suited for our marine environment. The Central Marine Fisheries Research Institute may be requested to take up this study as it is the best equipped agency in India to do such a study.

v. Future AFHs should have materials important for desired target species especially for cuttle fish. The experience of Thoothoor and Puthiathura AFHs confirm that cuttle fish, were atracted to and spawned in the AFHs. As cuttle fish do not have any permanent ground, they settle as a colony locally known as "mada" in different places in different seasons and years. AFHs structured to suit sheltering, feeding and breeding cuttle fish may be the future direction that AFHs construction must take.

vii. Food, shade and shelter are the main attractors of fish to a AFH. The size of the school of fish depends on the size and height of a AFH. Studies in other countries reveal that 10% of the water depth should be the height of the AFHs. The majority of the 22 AFHs didn't maintain this ratio. Future artificial fish habitats must maintain this minimum ratio atleast.

viii. In the selection of AFHs site fishermen were chiefly guided by two factors: Nearness to shore and already known productive muddy ground. But these factors are not very important as far as life and productivity of a AFHs is concerned. AFHs created on an already live bottom would disturb the natural fish habitat there and sinks very fast as the bottom is soft and muddy. AFHs must be sited on firm sandy bottom preferably in the fish channels. In the south west coast there are two fish channels, the monsoon channel at 15 fm and the non-monsoon channel at 18fm. The channels may shift - 1fm or 1fm. Since fishing

in AFHs is not done during monsoon it is advisable to select AFHs sites in 18 fm channel. For example Sangumughom AFHs at 18fm is the most productive AFHs in this region.

Conclusion

It becomes necessary to find out the indicators of tradition in order to go to the post industrial era with a clear perception. Kerala is a state which keeps tradition in high esteem.For example Kerala's traditional arts like world known "kathakali", indigenous medical system like "Ayurveda" are preserved and practiced till today.

This generation is going to the post industrial era. We can reach there only by looking at the indicators of tradition in the light of modern science and technology.

Even today there are people in Japan who construct huge and tall building without drawing any plan but keeping the traditional knowledge in mind. But their science is not taught in the Engineering Colleges. We have to integrate the essence of tradition with time. There is no meaning in keeping the indicators of tradition in Museums. They must be subjected to analysis and reinterpretation.

Notes

1. The hook and line fishing is a method of fishing in which the fish has to be baited by live or artificial bait attached to the hook. One end of the line is weighted down with iron or stones and the other end is held between the thumb and forefinger. The plumb line is gently jerked to attract the fish to the bait. Once bit, the line is drawn in, the fish removed and the process repeated. It is the size of the hooks and the depth to which the line sinks that determine the nature and the size of fish caught. After the line is laid, the craft may either remain anchored or drift with the current.

2. Kattamarams in Kerala or Kattumarams in Tamil Nadu are basically a raft of 3-5 log of wood fastened together with ropes. These logs are specially shaped to give the craft a boat-like appearance. *Melia dubia* and *Albizziya* spp are the timber most preferred for construction of these crafts.

3. Traditional fishermen in this region most commonly express distance in terms of the depth of the sea, i.e., in 'Maar' (1 'Marr' is approximately equal to a Fathom, and is the length of the outstretched hands of a fisherman). Sometimes, distance is measured in terms of the time it takes to sail there. Very rarely do they express distance in terms of geographical or nautical miles.

4. The National Workshop on Technology of Small-scale Fishworkers was held in Trivandrum from 27 Feb 1989 to 01 Mar 1989. It was sponsored by the Council for Advancement of People's Action and Rural Technology (CAPART) and organised by the South Indian Federation of Fishermen Societies (SIFFS).

5. What makes the monsoon launching of kattamarams adventurous is the tremendous amount of risk involved in the operation. The fisherman throws himself into the sea from the edge of the pier which is about 8 metres above the sea level. He holds on to one end of a rope, the other end of which is fastened to the kattamaram that is pushed into the sea. As soon as the kattamaram falls on the turbulent sea, he pulls it to him and rows to outer sea. This is highly risky and sometimes fatal too.

