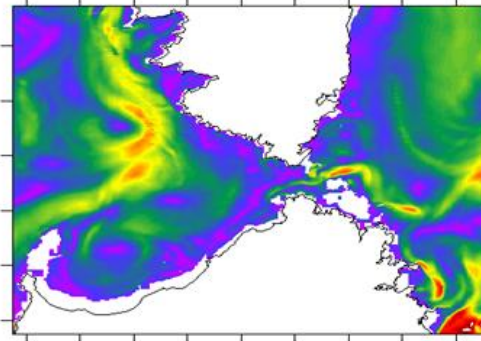


# Systemic approach in a Marine Protected Area Strait of Bonifacio – South of Corsica

*Modeling and currentology for applied research  
(larval dispersion, marine litter, chlorophyll).*

**O. GERIGNY , S. COUDRAY, P-A. BISGAMBIGLIA ,  
C. LAPUCCI , D. LE BERRE , F. GALGANI.**



JONSMOD Bruxelles, may 2014



# Introduction : Strait of Bonifacio

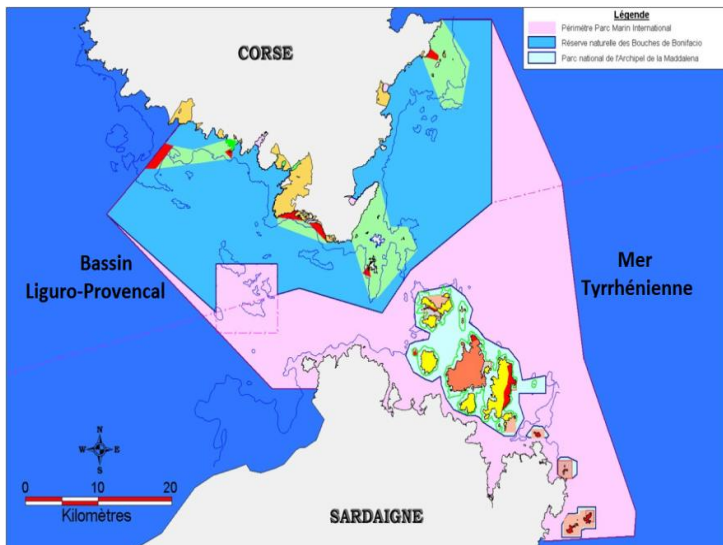


Mediterranean Sea – North-west basin, South of Corsica

**Marine Protected Area** (RNBB, future international marine park)

**Many activities** : tourism, fishing  
Ecological heritage : legacy species

**Marine complex ecosystem => exposed at many pressures**



# Introduction : Context of the study

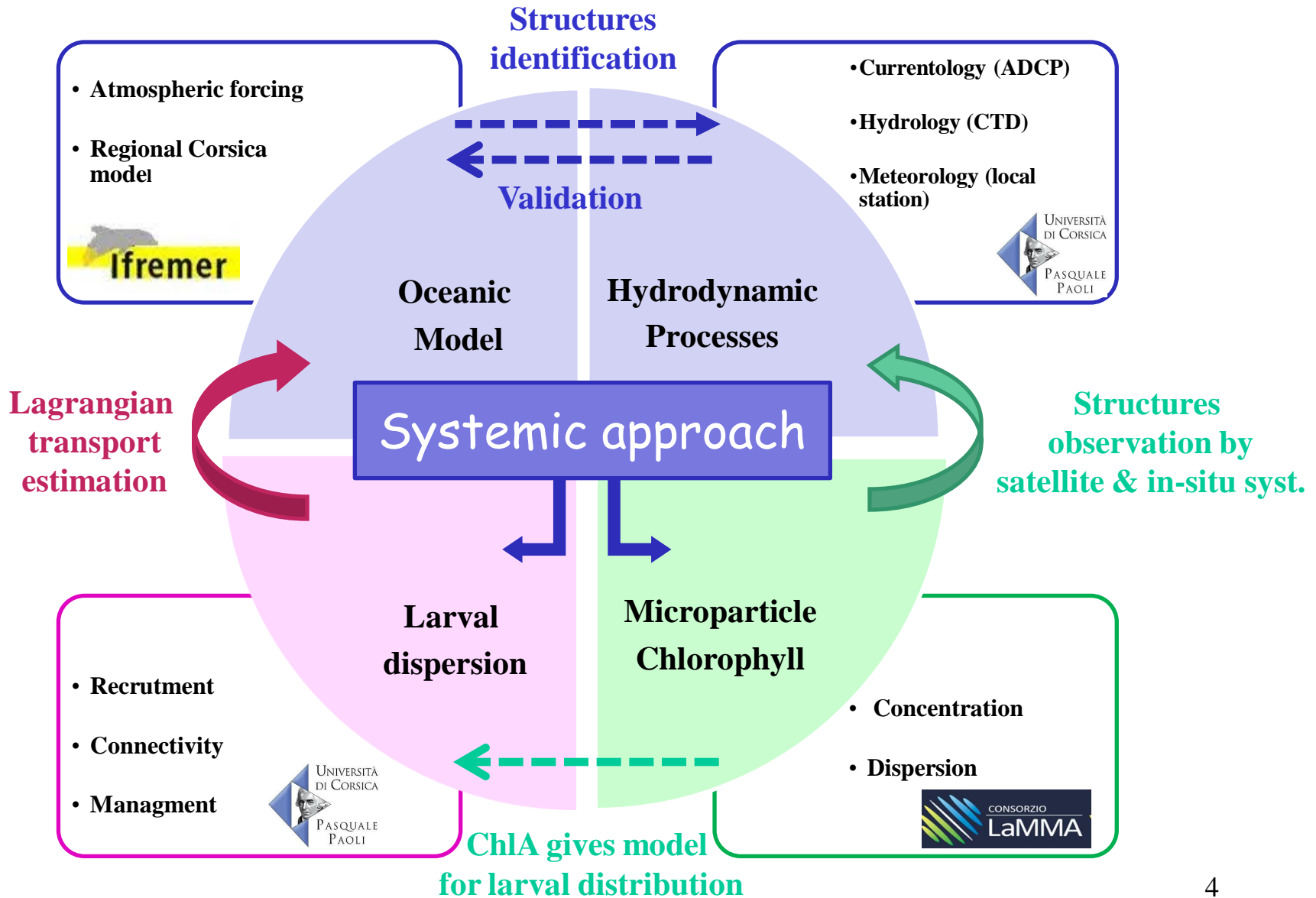
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- 1- **Better understand of the local hydrodynamic processes**
- 2- **To study the interactions with the biologic level**

