



Partnership for Observation of the Global Ocean



OpenMODs project: advancing toward the widespread application of low-cost technologies in coastal ocean observing

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ABSTRACT

The ability to access user-friendly, low-cost instrumentation remains a limiting factor in coastal ocean observing; the majority of state of the art equipment used in marine observation is difficult to deploy, costly to operate, and requires specific technical skills. Fortunately, recent technological advances have created opportunities to improve sensors, platforms, and communications that will enable a step change in coastal ocean observing by lowering their costs and enhancing their performances and endurance. Global observational systems are, however, mainly focused on open ocean waters (e.g. ARGO), while an equivalent observation program for the world's coastal waters is still missing. POGO's OpenMODs is a humanitarian project that tries to narrow this data and knowledge gap by proposing a user-oriented framework to co-design low-cost, fit-for-purpose equipment and modus operandi fit for developing countries. Within the project, general needs/requirements have been established by potential users from developing countries/remote regions according to their application and science priorities. Some user communities (e.g. artisanal fishery associations) have been identified as potential partners/beneficiaries. As requested observables, a subset of EOVS has been selected owing their relevance to the specific applications. A strong connection with the education sector was also recommended. To respond to the above requirements, we propose a cost-effective, modular architecture of a coastal probe equipped with basic sensors (T, S, Chl-a, etc.) based on readily available low-cost sensors, control and data transmission technologies that can be mounted/operated on various platforms with a minimum skill even by trained non-professionals. This probe is thus meant to fit the needs of a large community that includes scientific research (in particular in developing countries), non-scientists and educators.

