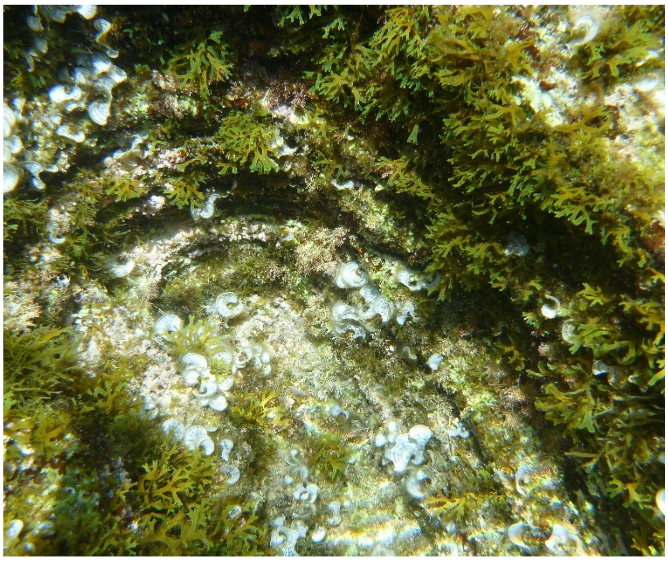
Achieving Biodiversity Uplift on Marine Infrastructure

RESEARCH & DISCUSSION - EXECUTIVE SUMMARY

Marine Biology Department
Yaeli Rosenberg, Ph.D.



BIODIVERSITY

The term ‘biodiversity’ is a simple contraction of ‘biological diversity’, and at first sight, the concept is simple too: biodiversity is the sum of all biotic variation from the level of genes to ecosystems [1]. Biodiversity is all the different organisms, from animals to bacteria, found in one area, working together to maintain balance and support life.

MARINE BIODIVERSITY

Although marine species richness accounts for only 4% of global diversity, life began in the sea, and much of deep diversity is still primarily or exclusively marine [2]. Nevertheless, our knowledge of marine diversity in the present is poor compared to our knowledge of terrestrial organisms, and an appreciation for the dramatic changes in marine ecosystems that have occurred in historic times is only just beginning to emerge [3-5].

While global marine biodiversity has changed and shown several trends of explosion and depletion over evolutionary timescales [6-8] biodiversity naturally changes locally at scales of years to centuries in what has been called ecological succession [9]. Biodiversity tends to slowly increase over time during a natural successional sequence and in the absence of further disturbance, on the contrary, at high disturbance levels diversity is lower when few opportunist species monopolize the community biomass [10].

Throughout time, the only disturbances resetting the successional clock and causing sudden declines in biodiversity at all levels were environmental disturbances, today, however, the concern is focused on the pressure humanity is placing on the natural world, and on the continued ability of ecosystems to deliver the services on which we all depend on. The immediate and most obvious change in marine biodiversity due to human activities affects the abundance of individual species.

The most common changes range from population reductions to global extinction caused by overexploitation or habitat loss. Global or regional losses of species are only the last steps of marine biodiversity decreases. Not all species decline in abundance because of human activities, highly invasive species can colonize new regions and eventually form monocultures. Although the arrival of new species may seem like an increase in species richness, the consequences for the local biodiversity are generally negative.

HABITAT LOSS

One immediate driver of change that has the potential to erode biodiversity is the loss of habitat [11]. Losses of marine diversity are highest in coastal areas largely because of conflicting uses of coastal habitats. With the increase in humans populating coastal areas [12] Concrete based coastal and marine infrastructure (CMI) such as ports, piers, industrial facilities, and coastal defense elements dominate coastal zones worldwide [13].

