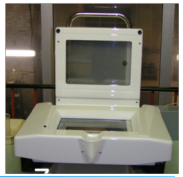
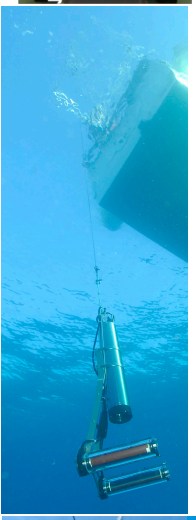
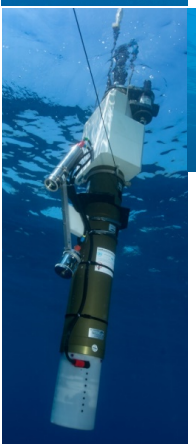


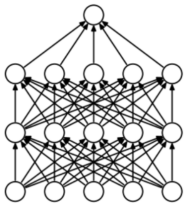


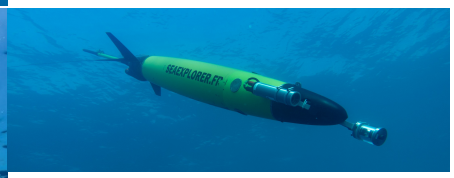


Towards a coordinated global marine biodiversity observing system

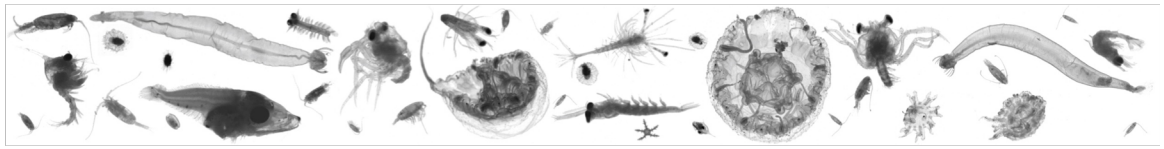
SORBONNE UNIVERSITÉ

Towards a global *in situ* monitoring of plankton using imaging systems: lessons learnt from the past 10 years of observation in Europe





Lars Stemmann, Romagnan Jean Baptiste, Alain Lefebvre, Gérald Grégori, Jean Olivier Irisson, Bengt Karlson, Jukka Seppala, Kaisa Kraft, Guidi Lionel, Luis Felipe Artigas, Dodji Soviadan, Guillaume Wacquet, Klas Ove Möller, Klaas Deneudt, Simon Claus, Fabien Lombard



OCEANOMICS

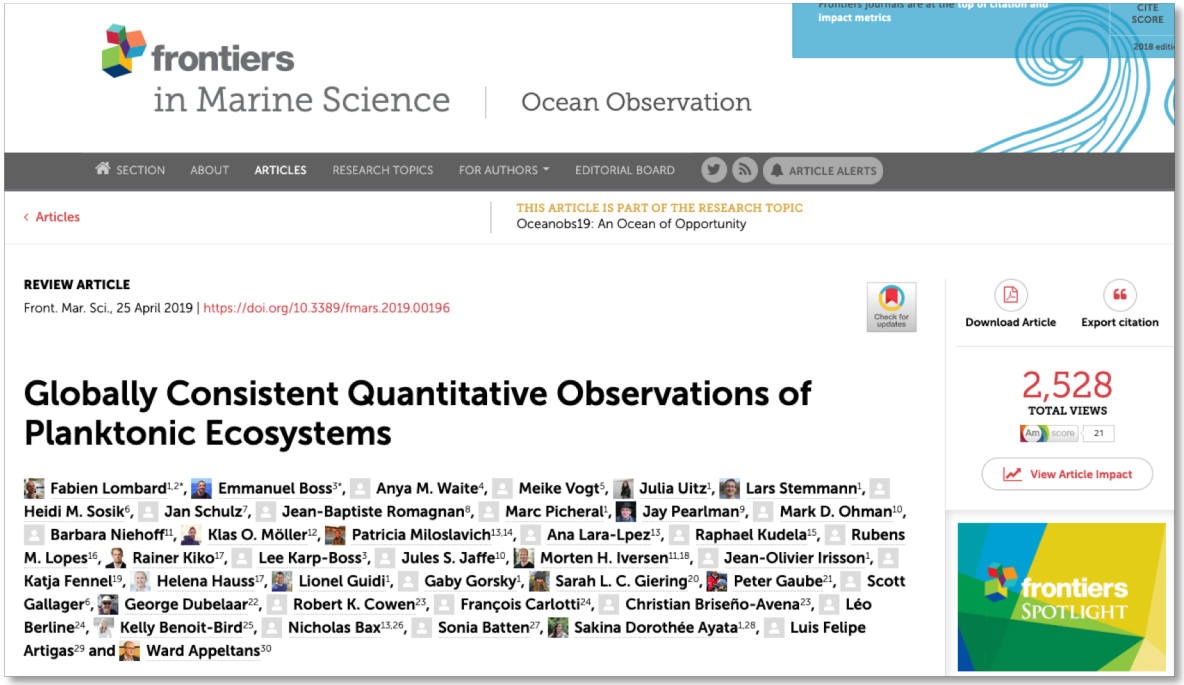
BRIDGES

JERICO next

Pôle Mer

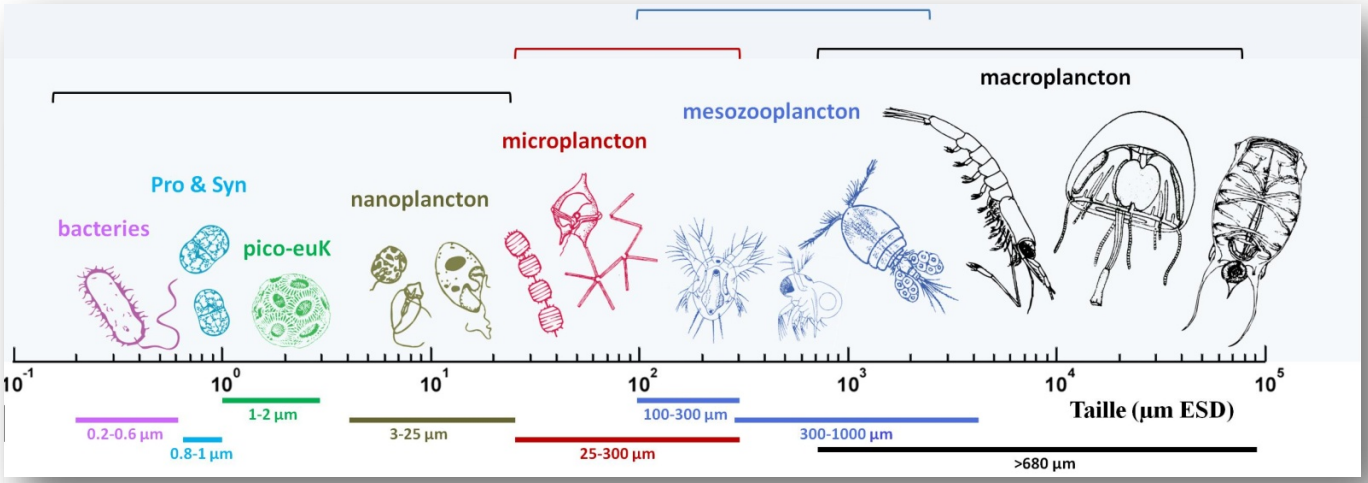
Phytoplankton and Zooplankton abundance and diversity have been tagged as

→ **Ecosystem Essential Ocean Variables** (eEOVs) by GOOS (Global Ocean Observing System)
→ **Essential Climate Variables** (ECVs) under GCOS (Global Climate Observing System)
→ **Ecosystem Biodiversity Variable** (GEO BON, Group on earth observation)

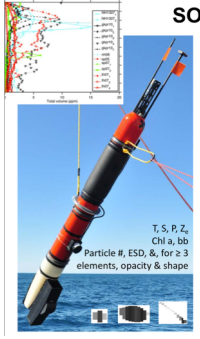


OCEAN OBS'19
AN OCEAN OF OPPORTUNITY
September 16-20, 2019

A whole suite of sea going and Lab imaging instruments

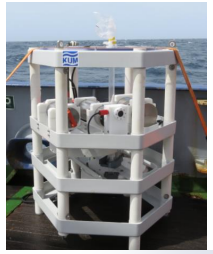


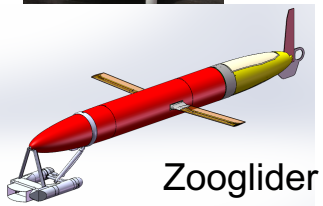
UVP6*



SOLOPC

BOP





Zooglider

Zooscan*

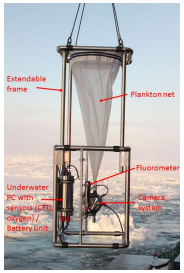
Flowcam*

SPC

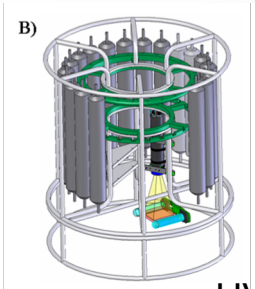
IFCB*

Cytobuoy *

CPICS *



LOKI*



UVP5*

USP/Brasil

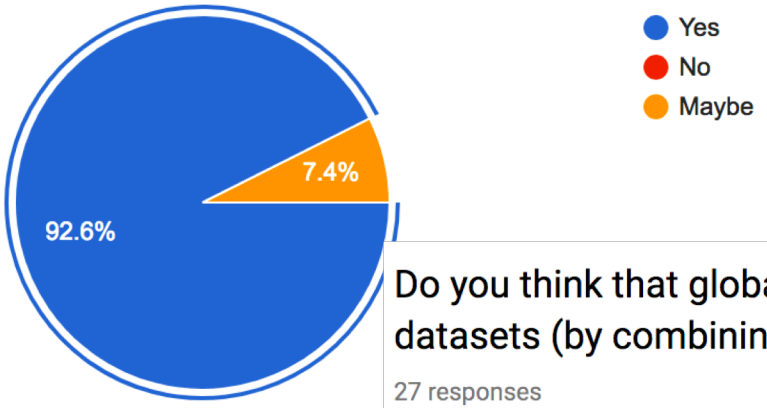
ISIS*

* Commercially available

A whole suite of colleagues (mostly biologists) sharing the same ideas (May 2018)

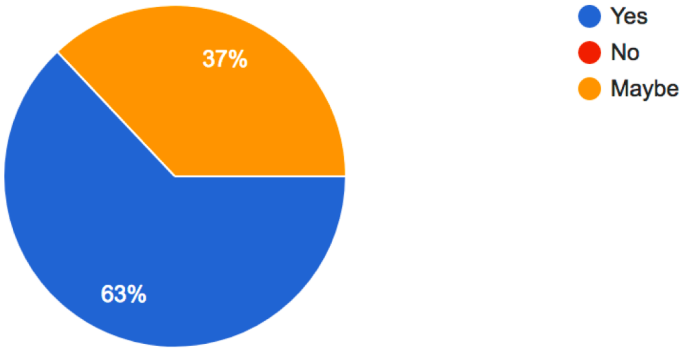
Do you think that collaborative ways to visualize, annotate, quality control, and share the resulting data is important ?

27 responses

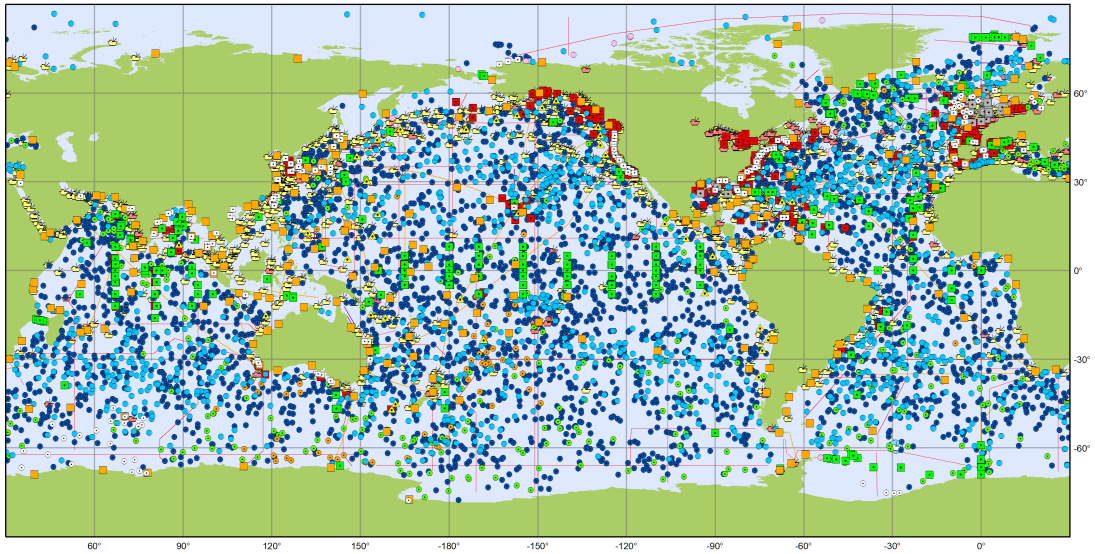


Do you think that global plankton datasets can emerge from local datasets (by combining regional results)

27 responses



The 10 years vision,
Plankton: global and regional monitoring with imaging systems



Main in situ Elements of the Global Ocean Observing System

April 2019

Profiling Floats (Argo)

- Core (3880)
- Deep (79)
- BioGeoChemical (352)

Data Buoys (DBCP)

- Surface Drifters (1444)
- Offshore Platforms (97)
- Ice Buoys (11)
- Moored Buoys (358)
- Tsunameters (38)

Timeseries (OceanSITES)

- Interdisciplinary Moorings (351)

Repeated Hydrography (GO-SHIP)

- Research Vessel Lines (62)

Sea Level (GLOSS)

- Tide Gauges (252)

Ship based Measurements (SOT)

