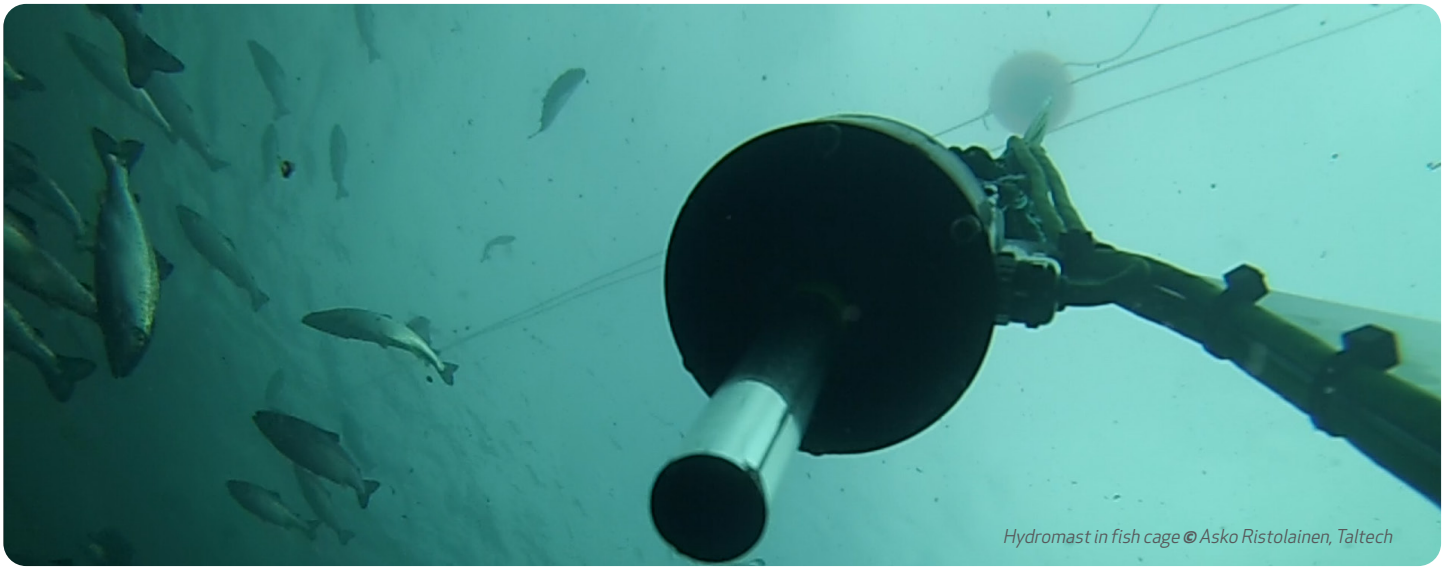
# NOVEL SENSORS TO MEASURE DISTRIBUTED FLOW IN AQUACULTURE SEA CAGES



*Hydromast in fish cage © Asko Ristolainen, Taltech*


## SUMMARY

**This innovative output concerns the development of a pilot installation of novel sensors to measure distributed flow in offshore aquaculture cages. Compared to other available technologies, this novel sensor network measures flow with high spatial and temporal resolution. This approach gives valuable, real-time information on flow circulation and patterns in offshore sea cages, which will support improved cage conditions, production and welfare for fish.**


## KNOWLEDGE NEED

*Hydromast sensor © Jeffrey Tuhtan, Taltech*

The popularity of marine finfish among consumers in recent years has led to an increased demand for marine aquaculture sites to culture these species. Offshore cages to culture marine finfish have been used successfully since the 1950s and are likely to increase in the future, given land-based and nearshore constraints. Effective monitoring systems are essential in these sea cages, to help farmers track conditions within the cages and manage these accordingly. To understand flow circulation, it is important to measure conditions such as flow patterns with high temporal and spatial resolution, as minimum flows are needed to keep the cages oxidised and clean, and to keep the fish healthy. As fish in cages are usually circulating in a rotational swarm and the cages are moving with the sea level, conventional measuring techniques such as Acoustic Doppler Velocimetry (ADV) and Acoustic Doppler Current Profiler (ADCP) are not appropriate because their precision is decreased by the background motion and also by fish swimming in the field of view of the measuring equipment. Additionally, the flow inside the cage can vary, and ADV or ADCP typically do not give information about the flow field distribution throughout the cage.