The result is a continuous and increasing trend of coastal hardening, replacing natural coastlines. The marine area impacted by artificial structures was estimated between 1 and 3.4 million km^2 in 2018 and is expected to increase by 50–70% by 2028 [14]. Most of these structures are made from concrete, the most durable material for the aggressive marine environment. Since the 2000s, hard artificial infrastructure made with concrete has been implicated as a major risk factor for local and native biodiversity, by introducing invasive species with ubiquitous and rapidly growing characteristics, in comparison with surrounding natural rocky areas [15-18].

However, ECOncrete has demonstrated that it is possible to enhance biodiversity through changes in concrete chemical composition, roughness, surface texture, and the addition of variously sized pits or holes [17-21].

ECONCRETE'S TECHNOLOGY

The ecological enhancement measures presented by ECOncrete are based on the use of innovative ecologically active concrete technologies, which harness biological processes for creating environmentally and structurally improved infrastructure.

These technologies increase the ability of concrete-based coastal infrastructure such as seawalls or pier piles to supply enhanced ecosystem services while improving their structural integrity and durability. The sensitive concrete solutions previously developed and validated by ECOncrete., including bio-enhancing concrete additives and science-based designs scientifically tested to enhance the biological and ecological value as part of the infrastructure [17-21].

ECOncrete's installations across the world indicate that slight modifications of concrete composition and design can improve the capabilities of concrete-based coastal and marine infrastructures to support marine fauna and flora and provide valuable ecosystem services. Such enhanced natural biological assemblages do not compromise the concrete's durability; on the contrary, they can provide physical protection with time, through weight addition and bioprotection [17-23].

ECONCRETE'S BIODIVERSITY UPLIFT

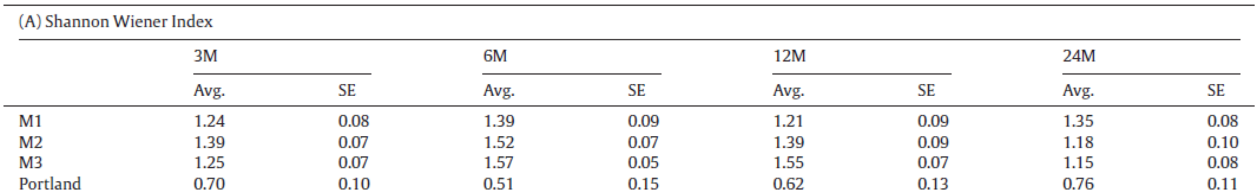
In all monitored installations across the globe, ECOncrete has shown a significant difference ($p< 0.05$) between standard and ECOncrete technology-based marine structures in regard to species assemblage, richness, and biodiversity [17-21, 24-25]. The presence of many invertebrate species on ECOncrete structures contributes to the biogenic build-up and elevates the complexity of the habitat while creating additional biological niches for other organisms, while at the same time providing bioprotection and reinforcing the structure itself. The biogenic crust has substantial ecological implications, as the benthic assemblages developing on and around the structure are less disturbed and can form a more mature marine community which is potentially healthier and more productive than communities undergoing periodic disturbances.

ECOncrete reported in a study from 2015 [18] continuously higher species diversity on the ecological antifer units compared to standard units (using Shannon Wiener Index) across the 24 months of monitoring (Table 1.). In the following research published in 2018 [19] investigating the ecological enhancement of ECOncrete's sea wall compared to the existing concrete sea wall, the univariate parameters (species richness [S] and biodiversity[H']) were significantly higher on the ECO panels compared to the control plots, throughout the sampling period (Figure 1.).

This trend in biodiversity uplift was also noticed in a study conducted in April 2017 in Florida, USA [21] that evaluated the structural and biological performance of ECOncrete's Marine Mattresses compared to controls of adjacent artificial structures and smooth - surface concrete blocks and monitored over a period of two years. These results there show a persistent trend in the increase of species richness [S] and biodiversity [H']) on the ECO blocks, whereas the control blocks showed fluctuations. Significant differences ($p < 0.05$) were found at 12- and 24-months post-deployment (MPD) at the intertidal area for both parameters, at 3 and 24 MPD in the subtidal area for average diversity, and at 24 MPD for average richness. After 24 months ECOncrete has shown the ability to significantly increase species richness and biodiversity presenting five to seven times the values of the control blocks (Figure 2.).

