ISSN 0254-380 X

MARINE FISHERIES INFORMATION SERVICE

No. 183

Janauary, February, March 2005

TECHNICAL AND EXTENSION SERIES

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

COCHIN, INDIA

(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)

1112 Artificial reef and its impact on artisanal fisheries

It has been widely recognized in several countries that the installation of Artificial Fish Habitat (AFH) is helpful in increasing fish production. An AFH is an object or a construction, which promotes an ecosystem, provides habitat for fishes by attracting and aggregating them. Any drifting or sunken objects serve as AFHs. Temporary structures such as logs, branches of trees, palm leaves and automobile tyres, whether employed as floating or hanging or sunken structures, are known as fish aggregating structures, and are useful for attracting and aggregating fishes. These structures may not last for more than a month. Semipermanent structures such as concrete rings, ferrocement modules, high density polyethylene and steel structures, which are called artificial reefs are submerged at a depth of 20 to 25 m, last for 1 to 5 years, and are helpful in developing an ecosystem, thereby increasing the productivity. Generally, hanging and floating structures are called Fish Aggregating Device (FAD) and sunken structures are called Artificial Reefs (AR). Thus an AFH can be either a FAD or an AR.

Fishermen of southeast Asia and western pacific countries have used their knowledge on the aggregating behaviour of fishes and launched a variety of AFHs. About 40 countries are using AFHs for the following purposes: (i) Commercial largescale fisheries in Japan (ii) sport fishing in the USA, (iii) smallscale fisheries in several countries including India. At present, Japan has the most extensive and technologically advanced AFH programme in the world with an annual expenditure of about 0.5 billion US$. In Japan, annually 60 million cubic feet of AFH costing 100 million $ have been launched in recent years. The reef productivity index has been estimated between 5 and 50 kg of fish per cubic meter of reef Volume. In Korea, 20,000ha have been covered as AFH, spending 13 million $ annually. It has been reported that the fish catching efficiency is 4 times higher in the reef grounds. In the Philippines, each purseseine operator launches his own AFH structure (called payaous) in the sea for exploiting tunas.

When an AR is first installed, microorganisms grow on it. A large number of small animals and fishes feed on the microorganisms and larger individuals aggregate to feed on the smaller ones. The advantages of the AFHs are: (i) They attract and concentrate fishes and help in establishing an ecosystem. (ii) They provide shelter for spawning populations, thereby serving as nurseries. (iii) The AFHs enable the artisanal fishermen to fish near the shore without spending much time and energy to locate fish. (iv) The AFHs improve the income of the artisanal fishfolk as they could increase the catch by fishing in the AFH areas

in addition to fishing in their regular fishing grounds.

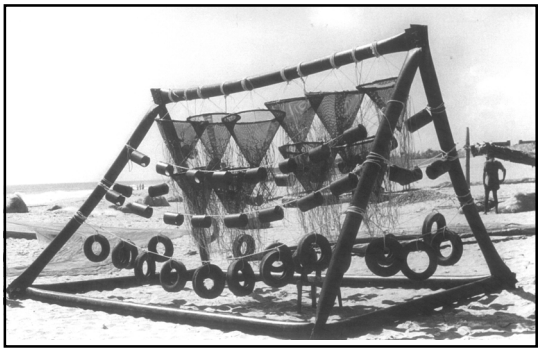
The following criteria should be followed for locating the AFHs. (i) The structures should be installed in waters closer and easily approachable to the fishing villages. The AFHs should be installed near the villages, where gears suitable for fishing around the structures such as hooks & line are available and are regularly employed by the fisherfolk. (ii) Coastal areas with strong current and wave action should be avoided, as unfavourable oceanographic conditions tend to disperse the structures to distant areas. (iii) Areas of heavy siltation, such as river mouth should be avoided. In areas of heavy siltation, the structures will sink in the seafloor very quickly. (iv) For launching bottom AR structures, the seafloor should be even and hard. Rocky areas are not suitable for launching these structures. Moreover, rocks are natural reefs, which support a unique ecosystem. (v) The AR areas should not be in the navigation route. It is also advisable to avoid trawling and shoreseining grounds.

There are several fishing methods which are particularly suited to use around the AFHs. Hooks & line is the most common method, contributing 53% to the catches from the AFH areas off Valiathura. Boatseines, shoreseines and drift gillnets are the other gears, which are operated in the AFHs.

