11th FerryBox Workshop - 28-29 September 2022
Helmholtz-Zentrum Hereon - Geesthacht - DE

Automated underway recording allow characterizing phytoplankton communities at sub-mesoscale in frontal marine systems

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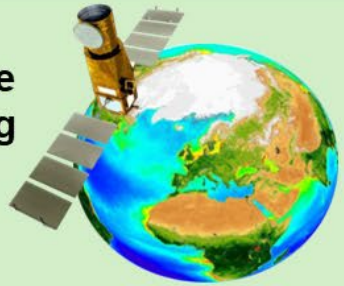
Approaches for phytoplankton observation

Research / Opportunity Vessels

Moorings

Gliders

Remote sensing

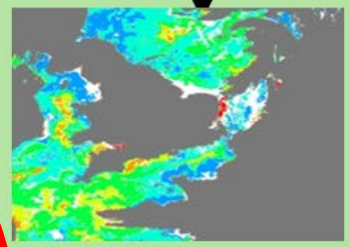


Monitoring strategy

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
Automated Flow cytometry
Image Analysis

In vivo
Total/spectral Fluorometry
Automated Flow cytometry
Image Analysis
Molecular tools

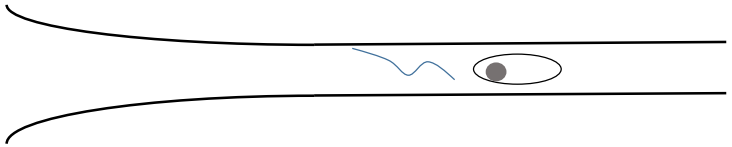
Ocean optics from satellites
Development of new Algorithms
Comparison with *in situ* data

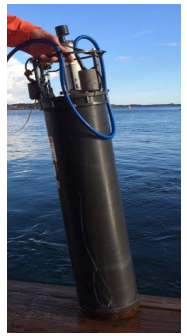
Techniques

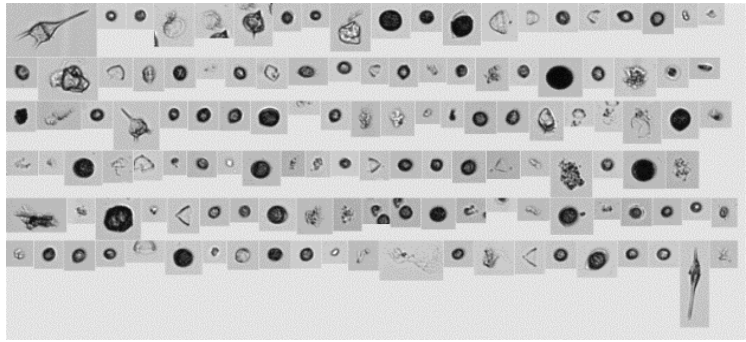
www.dymaphy.eu

In vivo / in situ automated techniques for phytoplankton observation

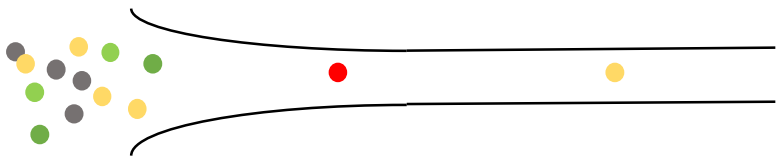
Imaging/in flow
Single cell-size and morphology
of organisms: taxa

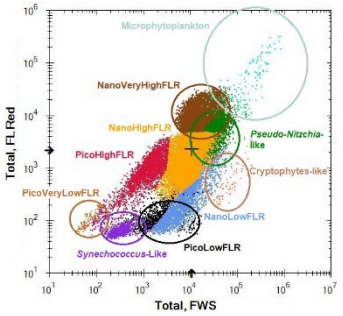


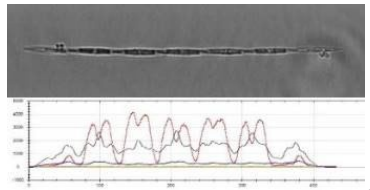


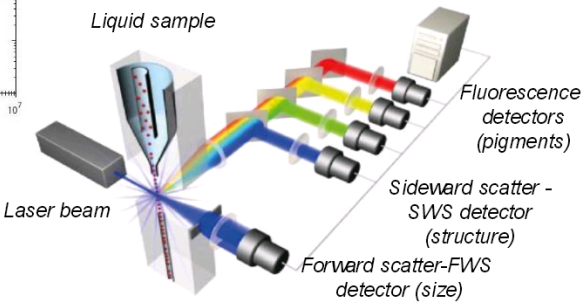


Automated flow cytometry (pulse shape-recording)
Single cell-fluorescence – pigment content and scattering
(size, shape):
functional groups

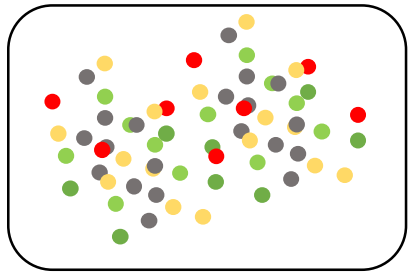


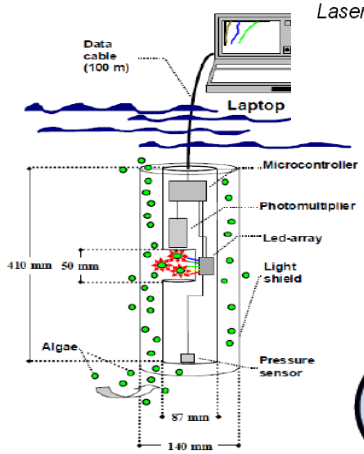


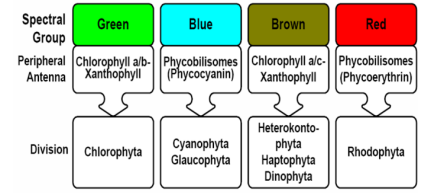




Fluorescence and absorption (multi-spectral)
Pigment based methods – bulk properties – pigmentary groups
Variable (induced) fluorometry:
photosynthetic parameters, primary productivity







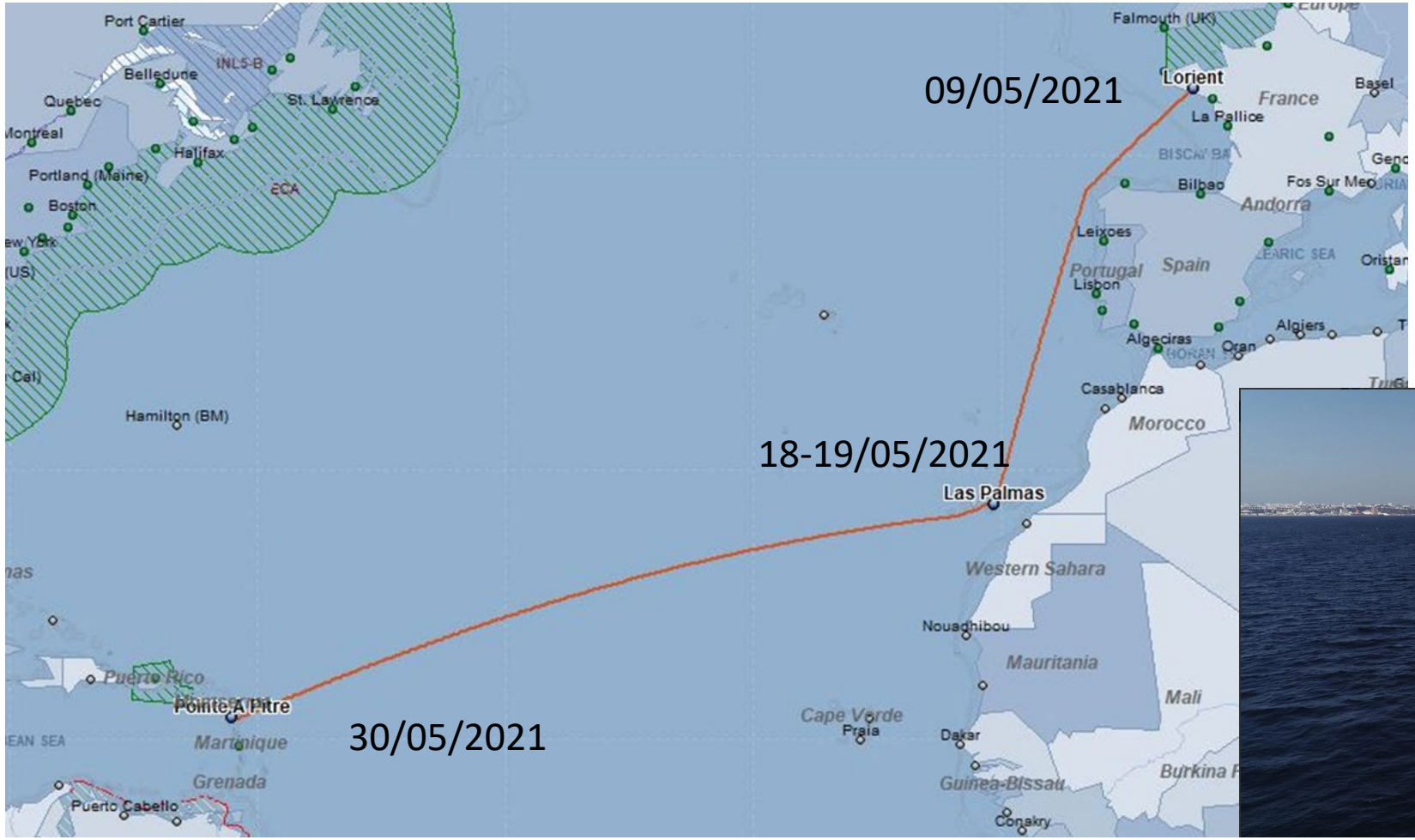
Application of automated optical approaches for exploring submesoscale phytoplankton dynamics in frontal systems

- To allow addressing biogeochemical and phytoplankton sub mesoscale variability and dynamics, having an impact in the functioning of frontal systems (i.e. upwellings, eddies).
- Associated to already existing hydrological continuous recording (thermo-salinographs, FerryBox)
- Increase the number of *in situ* and *in vivo* real-time measurements to improve remote sensing ocean colour algorithms
- In the frame of different projects and strategies (including dedicated cruises, measurements of opportunity, fixed stations and moorings, discrete sampling)
- Need of improving operational procedures, data treatment tools and data pipelines, some of them being explored for coastal projects/networks as the Joint European Research Infrasturcture for Coastal Observatories (JERICO S3) addressing multi-spectral fluorometry, automated imaging and flow cytometry.

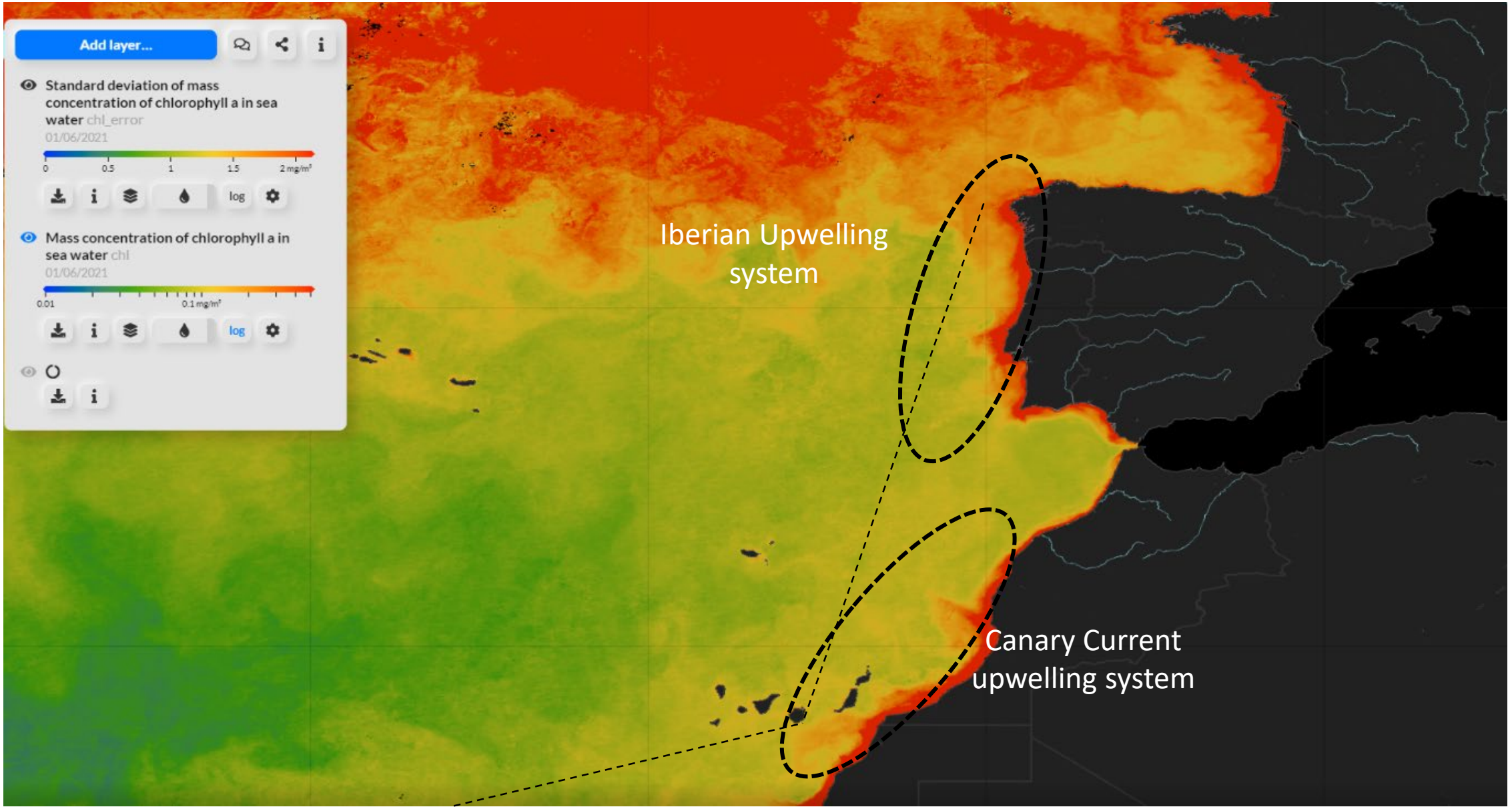
AMATLANTE (AMT)-H1 : example of measurements of opportunity to catch sub-mesoscale structures in the Atlantic