## Several team are working together :

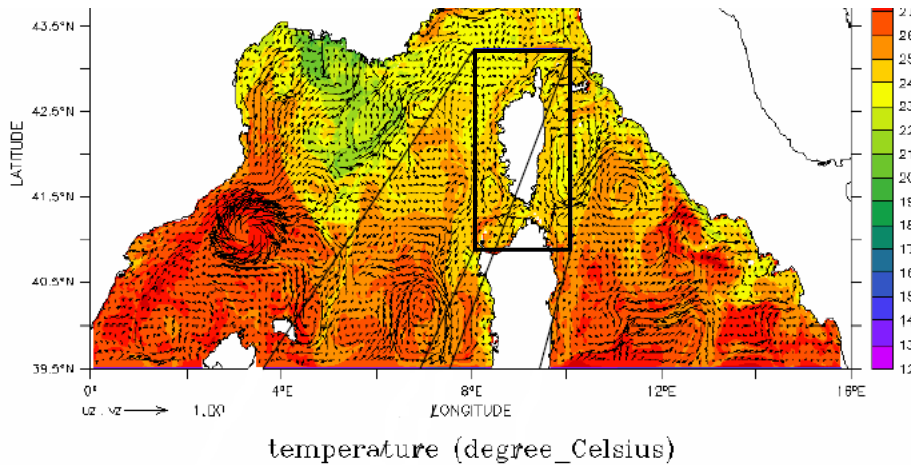
- **University of Corsica:** Sustainable Technologies for Littoral Aquaculture and Marine Research (Stellamare) project, to study the distribution of larvae communities.
- **IFREMER:** to improve hydrodynamic knowledge, and to prepare future work for the Marine Framework Strategy Directive.
- **Lamma consortium (Italia) :** to monitor coastal water (Inter-regional project SICOMAR), founded by Europe.

# Materials and Methods - 1. Systemic approach in a MPA





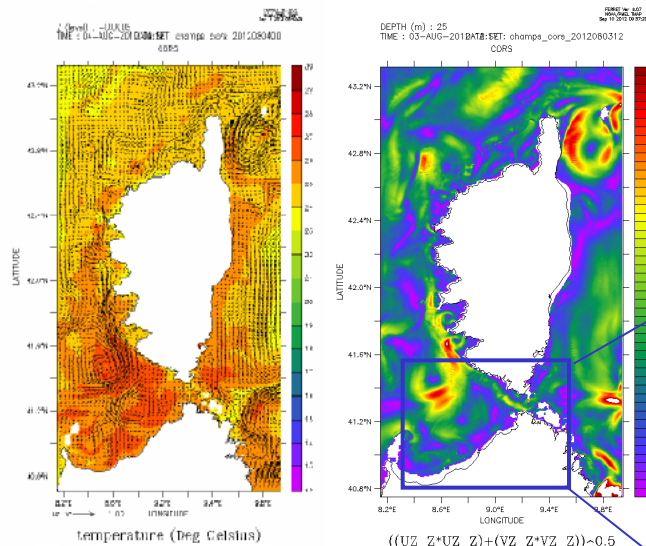
# Materials and Methods - 2. Mars3D Model– CORSE 400m



## Mars3d-MENOR (1.2 km)

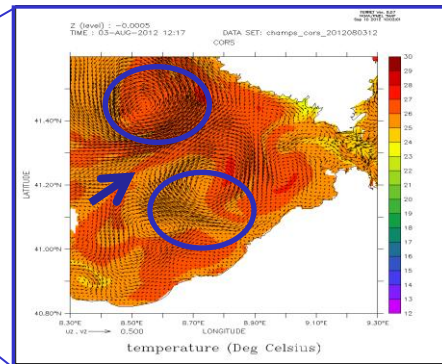
North-west Mediterranean model  
3D free-surface, hydrostatic

Atmospheric forcing MM5  
(now MF-ARPEGE 3 km)



## CORSICA regional model (400m)

Open boundary conditions given by MENOR



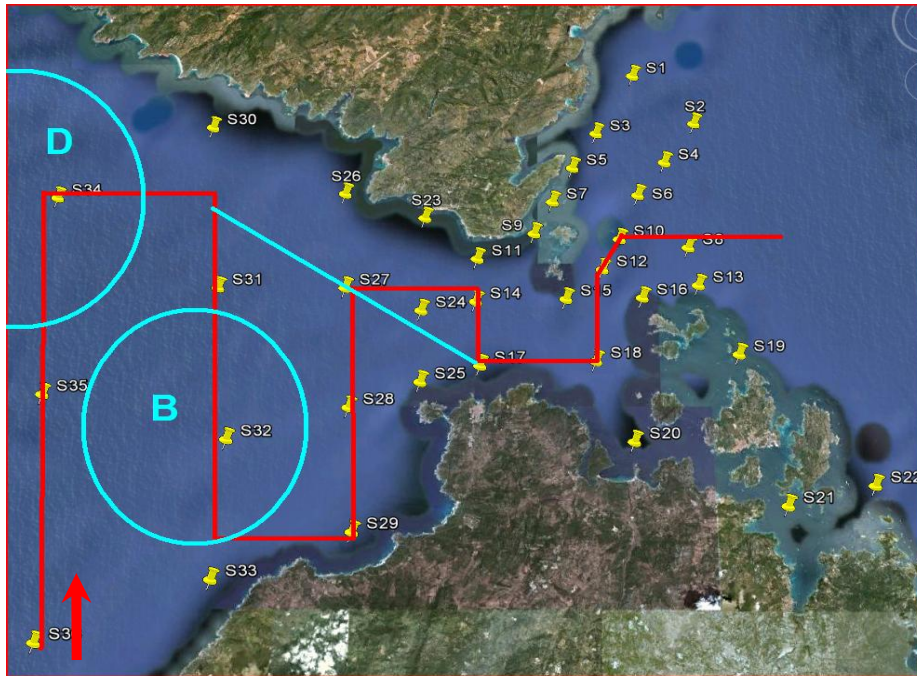
+ Zoom on  
Bonifacio strait  
to identify  
mesoscale structures