Often, disputes arise regarding ownership, maintenance and fishing rights of the AFHs within and between fishing villages. Deliberate damaging of structures and encroachment of the AFH areas by nonparticipants are common not only in India but in may other countries as well. The ownership and usage of the AFHs in other countries are as follows: (i) fisher groups utilize the structures owned by individuals; (ii) fisher groups launch common structures, which are utilized by the same groups (iii) partnership between fisher groups and entrepreneurs (iv) entire fishing village own and utilize the AFHs. Considering the conditions prevailing in India, it is the fourth option which appears best suited. There are good examples of such systems functioning successfully in Kerala .

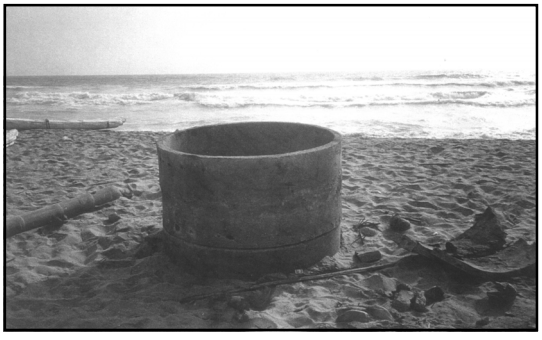
Inspite of the evidence that AFHs benefit the fishermen, detailed investigations on the suitability of AFH structures, biological characteristics of the aggregating fish populations such as maturity and feeding conditions, and cost-benefit ratio of different structures, which are necessary to recommend the ideal structures for different coastal areas, are not available. In most cases, the effects of AFHs, both positive and negative, are not monitored, and there is no assessment of the real impacts of costly AFHs on local fisheries. Given the nature of the AFHs, since they have limited life span, it is important to ascertain that the AFH deployment benefits the fisherfolk by means of increased production, efficient employment of capital and human resources and positive contributions to local and national economies. It is thus important that data on the impacts of the AFHs be

gathered, so that the benefit they bring can be demonstrated and quantified.



Hut shaped high density polyethelyene structure

Ferrocement triangular structure



Concrete ring

Artificial reef off Chennai

To quantify and qualify the catches, to understand the biological characteristics of the aggregating fish populations and as a measure of fishermen welfare, artificial reef (AR) structures were deployed in the coastal waters near Chennai.

Three types of ARS., viz., one high density polyethylene (HDPE) hut-shaped structure, 50 ferrocement modules and 100 concrete rings were deployed in January, 2003 on the seafloor at 20 m depth, 2 km off Chinnandikuppam, which is located 20 km south of Chennai. The HDPE structure was a multisided frame (length: 6; height: 6 m) made up of HDPE pipes, which was sealed at both ends by extrusion welding and joined together. Fish attractants such as nelton cones, old automobile tyres and plastic strips of different colours were attached to the structure. Anchors were attached to the four corners. The ferrocement triangular module was of equal size on all sides (length/height: 1.5 m; width: 0.7 m), and hence each module settles in a stable, identical position on the seafloor. The concrete ring (diameter: 0.6 m; height: 0.5 m) is a popular AR design used by the fishermen. The purpose of deployment of different types of structures was to remove the possible bias in fish aggregation that may arise if any one type of structure had been deployed. The cost of fabrication and deployment of all the structures was Rs. 2,50,000 and the total cost was granted by the ICAR under the AP Cess Fund.

Fishing effort, catch, catch composition and income from AR and non AR grounds

After deployment of the structures in January 2003, fishing in the AR ground started in April 2003. Fishermen reached the site by catamaran and used hooks & line. In addition

to fishing in the AR ground, fishermen carried out their regular fishing in non-AR grounds using gillnet.

