Deployment, orientation, capacity, and layout

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The critical activity resulting in the desired functioning of the ARs is the deployment of modules at the exact location, as derived after the studies, and setting them in a specified design and layout in the appropriate proportions of the species-specific and geography-specific numbers and modules.

As mentioned earlier, the proposed function of the AR is the target set. Accordingly, the grounds are to be chosen first, followed by the designs, modules, and the layout. The important factor again with regard to the fisheries and production-oriented reefs is the capacity of boats each reef area can facilitate for smooth/unhindered fishing at the same time of operation. Therefore, uniform design and the number of modules for all the villages will not reward well in terms of fishing, and management ease and levels of exploitation will vary. For eg., distributing 250 modules at each site with equal proportions of standard designs and modules will create identical area and spatial systems with variations in geography and local resources and the intensity of fishing and gears. It is always advisable to have a variable model approach to each situation where there is a need for recruitment promotion/forage fishing /predator fishing/proximal to nursery grounds/declining specific resources/number of active fishers and boats, etc.

Pre-deployment measures

The pre-requisites of a good reef deployment and service is to get them assembled in the proposed area in the required layout and ratio and geo-referenced in a quicker time. Larger barges and cargo vessels /Fatehmari /cargo ships could be used for the same with an inbuilt crane, facility for loading and unloading and skilled crew who can handle these activities with sufficient knowledge of the positioning and functions of the AR.

Fig. 3. Deployment of reef modules using cargo ships

Fig. 35. Flagging off and deploying the reef modules at the fixed coordinates

Fig. 36. Deploying the reef modules at the fixed coordinates in different locations

With a scaling up in the number of reef modules per site and an increase in the density and sizes of the modules (120 kg to 900 kg per unit) the gross tonnage increased from handling 80 tonnes to 250 tonnes. Therefore, the ideal choices were to engage professional cargo handling vessels, particularly the wooden Cuddalore/Thoothukudi/Mangalore type of vessel which can hold and safely transport up to 400 tonnes of solid materials. As these reef modules are more in surface area and volume each trip one such vessel is required to ship for deployment to one site. Barges of these capacities could also be employed as they have a shorter draft and navigation through smaller ports is convenient. However, the stability of barges at deployment sites when the sea is turbulent is a problem.

These vessels (115 feet OAL; 280 HP) need at least a draft clearance at harbours and ports of nearly 10 feet for unhindered sailing out with the full load. Therefore, the selection of ports and harbours for loading is very important. There should not be any disturbance in the loading and berthing of the vessel in the port, from other trading groups and vehicles.

Tentative sailing and berthing dates are to be informed to the port and harbour authorities well in advance and the anticipated load is also to be ascertained from a nearby taring station (weighbridge).

The units assembled at the fabrication site in order of the ratio and proportion decided must be loaded onto a truck according to the serial numbers for easy tally and then they are loaded onto boats. The unloading and loading are done using 10 tonne capacity cranes and the harbour berth/wharf space should be sufficiently wide enough for these operations.