# Materials and Methods – 3. Cruise organisation

**Planning** of the waypoints (in red) was done following the previously identified hydrodynamic structures and main fluxes

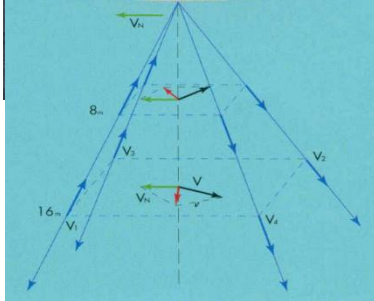
**Grid step** calculated in order to :

- cut the main structures (B and C) with ADCP profiles
- do samples of plankton and micro-particles along the same transects



- Direction were chosen according to wind conditions (west-east)
- CTD profiles were planned at the end of each segment

# Materials and Methods – 4. Current's measurement



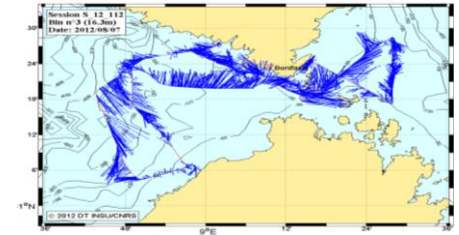
Ship « Tethys II » from INSU, equipped with

- fixed ADCP on hull,
- T°/salinity surface TSG system,
- meteorological station.

⇒ Data given a posteriori

⇒ Frequency data recording : 1 minute.

⇒ Adcp standard Bottom Track mode = 300m / 30 cells.



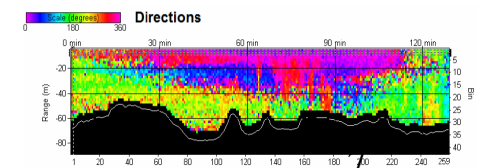
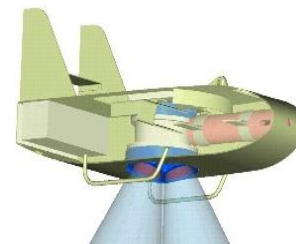
Mobile ADCP towed on a « fish »

- deployed along the ship and 3 meters under the surface
- Same axe as the ship

⇒ Frequency data recording : 30 seconds.

⇒ Data controlled onboard in Real Time via RDI-software

⇒ Adcp customized Bottom Track mode = 100m / 60 cells.



VMDAS RDI-software



# Materials and Methods – 5. Larval and microparticles data



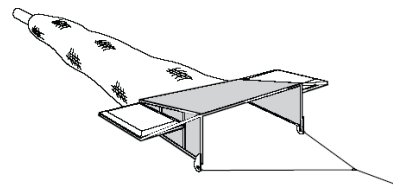
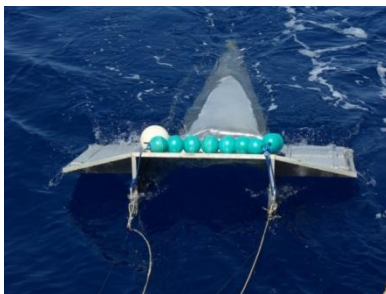
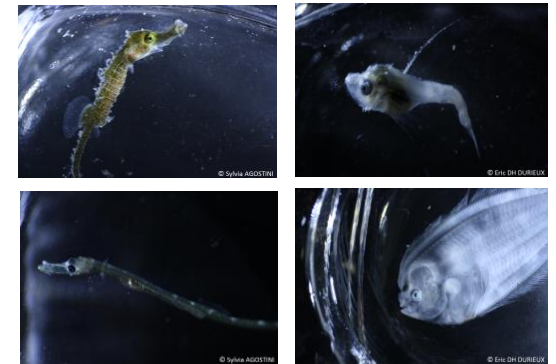
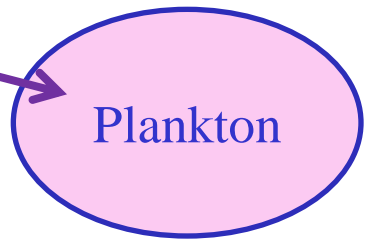
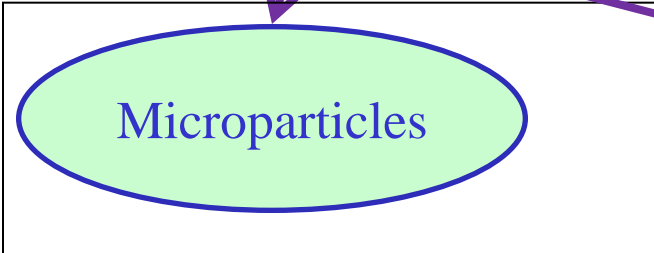
36 sampling stations



