**FINAL REPORT PROGRAM LEFE**

<table>
<thead>
<tr>
<th>Program LEFE/ CYBER</th>
<th>Project Title</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI Melilotus Thyssen, <a href="mailto:melilotus.thyssen@univ-amu.fr">melilotus.thyssen@univ-amu.fr</a>, lab: Mediterranean Institut of Oceanology, Marseille</td>
<td>«Structural and functional diversity of phytoplankton at the Eastern Channel regional scale: from the cell to the satellite view» CEL2SAT</td>
<td>2013</td>
</tr>
</tbody>
</table>

**Contribution to**
- CNES (TOSCA-PHYTOCOT, PI. S. Alvain).
- INTERREG Marinexus
- FP7 JERICO

**Objectives:**
The main objective of CEL2SAT was to study the phytoplankton community structure within the Eastern Channel at the sub-mesoscale (<10 km) during the spring-summer transition by coupling Ferry Box high frequency data with an automated remotely controlled flow cytometer (Cytosense).

**Main results:**
The implementation of the Cytosense onboard the Ferry “L’Armorique” was previously estimated for 1.5 months.

1. **The instrument was maintained running analysis on the ship for more than 4 months**, from May 16 2013 up to September 17 2013. The flow cytometer was entirely remotely controlled from Marseille and run samples automatically. The system built during this project will be used as a reference for any other implementation of this type of instrumentation onboard ships of opportunity or observation platforms. The project enabled several technological developments specific to the integration of a new sensor (the flow cytometer) linked to the Ferrybox (Fig. 1A). Software and data transfer were adapted for this very specific purpose.

2. The Cytosense data set represented 4600 samples of about 1 and 5 cm$^3$ of analysed seawater. The Cytosense data set was compared to the Ferrybox data set. From the coupling between both data sets collected, **878 Cytosense samples could be used for comparisons, in which up to 50 000 cells per sample were counted and manually clustered**. Up to 10 groups of cells sharing similar optical properties (Fig. 1B) were discriminated and were associated to phytoplankton functional groups (sensus Lequéré et al. 2005) or genera based on the photographs. The phytoplankton dataset will be coupled with the Ferrybox dataset (temperature, salinity, dissolved oxygen, chlorophyll fluorescence, turbidity, CDOM and pCO2, as analysed by Pierre Marrec; PhD supervisor, Yann Bozec, SBR). The CEL2SAT project delivered an unprecedented amount of phytoplankton absolute counts covering the entire channel between Roscoff to Plymouth. The ferry “L’Armorique” crossed the channel once a day and up to 3 times a day during summer.

3. In the meantime, samples for inter-comparison of phytoplankton counts were collected, fixed with glutaraldehyde and stored in -80°C in order to be analysed by the different flow cytometers of the partners. Comparisons between instruments validated the Cytosense measurements for picoplankton and nanoplanckton groups.

A final meeting hosted in the LOCEAN in Paris (5-6 November 2013) was organized to present the first results and discuss about the near-future projects. Besides the CELSAT partners, we also invited Yann Bozec and Pierre Marrec for discussions.

**Future of the project:**
We demonstrated the feasibility of the automated Cytosense, and this technique is currently applied in different projects aiming at describing phytoplankton community structure at the submeso scale (V. Creach, CEFAS, GB, onboard the Endheavour; M. Rijkeboer, RijkWaterstaat, NL; M. Thyssen, Marseille Tunis, onboard the “Le Carthage”, CTN, FR). Pierre Marrec is currently working on the A*MIDEX CHROME project (PI M. Thyssen) as post-doc for implementing the flow cytometer with a ferrybox onboard the Ferry “Le Carthage” between Marseille and Tunisia, thanks to the CEL2SAT success.
The phytoplankton abundances database from the flow cytometer and the relative fluorescence will be integrated into the labeling procedure for the channel, currently processed by M-H. Rêve (PhD student of Severine Alvain, Fig. 2). This part will benefit from recent classification of reflectance anomalies based on neuronal network tools and theoretical explanation of PHYSAT. A first attempt to do this based on previous in situ observations has allowed to detected different diatom assemblages as shown on Fig. 2.

![Image 1 A illustrates the cytoseNSE flow cytometer after its installation close to the ferry box onboard the ferry “L’Armorique”. The instrument was entirely controlled by the computer in an autonomous way and analysed the water passing through the ferry box. Fig. 1B illustrates a cytogram coupling two optical properties collected for each single phytoplankton cell. Pictures of larger cells were taken in the flow device (example of a Prorocentrum-like cell). Each particle is first recorded as a set of pulse shapes of diffusion and pigment fluorescence signals that enable several cytograms and increase the optical differentiation of the phytoplankton clusters. Fig. 1C illustrates several large cells collected along the track of the ferry. Fig. 2 illustrates the different bloom assemblages in the Channel and the North Sea in March 1998. In this case, labeling was enabled using the Continuous Plankton Recorder (CPR) data sets. This type of map will be available for the studied period of the CEL2SAT project. We will compare in situ flow cytometry data with PHYSAT anomalies in order to complete the CPR data sets in which Pico and Nanoplankton are not available.

1 publication, 5 communications

**Publication in link with the current project:**

**Communication:**
- Seminar at the Plymouth Marine Laboratory on the 26 June 2013 (Speakers: Pascal Morin (SMR Roscoff), Gerald Gregori (MIO Marseille), Melilotus Thyssen (MIO Marseille));
- Seminar JERICO workshop in Villefranche sur mer (speaker: Melilotus Thyssen) on the 15 October 2013
- Seminar Interreg 4A “2seas” DYMAPHY/RESOMAR workshop in Wimereux (Speakers: Gerald Gregori, Melilotus Thyssen), on the 3 december 2013.
- Seminar university of Xiamen, College of the Environment and Ecology, 4 December 2013, speaker : Michel Denis and Institute of Oceanology, Chinese Academy of Sciences (IOCAS), China, 12 December 2013, speaker : Michel Denis