Context

Measurements of opportunity : transit towards the Caribbean onboard the R.V. « Antéa » (IRD-IFREMER-FOF), with automated phytoplankton continuous underwater measurements



Remotely-sensed data – surface chlorophyll-a concentration for a subset of the cruise



Remotely-sensed data – surface chlorophyll *a* and underway measurements

CytoSense® (CytoBuoy©)
(pulse shape-recording
automated flow cytometer)

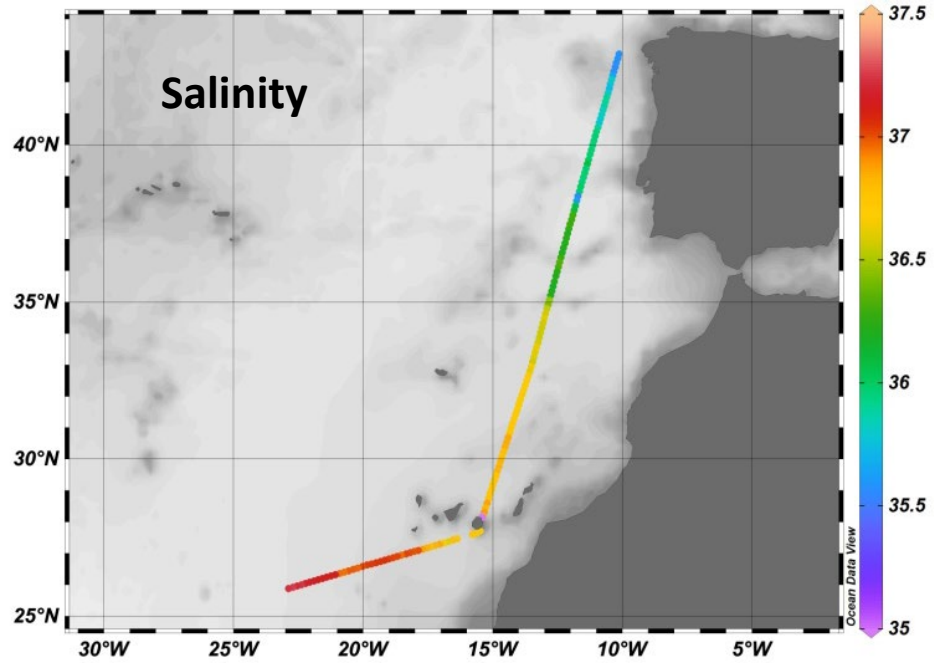
Canary Current
Upwelling System

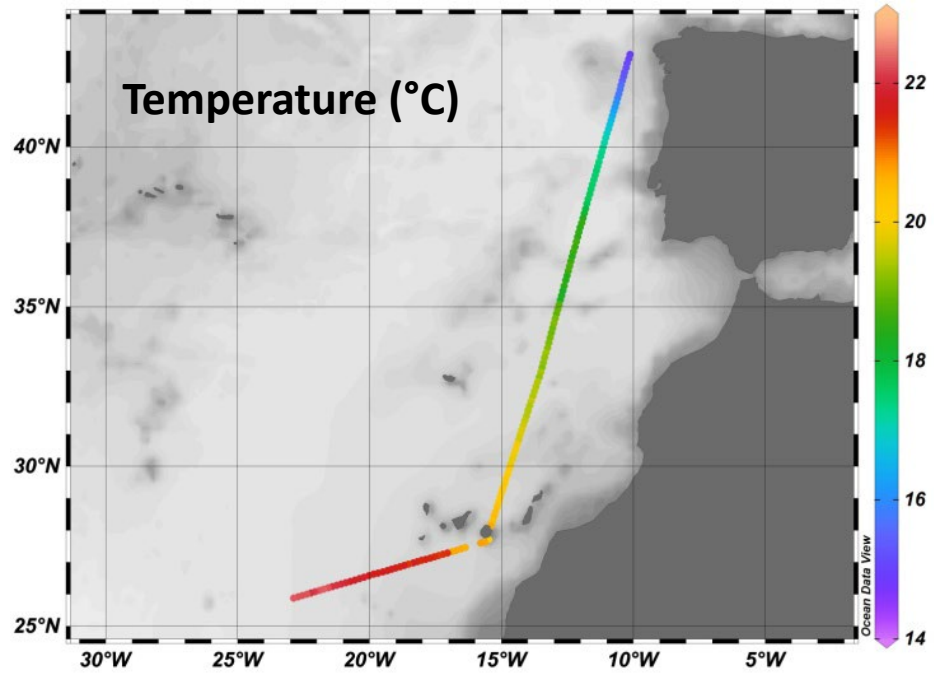
Upwelling filament

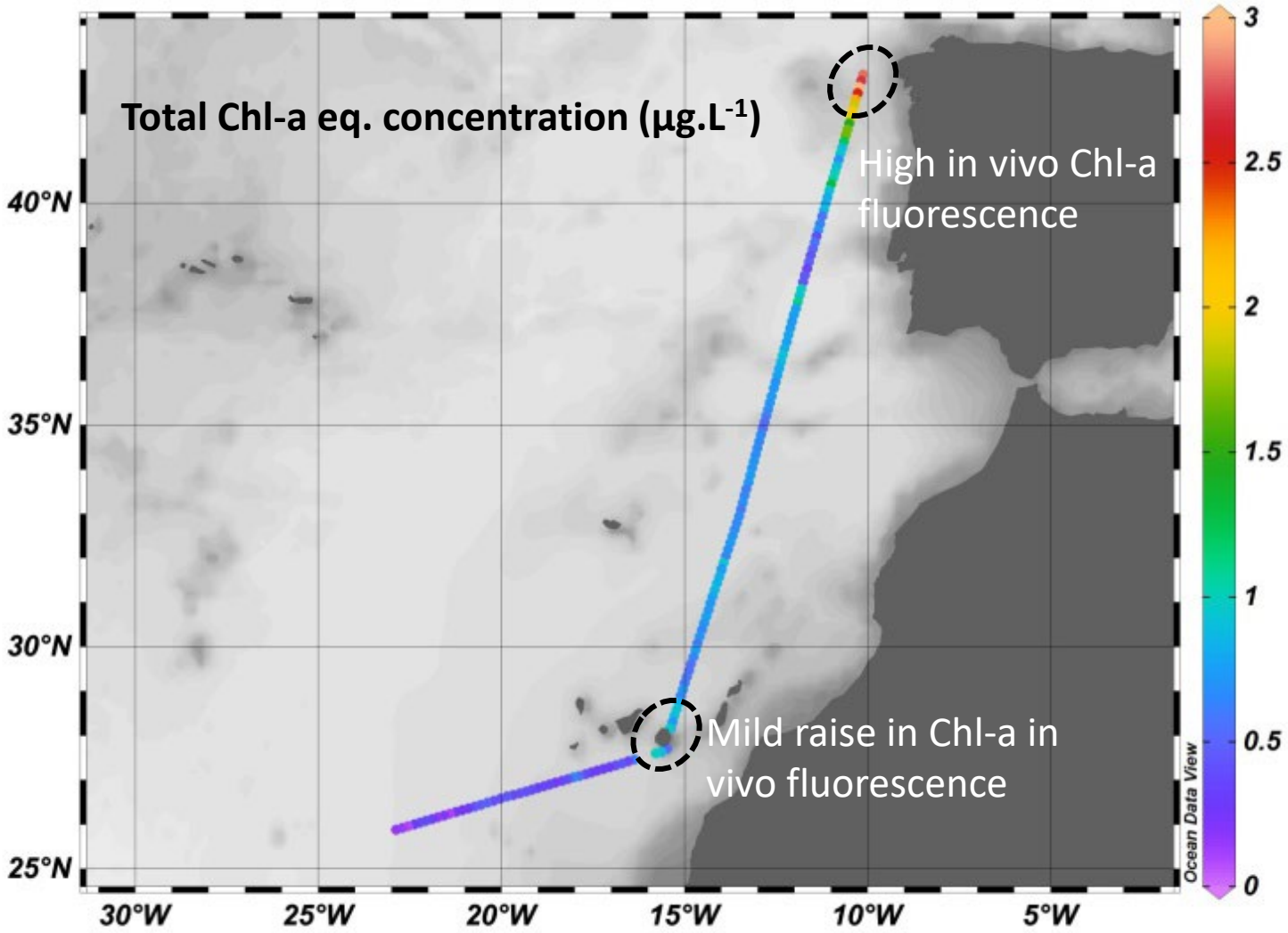
Fluoroprobe® (bbe
Moldaenke©)
(multispectral
fluorimeter)

SBE 21-SeaCat®
(Sea-Bird Scientific©)
Thermosalingraph

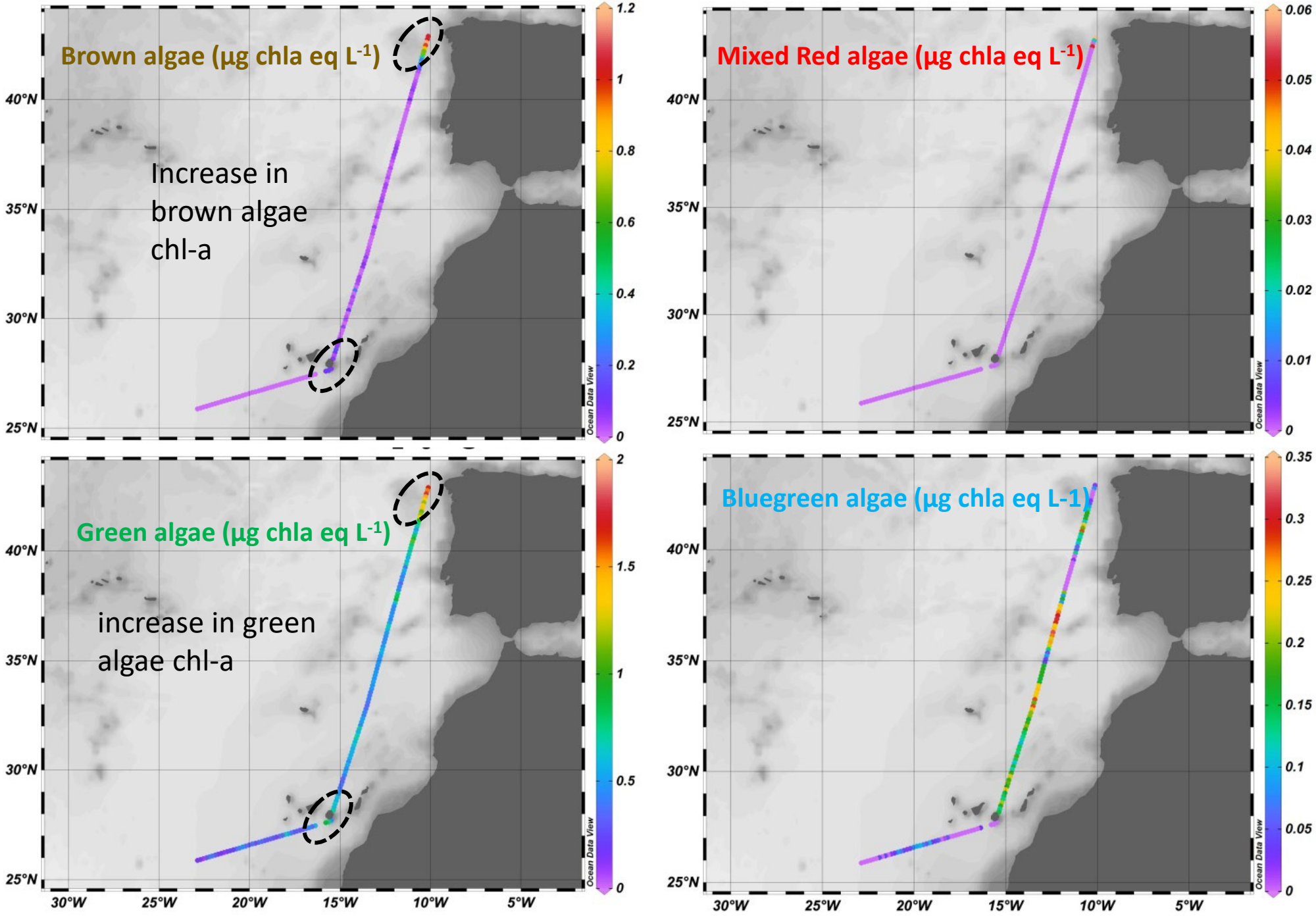
Underwater sub-surface measurements on the AMT-H1 cruise : Thersmosalinograph SBE21 – Fluoroprobe



