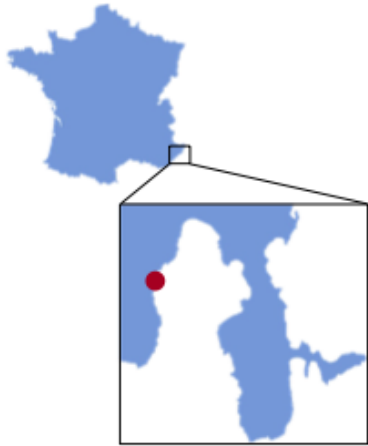


# World Wide Whole Plankton inferred using a series of imaging instruments

*Lars Stemmann,  
The Plankton Image Group of Villefranche*



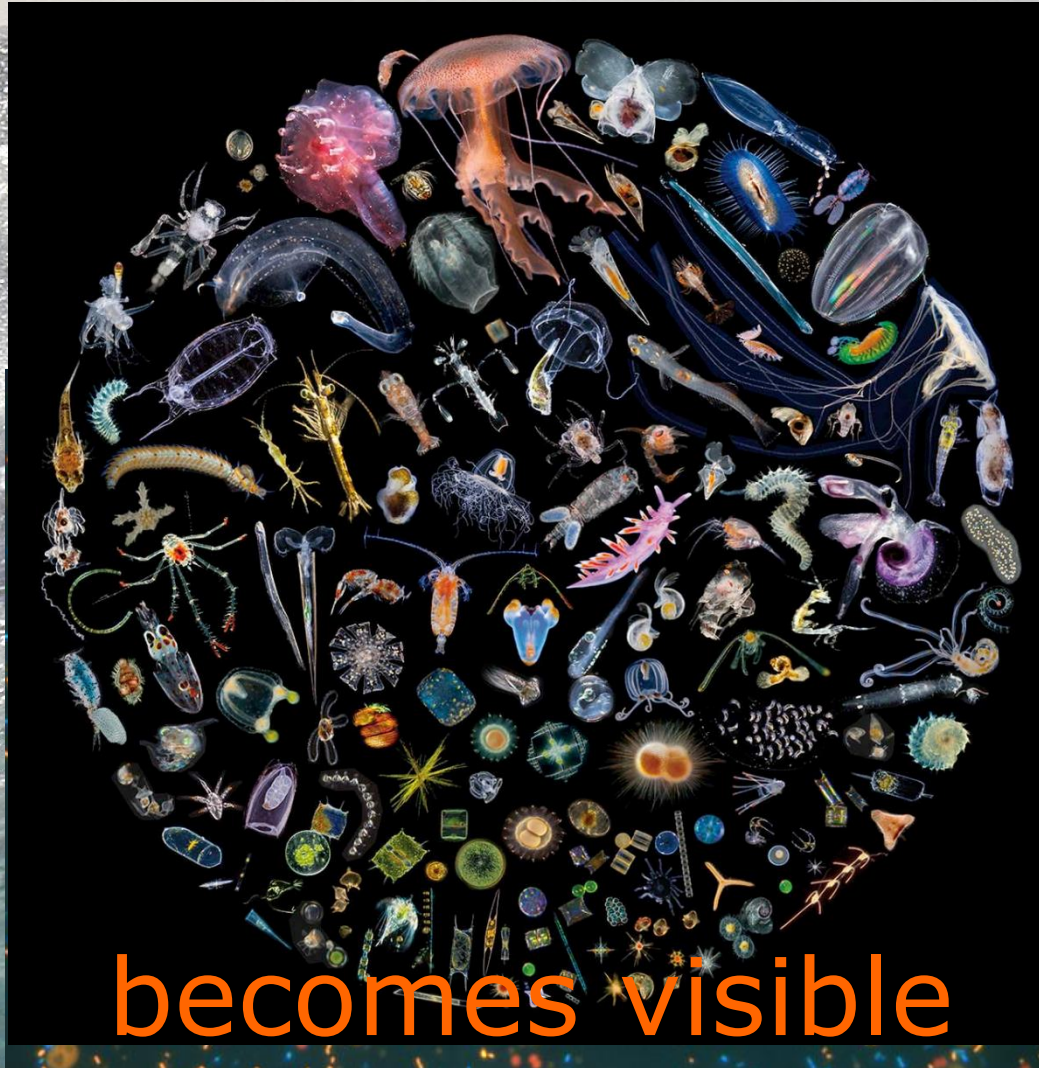
ICES 2016,  
Global Zooplankton Symposium Bergen

*Sorbonne Universités, UPMC Univ Paris 06,  
Laboratoire d'Océanographie de Villefranche , FRANCE*

