# Exploring novel DNA-based autonomous platform for marine water monitoring: Opportunities for petroleum and aquaculture industry

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## Why do we need to explore new means to monitor the environment?

Petroleum and aquaculture industries represent an important source of income for Norway. The sustainability of these industries is dependent on several factors, including mitigating environmental footprint, to protect the environment and contribute to societal acceptance. Today, these industries are facing several environmental challenges. Oil and gas activities are moving to oceanic regions posing larger technical, logistical and environmental challenges, particularly related to the detection of accidental discharges in the Northern areas. The aquaculture industry is facing several environmental issues, including disease, salmon lice invasions, escape of farmed fish and fish welfare in close systems. Meeting these challenges require novel approaches and innovative means of collecting environmental data at the correct temporal and spatial scale. *These challenges can be addressed by combining state-of-the art environmental genomic techniques and genosensors, like the ESP (Environmental Sampling Processor) for real-time monitoring.*

## What is the ESP technology?

The ESP instrument is a stand-alone, fully autonomous laboratory packed inside a pressure housing (See ESP photo illustration, figure 1) deployable at sea. Often referred as a "lab in a can", it is "taking the laboratory into the ocean" to analyze environmental signatures in near real-time and can do several operations at sea that include sample acquisition and processing, analyte detection, and telemetry of that data to shore (Scholin, 2013). This instrument performs normal laboratory methods that usually require several experts and technicians and a ship for sample acquisition. Three real-time detection methods are currently available on the ESP: they are referred as sandwich hybridization (SHA) and quantitative PCR (qPCR) for specific DNA/genes, and competitive enzyme-linked immunosorbent assay (ELISA) for toxins and proteins. qPCR assays compatible with ESP have been tested successfully for oil degrading-bacteria (Krolicka et al., 2014) The ESP also supports sample archival for other detailed analysis in the laboratory once the instrument is recovered. The ESP technology is well beyond the proof-of-concept, and is also available commercially. More technical information and a video of how ESP works can be obtained at http://www.mbari.org

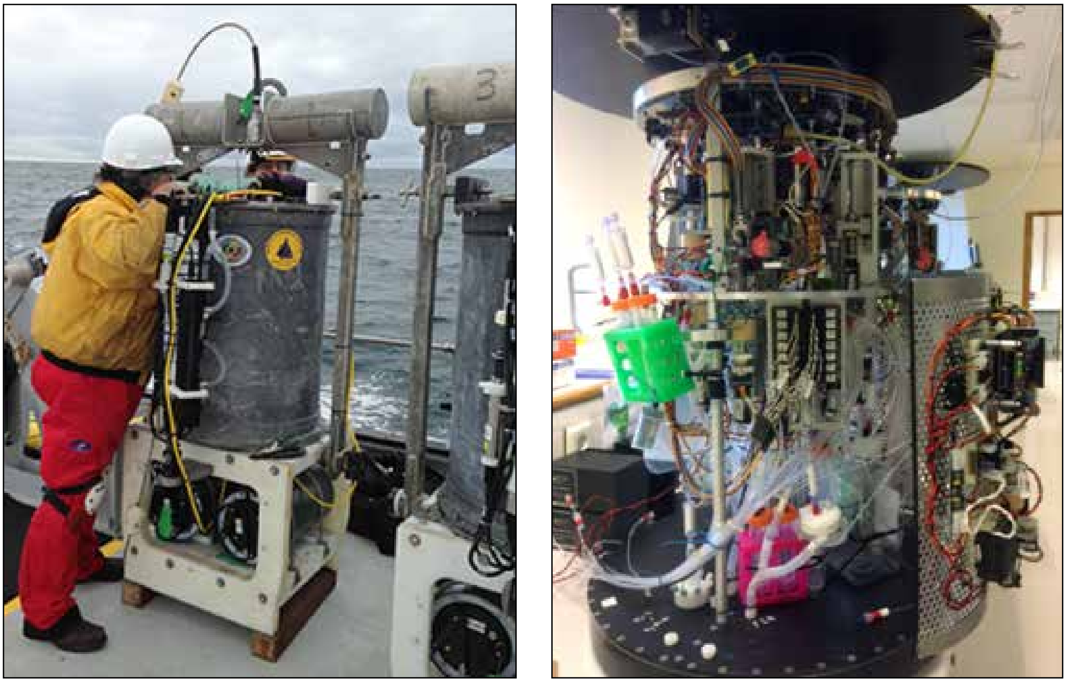

*Figure 1. Left: ESP with underwater casing and battery package ready for field deployment, Photo: Holly Bowers © 2014 MBARI; right: ESP on the bench without casing for laboratory tests, Photo: IRIS*