Table - I : Accidentally Formed Reefs

Sl. No.	Fishing Villages with accidentally formed reefs	Local name if any	Year of incident	Depth (in Fm)
1	Anjengo ship wreck	Kappal paar	1940	24.5
2	Puthukurichi		1986	8
3	Thumba (ISRO) Rocket nose		Since 1960's	15 - 40
4	Shangumugham ship wreck	Kappal paar	1960's	31.5
5	Valiathura pier and anchor		1940's	0-5 & 12
6	Vizhinjam boat wreck	Boat paar	1982	14
7	Chovvara boat wreck	Boat paar	1980's	12
8	Enayamputhenthura boat wreck	Boat paar	1980's	14

Table - II : Features of Artificial Fish Habitats

Sl. No	Fishing Villages with Artificial Reef	Local Name of reef if any	Year of Construction	Depth (Fm)	Distance (Km)	Substratum in which the reef is constructed	Length of Reef (M)	Breadth (M)	Height (M)	Direction of Construction
1	Eraimmenthura		1985	12	1.5	Clay	10	5	0.5	WE
2	Thoothoor	Chem paar	1987	10	1.5	Rocky Natural Reef	10	5	1	NS
3	Eraviputhenthura	Vattu paar	1957	11	1.5	Benthic Vegetation	15	5	1	WE
4	Paruthiyoor	Ora paar	1980	15	2	Benthic Vegetation				
5	Poovar	Kytha paar	1979	12	1.5	Rocky Natural Reef	40	10	0.5	NS
6	Puthiathura		1955	12	1.5	Rocky Natural Reef	20	15	1	NS
7	Pulluvila	Palli paar	1984	12	1.5	Sandy	10	5	0.5	SE-NW
8	Adimalathura	Kytha paar	1965	15	2	Sandy	15	7	0.5	NS
9	Vizhinjam	Boat paar	1982	14	1.8	Sandy	30	10	2	WE
10	Vizhinjam		1985	15	2	Sandy	7	3	0.5	WE
11	Vizhinjam	Kytha paar	1987	9	1.2	Sandy	15	5	0.5	WE
12	Beemapally		1984	10	1.5	Sandy	20	5	0.5	NS
13	Cheriyathura	Ora paar	1982	9	1.5	Sandy	25	4	0.5	WE
14	Cheriyathura	Ola paar	1983	11	1.5	Sandy	13	1	0.5	WE
15	Valiyathuta	Ouseph paar	1983	15	1.5	Sandy	50	15	1.5	WE
16	Valiyathura	Ora paar	1984	13	2	Sandy	10	5	0.5	Scattered
17	Valiyathuta	Society paar	1988	14.5	2	Sandy	30	15	0.75	SE-NW
18	Kochuthope	Ola paar	1984	15	2.25	Sandy	25	5	0.75	NS
19	Valiyathope		1984	18	3	Benthic Vegetation	50	25	3	SE-NW
20	Vettucadu		1983	8	1	Sandy	Very small size			Scattered
21	Puthukurichi		1986	8	1	Sandy	20	2	1.5	NS
22	Poothura		1982	12	2	Benthic Vegetation	10	2	1.5	WE

Fig. A: MATERIALS USED FOR ARTIFICIAL FISH HABITATS

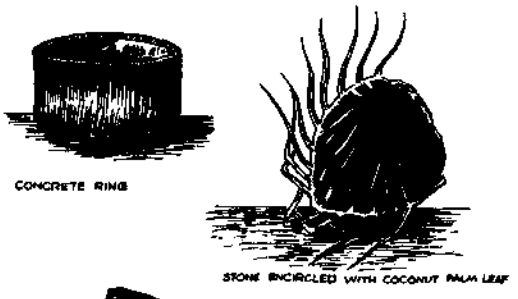


Fig. A :(Contd.)

