Title	COMMON SENSE: Cost-effective sensors, interoperable with international existing ocean observing systems, to meet EU policies requirements
Authors	Barton, John;Ni Cheallachain, Cliona;Magni, Paolo;Cleary, John;Vilallonga Gamboa, Javier;Piwowarczyk, Joanna;Pizarro, Carles;Moynihan, Emma;Sáez Zamora, Jose Alberto;Salat, Jordi;Fanjul, Pablo;Grozdanov, Anita;Confalonieri, Fabio;Lassoued, Yassine;Heckmann, Saskia;Challiss, Mike
Publication date	2014-01-01
Original Citation	Barton, J., Ni Cheallachain, C., Magni, P., Cleary, J., Gamboa, J. V., Piwowarczyk, J., Pizarro, C., Moynihan, E., Zamora, J. A. S., Salat, J., Fanjul, P., Grozdanov, A., Confalonieri, F., Lassoued, Y., Heckmann, S. and Challiss, M. (2014) 'COMMON SENSE: Cost-effective sensors, interoperable with international existing ocean observing systems, to meet EU policies requirements', International Journal on Smart Sensing and Intelligent Systems, 7(5), pp. 1-6. doi: 10.21307/IJSSIS-2019-114
Type of publication	Article (peer-reviewed)
Link to publisher's version	10.21307/IJSSIS-2019-114
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Download date	2025-07-30 18:24:33
Item downloaded from	https://hdl.handle.net/10468/13263

University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

COMMON SENSE

Cost-Effective Sensors, Interoperable With International Existing Ocean Observing Systems, To Meet EU Policies Requirements

John Barton
Tyndall National Institute
University College Cork
Cork, Ireland
john.barton@tyndall.ie

Cliona Ni Cheallachain
AquaTT
Dublin, Ireland

Paolo Magni
Consiglio Nazionale delle Ricerche (CNR)
Oristano, Italy

John Cleary
Dublin City University
Dublin, Ireland

Javier Vilallonga Gamboa
Barcelona Foundation for Ocean Sailing (FNOB)
Barcelona, Spain

Joanna Piwowarczyk
Institute of Oceanology Polish Academy of Science
Sopot, Poland

Carles Pizarro
SnellOptics
Terrassa, Spain

Emma Moynihan
TE Laboratories (TelLab)
Tullow, Ireland

Jose Alberto Sáez Zamora
Leitat Technological Centre
Terrassa, Spain

Jordi Salat
Consejo Superior de Investigaciones Científicas (CSIC)
Barcelona, Spain

Pablo Fanjul
DropSens
Oviedo, Spain

Anita Grozdanov
FTM-UCM
Skopje, Macedonia

Fabio Confalonieri
Idronaut
Brugherio, Italy

Yassine Lassoued
Coastal and Marine Research Centre, UCC
Cork, Ireland

Saskia Heckmann
SubCTech GMBH
Kiel, Germany

Mike Challiss
Cefas
Lowestoft, United Kingdom

Abstract—**COMMON SENSE is a new project that supports the implementation of European Union marine policies such as the Marine Strategy Framework Directive (MSFD) and the Common Fisheries Policy (CFP). The project, which was launched in November 2013, is funded by the EC Seventh Framework Programme (FP7) and has been designed to directly respond to requests for integrated and effective data acquisition systems by developing innovative sensors that will contribute to our understanding of how the marine environment functions. COMMON SENSE is coordinated by the Leitat Technological Centre, Spain, and its consortium brings together 15 partners from seven different countries, encompassing a wide range of technical expertise and know-how in the marine monitoring area.**

Keywords-component: Smart environmental monitoring, cost effective sensors, Marine Strategy Framework Directive

The COMMON SENSE project has received funding from the European Union's Seventh Framework Program (Ocean 2013-2) under the grant agreement no 614155

I. INTRODUCTION

Marine ecosystems are integral to key environmental functions which support life on Earth, including climate regulation, prevention of erosion, and absorption of carbon dioxide. The oceans also contribute to economic activities resulting in prosperity, social well-being and quality of life. However, many marine environments, including some of those in EU marine territories, face increasing challenges, such as loss of biodiversity and habitats, pollution, and the impacts of climate change. For Europe, increasing environmental interest and awareness in both public and private sectors is a strategic objective for sustainable development and for ensuring continuity of economic activities. To achieve this, and to

improve EU competitiveness, new technologies and methods for monitoring the marine environment are required.

