BLUE PLANET
ECOSYSTEMS
Turning sunlight into seafood™

White paper

Use of the Evo Mini to measure water level at BPE

1. Introduction

1.1. The mission of Blue Planet Ecosystems

The mission of Blue Planet Ecosystems is to turn sunlight into seafood. The company enables the production of sustainable seafood in urban and desert environments by replicating natural aquatic ecosystems in a modular and automated system called LARA - Land-based Automated Recirculating Aquaculture. By combining biology, energy engineering and computer science, Blue Planet Ecosystems decouples the production of animal protein from the ocean and from agricultural supply chains. The goal is to enable production of affordable, sustainable and healthy seafood close to the consumer on any piece of land. The LARA system replicates aquatic ecosystems in order to convert CO_2 and sunlight directly into organic, chemically unimpaired seafood using phyto- and zooplankton as intermediary stages. LARA systems consist of modular units that interact with each other as can be observed in natural aquatic ecosystems. A rendering is shown in Figure 1.1.

Figure 1.1: a LARA stack

1.2. The IBC system

The IBC system is the first large-scale prototype towards the LARA system. It consists of six IBC (intermediate bulk containers), three of which contain fish. The other three containers are used to collect waste, to contain biofilter and to aerate the system (see Figure 1.2). Most operations on the system are automated: feedings, water changes, lights, data acquisition. The control system can be operated from a website or via commands to one of the computers. It controls the different elements of the system (pumps, lights, feeders, ...), collects data from the sensors and automatically triggers actions depending on the measured values (see Figure 1.3).

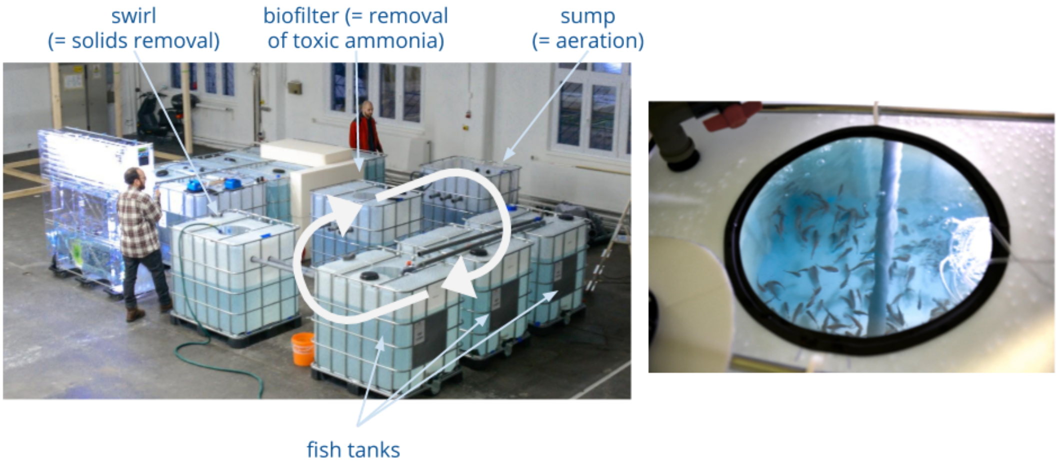

Figure 1.2: IBC system

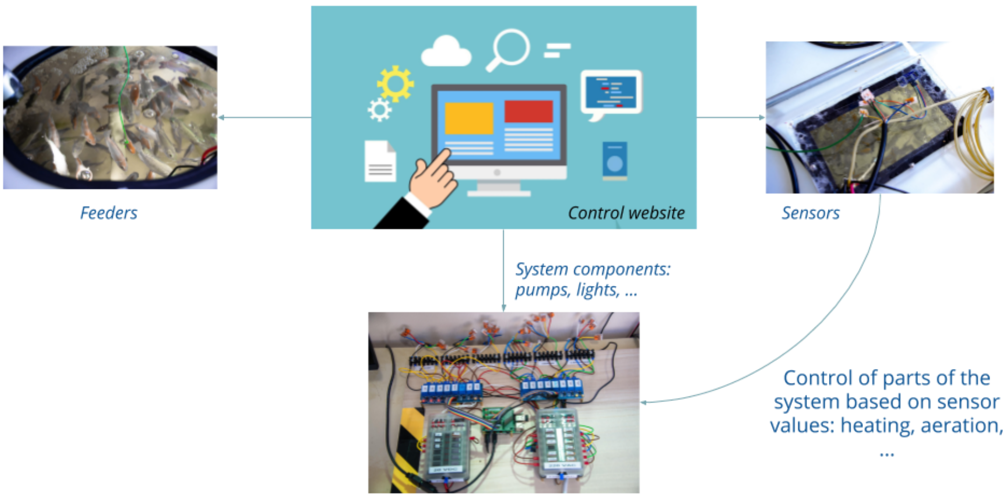

Figure 1.3: IBC control system

2. Terabee

Terabee is a French company (5km from Geneva airport) that produces sensor modules and provides sensing solutions for Smart Building, IoT, Robotics and Industry 4.0 applications. Their expertise includes Time-of-Flight distance and ranging (LiDAR), 3D depth cameras, thermal imaging, and radio-frequency positioning systems.
We were excited to find a low-cost distance sensor from their portfolio that appeared to fit out needs so well.

