Profiler's Control and Comunnications System

Gemma Berciano Rodríguez
University Institute of Applied Microelectronics (IUMA)
University of Las Palmas de Gran Canaria (ULPGC)
Las Palmas de Gran Canaria, Spain
gemma.berciano101@alu.ulpgc.es

The expenses and logistical difficulties of deploying scientific monitoring equipment in aquatic environments are the major limitations that exist while recording data. That is why less expensive alternatives focused on DIY (Do It Yourseft) were created using open-source microcontroller boards such as the one developed in this project. This Master's project is part of a project called "METEROSECO: Hacia una Nueva Metodología para el Estudio de Funciones y Servicios Ecosistémicos de Hábitats Submarinos" for which a monitoring system called Marine Profiler has been built in order to obtain information for the management and conservation of two marine ecosystems under studies of the project: Cymodocea nodosa meadows and rhodolith beds. This has been a first-time collaborative project between the university institutes IU-ECOAGUA, IUSIANI and IUMA.

I. INTRODUCTION

Good ecosystem management involves understanding how ecosystems function in order to identify the natural and human processes that cause changes in biological communities. In marine ecosystems, numerous ecosystem structures are yet to be evaluated for a great diversity of environments and biogeographical contexts throughout the world's oceans. Therefore, a research project called "METEROSECO: Hacia una Nueva Metodología para el Estudio de Funciones y Servicios Ecosistémicos de Hábitats Submarinos" was initiated. This project is based on the cooperation of three institutes of the University of Las Palmas de Gran Canaria (ULPGC): the University Institute of Sustainable Aquaculture and Marine Ecosystems (IU- ECOAQUA), the University Institute of Intelligent Systems and Numerical Applications in Engineering (IUSIANI) and the University Institute of Applied Microelectronics (IUMA). Its objective is to study the influence of the spatio-temporal configuration of two marine habitats on the provision of ecosystem functions and services. Knowledge of the spatio-temporal configuration of marine habitats could improve their conservation by reducing anthropogenic disturbances that threaten their structure and function [1].

For this study, a marine profiler has been developed that moves vertically from the bottom to the surface, equipped with sensors that will provide temporal and spatial sampling of the studied habitats, the Cymodocea nodosa meadows and the rhodolith beds [2]–[4]. This Master's project will focus on the task of designing and implementing a marine profiler control and communications system capable of obtaining data across an entire water column.

II. STATE OF THE ART

A. *Cymodocea nodosa*

Cymodocea nodosa is the second most important marine phanerogam plant in the Mediterranean due to its size and the extent of its formations. This plant, which forms underwater meadows in sandy and well-lit bottoms of the Canary coast, is known as "sebadales" or "seba" and is included by the Law 4/2010, of June 4, in the Canary Islands Catalog of Protected Species as a "species of interest for the Canary Islands ecosystems" [5], [6].

The growth of Cymodocea nodosa in sandy bottoms allows the development of an ecosystem with very peculiar characteristics, fulfilling several functions: they contribute to the fixation and stabilization of sandy sediments; they actively intervene in the cycle of elements, fixating the carbon and nitrogen in the sediments; and they allow the development of associated communities, both epiphytic and accompanying algae. For these reasons and for increasing animal diversity, these meadows are of great ecological interest [7], [8].

Figure 1 Meadow of Cymodocea nodosa

B. *Rhodolith beds*

Rhodolith beds, also called maërl beds, are composed mainly of free-living, non-geniculate, calcareous rhodophyte algae, which form rocky-looking nodules on the soft substrate. The rhodoliths have been catalogued as habitats of great biodiversity, breeding and refuge areas for commercial species of fish and invertebrates, and are also included in the Annex I of the Habitat Directive as a priority habitat to be conserved in the European Union territory [1], [9].

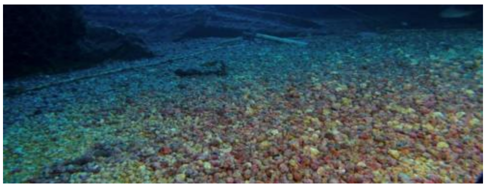

Figure 2. Rhodolith beds

Rhodoliths form a three-dimensional framework that favors the settlement of a great variety of organisms, which is why they play an essential role in marine ecosystems and constitute highly productive fishing grounds. However, the slow growth of this ecosystem (1-2 mm/year) and the peculiar conditions of its development make it highly vulnerable [9].

