DEVELOPMENT OF A LOW-POWER UNDERWATER NFC-ENABLED DATA ACQUISITION FOR SEAWEED MONITORING

Caroline Peres[1], Masoud Emam*[1], Hamed Jafarzadeh[1], Marco Belcastro[1], Joanne Casserly[2], Frank Kane[2], Brendan O'Flynn[1]

[1] Tyndall National Institute, University College Cork, Cork, Ireland.
[2] Marine Institute, Rinville, Oranmore, Co. Galway, Ireland. H91 R673

E-mail: caroline.peres@tyndall.ie

Introduction

Aquaculture farming faces challenges to increase production while maintaining welfare of livestock, using resources efficiently, and being environmentally sustainable. To achieve this, remote and real-time monitoring of the farm environmental and biological conditions is highly important (Føre et al. 2018). The H2020 IMPAQT project (https://impaqtproject.eu/), funded by the European Union aims to develop and validate in-situ a multi-purpose, multi-sensing and multi-functional management platform for sustainable Integrated Multi-Trophic Aquaculture production (Troell et al. 2009). As part of an IMTA Paradigm, seaweeds are at the intersection of many topical trends. They provide many inter-sectorial benefits: 1) they are a source of food and many other applications; 2) they provide several key ecosystem services; 3) they allow local diversification of a more balanced aquaculture industry; and 4) they participate in the dietary shift toward more decarbonized ocean-based sources of protein (Chopin and Tacon 2020). Global demand for seaweed is growing 8.1% per annum (Barbier et al. 2019) reflected in the industry with the establishment of new culture sites.

Environmental monitoring in an aquaculture setting is already well supplied by commercial off-the-shelf sensors that measure parameters such as temperature, light radiation, and water quality (dissolved oxygen, pH, salinity, nitrogen). However, these sensors usually measure only single parameters, which increases the power consumption and project cost. The collection of local data monitoring hydrodynamics and abiotic conditions combined with crop yield and crop quality throughout the growing cycle will help to maximise yields, optimise use of space, site selection and orientation, species selection, planting time and harvest dates. Wave and water movement are also important environmental factors that affect the production of seaweed and kelp, but the specifics are not completely understood (Hurd 2000). Wave sensors (such as wave-rider buoys) can be too expensive for some projects, which results in researchers and farm operators using computer modelling to estimate wave conditions that lack accuracy and specific local data (Focht and Shima 2020). Current monitoring solutions for seaweed and kelp also include satellite and aerial sensing, which cover large areas effectively. However, these methods do not offer high-resolution, specific local data for growing sites, and are usually limited by turbidity and weather conditions (Bennion et al. 2019).

Some research has been done to more finely monitor and log wave and water movement related to macroalgae, such as the work of (Stevens et al. 2002) in which an accelerometer was attached to a seaweed blade, and (Mullarney and Pilditch 2017) in which an accelerometer logger was attached to kelp. Nonetheless, in these cases only an accelerometer was attached to the macroalgae, and additional sensors such as pressure and temperature had to be deployed separately. An integrated solution that monitors different biotic and abiotic factors would lessen the cost and time to deploy the system and provide useful information on the dynamic forces affecting the plants.

System

In this work, we present a novel miniature low-power NFC-enabled data acquisition system to monitor seaweed in an IMTA setting. This sensor system monitors temperature, light intensity, depth, and motion, logging the data collected internally. The sensor device can communicate with NFC-enabled readers (such as smartphones) to configure the sensors with custom sampling frequencies, communicate status, and to download data. It also has an on-board machine learning enabled microcontroller, which can be used to perform data analysis internally. The device is designed to be attachable to a variety of seaweed types, kelp blades or stipes: it has a textured surface on the bottom side for gluing the system onto the blades of the seaweed directly; it also has holes for threading safety threads to secure the device to the mooring line or to tie it to the stipe.

Results

The device was manufactured and is currently undergoing testing and characterisation. Deployment results will be presented. **¡Error! No se encuentra el origen de la referencia.** show the waterproof enclosure for the device and the embedded system that we designed and fabricated for this seaweed growth parameter monitoring device.

