Marine sensors for the 21st Century

Why?

The marine environment plays an essential role in the earth's climate as well as providing resources, recreational opportunities and acting as a vital transportation route. However the inherent vastness of the oceans means that our ability to monitor the health of this important system remains limited. Measuring the physical, chemical and biological properties of the oceans enables us to understand e.g. the effects that climate change will have on fisheries, how pollutants move through the environment and how the environment changes over varying temporal and spatial scales.

Overall aim of the project

This project will provide a significant advance in the ability to measure crucial biogeochemical parameters. Innovations in analytical sciences, new techniques for microfabrications, cost effective mass production and state of the art sensor technology will be combined to produce a modular sensor system that can be deployed on many platforms. The system will measure a number of parameters including nutrients, micronutrients, the oceanic carbonate system, oxygen, nitrous oxide and chlorophyll at high precision and accuracy. A variety of sensor technologies: lab-on chip, micro electrochemical, optode and optical will be employed within the sensor system.

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Our Project Partners

The project brings together 12 European partners from academia and industry. Each partner has expertise in different particular aspects of research, development, production and commericalisation of sensor technology. Bringing together these experts allows SenseOCEAN to capitalise on the best available technologies and practices.

- Natural Environment Research Council [National Oceanography Centre (NOC), British Oceangraphic Data Centre (BODC)], UK
- Aarhus University, Denmark
- Alfred-Wegener-Institut Helmholtz Zentrum für Polar und Meereforschung, Germany
- CNRS-LEGOS, France
- Max-Planck-Gesellschaft zur Förderung der Wissenschaften, Germany
- Graz University of Technology, Austria
- University of Southampton, UK
- Chelsea Technologies Group, UK
- Unisense A/S, Denmark
- Pyro Science, Germany
- nke Instrumentation, France
- T. E. Laboratories, Ireland

Project Title
Marine sensors for the 21st Century

Funding
European Commission FP7 Environment Ocean 2013.2

EU Contribution
€5.9 million

Start Date
1st October 2014

Duration
48 months

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How will we achieve our aims?

Sensor Production

Design and adaptation for manufacturing and market
There is a key focus on the value engineering aspects of the pre-production sensor prototypes, to ensure the sensor designs are suitable for higher volume manufacture, while minimising costs and optimising sensor performance.

Testing and Validation
Detailed testing of each sensor technology and integrated sensor packages will take place in the laboratory (synthetic and real seawater at high pressure and low temperature) and in the environment.

Production and Integration
The systems, resource and supply routes required to manufacture large numbers of each sensor and the integrated sensor packages will be set up. Qualification tests will be developed to ensure that the sensors delivered for testing and demonstration are working to expected specifications.

Demonstration
To promote sales of the sensor and sensor packages, it is important to demonstrate them in relevant environments. They will be deployed in shallow water, continental shelf waters and deep sea waters via landers, cabled observatories deep sea observatories, autonomous underwater vehicles (AUVs) and water column moorings.

Underpinning technology

Development of Core Technologies
Common standards that can be adopted across all the sensors will be assessed or developed. This includes electronics, data management, communications systems, connectors and interfaces, mechanical systems, resource (power, reagents) management and bio-fouling protection.

Analytical Technologies
Individual sensors based on electrochemical, optode, lab on a chip and optical sensor technologies will be developed. Some biogeochemical species will have duplicate sensors based on one or more technologies. This is a deliberate strategy to cover different application requirements and reduce overall project risk.

Progress highlights to date

Development of Core Technologies
- Standards for the electronics have been adopted and communicated to other sensor developers outside SenseOCEAN to encourage wider adoption throughout the sensor community.
- A communication module has been designed and prototyped and the protocol for data exchange between the communication module and the acquisition CPU's has been described.
- The way sensors will transmit their identity and metadata has been decided and a web user interface is in preparation.
- Mechanical layouts for connectors have been determined.
- Materials for reagent containers have been assessed.

Design and adaptation for manufacturing and market
- Optode system housing construction evaluated and first designs finished.
- First batch of optode sensor caps manufactured.
- Multi-parameter optical sensor layout developed, electronic circuits currently being developed and prototyped.
- New production method being tested for electrochemical sensors.
- For lab-on-chip sensors, improved pump design has resulted in enhanced reliability and sensor lifespan.
- Automated production of lab-on-chip sensors (embossing, injection moulding) has been investigated

Production and Integration
- Common manufacturing approaches, materials and supply routes identified to produce sensor-suite and suite-platform interfaces.
- Optoelectronics PCBs for optode and Modbus interface have been designed to minimize production costs
- Protocol between communication and interface board (EMAP) established. PC simulator for assessing this protocol developed.
- A prototype including mechanics and amplification electronics has been developed for the N_2O and CO_2 electrochemical sensors.
- Manufacturing methods for the optoelectronic readout units assessed to reduce overall costs of the sensors.
- Lab-on-chip reagent containers evaluated and best option in terms of cost and functionality decided. Mechanical connectors fabricated.
- Compilation of best practices in environmental qualification methodology is underway.

Analytical Technologies
- The assembly of the first in situ electrochemical prototype to measure silicate is in progress.
- Square wave voltammetry method has been optimized to detect phosphate concentration in seawater and is currently in adaptation for laboratory prototype.
- Multi-parameter fluorometer design specification completed, optimisation work has begun.
- Significant advances in sensitivity of electrochemical sensor for N_2O due to successful removal of H_20 and O_2 interferences. CO_2 sensors progressing.
- pH, CO_2 and ammonia optode sensors are all on track, prototypes of the optoelectronics have been built and tested, sensor design and materials have been optimised.
- Lab-on-chip sensors capability extended to Ammonia and DIC. Analytical performance for all lab-on-chip parameters being optimised and advances made in further miniaturisation.

Testing and Validation
- Assembly, waterproof and pressure tests of electrochemical sensors are in progress. First in situ deployments in control environment (laboratory tests) are planned for beginning of 2016 followed by testing in the field by spring 2016.
- Multi-parameter fluorimetry system deployed in Arctic, data successfully collected.
- pH, pCO_2 and pO_2 optodes tested in Northern Baltic Sea, profiles recorded for each parameter.
- Initial testing of Lab-on-chip sensors done, extensive pressure testing successfully completed. Nitrate sensor deployed in harbour (1yr) and on sea gliders

Demonstration
- Very early phase of project for demonstration work.
- Initial compilation of test platforms completed, including technical and logistical requirements for deployment of sensors.
- Multi-parameter fluorometer already deployed at underwater node on Spitsbergen