Placement of Reef Balls in Ras Laffan Industrial City (Qatar)
(Project Report 2003)

Introduction

Coral reefs, by the virtue of their efficient biological recycling, retention of nutrients and provision of sheltered habitat to a variety of aquatic organisms, provide one of the most diverse and biologically productive ecosystems. Reef building corals are calcium depositing animals building colonies for numerous microscopic organisms mainly polyps. Each polyps has living plant cells, inside them, and during day time these cells photosynthesise and produce by products which are consumed by corals as food. Polyps secrete calcium carbonate which provides shelter to polyps and add to the structure of the existing colony. Several algae species thrive in calcified environment providing additional binding and adding to the beauty of reefs.

Coral reefs are very dynamic and fragile ecosystem, particularly vulnerable to extreme natural phenomenon and human activities. Corals have very specific environmental requirements such as light, temperature, water clarity, oxygen and salinity. Oceanographic features such as currents and wave actions also play a role on the life-cycle of corals. In Qatar, coral reefs are, shallow and of low diversity, found along the eastern coast. Coral reefs play an important role in the marine environment by providing nutrients, shelter and breeding grounds to various fish, shellfish (molluscs and crustaceans), turtles and algae. The major threats to corals include thermal discharges, oil spills, dredging and reclamation, anchoring of boats and activities causing silt dispersion. Ras Laffan Industrial City has initiated a coral protection programme which includes identification and assessment of the distribution of corals around Ras Laffan, and controlling industrial activities to minimize impacts on coral.

Ras Laffan Industrial City (RLC) is situated on the Northeastern side of Qatar along the Arabian Gulf in the State of Qatar occupying an area of 106 km^2 (Figure 1).

Figure 1. Location of Ras Laffan Industrial City

Ras Laffan Industrial City has a coastline of 9 km on the northern side and 5 km on the eastern side. The different seabed profiles are presented in Figure 2.

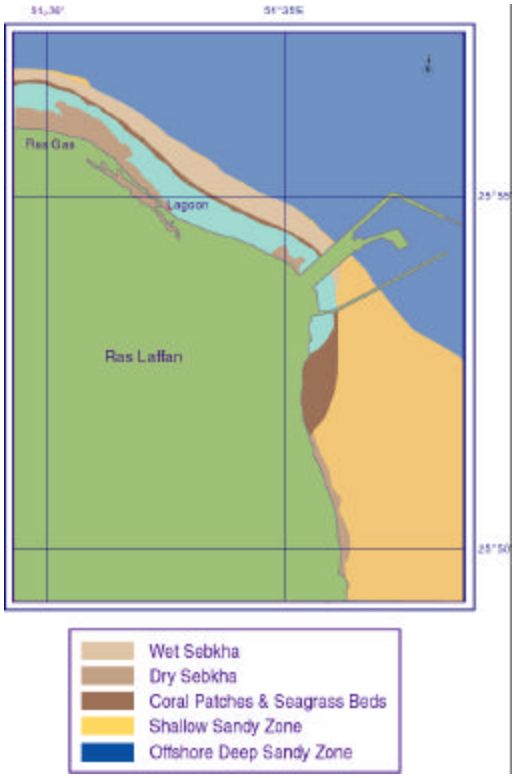

Figure 2 Location of Coastal Habitats in the Area (SARC, 1999a & b)

Mainly due to world wide warming events in 1997-8 and earlier development projects the most of corals along the coastal areas of Ras Laffan is dead. Since 1999 a gradual regeneration of coral reef has been reported.

In order to enhance the productivity of marine environment a reef ball placement programme was initiated. By providing hard, consolidated substratum for encrusting benthic organisms reef balls play an important role in local ecology. The majority of artificial reefs are placed in areas dominated by unconsolidated substrata (i.e. sand, mud or rubble), which support a relatively low level of productivity (Wells et al. 1985; Clark and Edwards 1994). As the majority of encrusting benthic organisms require hard consolidated substrata for larval settlement, artificial reefs promote benthic productivity in an otherwise inhospitable environment (Schuhmacher 1988). Encrusting organisms can then act as food and attractants to a diverse array of marine fauna (Fitzhardinge and Bailey-Brock 1989; Ch'ng and Thomas 1991); Increasing habitat complexity, i.e. provides shelter in otherwise "simple" habitats. Abundance and diversity of motile organisms, and to a lesser extent sessile organisms, is positively correlated to shelter availability within a reef's structure (Hixon and Beets 1989; Borntrager and Farrell 1992; Eggleston et al. 1992) and increased topographic complexity which allows vertical zonation (Grigg 1994).

