Bioerosion: Seeing the invisible and touching the untouchable

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Have you ever thought to 'hold' your underwater study site in your hands or to 'touch' a hole made by a boring sponge? By combining acoustic and electromagnetic technologies, such as Computed Tomography (CT), sophisticated image analysis, three-dimensional (3D) modelling software, and the versatility of 3D printers, it is possible to have your site at the tip of your fingers. All these new technologies are easily combined with each other thanks to the high performance computer, files format standardization, and interoperability among software, offering new perspectives and approaches in the analysis, understanding and representation of ecological processes. This is especially valuable for ecological processes the less evident due to the spatio-temporal scales or the places where they occur.

Bioconstruction and bioerosion are key processes in mesophotic biogenic temperate reefs. They occur in difficult to access places and act at many spatial and temporal scales. Investigation of bioerosion processes requires sampling species and analysing the shape of holes and cavities hidden inside the substrates, and the identification of the signs left by organisms, which often vanish after they are dead. High-resolution X-ray CT is a technology widely used in medical, archaeological, geological and industrial applications. CT combines the use of X-rays and computerised analysis of the images allowing 3D volume reconstruction of an object. This non-destructive imaging technique allows 3D stereo-visualization of the inner structure of biogenic substrates at a very fine scale and to investigate how the different species compete for the inner space. Three-dimensional printing technology allows physical reconstruction of the negative volumes dug into the substrate.

In this study, CT has been used to analyse short and long-term (i.e., 3 and 12 years) bioconstruction and bioerosion processes occurring in experiment travertine tiles deployed on different typologies of mesophotic biogenic reefs in the northern Adriatic Sea. The most important borers were sponges from the genus *Cliona* and the bivalve species *Rocellaria dubia*. Boring organisms leave recognisable traces inside the substrates allowing us to compute the eroded volume and estimate the net balance between construction and destruction processes. The bioeroding pattern of different species was then 3D printed in order to better visualize the shape of holes produces by different species growing and spreading inside the substrate. The 'augmented' poster presentation of the findings of this study testifies the utility of combining these different new technologies in marine ecological studies, as well as a new way to represent and communicate science.

Keywords: image analysis; 3D printer; coralligenous outcrops; ecological processes; mesophotic habitat; Mediterranean Sea