**Bongo net (200 & 500  $\mu\text{m}$ )**  
Zooplankton & Ichthyoplankton

- Volume count
- Depth measurement
- Slanting profil

=> integrated on water column



**Manta net**

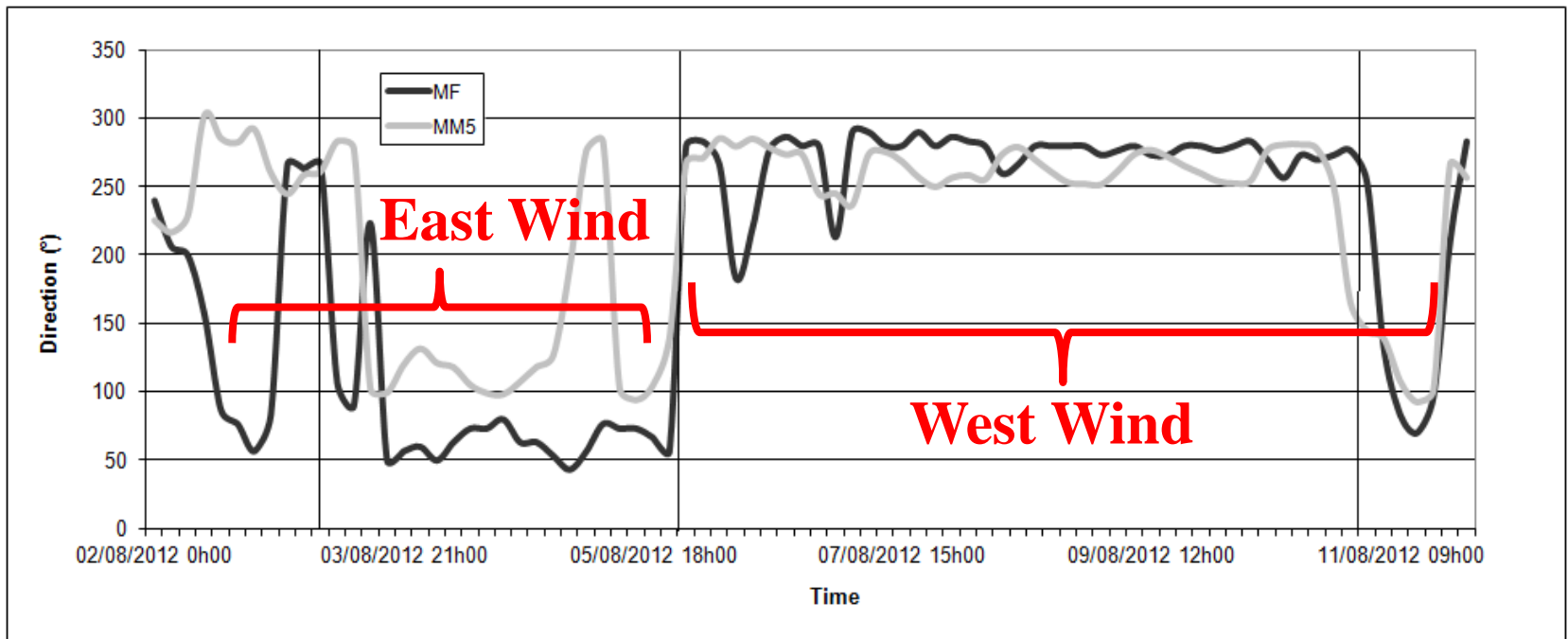
- during 30 min at the surface



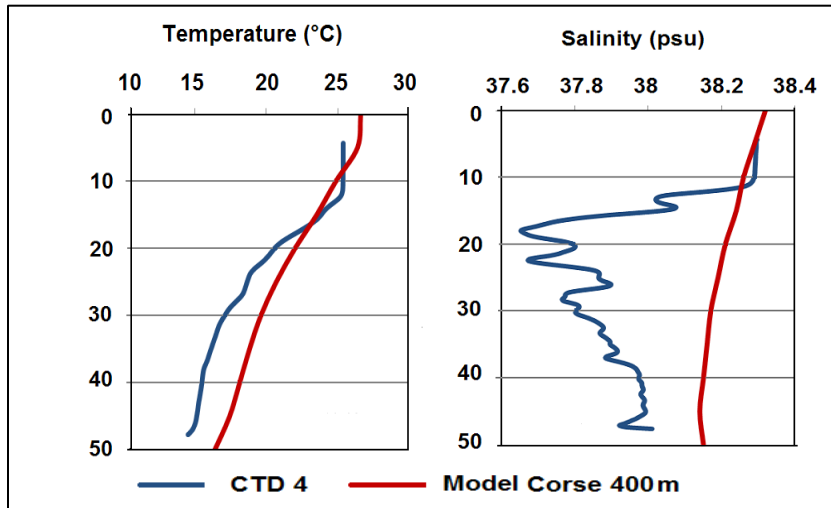


# Results - 1. Atmospheric forcing

- **Model** used during the cruise : MM5, 3km resolution (in grey)
  - **In-situ data** coming from MeteoFrance Pertusato semaphore (in black)
- ⇒ Wind direction is constrained by a **bi-modal system**
- ⇒ Direction has switch during the cruise giving us an **ideal configuration**

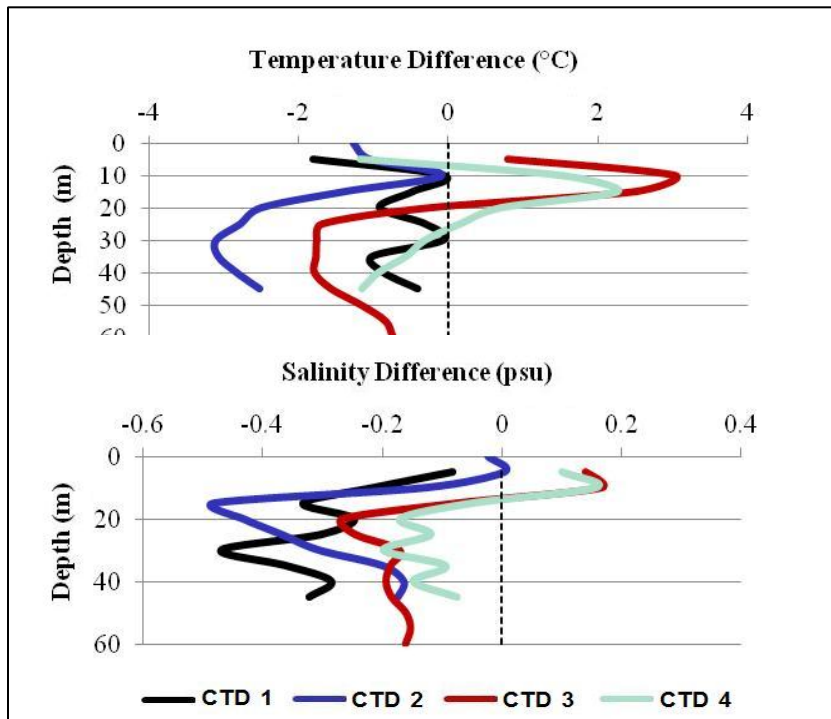


# Results – 2. model validation by CTD (hydrological parameters)



## *CTD4 profile in the channel :*

- Thermocline is 10 m higher in the model
- Bias of 0.3 psu is detected on salinity



