

Green Zones in Constructed Reefs

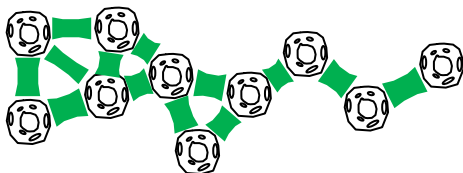
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What are Green Zones

Green zones are what I call **effective and usable** areas for fishes around and within constructed reef units.

Based on my observations of how fish interact and use a diverse range of natural reef and constructed reef units such as Reef Balls or coastal structures, I've noticed that the number of 'walls' or 'alleyways' that a reef provides has a big influence on abundance and diversity. This is another way of thinking of reef complexity or rugosity which is well known as a driver of biodiversity on reefs.

These walls and alleyways create these green zones as depicted in the diagram.



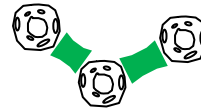
How to Create Green Zones

One Reef Ball by itself has no walls or alleyways except within its holes and centre void.



Fish abundance and diversity is usually relatively low or transient around a single Reef Ball. When you place a second or

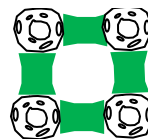
third Reef Ball next to the first you create walls and alleyways between them which create 'green zones' (GZ) that provide a sense of security to fish (just like the 'Green Zones' in a marine park that are no take areas).



Effective and usable space is increased and abundance and diversity increases.

Four Reef Balls have four green zones but by adding just one more Reef Ball you double the number of green zones to 8! You can start to see the benefits of adding reef units.

4 green zones
 4 Reef Balls
 1 GZ/RB



8 green zones
 5 Reef Balls
 1.6 GZ/RB



It is beautiful to watch this occur when building a reef and seeing the progression. Fish move in the same day when more units are added. I have seen solo Reef Balls that have been in over a year with nice growth, but very few fish, become transformed within the hour by the addition of a few more Reef Balls.

Think about how you would feel running around a vast open space being chased by a bull or if you were a soldier and under threat of attack; you would head for cover that provided a range of pathways for escape and a structure that makes it harder for the attacker. One tree or one building would not cut it!

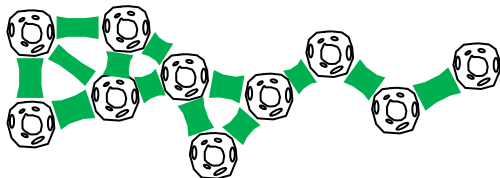
There are mini or micro green zones within each Reef Ball and there are macro or large scale green zones between individual reefs that can be 100-500+m wide.

TECHNOTE

The following diagrams illustrate how the configuration of 10 Reef Balls influences the number of green zones (GZ).

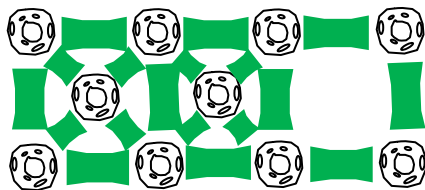
Group 1

13 green zones
10 Reef Balls
1.3 GZ /RB



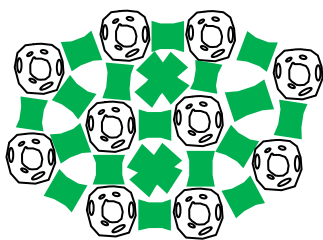
Group 2

18 green zones
10 Reef Balls
1.8 GZ /RBs



Group 3

22 green zones
10 Reef Balls
2.2 GZ /RB



Grid patterns are not my personal favourite as they look too unnatural, but functionally Group 2 does provide five more green zones than Group 1. Group 3 has the most at 22 green zones and provides a nice inner network of walls and alleyways.

Spacing

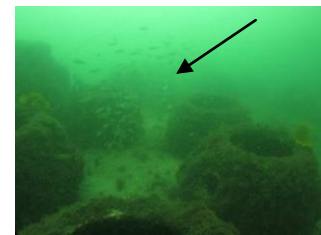
The spacing of Reef Balls and the number of green zones varies depending upon the fish type, its age and how they like to use reefs. Nakamura's classification of fish types in the 1980's can be used as a guide.

TYPE A FISH

Type A fish like to live in and on the reef. For these types I believe the spacing should be around 30cm or less. I dived on some concrete pipes in Hervey Bay (Queensland) recently and they had a diameter of around 90cm and were ghost towns; the pipes were like an open plan warehouse to a Type A fish. Imagine if you were looking for a single apartment. An open plan warehouse with no internal walls is not very attractive. The pipes could be easily enhanced by adding natural rock or concrete rubble to the inside which would create green zones for Type A fish.

TYPE B FISH

Type B fish hang around and above the reef. Scad are a good example. If you watch their behaviour they like spacing of around 2-4m between Reef Balls and at least four or more Reef Balls. This spacing



allows the school to move down into the green zones when threatened and also reduces the number of direct angles of attack by predators. Rigs, jetties and wrecks with large spacing (>3m) between members, can provide green zones that appeal to schools of Type B (and sometimes C) fish.

TYPE C FISH

Pelagics and transient fish would be considered Type C. Green zones for these

types can be anywhere from 2m to 30m or more.

Edge Effect

The edge effect is as important in reef design as it is in city design. Fish like to hang around the edges of reefs, therefore maximizing perimeter (edge) length is important.

Imagine a city. Vibrant cities have attractive 'edges' (streetscapes) consisting of diverse businesses and eateries. We can think of constructed reefs in the same way. How can we create vibrant edges? One way is by creating varying types of green zones and ensuring that they are accessible.

For example, combining 100 Reef Balls into a group similar to the Group 3 diagram could maximise the number of green zones over the whole reef but decrease effectiveness because of its reduced perimeter length and lack of accessibility to the green zones.

A reef comprising the same number of Reef Balls but in 6-10 groupings with 5-20m between groups can be a more effective option. Perimeter length is significantly increased as well as accessibility to green zones. The difference between successful shopping streets and the not so successful is often the accessibility of their 'green zones'. Shops or city centres that are too hard to get to are avoided!

Note: Keep in mind the target species and goal of the reefs when designing green zones.

In Summary...

1. Consider the number of Green Zones in the next reef you design or study, taking into consideration the target species.
2. Just a few extra units can make a big difference. Four Reef Balls have four green zones but by adding just one Reef Ball the number is doubled. Excellent gain for minimal extra cost. Note: we always recommend that at least 10 Reef Balls be deployed in one group.
3. Vibrant edges and accessible green zones is the key!

For more information or assistance with designing your reefs:

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TECHNOTE