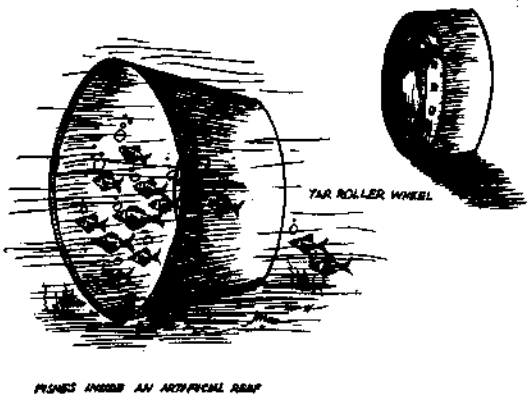


Table - III : Incremental Changes in Artificial Fish Habitats

Sl. No.	Fishing Villages with Artificial Reef	Local name of reef if any	Year	Materials used in the first installment	Year	Material used in the second installment	Year	Materials used in third installment
1	Eraimmenthura		1985	Stones, Coconut fronds	1986	Stones, Concrete ring	1987	Stones, Coconut stump
2	Thoothoor	Chem paar	1987	Stones painted with red color, Coconut fronds				
3	Eraviputhenthura	Vattu paar	1957	Stones, Ring, Coconut tree	1989	Stones, Coconut tree, Tar roller wheel	1987	Stones, Coconut tree, Palm fronds
4	Paruthiyoor	Ora paar	1980	Coconut fronds, Ring				
5	Poovar	Kytha paar	1979	Coconut fronds, Ring				
6	Puthiyathura		1955	Stones, Coconut fronds, Ring		Stones packed in bag		
7	Pulluvila	Pali paar	1984	Stones, Coconut fronds, Ring				
8	Adimalathura *	Kytha paar	1965	Stones, Ring, Screw pine				
9	Vizhinjam	Boat paar	1982	Boat wreck, Stones				
10	Vizhinjam		1985	Stones, Sea weeds	1989	Stones		
11	Vizhinjam	Kytha paar	1987	Stones, Screw pine				
12	Beemapally		1984	Stone, Coconut fronds, Stones and part of plants picked in the bag				
13	Cheriyathura *	Ora paar	1982	Stone, Coconut fronds, Ring				
14	Cheriyathura	Ola paar	1983	Stone, Coconut frondsd fronds/ stone				
15	Valiyathura	Ouseph paar	1983	Stones, Coconut stump, Screw pine, Tele. post	1986	Stones, Coconut tree, Anchor, Empty barrels		
16	Valiyathura	Ora paar	1984	Stone, Ring, Coconut tree				
17	Valiyathura	Society paar	1988	Stones, Coconut stump, Coconut fronds	1989	Stones, tyre tied over ring		
18	Kochuthope	Ola paar	1984	Stones, Coconut tree	1985	Stones, Coconut tree		
19	Valiyathope	"	1984	Stones, Coconut stump, Coconut fronds	1984	Stones, Coconut stump	1986	Stones, Coconut stump
20	Vettucadu *		1983	Coconut stump, Ring				
21	Puthukurichi		1986	Coconut fronds, Ring, Boat wreck	1989	Coconut fronds, ring		