## *CTD profiles intercomparison :*

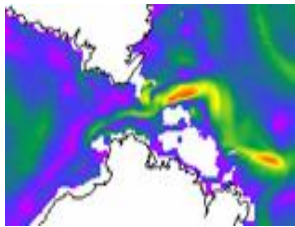
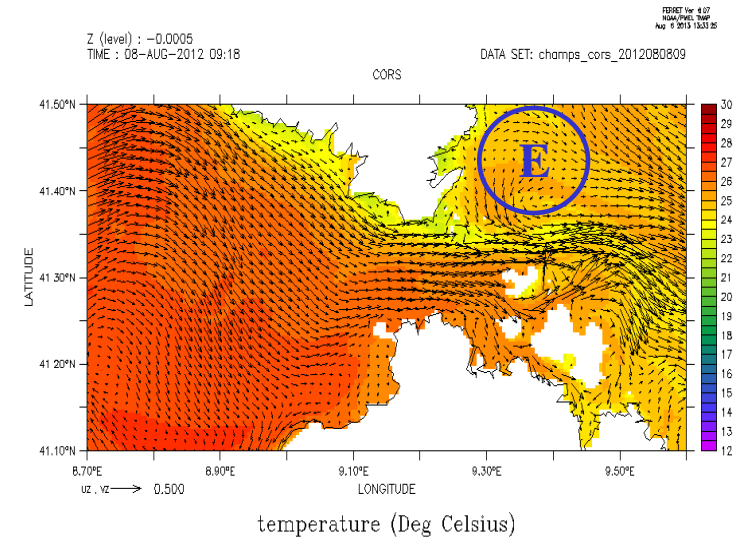
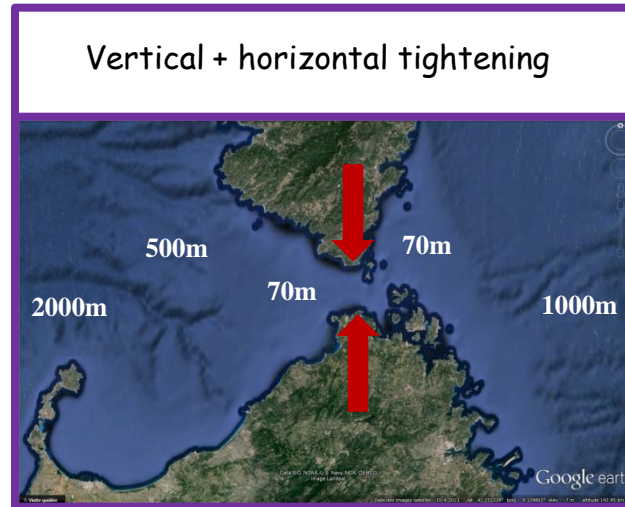
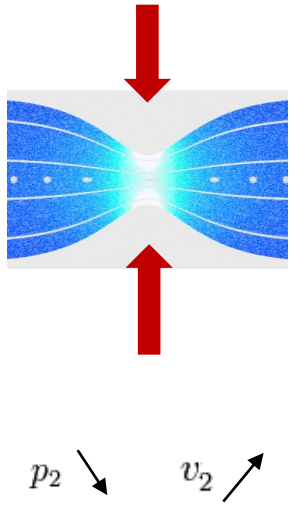
- Temperatures are better estimated along the coast (in black & blue) where thermocline is less important

⇒ Model's vertical scheme or viscosity needs to be verified  
⇒ Salinity needs a systematic correction (bad IR forcing)



# Results – 3. Currentology : Venturi effect

On the east part of the strait, a Venturi effect, both atmospheric and hydrodynamic, appears due to the contraction of the channel near Bonifacio.

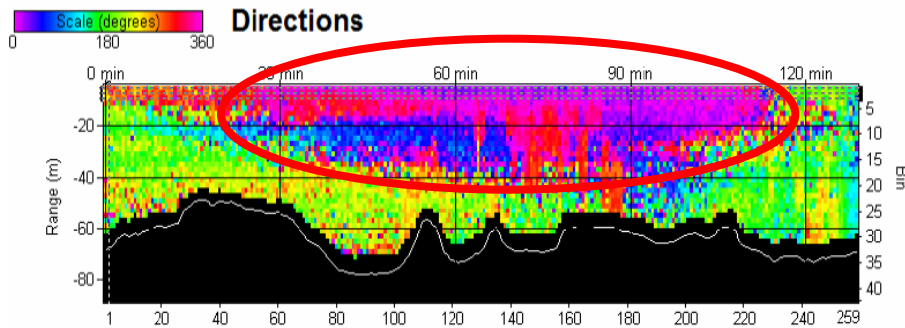


- ⇒ Acceleration of the flux is evident on model results
- ⇒ Measured at about 50 cm/s during our campaign
- ⇒ Well-known by navigators (danger)
- ⇒ Aspiration phenomenon when wind is blowing from the west

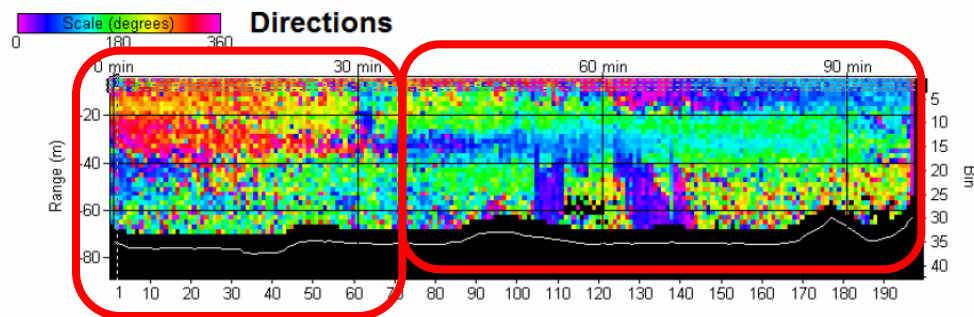


# Results – 3. Currentology : process analysis by ADCP

Focus has been given on the west part of the strait



**P12 profile** : *cutting the channel from North to South*  
 Surface (0-20m) : North-west current (Red/pink)  
 Mid layer (20-40m) : South (green) & East (blue) current