ECOncrete's technology aims to favor colonization in order to reduce the ecological impact of the structure and consequently increase biodiversity, without impacting the structure's strength and durability.

ECOncrete is committed to ensuring that marine construction and wildlife thrive together.



(A) Shannon Wiener Index

	3M		6M		12M		24M	
	Avg.	SE	Avg.	SE	Avg.	SE	Avg.	SE
M1	1.24	0.08	1.39	0.09	1.21	0.09	1.35	0.08
M2	1.39	0.07	1.52	0.07	1.39	0.09	1.18	0.10
M3	1.25	0.07	1.57	0.05	1.55	0.07	1.15	0.08
Portland	0.70	0.10	0.51	0.15	0.62	0.13	0.76	0.11

Table 1. *Average species diversity (Shannon Wiener Index) of the different matrices (EA – M1, M2, M3, Standard Antifers) after 24 months. [18].*

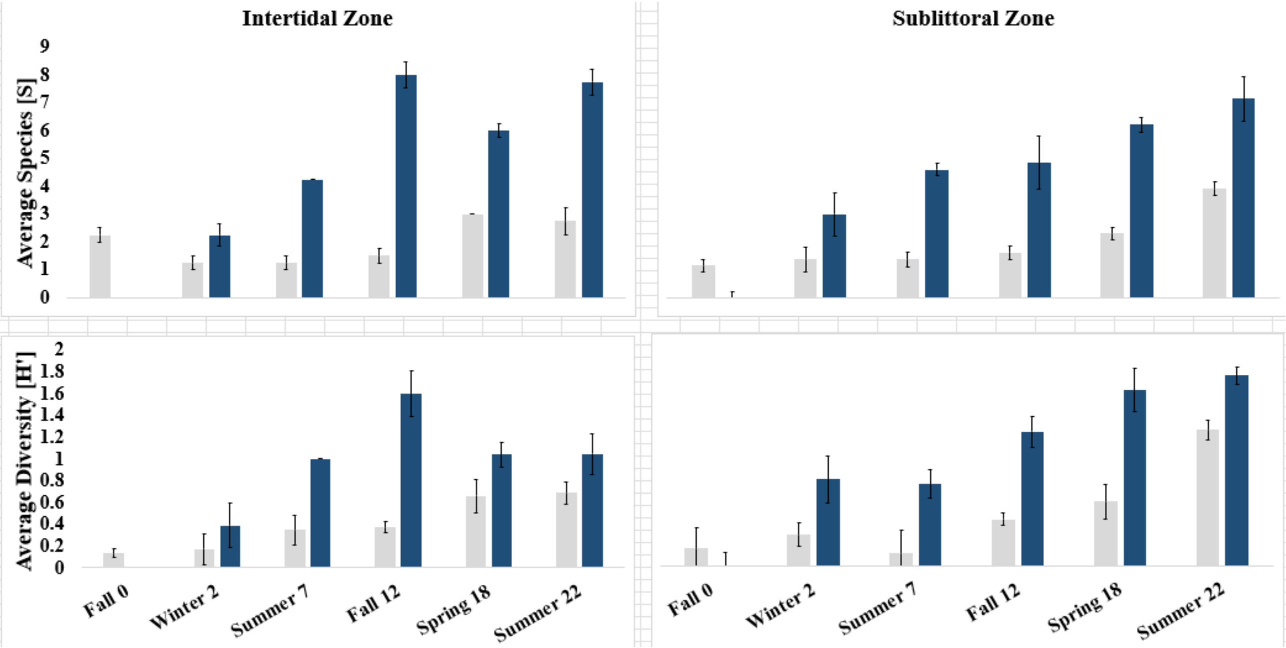


Figure 1. *The difference in univariate parameters between ECO panels (dark blue) and Control plots (light grey) at 2, 7-, 12-, 18- and 22 months post-deployment, for intertidal (left) and sublittoral (right) plots. Fall 0 is baseline data from the marina seawall, thus zero in ECO panels that were yet to be deployed. Error bars represent standard deviation [19].*

