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Achieving successful Marine Ecological Restoration and Shore Protection

H.A.M.E.R. - concept and implementation methods

***The purpose of the suggested plan is to ensure and eliminate the gap that often occurs between planning and executing marine restoration or enhancement plans that are aiming to restore and develop the marine and coastal environment - whether the need is for ecological restoration and research or economic (tourism and fishing) and social (livelihood and education) development* using natural materials and local resources.**

Introduction

Impacts of human activities and climate change are transforming marine ecosystems on a global scale to less diverse ecosystems, affecting the economies and societies that rely on marine resources.

Past measures attempting to ameliorate the dwindled biodiversity included the deployment of artificial structures, best known as Artificial Reefs (AR), measures dated to the Neolithic period, when fishermen submerged rocks, noticing a greater abundance of fish closer to these structures, while enhancing protection to the landing sites.

Since the 19th century, many efforts and resources have been invested in multiple regions, worldwide, with the purpose of rehabilitating and conserving the marine ecosystems, by restoring the loss of three-dimensional structures of a wide range of Marine Animal Fosters (MAFs), including coral reefs, to enhance biodiversity, support fisheries, recreation activities, and shore protection.

The concept leading those efforts was based mainly on the "Passive Restoration" notion (*Trying to minimize the causes for reef degradation without, or minimal, human intervention, hoping that the ecosystem will recover by itself*). One of the approaches used was the deployment of ARs (*most used designs of ARs were arrays of combined shapes of blocks and complex designs, mostly consisting of concrete or metal submerged at a depth of < 50m*). Other examples include the use of sunken ships and the use of abandoned infrastructure such as deserted oil rigs and coastal infrastructure as reefs as well as the establishment of MPAs.

Since the late 20th century, marine biologist Prof. Baruch Rinkevich has adopted the term “Active Reef Restoration”, suggesting that it became evident that ecosystem does not often recover naturally from anthropogenic stress without manipulation, and that developing a larger applied toolbox and supplementary ecological engineering approaches, are needed to achieve successful restoration initiatives (https://academic.oup.com/icesjms/article/78/1/410/5780429).

However, scant attention and consideration were given to the possible adverse impacts of post-implantation restoration practices in MAFs, aimed at emulating, or enhancing the natural environment and biodiversity. These adverse effects were not evaluated, although clearly observed, primarily in cases where restoration efforts were usually poorly executed.

To our view and based on our experience, the proposed discipline of "Active Reef Restoration", when integrates a robust scientific foundation and incorporates practical elements such as social and economic considerations, stakeholder' engagement, seascape planning, restocking of flora and fauna, controlled research, risk assessment, and management plans – it will evolve into what we propose to term as "Holistic Active Marine Ecosystem Restoration".

In view of the above, drawing from our observations and worldwide practices, and as we believe that:

- ***Simplicity and common sense are keystones in achieving any desired goals.***
- ***Using natural materials and simpler methods – than compared to "industrialized" designs and practices - make more sense and has more advantages.***
- ***Considering the "human factor" (such as: existential needs, morals, expectations) is to play a key role in planning and implementation of long-lasting sustainable conservation initiatives.***
- ***A "Holistic Active Marine Restoration Plan" can achieve greater and better restoration results.***

So, in consideration of the above, we are presenting our model of "Holistic Active Restoration Plan", for implementation at your desired locations.

Presentation

The presented plan, its planning, deployment, and management practices, are based on our knowledge and experience (and that of our colleagues) in different regions of the world.

The plan is suitable for any area that demonstrates aspects concerning the dismal state of the marine environment, including its ecological, social, and economic aspects.

Based on the project's Terms of Reference (TOR), we determine its exact location, physical size, materials for construction, placement, management and maintenance plan, and its future development.

The suggested plan is of a basic unit, and will achieve the desired results, by:

- ***Preparing the expected seascape of the project*** *- based on the location' Terms of Reference (TOR).*
- ***Building and deploying marine underwater structures (ARs) made of natural rocks and/or broken coral rock, to compensate the environment's loss of three-dimensional benthic habitat structure, attract and increase biodiversity, and support coastal protection.***
- ***Restocking of indigenous fauna and flora – to rehabilitate and enhance the ecological environment.***
- ***Providing sustainable livelihood sources for local communities and involving other stakeholders.***
- ***Creating and developing continuing programs for economic, social, educational, research and recreational activities - both for the residents of the region and other stakeholders.***
- ***Ongoing enhancement restocking, research, and quantitative monitoring surveys.***

Description

The suggested plan covers a basic area of about 3,000 m^2 and consists of one 25m long AR or two 13m ARs each, in that area.