**P14 profile** : *shows a complex stratified situation after 30mn*  
 South part : North-west current turning east (yellow/red/pink/blue)  
 North part : East current stronger at the bottom (blue)

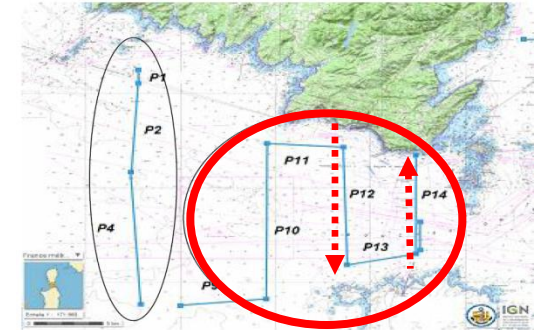
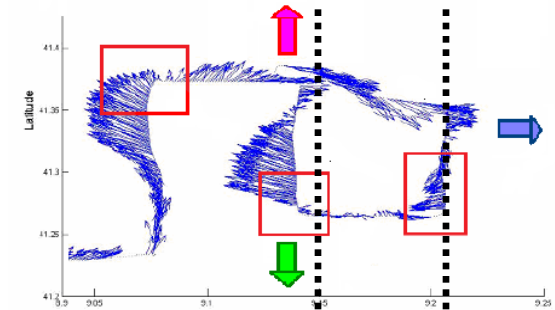
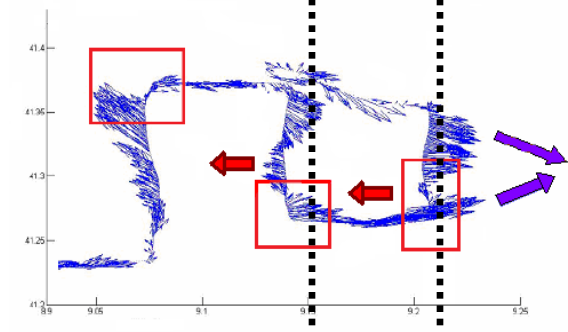


Figure 12 : Position des profils ADCP et CTD durant les legs 1a et 1b de la campagne STELLAMARE1

