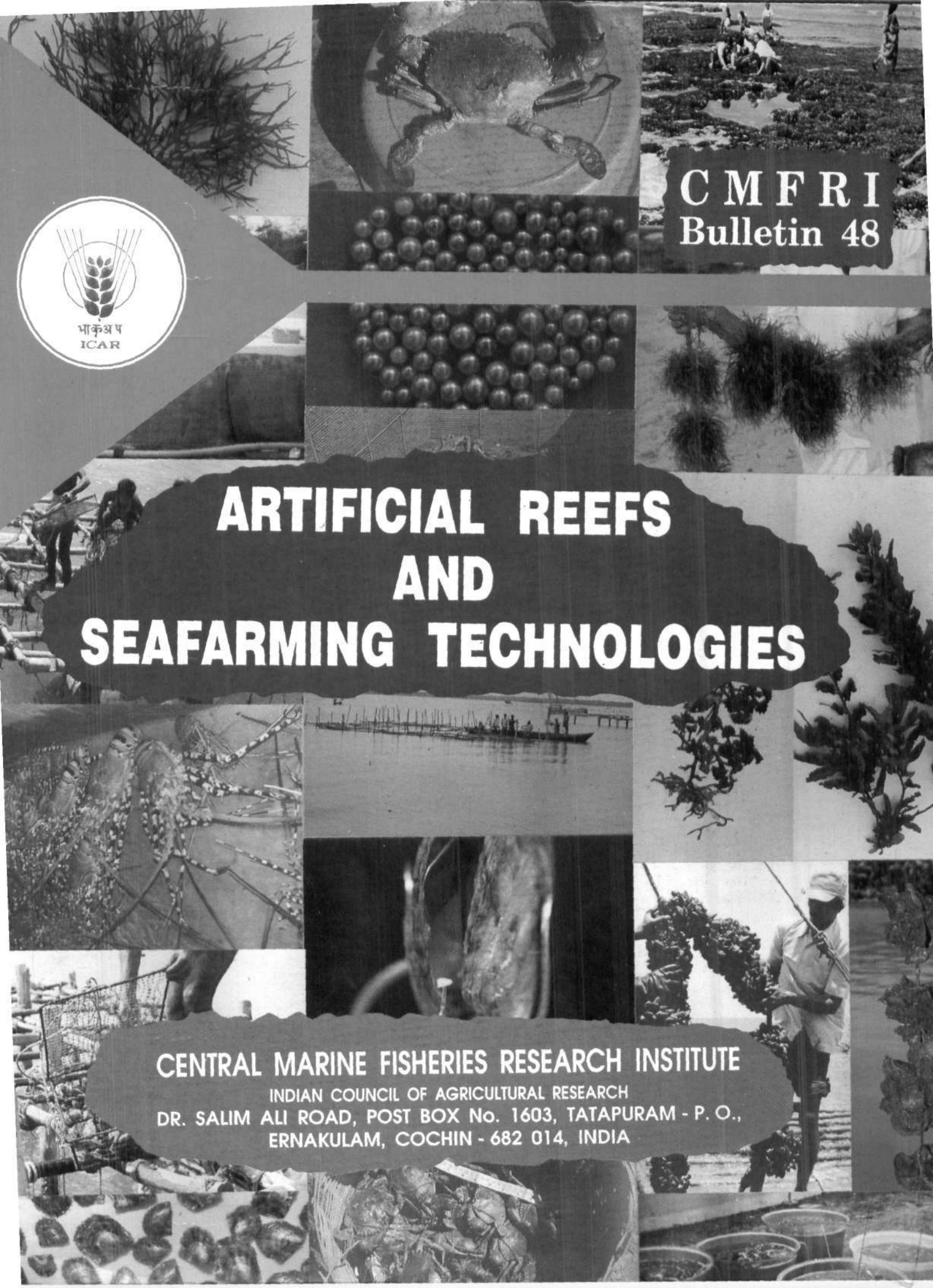

CMFRI
Bulletin 48

भाकृअप
ICAR

ARTIFICIAL REEFS AND SEAFARMING TECHNOLOGIES

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
Bulletin 48

ARTIFICIAL REEFS AND SEAFARMING TECHNOLOGIES

Dr. K. Rengarajan

Editor

January 1996

भाकृअप
ICAR

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

Bulletins are issued periodically by the **Central Marine Fisheries Research Institute,** Cochin to interpret current knowledge in various fields of research on marine fisheries and allied subjects in India.