i. On an area of about 3,000 m^2, at 30m to 150m from the shore, one (or two) underwater (and/or submerged) structures (ARs) will be constructed at the selected sites, on the sea bottom (preferably on thin sand layer or solid bottom), and at a depth of 5m to 8m (or 10 to 15m – according to the site requirements and conditions) *Appendix A*.

ii. The size of each AR will be a minimum length of 13m and maximum 25m, have a width of 5.0m and a height of 3.0m to 4.0m. (*final size will be according to the project's TOR*).

iii. The AR will be structured using natural limestone rocks and/or coral rock – each at size of minimum 1.0x1.0x1.0m = 1.0 m^3 *Appendix B*.

iv. Six (6) smaller ARs (made of the same material) are placed around the main AR (about 18m from it), each one of size 2.0x2.0m and height of 3.0m - as supporting habitats and trawler barriers.

v. Immediately after the establishment of the ARs, it will start to be stocked with fauna and flora that will be collected by trained staff *Appendix C*, including planting of sea grass in the area around the ARs (*This, in addition to the arrival and self-settlement of flora and fauna from around the constructed ARs that starts immediately after the placement of the AR*).

vi. Although the first and basic purpose of the AR is to create an optimal ecological environment, it can also be adapted to other purposes such as fishing, diving, and research.

vii. The implementation of the project and its operation will be accompanied by ongoing monitoring, enhancement stocking, maintenance, and research activities.

Stages

On-site visit for evaluation and preparation of the project's Terms of Reference (TOR)

Sites survey *Appendix D*:

a. Topographic and physical mapping of the project area.
b. Quantitative baseline survey (including invasive species).
c. Physiological and ecological data – currents, drift, waves, temperature, and salinity.
d. Selection of suitable sites (and depths) for placement of the ARs.
e. Preparing an ecological impact report (BACI1).

Preparation of the plan - including:

i. Preparation of the seascape plan.
ii. Preparation of technical and engineered specifications of the ARs.
iii. Locating sources and supply of the materials for the construction of the ARs (limestone rock).
iv. Selection of the means and contractors for the transport, placement, and underwater construction of the ARs.
v. Location and selection of suitable sources of benthic fauna and flora for enhancement stocking.
vi. Training of the required personnel for the establishment and continued activity (including fishermen, professionals, and those with relevant positions).
vii. Restocking and enhancement plan including sources, methods, means and required personnel.
viii. Work plan for the period from deploying the ARs till project' delivery (about 12 to 16 months).
ix. An ongoing annual work plan for each year after the implementation (including quantitative monitoring of survival and establishment success of transplants and overall developments in biodiversity).
x. Details, approvals, and regulations required for the establishment of the project + the institutional factors/authorities related to decision-making and management action.
xi. Detailed budget and schedule for implementation, management, monitoring, and follow-up.

Schedule*:*

As per our present experience and information, the time required for planning and implementing the project, from the date of approval and receipt of the budget is:

a. On-site visit for TOR preparation – 15 days.
b. Site survey and selection – 15 days.
c. Preparation of the placement and construction plan (technical) - 30 days.
d. Construction of the AR and the associated structures - approximately 90 days (from approval by the relevant authorities, and subject to sea conditions).
e. Preparation of enhancement restocking and monitoring plan - 30 days.
f. Personnel training – 30 days.
g. Initial project start-up phase and adjustments - 30 days.
h. Running – 180 days.

Total time for completion and delivery = 12 to 16 months

Budget for implementation will be determined according to its location, and will cover:

1. **On-site visit for T.O.R. preparation**
2. **Deployment -** including**:**

- Sites surveys + Engineering and deploying plans.
- Cost of AR materials + positioning + restocking materials + manpower.
- Management + monitoring + documenting.

3. **Operation costs - From deployment till delivery = 12 to 16 months,** including**:**

- Restocking materials, monitoring and documenting, manpower, supporting equipment, and management (*Including regulating the use by different users' groups (volume of fishing, diving, and boats)*.