Site Selection

Various locations for the placement of reef balls were evaluated and based on the following limitations a site measuring 25 m x 50 m (Figure 3) on the northern side, near (1 km) main breakwater was selected:

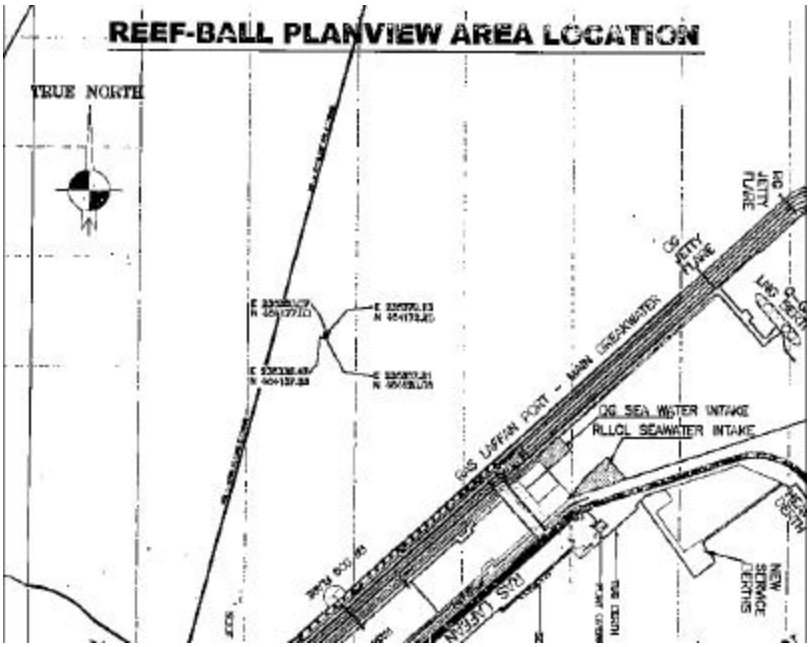

Figure 3: Location of Reef Ball Deployment Area

N 25 55.921
E 51 34.730

- **Physical Impacts from Future Developments**
  No future Developments are planned for near future (5 years)

- **Impacts from Thermal water Discharges**
  Qatargas outfall is approximately 3.5 km and thermal dispersion influence is not detected.

- Physical characteristics include:
  Substrata: particle size, type, depth profile; tidal fluctuation, depth related fluctuations
  Sandy, dead coral fragments, coarse particles, 8 meter, 1.2 m, 8-6 m

- Chemical characteristics include:
  pH;
  Marine water pH of the entire Ras Laffan Marine Area is towards alkaline side (7.8-8) which is good and favourable for the growth of flora especially algae (QP, 2002)

Salinity profile;
Salinity of the entire Ras Laffan Marine Area ranged between 41-42 %.

Dissolved Oxygen profile;
At The Northern Marine Area averaged DO levels were 5 mg l^{-1}

- Biological characteristics include:
  Abundance, distribution and life history traits of important organisms, Ecological relationships between existing site and adjacent ecosystems; and Potential recruitment pathways.

Reef Ball
Pyramid shape, due to ease in fabrication, was selected and approximately 304 reef balls were casted using marine grade concrete. The specifications of the concrete are presented in Table 1.

Table 1: Specifications of Concrete Used for Reef Balls

Characteristic Strength (N/mm2)	35
Aggregate Size (mm)	20
Cement Content (kg/m3)	370
Cement type	OPC to BS 12
Source Fine Aggregate	Qatar Sand Treatment Plant
Source Coarse aggregate	Gabbro Fujairah

Reef Ball Dimensions:

Surface area: 5 m^2
Weight: 250 kg
Height : 1 m
Base Width : 95 cm
Holes: Eight (2 on each side) (11cm Diameter) Top: 30 cm

Total Area Allocated: 40m x 48m (1920m2)
Area used: 24m x 12 m (288m2)

Design of the Artificial Reef System

The design used for an artificial reef system will determine its cost, biological effectiveness, durability and general performance. Factors that must be considered during the feasibility stage are horizontal spread, spacing and topographical complexity. Based on the above a scheme as shown in Figure 5 was adopted.