The COMMON SENSE project will contribute to supporting the implementation of the Marine Strategy Framework Directive (MSFD) [1], and other EU policies such as the Common Fisheries Policy and the Integrated Maritime Policy [2,3], providing robust, easily usable across several platforms, cost-effective, multi-functional new sensors in order to detect different reliable in-situ measurements on key parameters on good environmental status (GES) of marine waters by means of methodological standards. The project will focus on increasing availability of standardized data on eutrophication, marine litter, contaminants, underwater noise and other parameters (e.g. temperature, pressure, pH and pCO_2) according to MSFD descriptors 5, 8, 10 and 11.

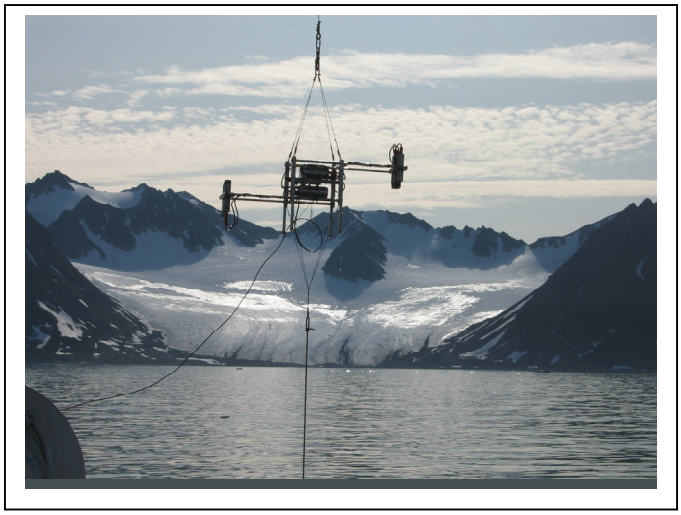

Figure 1. Typical marine monitoring deployment, courtesy IOPAN

II. MARINE STRATEGY FRAMEWORK DIRECTIVE

The COMMON SENSE project activities will be mainly based on the Marine Strategy Framework Directive (2008/56/EC) (MSFD) [1] and the COMMISSION DECISION of 1 September 2010 [4] on criteria and methodological standards on good environmental status of marine waters. Member States must provide a programme of cost-effective measures, among which automatic, low maintenance and cost-effective sensors are key tools in order to achieve MSFD monitoring objectives. Other EU legislation and initiatives will be addressed e.g. Common Fisheries Policy, Integrated Maritime Policy.

Conventional underwater sampling and research has assumed the cost of traditional sampling methodologies (sample return and/or scientist onsite), which tend to be expensive and in addition are not sustainable. Therefore, the use of in-situ new generation sensors as well as the integration of these sensors in different marine platforms will be necessary in order to reduce sampling and monitoring costs.

III. COMMON SENSE METHODOLOGY

The COMMON SENSE methodology can be grouped into four key phases:

- R&D basis for cost-effective sensor development
- Sensor development, sensor web platform and integration
- Field testing
- Knowledge and Technology transfer, dissemination & exploitation of results

Phase 1 aims to create a solid R&D basis in relation to new generation technologies and interoperability with observing systems in order to achieve successful sensor development and integration in phase 2.

Phase 2 aims to provide precompetitive prototype multifunctional sensors for in-situ monitoring focused on eutrophication (nutrients), marine litter (microplastics), contaminants (heavy metals) and underwater noise.

Phase 3 will deploy precompetitive prototypes at chosen platforms (e.g. research vessels, oil platforms, buoys and submerged moorings, ocean racing yachts, drifting buoys). This WP will test the operability of the sensors developed and will verify whether the transmission of data is properly made, correcting deviations.

Phase 4 will ensure effective external communication, dissemination and optimal knowledge transfer of COMMON SENSE results and applications leading to optimal exploitation of its research outputs [5].