(a) (b)

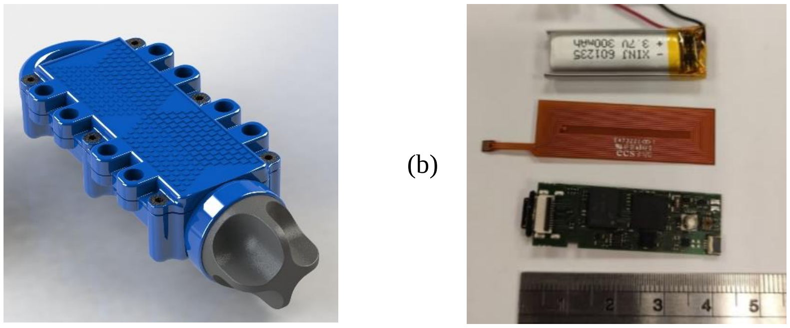

Figure 1 - (a) 3D design of the waterproof enclosure with texture for gluing to macroalgae blades and eyeholes for threading attachment lines; (b) Internal components of the sensor device: rechargeable battery, custom-designed NFC antenna, and custom-designed printed electronic circuit board with pressure, temperature, light and motion sensors.

Future Work

Future work involves incorporating data analytics and machine learning algorithms to process data internally, allowing for lower transmission requirements and enabling autonomous decision making in regards to optimum growth parameters for the seaweed species under investigation.

Acknowledgments: This work is part of the IMPAQT project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 774109. Aspects of this work were supported in part by Science Foundation Ireland (SFI) under Grant numbers 12/RC/2289-P2 (INSIGHT), 16/RC/3835 (VISTAMILK) ,13/RC/2077 (CONNECT) and 16/RC/3918 (CONFIRM) which are co-funded under the European Regional Development Fund (ERDF).

Barbier, M., Charrier, B., Araujo, R., Holdt, S.L., Jacquemin, B., Rebours. 2019. C. PEGASUS-PHYCOMORPH European Guidelines for a Sustainable Aquaculture of Seaweeds. COST Action FA1406: Roscoff, France.

Bennion, M., J. Fisher, C. Yesson, and J. Brodie. 2019. Remote Sensing of Kelp (Laminariales, Ochrophyta): Monitoring Tools and Implications for Wild Harvesting. Reviews in Fisheries Science & Aquaculture 27(2):127–141.

Chopin, T., and A. G. J. Tacon. 2020. Importance of Seaweeds and Extractive Species in Global Aquaculture Production. Reviews in Fisheries Science & Aquaculture 0(0):1–10. Taylor & Francis.

Focht, R. C., and J. S. Shima. 2020. Acceleration loggers reveal fine-scale heterogeneity in wave exposure along an open coast. Estuarine, Coastal and Shelf Science 233:106507.

Føre, M., K. Frank, T. Norton, E. Svendsen, J. A. Alfredsen, T. Dempster, H. Eguiraun, W. Watson, A. Stahl, L. M. Sunde, C. Schellewald, K. R. Skøien, M. O. Alver, and D. Berckmans. 2018. Precision fish farming: A new framework to improve production in aquaculture. Biosystems Engineering 173:176–193.

Hurd, C. L. 2000. Water Motion, Marine Macroalgal Physiology, and Production. Journal of Phycology 36(3):453–472.

Mullarney, J. C., and C. A. Pilditch. 2017. The differential response of kelp to swell and infragravity wave motion. Limnology and Oceanography 62(6):2524–2537.

Stevens, C. L., C. L. Hurd, and M. J. Smith. 2002. Field measurement of the dynamics of the bull kelp Durvillaea antarctica (Chamisso) Heriot. Journal of Experimental Marine Biology and Ecology 269(2):147–171.

Troell, M., A. Joyce, T. Chopin, A. Neori, A. H. Buschmann, and J.-G. Fang. 2009. Ecological engineering in aquaculture — Potential for integrated multi-trophic aquaculture (IMTA) in marine offshore systems. Aquaculture 297(1):1–9.