7th EuroGOOS conference
2nd Announcement
OPERATIONAL OCEANOGRAPHY FOR SUSTAINABLE BLUE GROWTH

Multifunctional and interoperable sensors for a changing ocean

Ayoze Castro (1), Carlos Barrera (1), Christoph Waldmann (2), Johan Gille (3), Jean-François Rolin (4), Joaquín del Río (5), Oliver Zielinski (6), Patrice Woerther (4), Lars Golmen (7), Nils Roar (8) & Eric Delory (1) for the NeXOS Consortium

(1).- The Oceanic Platform of the Canary Islands, Spain ; (2).- University of Bremen, Germany; (3).- Ecorys, Netherlands; (4).- French Institute for the Exploitation of the Sea, France; (5).- The Polytechnic University of Catalonia, Spain; (6).- University of Oldenburg, Germany; (7).- Norwegian Institute for Water Research, Norway; (8).- Research Environmental Centre, Norway

NeXOS has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No 614102

Summary

The NeXOS project is developing new multifunctional sensor systems supporting a number of scientific, technical and societal objectives, ranging from more precise monitoring and modelling of the marine environment to an improved management of fisheries. Several sensors will be developed, based on optical and passive acoustics technologies, addressing key environmental descriptors identified by the European Marine Strategy Framework Directive (MSFD) for Good Environmental Status (GES). Two of the new sensors will also contribute to the European Union Common Fisheries Policy (CFP), with a focus on variables of interest to an Ecosystem Approach to Fisheries (EAF). An objective is the improved cost-efficiency, from procurement to operations, via the implementation of several innovations, such as multiplatform integration, greater reliability through better antifouling management, greater sensor and data interoperability and the creation of market opportunities for European enterprises. Requirements will be further analysed for each new sensor system during the first phase of the project. Those will then be translated into engineering specifications, leading to the development phase. Sensors will then be tested, calibrated, integrated on several platform types, scientifically validated and demonstrated in the field. Translation to production and broad adoption are facilitated by participating industry.

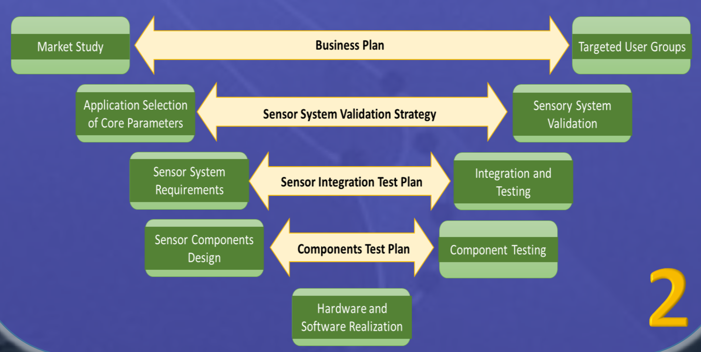
Requirements Framework

Requirements are difficult to generalize as observations are carried out from different platforms (ships, moorings, underwater vehicles, buoys) in different zones (coastal zones, ocean margins, and open oceans) and on different spatio-temporal scales. Thus there are a lot of diverse and potentially conflicting requirements that should be addressed and balanced. A **3 steps approach** has been taken as part of NeXOS in order to be used as baseline for sensor requirements :

Step1: to **define user scenarios** that are already in practice for ocean observations: **1**

Scenario	Short Description	Sensor capability	Platform
Observations for sustainable fisheries	Using fishing vessels for oceanography and better management of fisheries, installing sensors on the fishing gear	Physical, chemical, and biological	Fishing vessesl and nets
Soundscapes monitoring for GES	Measuring noise and presence of species from several platform types	Physical	Gliders, floats and buoys
Carbon Sequestration	Quantifying the complete carbon system in seawater	Physical, chemical, and biological	Ferrybox on vessels
Hydrocarbon observations	Discovering a small/medium seafloor leak of gas or oil	Physical, chemical, and biological	Gliders, floats, wave gliders

Step 2: to include the requirements definition as **a core part of the system engineering approach** in NeXOS which addresses the end-to-end process of defining, developing, and testing/validation of the system performance. Steps in the process are illustrated in a system engineering "V" diagram, shown below.