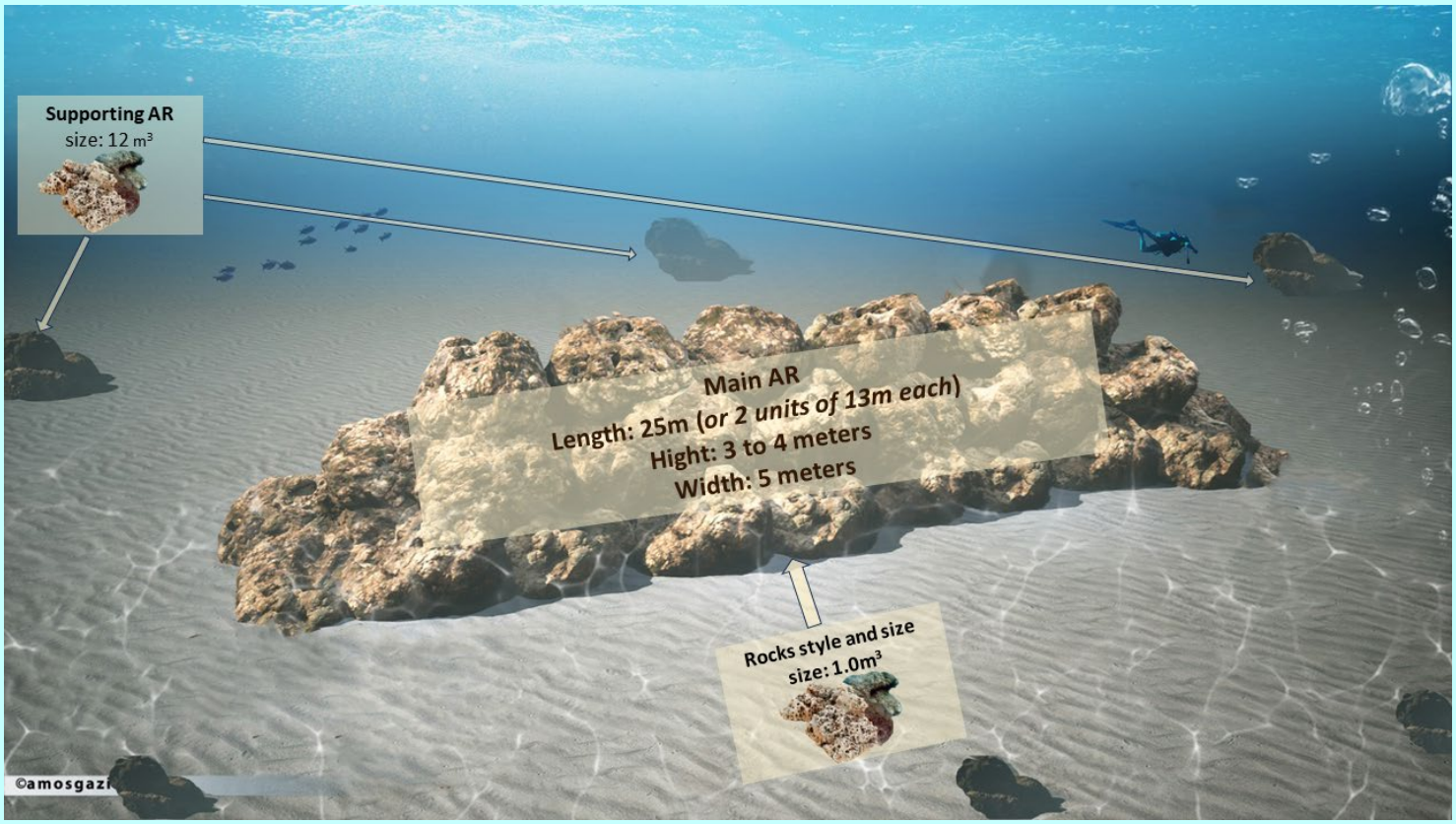
Post-delivery ongoing operation and development

Following the completion and delivery of the project, the structurally required annually recurrent activities should ideally be the following:

i. Management and supervision of the project's operation and development.
ii. Monitoring the changes in biological diversity in the ARs and their surroundings.
iii. Monitoring changes in the physical oceanographic conditions in the project area.
iv. Ongoing re-stocking of fauna and flora species.
v. Continue training and involving personnel in the ecological restoration.
vi. Production of regular monitoring reports.
vii. Economic/marketing development of fishing and related activities.
viii. Development of initiatives and plans for marketing eco-education and eco-tourism.
ix. Periodic removal of marine litter, from in and around, the project area.
x. Documenting project experiences and lessons learnt, to facilitate successful replication of such restoration plan projects elsewhere in the world.