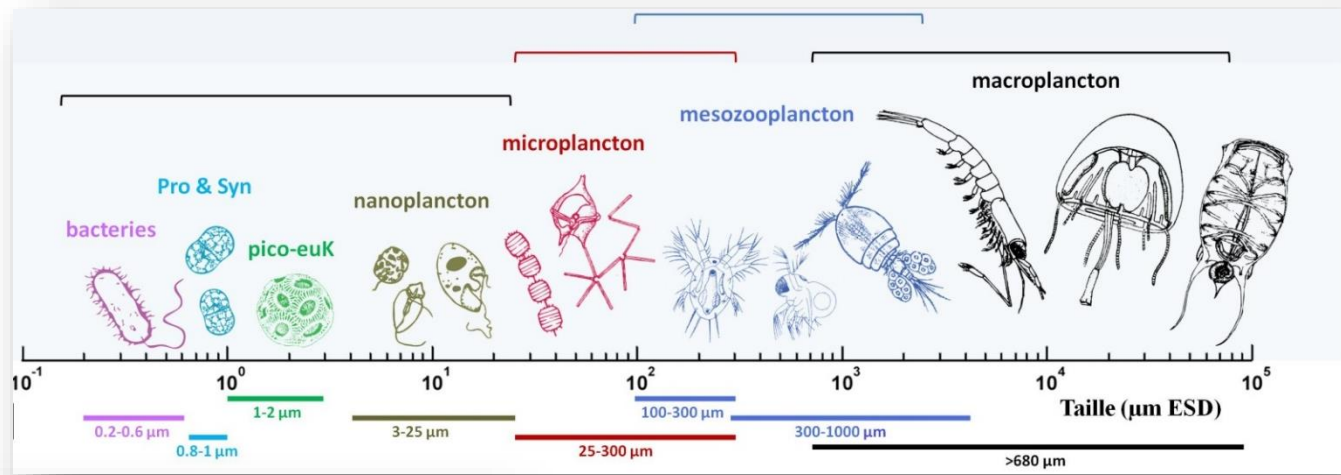
<http://rade.obs-vlfr.fr/RadeZoo>



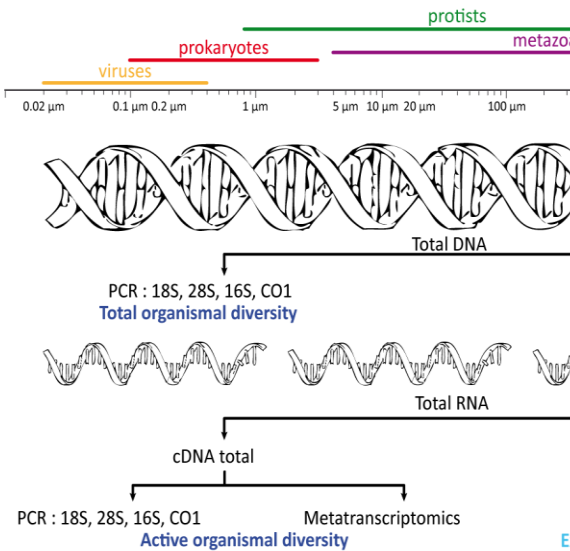
# The Invisible Multitude



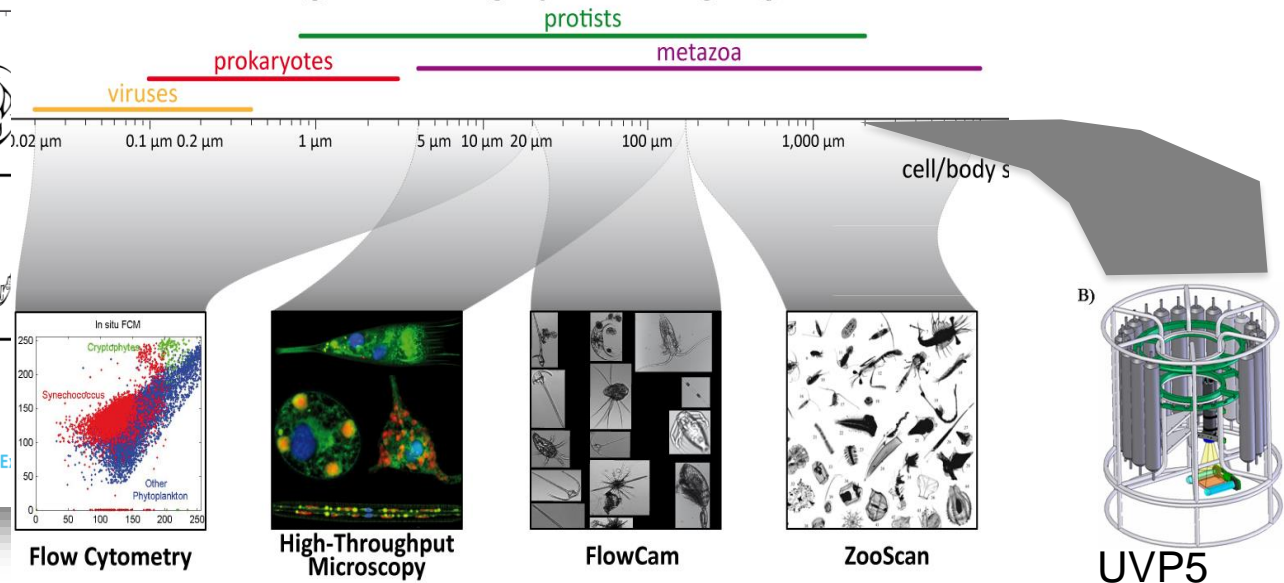
# WWW Plankton: high throughput data acquisition



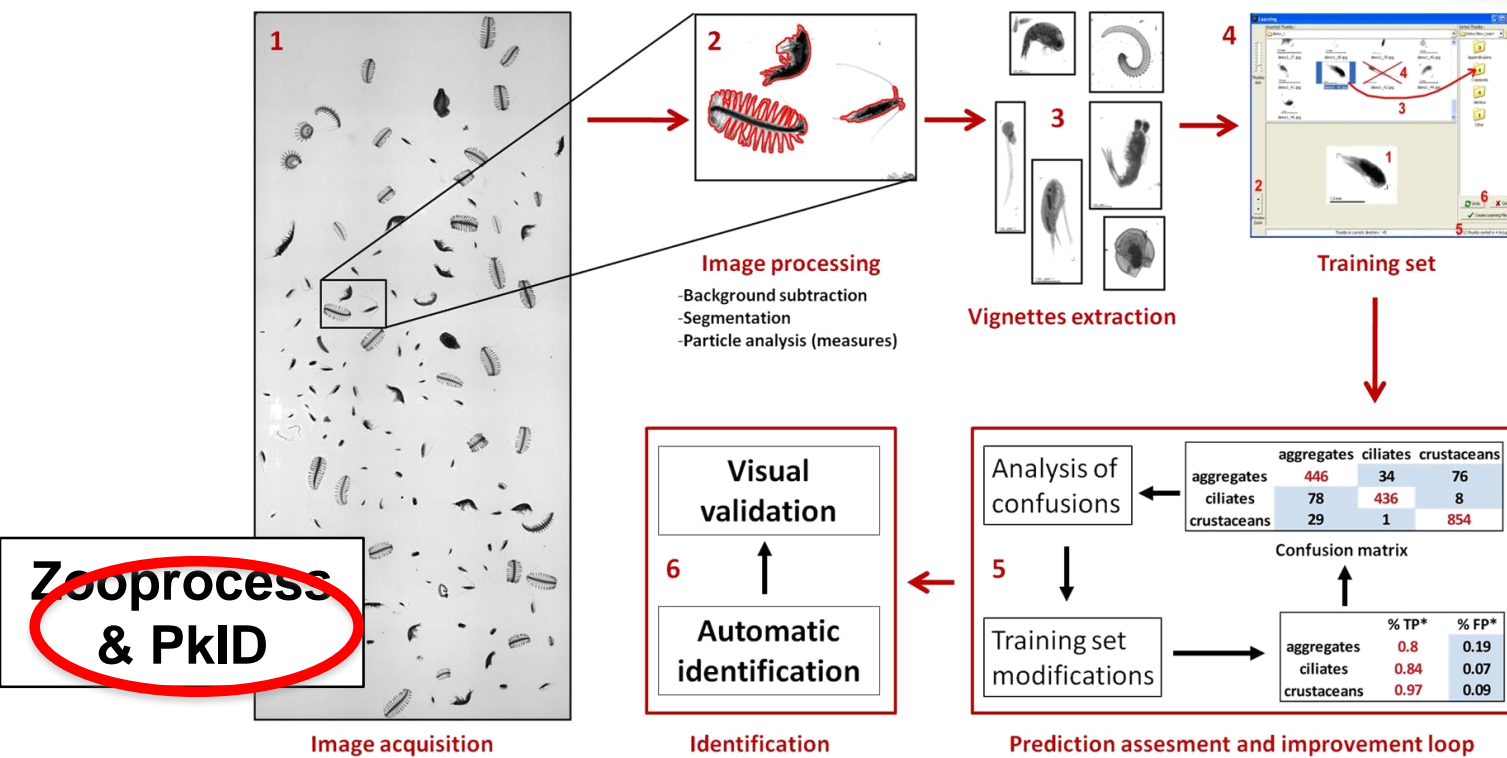
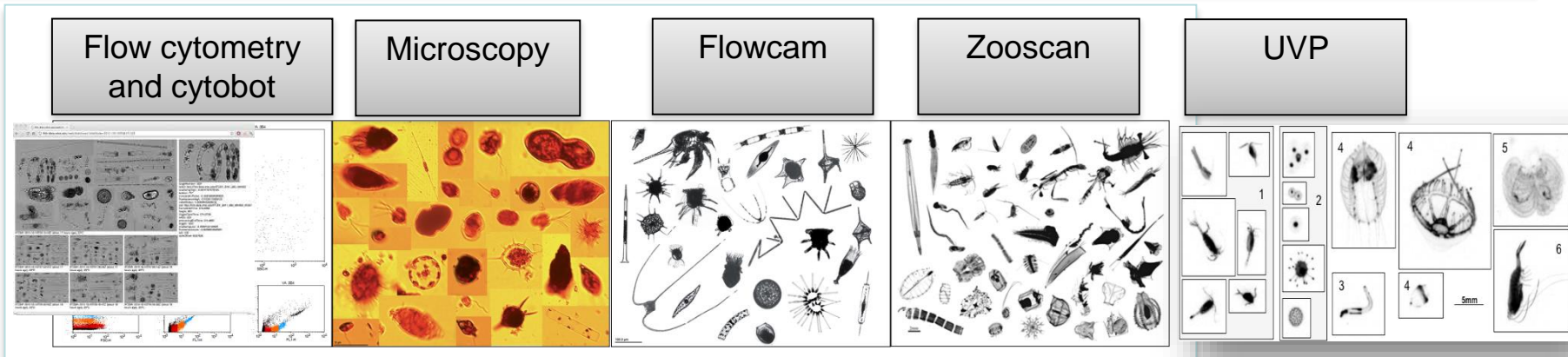
## High Throughput Sequencing



