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43 Artificial reefs

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ABSTRACT

At Tuticorin and Minicoy observations were made on the experimental artificial reefs constructed by the Scienttsts of CMFRI during 1988-'92, whereas at Vizhinjam the artificial reefs constructed by the local artisanal fishermen were monitored by the Scientists of the Institute. Good congregation of fishes was observed in the vicinity of the artificial reefs at all the three Centers. In the experimental artificial reef constructed at Tuticorin, four distinct groups of fishes were recognized based on their mode of attraction towards the reef structures. At Vizhinjam, an increase in the landing of fish was noticed in the commercial catches. At Minicoy, settlement of pearl oyster spat and growth of several species of seaweeds were recorded.

Introduction

Artificial reef technology is being used in many countries mainly for enhancing the marine fish production. The technology is well advanced in some of the Southeast Asian countries, particularly in Japan. There are two types of artificial reefs viz. (i) set on the bottom and (ii) floating on the surface or at sub-surface of the sea. Depending upon the structure,the artificial reefs may be classified into three categories, namely primitive, semi-scientific and scientific. In the first category, the reef is constructed mostly in shallow waters by dumping branches of trees, boulders or rocks, scrapped boats, junked cars, discarded building materials, etc. The artificial reef constructed this way lasts for a short period and fish aggregation also is poor in such areas. The semi-scientific method of construction involves using of structures having definite size and shape e.g. old automobile tyres, well rings, large cement pipes, etc. Here the structure remains stable for a considerable period and the fish aggregation also is reasonably good. In the scientific method,artificial

reef is constructed with structures designed to attract a particular group of finfish or shellfish based on the observations made on the behaviour of the group concerned under laboratory and field conditions. It may be mentioned here that in Japan about 150 species of fishes have been recognized as exhibiting distinct responses to reefs (Nakamura, 1985).

In India, the first method has been in vogue for a very long time in certain place along Tamil Nadu and Kerala coasts (Sanjeeva Raj, 1989 a, b, 1990; Kurien, 1996). Although the method is categorised as primitive, the ingenuity with which the artisanal fishermen have used their experience in such constructions over the years has formed the basis for further development of the artificial reef technology in India. The various types of artificial reefs and fish aggregating devices used by the traditional fishermen of India have been reviewed by Bergstrom (1983) and Fernandez (1996). The primitive method of artificial reef construction adopted by the traditional fishermen was developed into semi-scientific method during 1980's when a few voluntary organizations and private agencies took keen interest in this line of work and started collaborating with fisherfolk in improving the methods already adopted by them. Fish aggregating devices were fabricated from High Density Polyethylene (HDPE) pipes and discarded automobile tyres and were installed along Madras coast (Raja, 1996). Concrete well-rings were used in large numbers for the construction of artificial reefs along Madras and Trivandrum coasts and very recently triangular modules have been used for artificial reef construction along Trivandrum coast (James and Lazarus, 1990; Sanjeeva Raj, 1996; Philipose, 1996). All these structures have been found to be effective in attracting a variety of fishes.

The scientific method of artificial reef construction involves designing of species-specific structures and using such structures for specific purposes such as creation of aquaculture ground, creation of propagation ground, etc. It is in this direction the Central Marine Fisheries Research Institute initiated a project on artificial reefs during 1988 at three of its Research Centres at Tuticorin, Vizhinjam and Minicoy and the results obtained are presented in this paper.

Materials and methods

At Tuticorin, discarded lorry tyres were used for the construction of artificial reef in the break-water of Tuticorin Harbour at a depth of 6 m. Three

designs of modules were fabricated, each module consisting of three tyres which were fastened with polypropylene rope of 6 mm thickness. Design No. 1 was in the form of a tripod with the tyres standing vertically. A total number of 13 modules of this design were fabricated and released during July, 1989. Design No. 2 was in the form of a cylinder whereas Design No.3 was in the form of a well. Five modules each of Design No.2 and Design No.3 were released during August, 1989. The artificial reef thus constructed covered an area of 50 sq.m. Observations were made every fortnight either by snorkelling or by diving with SCUBA. The important fauna and flora associated with the reef and the congregation of finfish and shell-fish and their behaviour were studied. In order to assess the nature and extent of invertebrate colonisation of the reef structures, tyre pieces measuring a size of 100 cm^2 were tied along with the modules at the time of construction of the reef and these were periodically removed and observed. Experimental fishing was carried out during every observation using either hook and line or perch trap. The perch traps were made up of fibres of *Acacia* wood and had length of 1 m, width of 0.5 m and height of 0.3m. The fishes caught by the hook and line and perch trap were sorted out, identified and their sizes recorded.

At Vizhinjam, the artificial reef constructed by the traditional fishermen was monitored. Different kinds of materials were used initially. Granite stones, discarded tyres and coconut stumps were some of the common materials used by the fishermen. These materials were later replaced by concrete rings, concrete filled worn-out tyres and a variety of structures made out of concrete. The chamber-type concrete module which has been introduced very recently along Trivandrum coast is notable among all the structures used by the fishermen previously. The artificial reefs were built at a depth of about 30 m. The fish catches landed from the reef as well as the non-reef areas were recorded. Also, underwater surveys using SCUBA were undertaken to assess the fish congregation in the vicinity of the artificial reef.