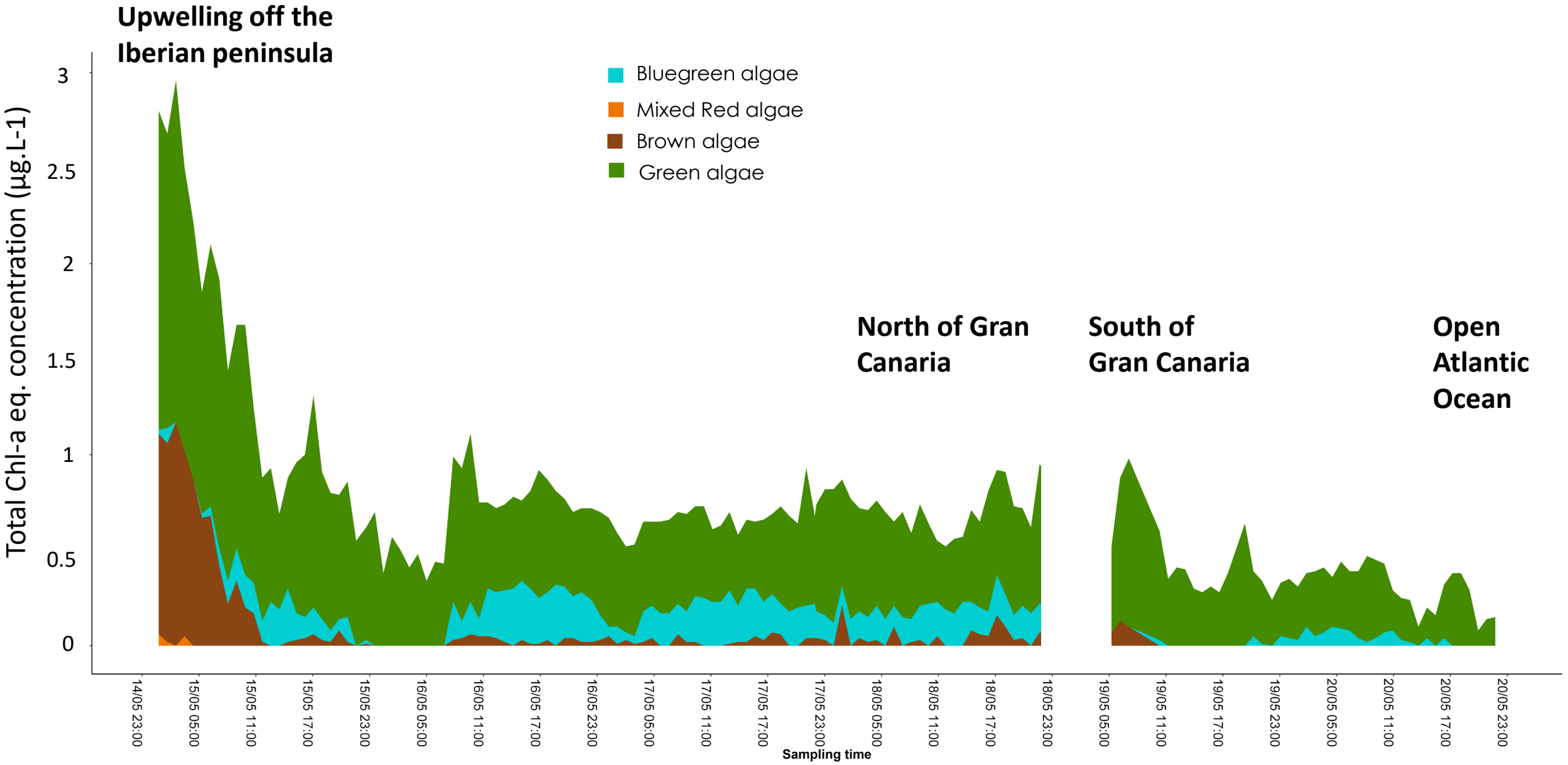




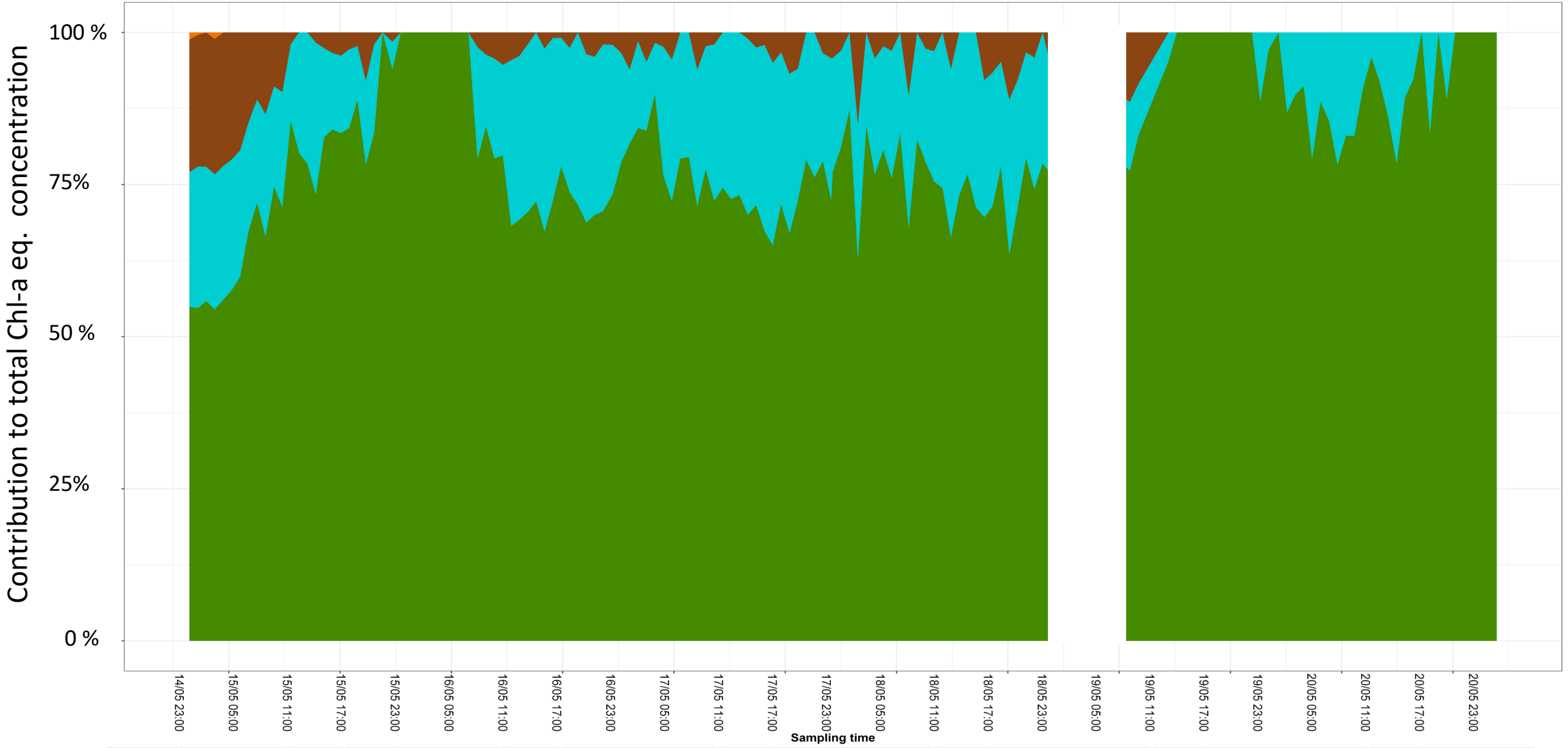
Underwater sub-surface measurements on the AMT-H1 cruise : Fluoroprobe and four different spectral groups



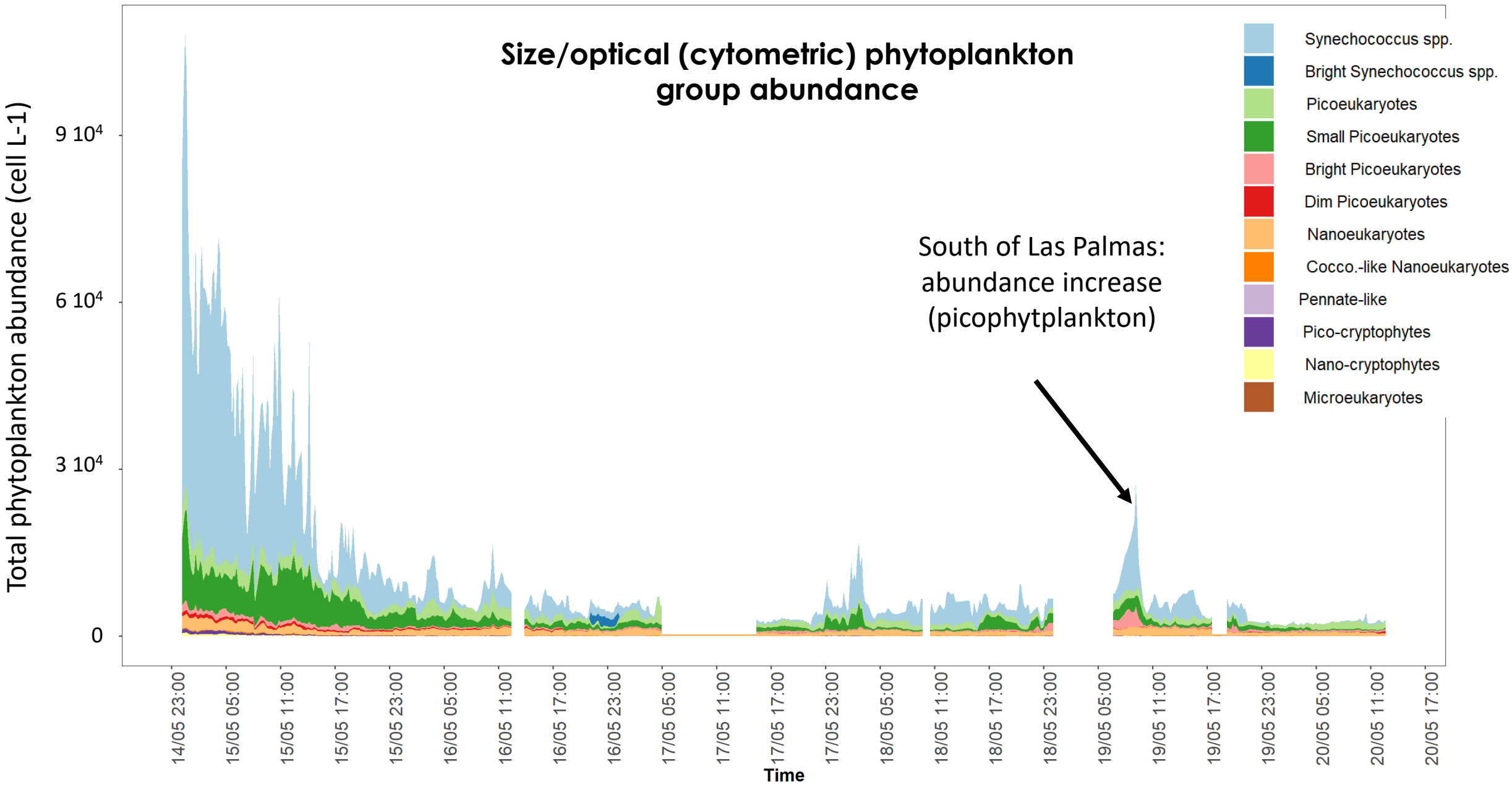
Underwater sub-surface measurements of phytoplankton spectral groups (Fluoroprobe)



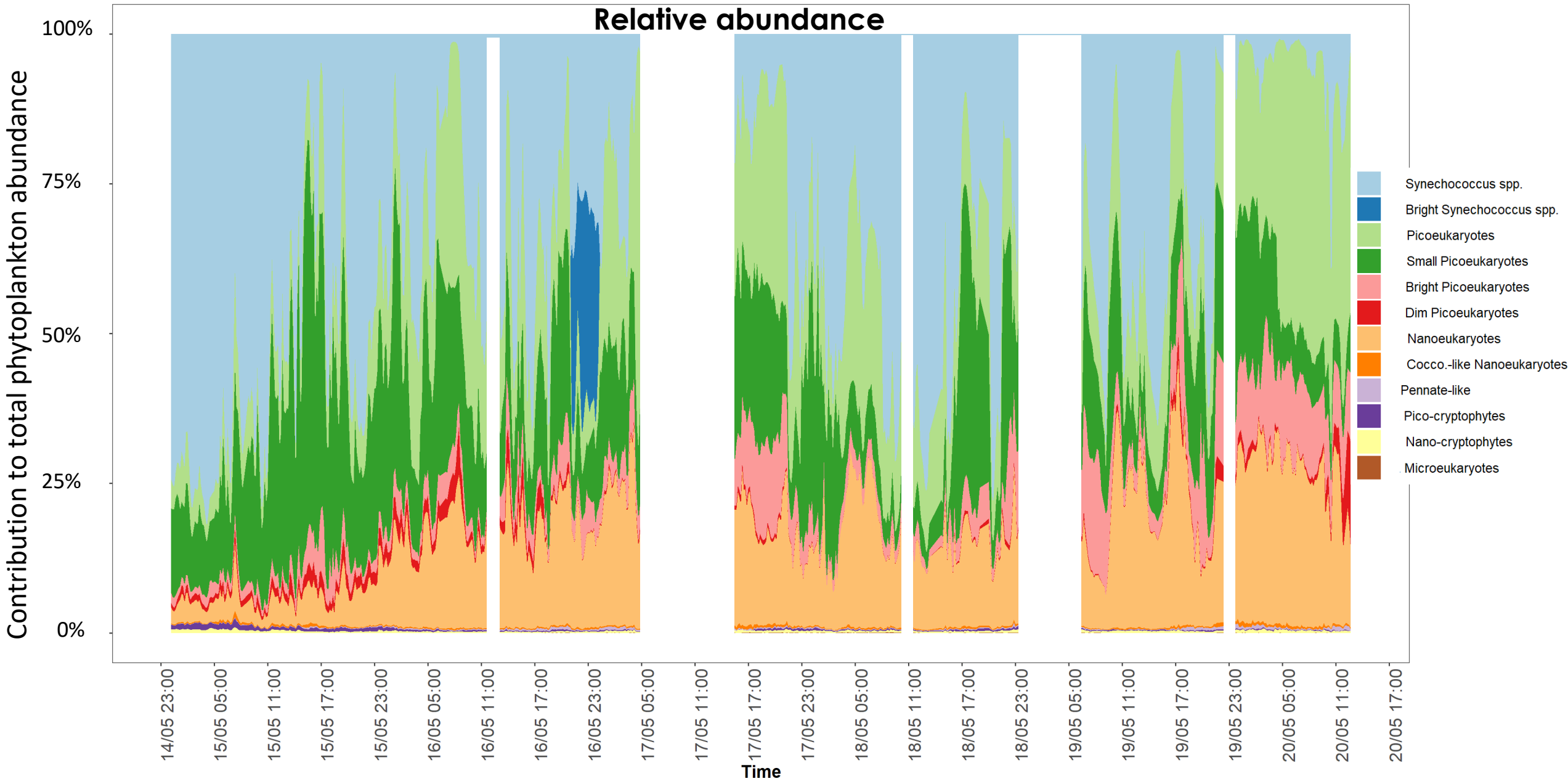
Underwater sub-surface measurements of phytoplankton spectral groups (Fluoroprobe)