A. Eutrophication,

Concerning descriptor 5 of the MSFD on human-induced eutrophication - the over-enrichment of water by nutrients such as nitrogen or phosphorus [6], the project will focus on the development of sensors for the detection of nutrients by utilising well-established colorimetric chemistries for phosphate, ammonia, nitrate and nitrite. Eutrophication is an extended problem within European marine regions. According to HELCOM, the whole Baltic Sea except the open Bothnian Bay and certain coastal areas in the Gulf of Bothnia were affected by eutrophication during 2003-2007 [7]. In a spatial

Figure 2. This divided body of water shows the remarkable difference between mesotrophic (moderately enriched) (upper basin) and eutrophic water (lower basin). (Image Credit Fisheries and Oceans Canada)

scale, eutrophication risk is concentrated, according to the EUTRISK index developed by the EU-JRC, in the Baltic coastal areas (except the northernmost areas), the central and southern North Sea and the coastal waters west of Jutland, the Azov Sea and western coastal belt of the Black Sea, the Northern Adriatic Sea, and the northern French coast of the Bay of Biscay [8, 9]. Apart from the extension of the problem, eutrophication may cause many different top-down impacts such as increased organic matter sedimentation and altered benthic-pelagic coupling, zooplankton over-grazing, food-web disruption and harmful algal blooms (HAB), among others risks focused on changes in the balance between different trophic groups, on ecosystem biodiversity and functioning, and on ecosystem goods and services [10]. In the COMMON SENSE project, marine-deployable sensors for nutrient parameters such as phosphate, nitrate, and ammonia are being developed based on microfluidic systems, colorimetric reagent chemistry, and low-cost optical detectors, building on autonomous nutrient monitoring systems previously developed at Dublin City University [11,12].

B. Heavy Metals

Heavy metals have been identified as hazardous substances of priority concern for the European marine environment by the Artic Council AMAP, the Black Sea Convention, the HELCOM, OSPAR, Mediterranean Action Plan (MEDPOL) and the Water Framework Directive [13,14]. Heavy metals are an important component of descriptors 8 and 9 of the MSFD. COMMON SENSE will address the monitoring of these substances contributing with the development of a sensor module for automatic detection of low concentrations of heavy metals (Pb, Hg Cd, Zn and Cu) in seawater. . The system is based on a disposable screen printed electrode manufactured with a novel carbon material nanostructured with bismuth particles previously developed [15]

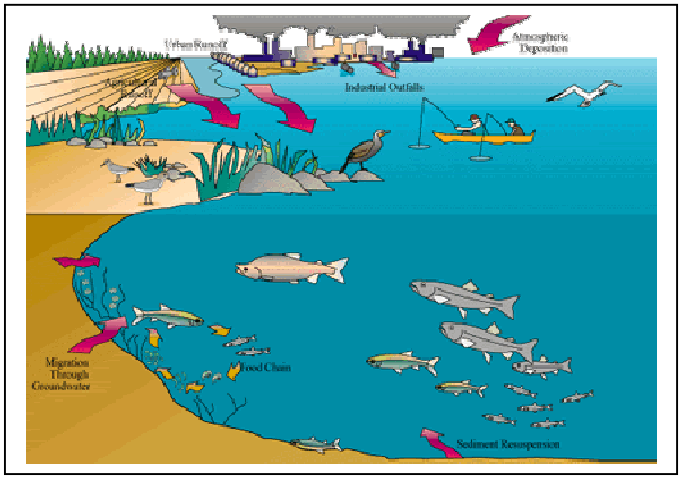

Figure 3. Bioaccumulation of Heavy Metals

C. Microplastics

Regarding the Marine Litter descriptor, (descriptor 10 of the MSFD), COMMON SENSE will focus on the microplastic fraction. Microplastics are defined as small plastic particles,

Figure 4. Microplastics are tiny bits of plastic that often originate from beach litter

usually below 1-5mm, present in the environment. [16, 17] There is a need to standardize sampling approaches in order to monitor the abundance of microplastic and a need for research to develop and subsequently validate new methods to identify and quantify microparticles. *"Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro- plastics)"* are specifically considered in the Commission Decision (2010/477/EU) [2]. COMMONSENSE will address the development of a marine litter sensor able to measure the surface concentration of microplastics in offshore waters. The detection system will be based on optical interrogation techniques according to currently used procedures [16]. The microplastic sensor will include the following elements: multi-channel photonic transducer in IR band, a high speed control board able to simultaneously acquire signals from different channels and a compact sampling system to allow integration in different marine platforms.