**Sub-surface layer (-16m)**



**Mid layer (-36m)**



**P12 P14**

# Results – 3. Currentology : process analysis by ADCP

Mesoscale system observed in the west part of the strait

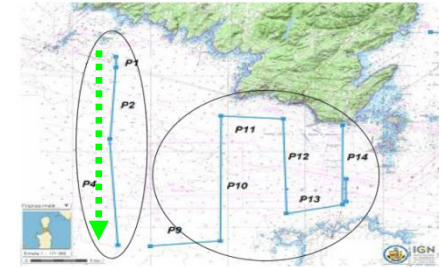
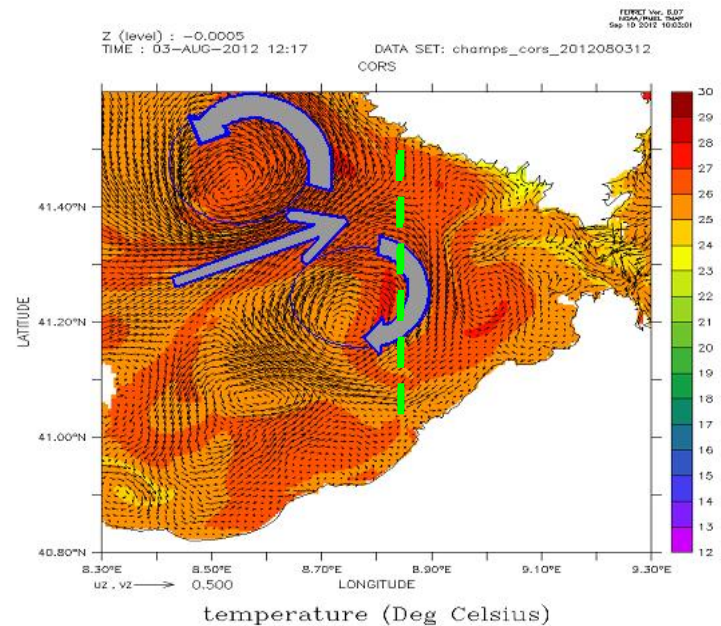
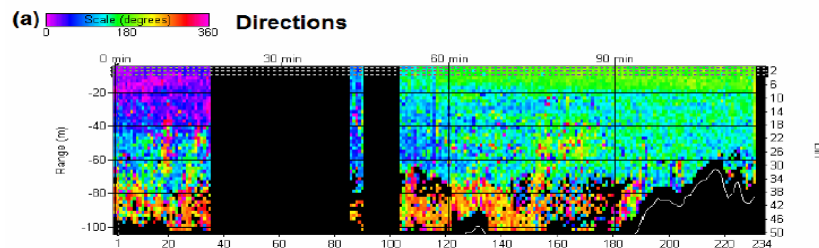
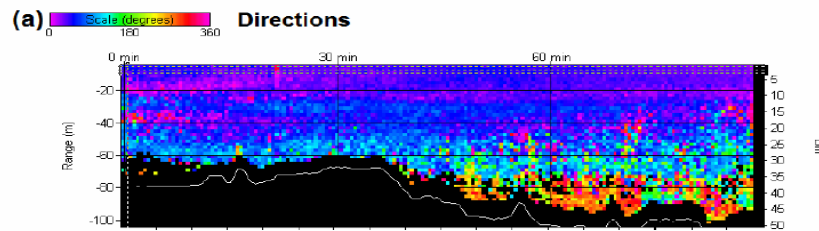
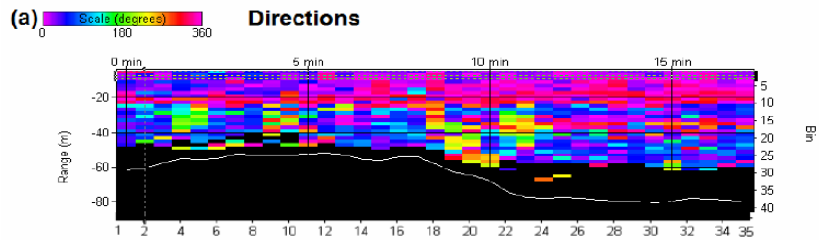
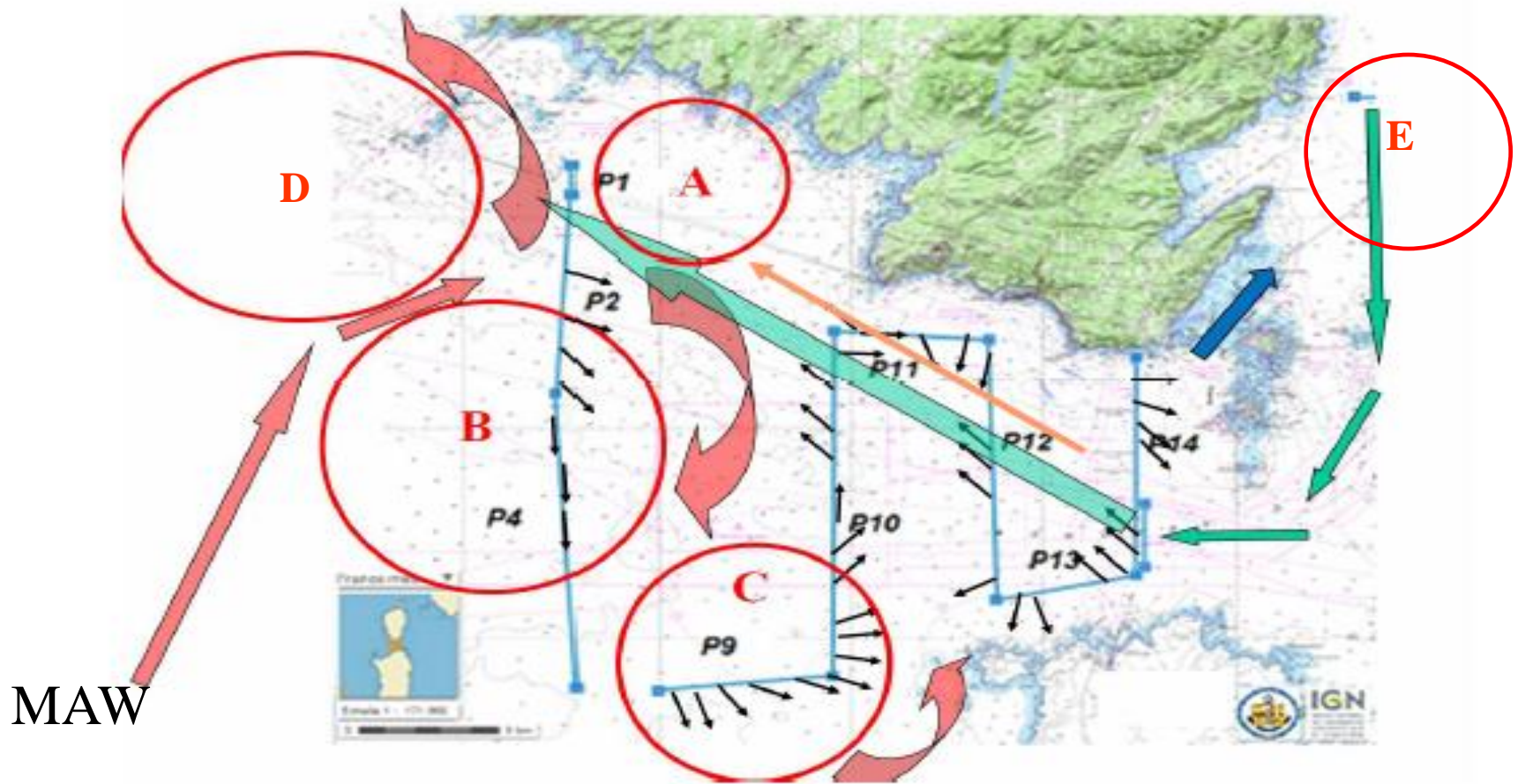


Figure 12 : Position des profils ADCP et CTD durant les legs 1a et 1b de la campagne STELLAMARE1



**P1-P2-P3 profiles** : *Water column is quasi-homogeneous*  
Current is first North (pink), turning East (blue), and then towards South (green)  
=> showing vortex activity.