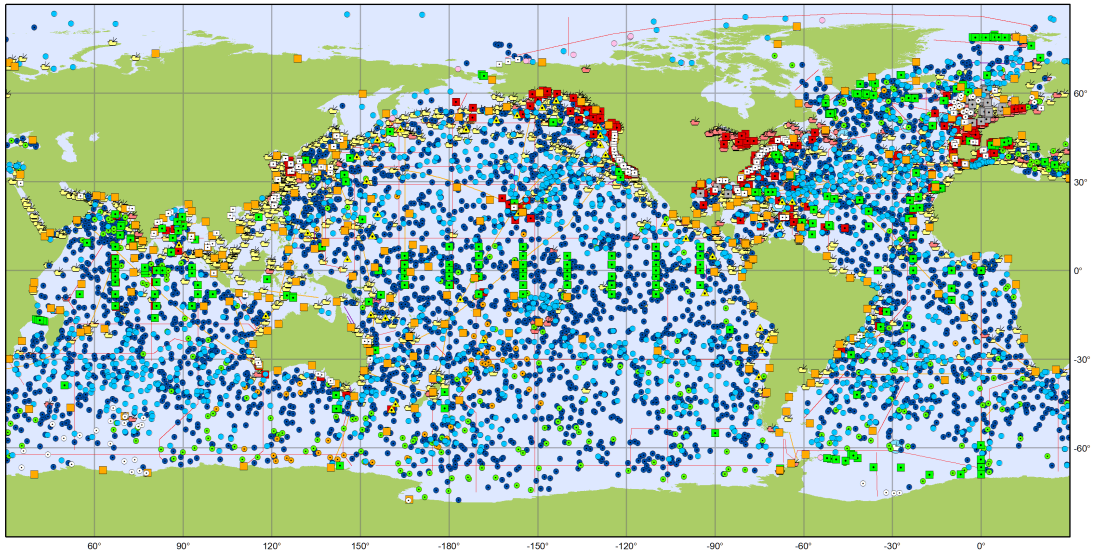
- Automated Weather Stations (257)
- Manned Weather Stations (1324)
- Radiosondes (11)
- eXpendable BathyThermographs (34)

Other Networks

- HF Radars (270)
- Animal Borne Sensors (53)
- Ocean Gliders (31)

Generated by www.jcommops.org, 14/05/2019

The 10 years vision,
Plankton: global and regional monitoring with imaging systems



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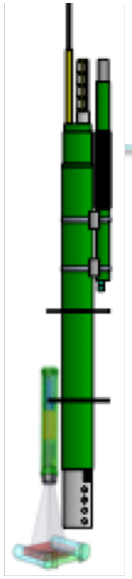
-Ecosystem monitoring

- Data assimilation in models for carbone cycles and marine ressources.



D_{PSD} ← **Particulate Organic Carbon**

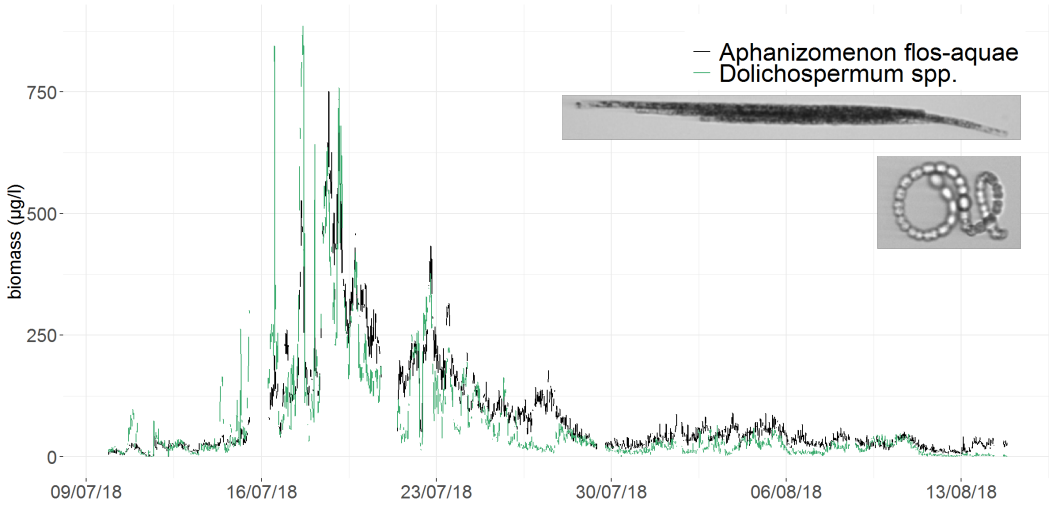
Z_n ← **macro and mesoplankton (Taxa size spectra)**

P_λ ← **Pico and microplankton (taxa, size spectra)**

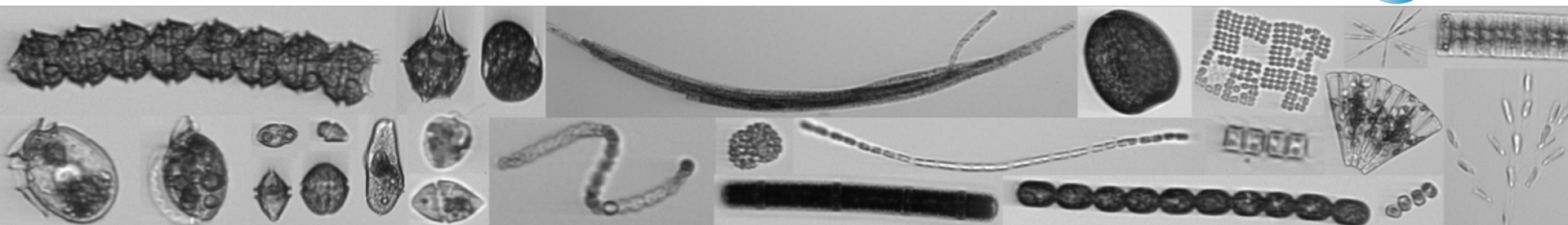
N ← **CTD and geochemical data**

Case study 1: long term monitoring – phytoplankton in the Baltic with IFCB

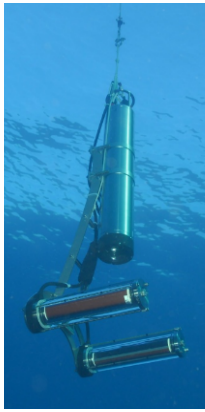
- IFCB has been deployed at Utö Atmospheric and Marine Research Station (Baltic Sea, Finland) **in 2017 and 2018**
- So far **60 taxonomic categories** identified
- **creating classifier** for nuisance filamentous cyanobacteria,
- IFCB data used at SYKE **for weekly algal reviews in 2018, to inform public** on extensive cyanobacteria blooms

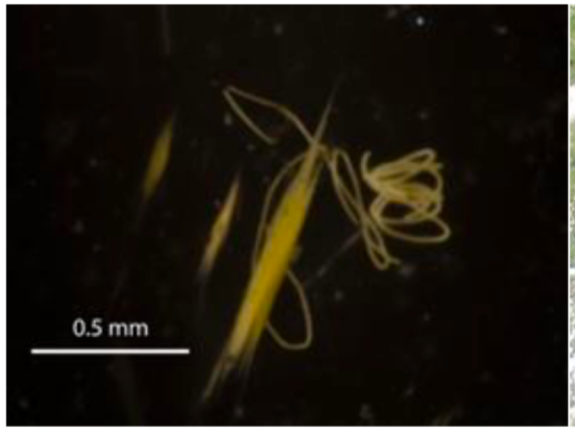


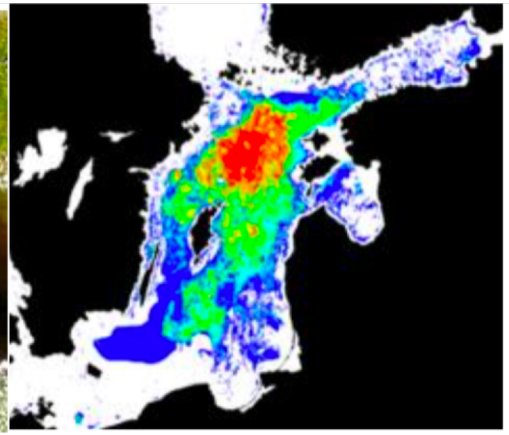
Cyanobacteria bloom in Baltic 2018



Case study 2: Spatial monitoring of cyanobacterial blooms in the Baltic (July 2017) with UVP5







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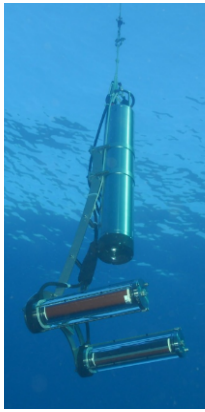

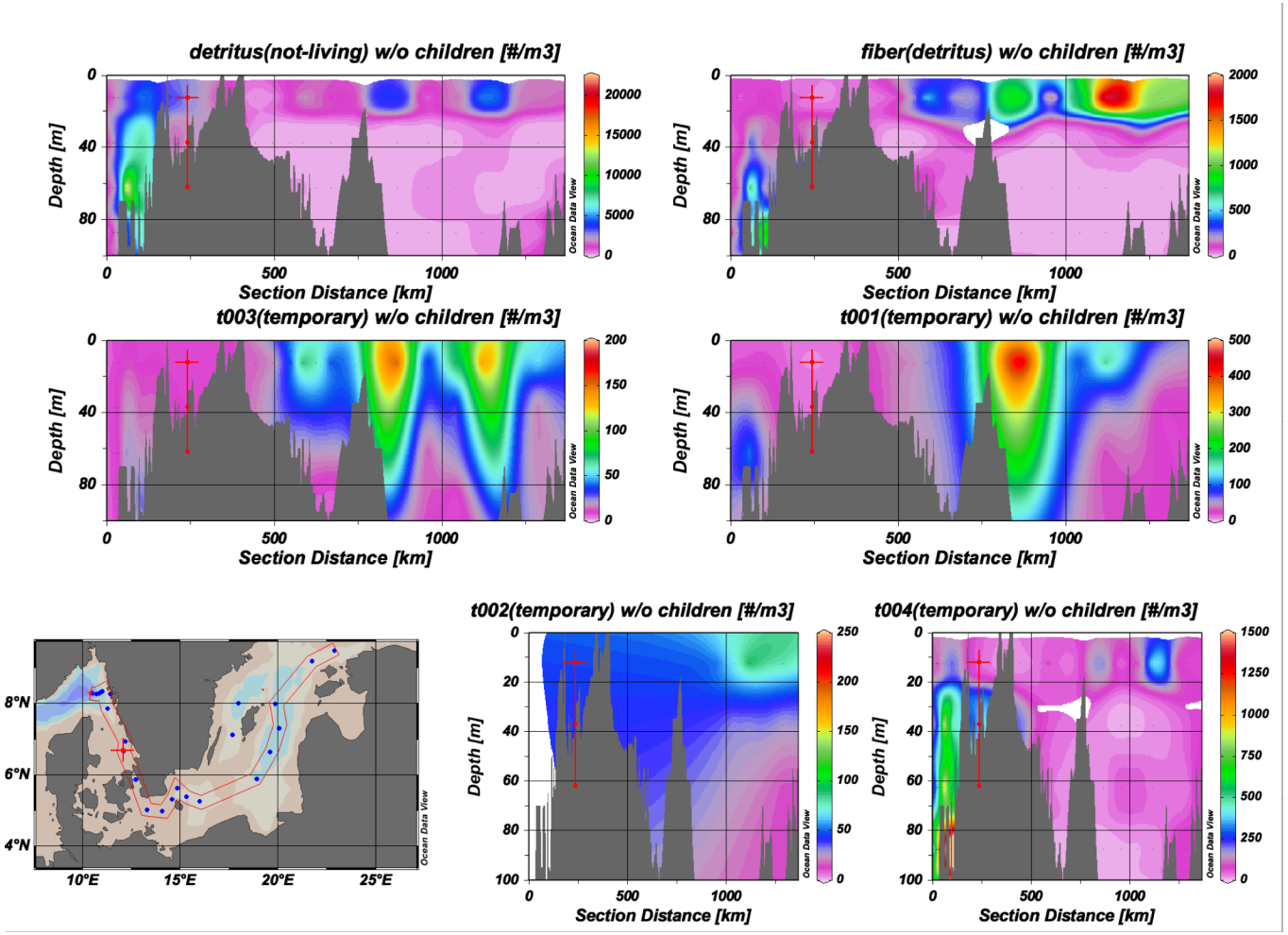

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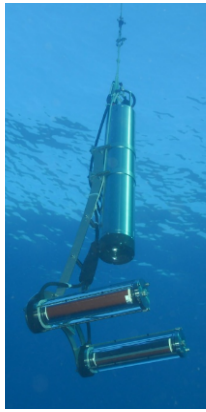
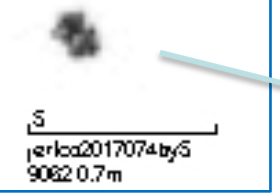
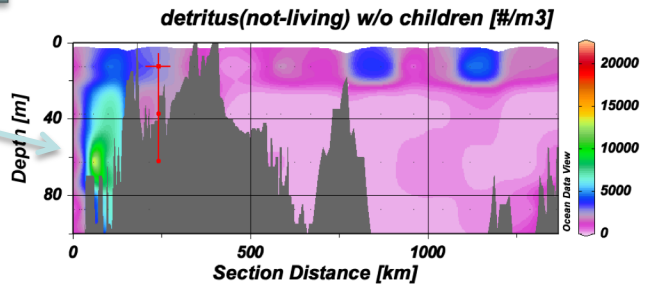
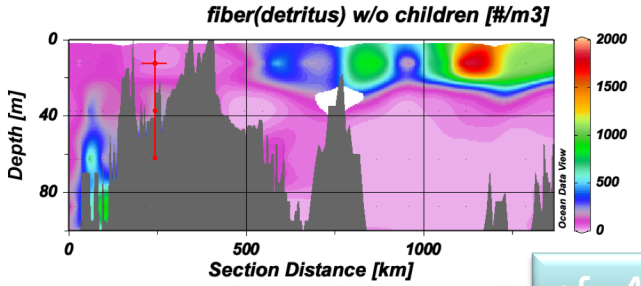