2

Step 3: to organize a **series of short workshops** focused on three classes of inputs: sensor designers and manufacturers; scientists and users; system operators and information repository leaders to get inputs for these scenarios. **3**

Preliminary results of inputs from NeXOS Requirement Workshops

- Sensors should be fit for purpose or adaptable to purpose consistent with cost and operational constraints. For certain applications like long-term measurements higher accuracies are needed
- The NeXOS observation system framework should enable and facilitate optimized use of existing sensors and the development and incorporation of new sensors
- Sensors shall be robust and long-term stable enabling lower maintenance costs
- Routine and systematic sensor calibration shall be supported where feasible and consistent with platform alternatives
- Sensors should permit multiple use of collected sensor information
- Sensors should be adaptable to inclusion on multiple classes of platforms through standardized hardware and software interfaces, preferably using plug-and-play formats
- Sensors shall store essential information for instance about the calibration status as part of their own electronic system
- Technology Readiness Level will be defined and assessed in a traceable manner.
- Common standards should be used for inputs, outputs and interfaces unless unavailable
- Physical configurations should allow rapid replacement of sensors on platforms
- Sensors shall be web-accessible
- Biochemical parameters/ measurements are of growing importance.
- Single use sensors should have a low priority

NeXOS Innovations

Optical Sensors

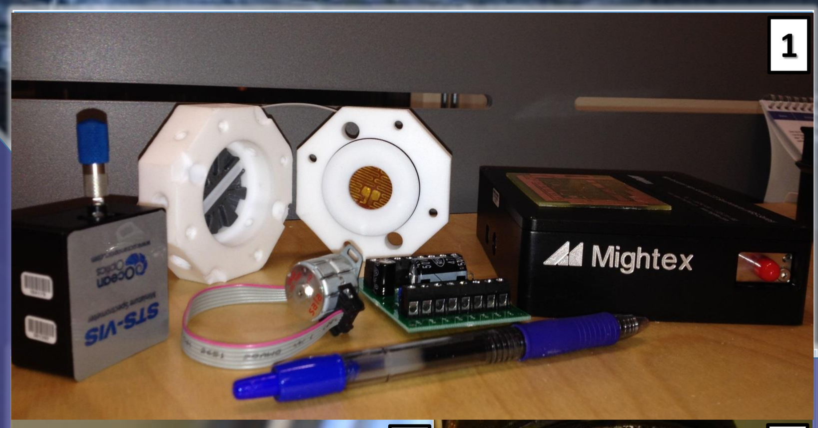
To meet the requirements of increasing environmental awareness, optical techniques offer a good opportunity for a wide range of application requiring spatio-temporal measurements. Within NeXOS a number of innovative, compact and cost efficient multifunctional sensor systems for optical measurements are under development:

Carbon sensor system: For the understanding and quantification of the carbon system in the ocean, a minimum of two of the following variables need to be assessed; pH, total alkalinity (AT), inorganic carbon (CT), carbonate ion (CO_3^{2-}), and the partial pressure of CO2 (pCO2). **NeXOS innovations:** a new compact autonomous sensor system combining high precision sensing of pH, AT, and the carbonate ion together with a membrane-based pCO2 sensor will be developed. This system should offer reliable measurements under varying conditions in terms of stability and precision to allow long-term observations without time-consuming maintenance **(Figure 1)**.

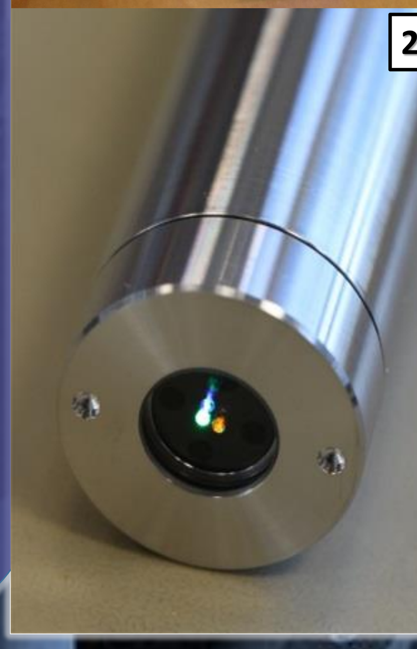
Matrix-fluorescence sensor: Fluorescence is a sensitive and very specific technique that is widely available as single wavelength fluorometers for in situ applications. The development of multi-wavelength fluorescence sensors has gained interest due to a broader application range while limiting the integration costs. **NeXOS innovations:** Inspired by the success of laboratory based excitation-emission-matrix fluorescence spectroscopy (EEMS), NeXOS will proceed from multi-wavelength to matrix-fluorescence in situ sensing **(Figure 2)**.