At Minicoy, an artificial reef was constructed with the primary objective of concentrating tuna live-baits. The structure consisted of 2 m diameter, three inch thick RCC slab base on which twelve vertical MS rod holders of 10 mm thickness and 1.9 m length were fixed at regular intervals. Fourteen discarded car tyres arranged in five rows and 15x10 cm size wooden block separators were interlocked by these vertical bars. The total number of wooden pieces used to maintain the gap along the inner periphery of the tyres was

sixty two. The structure thus fabricated had a total height of 1.2 m. It was installed in the area between Tunda Point (southern end of Minicoy) and Viringili during November 1988.

Results and discussion

In Tuticorin, good growth of algae was observed on the reef structure within one month from the time of construction of the artificial reef. When observed after 15 days the maximum length of the algal filament was 27 mm which increased to 48 mm after 37 days. The algae which belonged to Rhodophyceae and Phaeophyceae were mainly represented by *Acanthophora* sp., *Gracilaria* spp. and *Padina* sp. In addition to algae various groups of invertebrate organisms were found to have colonised the reef structures. The animals belonging to Porifera, Bryozoa, Polychaeta, Isopoda, Amphipoda and Cirripedia were observed in large numbers. It was observed that the colonisation by polychaetes and cirripedes was very rapid. Initially, the composition of both the polychaetes and cirripedes was almost in equal proportion. However, as the period advanced, the settlement of barnacles on the reef structures increased at a faster rate.

Experimental fishing carried out in the vicinity of the artificial reef has shown that three carangids namely, *Caranx carangus*, *C. sansun* and *Selar malam* were taking shelter in the mid-water column, whereas the perches *Lutjanus vitta*, *L. fulviflamma*, *Lethrinus nebulosus*, *Serranus boenack* and *Lates calcarifer* occupied the bottom area closely interacting with the reef structures. During January 1990, ie. six months after the construction of the reef, only *C. carangus* and *S. malam* were recorded. But during February, two species of *Caranx* and three species of *Lutianus* were observed in the catches. The composition of the species collected from the artificial reef further increased in March when the crabs *Portunus pelagicus* and *Charybdis* sp. and ten species of fishes dominated by *L. vitta* (35.4%) were recorded. During April, *Lethrinus nebulosus*, *Lutjanus rivulatus*, *L. vitta*, *Diagramma* sp., *Platex teira* and *Siganus oramin* were collected from the artifical reefs. *L. nebulosus* was the dominant species constituting 62% of the total numbers collected followed by *Diagramma* sp. (14%), *Platax teira* (8%), *L. rivulatus* (6%), *L.vitta* (4%) and *Siganus oramin* (4%). In the case of *L.nebulosus* the size ranged between 133 and 300 mm in total length, with the modal size at 156-160 mm.

During June, six species of fish were collected in addition to two species

of crabs. *L.nebulosus* was the dominant species as in April forming 61.9% of the total number of fish collected from the area. Other species collected in June were *Acanthurus mata* (14.3%), Scolopsis vosmeri (9.5%), *L.vitta* (4.8%), *Serranus boenack* (4.8%), *Tetradon immaculatus* (4.8%) and the crabs *Atergatis integerrimus* and *Charybdis* sp. The size of *L.nebulosus* during June ranged between 142 and 218 mm, with the model size at 156-160 mm as in April. During July, *L. nebulosus*, *Lates calcarifer*, *Serranus merra* and *Tetradon* sp. were collected. In the case of *L.nebulosus* the size ranged from 163 to 212 mm. During August *Callyodon bateviensis*, *L.nebulosus*, *Ostracion nasus* and *Serranus* sp. were collected.

Sixtyseven *L.nebulosus* collected from the artificial reef were tagged and released back into the same area in order to find out whether they permanently reside in the same area or migrate to some other area. Out of 67 tagged and released, two were recovered on 12th April, 1990 *i.e.* 27 days after they were released into the artificial reef area.

In addition to experimental fishing, underwater observations using SCUBA were carried out in the vicinity of the artificial reef and the inhabitation and behaviour of various species of finfish and shellfish were studied in detail. The presence of fish was recorded for the first time during the third month after the construction of the artificial reef. Thereafter, they could be noticed during every observation. From the underwater observations four distinct groups of fishes were recognized based on their mode of attraction towards the reef structures: (i) *Serranus* sp. - preferred to live within the crevices of the reef structures attaching a major part of its body to the object; (ii) *Lutjanus* spp. - preferred to swim within the stagnant water body of the well-type module without touching the reef structures; (iii) *Caranx* spp. and *S. malam* were observed to hover in large numbers about 2 m above the reef structures. It appears that these fishes were taking shelter in the lee waves produced under the influence of the structures placed on the floor of the sea; (iv) the blennids, *Dasson* sp. and *Petroscirtes lienardi* were observed in the sub-surface water clining to the marker rope and *P. pelagicus* was found to live near the marker float hiding themselves under the seaweeds grown on the float. Also, it was observed that the fish *Platax teira* ranging in size from 42 to 44 mm were swimming around the marker rope in the sub-surface water whereas the larger ones of the same species (205 -208 mm) were swimming close to the reef

structures. Thus, it appears that the larger fish are directly influenced by the reef structures.