C. Existing monitoring systems

DIY (Do It Yourself) is a growing movement that promotes the concept of working out ideas by yourself and refusing to buy off-the-shelf systems.
With this in mind, devices such as the Arduino are extremely useful, providing a modular and flexible system that offers enormous opportunities for automation, networking, and data collection and analysis [10].

The expenses and logistical difficulties of deploying scientific monitoring equipment in aquatic environments are the major constraints to such operations. The instruments for recording data in these environments are the most expensive commercial sensors in the market. This is why less expensive alternatives have been created using open source microcontroller boards such as Arduino [10].

However, this is not the first time that profilers have been used in aquatic environments. In Baja California, a state in Mexico, a project was carried out in which a free-elevation CTD (Conductivity Temperature Depth) platform that made profiles along a water column was developed (Figure 9). As its name suggests, it was a device that measured the electrical conductivity of seawater, its temperature and the depth at which it was located when making the two previous measurements. Unlike the marine profiler developed in this Master’s project, the device of that project avoided the use of electronics for the ascent and descent of the profiler [11].

D. Marine profiler

The high cost of scientific monitoring equipment used in studies of ecosystem services prevents its application in studies of large systems, limiting them to a few geographic points. In addition to this drawback, the current methodology only allows recording parameters of interest at a fixed depth, and it is only possible to access these data after recovering the measurement equipment. The design described in this Master’s project tries to overcome these three basic limitations by providing an alternative to the standard methodology based on expensive oceanographic sensors.

In this project, the basic variables of interest for study are pH, dissolved oxygen and photosynthetically active radiation. The typical cycle of operation that this device would have is conditioned by the moments in which changes in the variables of interest along the water column will be generated, so four synchronized daily profiles with the following four phases of the day are required: dawn, solar noon, twilight and night.

III. ADOPTED HARDWARE SOLUTION

The design consists of two volumes joined by three metal rods that together with the materials purchased from *BlueRobotics* company, provide stability and sturdiness to the marine profiler (Figure 3).

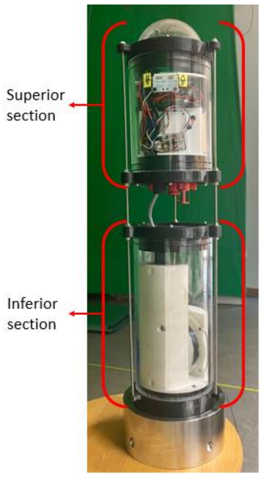

Figure 3 Marine profiler

A. Superior section

This section of the structure is airtight and contains all the electronics distributed and anchored in a fixed position thanks to three pieces which are designed and printed with a 3D printer.

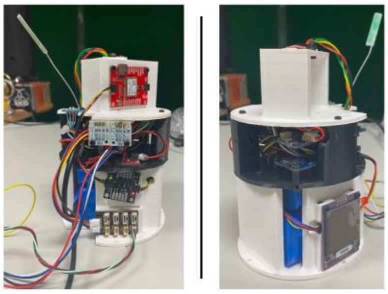

Figure 4 Internal structure of the upper part of the assembled profiler

B. Inferior section

This part will be flooded and will contain the motor inside a container that isolates it from the water (Figure 5).

Figure 5 Motor container

IV. ADOPTED SOFTWARE SOLUTION

The software was made in Arduino IDE and the project was divided into functions to make it more orderly.
In the communications sector, the FTP protocol (File Transfer Protocol) was used for the Arduino to connect to an FTP server able to transfer the files with the made readings.

V. Conclusions and future work

A. Conclusions

Functional tests have been carried out throughout the design process, first the electronic modules separately to verify their operation, continuing with other tests that integrated them step by step into the system while checking the consumption of the system when certain components were added.

Finally, a global functional test of all the electronic and mechanical elements that constitute the profiler was successfully completed. In this test the marine profiler performed a complete work cycle that has allowed to verify the motor movement, the sensor reading and the data saving in the SD card.