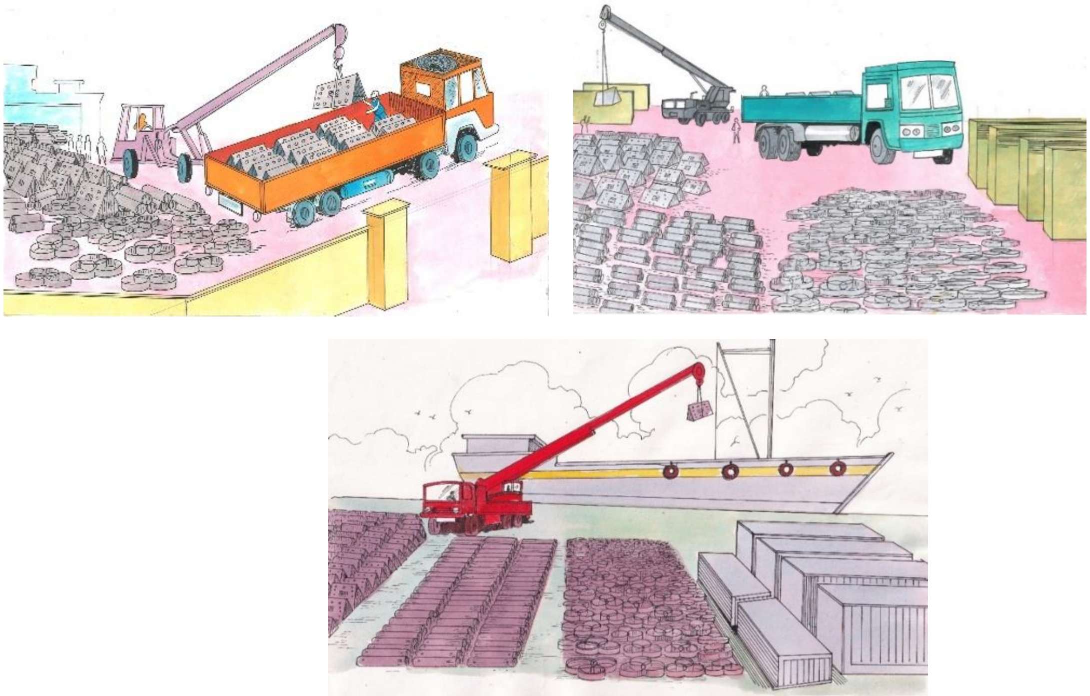

Fig.37. Loading of reef modules in the ship by cranes and JCB

The authorities who are to be informed well in advance for permissions to be sought include -

1. The state Fisheries Department officials /AD/DD
2. The state Marine Police Department
3. The state Harbour Office
4. The Port Authority with details of personnel sailing and load particulars
5. The Indian Navy or Coast guard station nearby with vessel particulars and purpose and material quantity.
6. The adjacent village's fisher society leaders.

Deployment

Deployment using boats

The normal practices followed during the centuries-old practices were loading stones/boulders secured with foliage's from known tree varieties and leaving at established spots of specific fish availabilities or aggregation sites or breeding sites following a seasonal calendar. The traditional canoes or catamarans load these structures (about 7-10 m tall when suspended) and logs would be floated as spotters in the sea. The catamarans would simply be tilted physically by rolling and leveraging weights onto one side. The coordinates were fixed and adjusted according to the visual triangulation methods by using visible shoreside landmarks like mountain

/chimneys/tree covers. But these locations were shared amongst a few operators particularly the ones who engaged in the process from the concerned village. These units were very few in number as the operation in itself was restrictive due to the physical inputs at loading and deploying.

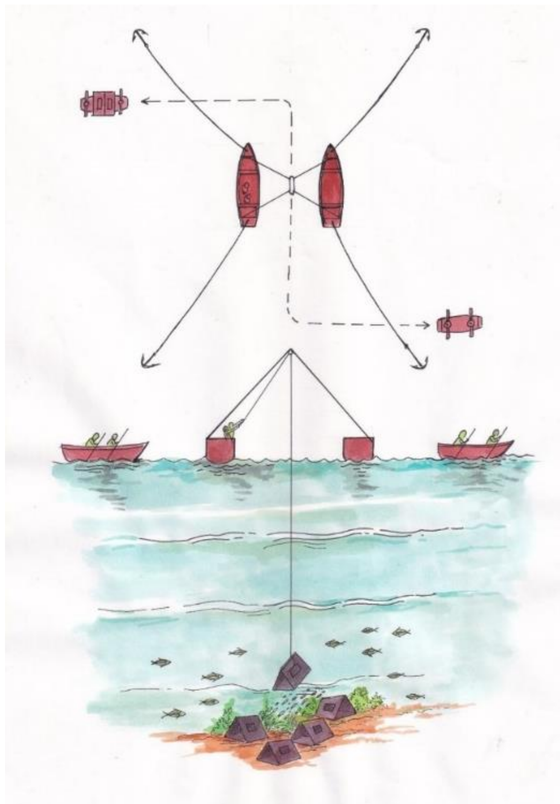

Fig.38. Deploying AR - method modified by ICAR-CMFRI in collaboration with ITGB

These methods were further modified by the fishers with the adoption of the advanced and heavier versions in larger numbers. With methods of having poles tied up between two boats and using the pulley rope leverage, the units were lowered in the sea (ICAR-CMFRI -ITGB); later this was modified into horizontally tying up two crafts with sound poles and loading modules over two crafts and transport to sites and deploying. This later shifted to single boat handling the units, when the boats used were more robust FRP make and had OBM engines to drive the loaded boats. These initiatives were good to involve the fishers themselves into the reef-building, however, it came up with issues such as the dispersion of units randomly and organizing a layout design was impractical when the operations were conducted for longer periods. The units while loading and deploying might develop hassles and damage boats and cause injuries at handling.

Deployment using barges and cargo vessels

The specified barges/vessels, if they can hold sufficient weights and have clearance draft at the respective harbours or ports, can be loaded with the full quota of the modules as far as possible, on one sailing, to reduce time and effort in gathering stakeholders and suspending other activities. ICAR-CMFRI has so far successfully deployed 250 modules/220 tonnes per site/trip**.**

The vessel anchoring facility is also very critical as it is often to be moved while deployment. A motor-driven winch-supported anchor would be ideal.