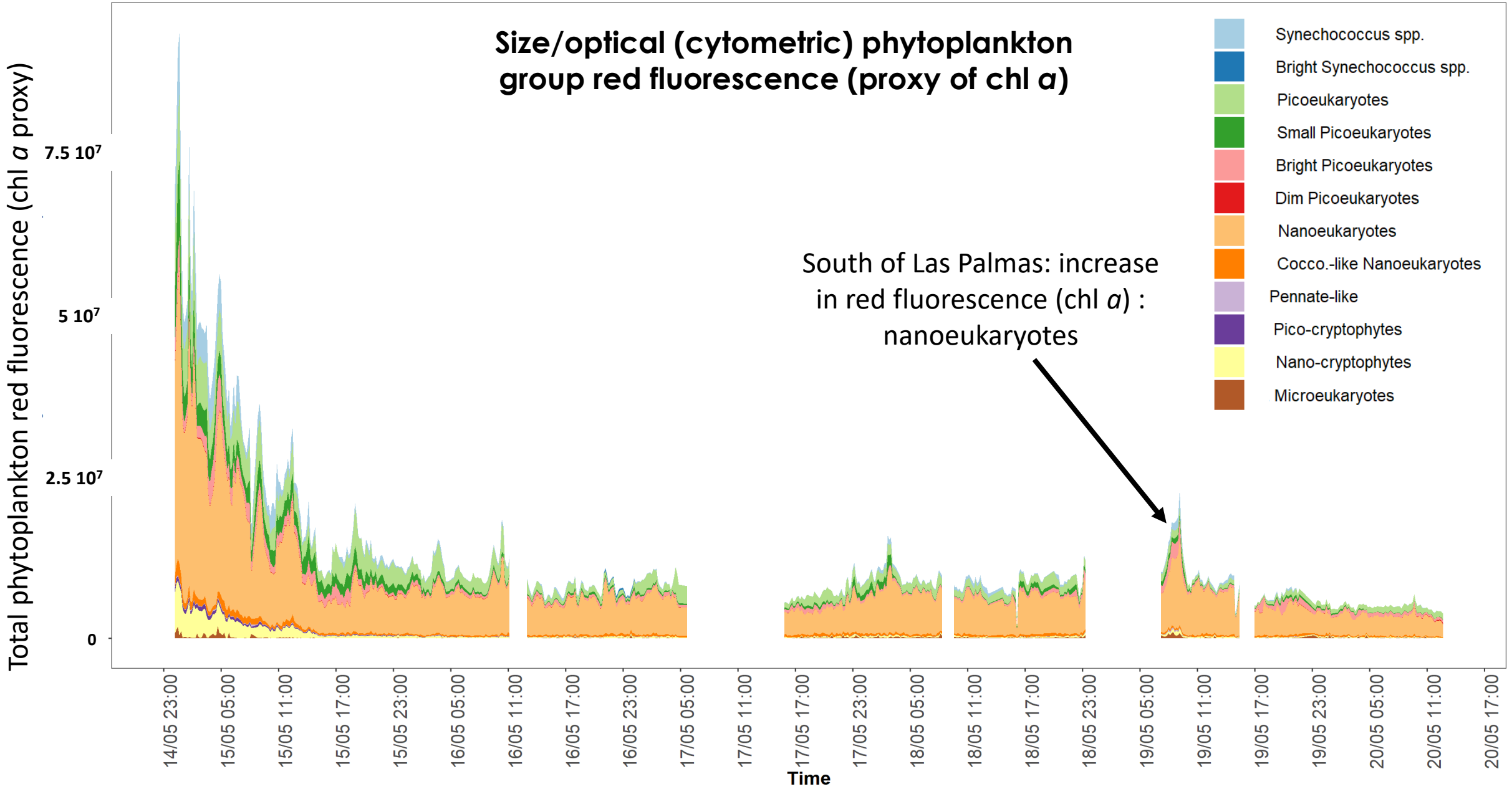
Underwater sub-surface measurements of phytoplankton functional groups (CytoSense)



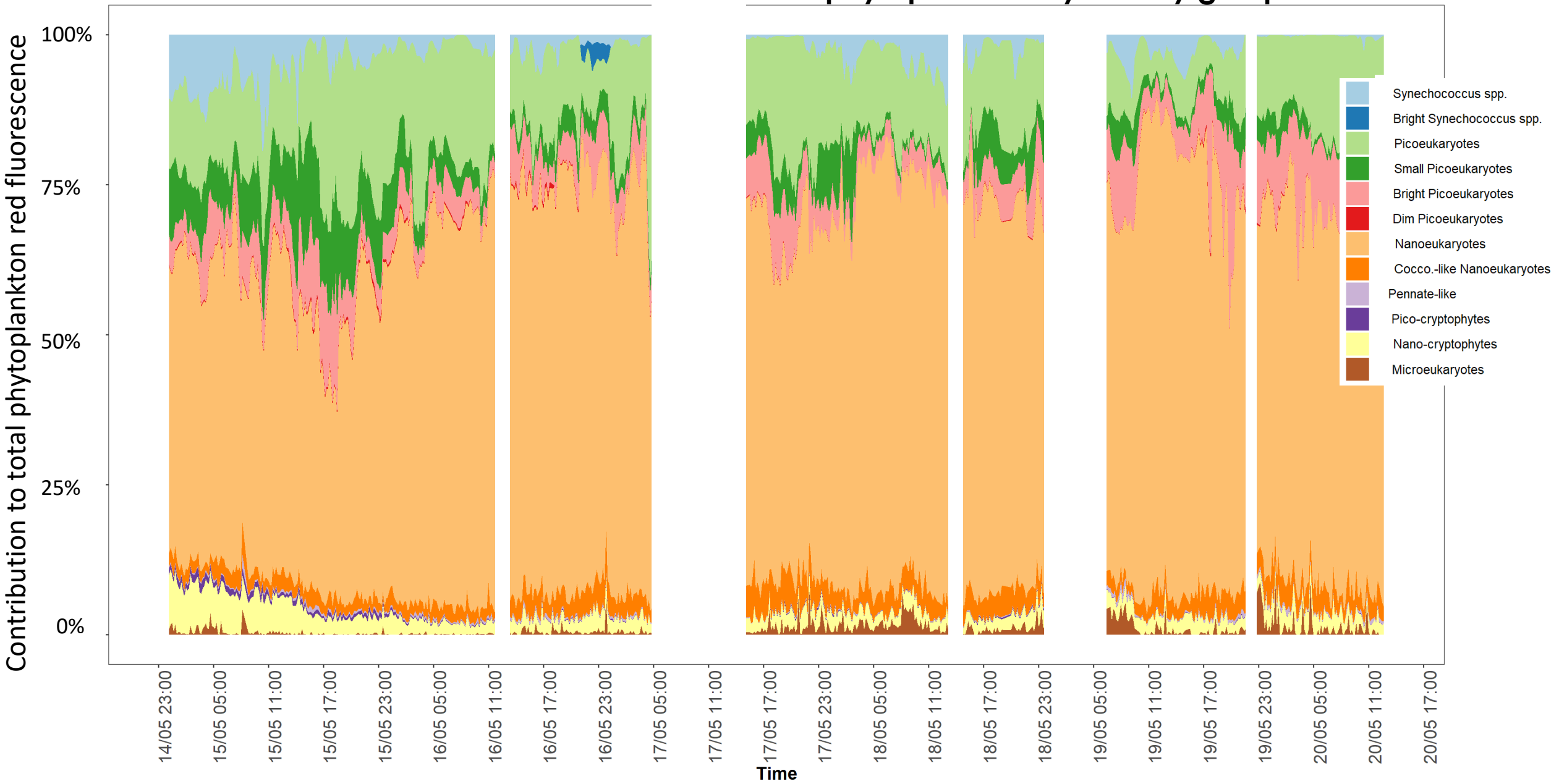
Underwater sub-surface measurements of phytoplankton functional groups (CytoSense)



Underwater sub-surface measurements of phytoplankton functional groups (CytoSense)



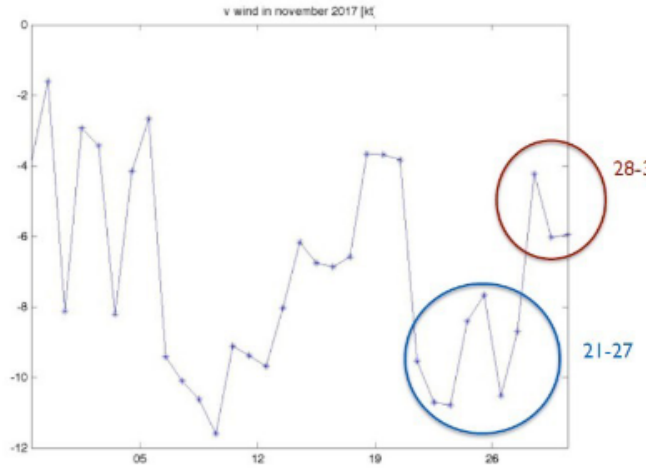
Relative red fluorescence of different phytoplankton cytometry groupe

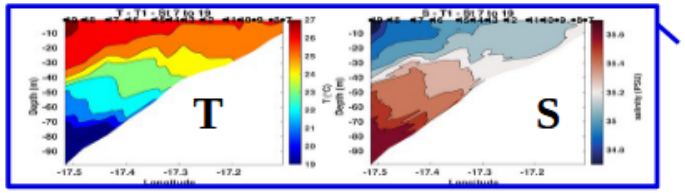


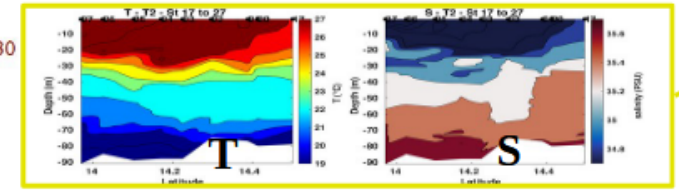
Mini-Scopes: an integrated study on the southern Canary Current Ecosystem (Sénégal upwelling)

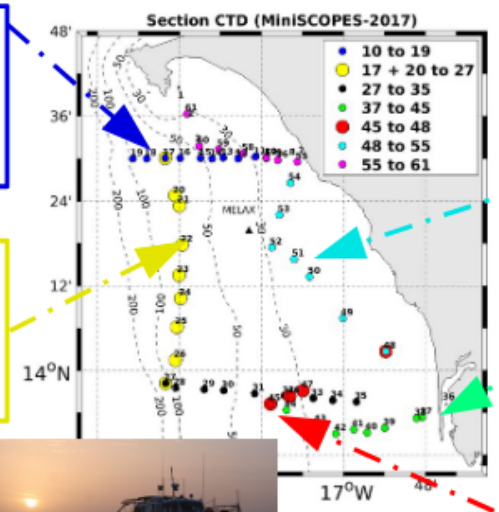
Water status during the campaign 2017 (29 November to 02 December)

