INTERIM REPORT ON THE ARTIFICIAL REEF CONSTRUCTED IN THE LONG BAY-OKURA MARINE RESERVE, AUCKLAND

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Preamble:

The aim of the research is to construct two small patterns of artificial reef comprising different sizes of pierced concrete hemispherical shells. These will be constructed utilising the American system called "Reefballs". Colonisation of these will then be monitored and the results made widely available. It is anticipated that this activity will increase conservation awareness from the use of the Reserve as an educational resource and recreational dive site, and will permit future informed decisions to be made on artificial reef construction in New Zealand.

Construction:

There are only three "reefball moulds" in New Zealand at present; David Head and Reefballs N.Z own these. As a condition of use, the reefs constructed at Long Bay will be monitored for at least three years with still and video images published on the web.

Firth Certified Concrete and Gibbons Crib Walls very kindly offered logistical support which has proved invaluable. Firth made supplies of sand, cement, aggregates, compression test facilities and technical advice available; Gibbons provided an invaluable site to pour and store the reefballs conveniently adjacent to the Firth Albany plant. In addition, their technical advice and use of their plant such as a forklift truck as well as a pouring platform, a pencil vibrator and labour was provided as needed

Concrete mix design:

After a series of tests of different aggregate mixes, it was decided to opt for 19 mm basalt aggregate with a chip and pebble content. This affords a mixed, rough exterior, which is largely "natural rock" after waterblasting, thus reducing the surface pH increasing effect of the cement. Standard Builders Mix with 19 mm aggregate and a 1:4 cement : mix ratio and a 0.4 :1 water : cement ratio proved the optimum mix with no additives. Using a microsilica additive increased both the strength of the mix (eliminating the need for reinforcing), and significantly reduced the surface pH and porosity. All of the units poured used a standard Firth recipe for a 19 mm aggregate; 4;1 mix:cement; 0.4:1 water:cement ratio with 8% microsilica by mass of cementitious material and a small amount of polycarboxylate superplasticiser [no toxic effects from this additive have been found in successive web

searches]. The superplasticiser is essential to make such a strong microsilica concrete workable. The compressive strength of this mix at 28 days is greater than 60 MPa. The exterior surfaces of the resulting units are very rough after waterblasting largely made up of exposed aggregate.

Further tests of microsilica content and pH are underway. An extension of the project might consider the inclusion of organic material such as crushed mussel shell, or reinforcements such as polymer fibres. The use of microkaolins rather than microsilicas could also be considered.

Placement:

The reefballs were aged for at least a month before being put out on the beach at morning low tides at Waiake Beach. There they were made buoyant by inserted inflated bladders as well as others attached by chains at the periphery. They were then towed by a 5.22 m Bonito Calais powered by a 120 hp Evinrude VRO outboard to the north end of Long Bay Beach. Here over fine sand and silt in 5+ m of water the two reef patterns were established.

Reef 1 – Zig Zag Reef:

This was started with the placement of two Bay Balls [mass approximately 300 kg, height 0.7 m, base diameter 1.0 m with about 10 piercings] on 23rd August 2001. There is now a series of 9 of these units in a N – S line. At the Northern end, there is a Pallet Ball [mass approximately 1200 kg height 0.9 m; base diameter 1.2m with about 15 piercings]. At the Southern end, there are two further Pallet Balls; one with a 30x30 cm slate plate attached to a vertical surface and the other with a plate attached to close the top hole of the unit; i.e. in a horizontal position. These slates are the same as the ones utilised by current E. O. S. intertidal studies. Placement took approximately 6 weeks because of tide/weather/logistical constraints. All 12 units lie on a N – S line parallel to the beach with an at angle of approximately 45^0 between this line and the zig zags. We were attended by Karl McLeod (Long Bay-Okura Regional Park Ranger) and he commented that it was good to see the speed of colonisation. The reef is located at 36^0 40' 52" S, 174^0 45' 14.8" E in 5.5 m at minimum spring low tides.

Reef 2 – Octagon Reef.

Placement of this started with four of the smaller Bay Ball units planted Thursday 25th October 2001 as the central core. There is now a Pallet Ball at the Eastern point of the octagon; four Bay Balls around the perimeter and one further Pallet Ball on the Southern margin. There are slate plates attached to a vertical surface of both Pallet Balls. It is hoped that two further Pallet Balls will be placed in the 5th – 11th December tide window. These will complete the perimeter of the octagon. The reef is located at 36^0 40' 51.1" S, 174^0 45' 14.8" E in 6.2 m at minimum spring low tides.

Colonisation sequence:

Hard surfaces are colonised firstly by planktonic organisms, e.g. pelagic phytoplankton. The first settlement to be observed (after a period of about 6-7 days) was a microfilamentous brown algae (unidentified, but common in the Gulf). The next colonising organisms are vagrant (and opportunistic) benthos, such as the cushion star: *Patiriella regularis*, and the hermit crab: *Pagurus* sp. c.f. *P. novaezelandiae* and herbivorous gastropods like the whelk: *Cominella adspersa* (egg cases of the latter were recorded on a number of the reefballs). Concurrent with this, nektonic organisms like the spotty: *Notolabrus celidotus* and triplefins: *Fosterygium varium* and *Fosterygium* sp. feed on small invertebrates and graze on the algae. The next wave of colonisation observed was that of sciaphilic invertebrates such as barnacles and polychaete worms. Two settlements of the rapidly colonising barnacle *Austrominius modestus* have been recorded; the first occurring about ten days after the placement of the reefballs. A second, more numerous settlement event of *A. modestus* occurred about four weeks later. Of the annelids, the first was the spiny tube worm: *Spirobranchus cariniferus* which settled about two-three weeks after reefball placement. After a month, these reached lengths of up to 12 mm.

Overall change in biota:

New organisms are present in the area. These have either migrated from other parts of the marine reserve, or have settled from the moving water body. (A combination of both is likely). The latter group probably would not have colonised the area if the reefballs had not been present.

Bottom Conditions:

Sediment: The sites selected have bottom sediments classified as grey-brown shelly muddy fine sand. Sediments around the reefballs contain a larger amount of fine silt than could be expected in this environment. The origin of this is probably urban run-off. There are large numbers of empty bivalve shells on/near the surface.

Settlement: After three months, the reefballs showed no appreciable settlement into the sediment. The holes in the base of the units were left open and no additional thickening measures taken in manufacture. There have been storms over the period with nor-east winds gusting up to 100 kmh^{-1} however the site selected appears to be well protected, with the artificial reef remaining stable with no significant scouring even during storm periods.

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