Steps to be followed further for the assembly and layout

1. Note the coordinates on the ship and the required anchorage length based on the existing current speed and direction.
2. Plan the anchor drop accordingly.
3. Check the coordinates again and confirm with the fisher team on board.
4. The cranes and deployment sides can be readied.
5. One by one the units can be lowered to the site.
6. At an average depth of 10 m, it is very unlikely that two units will fall on the same due to the currents, and flow rate existing at the site and the density of water.

Artificial reef orientation

a. Scattered into a square/rectangle/circle-a virtual boundary
b. Pyramid
c. Cluster formation - 4 patches of 50 each
d. Single large cluster - well spread but closely arranged
e. Corridor creation - making a village or hamlet-like lay out with exits and entrances using the different modules
f. Parallel to the coastline - a horizontal alignment
g. Vertical to the coastline - a perpendicular alignment to the coast line
h. A '**C**' shaped formation - the incurved space facing the horizon
i. An 'L' shaped formation - inner curve facing the horizon

All these orientations are to be decided based on the ground conditions and requirements in addition to the prevailing site weather. At times currents may not be favourable; then the desired results are to be obtained by using boats and tow energy to keep the deploying vessel in the required position at the drops.

Type (a) is more suited for fishing abundant forage fishes and pelagics. Type (b) is more preferred for raising only a select few species and larger predators. They are more suited for developing broodstock reefs of selected large predatory fishes (groupers/seabass/cobia). Types (c, d and e) are better for fisheries and management and creation of fish corridors and retention of the stocks over the reefs. Types (f, g, h and i) are more suited where the number of fisher operators are high and the sea conditions favour the orientation for the convenience of operations.