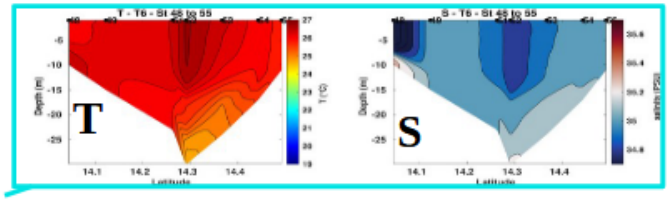
Meridian Wind November 2017

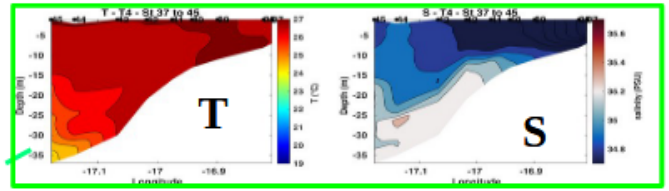


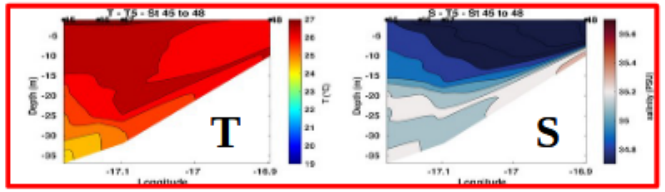




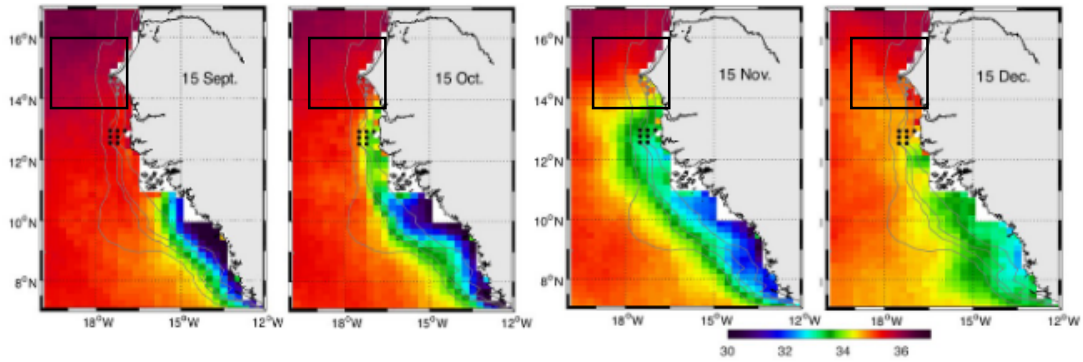






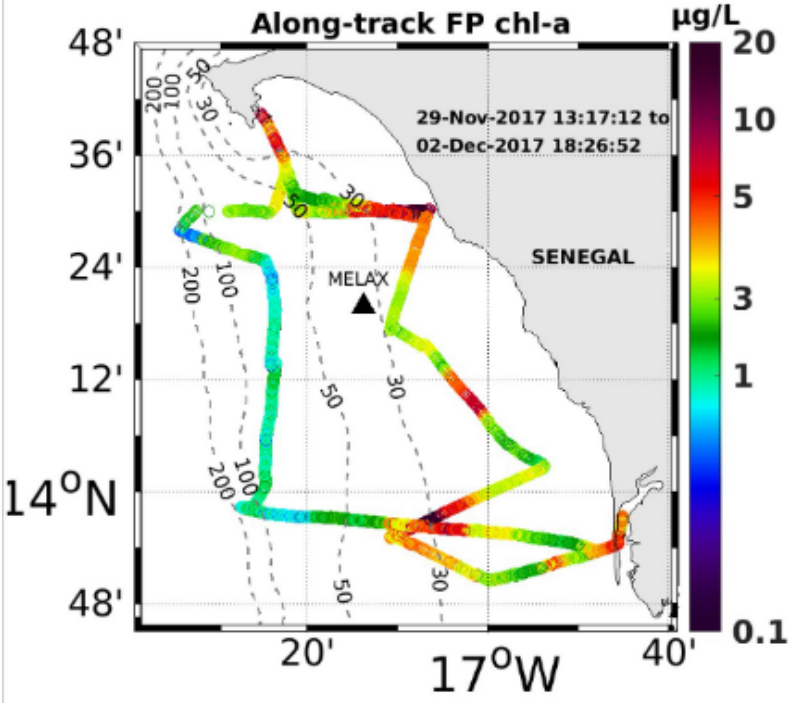


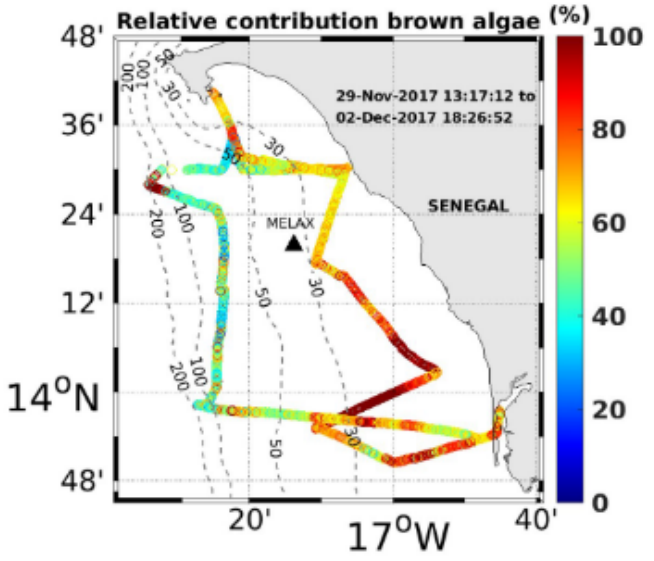
- Pre campaign period, 21-27 november, upwelling event.
- During the campaign 28 -30 november, relaxation phase.

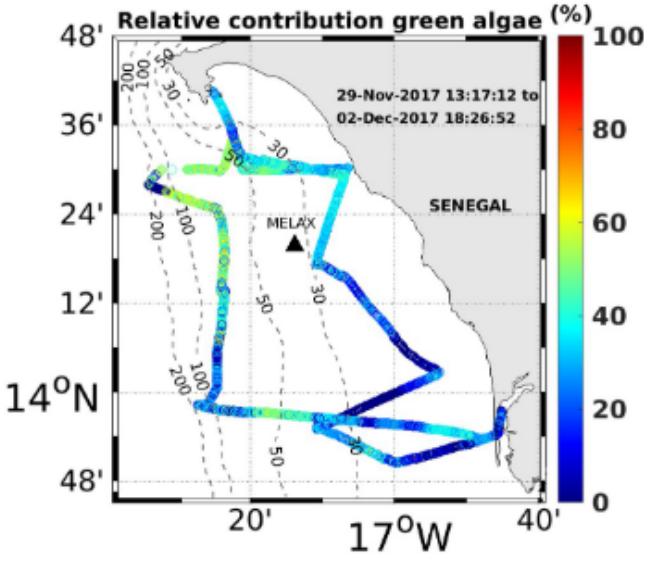


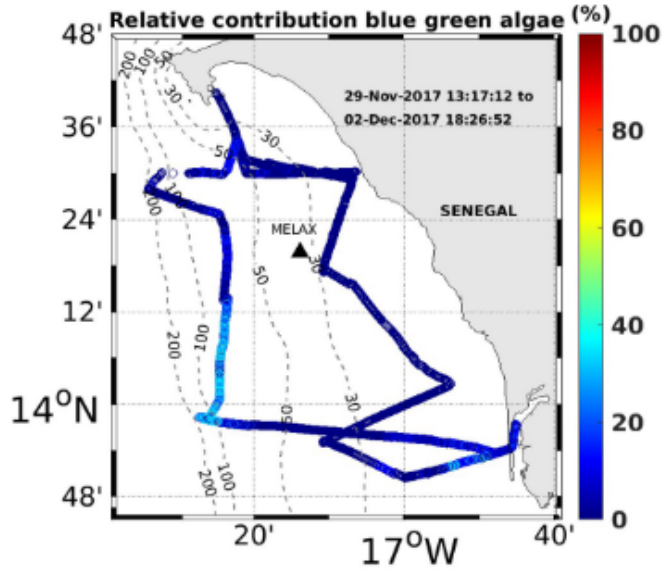
SSS (PSU) SMOS

Underwater sub-surface measurements of phytoplankton spectral groups (Fluoroprobe)



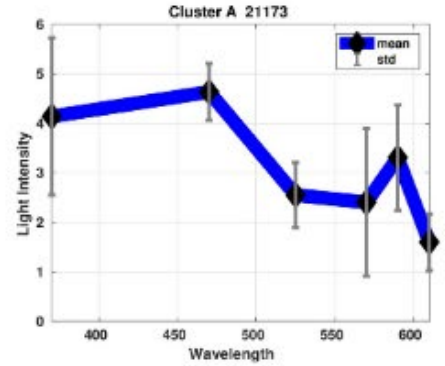


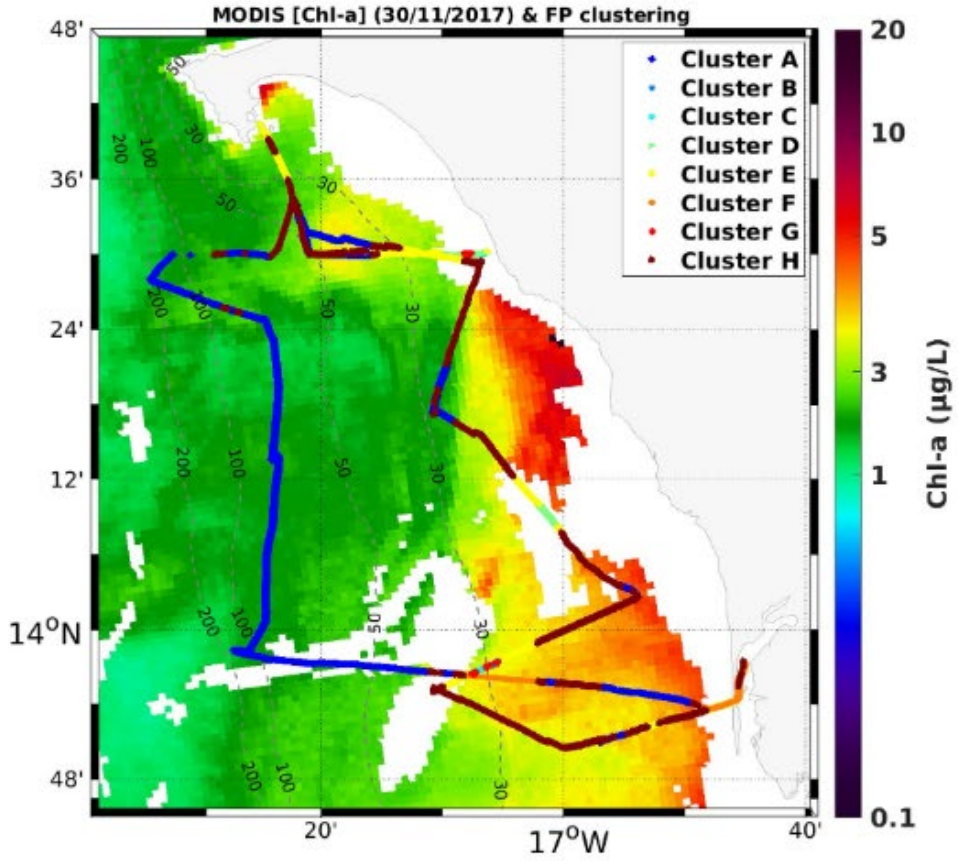


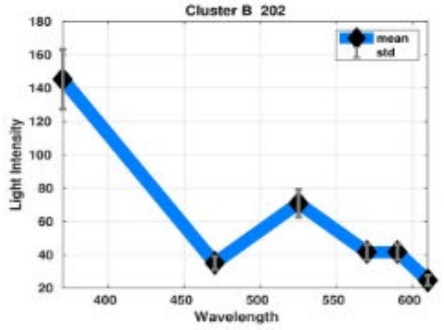


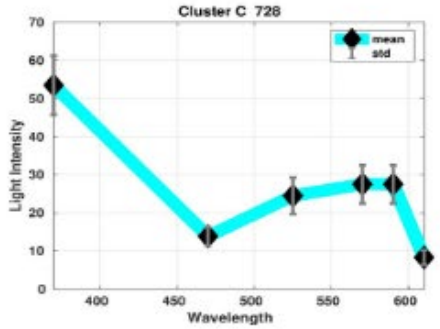
contribution (%) of three main spectral groups to total chlorophyll *a* eq.

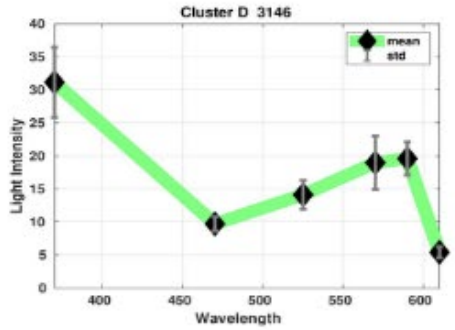
Spectral discrimination of different regions in the Sénégal shelf