Hyperspectral cavity absorption sensor: Hyperspectral light absorption measurements provide information about relevant water constituents such as dissolved organic matter, suspended matter and phytoplankton. Combined with a spectral analysis, a discrimination of different water constituents (including many parameters of water quality assessment) and phytoplankton taxonomic groups is made possible. **NeXOS innovations:** an optimization of the Online Hyperspectral integrating cavity absorption meter (OSCAR, TriOS GmbH, Germany) to fit the needs of a continuous measuring flow-through system (ft-PSICAM) is planned **(Figure 5)**.

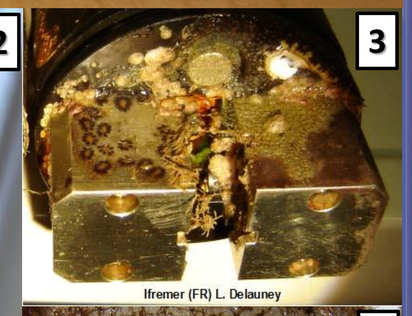
1



2



3



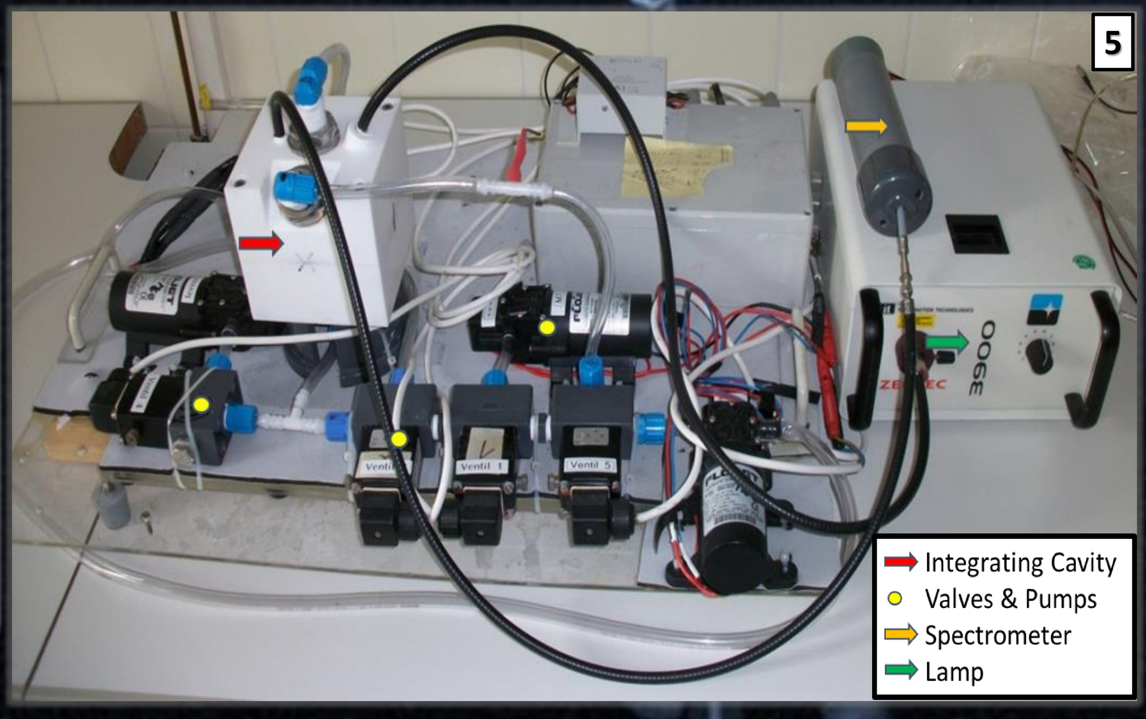
4

Antifouling

Innovative Biofouling Protection: NeXOS proposes an innovative scheme using active protection, controlling biocide generation with a biofilm sensor. This will have high efficiency for optical sensors, low power consumption and negligible environmental impact. The scheme will involve the application of a conductive coating on the transducing interfaces of the sensors. This coating will allow micro-surface-electrolysis, and very little biocide will be produced over the entire sensor.