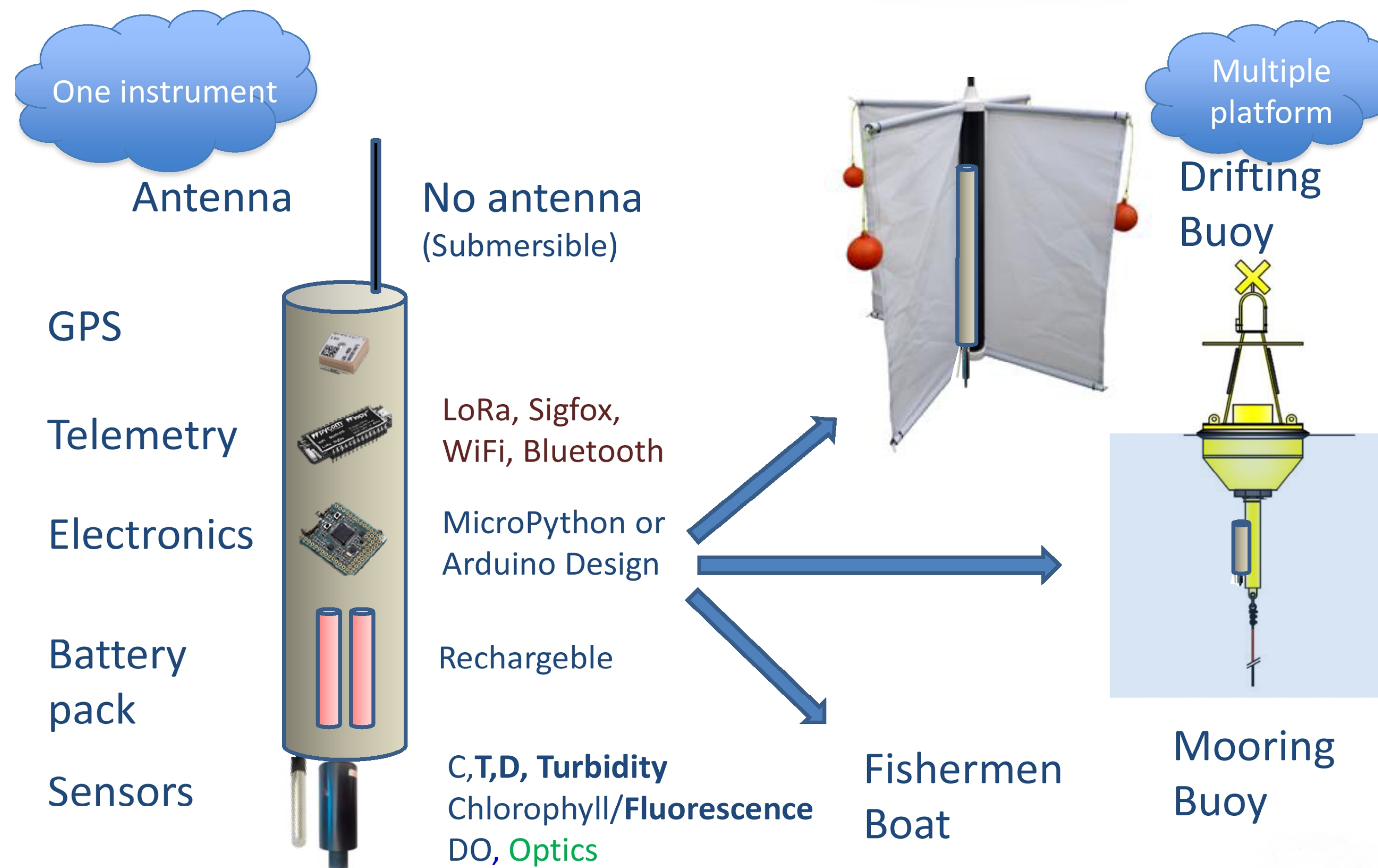
OCEAN OBSERVATIONS ARE CRITICAL

- Vast part of the coastal ocean is not regularly observed and very scarce publications are openly available
- The access to user-friendly, low cost instrumentation is a limiting factor in coastal ocean observing
- The majority of marine observation equipment is difficult to deploy, costly to operate and requests specific technical abilities
- The novel improvements in sensors, platforms and communication will enable a step change in (coastal) ocean observing philosophy

OVERARCHING NEEDS

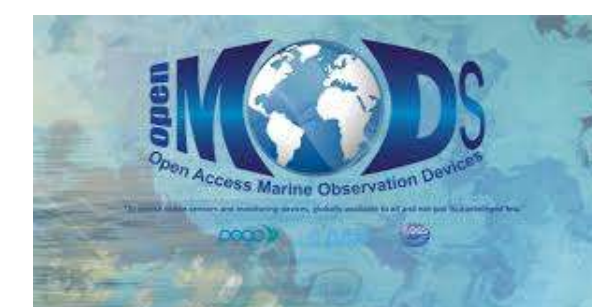
- Need for simple expendable instrumentation
- Need for additional platforms of opportunity (Involving Stakeholders)
- Need for shared infrastructure (e.g. reference infrastructure and reference stations)
- Need for discussion hub and networking of science West Africa
- Need for pilot studies
- Need for neutral umbrella (POGO)
- Need for plan for the way forward

Architecture of the multipurpose Low-cost Effective Ocean-observing (LEO) platform



WHAT IS POGO

POGO is an international forum for leaders of the major oceanographic institutions over the world aimed at fostering a wider partnerships that advance efficiency and effectiveness in studying and monitoring the world's oceans on a global scale. POGO has also promoted observations underpinning ocean and climate science providing training and technology transfer to emerging economies.



OpenMODs Concepts

- Humanitarian environmental project;
- Comply with the Open Science approach;
- Easy-to-use, sustainable (automated) equipment;
- Low-cost technologies for the components, modular approach.

OpenMODs Objectives

- to conceive/identify an easy-to-use, flexible and affordable core set of ocean sensors and platforms;
- to co-design the functionalities and the operational mode of a coastal observing network, closely working with the potential users to meet their requirements.