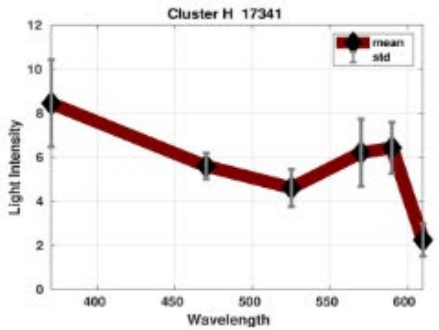


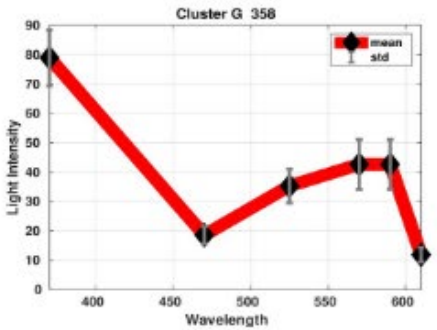


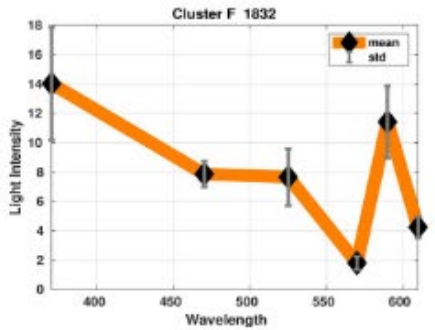


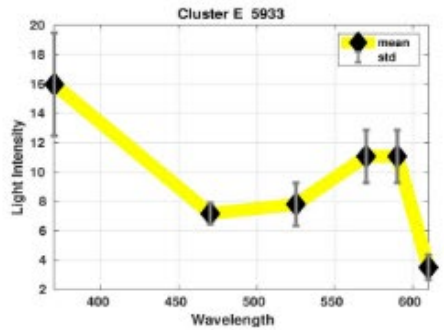








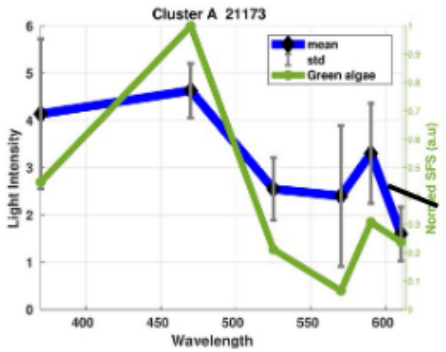


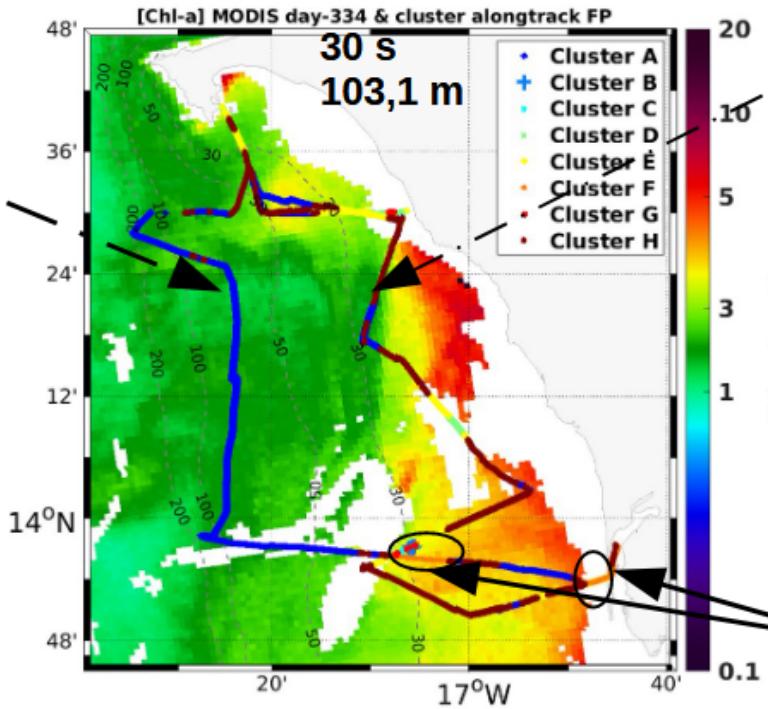


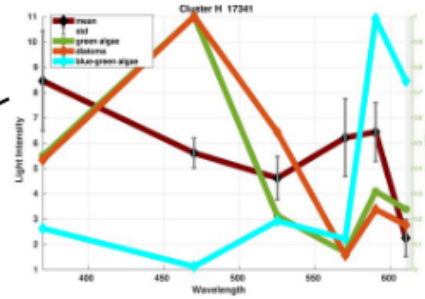
Phytoplankton communities observed along the ship's path with multispectral analysis

ACP and Clustering (K-means) applied to raw data FluoroProbe (FP)

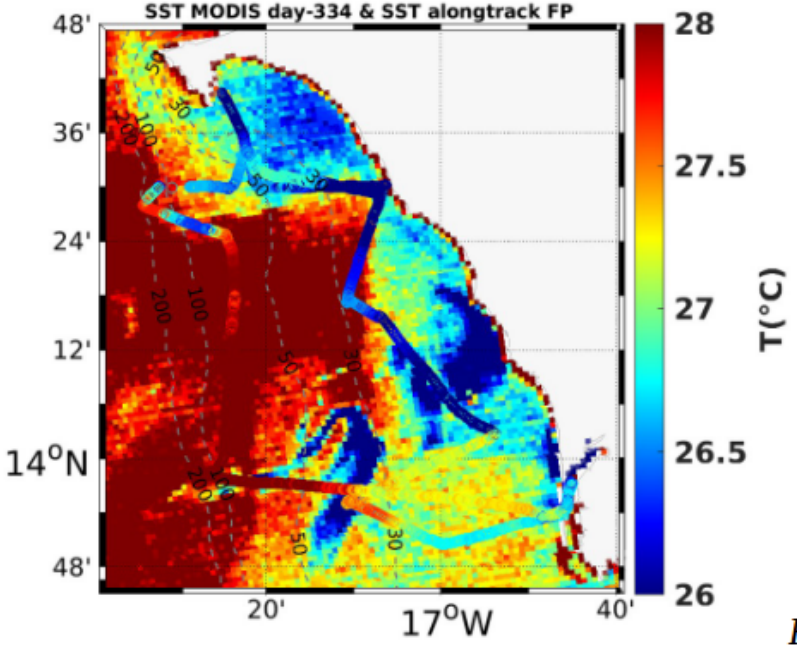
➔ Offshore, a spectral signature of green algae.

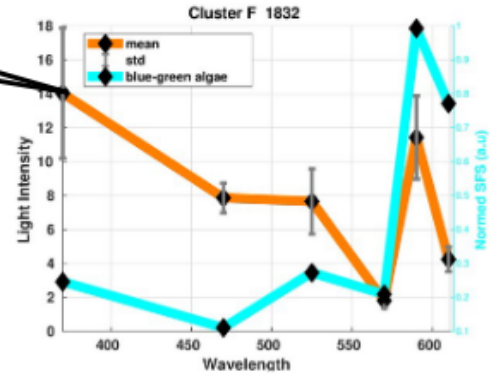






➔ The coastal fring is more mixed.

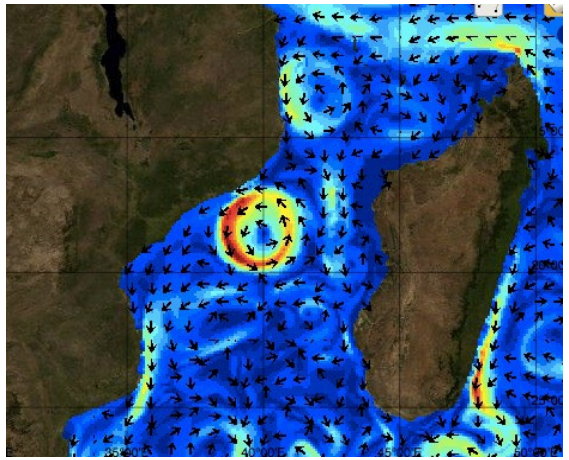




➔ In the estuarine zone and the southern part, a clear signature of blue-green algae.

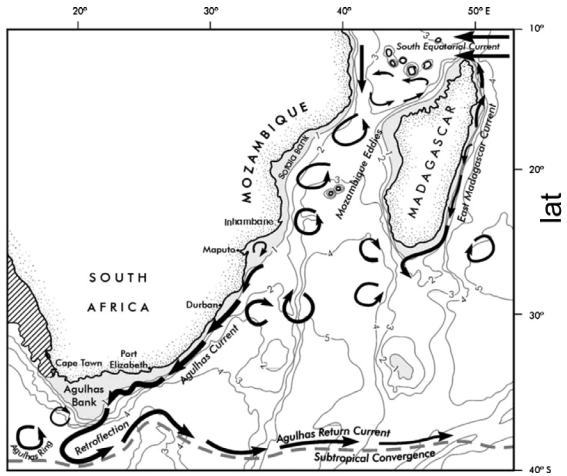
Reference fluorescence spectrum (RFS) adopted from the work of (Escoffier & al. 2014)

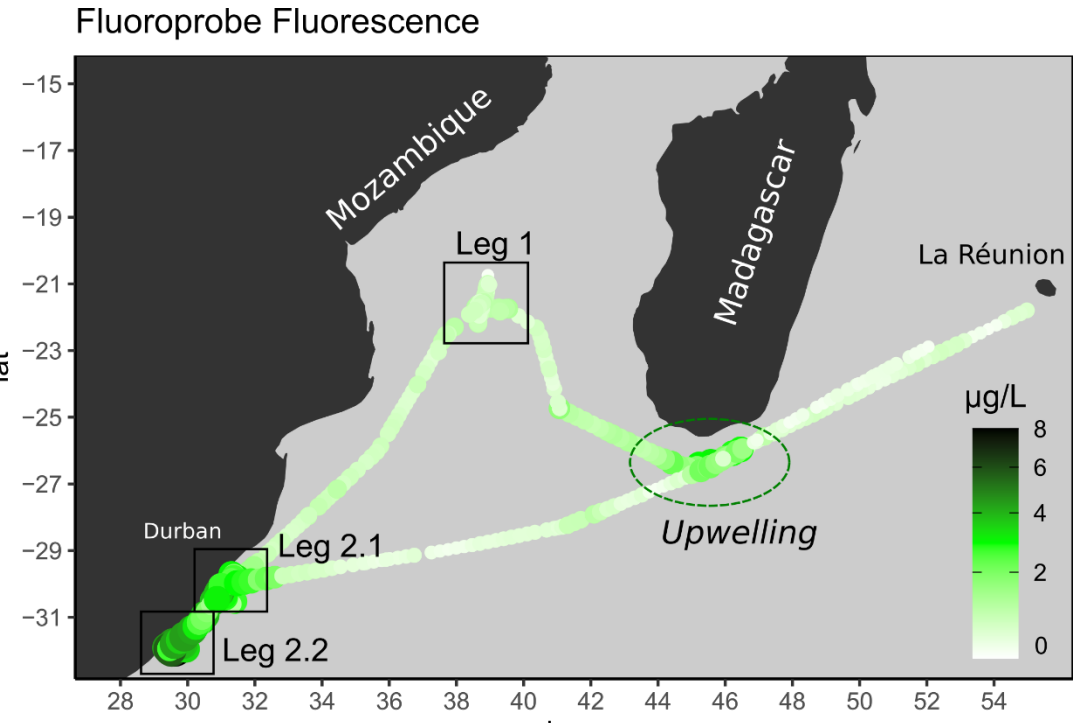
RESILIENCE 2022 on board the R.V. « Marion Dufresne »
Coupling between submesoscale eddies/fronts & marine life (western Indian Ocean)

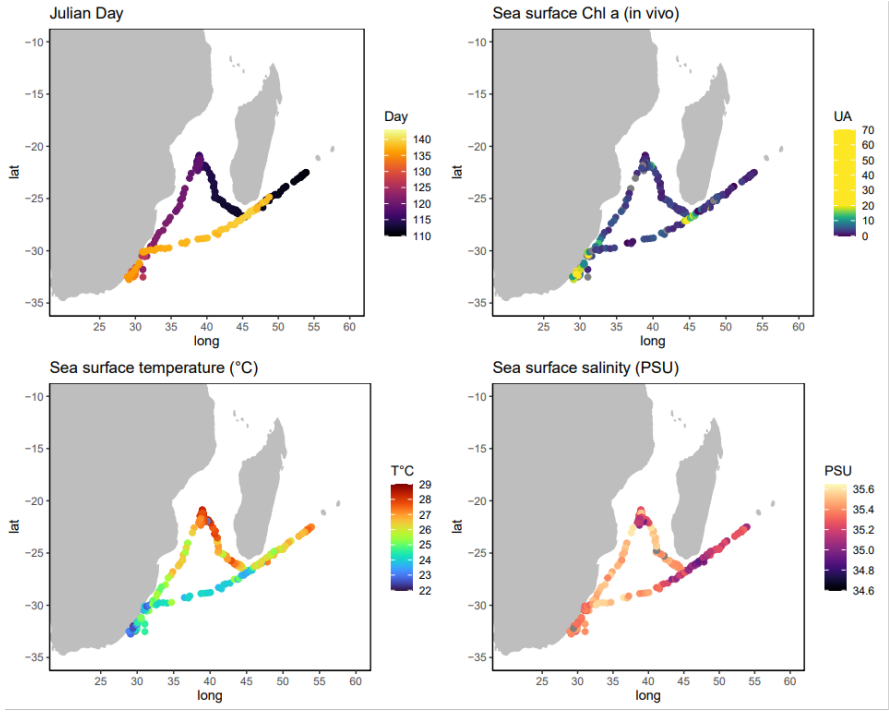


MARION DUFRESNE ATMOSPHERIC PROGRAM INDIAN OCEAN

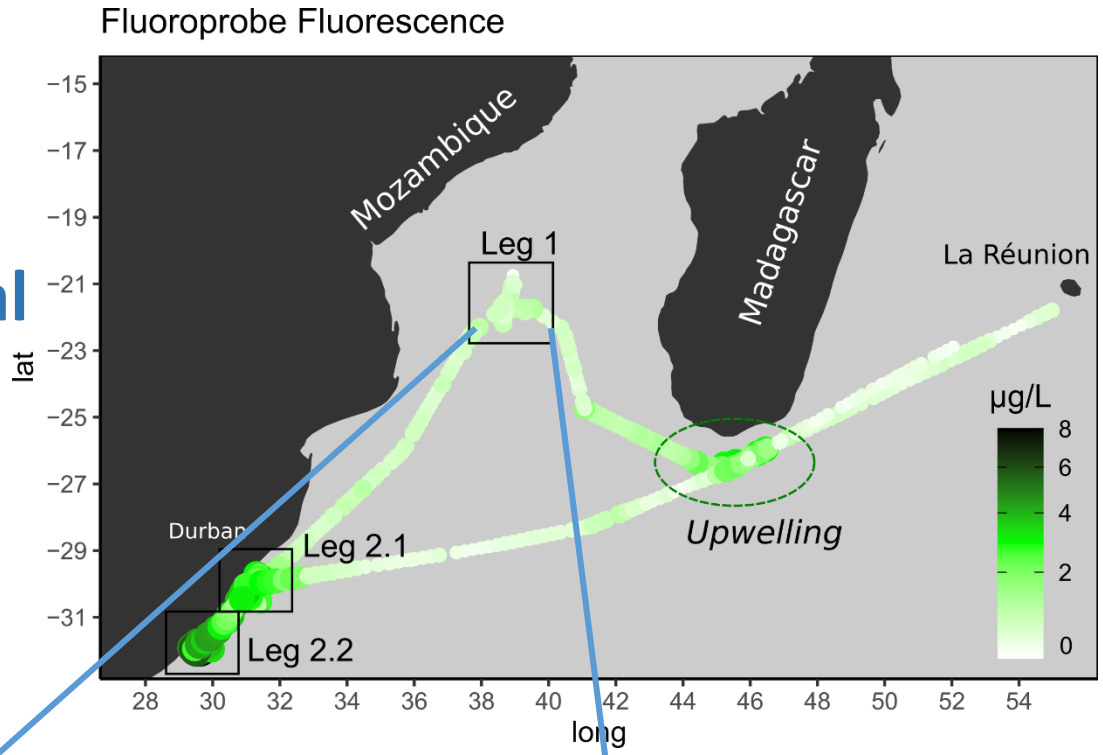
East African Coastal province (EAFR)