## High Throughput Imaging



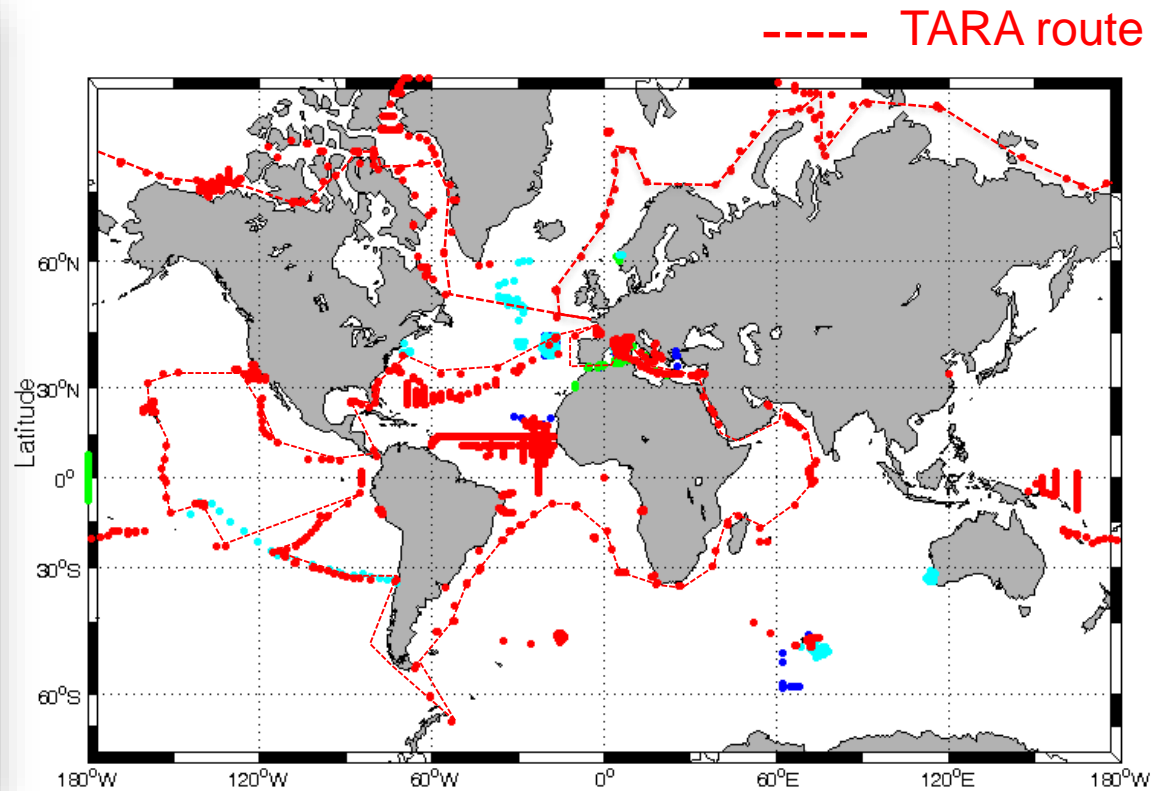
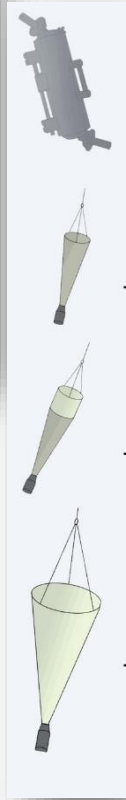
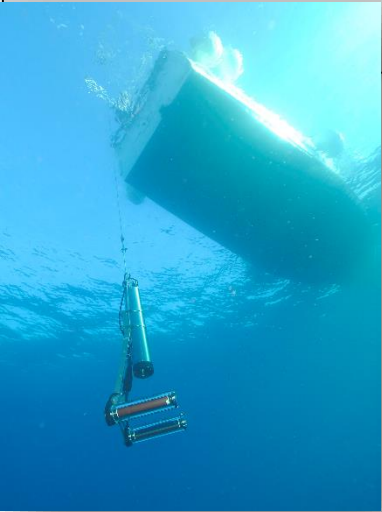
# WWW Plankton: image analysis



Gorsky et al., 2010

How to share easily images? -> Now ECOTAXA (web application)

# World Wide whole Plankton: Images acquisition (2008-2016)



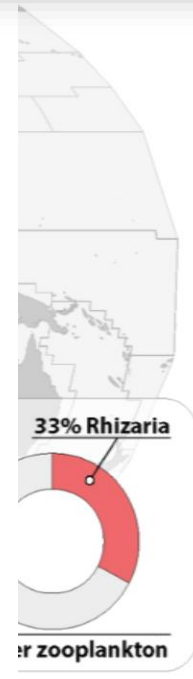
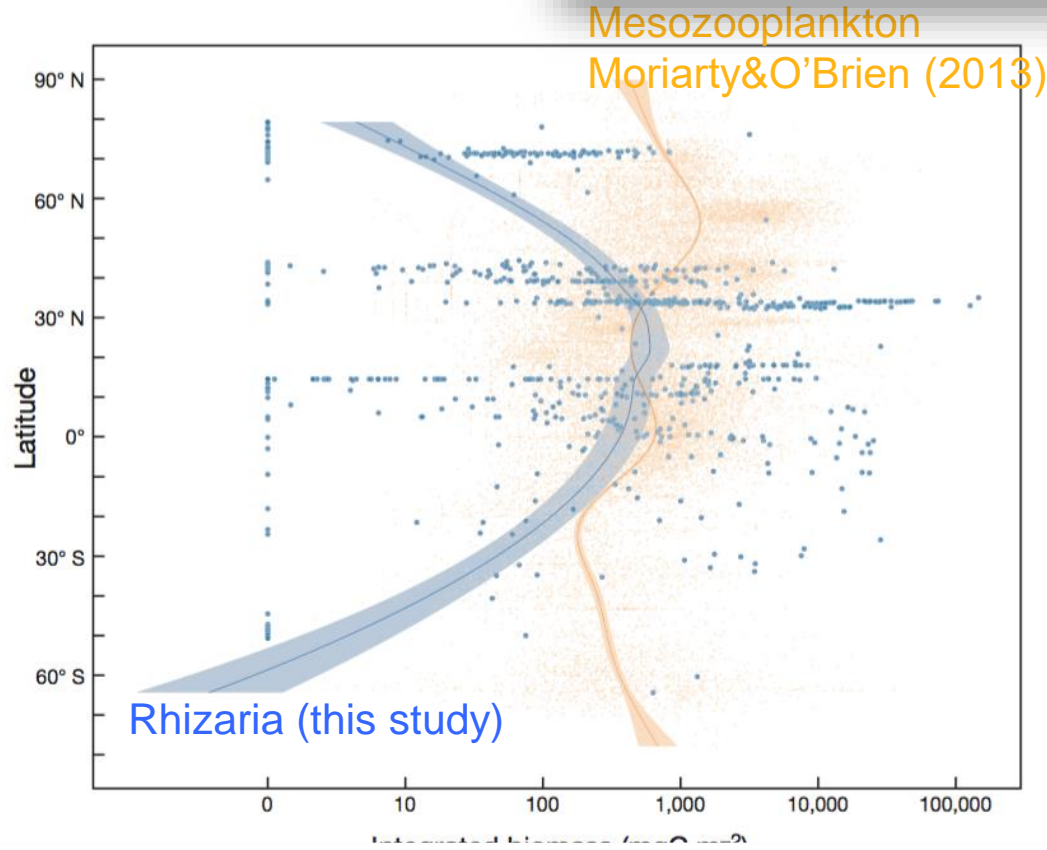
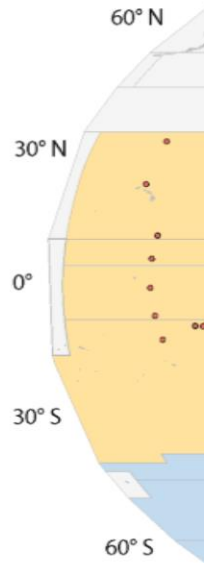
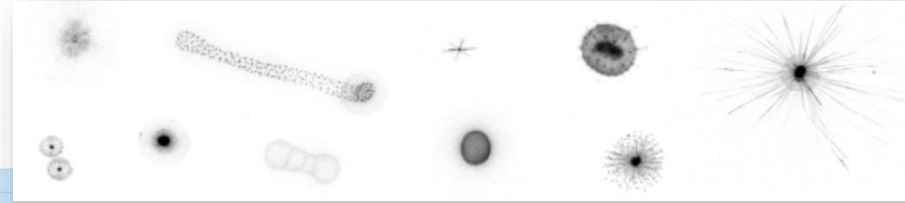
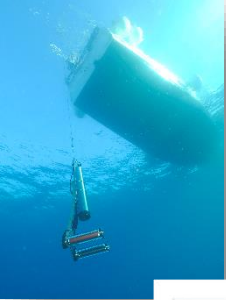
- $10^4$  samples,  $10^7$  images
- spatial survey of a single group
- time series of WWW plankton

Gorsky et al., 2010, JPR

Picheral et al., 2010, L&O

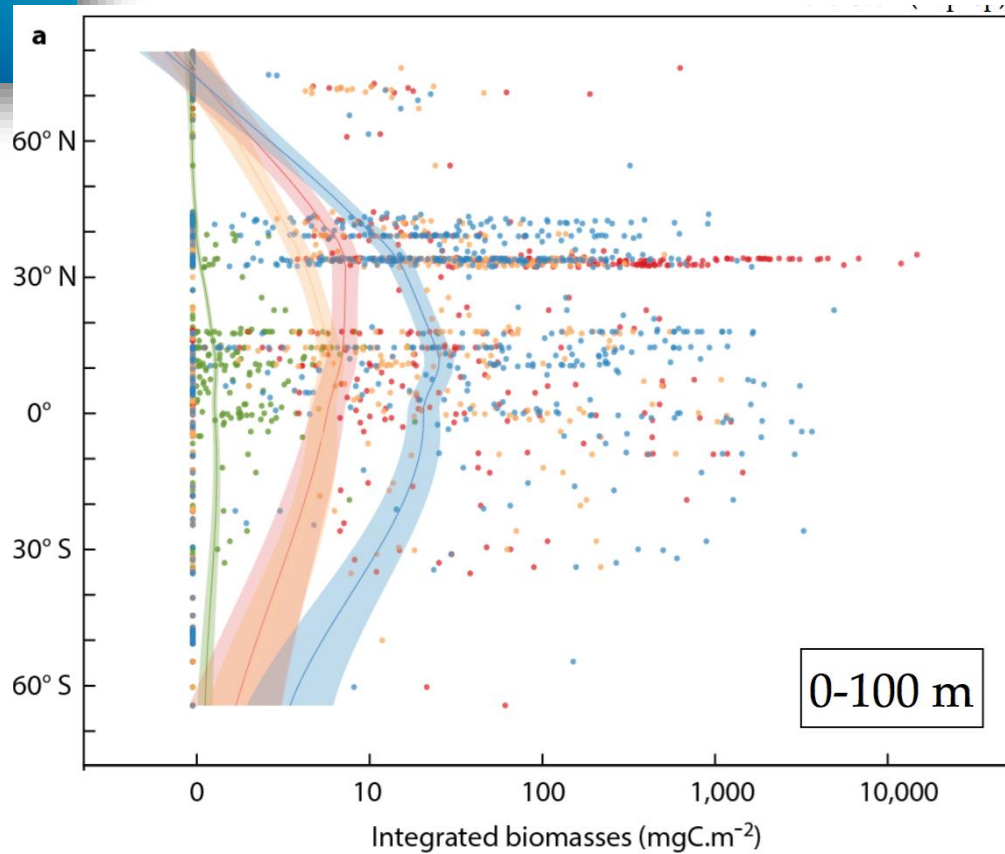
Stemmann and Boss 2014, Ann. Rev. Mar. Sci.

