# ID21 ARDUINO CONTROLLED VALVOMETRY EQUIPMENT FOR MUSSEL RAFT MONITORING

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*ABSTRACT*

High-Frequency Non-Invasive (HFNI) instruments are currently used in bivalve mollusks in order to use them as bio-indicators 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 mussels (Mytilus galloprovincialis) using Hall-effect sensors. The equipment is able to record at 10Hz the signals of 27 Hall-sensors, temperature, fluorescence and , to store the records in internal microSD cards and to send the stream of data to in premisses data servers for storing and plotting them.

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

*MOTIVATION*

There is an increasing demand, when socioeconomic implications exist (e.g. shellfisheries), to understand the impacts of coastal environments variability on marine fauna. The use of biosensors is playing an key role on exploring natural environmental variability and a number of natural and anthropogenic stressors. Emerging monitoring systems and technologies, as High-Frequency Non-Invasive (HFNI) instruments, are also being very useful [1]. Since they are bio-indicators of the local conditions, bivalve mollusks are target organisms for this type of studies combining biosensors and HFNI. Several devices have been implemented for both laboratory and field experiments and used as early warning alerts in environmental monitoring through changes in animal´s behaviour (e.g. MolluSCAN eye; [1]). In fact, from valve´s movements of these organisms it is possible to infer individuals' health or status [2]. The amplitude and frequency of valve opening would be an indication of stress, modulations in these variables may offer signalling of environmental change. The use of these bio-sensors includes the gluing a Hall-effect sensor in one valve and a magnet in the other valve (Fig 1c), the intensity of the magnetic field felt by the sensor will change with the distance between the two valves.

HFNI valvometry 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 thought cheaper options are available [7]. Trying to reduce costs, we have developed an Arduino controlled equipment (Figure 1a). 9,20th June. Castellón de la Plana, València, Spain

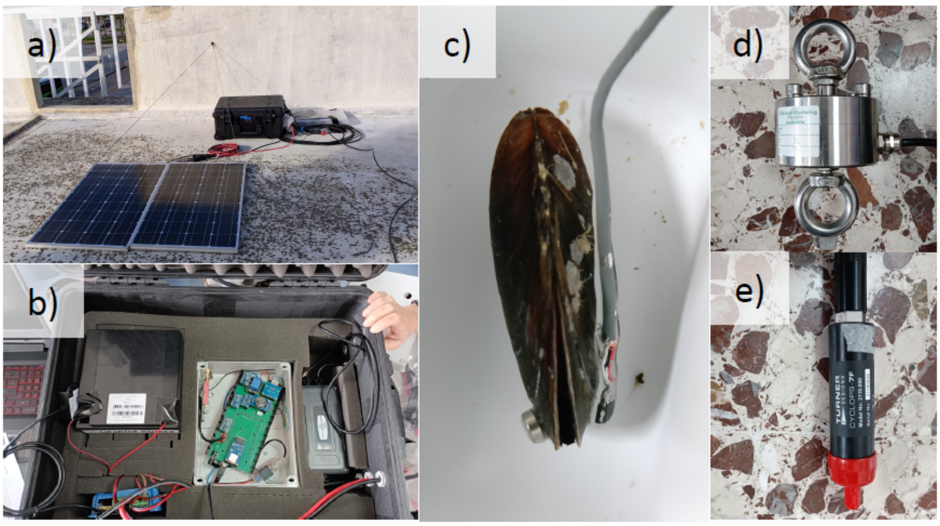


*Fig 1. a) Equipment on the IIM terrace, b) case with electronics and battery, c) mussel with magnet and hall sensor, d) load cell, and e) fluorometer.*

*EQUIPMENT DESCRIPTION*

The hardware components of the equipment were integrated in a Mega2560 R3 Arduino board (Table 1) through a custom-made PCB (Fig. 1b) designed by Javier Vila (https:\\vilabesada.com). The final global design was polished by SC Robotics (https:\\scrobotics.com). Several sensors have been added to monitor other interesting variables: a load cell unit (Fig. 1d) to record the weight change in the mussel ropes of the raft, a fluorometer sensor (Fig. 1e) to estimate chlorophyl water content, an Inertial Movement Unit to monitor the mussel raft movements under ocean waves, and a temperature sensor. The equipment has been designed to operate as an autonomous instrument with solar panels, batteries and GPRS communication with the data servers at IIM premises. A microSD card adapter serves main storage system, and a real time clock (RTC) is used to timestamp each record stored in the SD card. The data stream arriving at the data servers is stored in a InfluxDB database. The InfluxDB 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 |
| Temperature sensor | DS18B20 |
| Fluorometer | Turner Cyclops – 7F |
| Load Cell | JCM Load Monitoring, TNC600 |
| IMU | MPU9250 |
| Communications (GPRS) | SIM900 |
| Solar Panels | 2x100W |
| Solar Charge Controller | Victron MPPT 75 \| 10 |
| Battery | LiFePO4, 12.8V 26.6Ah |
| PCB | Custom-made |
| Database Software | InfluxDB |
| Visualization | Grafana 7.3.6 and FireFox/Chrome/Safari |

*Table 1. System/Equipment components*

## *CONCLUSIONS*

In the context of STRAUSS project, a real-time monitoring system has been developed, using an Aduino controlled equipment with 27 Hall-effect sensors sampled at 10Hz, to log the valvometry activity on clams Mytilus galloprovincialis plus a load cell, a fluorometer, an IMU and a temperature sensor in order assess the effects of waves in mussel dislodgments.


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