ID30- ARDUINO CONTROLLED VALVOMETRY EQUIPMENT FOR LABORATORY MONITORING

MIGUEL GILCOTO[1], WALDO REDONDO-CARIDE[2], ELSA SILVA[1], ANTÓN VELO[1], LUC A. COMEAU[3], RAMÓN FILGUEIRA[4], JOSÉ M.F. BABARRO[1]

1 Instituto de Investigaciones Marinas (IIM-CSIC, Eduardo Cabello 6, 36208 Vigo,986231930, mgilcoto@iim.csic.es, elsi@iim.csic.es, avelo@iim.csic.es, jbabarro@iim.csic.es)
2 Centro Oceanográfico de Vigo (IEO, Subida a Radio Faro 50-52, 36390 Vigo, +34986492111, waldo.redondo@ieo.es)
3 Fisheries and Oceans Canada, Gulf Fisheries Centre, 343 Université Avenue, Moncton, New Brunswick E1C 9B6, Canada, Luc.Comeau@dfo-mpo.gc.ca)
4 Marine Affairs Program, Dalhousie University, Halifax, NS,Canada, Ramon.Filgueira@dal.ca

Abstract
High-Frequency Non-Invasive (HFNI) instruments are currently used in bivalve mollusks in order to use them as bioindicators of the local conditions of the environment. Under the STRAUSS project an Arduino controlled equipment has been developed to log the valve movements activity of clams (Polititapes rhomboides) using Hall-effect sensors. The equipment is able to record at 10Hz the signals of 16 Hall-sensors, to store the records in internal microSD cards and to send the stream of data to a personal computer for storing and plotting them in real-time.

Keywords
HFNI, Arduino, Hall-effect, bio-sensor.

MOTIVATION
There is an increasing demand to fully understand the impacts of coastal environments variability on marine fauna. Particularly, when socioeconomic implications exist, e.g. shellfisheries. Currently, the use of biosensors is playing a crucial role on exploring either natural environmental variability or a number of natural and anthropogenic stressors while emerging monitoring systems and technologies, as High-Frequency Non-Invasive (HFNI) instruments, are also being very useful [1]. Accordingly, since they are (bio)indicators of the local conditions, bivalve mollusks are target organisms for this type of studies combining biosensors and HFNI. From valve´s movements of these organisms it is possible to infer individuals' health or status [2]. Amplitude of valve opening and tendency to (or fully) closure would be an indication of stress and the magnitude of these changes in behaviour may offer signalling of environmental change. A number of monitoring devices have been implemented for both laboratory or field experiments to be used as early warning alerts in environmental monitoring through changes in animal´s behaviour (e.g. MolluSCAN eye; [1]). The principle for the use of these (bio)sensors includes the gluing a Hall-effect sensor in one valve and a magnet in the other valve, the intensity of the magnetic field felt by the sensor will change with the distance between the two valves. The Hall-effect sensor outputs the magnetic intensity as voltage levels that can be logged with dynamic-strain recording devices (DC 204R, Tokyo Sokki Kenkyujo Co., Japan).

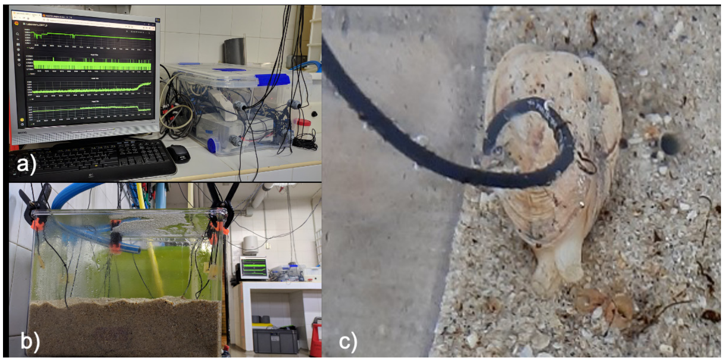

Fig 1. a) Grafana dashboard on the TFT screen and the equipment electronics stored in the plastic box, b) small tank with 4 buried clams monitored with hall sensors as shown in c) close-up.

The method to evaluate the quality of the exposition is observing the histogram of the picture. Only histograms with all the pixel values different from 0 and 255 are accepted. This method avoids that dark or overexposed images can be used to compute the light of the scene.

Then the value for the light (L) is a function of the Exposure Value (EV), Illuminance (Y) and Gain (G).