# WWW Plankton: a new player ( $>600\mu\text{m}$ ) ??

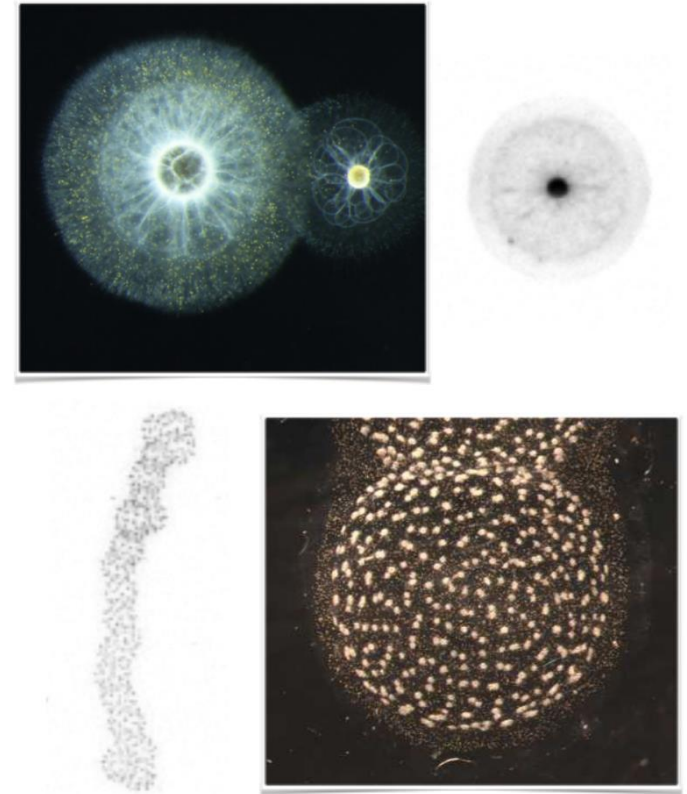


Rhizaria are more abundant in the vast intertropical region

# WWW Plankton: a new player (>600 $\mu\text{m}$ ) ??

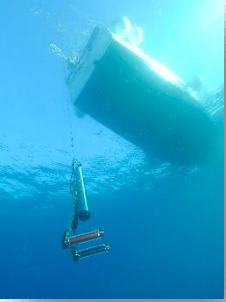


— Acantharia    — Collodaria    — Phaeodaria    — Rhizaria (other)

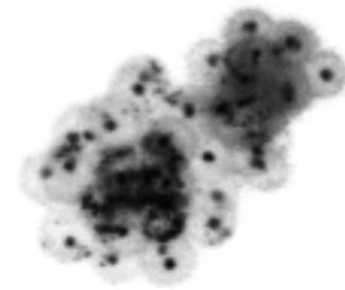
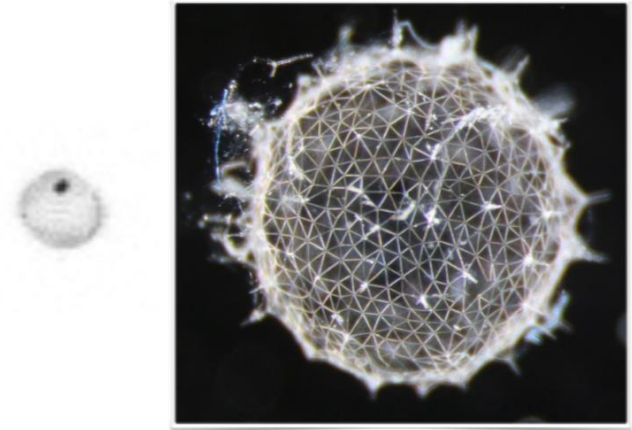
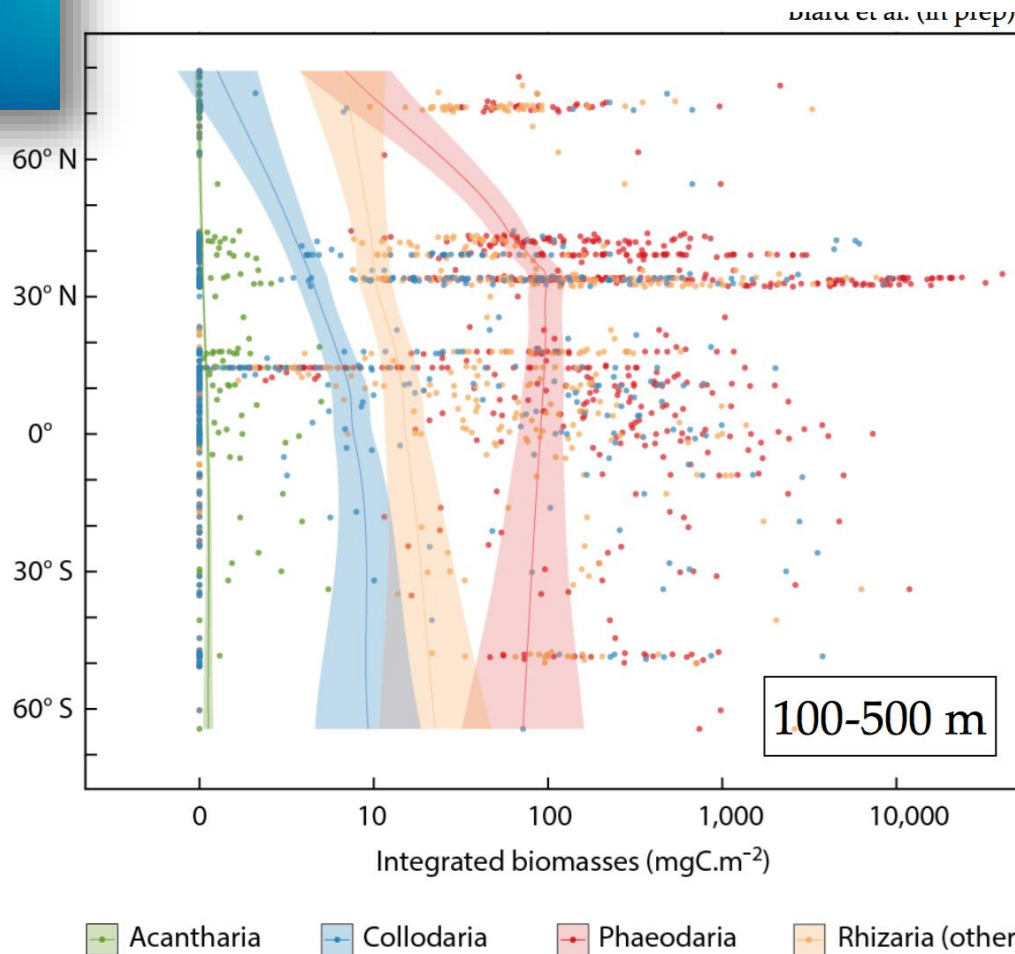


Collodaria solitary and colonial spp.