D. Underwater Noise

Descriptor 11 of the MSFD states that the *'introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment'*. Evidence exists of physiological and behavioural effects, behavioural disturbance and death due to high amplitude, low and mid-frequency impulsive anthropogenic sounds in marine environments [18, 19]. Recreational craft sonar usage is increasing and is not regulated. Marine mammals' frequencies (180 kHz) used for communication find an overlap in frequency usage. Even though little research and evidence exist in relation to these sonar systems effects, these are expected to cause adverse effects since similar sounds are currently used to scare cetaceans away. In order to monitor the underwater noise, the COMMON SENSE partnership will design and pre-produce a bespoke acoustic sensor pod, to be integrated in platforms as diverse as Smartbuoys, gliders or UAVs. The system shall comprise of an acoustic hydrophone that is coupled to a data

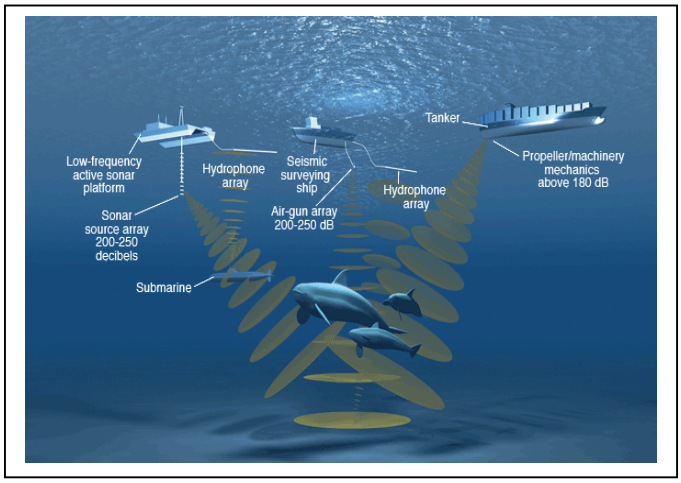

Figure 5. Marine noise pollution - —Image source: http://www.marineinsight.com/marine/environment/effects-of-noise-pollution-from-ships-on-marine-life/

acquisition module. Data captured will be processed by an embedded PC system and saved to onboard data storage. The data shall be processed allowing key events to be identified.

E. Transversal Sensors

The mentioned sensors, developed onto modular systems, will be integrated into multifunctional packages. Moreover, some innovative transversal sensors (temperature, pressure, pH, conductivity and pCO_2, among others) based on cost effective "new generation" technologies for the continuous monitoring of water parameters will also be developed. The integration of these transversal sensors will provide variables measurement with a reference frame (time, position, depth, temperature, etc.). It will also be necessary to have a complete understanding of the properties of sensing materials in order to ensure the performance of the micro and nanosensors developed. Sensors are based on a nanocomposite tunable organic conductor material in intimate contact with a polymeric substrate. This material, developed in NANOMOL group of CSIC, provides to the sensors devices lightness, flexibility and transparency. In addition, its preparation is performed at atmospheric pressure with a low cost. Similar materials have been used to develop electronic components [20], smart textiles [21], and in monitorization of biomedical parameters [22].

F. Web Platform/Interoperability

Sensors networks are currently collecting a great amount of environmental data and technologies are progressing and becoming more and more efficient and cheaper. The Common Sensor Web Platform aims at bringing a more sophisticated view of the environment implementing the Sensor Web Enablement standards and optimising data acquisition, indexing, access and interoperability [23, 24]. It will feed the data collected by the Common Sense sensors into international initiatives, notably the Global Earth Observation System of Systems (GEOSS) [25] and the Global Ocean Observing System (GOOS) [26], without any restrictions on discovery, access, or use. In addition, through collaboration with the other projects funded under topic 2 of the FP7-OCEAN-2013 call, it will contribute to the establishment of, and implement, common methodologies and standards for data archiving, discovery, and access within the GEOSS framework.

The sensors developed will be interoperable with existing and new observing systems and they will also be field tested by means of autonomous platforms and opportunity vessels. In addition to the implementation of the MFSD, the tools provided by the project will also support other European Maritime and Environmental Policies.