The fishing effort in the AR and non AR grounds during the 16 month period from April 2003 to July 2004 was 3,844 hours and 21,048 h, respectively. The major differences between the effort employed in the AR and non-AR grounds are as follows: (i) Compared to the AR ground, the effort was 3.3, 7.0, 5.7 and 5.5 times more in the non-AR grounds in terms of number of units, number of fishermen, actual fishing hours and total effort respectively. (ii) The manpower required for hooks & line operation in the non-AR grounds was only half (1.3 fishermen/unit) of that required for gill net operation in the AR grounds (2.8 fishermen/unit). (iii) The actual fishing hour per unit was only 4.7 in the AR ground compared to 8.1 hour in the non-AR grounds. Gillnet fishing requires more net soaking time compared to hooking, and hence, the actual fishing hour per unit was more in the non-AR grounds. (iv) The total effort per unit in the non-AR grounds was 66% more than that in the AR ground. The travel time to the non-AR grounds (1.9 hour/unit) is more than that to the AR ground (1.4 hour/unit) since the boats venturing into the non-AR grounds have to scout for fish shoal. On the contrary scouting time is eliminated when the boats venture into the AR ground for fishing. During April 03-July 04, the total catch from the AR ground was 6,404.0 kg. The catch per 100 actual fishing hours was 215.7 kg and the catch per 100 hours of total effort was 166.6 kg. The catch per fisherman was 7.6 kg. The catch was low in the initial months of April 2003 (19.3 kg) and May (92.5 kg) 2003, but substantially increased in June 2003 (653.5 kg). The maximum catch was in June 2004 (852.0 kg)

During the 16 month period, the total catch from the non-AR grounds was 43,818.2 kg. The catch per 100 actual fishing hours was 258.0 kg and the catch per 100 hours of total effort was 208.2 kg. The catch per fisherman was 7.4 kg. The catch and CPUE were highest in February 2004 (9349.9 kg; 2292 kg/ 100 actual fishing hours), but lowest in January 2004 (679kg; 114 kg/100 actual fishing hours). However, the effort, in terms of number of units, number of fishermen and actual fishing hours and total effort in the non-Ar grounds were lowest in February 2004. The spurt in gillnet catch in February 2004 was due to incursion of huge shoal of the whitebait *Stolephorus indicus* (catch: 6,900 kg) and the Indian mackerel, *Rastrelliger kanagurta* (catch: 1,035 kg) into the fishery.

Thus the catch per hour from non-AR grounds was marginally higher than that from the AR grounds. However, the catch per fisherman was marginally higher in the AR ground.

Analysis of catch composition from the AR gounds indicates the types of fishes that aggregate around the structures. During April 03 – July 04, the catch from the AR grounds consisted of snappers (42.7%), emperors (23.4%) and carangids (22.9%) in addition to pomocentrids, groupers, halfbeaks, clupeids, threadfins and threadfin breams (Table 1).

Table 1. Catch and income from the AR ground during April 2003-July 2004

Group/species	Catch		Income	
	(kg)	(%)	(Rs)	(%)
Clupeid				
Sardinella longiceps	13.2	0.2	330.0	0.1
Grouper				
Epinephelus tauvina	51.1	0.8	3066.0	1.1
Eperor				
Lethrinus nebulosus	1500.5	23.4	90025.0	32.9
Snappers				
Lutjanus argentimaculatus	33.9	0.5	677.0	0.2
Lutjanus johni	77.5	1.2	1938.0	0.7
Lutjanus lineolatus	1429.3	22.3	42880.0	15.6
Pinjalo pinjalo	1199.9	18.7	96004.0	35.0
Threadfin bream				
Nemipterus japonicus	5.5	0.1	94.0	0.0
Threadfin		0.0	0.0	0.0
Polynemus indicus	14.9	0.2	743.0	0.3
Carangids				
Alepes djeddaba	482.8	7.5	10482.0	3.8
Alepes melanopetra	346.6	5.4	3718.0	1.4
Carangoides spp.	393.6	6.1	5799.0	2.1
Caranx williamsoni	110.8	1.7	5790.0	2.1
Decapterus russelli	76.8	1.2	1152.0	0.4
Scomberoides commersoni	67.1	1.0	1273.0	0.5
Halfbeak				
Hemirhamphus spp.	41.0	0.6	1636.0	0.6
Pomocentrid				
Pomocentrus demoselle	528.0	8.2	7920.0	2.9
Miscellaneous	0.0	0.0	0.0	
Acanthes spp.	8.5	0.1	128.0	0.0
Terapon spp.	23.0	0.4	345.0	0.1
Total	6404.0	100.0	274000.0	100.0

The catch from the non-AR grounds consisted of clupeids (29.9%), Crabs (27.4%) and Indian mackerel (15.6%) in addition to carangids, lizardfishes, flatfishes and threadfin breams and several other groups.