3. Use of the TeraRanger Evo Mini

A critical piece of information to monitor in the IBC system is the water level in each of the tanks. In normal running conditions, at least two situations can cause the water level to vary:
- if additional pumps are used to pump water out of the aeration tank, the level in the fish tank can increase;
- if a water change is performed, the level in the whole system will most likely change.
Other more problematic cases can occur. It could be that the in or outflow of one of the tanks is blocked by a fish or another object. In that case, the water level in the tank would change dramatically and could cause serious problems. It could also be that there is a leak in the system, or the pumps performing the water changes are not well calibrated and add or remove too much water. If the water level in the aeration tank becomes too low or too high, the aeration can't work properly, resulting in the fish not receiving enough oxygen. It is thus critical to continuously monitor the water level in each of the tanks in real time, and have a system that reacts quickly enough to avoid any serious problem, and minimize potential damage.
This document reports on the use of the TeraRanger Evo Mini sensor (Figure 3.1), with a goal to measure the water level in the IBC tank system over a few weeks. The sensor is placed on an arm at different distances from the water surface (as shown in Figure 3.3), and the distance is checked manually in each configuration.

Figure 3.1: the TeraRanger Evo Mini sensor

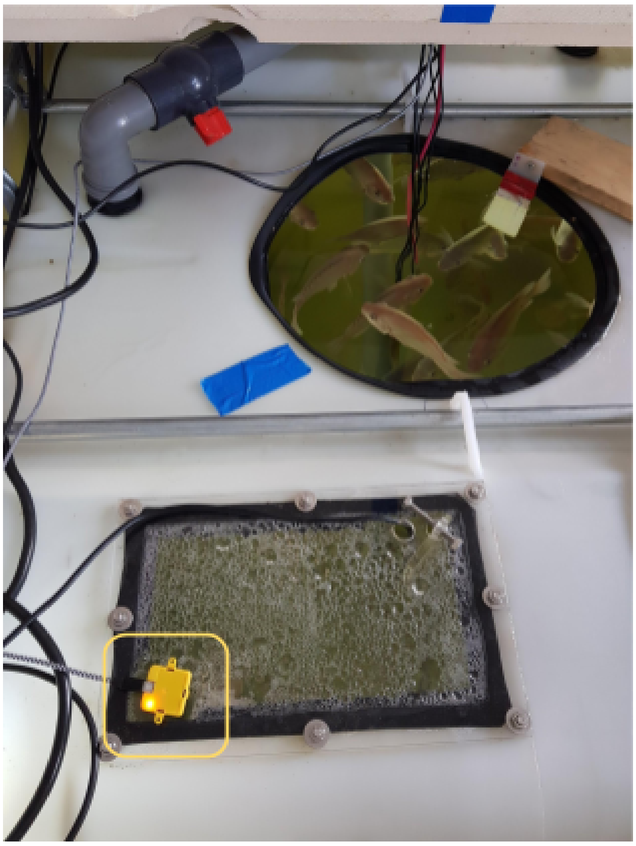

Figure 3.2: the Evo Mini sensor placed above the water surface of a fish tank

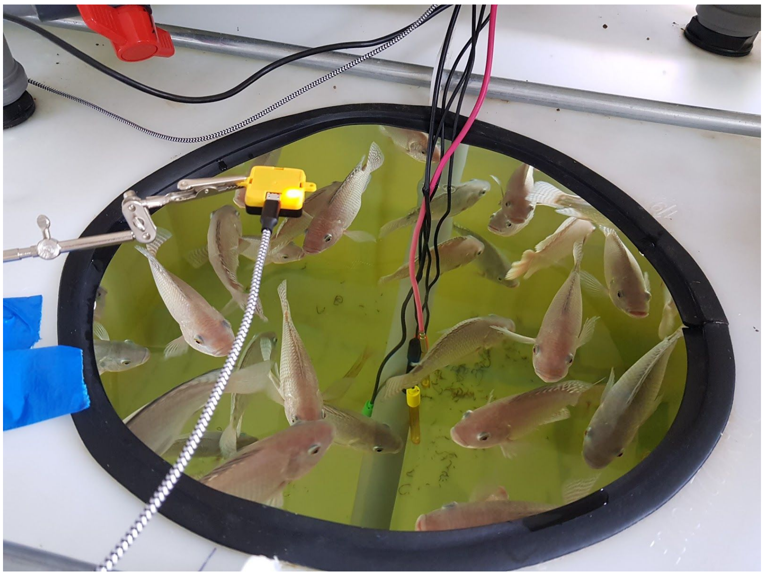

Figure 3.3: test setup

In normal conditions, the distance between the sensor and the water is expected to vary between 5 and 15 cm. For the tests, the distance between the sensor and the water was set to different values between 11 and 52 cm. Figure 3.4 shows the comparison of the values measured by the sensor and the values measured by hand. The measurements from the sensor are pretty stable over time. There