Domination of photosymbiotic Collodaria in the shallow photic layers



# WWW Plankton: a new player (>600μm) ??

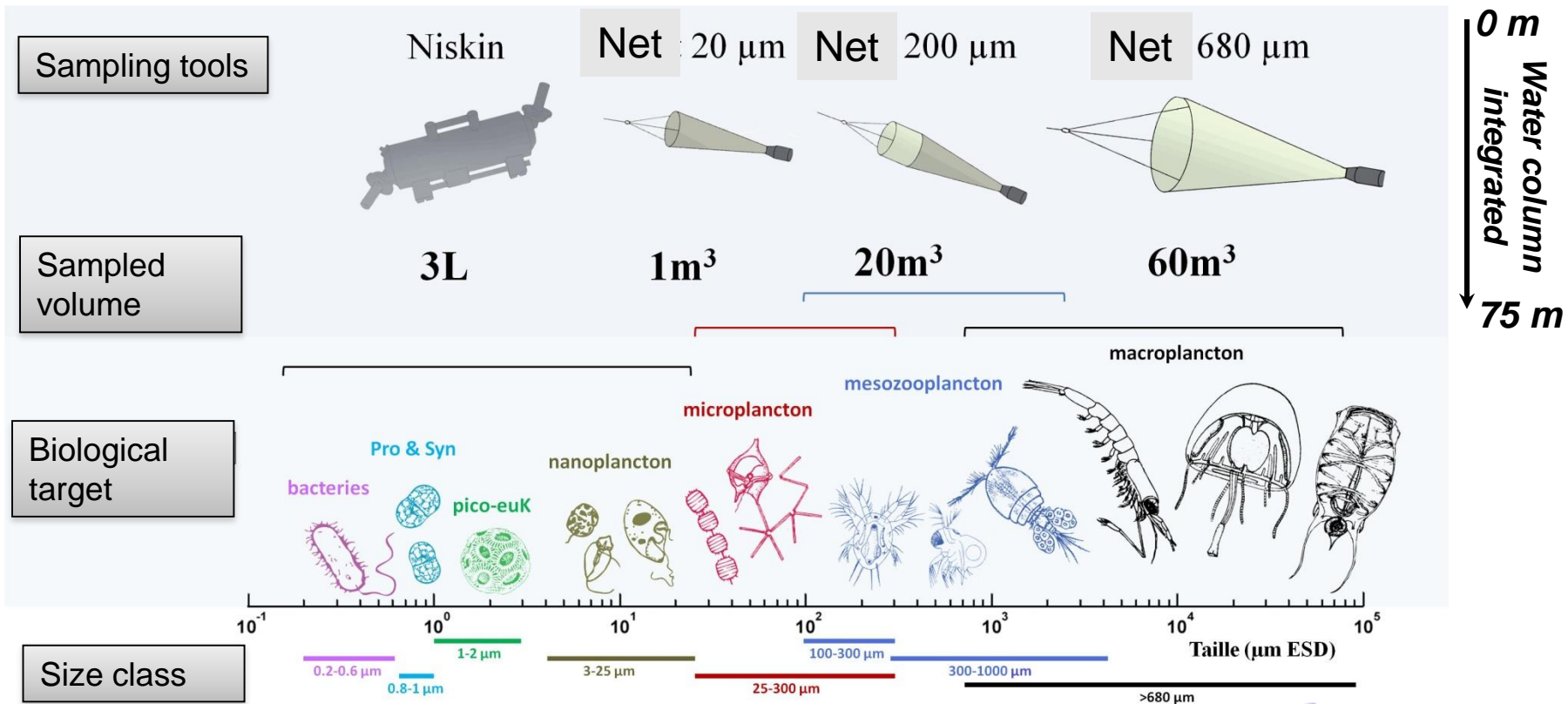


Phaeosphaeridae spp.

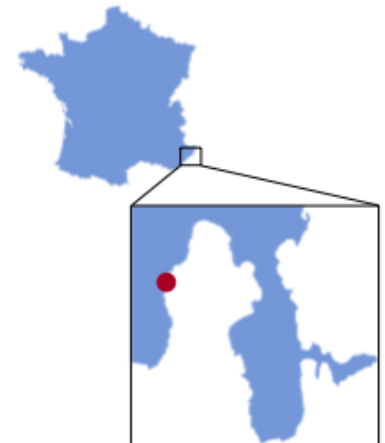
Domination of large asymbiotic Phaeodaria in deeper layers



# WWW Plankton: Weekly time series (2011)



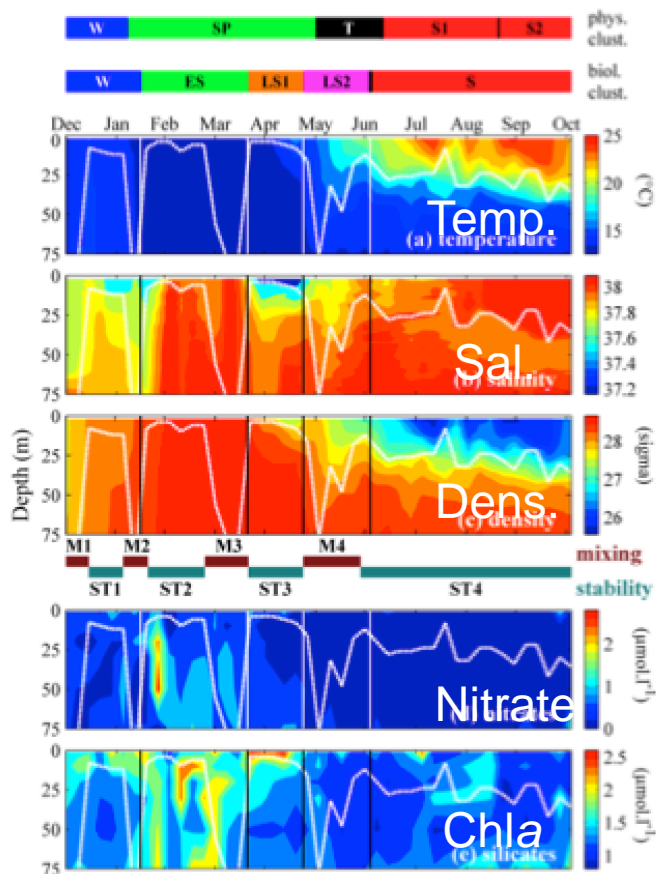
Simultaneous quantitative sampling of each size fraction weekly during one year  
(**flowcytometer, microscopy, FLOWCAM, ZOOSCAN**)



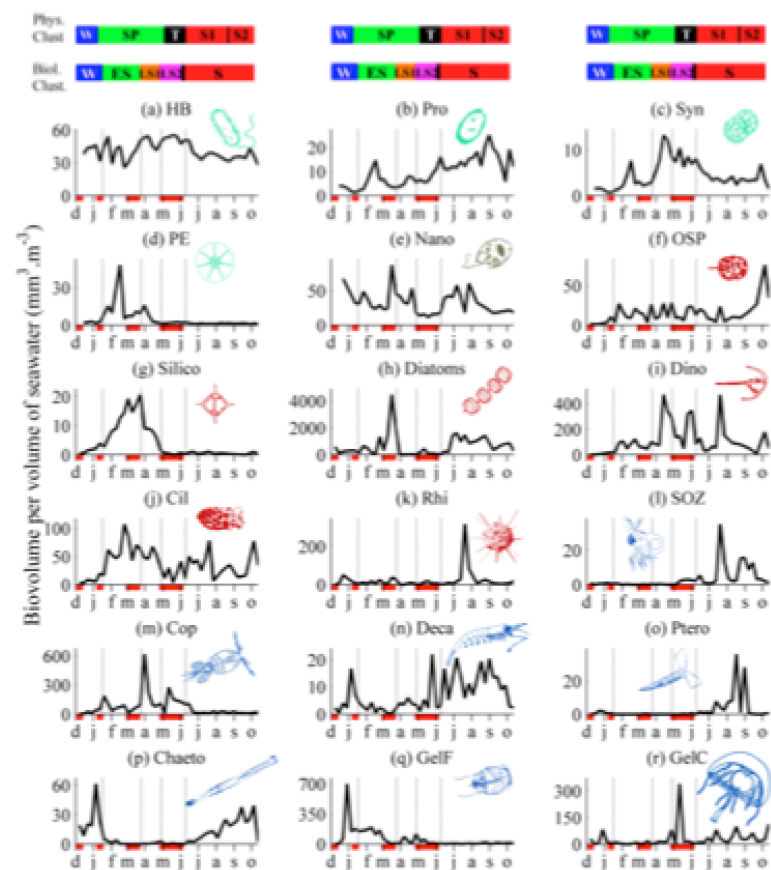
# WWW Plankton: Weekly time series (2011)