At Vizhinjam, underwater observations revealed the congregation of large shoals of small fishes such as *Apogon novemfaciatus*, *Amphiprion* spp. and *Dascyllus* spp. Larger ones like *Epinephelus corallicola*, *Lutjanus argentimaculatus*. *L.lineolatus*, *Pterois antennata*, *Spillotichthys pictus* and *Heniochus acuminiatus* were found in small numbers.

The reef building polychaetes *Sabellaria spinulosa* and *S.spinulosa* var *gravieri* were collected from the site of the reef in large numbers by SCUBA divers. These polychaetes served as important source of food for demersal fishes. It was also observed that the cuttlefish *Sepia pharaonis* congregated around artificial reef for attaching its egg mass. It is interesting to note that fishes like *Carangoides plagiotaenia*, *Lethrinus harak*, *Selar kalla*, *C.malabaricus* and *Selaroides leptolrpis* were recorded only in the reef region at a point of time. A slight increase in the landings at Valiathura was noticed after the establishment of artificial reef in that area. From 669.0 t in the year 1988-'89 the landing increased to 857.5 t during 1989-'90 and then to 1442.8 t during the subsequent year.

It was observed that out of the two types i.e. the tubular and well-type arrangements of the concrete rings, the first one was found to be more effective in attracting the fishes. The hut-type bamboo modules and three-dimentional chamber type concrete modules were found to be more effective than the semi-circular concrete module. The sunny days from November to April appear to be the best period for fishing by hook and line in the artificial reef area.

In the lagoon of Minicoy, filamentous algae belonging to *Ectocarpus* spp. were found to have grown on the tyres and wooden separators within three months of the installation of the artificial reef. A large concentration of mysids belonging to *Neomysis* spp. was observed during the fourth month. From seventh month onwards encrusting types of brown algae replaced *Ectocarpus* spp. Epizoites were found to concentrate on the inner sheltered sides of the artificial reef by the end of the first year. The settlement of pearl oyster spat on the reef platform was observed after a period of fifteen months. The seaweeds, *Halimeda gracilis*, *Dictyota dichotoma*, *Turbinaria ornata*, *Gelidiella acerosa* and *Ceramium* sp. were also found to have grown on the platform around this time.

The following species of fishes were found to have colonised the artificial reef constructed in the lagoon of Minicoy: *Abudefduf sexfaciatus, Caesio pisang, Dascyllus aruanus, D.trimaculatus, D.reticulatus, A.bengalenis, Thalassoma umbrostigma, Arotheran* sp. and *Heniochus* sp. in their order of abundance. It was observed that the tidal variation inside the lagoon influenced the quantitative distribution of fishes around the artificial reef with lesser numbers during the low tide period.

Future research priorities and conclusion

These investigations by the Central Marine Fisheries Research Institute at three different Centres have clearly shown that artificial reefs can play an important role in marine fisheries development by increasing the production. The variety of algae growing on the reef structures, provides an excellent feeding ground for various species of finfish and shellfish, particularly for their young ones. Further, it has been observed at all the three Centres that the artificial reefs form the base for the development of various invertebrate organisms. The biological productivity is thus higher in the reef area as compared to the barren sea since 'ecological succession' takes place in the former. Hence it is suggested that the construction of artificial reefs along Indian coasts may be taken up on a large scale as a Government-sponsored programme involving fisherfolk, research institutions and voluntary agencies with the main objective of increasing the marine fish production.

As it has been observed that fishes exhibit distinct responses to reef structures, the studies on the behaviour of various species of finfish and shellfish in the artificial reefs may be intensified in order to design and fabricate suitable structures with the specific purpose of attracting a particular group of fish or shellfish.

As many species of finfish and shellfish congregate around artificial reefs mainly to feed on the algae that naturally grow on the reef structures, it is suggested that selected species of algae may be transplanted at the time of construction of the reef so as to augument the natural algal production. It may be mentioned here that a direct relationship between the production of red algae, *Gelidium* sp. and the production of spiny lobsters has been well established in Japan. Hence, in order to increase the production of spiny lobsters in our waters, culture of red algae in artificial reefs may be taken up on a large scale.

As the design and dimensions of the artificial reefs depend upon the purpose of the reef as also on reef site characteristics such as bottom topography, current pattern in the area, etc., the work on artificial reef should be carried out as an inter-disciplinary one involving scientists from various branches of science.

As local scour is one of the important phenomena connected with the sinking of artificial reef structures when they are constructed on the sandy or muddy bottom, basic research on this line may be intensified in the laboratory and sea in order to design suitable structures which will withstand such conditions for many years.

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