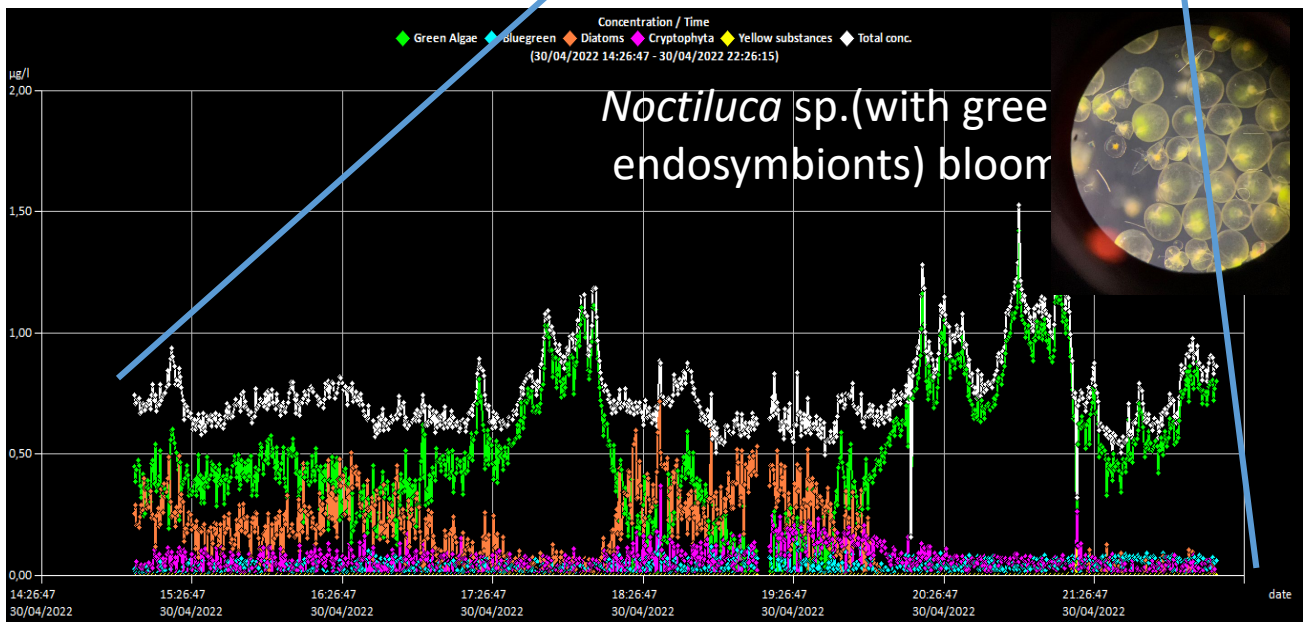






East African Coastal province (EAFR)





Noctiluca sp.(with gree endosymbionts) bloom

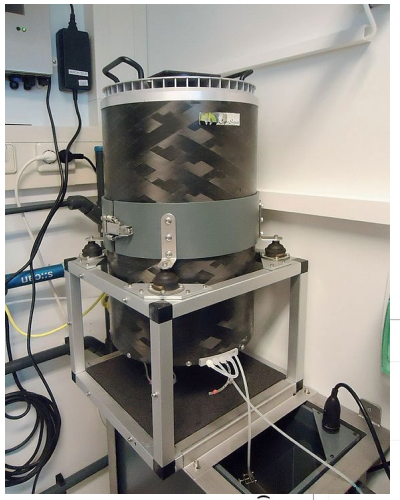
Presence of mesoscale cyclonic and anticyclonic eddies propagating southwards through the Mozambique Channel (Schouten et al., 2003; Quartly and Srokosz, 2004).

These eddies are known to enhance oceanic production in low and high trophic levels in the Mozambique Channel (Lamont et al., 2014; Lebourges-Dhaussy et al., 2014; Béhagle et al., 2014; Potier et al., 2014; Jaquemet et al., 2014).

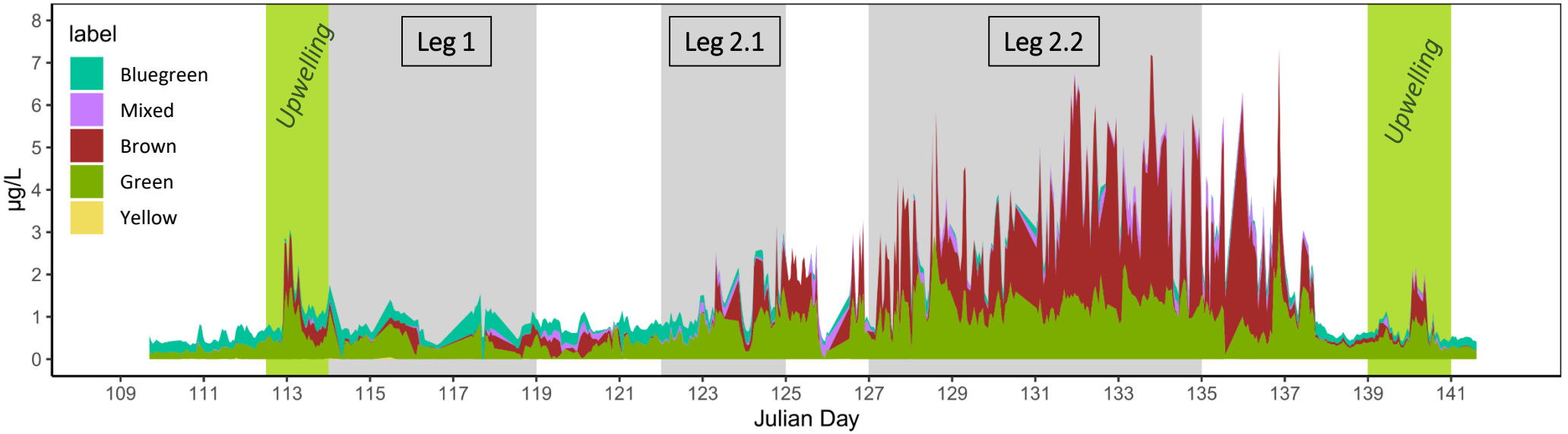
Signature of less saltier and warmer waters of the Mozambique Channel eddy (Leg 1)

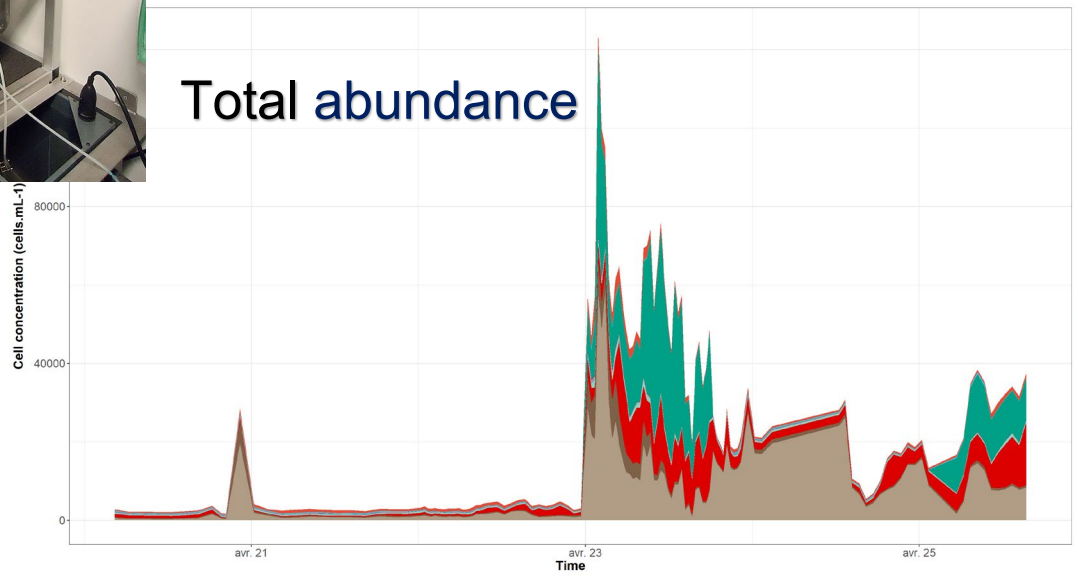
Signature of the upwelling system South Madagascar, Eddies in the Mozambique Channel and both eddies and upwelling east South Africa

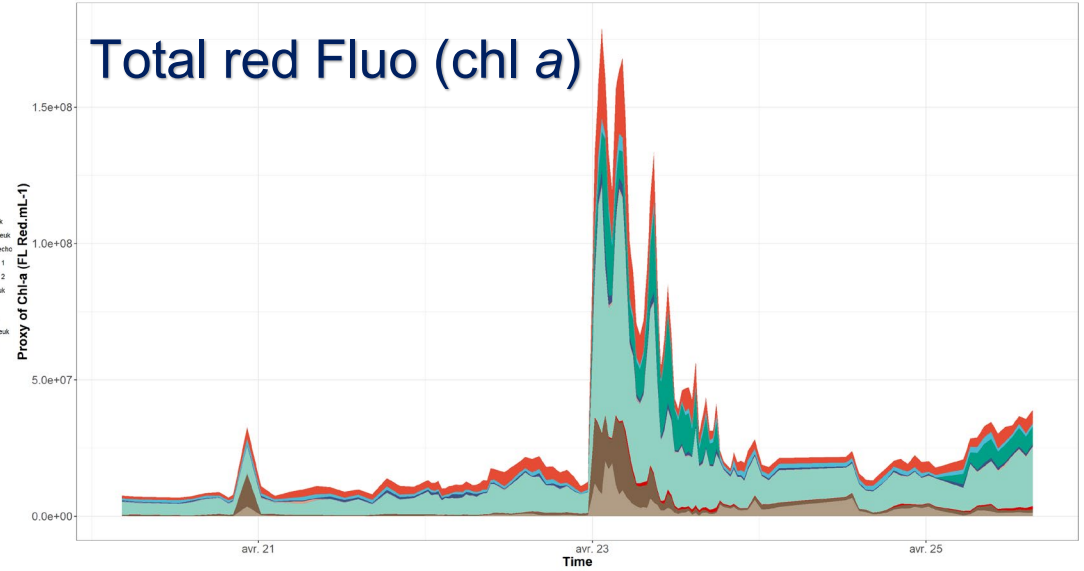
Fluoroprobe (bbe Moldaenke)



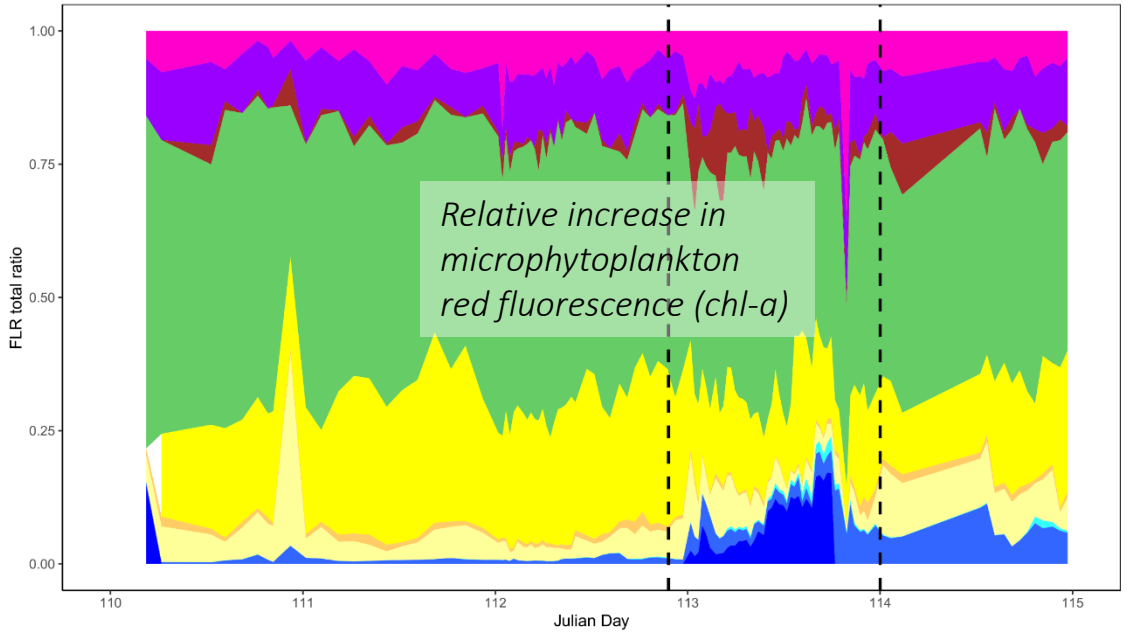
CytoSense (Cytobuoy)