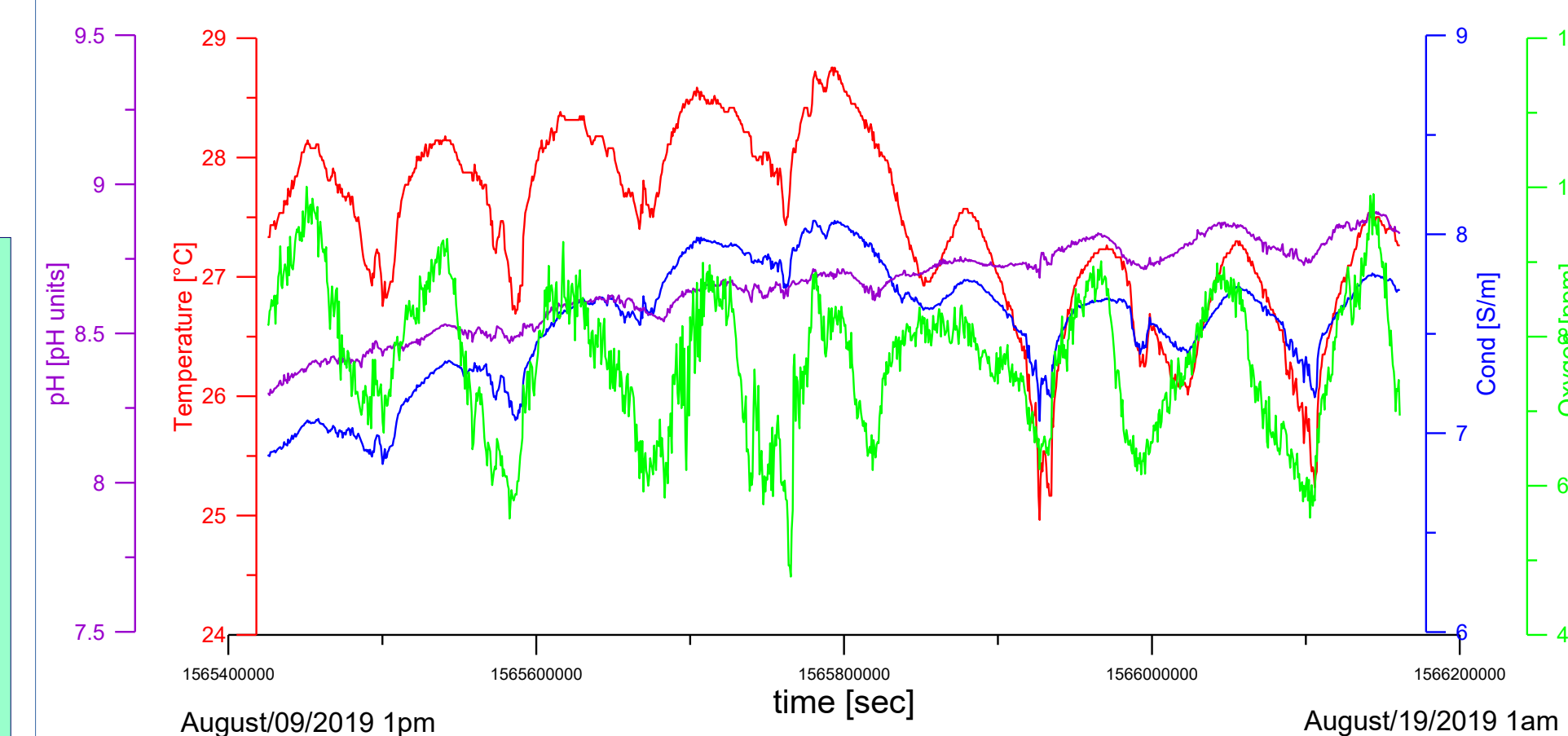
OpenMODs project needs/requirements

- definition of simple modular design of autonomous platforms hosting multiple sensors for coastal ocean observations;
- identification of (site-dependent) socio-economic priorities and associated knowledge gaps;
- effective choice of those essential ocean variables that meet socio-economic priorities (temperature, salinity, chlorophyll a, turbidity, currents) via a comparative market analysis of relevant low-cost sensors;
- open science approach to remove the barriers for sharing/reuse any kind of output, resources, methods or tools at any stage of the development process;
- regional discussion hubs and networking in developing countries (e.g. West Africa and Asia?) for self-support and capacity creation;
- urgent definition of areas where pilot studies adopting the OpenMODs philosophy can be implemented;
- need of neutral international umbrella to support the way forward (e.g. POGO)

ALREADY AVAILABLE LOW-COST INSTRUMENTATIONS Examples of new technologies to measure EOVS

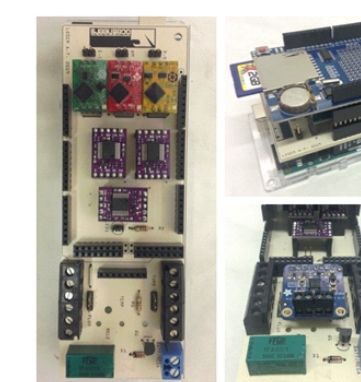
	Physics	Biogeochemistry	Biology and Ecosystems
Sensor Buoy System (1) Albaladejo et al., 2012	X		
Drifter (2) Lacharme et al., 2016	X		
Environmental Sample Processor (ESP) (3) Shoemaker, 2013	X		X
Oceanographic multisensors buoy (4) Serrão et al., 2018	X	X	X
Genetic analyzer for microbiology (5) Fukuda et al., 2011			X
Animal-borne CTD (6) Bohmer et al., 2009	X		X