## Weekly data from microbes to jellies + physical background

### Water column

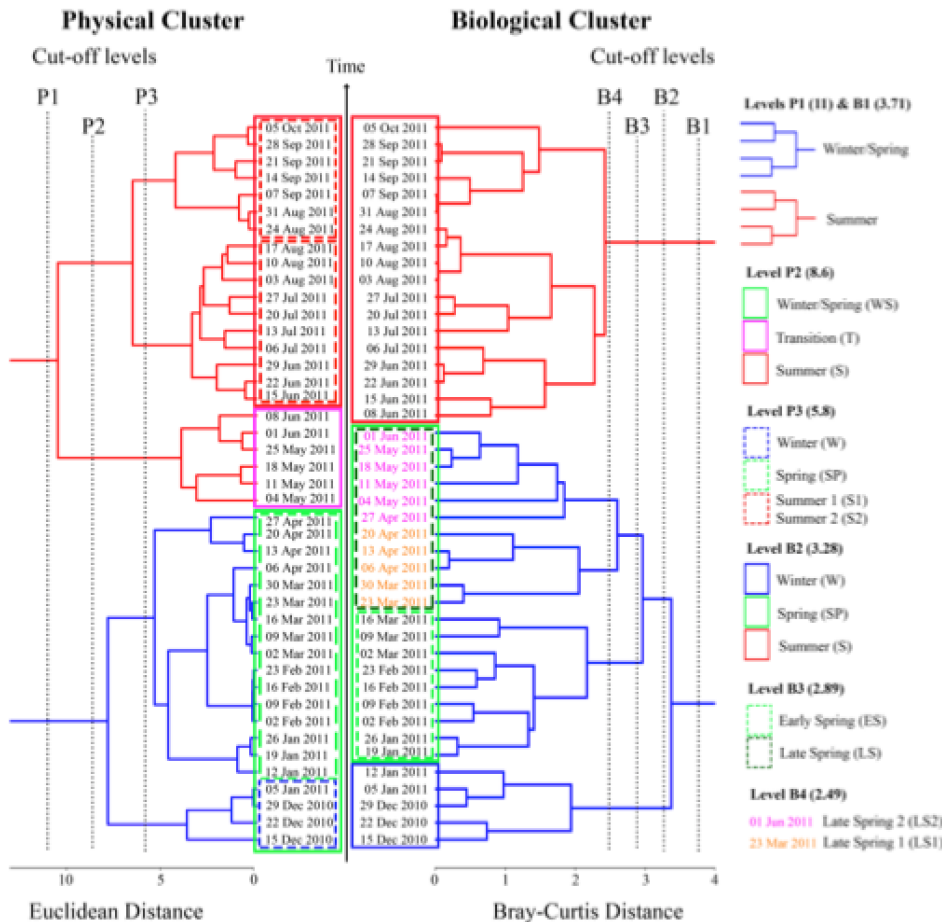


### Whole-plankton

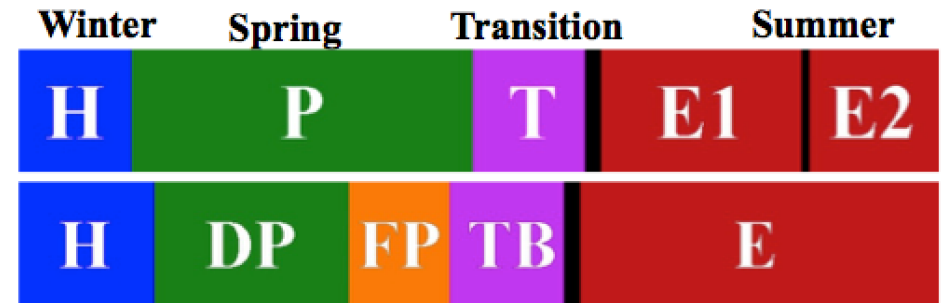


# WWW Plankton: Weekly time series (2011)

## Chronological clustering



### Physical structure sequence

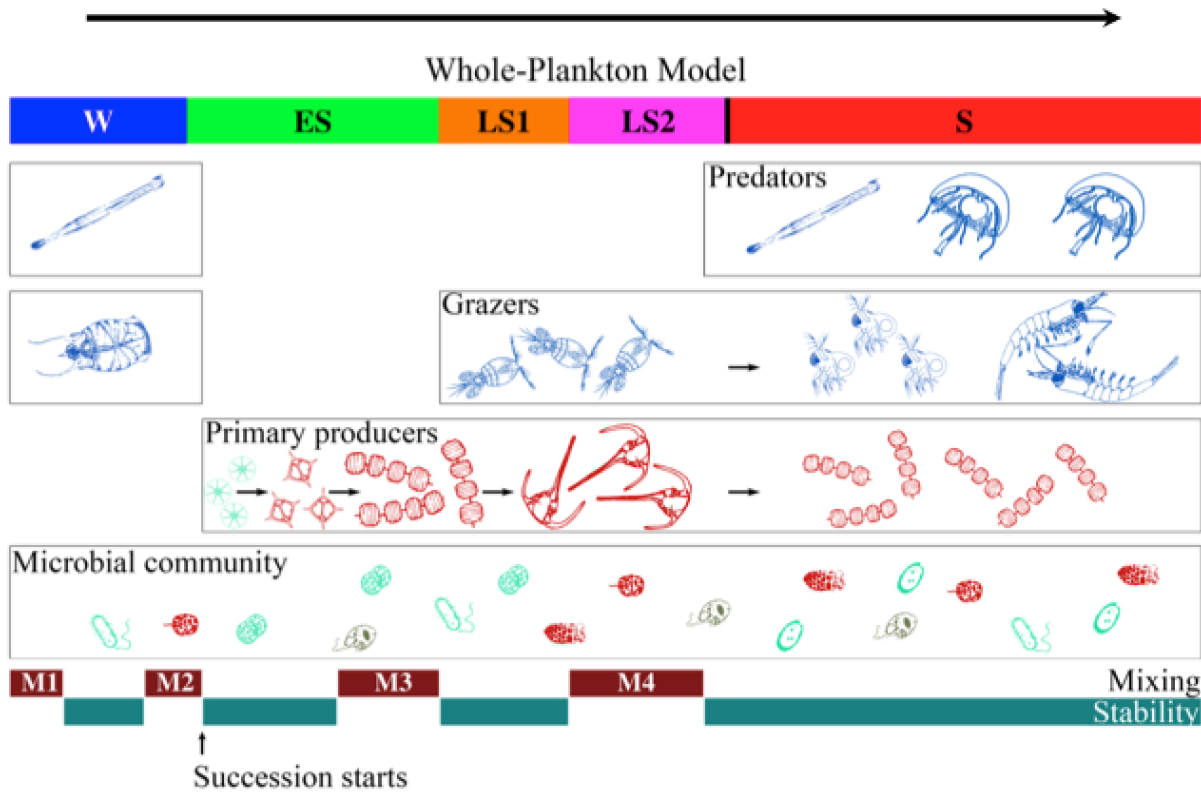


### Whole-Plankton sequence

Remarkable match!!  
 → Physical forcing on whole-plankton succession?

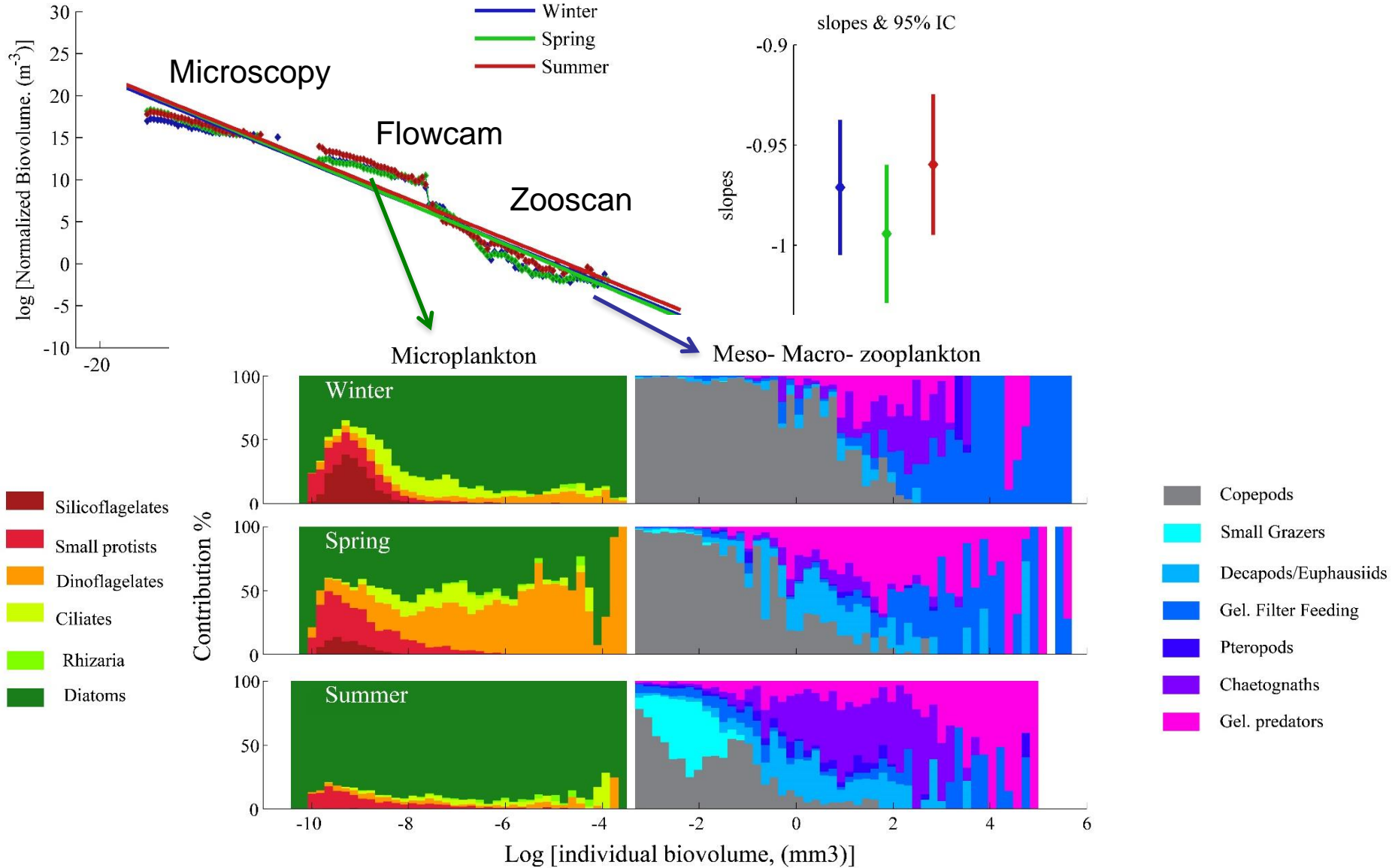
# WWW Plankton: Weekly time series (2011)