is a shift between 1 and 2 cm for each measurement, which is expected based on the specified sensor performance specifications. The expected accuracy of the sensor is 2 cm, and the differences observed are within this range. The sensor was set to measure water level at a rate of 40 Hz.
Occasionally some readings are returned as "invalid measurements", which might mean one the following: (1) water level measured closer than specified sensor minimum range, 3cm; (2) challenges detecting water surface when lots of movement occurs. Around 40 readings are taken every minute, error readings are easily filtered (discarded) and the median of the readings is kept as the final value. The same process is repeated every minute to read the water level continuously.

Figure 3.4: comparison of the sensor data and manual measurements of the water distance (in cm).

Figure 3.5 illustrates water level changes detected by the TeraRanger Evo Mni in the IBC system, captured between September 15th and September 17th, 2020. The graph clearly shows the occurrence of two events during the 2 day timeframe. On September 15th, one of the pumps experienced a failure which caused the water level to increase, which was accurately detected and registered. On September 16th, the water tank was completely emptied and fish taken for examination. Data on Figure 3.5 also clearly demonstrates that.

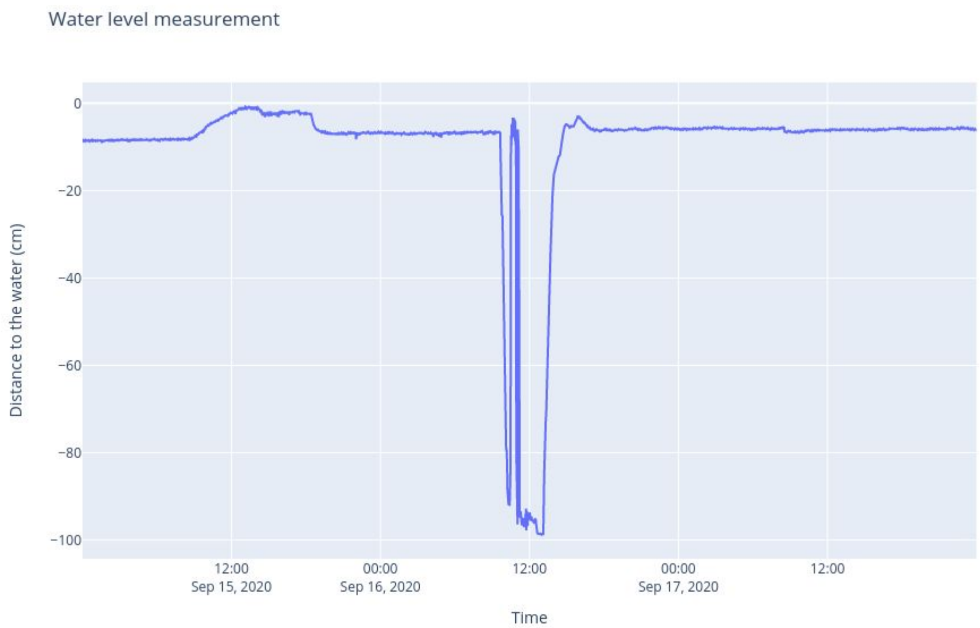

Figure 3.5: sensor data taken from September 15th until September 17th 2020 showing the water level evolution in the IBC system.

4. Conclusion

Cécile Deterre, Data scientist at Blue Planet Ecosystems: "The use of the TeraRanger Evo Mini seems well adapted for our system and our needs. Although the values measured can differ by up to 2 cm from the real distance, this accuracy is sufficient for our tank monitoring application. To add, the sensor does not seem to be affected by the high humidity environment, and it has worked reliably over a few months in our water tank system. We are looking at equipping our other tanks with Terabee sensors to obtain an even better overview of the water level in our whole system. Terabee technology is also a good candidate for a larger scale LARA prototype deployment in 2020 / 2021."