HFNI technology has been already successfully applied to mussels in Galician waters and laboratory studies, under natural variability rhythms of mussels attached to cultivation system (rafts [3]) and under toxic Alexandrium minutum exposure in experimental tanks [4], respectively. Recently, the impact of ocean acidification and seawater warming on populations of the Mediterranean mussel Mytilus galloprovincialis were also explored using this technology [5,6]. In these cases, very expensive devices were used (DC 204R) with limitations for the number of organisms to be tested. Since another cheaper options are available [7], our intention is to implement the HFNI technology with lower costs for real-time monitoring of the behaviour of marine bivalves. Pursuing that, we have developed an Arduino controlled equipment (Figure 1) using this open source electronic ecosystem and also, as much as possible, open source software.

EQUIPMENT DESCRIPTION
The hardware components of the equipment were integrated in a Mega2560 R3 Arduino board (Table 1). The equipment has been designed to operate as part of a real-time monitoring system using a personal computer (PC). A USB cable is used to communicate the PC with the Arduino. A microSD card adapter serves as backup storage system, independent from the PC, and a real time clock (RTC) is used to timestamp each record stored in the SD card. The data stream arriving at the PC through the USB is received by a Python script that logs the records as ASCII files in the hard disk of the PC and also transfers the data to a MySQL Server running in the computer. The MySQL dabatabase is connected to a Grafana visualization platform that, in turn, can plot the data through dashboards in any Internet browser.

Component description	Model/Version
Hall-effect Sensor	49E
Cable from sensor to AD converter	MOGAMI AWG33 -3C
Real Time Clock Module	Adafruit DS3231
MicroSD Card Adapter Module	HW-115
Analog-to-Digital Converter Module	Adafruit ADS1115
Power Supply Unit	Mean Well 5V-5A
Arduino board	Elegoo Mega2560 R3
Workstation	Dell Precision T1700 Windows10
Python Script	Python 3.9
Database Software	MySQL Server 8.0.20
Visualization	Grafana 7.3.6 and FireFox/Chrome/Safari

Table 1. Equipment components

CONCLUSIONS
In the context of STRAUSS project, a real-time monitoring system has been developed, using an Aduino controlled equipment with 16 Hall-effect sensors sampled at 10Hz, to log the valvometry activity on clams Polititapes rhomboides in order assess the effects of temperature and turbulence as stress factors.

ACKNOWLEDGMENTS
The authors also would like to thank the support of Project STRAUSS (PID2019-106008RB-C21) funded by the Spanish Ministry of Science and Innovation.

REFERENCES

[1] Andrade, H., Massabuau, J,C., Cochrane, S., Ciret, P., 627 Tran, D., Sow, S., and Camus, L., "High Frequency Non-invasive (HFNI) Bio-Sensors As a Potential Tool for Marine Monitoring and Assessments", Front. Mar. Sci. vol. 8, pp. 137, 2016, doi: 10.3389/fmars.2016.00187

[2] Nagai, K., Honjo, T., Go, J., Yamashita, H., Seok Jin, O, "Detecting the shellfish killer Heterocapsa circularisquama (Dinophyceae) by measuring bivalve valve activity with a Hall element sensor", Aquaculture vol. 255, pp. 395–401, 2006

[3] Comeau, L.A., Babarro, J.M.F., Longa, A., Padin, X.A., "Valve-gaping behavior of raft-cultivated mussels in the Ria de Arousa, Spain", Aquacult Rep vol. 9, pp. 68–73, 2018, doi: 10.1016/j.aqrep.2017.12.005

[4] Comeau, L.A., Babarro, J.M.F., Rioboó, P., Scarratt, M., Starr, M., Tremblay, R., "PSP-producing dinoflagellate Alexandrium minutum induces valve microclosures in the mussel Mytilus galloprovincialis", Aquaculture vol. 500, pp. 407-413, 2019, doi: 10.1016/j.aquaculture.2018.10.025

[5] Lassoued, J., Babarro, J.M.F., Padín, X.A., Comeau L.A, Bejaoui, N., Pérez, F.F., "Behavioural and eco-physiological responses of the mussel Mytilus galloprovincialis to acidification and distinct feeding regimes", Mar. Ecol. Prog. Ser. Vol. 626, pp. 97–108, 2019, doi: 10.3354/meps13075

[6] Lassoued, J., Padín, X.A., Comeau, L.A., Bejaoui, N., Pérez F.F., Babarro, J.M.F., "The Mediterranean mussel Mytilus galloprovincialis: responses to climate change scenarios as a function of the original habitat", Conserv. Physiol. vol. 9(1), pp. coaa114, doi:10.1093/conphys/coaa114

[7] Gandra, M., Seabra, R., Lima, F.P., "A low- cost, versatile data logging system for ecological applications", Limnol. Oceanogr: Meth. vol. 13(3), pp. 115-126, 2015, doi: 10.1002/lom3.10012