Published by : **Dr. M. Devaraj**
Director,
Central Marine Fisheries Research Institute,
Cochin - 682 014.

Citation

PARAMESWARAN PILLAI, P. 1996. Artificial reef research in Minicoy, Lakshadweep. *Bull. Cent. Mar. Fish. Res. Inst.*, **48** : 11 & 12.

Cover Layout by : **Dr. K. Rengarajan.**

Cover Photos by : **The authors.**

PRINTED IN INDIA
AT PAICO PRINTING PRESS, ERNAKULAM, COCHIN - 682 035

Bull. Cent. Mar. Fish. Res. Inst., 1996, 48 : 18 - 23

6
ARTIFICIAL REEF FOR ARTISANAL FISHERIES ENHANCEMENT - AN ATTEMPT OFF TRIVANDRUM COAST*

P. S. B. R. JAMES AND S. LAZARUS **
Central Marine Fisheries Research Institute, Cochin - 682 031

INTRODUCTION

Several demersal fishes are found to congregate in the vicinity of submerged objects such as reefs, logs, ship-wrecks and rock out-crops where plants and benthic animals flourish than in areas where the bottom is flat and barren. These communities serve as food for larger predators. Submerged objects may, at times, provide shelter and even spawning locations for many-a-fish. Underwater observations made by divers while retrieving portions of submerged vessels also report that such habitats harbour considerable concentration of fishes .

The use of artificial structures to attract fish and/or enhance fisheries has long been practiced. Increasing impacts on nearshore fisheries from fishing pressure, habitat loss and pollution have caused fisheries authorities in coastal areas of the world to consider the potential for artificial reefs. Artificial reefs and fish aggregating devices are frequently and successfully used to create fishing areas near artisanal villages in several nations . Although utilization of artificial aquatic habitats has occurred for centuries, scientific description of their function and impact has been done only recently. In India, Bergstrom (*BOBP/WP* - **23**, 1983) reveiwed the traditional fish aggregating devices used in the Bay of Bengal. A modified artisanal artificial fish habitat on the Tamil Nadu coast of India has been described by Sanjeevaraj (*Bull. Mar. Sci.*, **44** (2) 1989). A synthetic fish aggregating device-cum-artificial reef has been developed by the Murugappa Chettiar Research Centre (The Hindu, 22 Feb., 1989). An artificial reef structure made of automobile tyre attached to R. C. C. base by M. S. rods is being installed at Minicoy by the Central Marine Fisheries Research Institute to study the aggregating behaviour of tuna live-baits (*CMFRI News Letter No.* **41**, 1988).

The benthic realm of the shelf area stretching between Cape Comorin and Vizhinjam in the south-west coast of India has plenty of rocky out-croppings which harbour rich and varied fauna of fish and the fishermen are immensely benefited by this favourable environment. Similarly, the ship-wreck found off Angengo at a distance of about 10 km from the shore at 40 - 50 m depth also harbours a variety of fish which are being exploited by the fishermen of the neighbouring villages. But, as the adjoining area found in between Panathura and Valia Veli (Fig. 1) being free from any such out-croppings, the fishermen are deprived of the benefits which their counterparts in the neighbouring areas enjoy. This has prompted them to develop artificial reefs, called *paars* in vernacular, in that area to make the fish to congregate there. An attempt is made here to study the impact of such artificial reefs on the local fisheries and the salient findings emerged during a study spread over a period of two years ie., from May. '87 to April, '89 are presented here.

The general information given regarding the first six artificial reefs was collected from the fishermen who were involved in the construction and management of the artificial reefs in the area in the recent past. Details pertaining to the 7th artificial reef were collected by making direct onboard and shore based observations. Out of the seven reefs, fishing was done only in three reefs (Valiyathura, Kochuthoppu-I and Kochuthoppu-II) and hence the data given here relate to these three reefs only. Among these the Kochuthoppu-II reef was in operation only for one year from April, 1988. As the landings were brought to Valiathura landing centre from the reef as well as from the neighbouring fishing areas, the centre was visited weekly once and the landings were recorded separately for the reef as well as for other areas and their total landings were estimated monthwise. On-the-spot observations were also made on the fishing in the reef. Fourteen sampling units, each consisting of a granite stone weighing 2 kg, (square) bits of tyre, plywood, asbestose and roof tile tied to a nylon rope (1cm thickness) at 25 cm interspace, were placed over the reef to study the benthic community. Underwater observations were made on the reef site by scuba diving.