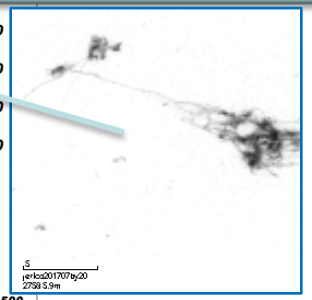
Aggregates



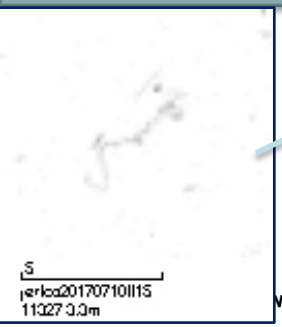


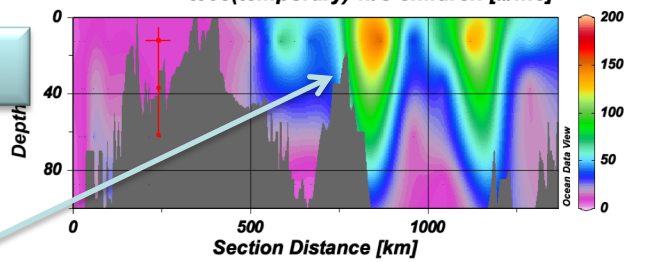


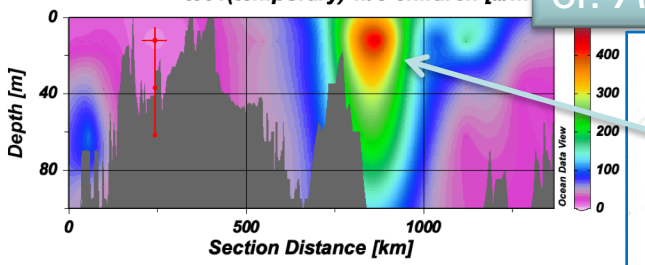
cf. *Aphanizomenon*

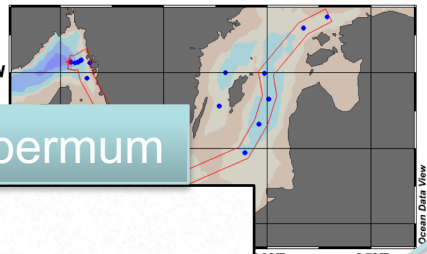


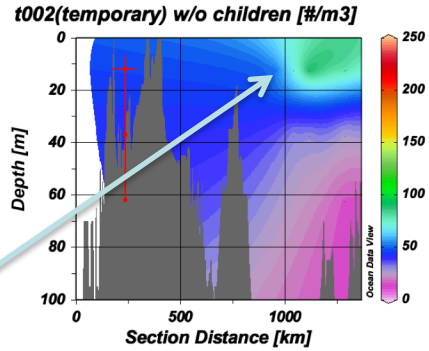
cf. *Nodularia*

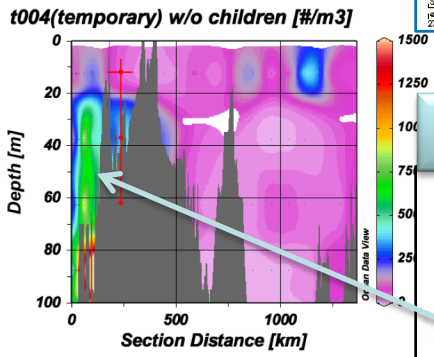




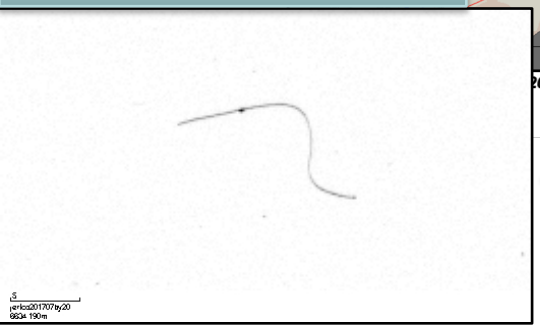




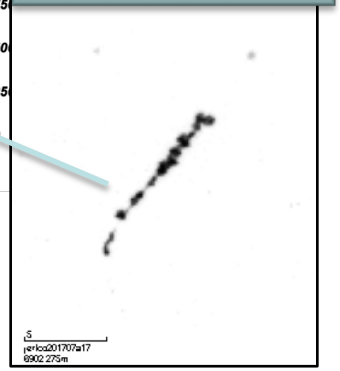




cf. Dolichospermum

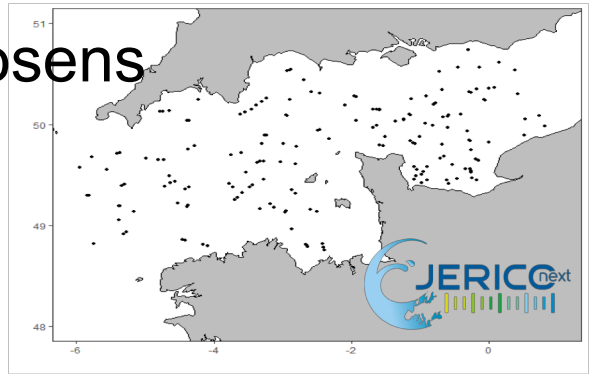


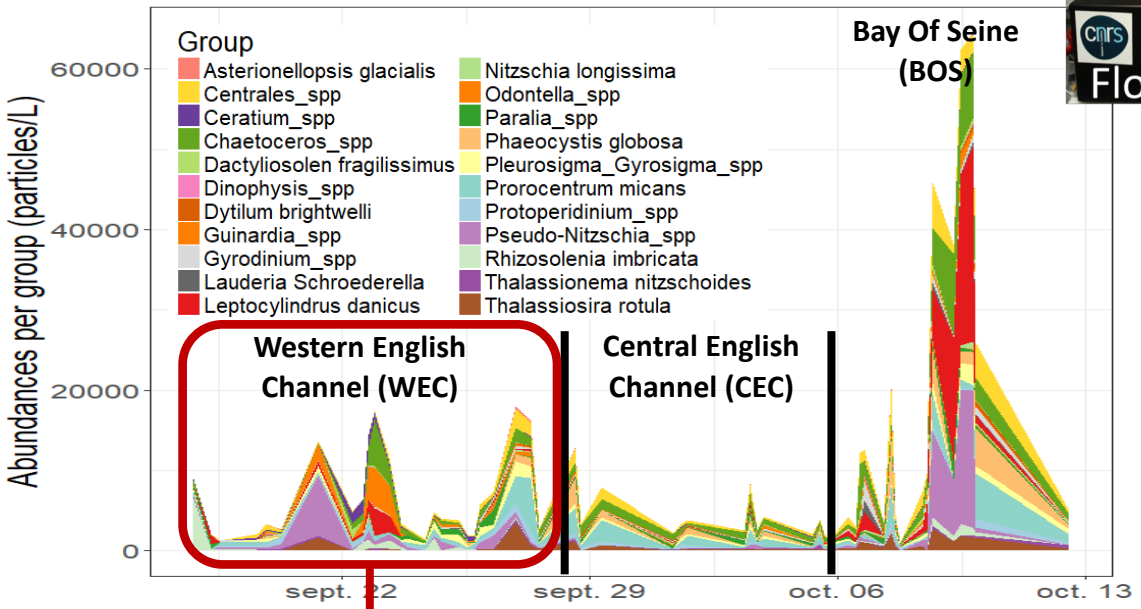
« Stringers »

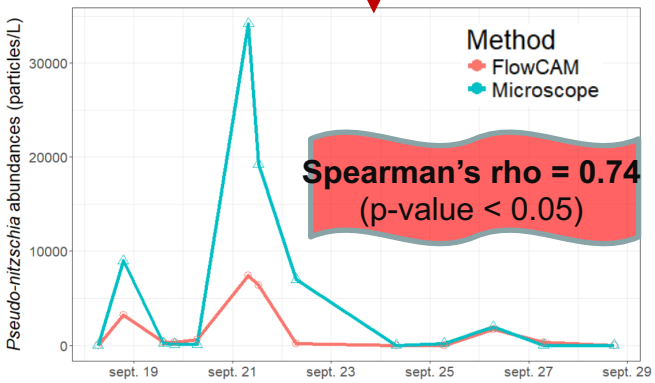


Case study 3: Monitoring with FlowCam, Cytosens

Period: 16th September-12th October, 2014
Area: Channel (R/V « Thalassa II » - IFREMER)
Classifier: Random Forest







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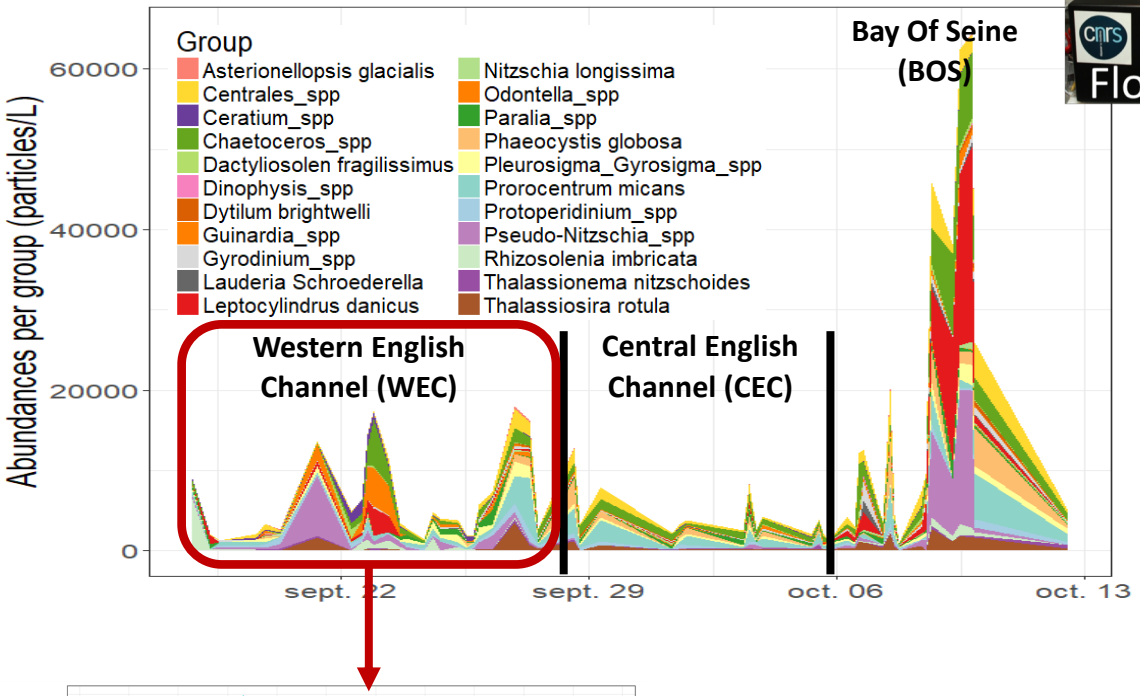
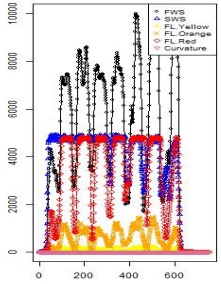
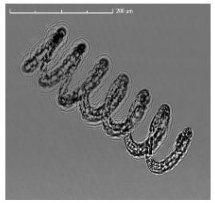
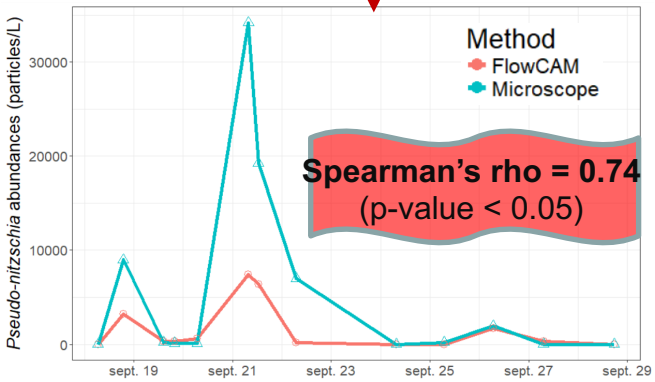






Guinardia spp.

