ReefBall
AUSTRALIA

TECH NOTE

Designing artificial reefs and cities - the shared principles

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Artificial reefs (ARs) are basically underwater 'cities' and their design and planning is similar to the design and planning of our towns and cities on land. A comparison of the similarities can help stakeholders quickly understand important considerations.

'Principles of Intelligent Urbanism' (PIU) evolved from city planning guidelines from the International Congress of Modern Architecture (CIAM), Joseph Lluis Sert and his colleagues at the Harvard's Urban Design Department, and a group of influential architects known as 'Team Ten'. Ten principles were created to assist planners and others to develop built environments that are both attractive and functional. Five of these principles are discussed here as a guide, and our standard reef planning strategy incorporates all ten.

A balance with nature (Principle 1)

According to the PIU, nature must be utilized not exploited in the urban environment, and fragile zones, threatened ecosystems and habitats that can be enhanced should be assessed before planning takes place.

In a similar way, a critical first step in planning an AR is the underwater site assessment that can highlight existing fauna and flora and the location of areas of potential enhancement and protection. ARs should not be placed on sensitive or protected habitats. ARs are regularly used to enhance barren areas of seabed, or replace habitat that has been lost due to burial (eg beach renourishment programs) or removal (eg dredging or trawling), or constructed to take pressure off valuable natural habitat (eg coral reefs), or to create no-take zones (Marine Protected Areas).

The PIU make several points that directly relate to the building of ARs:

- **Nature must be able to resurge each year**: The AR should be sited in an area that guarantees long term water quality, a regular supply of plankton and larvae and sustainable fishing pressure to allow its population to 'resurge'.
- **Biomass must be able to survive within its own eco-system**: The AR must not only be correctly sited but the design must be large enough and diverse enough to ensure biomass survival given the typical extractive pressures placed on it through fishing and utilisation by scuba divers.
- **Breeding grounds of fauna must be safe**: An understanding of breeding grounds and times must be incorporated in an AR and its management. Timing of deployment can be intentionally coincided with spawning/egg laying events to maximise settlement of specific species; fishing activity can be restricted during the breeding season of key species.
- **No erosion and the biomass maintained**: The effectiveness of artificial reef units to maintain biomass in a water body can be reduced significantly due to settling, burial by moving sediment or scouring (erosion) due to currents, wave action, orientation of units and bottom type. Therefore erosion is a very important principle when designing an AR.

Appropriate technology (Principle 3)

PIU's principle of appropriate technology emphasises the use of building materials, techniques, systems and project management that are consistent with local contexts. In the past, artificial reefs have been built with materials that do not necessarily complement the underwater environment – tyres, old vehicles and general waste materials. In Florida there is currently a major project underway involving the US

Navy to remove 700,000 tyres that were deployed to create an artificial reef. The Australian and international trend now is to use specific artificial reef modules that are environmentally safe and appropriate for the environment.

The local context includes the availability of deployment vessels (eg barges) and cranes and the availability of local labour and supplies. Remote locations will have different resources than those available near cities. These aspects influence the material, type of AR unit and size that can be efficiently and economically used.

Efficiency (Principle 5)

According to the PIU, efficient design uses 'compact settlements along dense urban corridors, and within populated networks'. Similarly, the location of artificial reefs is very important from an ecological and human use perspective. Artificial reef planning should consider distance to surrounding habitats such as natural reefs, mangroves and seagrass meadows and any known migratory pathways used by a species. For example it has recently been discovered that nearly all snapper on the west coast of the North Island of New Zealand come from nurseries in one harbour (http://www.niwa.co.nz/news-and-publications/publications/all/wa/16-4/news1).

The amount of energy a fish for example has to expend to obtain its food is a key factor in its behaviour, growth and survival. Higher diversity and numbers of individuals can be sustained when artificial reefs are placed near other productive habitats and in effect demonstrate increased 'efficiency' in foraging and reproduction of a species.

