EXPERIMENTAL STUDY OF A 3D PRINTING APPLICATION TO PRODUCE SUBSTRATES FOR CORAL PROPAGATION
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ABSTRACT
Additive Manufacturing provided an innovative method of production for ecology restoration areas, allowing rapid prototyping of substrates with high complexity morphologies, a critical and fundamental attribute to guarantee coral growth and Crustose Coralline Algae. The experimental study has a purpose to prove and qualify the influence of textured surface substrates morphology and chemical composition on the growth and propagation of transplanted corals. It was used Additive Manufacturing and silicone moulds for converting three-dimensional samples into limestone mortar with white Portland cement substrates for coral growth. Based on literature review, tiles samples were designed and printed with different geometries and textures inspired by soil erosion and nature marine environment. Commercial coral frag tiles were analysed through Scanning Electron Microscopy (SEM) to identify the main chemical elements. Tropical coral species with fast growth rate in captivity were selected namely Montipora Danae; Montipora Confusa and Montipora Undata. The developed substrates were introduced into a closed-circuit aquarium to monitor the coral weekly evolution process and analyse the results obtained.

OBJECTIVES
(1) Study the 3D printing applications to produce artificial reefs, through a deeply international and national research.
(2) Research and introduce innovative technologies and materials.
(3) Develop substrates for coral propagation and determine an experimental plan to validate the results.
(4) Idealize an artificial reef concept.

METODOLOGY
The substrates were monitored weekly by photography record and visual analysis to evaluate the growth evolution according with the Crustose Coralline Algae (CCA) expansion on the tile and coral growth. During the first three weeks the corals were into an adaptation phase. From the fourth week, CCA began to cover the substrates, a positive indicator for the calcium skeleton layer formation and coral settlement. During this week, the substrates whose texture were more pronounced showed a favourable evolution, validating the principle that higher surface complexity with deep recesses, facilitate the CCA propagation and coral growing. Between the fifth and ninth week, Montipora Danae showed a higher growth rate compared to the other species. Corals had growth and covered all tiles with different timings, which provides a positive indicator regarding the nutrients given, mainly composed of calcium carbonate.

RESULTS AND CONCLUSIONS
Coral species and CCA weekly evolution during week 12