CytoSub

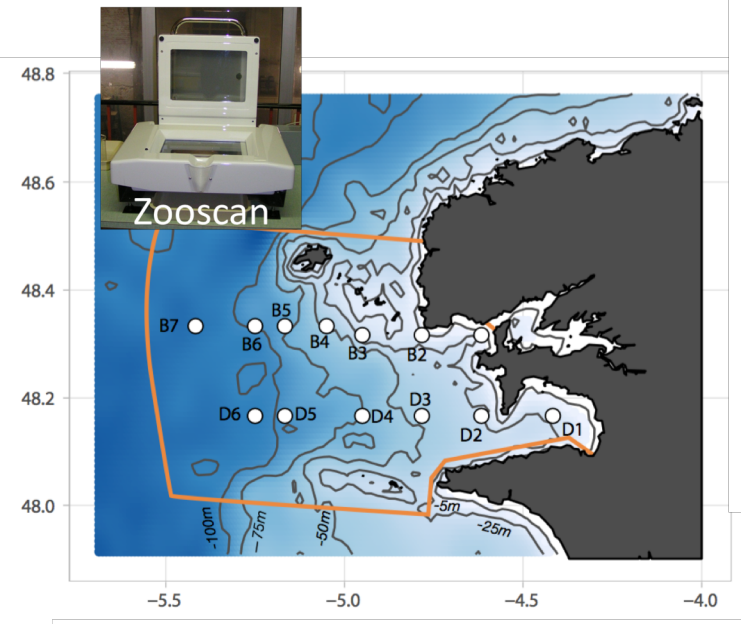


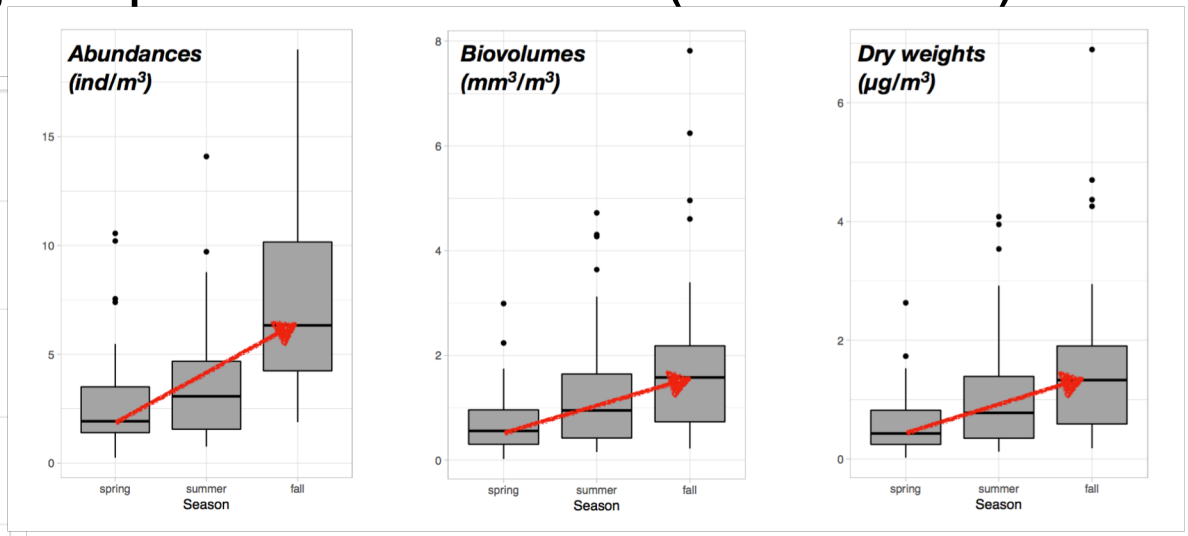
Overall dynamics of abundances obtained by microscopy and FlowCam for *Pseudo-Nitzschia* genus are **close.**

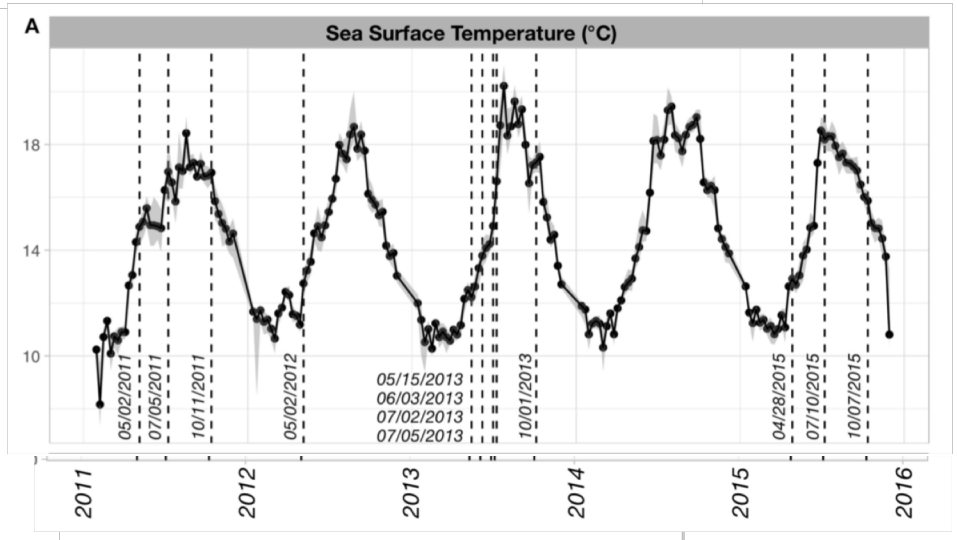
Building training set coupling optics and images by Cytosens

Develop classifiers

Case study 4: Monitoring zooplankton in a MPA (2011-2015)

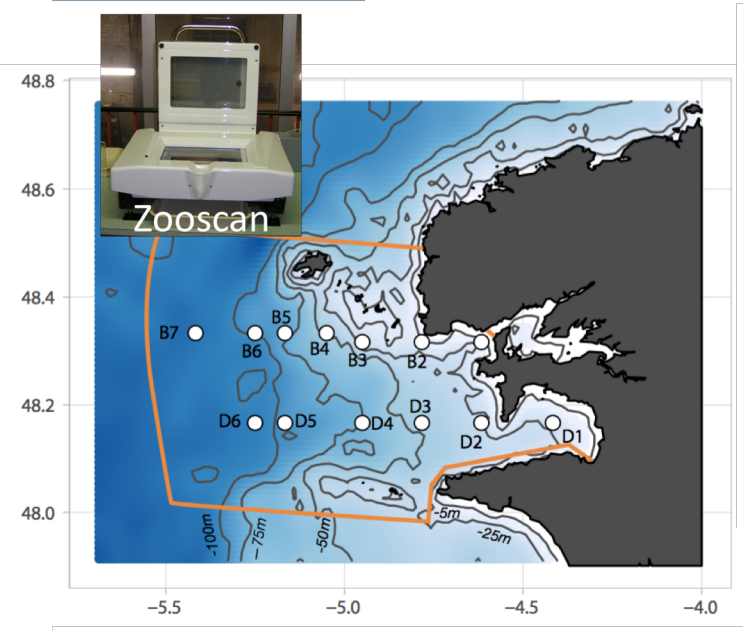


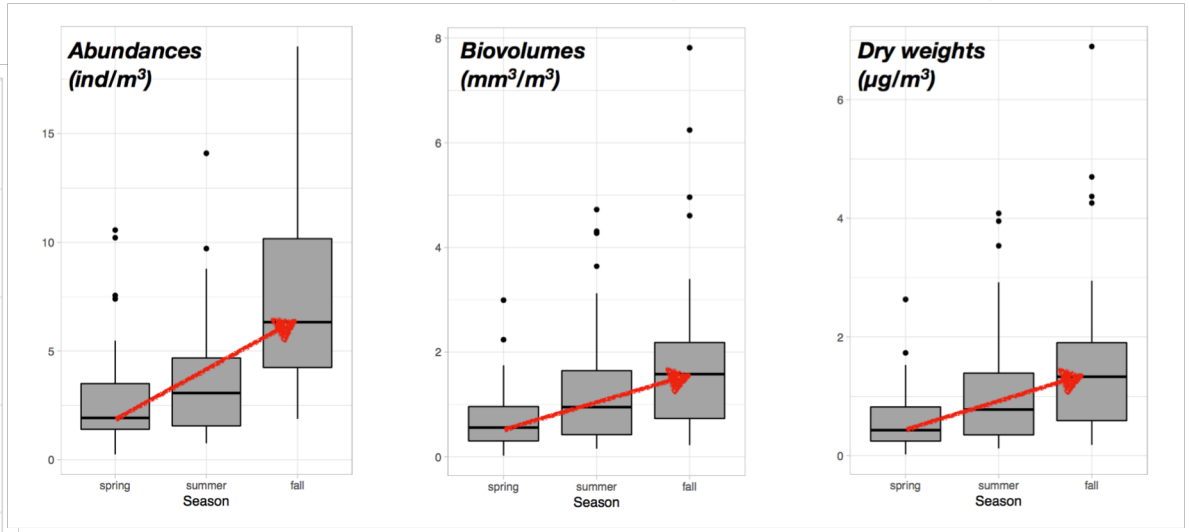


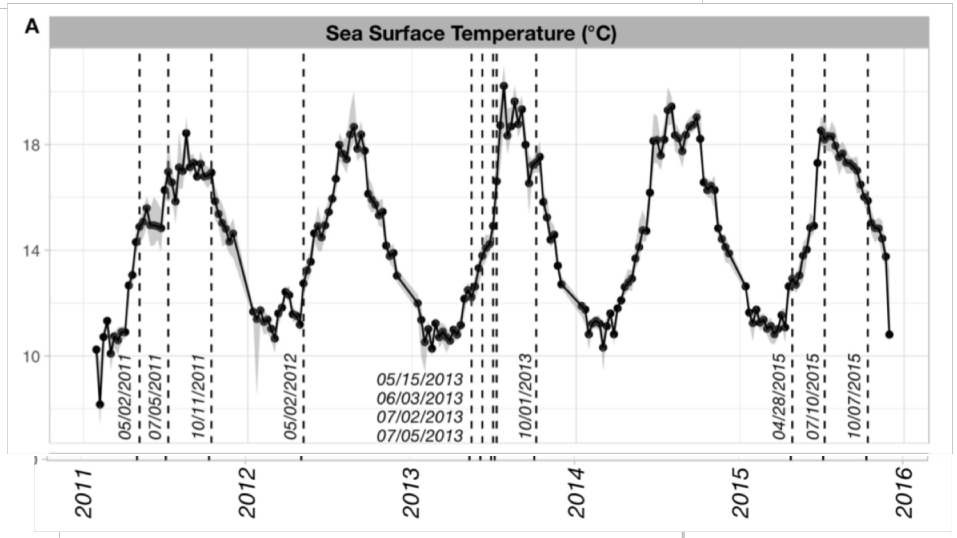


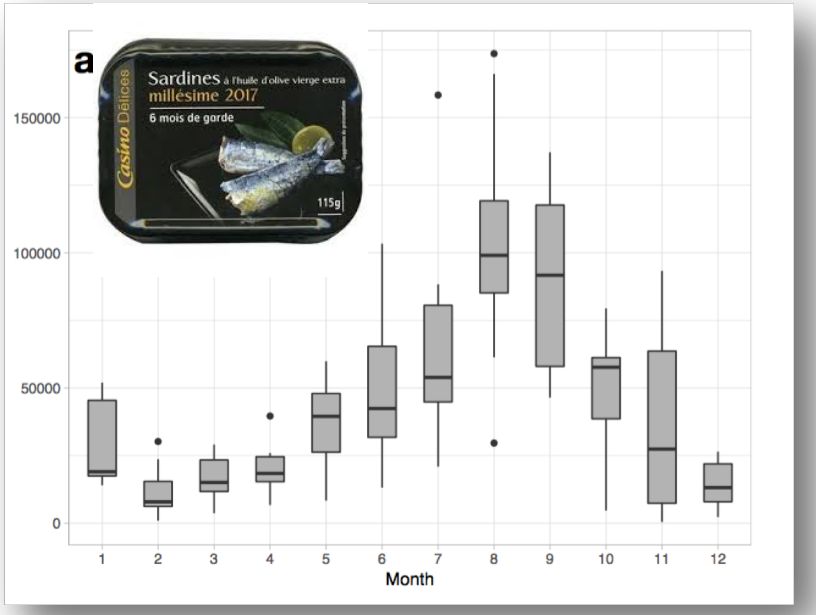
Benedetti et al., 2019

Case study 4: Monitoring zooplankton in a MPA (2011-2015)