* Reprinted with the permission of the Director, CMFRI, Cochin, from *Mar. Fish. Infor. Serv., T & E Ser.*, **104** (1990) : 1 - 6.

** Present address : Manonmaniam Sundaranar University, Scott Christian College Campus, Nagarcoil 629 003, Tamil Nadu.

Artificial reef construction and managment

Reef construction

Reefs were constructed mostly in the sandy region at a depth varying from 5 to 27m. Granite stones of varying sizes were put first on the site selected for the reef construction so as to form a circular or rectangular ridge. Over these, concrete rings (Front cover photo) of 150 cm diameter into 45 cm height locally called 'urai' used for lining the inner side of commmunity wells, were placed. After this, any locally available unwanted/cheap materials like broken concrete slabs, worn-out rubber tyres, empty barrels, up-rooted coconut tree stumps and leaves, screw pine plants etc., were placed in an unorderly manner over this, so as to provide shade and shelter for the fish (Fig. 2). Coconut leaves were also used to tie 2 to 3 granite stones together at the time of loading the stones to the catamarans. Some reefs are even known after the material used such as 'ola paru' and 'kaitha paru' meaning, reef made of coconut leaves or of screw pine plants respcetively. The materials were transported to the reef site by catamarans (non-mechanised). Sometimes 2 or 3 loaded catamarans are towed to the reef site by mechanised boats if the distance to the site from the shore is considerable. After reaching the spot, the material are dumped by turning the catamaran upside-down. As given earlier, seven artificial reefs, as listed in Table 1, have been diveloped in this region. Of these the first six were constructed in 1988 by the Kochuthoppu fishermen by utilising SIFFS funds. Of the first six listed, two got submerged due to silting and 2 were abandoned due to objection from local fishermen; since they were built within the reach of shore seine operation. The first two in the list were renovated subsequently and they along with the 7th one, are of little use as fish congregating device now.

Fishing

Those who were involved in the construction of the reef only are allowed to fish from the artificial reef. There is no float or flag to locate the reef site for fear of poaching by other fishermen. Eventhough fishing was done throughout the year in the neighbouring areas, in the reef environment, it is done only during the calm season between November and April. The fishermen venture into the reef only during day time. Though a variety of gears are employed in the neighbouring areas, only hooks and line (non-mechanised) are operated in the artificial reefs. "Achil", a kind of hooks and line with hooks varying in size from No. 12 to 8, with artificial baits are used. On bright sunny days and in clear weather conditions the fishing operations are found more economical. A single unit goes thrice a day during the peak season. At a time about 15 to 20 such units are operated at a single reef site. Normally single manned catamarans of the size 5 m with 4 logs are used for fishing.

Fisheries

Trend in fisheries

Landings realised during the period 1987-'88 and 1988-'89 from the artificial reef environment and 'other region', ie., from Cheriyathura in the south to Shangumugam in the north are furnished in Table 2. A perusal of the above table indicates that the landing during 1987-'88 from the reef environment was only 59.0 tonnes as against 636.0 tonnes from the 'other region'. A drastic reduction in the landing from the reef environment could be noted during the subsequent year, ie., 1988-'89, with a total of 24.2 tonnes. In otherwords, the percentage contribution of fishes from the artificial reef environment dwindled to 3.6 from 8.5.

The fishing season in the reef environment lasted for about 6 months from November in 1987-'88, while in 1988-'89 it lasted only for 5 months from December. Peak landing was observed during February in 1987-'88 and in March during 1988-'89. The landing from the 'other region', on the contrary, was spread over the year with peak landing during February and March respectively for the above two years (Table 2).

Gear - wise contribution

As mentioned earlier, hooks and line operated from non-mechanised units were in vogue to exploit the fishes from the reef region. But in the 'other region', in additon to the above gear, hooks and line operated from mechanised craft, shore seine, boat seine and gill nets were also operated.

