

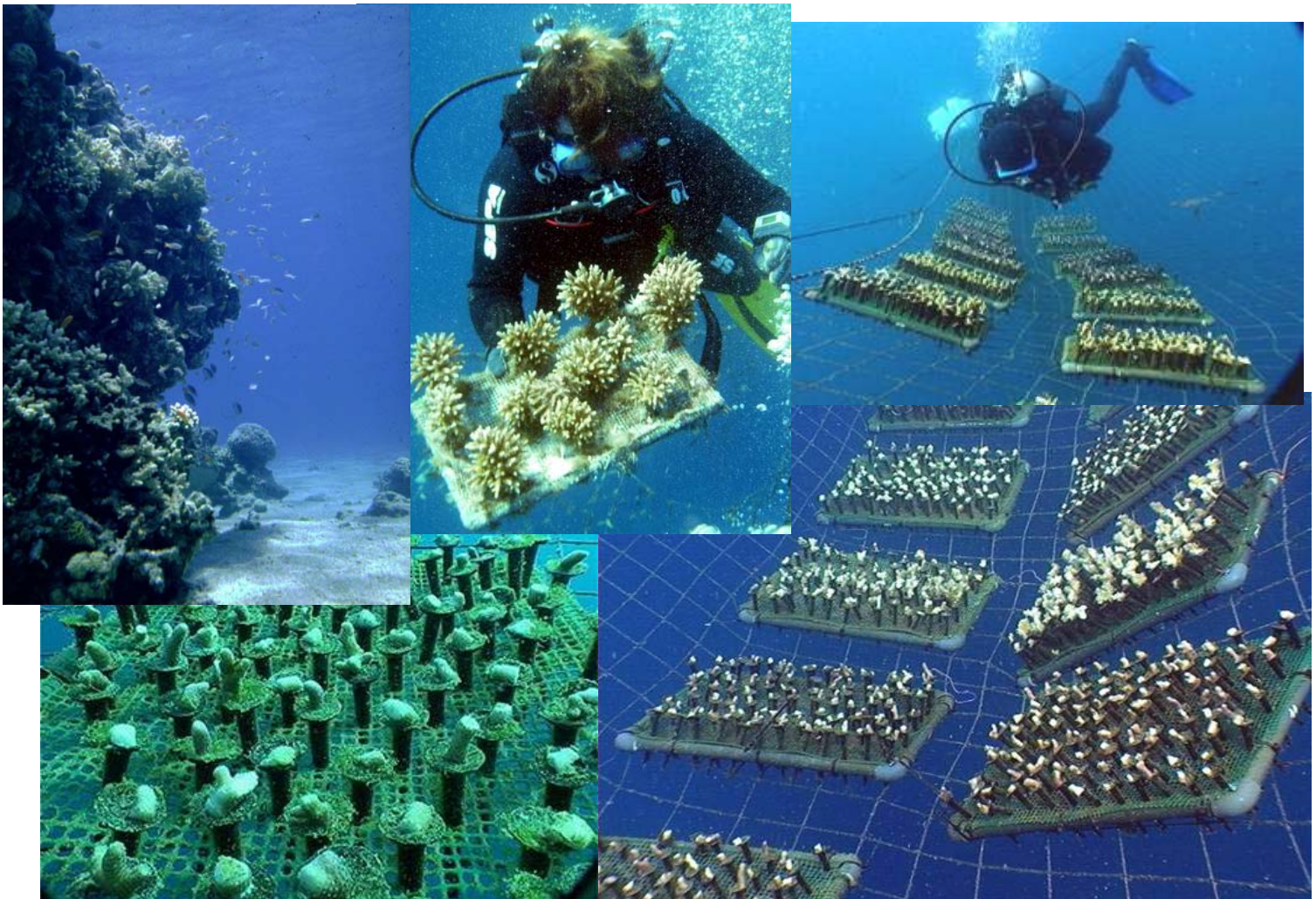


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The Red Sea regional coral nursery- managing reef restoration through the gardening concept

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Executive Summary

Worldwide degradation of coral reefs, particularly in the last two decades, has increased attention to restoration activities, in spite of the failure to implement these measures on a large scale. To address this challenge, we adapted the concept of silviculture, the restoration of forests, to reef restoration. Following a decade of extensive research, a prototype underwater floating nursery was established in Eilat, where we already farmed thousands of coral colonies, used for research and transplantation acts. All colonies originated from nubbins, minute coral fragments, each in the size of few millimeters only, thus inflicting zero stress to donor colonies. Using our expertise and developed technologies, this proposal seeks support for the establishment of first regional coral nursery that will provide to all stakeholders in the region, thousands of coral colonies/year for regional coral reefs restoration acts and for tourist projects (transplanting of artificial reefs, gardening artificial/natural habitats in front of hotels and other tourist attraction sites).

Brief Description of Project

Over the past 2-3 decades, the coral reefs, of the most productive biological ecosystems on earth, have been degrading throughout the world in an alarming rate. The global decline in reef status and health is even more significant as natural recruitment may be prolonged or prevented because of permanent shifts in reef communities and changes in physical and environmental conditions. Consequently, varying levels of coral reef degradation were documented around the world, showing that many reefs have already been partly or completely destroyed. This situation stirred the discussion on the development of various active restoration measures to be applied as supplementary management options to the traditional operations of conservation. One of the most promising avenues is the employment of active restoration measures,

based on silviculture (forest restoration) principles as are performed by KKL in denuded terrestrial areas in Israel.