From the AR ground, a sum of Rs. 2,74,000/- was realized in 16 months. The monthly income from fishing in the AR grounds works out to Rs. 17,125. The maximum income was in May 04 (Rs. 37,560) and June 04 (Rs. 49,720).

Snappers fetched maximum income (51.5% of the total) from the AR ground followed by emperor (32.9%) and carangids (Table 1).

From the non-AR grounds Rs. 11,06,066/- was realized in 16 months. The monthly revenue for the village works out to Rs. 69,129 from gillnet fishery. The maximum income was in February 04 (Rs. 2,70,015). Clupeids (mainly the whitebait *Stolephorus indicus* and the oil sardine *Sardinella longiceps*) fetched maximum income (28.9% of the total) from the non-AR grounds followed by the crabs (mainly *Portunus sanguinolentus*) and the Indian mackerel (*Rstrelliger kanagurta*).

Whereas the catch rate (kg/h) was higher in the non-AR grounds and the catch per fisherman was almost equal in the AR and non AR grounds, the actual gain from the AR ground was the higher income realized per hour of operation. The fishermen realized Rs. 71.3 per hour of effort from the AR ground, but only Rs. 52.5 per hour from the non-AR grounds. Thus income from the AR ground was 36% higher than that from the non-AR grounds. This was possible because of the contribution of better priced fishes such as snappers, emperors and carangids to the catch. The average value of the catch from the AR ground (Rs. 42.5/Kg) was 67% higher than the catch from the non-AR grounds (Rs. 25.4/kg). An analysis of the catch off Valiathura (Trivandrum coast, Kerala) where a number of reefs has been installed by the fishermen revealed that the ARs contributed a significant share of 6.9% to the total fish production of the village in terms of value, but only 2.8% in terms of quantity. In other words, high quality fishes aggregate in the ARs realising better earnings.

Biological characteristics of fish caught from AR ground

By collecting fish samples from the catches from the AR, the length range, midlength, maturity and feeding conditions of three species, viz., the bigeye snapper *Lutjanus lineolatus,* the pinjalo snapper *Pinjalo pinhalo* and the trevalle *Alepes djeddaba* were examined. The analysis of midlengh and maturity stages indicate that juvenile fish colonize in the initial months of deployment and grow to a large size and spawn around the AR. This study suggests that fish use the AR as a habitat, thereby help to increase the productivity, rather than merely aggregating around the structures. However, more studies by undertaking scuba diving and underwater photography are needed to confirm the role of the AR as a tool of resource enhancement.

Fishermen opinion on the AR

In the present study the reef structures were deployed at a cost of about Rs. 2.5 lakhs. The fishermen realized Rs. 2.7 lakhs from 16 months of fishing in the AR. The fishermen were trained on fabrication and deployment of ARs. The opinion of fishermen of Chinnandikuppam was sought in July 2004. All

the fishermen were immensely satisfied with the performance of the AR and evinced keen interest for deployment of more structures.

Problems related to ownership of the AR did not arise either within the village or with the fishermen of nearby villages. The structures deployed in the present project were made the property of the entire fishing community and not of individuals or groups. The fishermen in the community had access to the reef on a rotational basis. This arrangement of community participation functioned well without property disputes.

Conclusions and recommendations

i. The economic advantages of AR are mainly due to capture of quality fishes, rather than on higher catch.

ii. Depending on the type of structures used, the cost of investment and deployment of structures could be realized in 12 to 15 months of fishing.

iii. In addition to hooks and line, which was the only gear used by the fishermen, gears such as gillnet, trap and pot may be used to catch pelagics, lobsters, crabs, octopus etc.

iv. If the reef is closed for fishing for 3 to 4 months in a year, there is a possibility that the aggregating fish would proliferate and disperse to nearby fishing grounds.

v. AR should be deployed at carefully planned sites. They should not be installed irrationally and the coastal waters should not be used as dumping sites.

vi. Acceptance of AR by the users and community participation are essential for the success of the programme.

Prepared by: **E. Vivekanandan, S. Venkatesan and G. Mohanraj, Madras Research Centre of CMFRI, Chennai**