Species composition

Fishes like *Decapterus dayi, Carangoides plagiotaenia, Priacanthus hamrur, Sphyraena* sp. *Rastrelliger kanagurta* and *Nemipterus* spp. dominated the catch of the reef region, while in the 'other region' *Selar crumenophthalmus, D. dayi, Auxis rochei, Trichiurus lepturus, Rastrelliger kanagurta, Euthynnus affinis, Nemipterus* spp. *Sarda orientalis* and *Dussumieria* spp. dominated (Table 3). Among the dominant groups, fishes such as *D. dayi, R. kanagurta* and *Nemipterus* spp. were common in the catches of both the regions. The dominance of species like *Carangoides plagiotaenia, Priacanthus hamrur* and *Sphyraena* sp. in the reef region shows that the reefs attract both reef dwelling and demersal forms of fishes as expected. Fishes like *Carangoides plagiotaenia, Lethrinus harak, Selar*

TABLE 1. *Details of the artificial reefs constructed off Trivandrum coast*

Name of the reef	Location of the reef	Year of construction	Depth (m)	Distance from shore	Materials used for the construction	Remarks
Valiathura reef (*Kaitha Paru*)	On the south-western side of Valiathura pier	1983	20	Beyond the reach of shore seine operation	Coconut tree stumps, concrete rings, granite stones, empty barrels and screw pine trees	A local ex- service man and the village parish priest supported the fishermen. Renovated once. Slight fish aggregation
Kochuthoppu reef I (*Ola Paru*)	On the south-western side of Kochuthoppu	1984	18	Beyond the reach of shore seine operation	Granite stones concrete tub (4x4') used for salting fish, coconut tree stumps and plaited coconut leaves	Fishermen belonging to the Vanakkapura committee. Renovated once. Slight fish aggregation
Beemapally reef	In between of Beemapally and Poonthura	1984	10	With in the reach of shore seine operation	Granite stones and coconut tree stumps	Discontinued as the shore seines got entangled to the reef material
Vettukadu reef	North - west of Kannanthura	1984	5	Within the reach of shore seine operation	Concrete rings, coconut tree stumps and wooden logs	Discontinued as the shore seine fishermen objected to it
Cheriathura reef	In between of Cheriathura and Valiathura	1984	16	Beyond the reach of shore seine operation	Concrete rings and granite stones	Almost burried due to silting
Shanmugam reef	Off Shanmugam	1985	20	Beyond the reach of shore seine operation	Materials used for the construction of stage for the Papal Visit to Trivandrum	Almost buried due to silting
Kochuthoppu reef II	South - west of Kochuthoppu	1988	27	3 km beyond the reach of shore seine	Granite stones, coconut leaves and rubber tyres	Funded by SIFFS and managed by the local fishermen welfare society

kalla, *Carangoides malabaricus* and *Selaroides leptolepis* were found only in the reef region. It is interesting to note that these forms live normally in reef areas.

Underwater studies

Underwater observations were made on 26 - 10 - '88 and 10 - 1 - '89 by CMFRI scientists using Aqua lung in the Kochuthoppu reef II (Reef No. 7) constructed on 28 - 2 - '88. Due to poor visibility, the divers could not reach the reef bottom on 26 - 10 - '88. But during the second occasion they could reach upto the bottom and study the conditions there. The sea bottom at the reef site was found to be sandy and some of the reef materials were partly buried in sand due to heavy bottom current which was rushing from south to north. Even after one year of its construction the reef materials including the coconut tree trunks were found to be intact except the coconut leaf splinters used for binding the stones and the sampling units. It was found during diving that the layout of the reef was not properly made as to attract bigger fishes. However, the divers could observe large numbers of small fishes such as *Apogon novemfaciatus*, *Amphiprion* spp., *Chaetodon* sp. and *Dascyllus* spp. hovering over the reef materials. Fishes like *Epinephelus corallicola*, *Lutianus argentimaculatus*, *L. lineolatus*, *Petrois antennata*, *Spiloticthys pictus* and *Heniochus acuminiatus* were found in small numbers.