From the human use perspective, 'mass corridors' and 'urban hubs' equate to navigation channels, shipping lanes, boat ramps and harbours/marinas. ARs constructed for fishing or diving need to be located close enough for the user groups to cost effectively reach them with the means of transport they typically use and this includes consideration of wave climate to avoid locating reefs in areas that are frequently too rough to access by local boats. Recent recreational fishing reefs constructed in Port Philip Bay in Victoria Australia for example are within 1km from shore and therefore accessible by a range of craft including sea kayaks.

Opportunity matrix (Principle 7)

Cities are sites of opportunity that provide the services and facilities for residents (and visitors) to grow according to their needs and well as those needs that change over time. There must also be the policing in place to allow this to occur in peace and safety.

Catering to changing needs of marine organisms requires ARs that have a diversity of nooks and crannies, and a range of different materials and angled surfaces with varying height and density. ARs can be designed to have 'neighbourhoods' that include features that appeal to juveniles and exclude predators or they can be designed to work with natural habitats such as seagrass meadows to cater for the different needs of residents.

Urban spaces are visited by not only locals but also visitors from outside the neighbourhood, the state or the country. This is also very true for artificial reefs in open ocean areas and deeper than 20m. Such reefs can act as temporary foraging, resting or spawning grounds for pelagic fish that move along coastlines and the reefs may be designed to specifically enhance and cater to this behaviour.

Likewise artificial reef design needs to consider how the design can provide a range of opportunities for human users. For example, the reef could incorporate a shallow water trail for beginner divers or snorkelers and a deep water reef for the more advanced diver, or permanent moorings for charter boats, or be constructed adjacent to natural reefs in order to provide more opportunities and reduce pressure on natural reefs.

Policing and monitoring for ARs is as important as in an urban community to prevent illegal fishing and unsustainable fishing practices. A fishing limit or ban may be required to facilitate a healthy fish population that will then contribute to surrounding fish stocks.

Regional integration (Principle 8)

PIU sees the city as an 'organic part of a larger environmental, socio-economic and cultural geographic systems'. Cities are connected and dependent upon their regional areas from which people will visit for shopping, work and entertainment. The region may also play a key role in supplying the city with foods and supplies. There is spillover from the city to the region and the region's geographic portals may define defense and security.

In the underwater environment, ARs depend upon continuous input from the region for food and new settlers whether they be plankton, seaweeds, nutrients, larvae, fish, invertebrates etc. A reef can not operate in isolation and colonisation is more rapid and diversity greatest when the reefs are located near natural reefs and exposed to currents. The East Australian Current (EAC) popularized in the film 'Finding Nemo' is a current that transports fish larvae and even tropical fish 100's to 1000's of kilometers south along the east Australian coast (http://sims.org.au/research). These fish then show up on coastal reefs and this is an example of a macro scale connection of reefs and currents, and most coastal reefs, bays and inlets would have their own smaller scale currents that play important roles in the distribution of larvae and nutrients.

ARs need to be integrated and planned with the broader region in mind. The AR may need to be located away from a major city in order to avoid pollution however its funding may be dependent upon the city because a key objective of the AR is to provide fish to sell and consume within the city.

There are five other important principles to consider when designing reefs. For further information and assistance with artificial reef design, contact:

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Exercise for Students

Select a section of your coastline that has a range of different habitats such as rocky headlands, wetlands, artificial reefs or natural reefs. Perhaps you have a marine park or protected area. Government departments often have habitat maps that provide information such as habitat type, location, area and marine life found within it.

Now think about the functioning of your local neighbourhood, town or city and the different services provided by each section of it.

Can you find a marine equivalent to your central city area and what features do you think make it similar?

Can you find a marine habitat that functions like a residential neighbourhood that has many similar houses close together?

Are there any marine areas that would be equivalent to open park areas?

Principles of Intelligent Urbanism – http://en.wikipedia.org/wiki/Principles_of_Intelligent_Urbanism