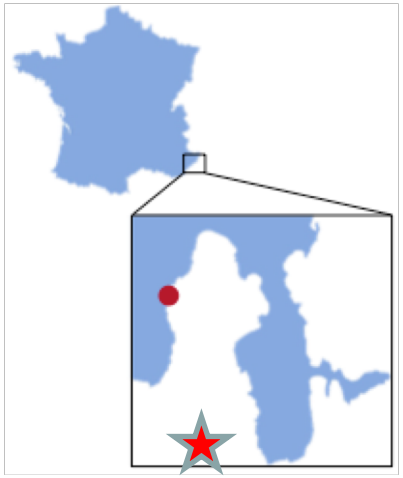


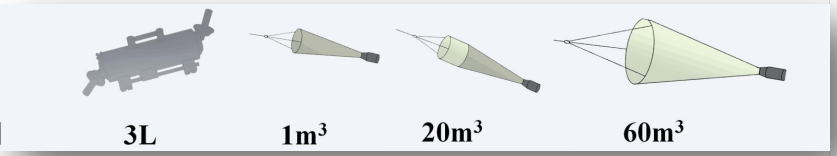


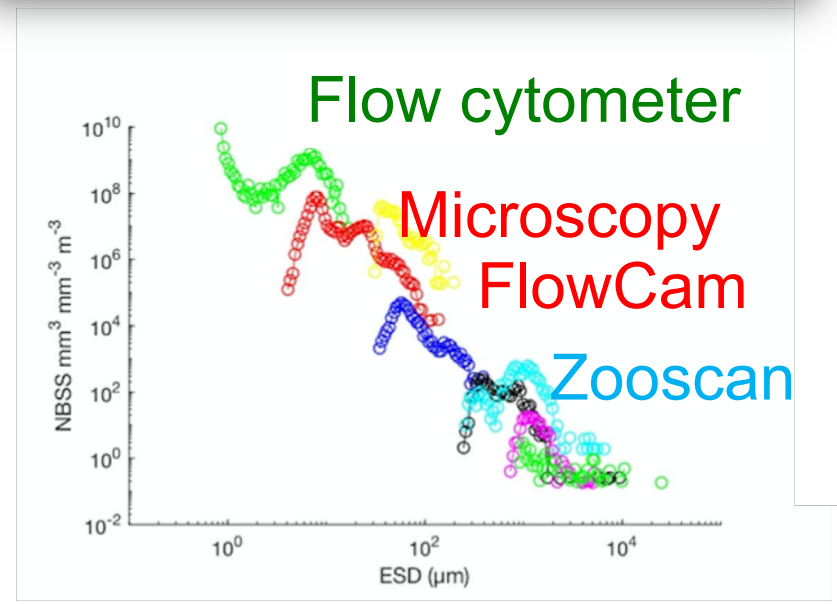


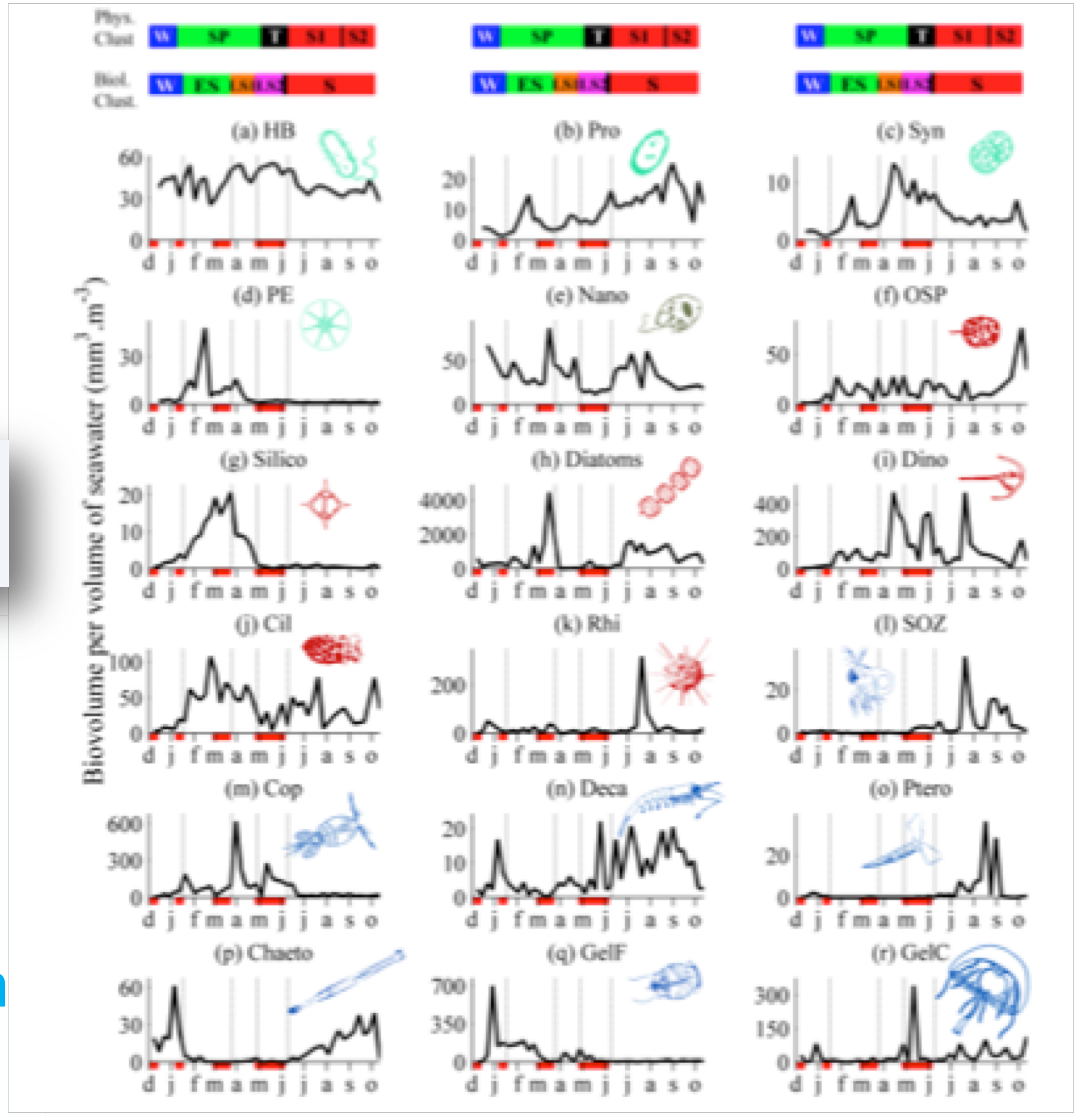
Benedetti et al., 2019

Case 5: Time series of the whole pelagic ecosystem









Romagnan et al., 2015, PLOS

Lessons learned from end-to-end approach

Imaging can bring a common and unified measurement across plankton types

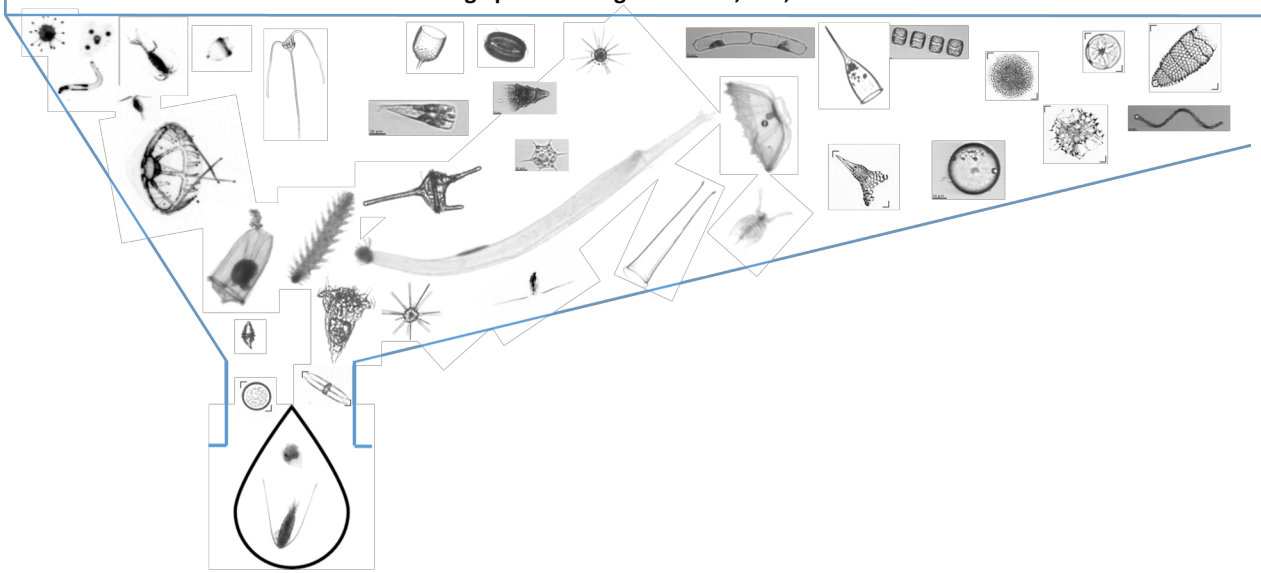
Need for inter-calibration

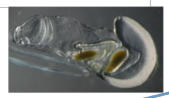
Current technological breakthrough for extensive observation of plankton - eEOV, EBV

IFCB

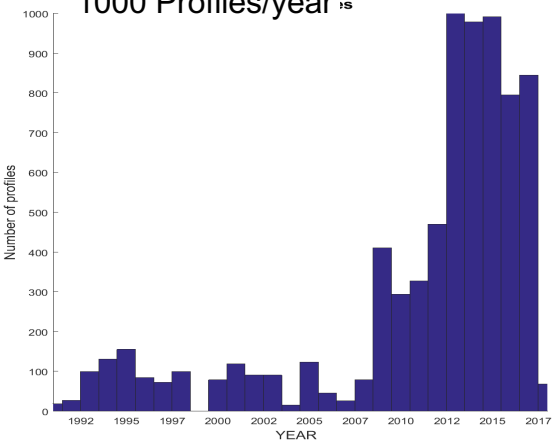
Automated microscope

Initial image process : segmentation, ROI, extraction of features





1000 Profiles/year

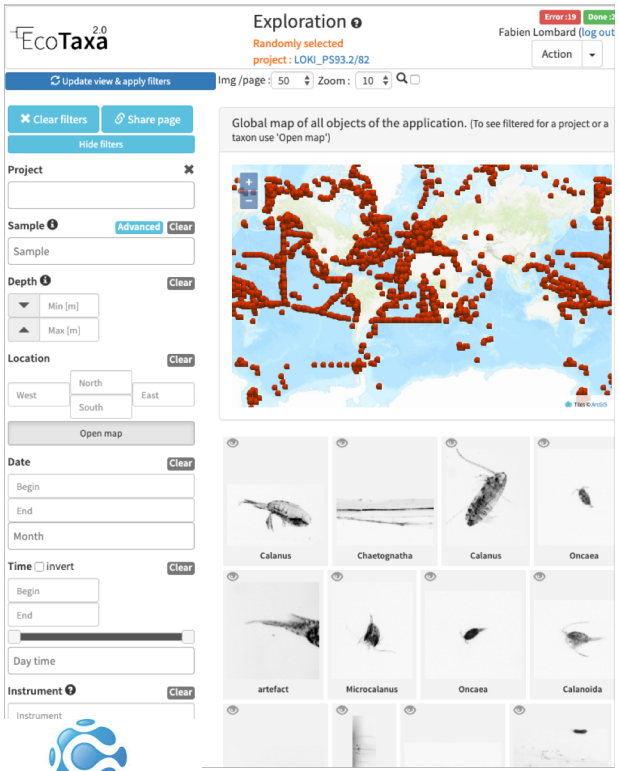


Bottlenecks: manual classification and/or validation, lack of local expert

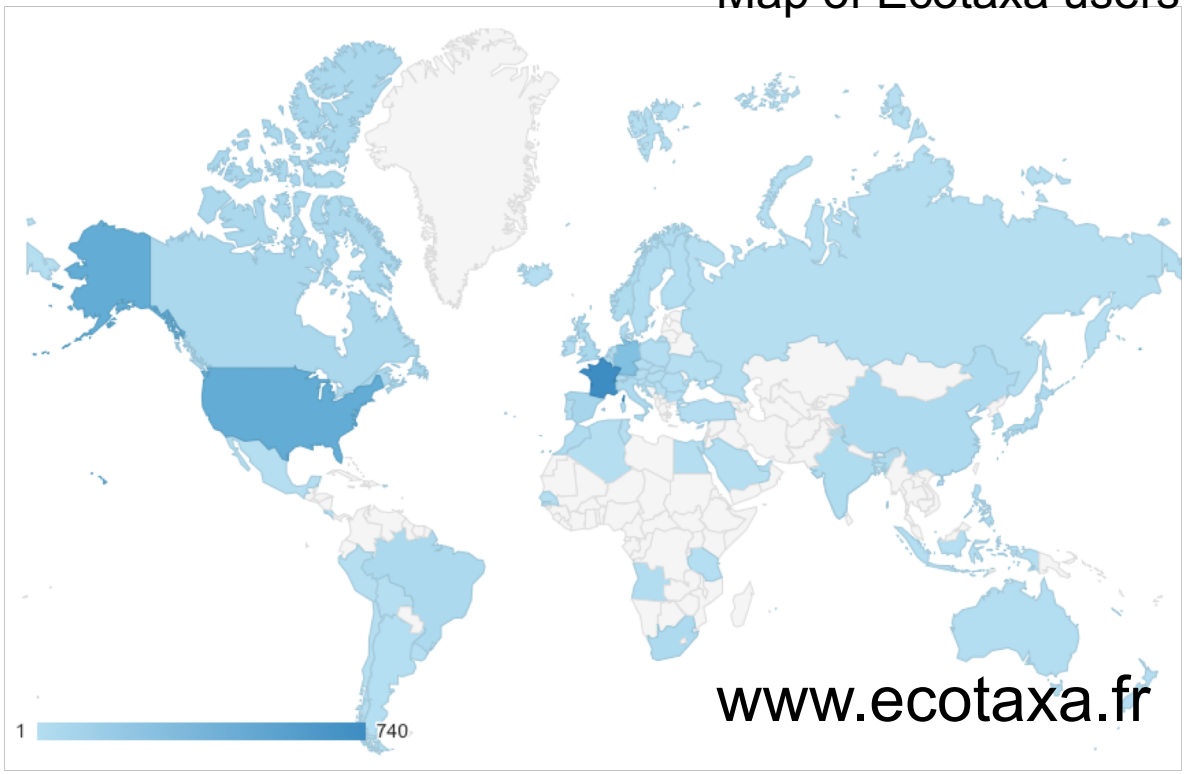
Ecotaxa : a first step toward distributed plankton data

A free collaborative tool for hosting, sorting, annotating taxonomically and sharing images

- Built-in automatic classification algorithms (random tree forest, CNN networks)
- 543 users/ 156 organisations (about 40 simultaneous users)→ 80 10^6 images
- About 11 types of instruments (IFCB, Cytosense in test, flowcam, zooscan, zoocam, UVP, LOKI, eHFCM, bioscope, planktoscope… still growing)
- Full control of dataset and permissions by data-owner



Map of Ecotaxa users

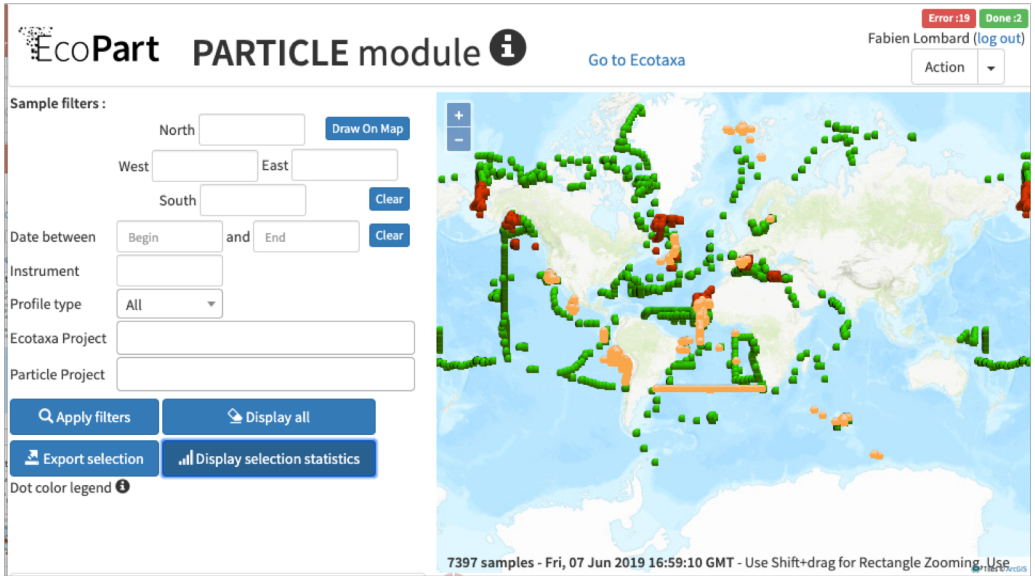


www.ecotaxa.fr

OCEANOMICS

Ecotaxa : a first step toward distributed plankton and particle data for real time monitoring