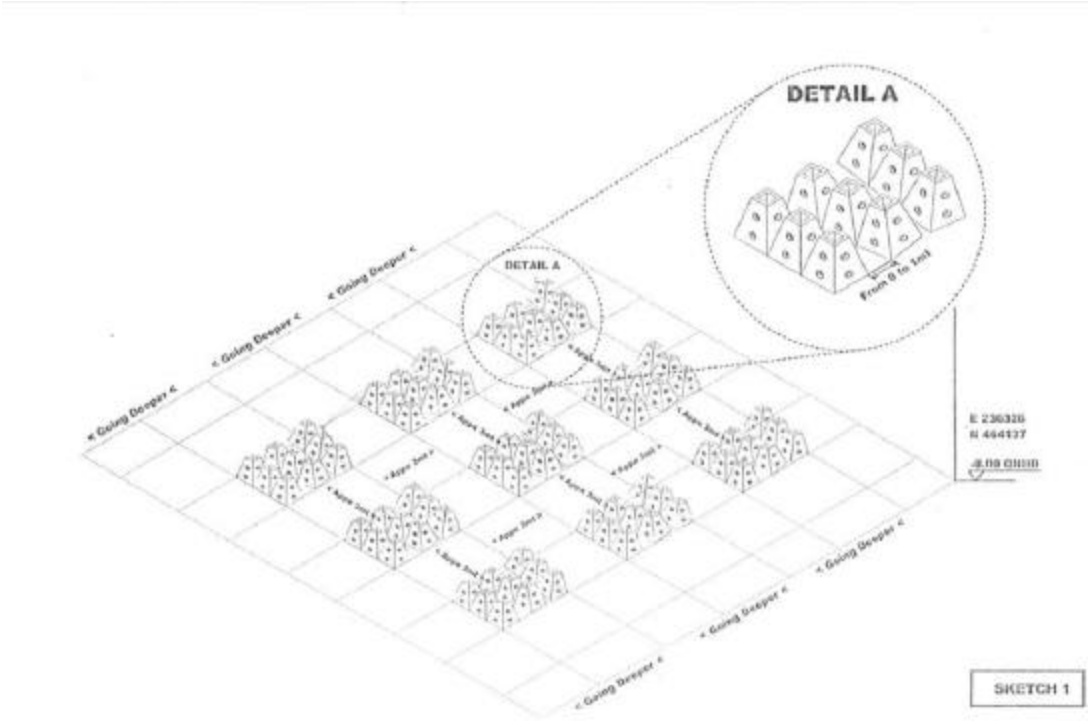

Figure 4: Isometric Plan of Artificial Reef System at Ras Laffan

Figure 5 & 6: Deployment of Reef Balls

Deployment of Reef Balls

Post Deployment Monitoring

On 18th August, 2003 the visual observations were made to assess the conditions of these reef balls. It showed significant growth of algae, barnacles and coral polyps and sea urchins, sea squirts, epibenthic (coral associated fish), pelagic fishes were found on or near reef balls. Indicating a realistic review of ecological processes and function. On 20th September, 2003, benthic growth from 9 inches x 9 inches area of a reef ball selected at random was scraped and send for detailed analyses.

The results of the analyses are presented in Table 2. The bulk of the sample was composed of blue-green algae (*Oscillatoria* sp) and red algae (*Centroceras* sp). These two small-sized algae with the mud particles attached to them formed the slime. Four small pieces (3 to 5 cm in height) of *Obelia* colony was found in the sample. A small **coral polyp** (2 mm in height and 2.5 mm in diameter) was also present in the sample. Five hydroid (?) polyps, about 1.5 to 2.5 mm in length, were present in the slime. Three spirorbid polychaetes (a type of bristle worm, which forms coiled calcareous tube attached to the substratum) were present. The diameter of the coiled tube varies from 2.5 to 3 cm. The number of biota specimen were counted as 279 (4292 specimen/m2) which were regarded as highest biota density for marine areas around RLC.

Future Plans

Based on earlier concerns the following will be incorporated in construction & placement of future reef balls:

- Surface Roughness: In future reef balls use aggregate size 30mm
- Size of Holes: Increase size of holes (15-20 cm diameter)
- Plan to Relocate Reef Balls from Dead Reef Measuring Height over 25 cm (20-30 reef Balls).

- Place Remaining 200 Reef Balls on sandy seabed.

Table 2. Biota present in the Reef Ball sample collected in September 2003

Phylum/ Species	Number of specimen
Phylum Cynobacteria (blue-green algae)	
Oscillatoria sp.	
Phylum Rhodophyta (Red algae)	
Centroceras sp.	
Phylum Cnidaria (=Coelenterata)	
Obelia colony	4 small pieces
Coral polyp	1
Hydroid polyp (?)	5
Phylum Nematoda (Unsegmented worm)	
Nematodes	74
Phylum Annelida (Segmented worms)	
Class Polychaeta (Bristle worms)	
Spirorbid worms	3
Nereid worms	15
Sabellid worm	3
Unidentified worms	9
Phylum Arthropoda	
Class Crustacea	
Isopoda	29
Amphipoda	35
Copepoda	61
Phylum Mollusca	
Spats of *Pinctada* sp	6
Gastropods (?*Bulla* sp.)	9
Phylum Chordata	
Sea squirts	3
Unidentified	
Worm-like/may be insect larvae	18

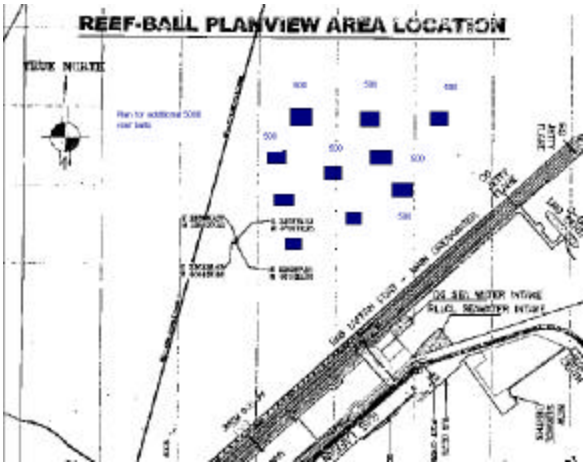

Figure 7: Area for future deployment of Reef Balls (5,000-10,000)

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