## POTENTIAL IMPACT

- The output could support increased production of marine finfish in offshore aquaculture cages to respond to the increasing global demand for seafood.
- Improved fish welfare in offshore sea cages due to a better understanding of how oxygen, parasites, waste and nutrients are transported throughout the cage.
- The output could inform the optimal design of offshore aquaculture sea cages to maximise the use of flow to keep cages oxidised and clean. This would also allow for the optimisation of maintenance intervals.

**EATiP - Strategic Research and Innovation Agenda (SRIA)** Thematic Area 4 - Sustainable Feed Production; Goal 1. To see the full list and descriptions of the thematic areas and goals, please visit: **eatip.eu/?page_id=46**

## UNDERLYING SCIENCE

A pilot installation of novel sensors was deployed in offshore aquaculture cages near the island of Frøya (Norway) to measure the flow direction and magnitude in these cages at different depths. The sensors were developed to measure flows at the seabed and near obstacles where traditional acoustic technology usually fails. The novel sensors are based on converting mechanical vibrations of sensor stems into electrical signals and thus are passive and only measure local flow field. The novel flow meter, the hydromast, uses inertial sensing by the mast and motions of the sensors' body. The two measurements in combination remove background noise. In contrast to ADCP or ADV, they are not as sensitive to disturbances of the flow (for example from swimming fish) and measure flow patterns with high spatial and temporal resolution. These sensors are also cheaper than ADVs and ADCPs. Placing several of these sensors in a network allows measurement of the distribution of flow, and consequently detection of different flows within one cage. The data are transferred wirelessly and can be integrated into existing farm management systems, resulting in real-time identification of problems. For offshore applications, power modules would need to be developed to provide power on-site.

## RESULTS

- The installation of novel sensors enables long-term, real-time observation of flow distribution in offshore sea cages.
- Measurements so far confirmed that currents are not uniform along the depth of the sea cage. The currents are stronger closer to the surface and diminish with increasing depth.

## END-USERS & POTENTIAL APPLICATIONS

**END-USER 1: Aquaculture Farmers**
**APPLICATION:** Managing health and welfare of fish in sea cages by monitoring the distribution of oxygen, parasites, waste or nutrients throughout the sea cage. Real-time updates would allow for faster identification of problems.

**END-USER 2: Aquaculture Researchers**
**APPLICATION:** Increasing the understanding of the distribution of flow in a sea cage can be used as an input to computer models predicting the distribution of oxygen, parasites, waste or nutrients in a sea cage, or directly applied to improve the condition of fish in aquaculture facilities.

**END-USER 3: Fish processors and wholesalers**
**APPLICATION:** Good quality certification of aquaculture products through the monitoring of the welfare status of the fish, increasing its appeal to consumers and potentially increased profitability.

## STATUS

**Technology Readiness Level (TRL) 5 – technology validated in relevant environment**

- For future long-term deployments, better ruggedised cables and data loggers are needed.
- A manuscript is currently being prepared for publication.

## AT A GLANCE

**TITLE:** Novel sensors to measure distributed flow in offshore aquaculture sea cages
**KNOWLEDGE TYPE:** Publication
**WHERE TO FIND IT:** taltech.ee/en/biorobotics
**STATUS:** Publication in preparation
**TNA FACILITY USED:** SINTEF ACE, Norway
**CONTACT DETAILS:** Maarja Kruusmaa, maarja.kruusmaa@taltech.ee; Asko Ristolanen, asko.ristolainen@taltech.ee. Tallinn University of Technology, Estonia
**PATENTS OR OTHER IPR EXPLOITATIONS:** US2018023986A1

Designed and developed by AquaTT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 652831. This output reflects the views only of the author(s), and the European Commission cannot be held responsible for any use which may be made of the information contained therein.