Plankton, particles and marine snow data



Future: World Wide Web of Plankton Image Curation

-3 more servers (US, Brazil, Japan) under a joint infrastructure

-Scaling up from million to billion images

-linking with OBIS and other global repository

-better recognition algorythms

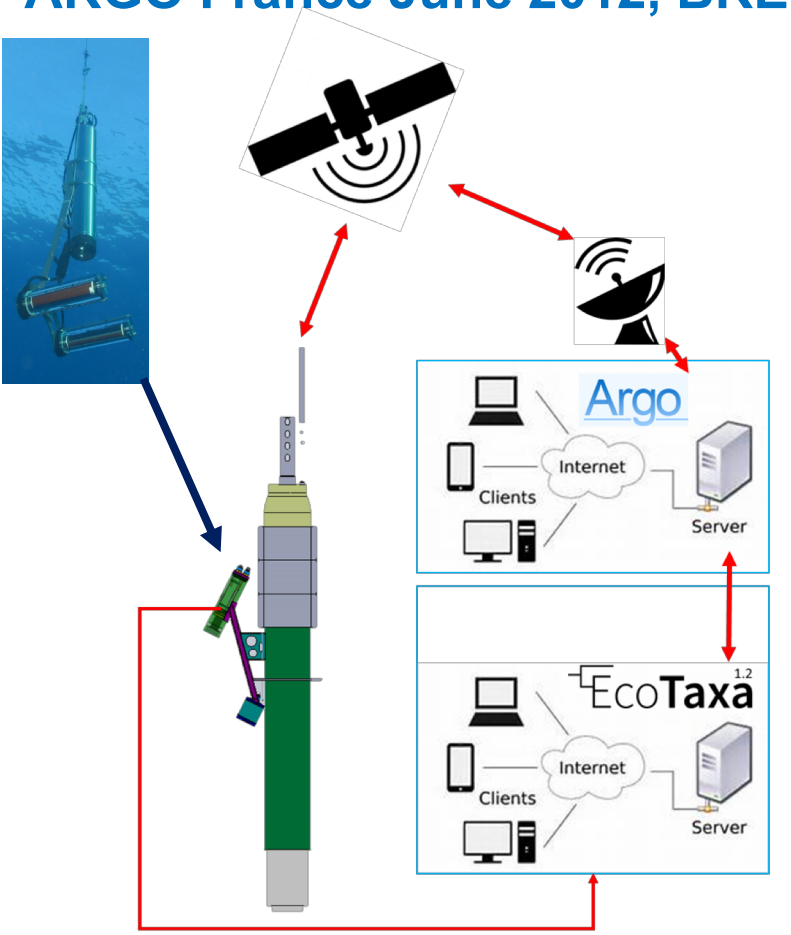
-better export and visualisation of results

-better import from different sensors

BELMONT FORUM

TOWARDS JERICO3

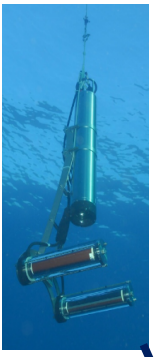
Build a camera for float
ARGO France June 2012, BREST

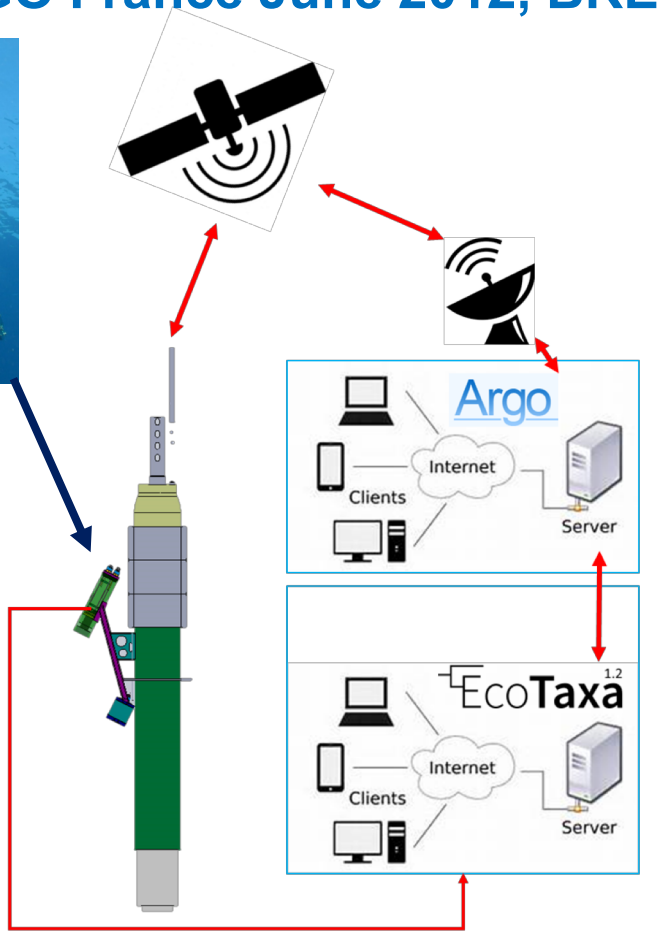


BRIDGES
BRINGING TOGETHER RESEARCH AND INDUSTRY FOR THE DEVELOPMENT OF GLIDER ENVIRONMENTAL SERVICES

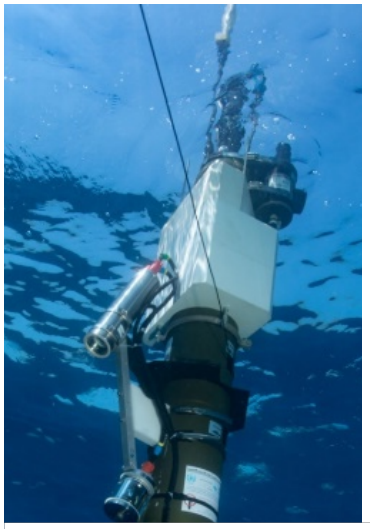
Pôle Mer

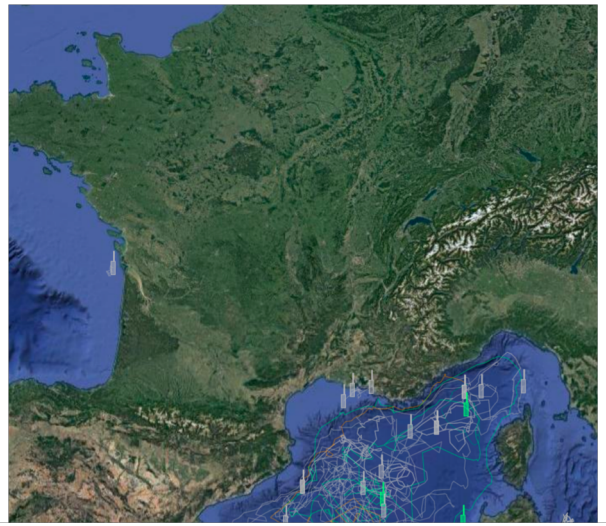
Build a camera for float
ARGO France June 2012, BREST

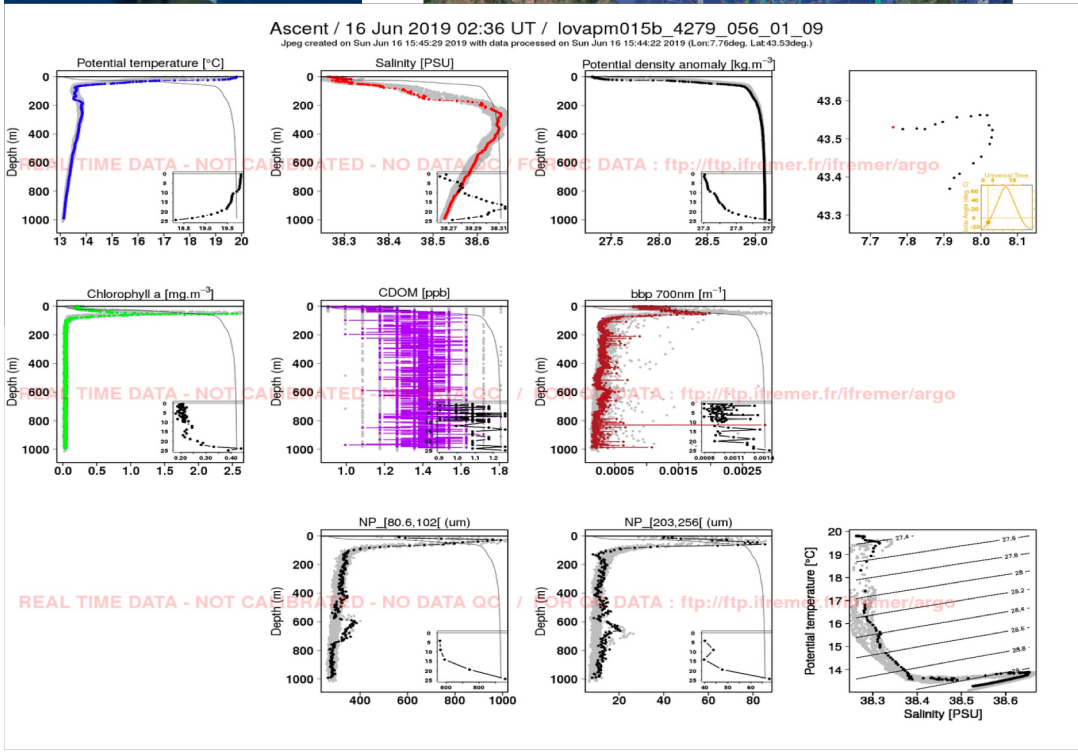




2019: time/space surveys by UVP6







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Pôle Mer

take home message

- **Images can be obtained with high throughput imaging systems for the whole plankton community**
- **Large image datasets can be analysed by a community of scientists and data can be easely shared for regional and global studies**
- **Images provide new information revealing poorly known fragile groups**
- **Plankton size distribution per taxa is more informative than only total plankton size distribution .**

THE KEY OF THE SUCCESS:

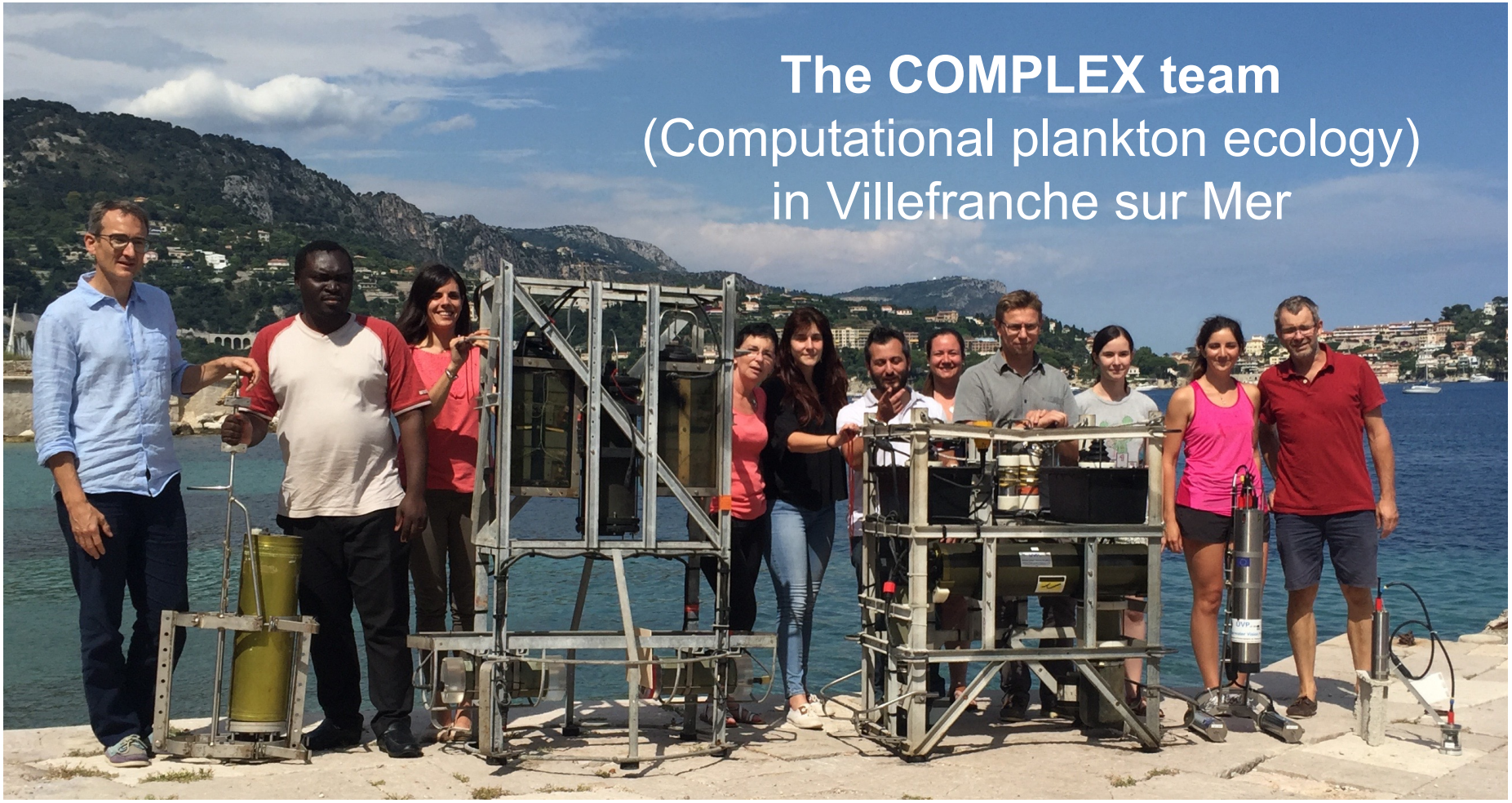
→ TECHNOLOGY

- **→ RELIABLE IMAGING SENSORS (lab, in situ, autonomous)**
- **→ IMPROVING RECOGNITION**
- **→ « friendly » SOFTWARE for image analysis, data streaming**

- **→ COORDINATION**
- **AGREED USE: It is not a question of more data but the « right » data at « right » location for the good scientific reason**
- **AGREED PROCEDURES (image format, treatment, semi-automatic recognition, intercalibration)**
- **AGREED DATA MANAGEMENT AND DISTRIBUTION**
- **COMPATIBLE TO MODELING FRAMEWORKS**

Be fast, be collaborative, be opportunistic (Alistair Hobday, Imber Brest 2018)

Thank you for your attention,
Any questions?



