MARINE OPTICS LAB, REMOTE SENSING AND BIOGEOCHEMICAL APPLICATIONS, OCEANOGRAPHIC OBSERVATORY OF VILLEFRANCHE-SUR-MER

Enhancing Open Ocean Observatories Services

Ocean observing systems maintain real-time surveys and high-quality measurements of the ocean state with the aim of monitoring marine ecosystems exposed to changing climate and human pressures. The Marine Optics Lab of Villefranche is one of the leading groups that coordinate this observational effort and, thanks to their partnerships with industrial projects for innovation, contribute to the enhancement of marine services.

On behalf of the Oceanographic Observatory of Villefranche-sur-Mer (CNRS / UPMC), the Marine Optics Lab develops non-intrusive optical methods to describe the stocks of particulate and dissolved material in the ocean, and to study the underlying biogeochemical processes that drive their spatial and temporal variations.

The Marine Optics Lab's past and current research projects have benefited from staff expertise covering hydrological and optical sensing metrology, oceanographic instrumentation, data management, low-consumption electronics and embedded computing; as well as lab facilities (ballast pool, laser chamber, chromatographic bench, ships) and a geographic situation favourable for rapid access to open sea conditions.

For these reasons, the Ligurian Sea has become a hotspot for conducting ocean monitoring together with R&D activities. Recurrent observational efforts were initiated there during the 1980s by monthly CTD-Rosette sampling along a 30nm cross-shore transect, augmented since 2000 with an instrumented taut mooring for vicarious calibration of ocean colour satellites. Presence at sea has drastically increased since 2006 with the routine use of autonomous mobile vehicles (profiling floats and gliders) embarking bio-optical and biogeochemical sensors.

Expected adoption of novel sensors and autonomous platforms for assessing scientifically required accuracy of measurements among the Ligurian observing system, have been internationally acknowledged as a significant contribution to capacity building for in-situ ocean monitoring.

Developing Glider Technology with the Business

The glider SeaExplorer illustrates the recent achievements that came from the synergy with industrial consortiums, like the French company ACSA. The Marine Optics Lab was involved at every stage of this 6-year project, from the vehicle conception to its field testing, from data flow management to sharing the processing tools with end-users.

On the basis of our experience on glider operations, we were initially in charge of defining the general characteristics of what should be a glider mission dedicated to multi-disciplinary observation. These specifications ranged from specificity related to the platforms (e.g. depth range and resolution, mission duration, speed) to the typical scientific payload the platform should accommodate, i.e. a suite of sensors that would efficiently address the core parameters routinely sampled in open-ocean observing systems, based on the non-intrusive measurement of physical and optical seawater properties. Sensor specifications were formulated with respect to metrological characteristics (accuracy, sensitivity, ruggedness, dynamic response) from a large panel of sensor technologies tested in the lab and during in-situ surveys, clamped with the CTD-Rosette. This activity was extended to novel sensing purposes dedicated to water quality assessment, such as the measurement of nitrate concentration with an UV spectrophotometer or the detection of plastic debris and jellyfish with a video camera.

Our experience on interfacing sensors with autonomous platforms was appreciated for the design of the glider payload. This interactive part of the project reviewed some technical solutions about mechanics (available volumes and inlet configurations given degrees of miniaturisation and customisation, pressure limits and light exposure) and electronics (consumption versus sampling rate to resolve gradients, complexity of embedded data processing versus real-time transmission) that make the SeaExplorer stand out from the other gliders.

Field testing of glider prototypes has been one of the main activities of the Ligurian observing system since September 2013. In this temperate area, ecosystems follow seasonal patterns that are significantly modulated by smaller scale features triggered at the edge of the geostrophic jet following the Riviera coast or in response to wind bursts. The SeaExplorer showed its ability to sample these various situations, whether marked by strong density gradients during mixing events, intense currents neighbouring fronts, or abrupt changes in meandering structures. Hydrological measurements were properly compared with shipborne SeaBird's 911plus CTD at match up points. Assessment of interoperability with an emerging Mediterranean Bio-Argo network revealed the glider efficiency to chart spatial variations around the seasonal signal acquired by a biogeochemical profiling float, also developed in the context of an industrial partnership with the French company NKE.

Designing Ocean Observing Systems of Tomorrow

One decade ago, the Marine Optics Lab proposed dedicated field surveys of various open ocean ecosystems, welcoming trans-disciplinary studies on board a single research vessel and providing management facilities for quality-controlled datasets. These concerns remain today, even though the way to observe has changed thanks to technological innovation. We ensure the interoperability of in-situ and remote sensing platforms that have extended the coverage over the years and oceanic basins; we watch for intercalibration of sensors where instrumental drifts and nominal accuracy need to be constantly assessed.

Challenges for observing systems encompass various environmental impacts of human pressure on marine resources, which range from exploitation of seafloors to climate change. These challenges aim to preserve high standards of measurement, high sampling rate, high presence at sea in order to catch the development and the fate of such perturbations and to allow anthropic perturbations to be identified from long time-series. They require more flexible and reliable platforms, larger and interchangeable sensor payloads, more efficient embedded computing to submit real-time summaries and navigation commands of detected events, more permissive data management policy to feed research and operational oceanographic services. From this perspective, the Marine Optics Lab appears to be one of today's indisputable partners for designing solutions for open ocean monitoring.