TABLE 2. *Monthly fish landings (kg) recorded at Valiathura landing centre during the years 1987 - '88 and 1988 - '89*

Month	From reef region				From 'other region'			
	1987 - '88	1988 - '89	Total	Average	1987 - '88	1988 - '89	Total	Average
May	-	-	-	-	33,384	18,600	51,984	25,992.0
Jun.	-	-	-	-	3,562	1,49,400	1,52,962	76,481.0
Jul.	-	-	-	-	33,534	12,710	46,244	23,122.0
Aug.	-	-	-	-	39,377	No data	39,377	19,688.5
Sep.	-	-	-	-	68,640	79,065	1,47,705	73,852.5
Oct.	-	-	-	-	18,792	56,460	75,252	37,626.0
Nov.	8,060	-	8,060	4,030.0	94,628	41,730	1,36,358	68,179.0
Dec.	465	372	837	418.5	81,237	45,203	1,26,672	63,336.0
Jan.	10,401	3,226	13,627	6,813.5	81,637	72,480	1,53,717	76,858.5
Feb.	28,304	7,392	35,696	17,848.0	61,637	67,620	1,29,257	64,628.5
Mar.	11,036	9,145	20,181	10,090.5	54,067	49,228	1,03,295	51,647.5
Apr.	687	4,050	4,737	2,368.5	65,646	51,690	1,17,336	58,668.0
Total	58,953	24,185	83,138	41,569.0	6,35,973	6,44,186	12,80,159	6,40,079.5

The general fish catch around that area on that day consisted of *Saurida* spp., *Priacanthus* sp., *Nemipterus* spp. *Decapterus dayi* and smaller carangids. The reef building poychaete, *Sabellaria spinulosa* was found plenty in the reef site.

Food preference

The gut contents of fish such as *Saurida undosquamis, S. tumbil, S. gracillis, Apogon novemfaciatus* and *Lutianus lineolatus* caught from the reef were dominated by the polychaete, *Sabellaria spinulosa*. However, the above species caught from the 'other region' and *Decapterus dayi* caught from the reef did not contain polychaete in their stomach.

General remarks

Recent studies (Artificial reefs and fish aggregating device, National Academic Press, Washington, 1988) on artificial reefs suggest that the reef site is more important than the design of the reef. The general guidelines for the placement of artificial reefs suggested are: (1) The site should be nearer to fishing villages to simplify the logistics of installation and to minimise travel time and fuel consumption before the fish can be processsed on land. (2) An artificial reef should not be placed in commercial fishing areas unless it is specially intended to close an area to these operations. (3) The artificial reef should be located 1 km from natural reefs, otherwise, the fish will tend to swim from one to the other. (4) Sites with strong tidal currents should also be avoided because these currents will cause erosion around the reef, unless the bottom is hard. (5) Mouths of rivers where siltation may bury the reef should also be avoided. (6) The long axis of the reef should be perpendicular to the prevailing current and along fish migratory patterns. A constant current is quite acceptable and is favourable to benthic filter feeders inhabiting the structures. (7) The depth of the reef must be approporiate for the target species. (8) A firm sand or shell bottom is most suitable for an artificial reef to prevent subsidence. (9) The bottom profile should be flat or gently sloping. (10) Soft clay,

TABLE 3. *Species constituting the catch (%) at Valiathura landing centre during the years 1987 - '88 and 1988 - '89 combined*

Species	Reef region	'Other region'
Rastrlliger kanagurta	7.46	8.96
Euthynnus affinis	0.22	7.70
Sarda orientalis	-	4.27
Auxis rochei	-	10.24
Auxis thazard	-	0.99
Istiophorus sp.	-	0.82
Cybium sp.	-	0.30
Nemipterus spp.	5.71	4.68
Epinephelus spp.	2.05	0.36
Lutjanus malabaricus	0.76	0.36
Lethrinus nebulosus	0.90	0.17
Lethrinus harak	0.75	-
Pristipomoides typus	-	0.30
Priacanthus hamrur	17.15	0.93
Therapon sp.	-	0.34
Leiognathus spp.	-	0.82
Decapterus dayi	30.60	14.36
Selar crumenophthalmus	1.34	16.38
S. mate -	0.34	
S. kalla 0.17	-	
Carangoides malabaricus	0.01	-
Selaroides leptolepis	0.01	-
Carangoides plagiotaenia	17.28	-
Other carangids	3.30	5.76
Coryphaena sp.	-	1.06
Trichiurus lepturus	-	5.94
Lesser sardines	-	1.11
Stolephorus spp.	-	0.53
Dussumieria sp.	-	5.11
Sphyraena spp.	11.58	1.15
Saurida spp.	0.70	1.04
Balistids	-	0.26
Tylosurus sp.	-	0.45
Triacanthus sp.	0.01	0.04
Chorinemus sp.	-	0.32
Rays	-	0.02
Sepia spp.	-	2.47
Crab	-	0.04
Miscellaneous	-	2.38

silt sediments and areas that are already productive should be avoided. (11) High wave energy locations and areas with seasonally shifting sands should not be considered. The Japanese National Programme suggests that artificial reefs should have a hierarchial arrangement where modules form 'sets', 10-20 sets form a 'group' and several groups form a 'complex'. They advocate minimum effective sizes of 400m^3 for a set and 50,000 m^3 for a group, with at least a 1 km seperation between each group.