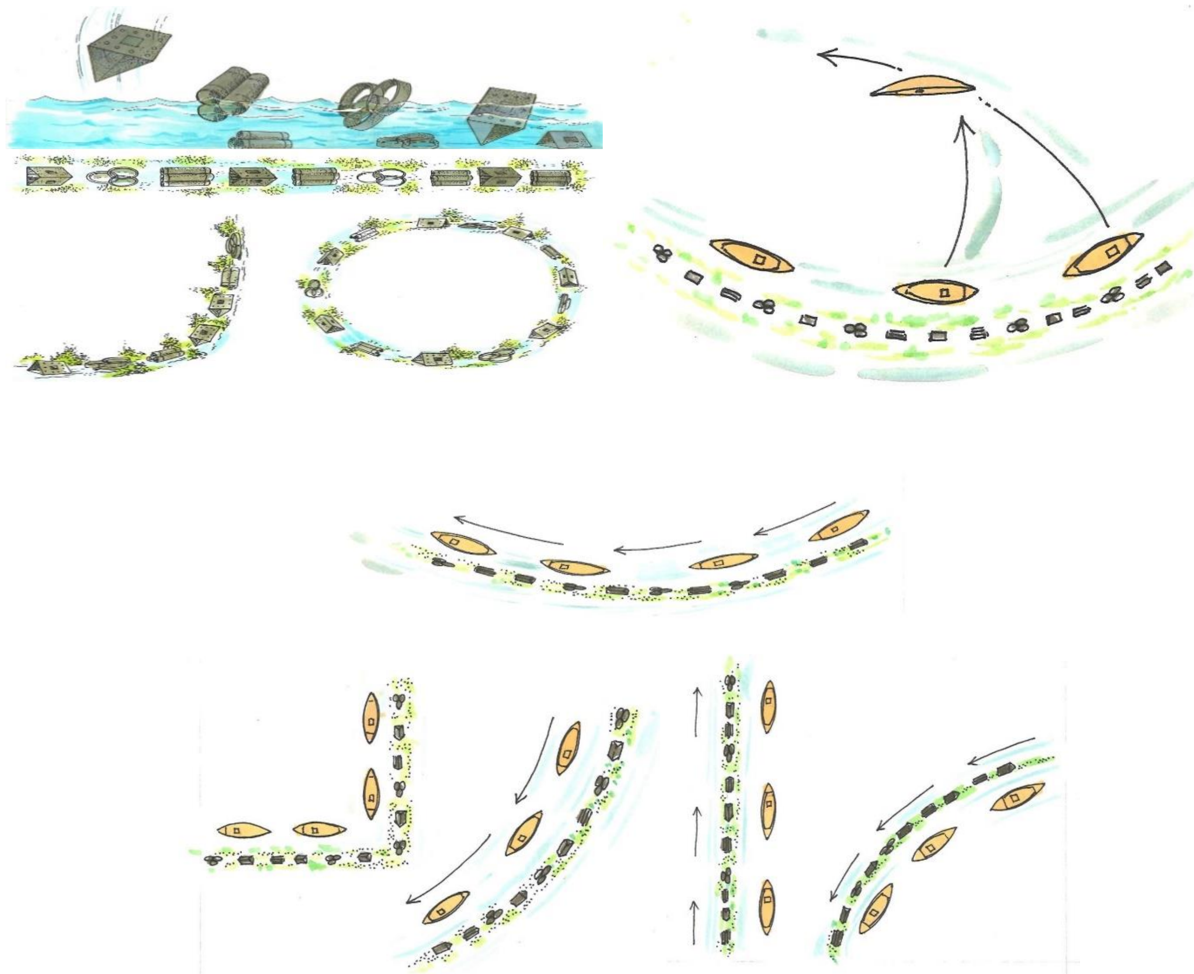

Fig. 39. Orientation of deployed reef modules-linear/along a curve, circles, patches, vertical line to the shore and L-shaped and C-shaped arrangement of modules on the seabed.

Artificial reef capacity

A well laid out production reef with multiple fish species as the target, the present densities and numbers of reef modules per site of 250 is adequate to support only 10-20 FRP boats of 18-20 ft at a time, and if gill nets and short seines are in operation this is restricted to a max of only 3-5 boats. A fisher hamlet with near about 100 crafts of such operation needs at least 3-4 reef patches for simultaneous operations and to reduce the exploitation stress on the fish stocks.

Essential: A portable GPS, compass, sonar on board vessel, and SCUBA team on board

(The primary unit in which longitude and latitude are given is ***degrees*** *(°). There are 360° of longitude (180° E ↔ 180° W) and 180° of latitude (90° N ↔ 90° S). Each degree can be broken into 60* ***minutes*** *(′). Each minute can be divided into 60* ***seconds*** *(″). For finer accuracy, fractions of seconds given by a decimal point are used. A base-sixty notation is called a* ***sexagesimal*** *notation. 1° = 60′ = 3600″. For example, a spot of ground can be designated by 43°2′27″ N, 77°14′30.60″ E. Sometimes instead of using minutes and seconds to measure the fraction of a degree, a decimal value is used. With such a convention the coordinates above are 43.040833° N, 77.241833° E. The first number was converted by taking the minutes divided by 60 and the seconds divided by 3600 and adding them together. That is: 43.040833° = 43° + 2′ × (1°/60′) + 27″ × (1°/3600″).*

Artificial reef layout

The better utility of an AR lies in the services it renders in fulfilment of the proposed functions and set targets. A series of field-level deployment trials and monitoring and fishery assessment studies have revealed that the layout of the AR plays a major role in achieving these targets. Pinnacle and pyramid formations benefit only larger predator fish assemblages and the diversity is less when compared to the broader peripheral distributed AR layout. The linear and cluster patch formations are also better than the pyramid ones. The advantage of a dispersed and spread-out reef is the scope for increased activity and fish mobility over a higher surface area such that the stock gets retained in the system itself. Several diver and fisher friend advisors have generated ideas and concepts on the layouts in our waters with (a) small pinnacle and randomly distributed modules, (b) a central pyramid cluster surrounded by small clusters of modules, and (c) preparing clusters on sand mounds in a random design such that fish gets escape and refuge routes to counter severe currents and predator attacks, and keep shifting or shuttling through the **proximal fish corridors** instead of exiting the reef area.

Fig.40. Central pyramid cluster and surrounded by small clusters of modules

Fig.41. Small pinnacles and randomly distributed modules

Fig.42. Clusters on sand mounds in a random design

The AR structures are therefore to be individually set with the proper understanding of the existing fauna and habitat characteristics. The AR situated in proximity to other reefs or rock patches are more productive and sustaining than the ones that stand alone in a plain area. The modules used in conservation areas could be arranged closely to limit the protected and no-take zones to specific locations with densely populated artificial reefs, which will ensure that conserved species and ranched seeds can be limited to and remain within the undisturbed MPAs. However, if the intention is for nursing and growth, the reefs could be more evenly spaced and random to generate more food resources.

A very healthy functioning unit could run sustainably for 10 years but for sustained fishing efforts and harvests every year it is advisable to add on 20% area or the number of modules every 3 to 4 years post-deployment, with regular upkeep of reef structures by diving teams. A well-planned and well-managed artificial reef can develop into a sustainable ecosystem supporting both, fisheries and conservation. This can, thus, effectively be recognized as an “Other Effective (area-based) Conservation Measure” (OECM) in marine fisheries.