Figures 3 and 4:Biofouling in optical sensors

5



Passive Acoustics Sensors

The MSFD and the increasing need to monitor underwater noise for Environmental Impact Assessments of marine activities have increased demand for cost-effective multipurpose acoustic instrumentation. Nevertheless, it has been hard to meet the demand for acoustic measurements because of the cost of marine acoustic sensors and acoustic data processing, driven, in part, by operational costs of labor.

NeXOS innovations: a novel, cost-efficient compact and integrated sensor system for passive acoustic measurements is under development focused on the pre and post-processing of acoustic information and improved transducer integration, reducing size and cost while increasing functionality **(Figure 6)**.

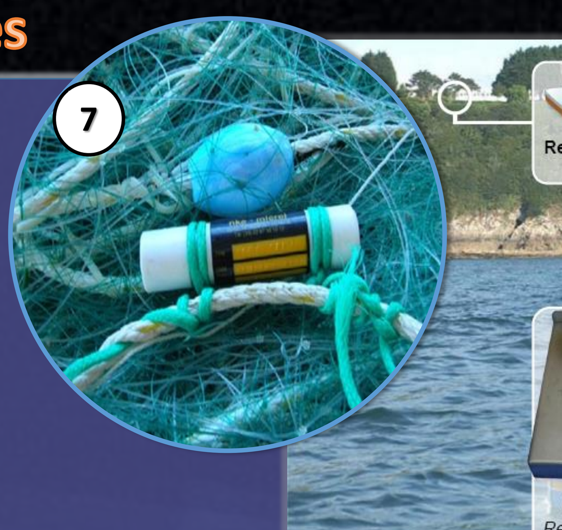
6

Ecosystem Approach to Fisheries

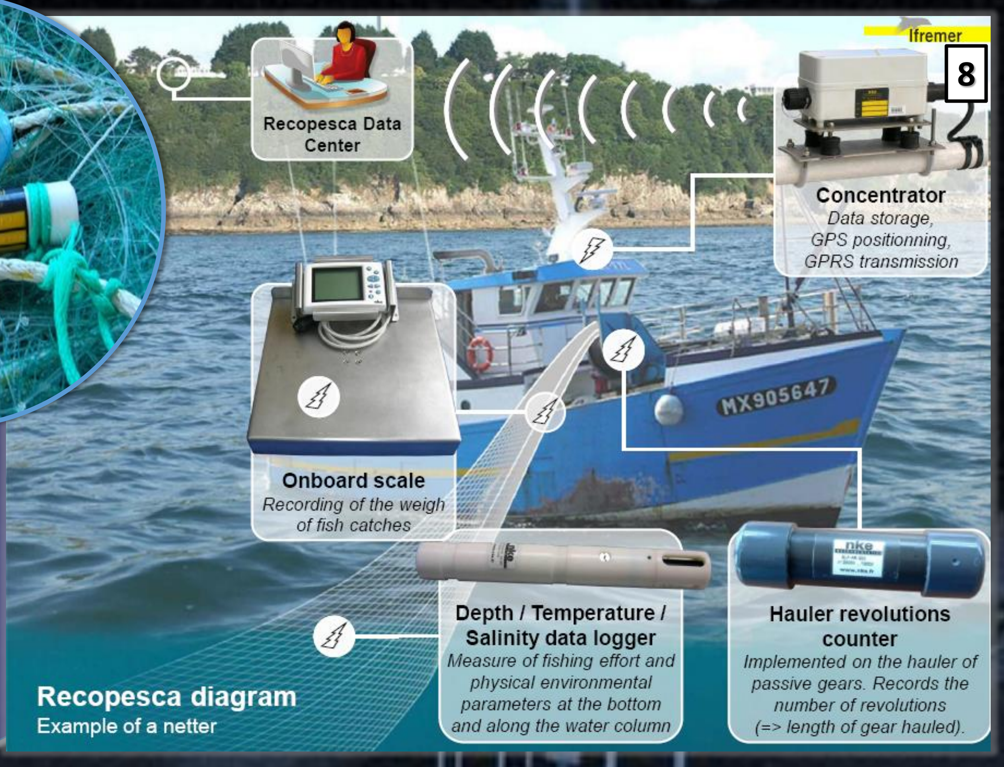
Wireless miniaturized sensors are of interest to fisheries managers, fishermen, fisheries research institutes and oceanographers. Faced with the lack of data to assess precisely the spatial distribution of catch and fishing effort and for the environmental characterization of the fishing area, IFREMER has implemented the **RECOPESCA project**. The project consists in fitting out fishing vessels with sensors on fishing gears **(Figure 7)** and aboard the vessel itself **(Figure 8)**. These sensors record data on fishing effort and physical parameters such as depth, temperature, salinity or turbidity.

