Fig. 2. Integrated chart of significant daily increases in measured values for the 5 biologically relevant oceanographic variables, and visual counts of the 17 taxa, unclassified and total fishes obtained from 1st of December 2016 to 31st March 2017 of continuous measurement by the EGIM sensor infrastructure in front of the OBSEA (dark gray horizontal bars report values above the MESOR for the oceanographic measures, while black horizontal are used for visual counts). With light gray boxes in background is showed the duration of the night hours.

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ID14 DEVELOPMENT OF AN AUTONOMOUS SUBMERSIBLE PROFILER WITH THE ABILITY TO STOP AT SPECIFIC DEPTHS FOR MEASUREMENT OF MARINE PARAMETERS

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ABSTRACT

Understanding marine pollution problems is a complex topic that has led to a wide range of research over the last decades. In this research, an autonomous submersible profiler with controlled depth detention for the measurement of parameters of interest in shallow marine environments -is presented. The device has been designed to carry on several sensors including dissolved oxygen, chlorophyll, electrical conductivity and temperature among others. The profiler includes the performance for sampling, collecting and wireless sending reliable real-time data in marine environments. In addition, its ability to stop at a given depth allows for more accurate and stable measurement of marine parameters at different depth levels. This research describes the design of the profiler as well as the different control assumptions made to achieve zero buoyancy at a given depth. The results show that the submersible profiler is a valuable tool for continuous monitoring of marine parameters relevant to study the causes leading to critical environmental situations.

Keywords – sensor carrier platform, submarine profiler, WSN, depth control, process simulation.

INTRODUCTION

Coastal marine ecosystems, especially coastal lagoons, are natural spaces with high ecological value that provide goods and services to society, but at the same time they are extremely vulnerable to environmental pressures derived from the exploitation of their resources. The socio-ecological system of the Mar Menor [1], unique in Europe and emblematic in the Region of Murcia, has suffered its greatest environmental crisis in recent years, which has compromised its identity and caused economic losses and loss of natural values [2]. The different scientific groups, governments and associations with scientific competence in the biological behaviour of these vulnerable ecosystems, have highlighted the need for continuous monitoring of relevant marine parameters to study the causes that lead to these critical situations and determine the effectiveness of the actions undertaken for their recovery.

This research presents a portable and autonomous underwater profiler made of low-cost materials, capable of submerging, surfacing and serving as a multi-sensor carrier platform, offering the possibility of measuring at different depths and sending real-time data to a web server.

MATERIALS AND METHODS

a. Mechanical design

The mechanical and electronic design has been developed with the objective of achieving a flexible monitoring without the need of infrastructure for its installation. A low economic cost to have enough measurement points that, on the one hand, minimize spatial variability and, on the other hand, allow the instrumentation of different areas and model the hydrodynamic characteristics of the lagoon. In addition, it has been designed with the aim of instrumenting the parameters at different depths. The sampling time is adjustable to allow an adequate balance between the energy consumption and the measurement time of the several sensors. The system is fully autonomous, designed to allow to know the state of the lagoon several times a day, as well as to send the information obtained to a web server in real time using IoT technologies, such as Sigfox.+

b. Control design

This research proposes two types of depth control that differ in the actuators used and their dynamic response. One case is based on achieving static equilibrium using thrusters for high speed actuation but is only suitable for short time lapses due to energy consumption and the fouling issues. In the second case, zero buoyancy is achieved by adjusting the weight of the profiler by means of ballast tanks, which allows longer tracking at the cost of slower actuation speed.

c. Field testing

In order to check the validity of the profiler's depth control operation, several tests have been carried out in different environments: In a two meter high tank installed at the Polytechnic University of Cartagena for the preliminary test, at the "Real Club de Regatas de Cartagena" for real depth operation and at different sea points of the Mar Menor to check the control management in response to disturbances caused by sea conditions.

RESULTS

In order to optimise the use of energy, it is necessary to balance the operation of thrusters and ballast, which requires the use of different control strategies. Thruster control is based on a conventional PID controller. However, when using ballast tanks, due to their operating principle it was necessary to use a fuzzy control. After experimental tests, both scenarios showed satisfactory control and a steady-state error of less than 10 cm and tunability. By using thrusters, a higher response speed is obtained to reach the setpoint and to act on disturbances. The settling time obtained for control with thrusters and ballast tanks is 30 and 50 seconds, respectively. On the other hand, ballast tanks allow to stay at the desired setpoint with minimum consumption. However, thrusters must always be in motion to stay at a certain depth in addition to being affected by fouling. Therefore, the decision on the optimal control will depend on the specific application for which it is to be used.

In addition, it should be noted that, in parallel to the control study, several profilers were installed in the Mar Menor to test their behaviour in a real environment. In this way, it was possible to conclude that the mechanical and electronic design of the profiler was correctly carried out and that, in the absence of depth control, the autonomy of the profiler reached 2 months. However, due to fouling in the Mar Menor, the profiler must be maintained every 3 weeks to ensure reliable measurements.

CONCLUSIONS

This research presents a profiler with the ability to stabilise at a given depth. In this way, it allows the built-in sensors to provide more stable and accurate measurements for each desired depth. Therefore, this type of profiler could be used as a tool capable of obtaining the state of the physico-chemical alterations and fluctuations in the Mar Menor or any type of shallow water in real time.

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