"An Ocean of Science": an educational laboratory approach for the protection and preservation of the marine environment

M. Ricca[1], M.P. Albanese[1], F. Bruno[2], L. Barbieri[2], A. Macchia[1][3], M.F. La Russa[1]

[1] *Department of Biology, Ecology and Earth Science (DiBEST), University of Calabria, Via Pietro Bucci, Cubo 12B II piano, 87036 Arcavacata di Rende, CS, Italy. michela.ricca@unical.it, mariapia.albanese@unical.it, mlarussa@unical.it., andrea-macchia@tiscali.it*

[2] *Department of Mechanical, Energy and Management Engineering, University of Calabria, Via Pietro Bucci Cubo 46C, III Piano, 87036 Arcavacata di Rende, CS, Italy. fabio.bruno@unical.it loris.barbieri@unical.it*

[3] *YOCOCU, Youth in Conservation of Cultural Heritage, Via T. Tasso 108, 00185 Rome, Italy2 andrea-macchia@tiscali.it*

Abstract – **The "An Ocean of Science" project promotes effective interventions and innovative educational paths to support the growth of knowledge and skills in schools, helping competent institutions to guarantee more inclusive cohesion policies with a high cultural and scientific impact. The project also supports innovation in education and training by providing opportunities for cultural and socio-educational development within the framework of the cultural heritage located in the marine environment and the protection of the sea.**

I.   INTRODUCTION

The protection of the submerged cultural heritage, as an integral part of the cultural heritage of Humanity, is exercised according to the same general principles envisaged for the underground archaeological/historical heritage. Archaeological and historical materials from underwater environments are of great importance for the study of technologies, the origin and progressive evolution of past civilizations and for a better understanding of historical events [1]. These principles are reaffirmed and extended in a fundamental international legal instrument, the Convention for the Protection of Underwater Cultural Heritage, adopted in Paris on November 2, 2001, by the General Conference of the Member States of UNESCO [2-3]. Shipwrecks, sunken cities, submerged settlements, and other artefacts represent irreplaceable historical resources that also constitute habitats for flora and fauna [4]. The underwater archaeological/historical sites are highly dynamic environments that are influenced by the entire marine system [1] and as such must be protected over time. In places with a long maritime history, such as the Mediterranean, they are particularly abundant [4]. For example, in Italy, there are over 30 marine protected areas and submerged parks for a total protection of 228 thousand hectares of sea. The submerged historical and archaeological sites are of considerable interest for their natural, geomorphic, physical, and biochemical characteristics and with particular regard to marine and coastal flora and fauna, as well as for their scientific, ecological, cultural, educational and economic importance. Being the umpteenth testimony of the vast culture that enriches our territory, the submerged heritage testifies to our cultural identity. The poor degree of protection and attention to the treasures that lie in our seas, in addition to the well-known illegal trafficking activities, contribute to the environmental damage and, consequently, the protection of the submerged cultural heritage.

"An Ocean of Science" promotes the improvement of educational processes through innovative educational paths that aim to change the attitude of the younger generations towards significant areas of knowledge, increasing knowledge and skills. The project is aimed at high school students with the aim of raising awareness of the enhancement and use of the finds and testimonies of the past culture that lie on the seabed and also to study the pollution of the seas, as one of the greatest threats to the marine ecosystem. The results will be aimed at increasing students' knowledge and awareness of their own cultural identity and at promoting the enhancement of the national submerged cultural heritage, also acquiring awareness of its environmental relevance. An

important section of the project was dedicated to raising awareness of the issue of pollution of the seas due to plastics [5] and, on a large scale, port discharges, oil and waste. Specifically, the younger generations were entertained through lectures and laboratory activities. Part of the experimentation carried out in the classroom was aimed at recognizing microplastic pollution, studying underwater finds and understanding the causes and effects of degradation in submerged contexts. The project activities included also the adoption of serious game technology because of its considerable potential for facilitating both informal and formal learning. In fact, intrinsic motivations, such as enjoyment or fun, produce deeper engagement and higher persistence in learning activities.

Innovative learning opportunities, oriented to scientific disciplines and research themes functional to the Conservation and Enhancement of the Historical-Archaeological Heritage preserved on the seabed and to the Environmental Protection of the Seas, were at the centre of the didactic-laboratory activities. Furthermore, these activities were made even more interactive thanks to the adoption of a Serious Game, specifically developed for this project, that allows to raise awareness and encourage learning in a playful manner. Students will challenge their ideas and attitudes within the scientific-cultural context analysed.

II. LABORATORY ACTIVITIES: BETWEEN SUBMERGED FINDS AND MICROPLASTICS

During the project activities carried out at school, the students learned about what submerged finds look like and what issues afflict our seas. Specifically, three didactic-laboratory activities were carried out at the school facilities involved in the project. The first activity, namely "treasures in the sea", was conducted with microscopic instruments capable of recognizing the forms of surface damage that affect archaeological/historical materials coming from the sea, due to the colonization of marine flora and fauna (Fig. 1-3). Students analysed under a portable microscope (Dino-Lite) pieces of ancient altered calcareous stones colonized by microorganisms (Fig. 1, 3) and metal finds (i.e. projectile, a plate of a rifle) dating from the First World War, whose state of decay is clearly detectable by rust (Fig. 2). During the experimental activities, the methods and causes for which these materials of different nature alter in contact with the aquatic environment were illustrated. Thanks to this first approach to the Underwater Cultural Heritage, the students understood what and how many treasures our seas hide and how important is the protection and conservation of these cultural assets that are affected by both natural marine

degradation and pollution caused by human neglect towards the environment.

