Automated optical approaches for marine phytoplankton observation and monitoring in coastal seas within the JERICO-Next (H2020) network

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Context & Objectives: Phytoplankton current monitoring is based on discrete sampling and reference laboratory methods such as microscopic identification and counts, as well as pigment analysis and, since a decade, molecular analysis.

Notwithstanding their accuracy in terms of taxonomical resolution, the sampling frequency/spatial coverage of these long-term series (discrete stations sampled monthly or fortnightly) or extended spatial series of observations (short duration dedicated cruises) might not be sufficient to fully understand and evidence of phytoplankton dynamics.

In order to address phytoplankton temporal changes and spatial distribution at fine resolution, automated *in vivo* and *in situ* approaches were explored, inter compared and implemented in different coastal systems within the Joint European Research network for Coastal Observatories – Novel European EXperTise for coastal observatories (JERICO-NEXT- H2020, 2015-2019).

Methods: Three main techniques, image in-flow acquisition and analysis, pulse shape-recording flow cytometry, as well as multispectral and variable fluorometry were implemented into platforms or vessels in a variety of coastal systems of different hydrological and ecological characteristics

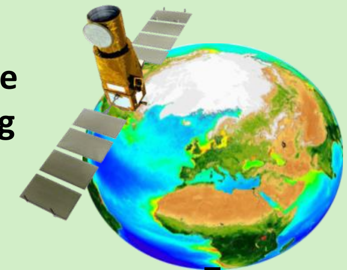
Approaches for phytoplankton observation

Research / Opportunity Vessels

Moorings

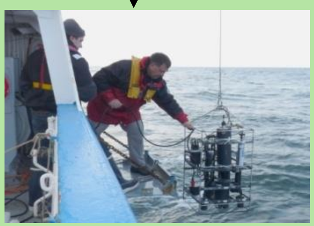
Gliders

Remote sensing



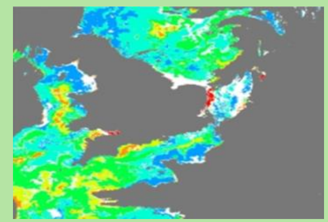
Monitoring strategy

Discrete sampling



Profiles

Continuous pumping/recording



Synoptic/regional

Sampling strategy

At the laboratory/ On board

Real time

Real time

Real time

Analysis

Microscopy
Pigment analysis
Total/Spectral Fluorometry
Flow cytometry
Image Analysis
Molecular tools

In vivo Total/Spectral Fluorometry
Optic probes
Pulse shape-recording
Flow cytometry
Image Analysis

CTD
Total/spectral Fluorometry
Pulse shape-recording
Flow cytomaetry
Image Analysis
Molecular tools

Ocean optics from satellites
Development of new Algorithms
Comparison with *in situ* data

Techniques

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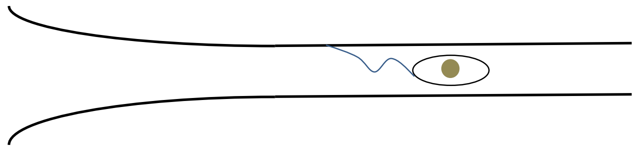
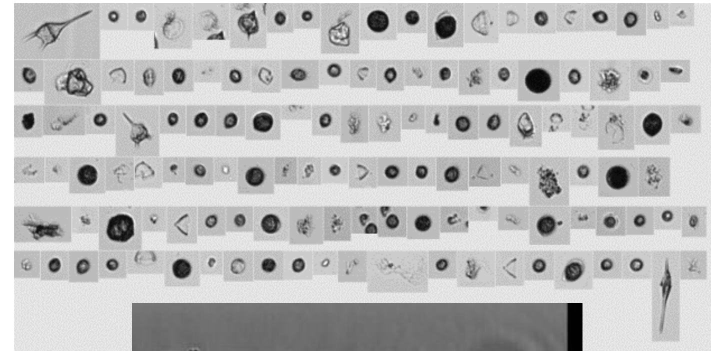
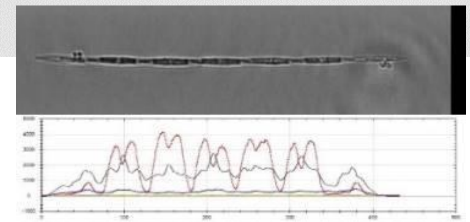
Automated observation of phytoplankton