## Replacement of PECs within trophic communities

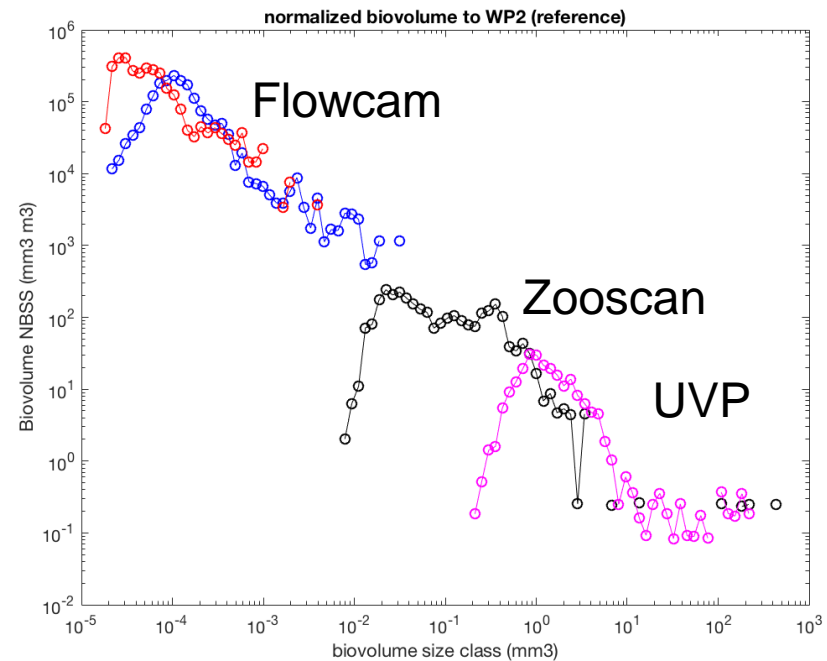
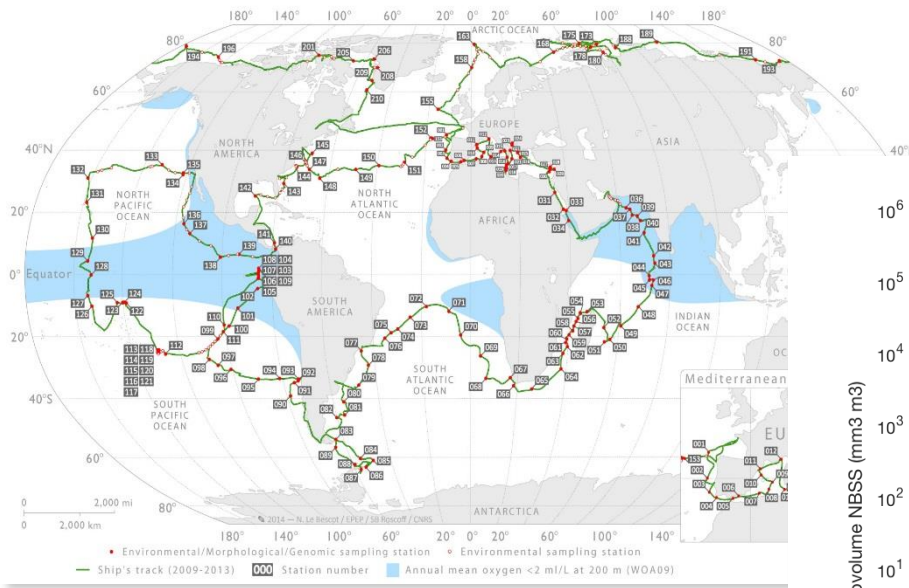


Stacking of trophic communities over time

# WWW Plankton: Time series of full size spectrum



# WWW Plankton: full size spectrum TARA ocean



One station among 171

Work in progress:

- need expert recognition of zooplankton samples in areas outside our expertise (mostly european waters)
- need a software to handle all kind of images

Call for Postdocs working (capacity building program for specific countries South America, Africa):

[http://www.embl.de/jobs/partners/index.html#anchor\\_postdoc](http://www.embl.de/jobs/partners/index.html#anchor_postdoc)

# WWW Plankton: ECOTAXA (6 10<sup>6</sup> images)

**Web based application** to semi-automatically sort plankton images in a network (intranet/internet), share image metadata/data in a secured mode and directly connect images to genomic taxonomy (uniEuk).



**40h : 80 000 objects / 24 categories**

**FILTERS :**

- PROJECT / SAMPLE
- POSITION
- DATE / TIME
- DEPTH

**SORTING & DISPLAY :**

- SORT using SCORE (of prediction)
- Display variables
- Zoom
- Legend

**ACTIONS :**

- IMPORT DATA
- AUTOMATIC CLASSIFICATION (prediction)
- EXPORT results
- Other : settings, corrections, subsets...

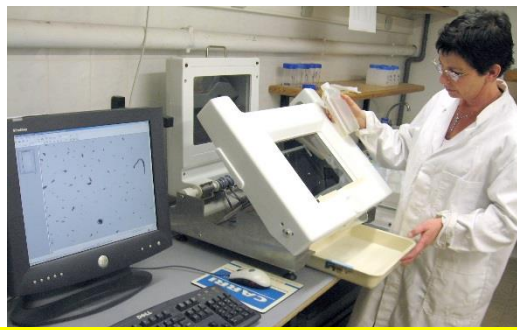
**MANUAL ANNOTATION :**

- DRAG & DROP
- AUTOCOMPLETION

**TAXONOMY filter & PRESET**

# WWW Plankton: linking images with samples

Digitalization (Zooscan)



Analysis (ECOTAXA)



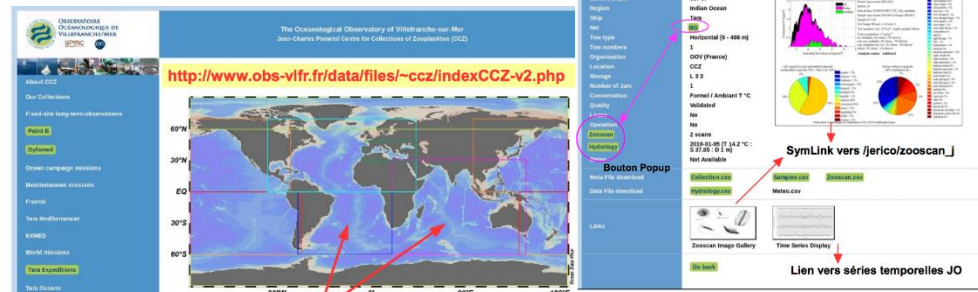
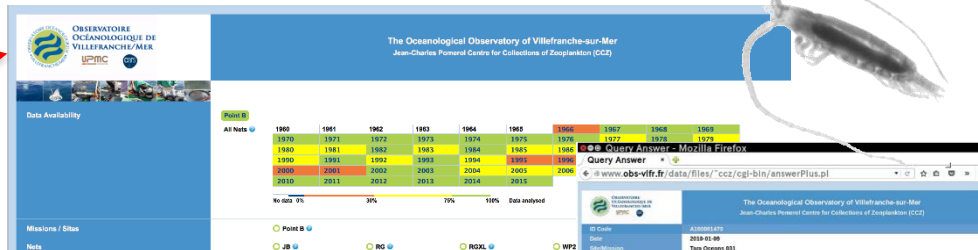
Metadata  
*Formol*  
*ethanol*



