Three-dimensional matrices for enhanced coral settlement through design for additive manufacturing

Miguel Vieira[1, 2], Sérgio M.O. Tavares[2], Silvina L. Félix[1, 3]

1 – ID+, University of Aveiro.
2 – TEMA & Department of Mechanical Engineering, University of Aveiro.
3 – School of Design, Management and Production Technologies Northern Aveiro (ESAN), University of Aveiro.

The effects of climate change have contributed to the degradation of coral reefs. One approach to mitigating this damage is the use of artificial reefs. However, the most common artificial approaches, such as sunken vehicles and prefabricated cement reefs, do not allow adequate coral development. This research explores how designers can utilise additive manufacturing (AM) and Computational Design techniques to create artificial reefs that mimic natural reef structures, promoting better coral settlement. This project was carried out in collaboration with ECOMARE – Laboratory for Innovation and Sustainability of Marine Biological Resources of the University of Aveiro. It focuses on developing three-dimensional matrices using parametric and algorithmic modelling techniques to generate complex surface patterns fabricated using AM. A Nature-Centered Design approach was adopted, placing nature at the centre of the design process to enable the creation of reefs tailored to specific coral species and environmental conditions. Samples with different geometries and roughness, produced using paste-based extrusion with porcelain and porcelain with oyster shell, were tested in a controlled environment to investigate the settlement, survival, adaptation, and growth of soft corals. The AM of samples confirmed the corals' preference for settling on complex surfaces compared to smooth surfaces. Porcelain showed comparable results to Portland cement, suggesting further testing potential. This research proposes a new approach that combines additive manufacturing with coral's biological responses to enhance understanding of their surface settlement preferences. With additive manufacturing, computational design and a Nature-Centered Design approach it was possible to create an innovative working model that could be customized depending on the implementation area or intended coral species, validating the design approach as a method to support environmental conservation.

FIGURE 1
Samples printed with the paste-based extrusion (PBE) technique using porcelain and oyster.

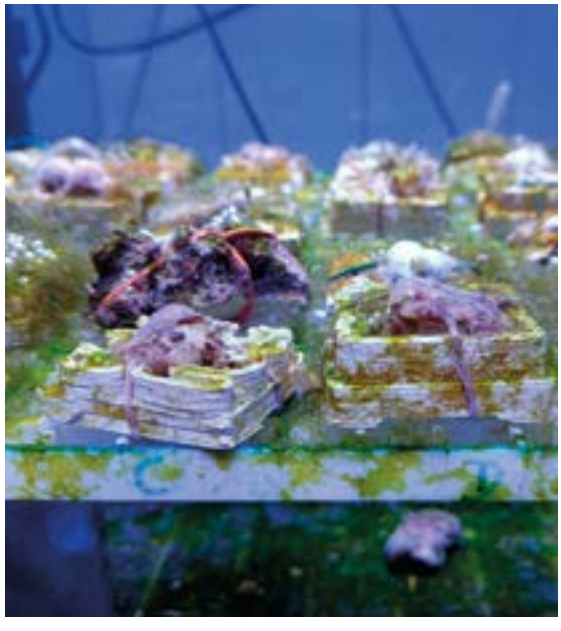

FIGURE 2
Coral settlement on samples in the ECOMARE aquarium.