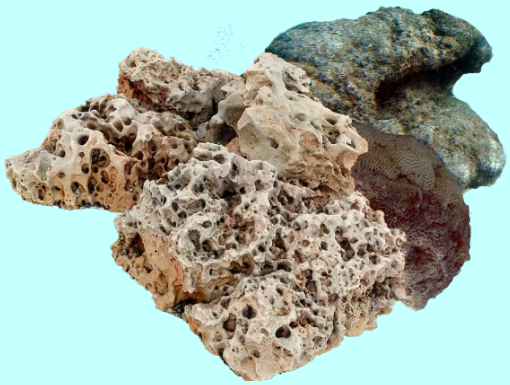
Appendix A

Layout of AR unit



Appendix B

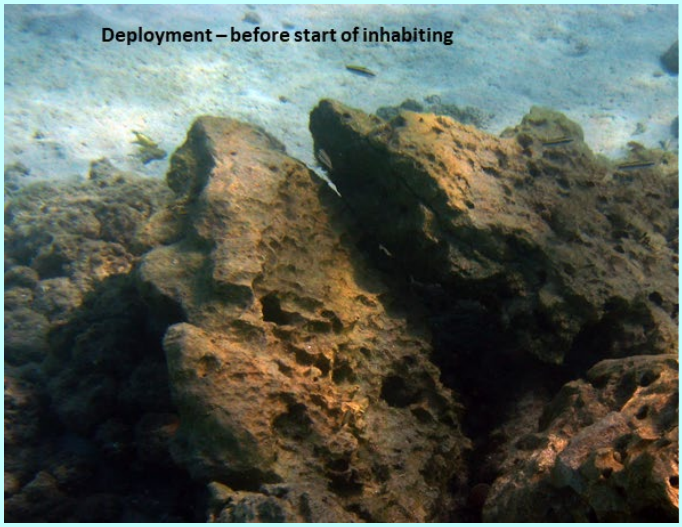
Building materials – Limestones and/or broken coral rock

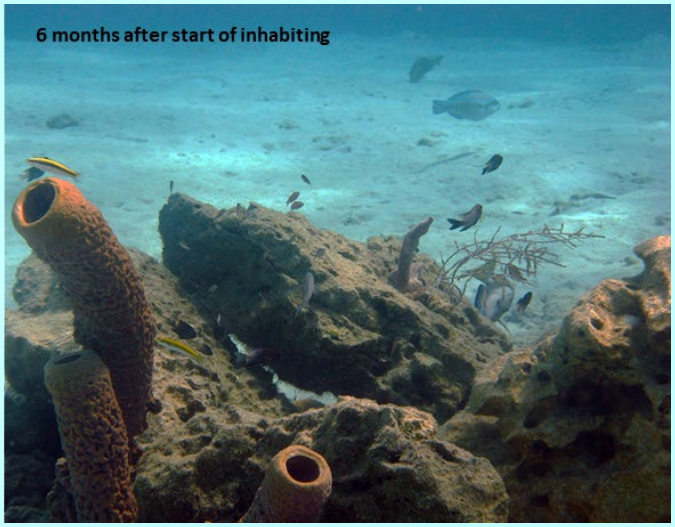


Appendix C

Inhabiting fauna and flora

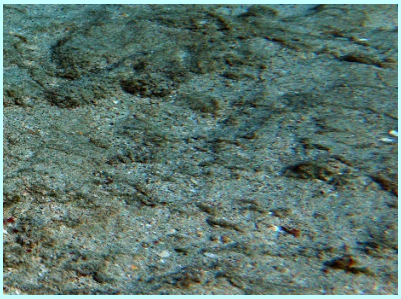
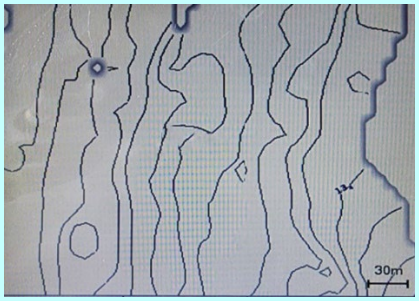
Pre VS Post Inhabiting





Appendix D

Site survey

Survey is applicable in sandy or solid bottom

Goals

The goal of the survey is to provide information and current ecological background that can assist in making informed decisions for optimal site selection for establishment of permanent artificial reef sites on the seabed, which are intended to increase marine biodiversity. In addition to checking the suitability of the selected site for the establishment of reef structures, this survey will be used as a basis for a future examination of the effect of placing the reefs and the consequent change in marine life near the reefs according to the BACI principle.

According to the results of the surveys conducted at the selected points, it will be determined if the selected site is suitable for placing the artificial structures (ARs), which will increase the structural complexity and contribute to the increase of biodiversity by changing the currents, creating a variety of ecological niches that encourage settlement, food supply, and protection from predation.

Methods

At each selected site, a bathymetric survey will be conducted from a survey vessel to characterize the substrate in the immediate surroundings. Drop cameras will also be used to record the substrate.

Finally, tow-board diving surveys will be carried out in the selected site to characterize the composition of the fish community as well as the sessile and mobile invertebrates.

During the tow-board survey, in addition to the data recording by the diving team, continuous video will be recorded of the surveyed environment for further in-depth analysis and to make the data accessible to the ultimate decision makers.