Fig. 1 "Treasures in the sea" laboratory - Ancient stones from underwater site

Fig. 2 "Treasures in the sea" laboratory - Ancient metals from underwater site

Fig. 3 "Treasures in the sea" laboratory - Ancient stones from underwater site

The second laboratory activity, called "a sea of plastic", was dedicated to raising awareness of the pollution of the seas due to plastic, in particular to microplastics with dimensions of less than a millimeter. Through experiments, in the laboratory, the students were able to evaluate how plastic develops and how slow the disposal process is. For example, in figures 4-6 using sodium polyacrylate in contact with water, it was possible to observe how it develops rapidly and increases in volume. This process is the same as in baby diapers and is also used in the world of cinema for the creation of fake snow, even if it is very polluting. Then, with a portable Raman spectrometer (Fig. 7), the students observed, the different nature of plastic materials, i.e. the polymers of which they were composed. Further evidence is shown in Figures 4 and 5 where the students conducted a plastic corrosion experiment, simulating accelerated plastic corrosion and disposal times, evaluating their effective biodegradability.

Fig. 4 "A sea of plastic" laboratory

Fig. 5 "A sea of plastic" laboratory

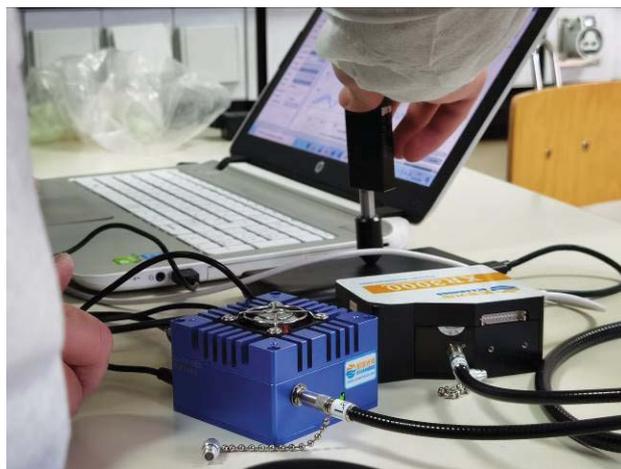*Fig. 6 "A sea of plastic" laboratory*

Fig. 7 "A sea of plastic" laboratory

In the third activity, called "Virtual Exploration of

Underwater Archaeological Sites", students were informed about modern technologies and methods employed for the development of virtual 3D reconstructions of underwater environments. The laboratory activities consisted of an immersive virtual experience set within an underwater archaeological site. In particular, the immersive experience was based on HMD (head-mounted display) technology for the visualization of both 3D data and learning contents and a joystick for the interaction (Fig. 8).

Fig. 8 Students wear HMDs

of a submerged environment The adoption of virtual reality technologies allows to provide a learning and educative experience in a playful manner [6,7]. Students, in fact, can simulate a realistic diving experience, in the virtual reconstruction of a submerged shipwreck site, through the use of modern technologies popular in the gaming field. Nevertheless, the recreational activity is coupled with the educational one, as the interactive content of the virtual scenario allows students to learn archaeological, historical and biological information about the specific site. Furthermore, creative educational practices mediated by the use of learning games were implemented during this laboratory activity. In fact, students were instructed to use a Serious Game [8,9], specifically developed for the project, that allows to infuse instruction into the game play experience. In fact, the player's goal is to protect and clean up an area of sea through the detection and removal of different types of plastic waste (Fig. 9) present both on the surface and in the depths.
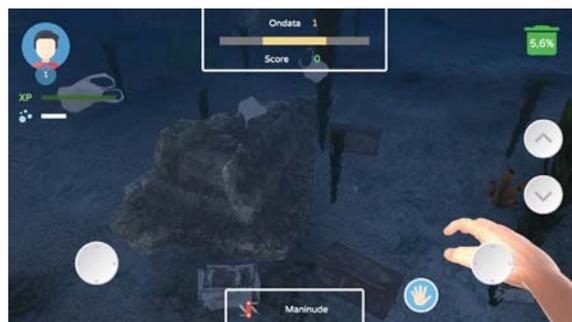

Fig. 9 Serious Game - collection of plastic waste found in the sea

The goal of the game is to collect as much plastic litter as possible in a predetermined amount of time. The greater the amount of waste collected, the higher the score. Each type of plastic waste is also associated with an informative card (Fig.10) through which the player acquires specific information and, at the same time, increases his/her personal score.

Fig. 10 Serious Game – informative card by waste type

FINAL REMARKS

The awareness of the treasures hidden in our seas and of the problems linked to pollution was at the center of the "An Ocean of Science" project.
Students in the role of scientists have learned, as protagonists, the importance of our seas, not only as places of hidden treasures but also as places threatened by human actions.
The project (CUP H23D21002060001) fostered students' awareness of their cultural identity through the discovery of the submerged cultural heritage and, consequently, the protection and conservation of the seas.

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