UVP1
1991

UVP2
1992-1996

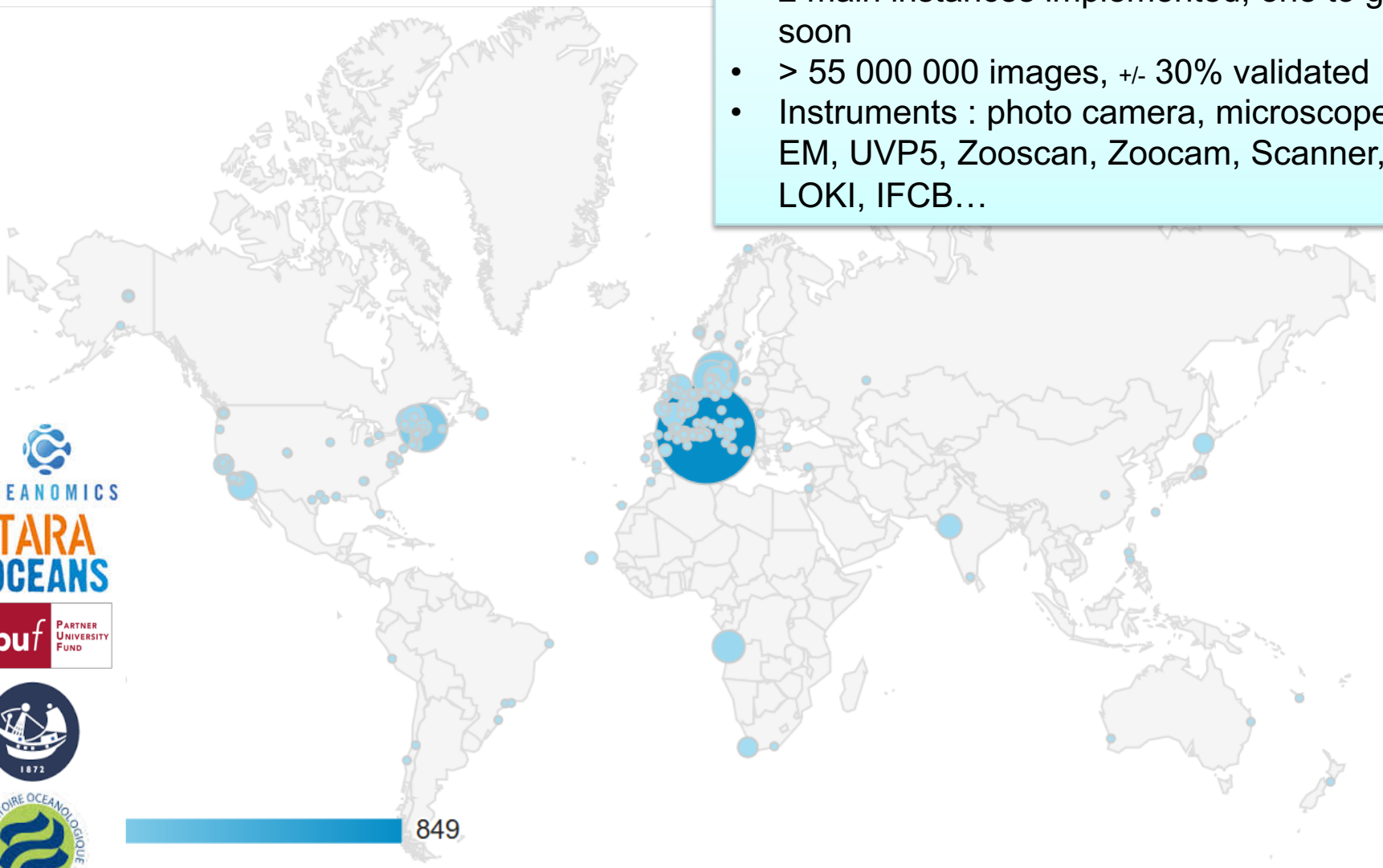
UVP3-4
1996-2008

UVP5
2008-..

UVP6
2018-..

EcoTaxa today

- 2 main instances implemented, one to go soon
- > 55 000 000 images, +/- 30% validated
- Instruments : photo camera, microscope, EM, UVP5, Zooscan, Zoocam, Scanner, LOKI, IFCB…



Case study 2: Spatial survey of cyanobacterial blooms in the Baltic

EcoTaxa 1.3

PARTICLE module

Not logged (log in)

Sample filters :

North 42.7520 Draw On Map

West -137.1664 East -105.8773

East

South 24.1329 Clear

Date between Begin and End Clear

Instrument

Profile type All

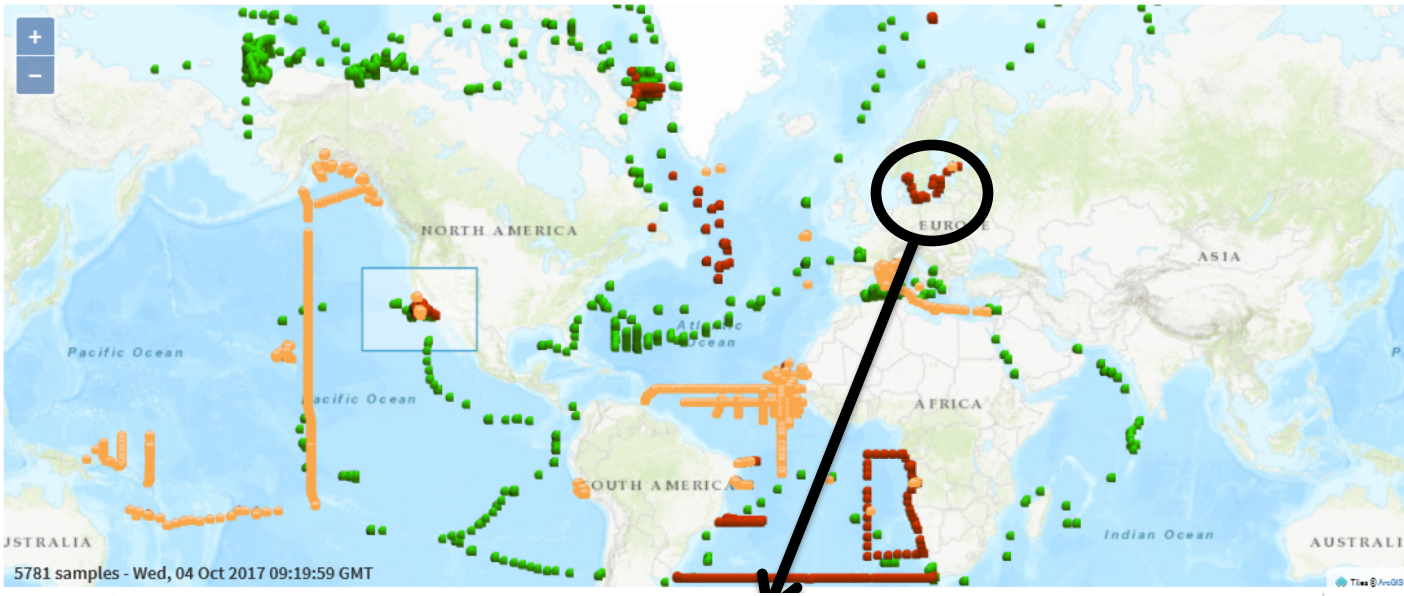
Ecotaxa Project

Particle Project

Apply filters Display all

Export selection Display selection statistics

Dot color legend



Graph configuration Draw graph

Reduced particle histogram -

×#/l 08 : 128-256 µm ×#/l 09 : 256-512 µm

Detailled particle histogram -

Clear

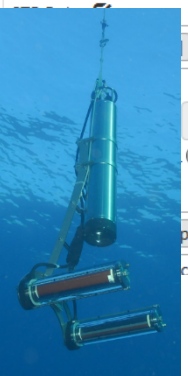
500

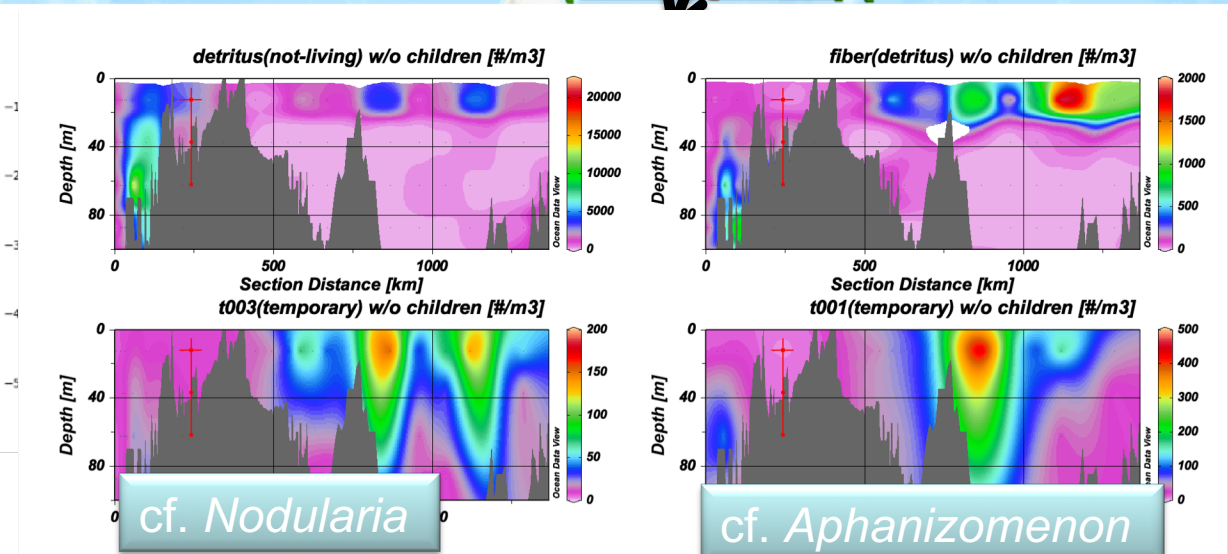
Log - Symlog

Clear

poda)

children categories





cf. *Nodularia*

cf. *Aphanizomenon*

Case study 3: Spatial surveys around the world

EcoTaxa 1.3

PARTICLE module

Not logged (log in)

Sample filters :

North 42.7520 Draw On Map

West -137.1664 East -105.8773

East

South 24.1329 Clear

Date between Begin and End Clear

Instrument

Profile type All

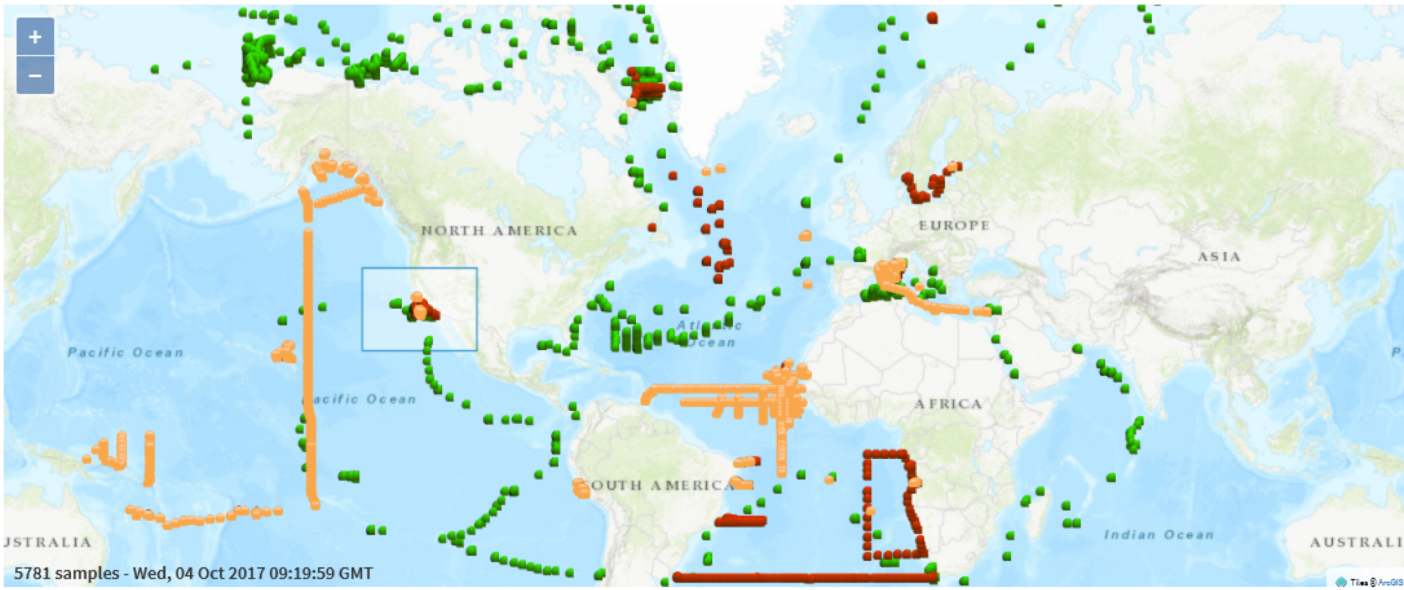
Ecotaxa Project

Particle Project

Apply filters | Display all

Export selection | Display selection statistics

Dot color legend



Graph configuration Draw graph

Reduced particle histogram -

×#/l 08 : 128-256 µm ×#/l 09 : 256-512 µm

Detailled particle histogram -

Clear

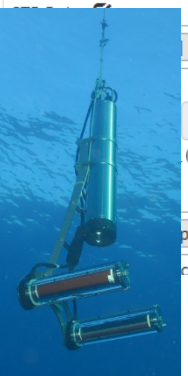
500

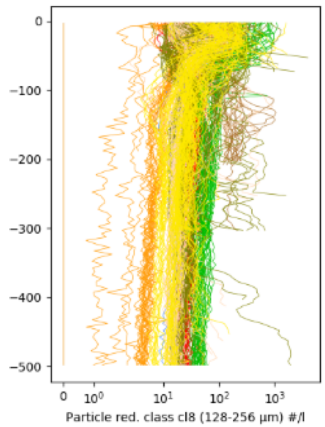
Log - Symlog

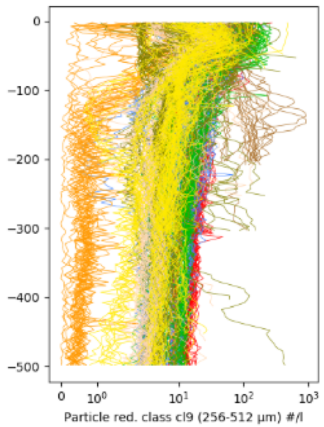
Clear

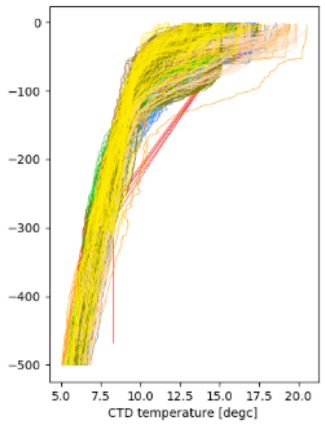
poda)