Arctic Low-Cost probe (ArLoC) (7) Piermattei et al., 2018	X		X

The table lists various low-cost instrumentations and their capabilities. The images show examples of these instruments: (1) Sensor Buoy System, (2) Drifter, (3) Environmental Sample Processor, (4) Oceanographic multisensors buoy, (5) Genetic analyzer for microbiology, (6) Animal-borne CTD, and (7) Arctic Low-Cost probe.



SAGACE Experiment
Low cost arduino-based probe has been tested on a coastal buoy in south Adriatic sea for 10 days.

A PT100 1/3 Din (by adafruit 15 bit AD converter), Atlas scientific conductivity, oxygen and pH and other arduino components from amazon have been integrated



EOVs and readiness level

CONCEPT PILOT MATURE

Physics

- Sea State
- Ocean surface vector stress
- Sea Ice
- Sea level
- SST
- Subsurface temperature
- Surface currents
- Subsurface currents
- SSS
- Subsurface salinity

Biogeochemistry

- Oxygen
- Inorganic macro nutrients
- Carbonate system
- Transient tracers
- Suspended particulates
- Nitrous oxide
- Carbon isotope (¹³C)
- Dissolved organic carbon

Biology and Ecosystems

- Phytoplankton biomass and productivity
- HAB incidence
- Zooplankton diversity
- Fish abundance and distribution
- Apex predator abundance and distribution
- Live coral cover
- Seagrass cover
- Mangrove cover
- Microalgal canopy cover

Concerning the measures to consider, the "GOOS Expert Panels" have identified the Essential Ocean Variables based on the following criteria: Relevance, Feasibility, Cost effectiveness

