

ESAI Postgraduate of the Year 2022 Winner

Larissa Macedo Cruz de Oliveira, University College Cork

Cold-water coral reefs are complex structural habitats that represent one of the most important deep marine ecosystems. As three-dimensional habitats with high structural complexity, they provide ecosystem services that influence species abundance and biodiversity, being indicators of ecosystem health. These habitats are considered hotspots of marine biodiversity, especially in cold and deep waters around the world. Similar to their tropical counterparts, these habitats are subject to several climate and anthropogenic threats.

Over the last two decades, research efforts to identify, map and manage these environments have increased along with the advances in data acquisition. Technologies such as remotely operated underwater vehicles are equipped with high-resolution sensors that generate gigabytes to terabytes of data. However, data analysis methods are being outpaced by acquisition technologies and there is a latency in the extraction of meaningful information from large datasets. Furthermore, the fine-scale heterogeneity promoted by the three-dimensional scleractinian coral branching structure is often overlooked, being reduced to a two-dimensional scale.

[Larissa's](#) PhD project "Advancing seabed mapping techniques for deep-water habitat classification in Submarine Canyons" (ASMaT) explores methods that can advance seabed mapping to further understand cold-water coral reef habitat features in the deep sea considering their natural, three-dimensional structure and posed data analysis demands given the current technologies.

For the ASMaT research, Larissa used high-definition video footage collected with remotely operated vehicles to reconstruct CWC reef habitats in the Porcupine Bank Canyon and the Belgica Mound in the Porcupine Seabight, SW of Ireland in 3D, using Structure-from-Motion (SfM) photogrammetry. Point clouds, meshes, orthomosaics and digital elevation models (DEMs) were produced at sub-centimetric resolution. Three different classification workflows were developed and analysed, namely: Multiscale Geometrical Classification (MGC); Colour and Geometrical Classification (CGC); Object-Based Image Classification (OBIA). The three workflows provided a binary (coral, seabed) classification with accuracy ranging 56 to 74% and provided the analysis of the percentage class distribution for each habitat in 2D and 3D. The results of this work also show that there is an impact in mapping CWC in 3D and 2D of at least a tenth of order of magnitude, which can influence important metrics such as coral growth rates and biomass. The findings of this study have been published open access [here](#). The novelty and quality of this research awarded Larissa with the Bronze [Delap Prize for Best peer-reviewed publication](#) of the School of Biological, Earth and Environmental Sciences, UCC.

Aiming to bridge the gap between deep-sea 3D mapping and artificial intelligence, Larissa developed an unprecedented study testing six different machine learning algorithms to classify the CWC habitats into four different facies. The Machine Learning Multiclass classification (MLMC) methods

developed provided the classification of photogrammetry-derived point clouds that achieved *f1* scores of up to 95.1%. The main findings of the study, published [here](#), represent an important contribution towards advancing automatic classification methods for the mapping of deep-sea environments at high-resolution.

Furthermore, Larissa also used DEMs and classification results to analyse the size and distribution patterns of cold-water corals in relation to seabed terrain descriptors to better understand the local and regional interactions of these habitats. Further investigation revealed that cold-water corals are not randomly distributed within reefs, instead, their distribution may be driven by local geomorphometric properties, highlighting the high variability resulting from coral mounds' morphological and biological traits across both regional and local scales.

Motivated by the need to raise awareness and facilitate the interaction of humans with deep-water environments, Larissa also developed an mobile APP for visualisation of 3D models of coral reefs in Android phones whilst also quantifying data thresholds necessary to integrate 3D models into augmented reality applications. This study, published [here](#), demonstrates how augmented reality and 3D photogrammetry and gaming development platforms can be integrated to create an accessible visualization platform to bring cold-water coral environments to light.

In sum, Larissa's PhD project demonstrates how SfM, machine learning and augmented reality can be used to quantify and understand vulnerable CWC reef habitats in Ireland and around the world in high resolution.