* Reefs non functional now

Fig. B: INCREMENTAL CHANGES IN ARTIFICIAL FISH HABITATS

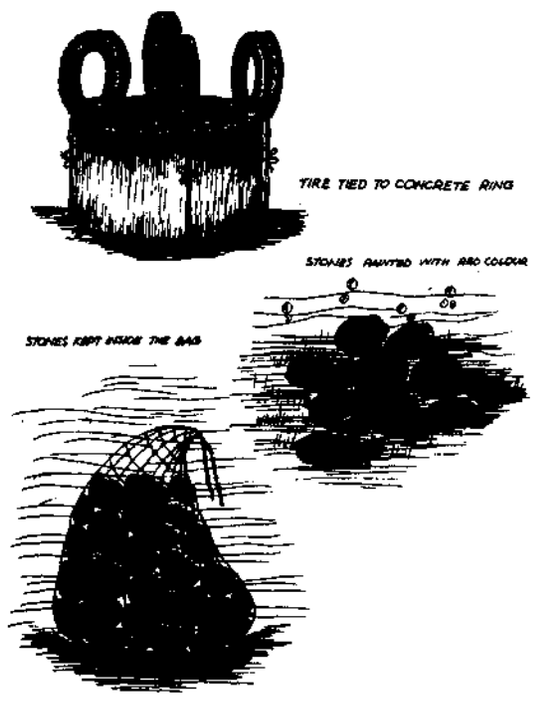
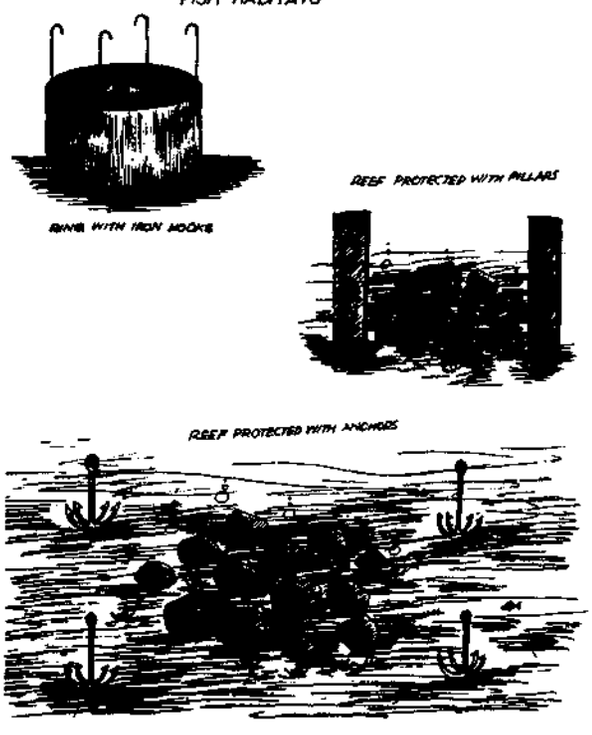
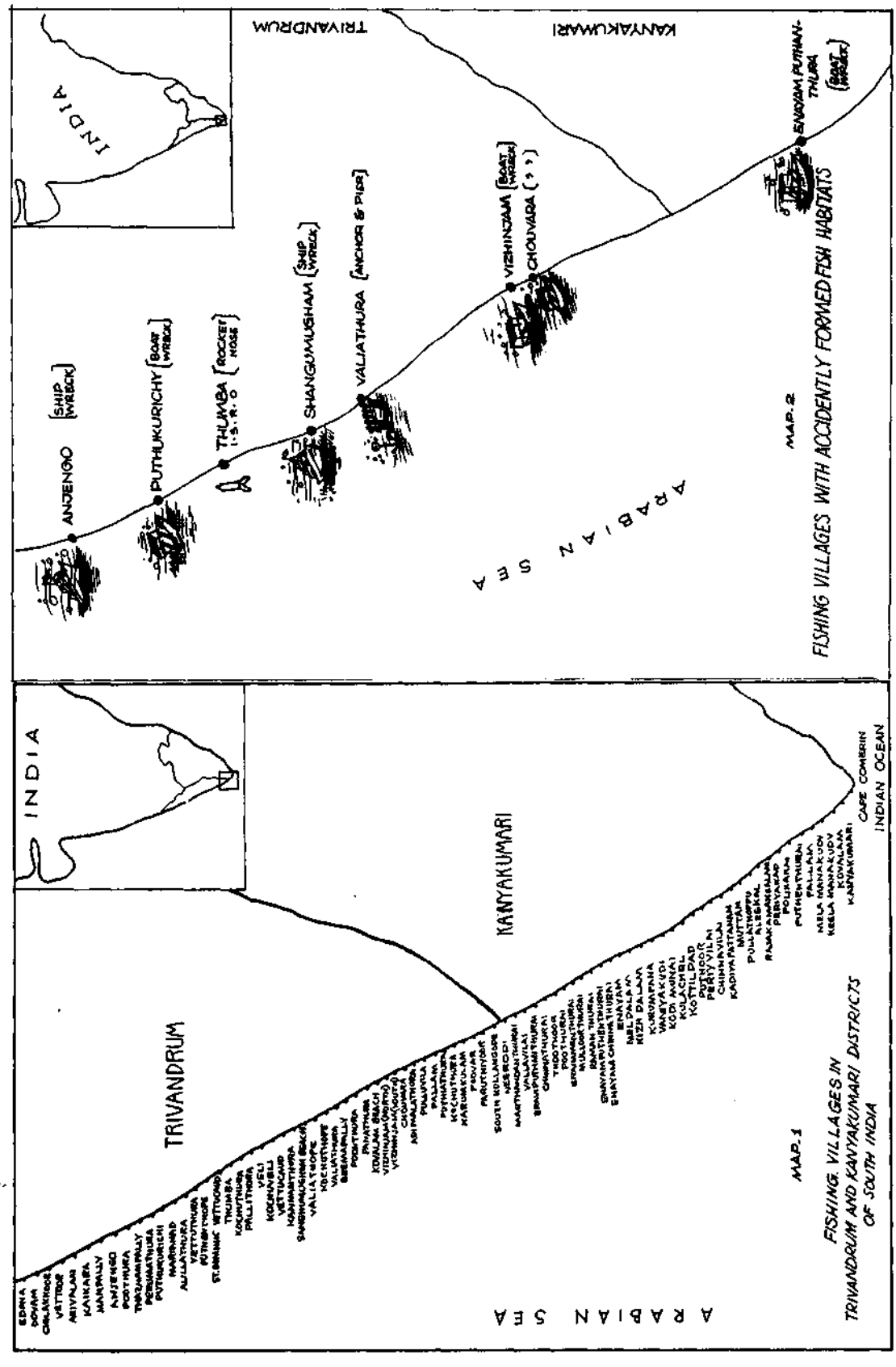
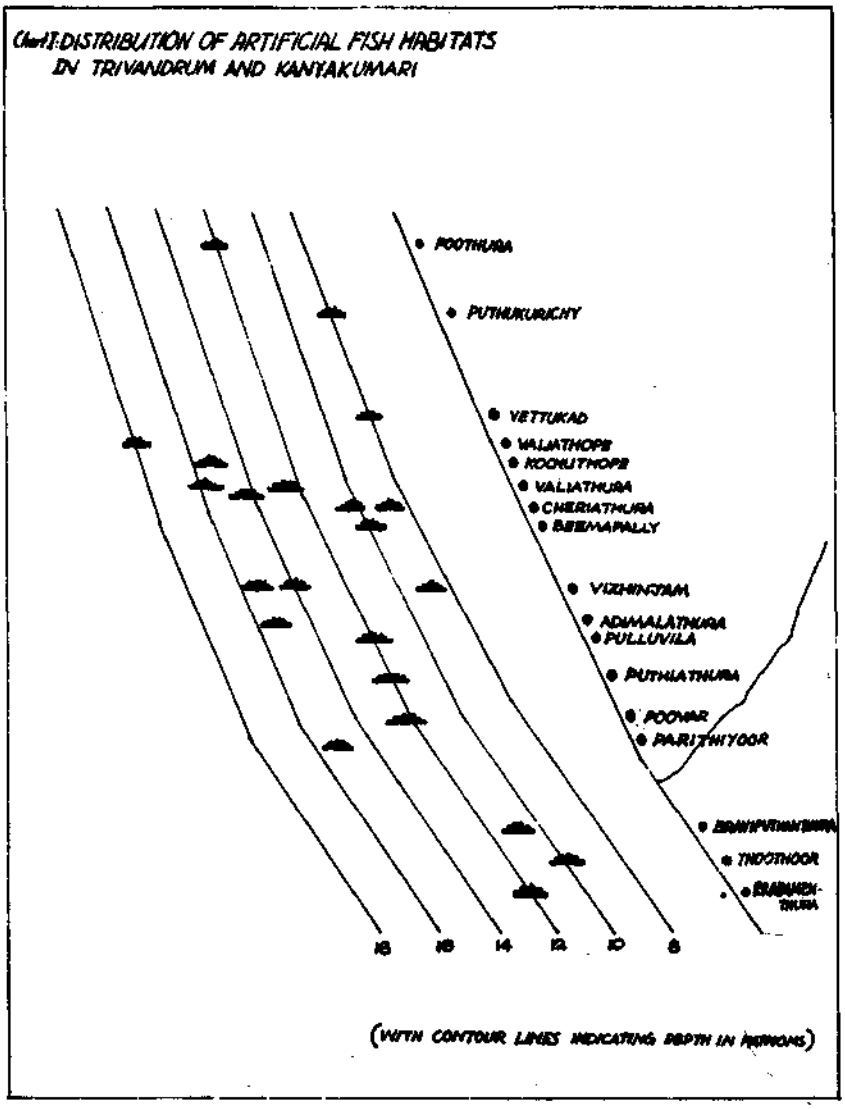


Fig. C: MATERIALS MODIFIED FOR THE PROTECTION OF ARTIFICIAL FISH HABITATS




INDIA
TRIVANDRUM
KANYAKUMARI
ARABIAN SEA
MAP-1
FISHING VILLAGES IN
TRIVANDRUM AND KANYAKUMARI DISTRICTS
OF SOUTH INDIA
CAPE COMORIN
INDIAN OCEAN
MAP-2
FISHING VILLAGES WITH ACCIDENTLY FORMED FISH HABITATS
ANJENGO (SHIP WRECK)
PUTHUKURICHY (BOAT WRECK)
THUMBA (ROCKET I.S.R.O HOUSE)
SHANGUMUGHAM (SHIP WRECK)
VALIATHURA (ANCHOR & PIPE)
VIZHINJAM (BOAT WRECK)
CHOUVARA (? ?)
ENAYAM PUTHAN-THURA (BOAT WRECK)



6. **Innovation of artificial bait began with bait made from coconut fibre freely available in Kerala (*Kera=Coconut tree, Kerala=land of coconut trees*). For many years artificial bait didn't cost anything. With the introduction of 'maral' made from the bark of a tree, artificial baits began to be economic goods but costing very little compared to natural baits especially prawns and squids.**

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