While past techniques used for reef rehabilitation are straightforward and seemingly simple, the varying degrees of success that had been reported indicated significant limitations entailed in all transplantation methodologies employed. This is caused by stress inflicted on the transplanted coral material, the use of insufficient donor colonies and/or too small fragments and the disturbances inflicted on the donor coral populations. In other cases, the failure of corals to recover denuded reef areas also reflects post-settlement mortalities. To alleviate these problems, we, a scientific team from the National Institute of Oceanography of IOLR, Haifa, Israel have suggested about a decade ago the strategy of “*gardening coral reefs*”, a two-step restoration protocol which central concept is the mariculture of coral recruits (spats, nubbins, coral fragments) in nurseries. Firstly, instead of direct transplantation, large pools of farmed corals and spats are constructed within specially designed underwater coral nurseries. These nurseries are installed in sheltered zones where the different types of coral recruits are maricultured to sizes suitable for transplantation. This practice also makes use of minute size coral fragments that would have died in direct transplantation. Secondly, nursery-grown coral colonies, in different size and species combinations, are transplanted to degraded reef sites.



Fig. 1: Eilat's coral nursery at the beginning: the nursery is made with underwater rope net (10x10m size) that serves as the nursery basis (situated at various depths, according to the specific needs). Coral nubbins are glued on plastic pins (9 cm long, 0.3-0.6 cm width leg and 2 cm diameter “head”). The plastic pins carrying the glued coral ramets are positioned within plastic nets stretched over PVC frames (30x50cm). The frames carrying corals are attached to the nursery base.



Fig. 2. Nursery grown branching corals after about 8 months (a,b) and one year (c) in the underwater nursery at Eilat, the Red Sea. a, fast growing colonies of *Pocillopora*; b, fast growing colonies of *Acropora*; c, after 1 year in the nursery, large size *Acropora* colonies, ready for transplantation.

Following our success in rearing of colonies in our Eilat's mid-water nursery it is the time now to initiate the plans for establishing a regional coral nursery that will supply to stakeholders (reef managers, official authorities, scientists, NGOs, etc.) in the area enough coral colonies for all needs and requests, including restoring of denuded coral reefs in the northern gulf, transplantation of coral colonies into tourist areas, education of high school students with coral reef management and restoration, 'adapt a coral colony' project, etc. The three countries bordering the northern part of the Gulf (Israel, Jordan, Egypt) have a common interest in the regional coral reef status (that is dramatically deteriorating in the last two decades, mainly from tourist activities) and have expressed concerns with regard to the fate of the coral reefs in the area. Moreover, the coral reefs in the northern gulf, are of prime human interest and are at the center of the economical development of the cities of Aqaba (Jordan) and Eilat (Israel). Yet, all along the Gulf, coral reefs are under severe human pressure and are degrading rapidly. In Israel the reefs have been classified as being in a critical stage, and the reefs in Aqaba, Jordan are suffering as well. Deterioration of the reefs may literally endanger the livelihood of the two cities by dropping the foundation of tourist attraction in these two tourist destinations, and hampering commercial fishing in Aqaba. Restoration of the reef by corals, farmed in the regional nursery, will not only help the reefs and the economy of the cities bordering the gulf, but also enhance peace through collaborative reef gardening.

Here we shall also transplant corals to barren natural reefs along the coast of Eilat. The site selected for this study is the Dekel beach, found just 1 km north to the coral nature reserve in Eilat. This is an open to the public area, in front of a large diving center that is imposed to increasing anthropogenic impacts (tourism, SCUBA diving, snorklers, general pollution including sewage seeping, and more). This site that has been selected in collaboration with Israeli governmental agencies (the Nature Reserve Authority) is characterized by sandy substrate with

marked, mainly denuded, knolls. Successful transplantation act could develop this area as attractive coral reef for tourists and SCUBA divers. We aim to monitor the effects of the transplantation on the selected sites and on their surroundings. Coral monitoring will take place continuously after transplantation. Data collected will include coral growth, partial mortality, bleaching events, survivorship, invertebrates and fish recruitments into the transplanted corals, recruitment of new coral colonies in vicinity to transplanted colonies, impacts of fish populations in the area and the appearance of fleshy algae. Following the results obtained in the project, we will produce a protocol and provide theoretical and hands-on guidance for using our technique in other sites, both locally and internationally. In parallel for taking out transplants from the nursery, new transplants will be prepared and put in the nursery.

Budget Requested

This is a 3 years proposal. The total requested budget for the whole duration is 300,000\$. Costs (US\$) are equally distributed between the three years, as follows (per year):

Personnel: Two highly skilled technicians for the maintenance of the underwater coral nursery, farming of corals, transplantation and data collections (30,000\$ per person/year)	60,000
Consumables: plastic pins, nets, PVC frames, maintenance parts for the nursery, underwater equipment, ropes, glue, etc.	16,000
Diving : maintenance of diving gear, air filling, yearly check up, diving insurance	9,000
Transportation/accommodation: For the PI (B. Rinkevich)- monthly visits (3 days/month) to Eilat and for the two technicians (two weeks/month residency in Eilat), including local (car rental, local public transportation) and Haifa-Eilat transportation.	12,000
Project presentation: (presentations for potential donors)- photographs, short films on coral maintenance and transplantation. In the 3 rd year budget, this item will increase to 5,000\$ in expense of consumables	3,000
Total: for one year	100,000
Grand total: for 3 years, the whole project	300,000