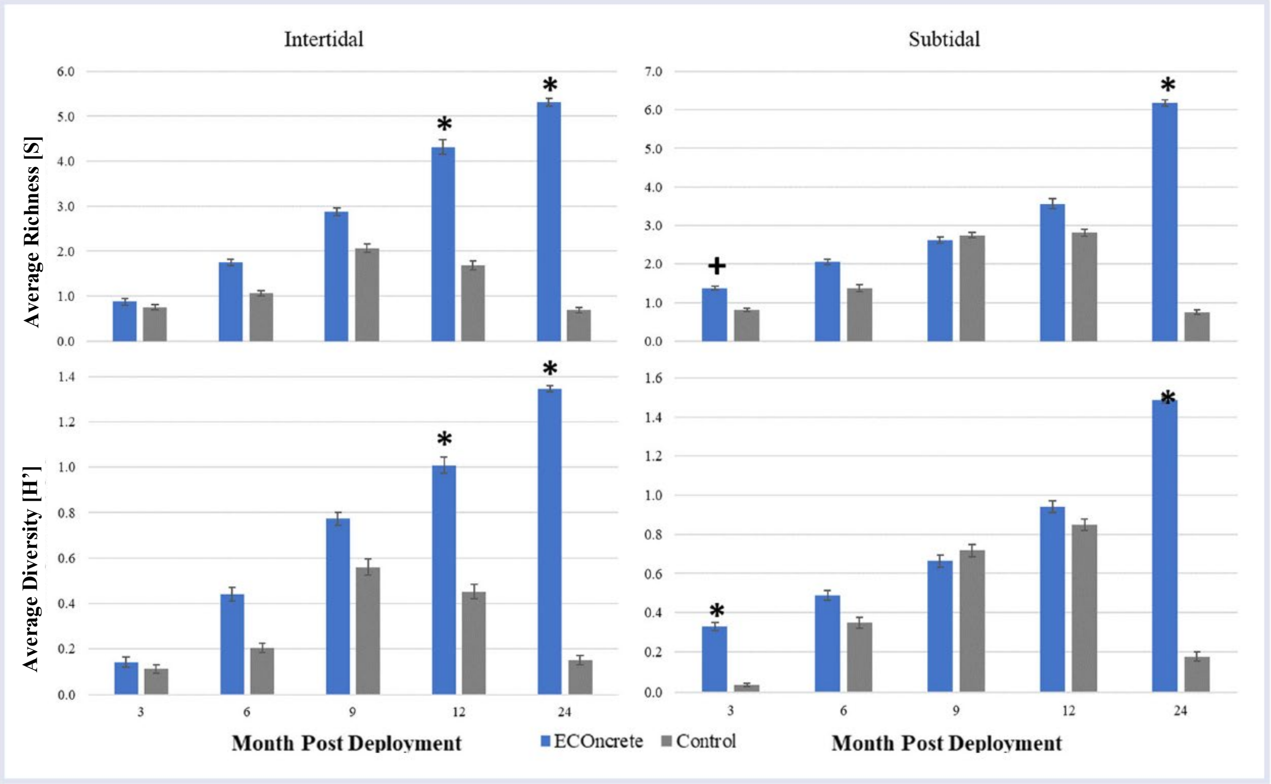


*__Figure 2.__ Differences in univariate parameters between ECO and control blocks at 3, 6-, 9-, 12-, and 24 months post-deployment for intertidal (left) and subtidal (right) areas. *Significant differences ($p < 0.05$); +Marginal differences. Error bars represent the standard error [21].*

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