Collection room  
(15000 samples)

Files  
Metadata  
Data  
Raw image  
Sorted vignettes

Web applications



Pt B (150 nets/y since 1966)  
TARA cruise (650 nets)  
other cruises (100 nets/y)

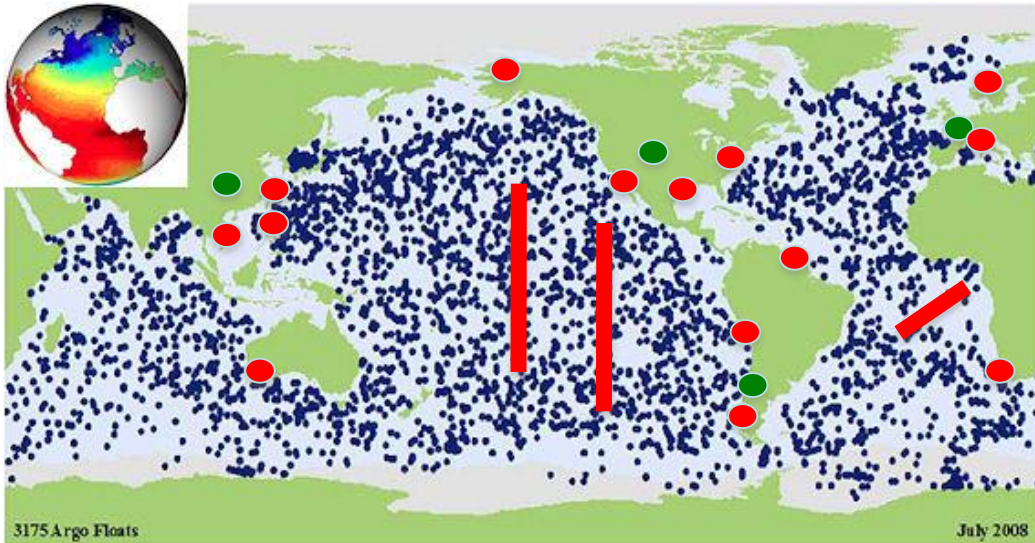
See <http://rade.obs-vlfr.fr/RadeZoo>



# **WWW Plankton: take home message**

- Images can be obtained with high throughput imaging systems for the whole plankton community**
- Large image datasets can be easily analysed by a community of scientists and data can be easily 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 .**

# WWW Plankton: global and regional monitoring



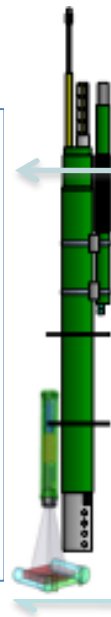
## Global network of observations

- - ARGO-> BIOARGO+vision
- - fixed stations + vision
- - cruises of opportunity

● Oceanographic data center for QC and large diffusion

-Ecosystem monitoring

- Data assimilation in models for Carbon fluxes and marine resources.



$D_{PSD}$  Particulate Organic Carbon

$Z_n$

P

N

macro and mesoplankton (Taxa size spectra)

Pico and microplankton (taxa, size spectra)

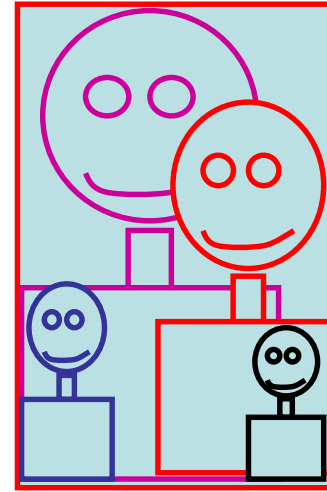
CTD and geochemical data

# Thank you

**PostDoc, PhDs,  
Masters**

**all cruise leaders:**

M. Babin  
E. Karsenti  
V. Smetacek  
S. Blain  
T. Moutin  
Z. Kolbert  
M. Ohman  
D. Checkley  
P. Brandt  
X. Demadron  
A. McDonnell  
E. Boss



Carmen Garia Comas,  
Pieter Vandromme,, F.  
Roullier, Anthony Ouba,  
Nicolas Mayot, Rizlaine  
IdAoud, JB Romagnan N  
Llopis- Montferrer, Marion  
Olivier

**and we are looking for more interested people (Marie Curie Fellowships, ...)**

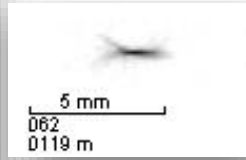
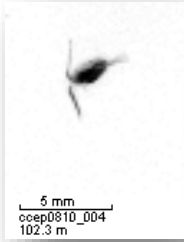
FP7 (EUROCEAN, SESAME, EuroBasin), FP8 (Perseus,  
GROOM, JERICO), H2020 (BRIDGES, JERICOnext),

PROOF, PNEC, ANR POTES, OCEANOMICS et MAORY,  
Services d'Observation RADEZOO and MOOSE

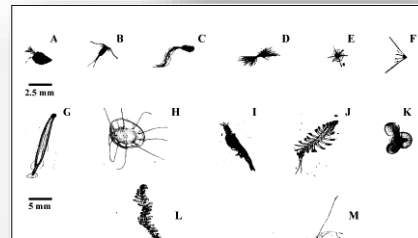
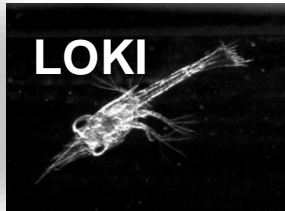
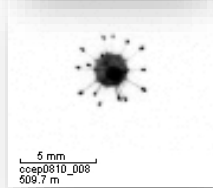
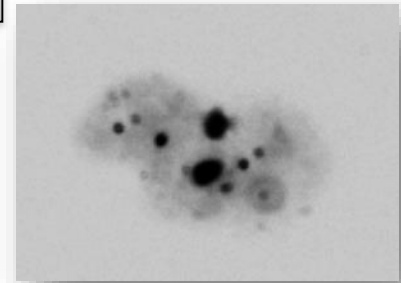
UVP

# WWW Plankton: BIG DATA ?

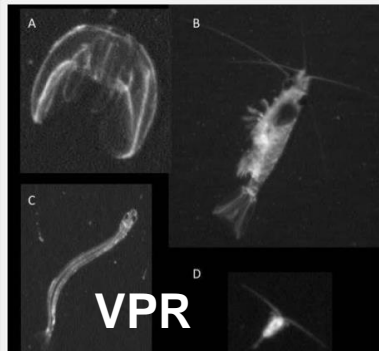
UVP



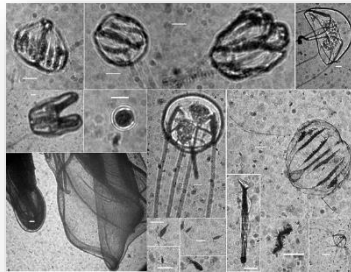
Particle



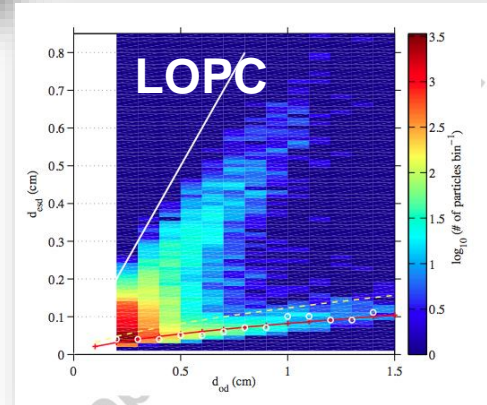
Plankton



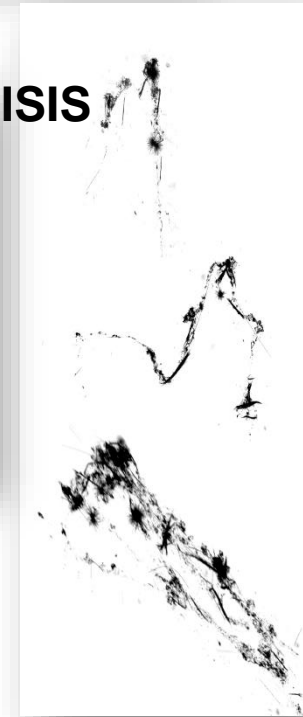
ZOOVIS



SIPPER



ISIS



Then we are ready for a network of octopus eyes.

## **THE KEY OF THE SUCCESS:**

- **AGREED PROCEDURES** (image format, treatment, semi-automatic recognition, intercalibration)
- **AGREED DATA MANAGEMENT**
- **AGREED DATA DISTRIBUTION**
- **AGREED MODELING FRAMEWORKS**
- **SUMMER SCHOOLS FOR THE USERS**

**These are propositions that we could discuss.**