NeXOS innovations: prototype sensors for oxygen and chlorophyll measurements are under development for their applications to fish population assessments. These parameters have been reported as Essential Ocean Variables by the operational oceanographic community.

7



8

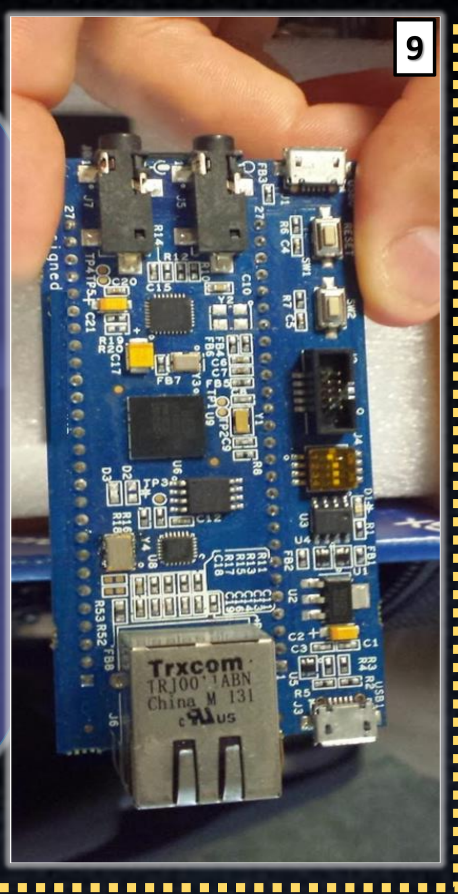


Smart Sensor Interface & SWE

The variety of systems, sensors and platform types calls for a standard approach to collect data from instruments. This is the objective of **the SEISI (Smart Electronic Interface for Sensors and Instruments) (Figure 9)** for the instrument side, and the NeOS Sensor Web architecture for the client side.
SEISI will employ a set of standards and functionalities that the NeXOS instruments will incorporate in order to harmonise the way of accessing instruments data and metadata. Manufacturers, observatory operators and platform designers will be encouraged to apply this set of standards and functionalities.

On the user side, a driving factor behind the design of the Sensor Web architecture is the provision of a cost-efficient solution that allows data providers to integrate their sensors and sensor data easily into a web-based infrastructure. This aim of a cost-efficient approach is achieved through several characteristics of the architecture: Re-Usability, Interoperability (through the use of international standards; **Sensor Web Enablement**) and Open Source.

9



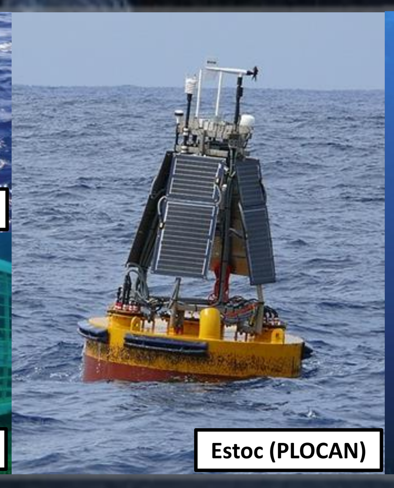
Integration, Validation & Demonstration

NeXOS promotes a **multi-platform strategy** shifting traditional sensor use on a dedicated platform to the use of multifunctional sensors on several types of platforms. The innovative aspects of NeXOS include the **platform integration process** and novel methods of sensor management including two-way communication (SEISI smart sensor interface) and direct data dissemination (Sensor Web) to end users. NeXOS will **demonstrate** the new sensor developments in real operational scenarios on various platforms.


Havila Shipping (RUNDE)


Sailbuoy (CMR)


Obsea (UPC)


Estoc (PLOCAN)


SeaExplorer (ACSA)


Provor (NKE)