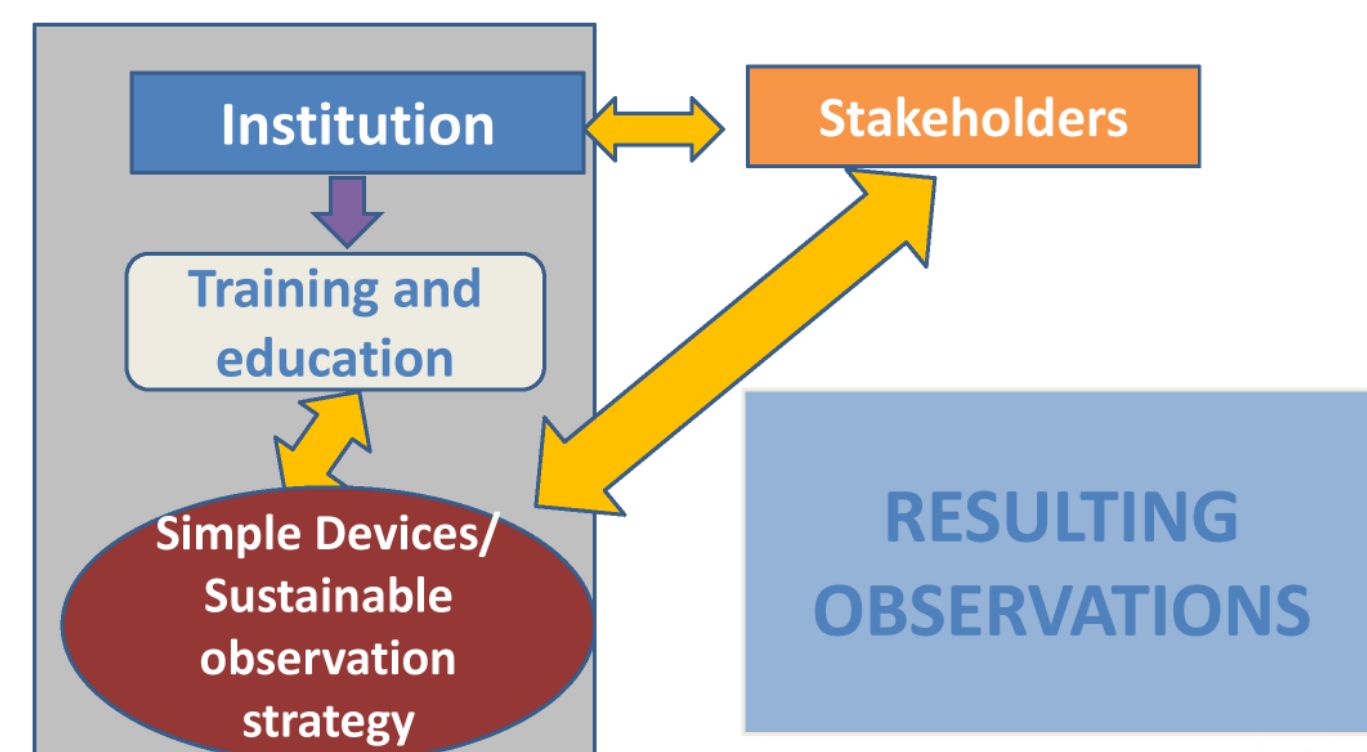
Only some of the GOOS EOVS has been selected as the subset that provides the minimum information to meet the socio-economic requirements. This does not mean that other EOVS are not relevant or different or that more advanced technologies are not useful; this means that they cannot be safely deployed in the frame of the routine monitoring of a harsh environment such as the coastal zone of developing countries.

OpenMODs propose a way to respond to different operational scenarios and, according to the operational needs, in a modular way to integrate different sensors that can be easily integrated in different platforms.

The general issues are:

- to involve scientific institutes and universities from developing countries interested in implementing the OpenMODs infrastructure;
- to produce a blueprint of the architecture of a modular platform capable of hosting the basic sensors;
- to revise the requirements/progress in the preparation of the pilot studies that implement the OpenMODs philosophy in terms of education, science, and services and to pave the way for future initiatives;
- to conceive/identify an easy-to-use, flexible, and affordable core set of ocean sensors and platforms;
- to co-design the functionalities and the operational mode of a coastal observing network closely working with the potential users to meet their requirements.

PILOT STUDIES IMPLEMENTATION FLOW-CHART



RESULTS IMPACTS