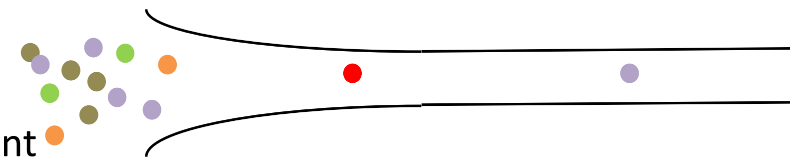
Imaging/in flow
Single cells – size and morphology of organisms: taxa

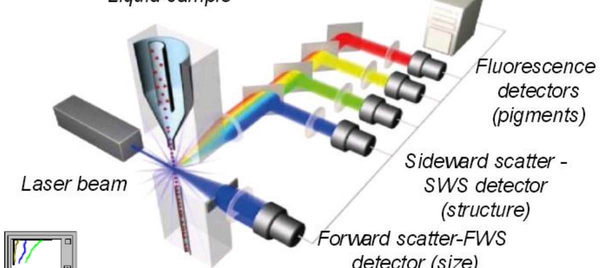






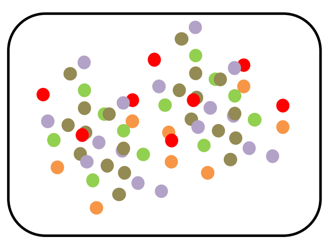
Automated flow cytometry (pulse shape-recording)
Single cells – fluorescence – pigment content and scattering (size, shape): functional groups

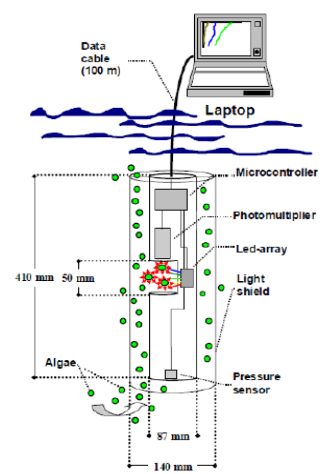


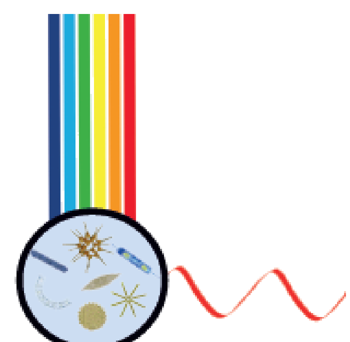


Fluorescence and absorption (multi-spectral)
Pigment based methods – bulk properties – pigmentary groups