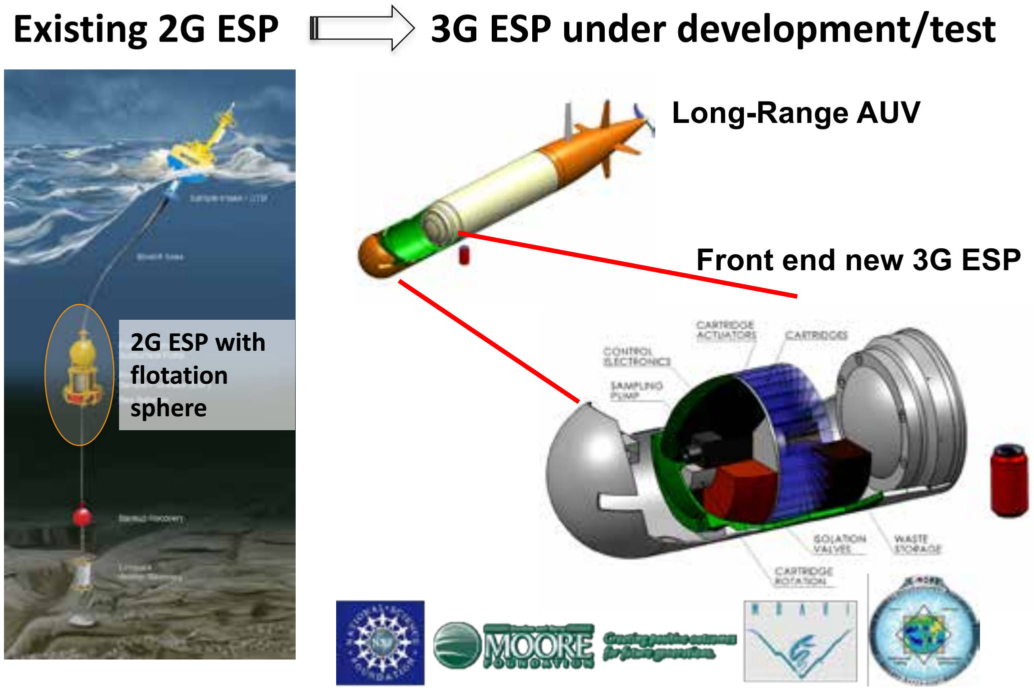


*Figure 2. ESP development trajectory: from the existing 2G ESP (here on a mooring) used for IRIS RCN-funded projects to the future 3G ESP on a long-range AUV (currently developed and tested at MBARI).*

## How can DNA-based approaches and ESP help petroleum and aquaculture industries?

Industries need to use innovative and robust means to measure the potential impact of their activities on the environment that align with environmental regulations and commitment. Currently, this requires a heavy infrastructure and a costly cumbersome process from sampling to communication of the results to decision-makers and end-users. Areas where DNA-based approach and tools can potentially improve today's procedures for the monitoring of petroleum and aquaculture industries include:

- Biodiversity assessment in sediment and water
- Routine monitoring using bioindicator species associated to changes of the environment from industry activities
- Search for rare, difficult to collect, difficult to identify taxonomically and invasive species
- Detection of toxic/disease agents including algae, parasites and pathogens

## Examples of applications

In Ismotool (In-situ molecular-based monitoring: a tool for tackling the operational and environmental challenges of aquaculture), specific DNA-based assays and protocols will be developed in the laboratory first, adapting the ESP to recognize (1) fish pathogens (amoebic gill disease AGD) and parasites (salmon lice) in the water column, and - (2) escaped farmed fish (eDNA of Atlantic salmon and rainbow trout). Experimental work will then move to the field, to test the operation of the device at an aquaculture farm. The Genomape (Implementing gene-based assays on a robotized genosensor for environmental surveillance in offshore marine operations) project is exploring further gene-assays and the capacity of the ESP to identify oil-degrading bacteria using current and future ESP analytical units like surface plasmon resonance (SPR). Both projects are led by IRIS and funded by the Research Council of Norway. Partners include both Norwegian and US institutes.

## Conclusions/Closing remarks

Industries need to find innovative means to carry out environmental quality assessments associated with their activities in relation to guidelines and needs demanded by government agencies. This requires new tools for a cost-effective measurement of key agents or species, and their response to environmental changes over different time scales. Platforms like ESP can help to cope with these environmental challenges. An overall objective of the above-mentioned projects is to demonstrate that DNA-based assays developed in the laboratory towards different environmental targets are fully transferable to the ESP instrument and that the device can be used to perform in-situ monitoring for routine detection and provide same day notifications to end-users.

A new generation ESP is under development, and will be integrated in a Long-Range Autonomous Underwater Vehicle (LRAUV) to provide an autonomous *mobile platform* for real-time molecular analysis at sea (figure 2). When fully realized, this new generation of instruments will transform the future means of conducting monitoring and will strengthen the vision of an environmentally-sustainable industrial exploitation of marine waters for societal benefit.

## References

Scholin C. A. (2013) Ecogenomic Sensors. In: Levin S.A. (ed.) Encyclopedia of Biodiversity, second edition,Volume 2, pp. 690-700. Waltham, MA: Academic Press.

Krolicka A., Boccadoro C., Mæland M., Preston C., Birch J., Scholin C., and Baussant T. 2014 Detection of oil leaks by quantifying hydrocarbonoclastic bacteria in cold marine environments using the Environmental Sample Processor. *Proceedings of the 37th AMOP Technical Seminar on Environmental Contamination and Response*, Canada.