B. Future work:

With the METEROSECO project, the profiler will be tested in the coming months in the marine environment of Gando Bay by researchers from the University Institute of Sustainable Aquaculture and Marine Ecosystems (IU-ECOAQUA), under the supervision of the project's lead investigator Fernando Tuya Cortés.

Future work on this project will allow for a complete redesign of the profiler's structure. In pursuit of a less costly prototype, the *BlueRobotics* outer structure parts will be left out and a PVC casing will be designed.
The design of a custom electronics system that is better suited for the low power consumption requirements and allows an extended battery run time will be taken into consideration. Aditionally, the design of a specific printed circuit board will facilitate the reduction of sensor wiring. It will also reduce the manufacturing and assembling costs of the different elements of the profiler in the production of small series of profilers.

Focusing on the field of programming, we would consider using a real-time system by dividing the work cycle into tasks with different priorities that would be performed simultaneously providing a more structured and flexible programming framework than that provided with the Arduino programming.

References

[1] F. Tuya Cortés, "METOSERECO: Hacia una Nueva Metodología para el Estudio de Funciones y Servicios Ecosistémicos de Hábitats Submarinos," pp. 1–20, 2020.

[2] P. A. Beddows and E. K. Mallon, "Cave Pearl Data Logger: A Flexible Arduino-Based Logging Platform for Long-Term Monitoring in Harsh Environments," *Sensors*, vol. 18, no. 2, p. 530, Feb. 2018, doi: 10.3390/s18020530.

[3] Beddows, P.A., Mallon, and E.K., "Cave Pearl Data Logger: A Flexible Arduino-Based Logging Platform for Long-Term Monitoring in Harsh Environments," *Sensors*, 2018. https://www.mdpi.com/1424-8220/18/2/530/htm (accessed Feb. 24, 2021).

[4] R. Bardaji, A.-M. Sánchez, C. Simon, M. R. Wernand, and J. Piera, "Estimating the Underwater Diffuse Attenuation Coefficient with a Low-Cost Instrument: The KdUINO DIY Buoy," *Sensors*, 2016. https://www.mdpi.com/1424-8220/16/3/373/htm (accessed Feb. 24, 2021).

[5] M. Z. Elso, P. G. Jiménez, N. G. Henríquez, and R. R. Romero, "La planta marina Cymodocea nodosa. Biología y Cultivo - Universidad de Las Palmas de Gran Canaria." https://spdc.ulpgc.es/libro/la-planta-marina-cymodocea-nodosa_83404/ (accessed Aug. 25, 2021).

[6] G. de C. (BOC), "Catálogo Canario de especies protegidas (Ley 4/2010 de 4 de junio)," pp. 15200–15225, 2010.

[7] F. E. Rodríguez, "Las praderas de fanerógamas marinas en Canarias y su diversidad." http://www.gobiernodecanarias.org/medioambiente/sostenibilidad/apps/revista/2001/21/265/index.html (accessed Aug. 25, 2021).

[8] Disputación de Málaga, "Cymodocea (Cymodocea nodosa). Senda Litoral - Costa del Sol Málaga - Diputación de Málaga." https://www.malaga.es/es/turismo/naturaleza/lis_cd-10247/cymodocea-cymodocea-nodosa-senda-litoral (accessed Aug. 25, 2021).

[9] Instituto Español de Oceanografía, "Noticias - Instituto Español de Oceanografía." http://193.146.153.5/es/web/baleares/noticias?p_p_id=ieolistadosestructuramain_WAR_IEOListadoContenidosPorEstructuraportlet&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-7&p_p_col_count=2&_ieolistadosestructuramain_WAR_IEOListadoConteni (accessed Aug. 26, 2021).

[10] D. Cressey, "The DIY electronics transforming research," *Nature*, vol. 544, no. 7648, pp. 125–126, Apr. 2017, doi: 10.1038/544125a.

[11] H. Maske, J. Ochoa, C. A. Jáureguí, and A. C. Avendaño, "Free-rising, tethered CTD profiler: increased vertical resolution and near surface profiling." https://aslopubs.onlinelibrary.wiley.com/doi/abs/10.4319/lom.2012.10.475 (accessed Feb. 23, 2021).