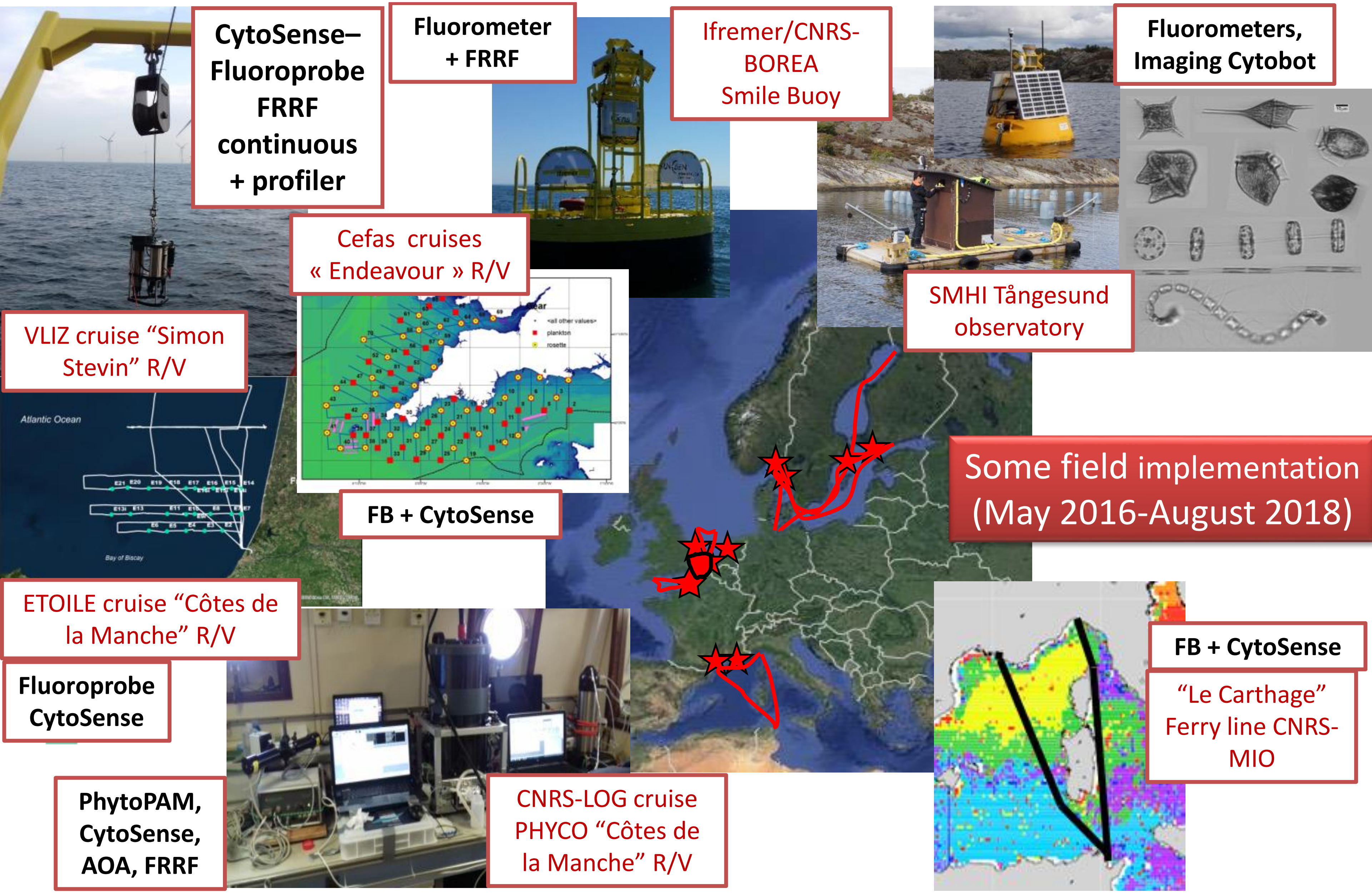
Variable (active) fluorescence
: photosynthetic parameters, primary productivity







Platforms & devices for phytoplankotn automated observation



CytoSense–Fluoroprobe FRRF continuous + profiler

Fluorometer + FRRF

Ifremer/CNRS-BOREA Smile Buoy

Fluorometers, Imaging Cytobot

Cefas cruises « Endeavour » R/V

VLIZ cruise "Simon Stevin" R/V

FB + CytoSense

SMHI Tångesund observatory

Some field implementation (May 2016-August 2018)

ETOILE cruise "Côtes de la Manche" R/V

Fluoroprobe CytoSense

PhytoPAM, CytoSense, AOA, FRRF

CNRS-LOG cruise PHYCO "Côtes de la Manche" R/V

FB + CytoSense

"Le Carthage" Ferry line CNRS-MIO

Results: The operability (procedures, data analysis, data vocabulary) and the discrimination (classification tools) capacity of different automated techniques addressing phytoplankton dynamics, diversity (at low or high taxonomical and/or functional levels) and productivity were addressed.
Automated tools for raw data analysis were settled and improved and are being made available for the scientific community.
Moreover, advances were made for defining a common vocabulary to advance in their inclusion into general or specialized data bases.
A combination of selected phytoplankton automated observation approaches, based on single cell/particle or bulk optical characteristics, were implemented in several coastal & marine systems ranging from oligotrophic (West Mediterranean) to mesotrophic and eutrophic marine waters (Channel, North Sea & Baltic Sea) and it was possible to tackle the conditions of different phytoplankton blooms developments as well as the variability of pghytoplankton diversity at fine temporal and spatial resolution.

Conclusions/Perspectives: Novel automated techniques provided new insights into phytoplankton dynamics at fine spatial (horizontal and vertical) and temporal scales and useful complementary information for calculation of indicators of the environmental state, trends and potential regime shifts within marine ecosystems. We need to continue working on their automation and discrimination capabilities, as well as moving towards their widespread implementation in sustained coastal platforms.