G. Field Testing

Field testing activities and platforms chosen will allow the COMMON SENSE project to partially cover the following marine regions and subregions included in the MSFD:

(a) the Baltic Sea;

(b) the North-east Atlantic Ocean:

- (i) the Greater North Sea, including the Kattegat, and the English Channel;
- (ii) the Celtic Seas;
- (iii) the Bay of Biscay and the Iberian Coast;
- (iv) in the Atlantic Ocean, the Macaronesian biogeographic region, being the waters surrounding the Azores, Madeira and the Canary Islands;

(c) the Mediterranean Sea:

- (i) the Western Mediterranean Sea;
- (ii) the Ionian Sea and
- (iii) the Central Mediterranean Sea;

H. Cost Effective Sensors

A feasibility analysis will be carried out in order to ensure that the sensors developed within the frame of the project are

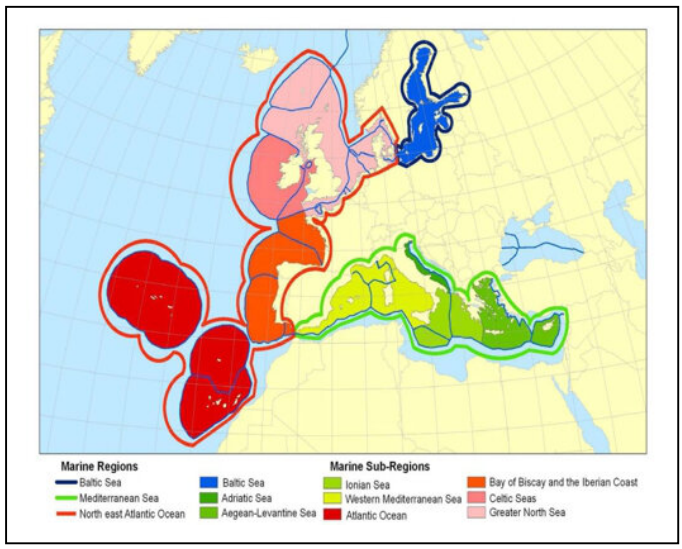

Figure 6. Marine regions and Sub-regions as defined by the MSFD

operative and able for a large-scale production and a widespread use. The extended use of the sensors developed will provide an increase in the temporal and geographic coverage from in-situ eutrophication, heavy metals, microplastics and noise sensors to enhance European

monitoring of the oceans. This will allow a reduction in the cost of standardised data collection making marine observation data available and suitable for integration with existing observing systems.

The morphology of the COMMON SENSE consortium, including industrial SMEs, research organizations and end-users from 6 different EU countries and a University from an associated country, will allow advancing competitiveness for European's industry as well as for European oceans understanding and management strategies.

IV. Conclusions and Future impact

The COMMON SENSE project will contribute to supporting the implementation of the MSFD, and other EU policies such as the Common Fisheries Policy and the Maritime Integrated Policy, by providing new sensors that are robust, easy-to-use, multi platform compatible, cost-effective, and multi-functional. These sensors will be used to make different reliable in-situ measurements of key parameters relating to Good Environmental Status (GES) of marine waters by means of methodological standards. The project will focus on increasing availability of standardised data on eutrophication, marine litter, contaminants, underwater noise and other parameters (e.g. temperature, pressure, pH and pCO_2) according to the MSFD descriptors.

A. Expected results and impact

- Innovative transversal sensors for temperature, pressure and conductivity measurements which will enable continuous monitoring of water parameters.
- Microcomposite and nanocomposite films and nanosensors for autonomous pH and partial pressure of carbon dioxide (pCO_2) measurements.
- Precompetitive prototypes for the detection of nutrient analyses using quantitative chemical analysis by colour (colourimetry) for phosphate, ammonia, nitrate and nitrite.
- Marine litter sensor to measure and quantify the surface concentration of small plastic particles (microplastics) in the off-shore environment.
- Sensor module for automatic detection low concentrations of heavy metals (lead, mercury, cadmium, zinc and copper) in seawater.
- Precompetitive fully functional prototype of a bespoke acoustic sensor pod for in-situ monitoring of underwater noise.
- Innovative specific sensors integrated into modular systems which can be easily adapted to different monitoring requirements and deployment platforms.
- Common Sensor Web Platform which will provide a more sophisticated view of the environment by implementing the Sensor Web Enablement standards and optimising data acquisition, indexing, access and interoperability.
- Deployment and testing of multifunctional sensor packages using floating devices, buoys, platforms and ships, under different sea conditions in key locations.
- Effective Knowledge and Technology Transfer ensuring maximum value and benefit from the COMMON SENSE project

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