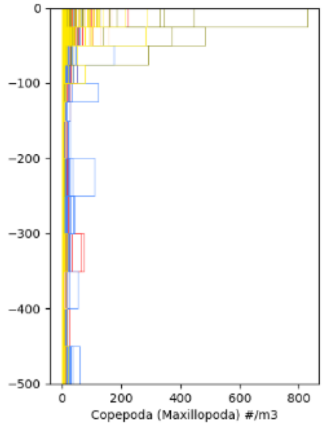
children categories







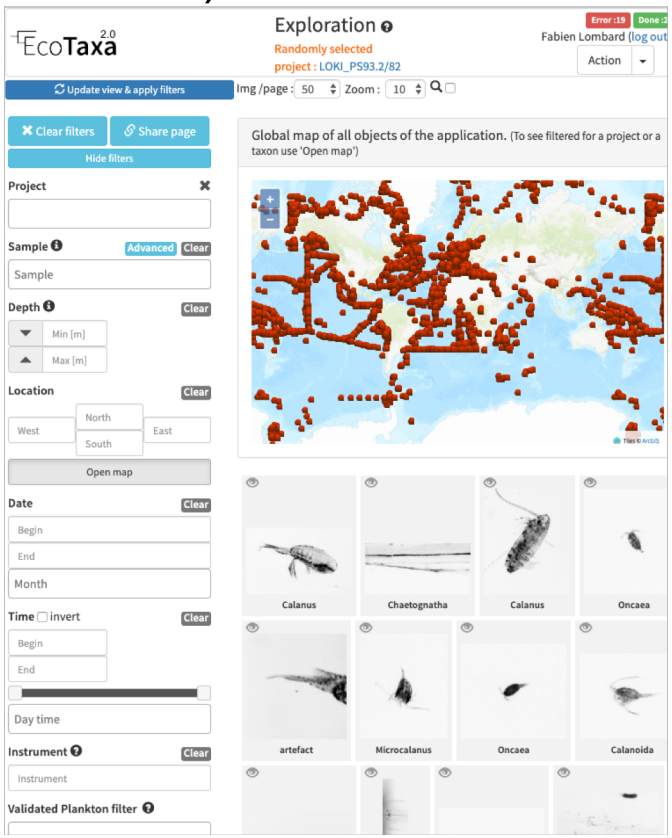


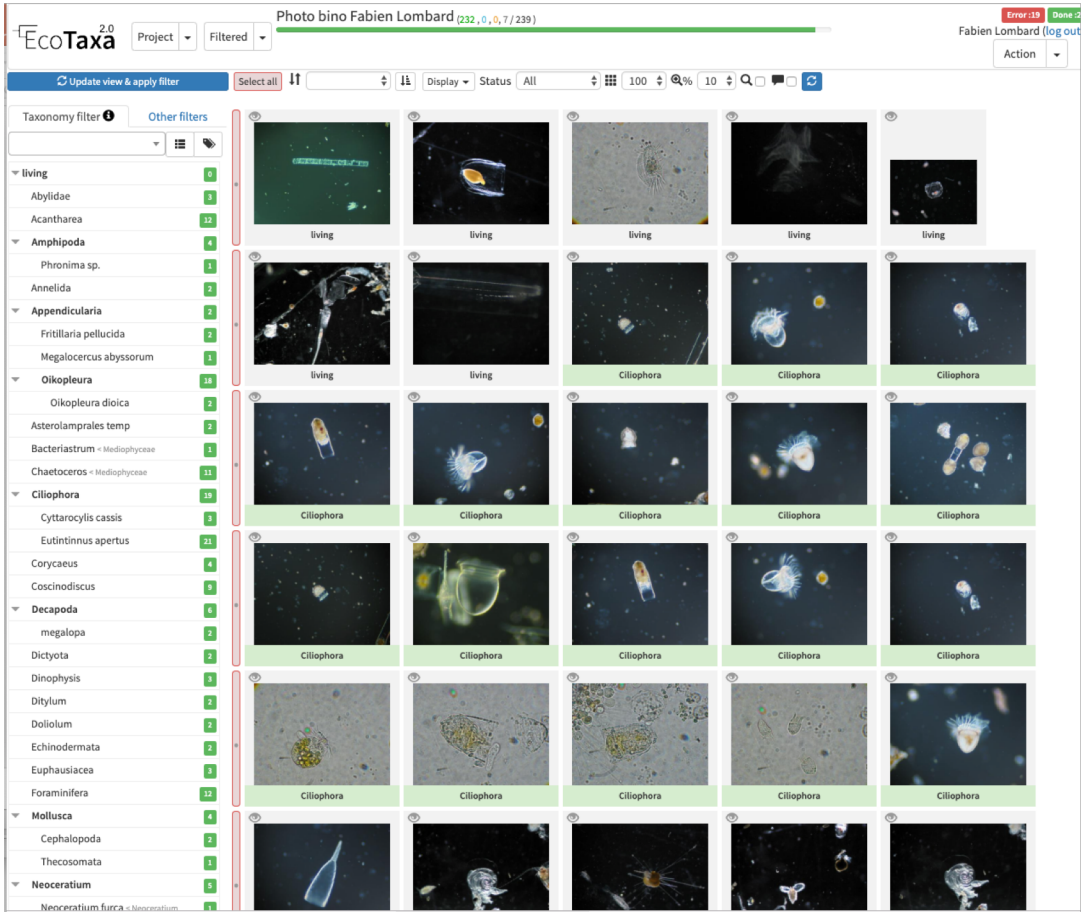


Ecotaxa : a first step toward distributed data

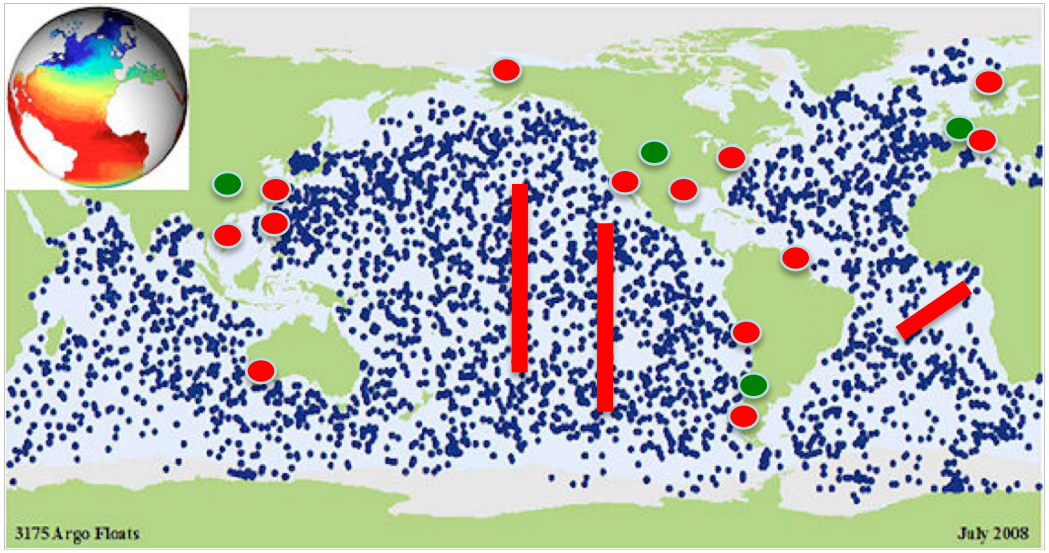
Free exploration of validated images
Launched in 2016 … 80 million images now (42% validated)

Powerful filters
Powerful manual annotation (>20 000 day^{-1})
Explicit taxonomy (UniEuk→WORMS)



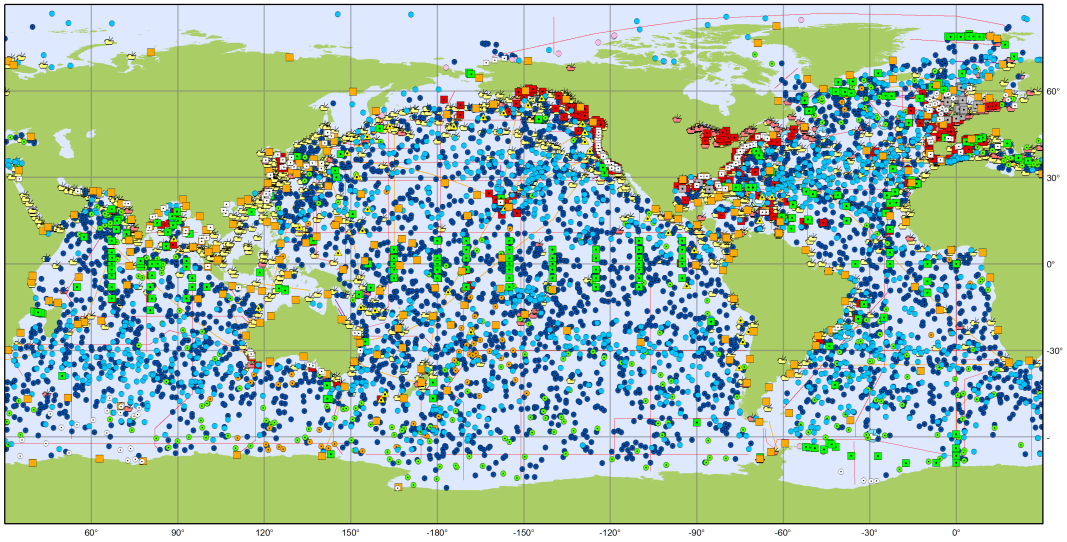


The 10 years vision,
Plankton: global and regional monitoring with imaging systems



Global network of observations

- ARGO-> BIOARGO +vision
- fixed stations + vision
- cruises of opportunity (vision on in line systems)
- Oceanographic data center for QC and large diffusion



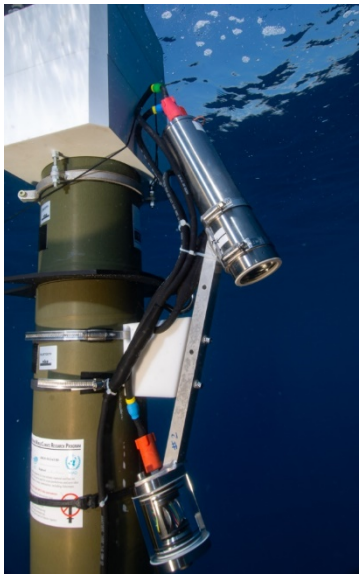
Main in situ Elements of the Global Ocean Observing System

April 2019

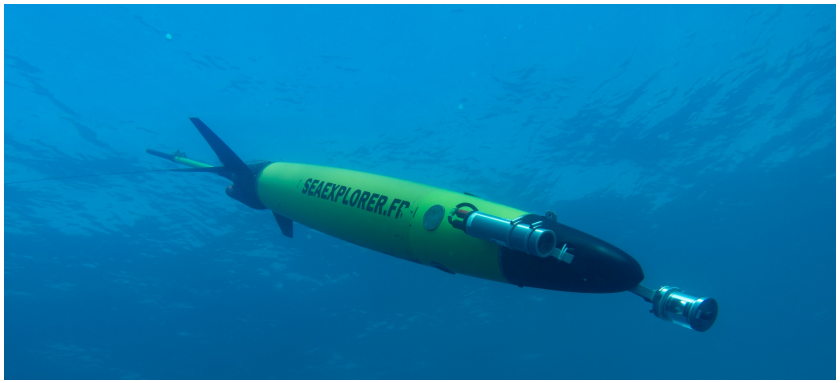
BRIDGES
BRINGING TOGETHER RESEARCH AND INDUSTRY FOR THE DEVELOPMENT OF GLIDER ENVIRONMENTAL SERVICES

UVP-6

Currently under tests and cross calibrations







Already planned in several large scale projects (H2020, ERC, ANR, ANR jcjc)
Integration test on several vectors (gliders, Argo floats, moorings, ROV)

Case study 2: Spatial survey of cyanobacterial blooms in the Baltic (July 2018) with UVP5