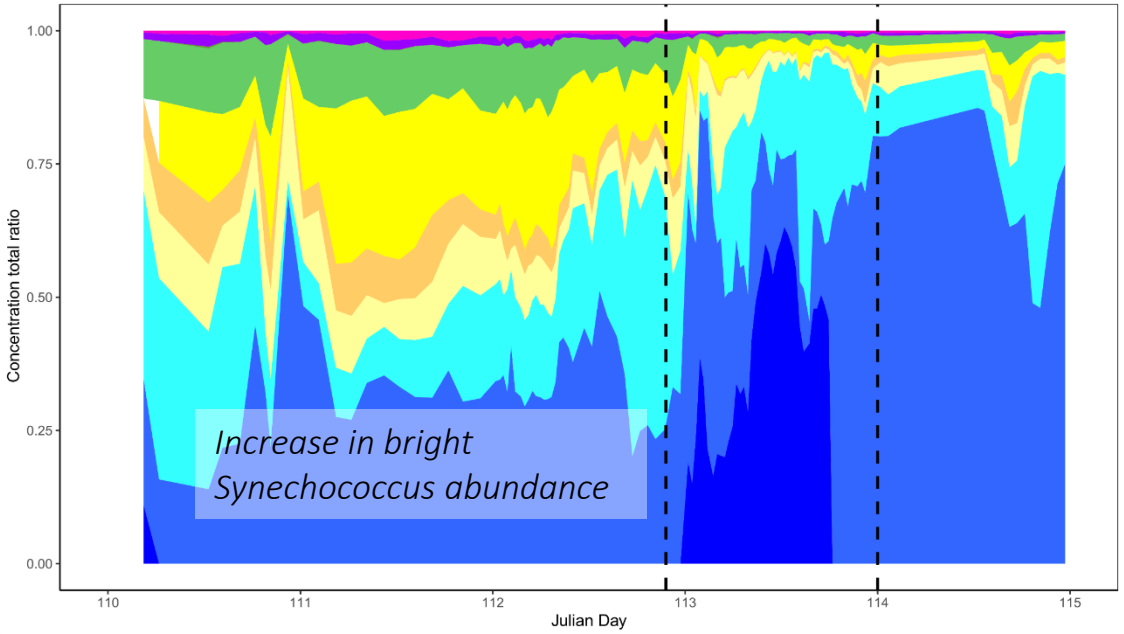


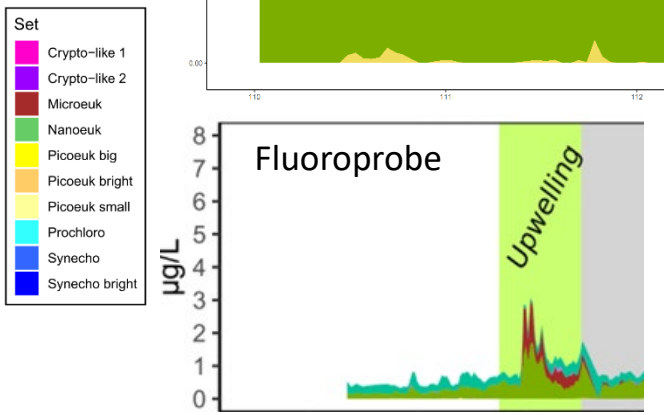


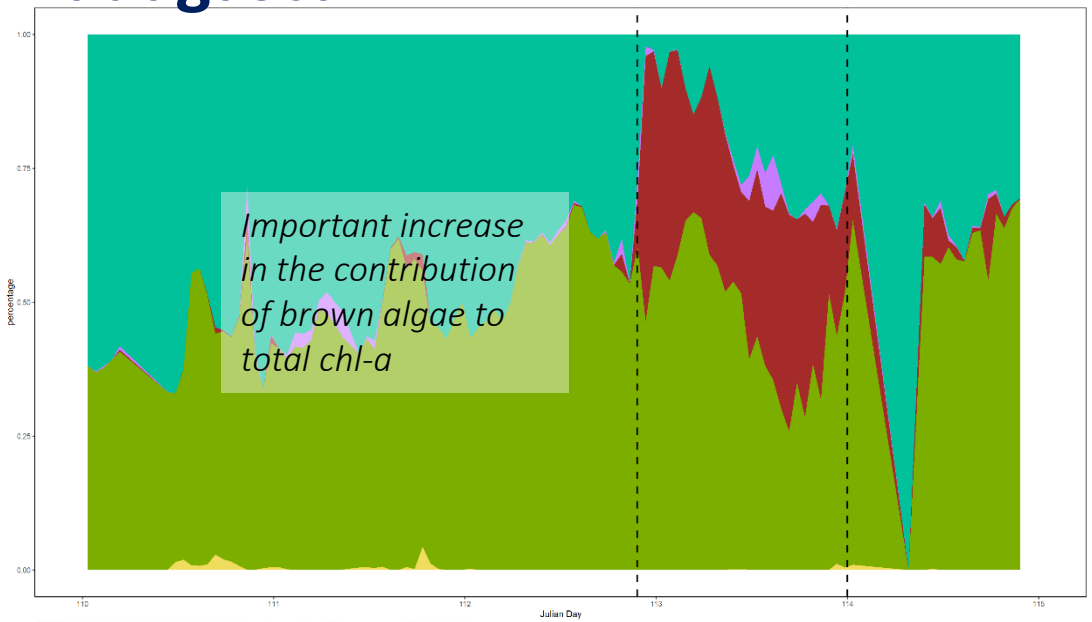


Signature of the upwelling system South Madagascar

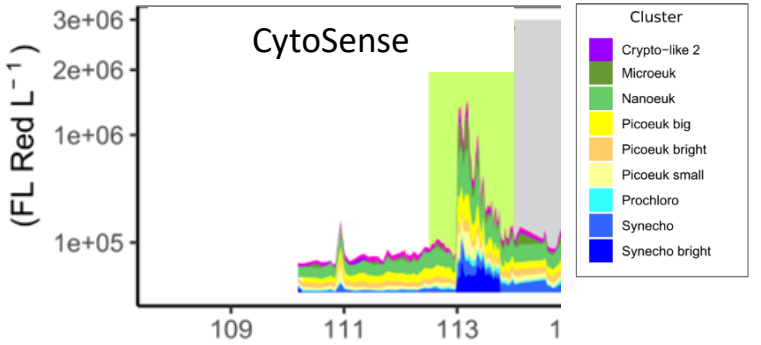




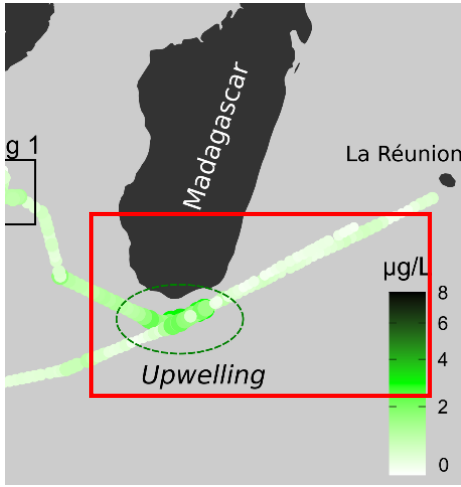




- *Decrease in bluegreen group*
- *Increase in green green group*
- *Increase in brown group*



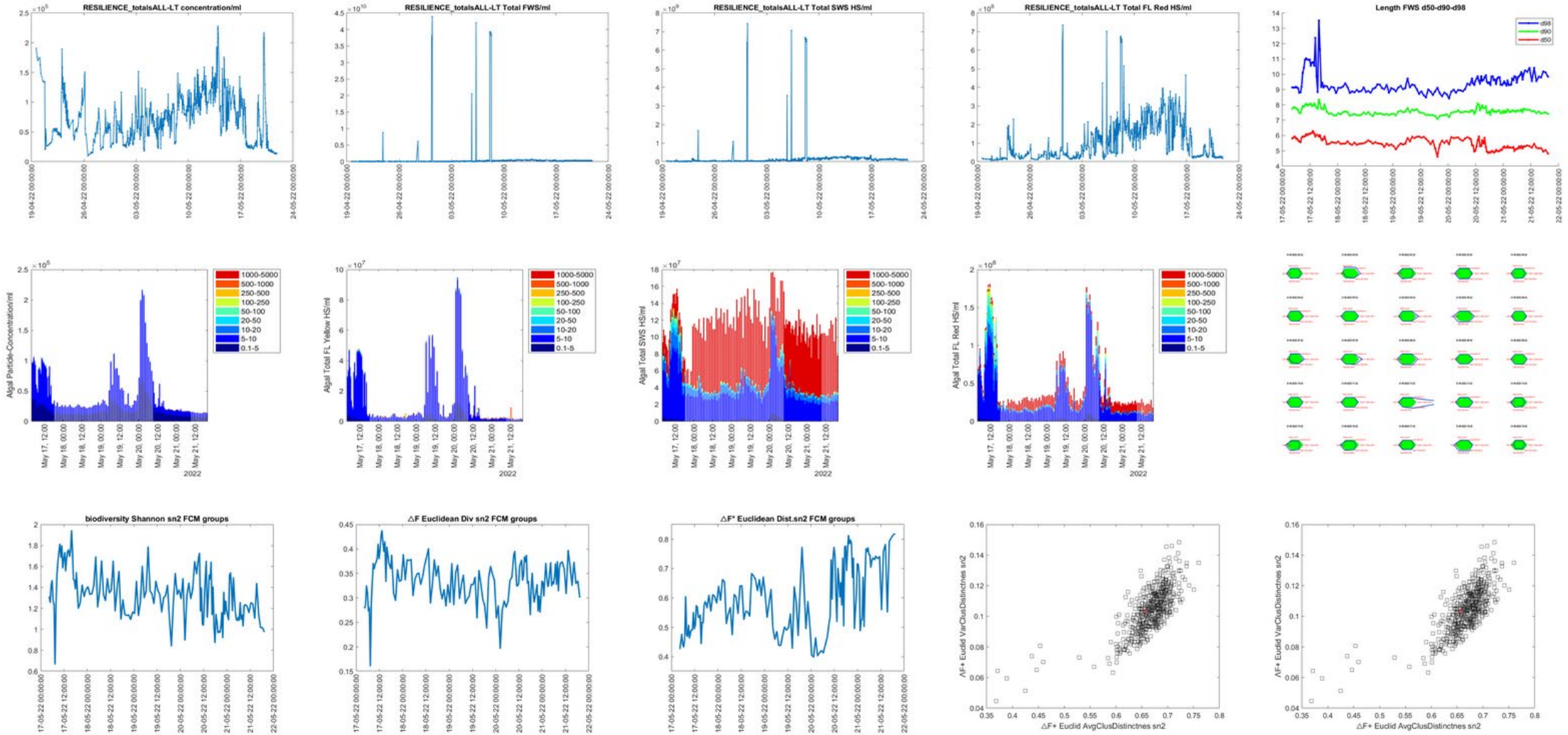
- *Increase in most optical groups*



https://fytoplankton.nl/ULCO-CNRS/RESILIENCE/phytoplankton_liveloc.shtml

Live Results RESILIENCE

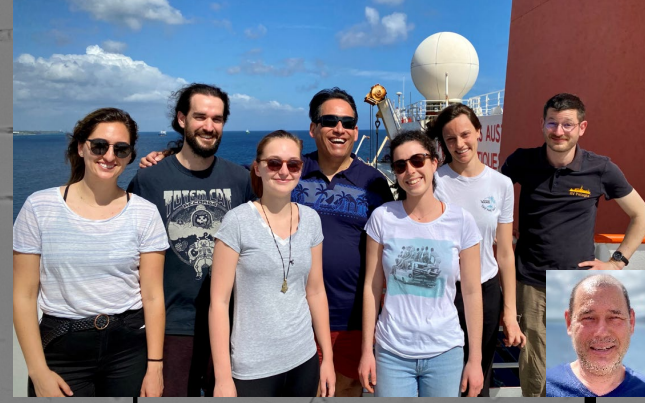
to image gallery (if available)



Easyclus Live web app. Instrument check; Unsupervised wlustering Totals per sample (abundance, chl a); Cluster plots; Biodiversity indicators - **EasyClus tool :** Possibility to build a classifier to perform supervised analysis - ***Thomas Rutten Projects***

Conclusion and perspectives

- Generalization of measurements of opportunity, in addition to dedicated oceanographic cruises for studying frontal ecosystems (spatial coverage) and application on fixed automated stations at high frequency (Eulerian approach) and/or on drifter studies (Lagrangian)
- Functional diversity coupled to taxonomical diversity (imaging) and phosotynthesis (FRRf), associated to hydrological, biogeochemical (pCO_2, nutrients) and optical measurements to improve understanding of sub-mesoscale processes and to help improving remote sensing ocean colour algorithms
- Exploring new angle on the definition of phytoplankton functional groups and ecological traits to include into ecological models
- Benefit of current networks in coastal (JERICO S3) and in open ocean systems as ICOS for C measurements, GOSHIP, I/ITAPINA “Imagine/Imaging the Atlantic - A Pelagic Imaging Network Approach”, the "Coastal Observatory for Climate, CO2 and Acidification for Global South Society" (COCAS, endorsed to the UN Ocean Decade, 2021-2030) and the IOC CCLME project, as frames for reinforcing and extending the application of these approaches in different frontal systems (eddies, upwelling), adapting and adopting common operational practices for both measurements, data treatment and data pipelines.



Thanks for your attention!

Merci pour votre attention!

Vielen Dank für Ihre Aufmerksamkeit

¡Muchas gracias por su atención!

…and thanks to the scientific teams, students and crews of the different cruises and R.V.s!