Though the reef sites selected at the Trivandrum coast have many of the favourable aspects mentioned in the guidelines, they lack certain important aspects such as a suitable depth to attract many of the reef fishes, a suitable bottom to increase the durability of the reefs and an area free from wave action to avoid silting. The bottom of the area in which the present reefs are built is sandy with high rate of silting due to high wave action. Because of high wave action and silting, the water becomes turbid especially during the monsoon months thereby making the fishing in the reef regions impossible for a major period. So it is suggested that the reefs should be constructed at a deeper area having sandy or some hard substrtatum so as to avoid turbidity of the water as well as sinking of the reefs. Already two out of six reefs are buried due to wave action and silting within a period of 2 - 3 years. Other two artificial reefs (Nos. 3 and 4 of the list given in Table 3) had to be abandoned subsequently since they were located within the zone of shore seine operation. This point requires special consideration in the present context since there is a marked delimitation in the operation of various gears along the coastal water. However, it seems that this point has not been considered while constructing the above said two artificial reefs. If the reefs are constructed at a deeper area, there is possibility of getting more varieties of fish especially perches and other economically important reef fishes. This needs careful monitoring of the area scientifically before fixing up the site. However, this has not been done in any of the present cases.

The material used for the construction of reef in the different parts of the world also vary considerably. The actual choice of the material shall be based on what is readily available and economically feasible. Bundles of brush wood are tied to lines to capture crabs, shrimps and small fishes in Japn, Philippines, Indonesia and Vietnam. In Central Africa, boxes full of leaves are placed at the bottom of lakes and estuaries. Ivory Coast fishermen place coconut palm fronds in shallow waters to attract shrimps. In the protected areas inside the bays on the south coast of Cuba, fishermen are still using "mangrove fisheries". Lobster shelters are also

Fig. 1. Concrete rings kept ready for transporting to reef building site.

made by constructing reef with mangrove branches. In the Philippines, "brush parks" have been developed to provide shelter and spawning grounds for fish. The traditional Japanses artificial reef involved simply placing shore or quarry rocks at shallow depths as a way to enhance fishing grounds. In North Japan, rocks are placed to enhance kelp production. In Virginia and New York (USA), slit tyres have been imbeded in a 10 cm concrete base for use as a reef module. A steel rod or cable is passed through the tyres for additional reinforcement. Automobile tyres are also used in Thailand for reef construction. An experimental artificial reef constructed of old tyres has been placed near Haifa, Israel. The Japanese have developed hundreds of types of concrete modules to increase fishing grounds. Damaged concrete pipes have been used for artificial reef construction in Hawaii. In Taiwan, concrete blocks have been used on sandy bottoms for over 10 years. In Thailand, artificial reefs have been made with concrete modules to enhance fishing grounds for artisanal fishermen. The trawler exclusion modules are also being combined with groups of artificial reefs to make the area free from trawling. In the United States, ribbons of fiberglass reinforced plastic (FRP) have been bonded into openmesh cylindrical shapes and then joined in arrays of 2 - 10. Cement ballast is used to anchor the units. In the United States obsolate oil and gas drilling rigs and its steel towers have been used to serve as artificial reefs. Here in Trivandrum, granite stones, empty barrels, cocrete rings, coconut tree stumps and leaves and worn-out automobile tyres are used in the construction of reefs.

For a country like India, two approaches are suggested for an artificial reef programme, depending on the available resources. According to the first, commonly available materials withstanding extreme weather conditions such as granite stones can be used for reef construction where funding is limited. The second approach is to fabricate specially designed permanent structure. This requires well-funded programmes, steel and concrete for construction, and larger vessels for their installation.

Acknowledgements

The facilities provided for taking the photographs of the artificial reef construction work by the authorities of South Indian Federation of Fishermen Societies, Trivandrum are greatly acknowledged.