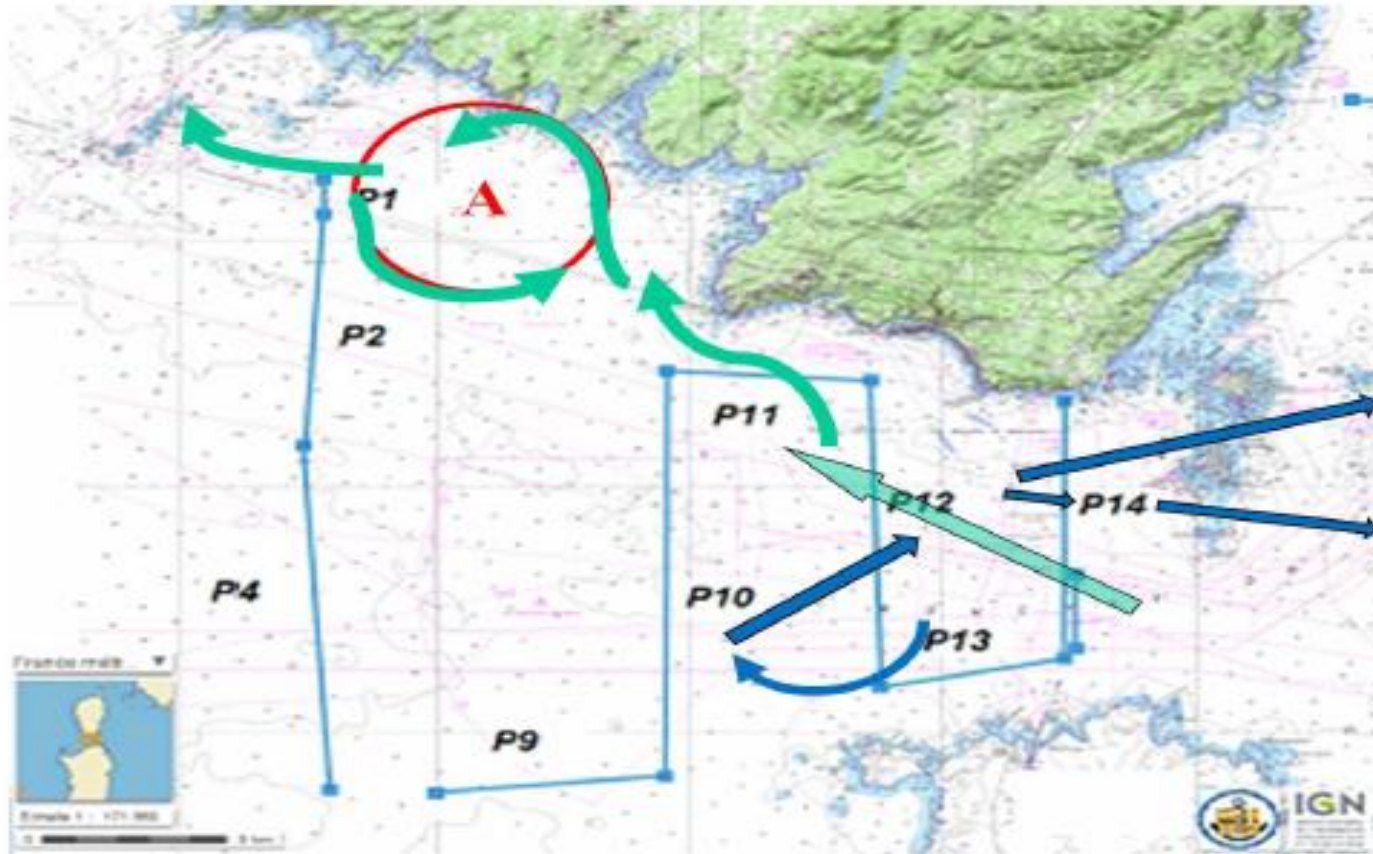
## Results – 4. Current's synthetic view above the thermocline



- **Cyclonic-Anticyclonic system** appears, due to the MAW current coming along the rift
- **A channel** (in green) formed by the bathymetric relief follows the Corsica south coast when wind is blowing from the East.
- Local and **smaller structures** appear along the shore creating two secondary bassins



## Results – 4. Current's synthetic view under the thermocline

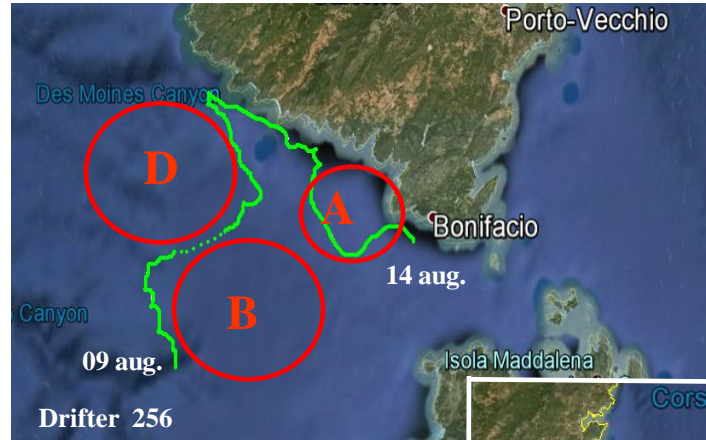
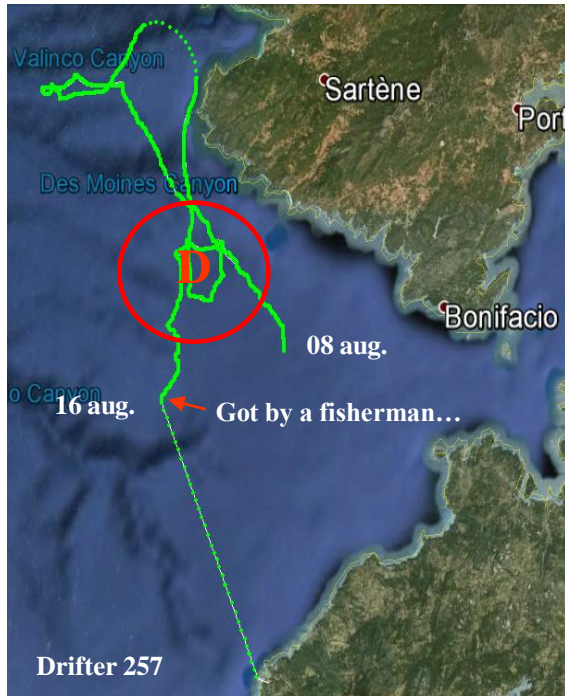


➤ The already mentioned channel (in green) crosses the exiting flux => **stratified** water column

➤ The entering flux goes along the Corsica coast

# Results – 5. Currentology : process validation by drifters

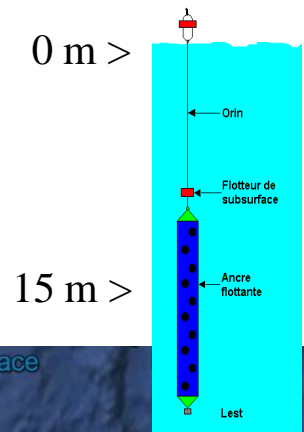
Mesoscale systems were observed in spatial-temporal mode by using 15m deep lagrangian drifters



1st

2d

3d



## Three drifters launched :

- First drifter n°256 shows very well the coupled vortex system D,B and A
- Second drifter n°257 shows flux along the coast and then, coming back, the big vortex D
- Third drifter n°258 shows a small vortex E linked to the Venturi effect along the east coast

# Application: Larval dispersion (Gérigny and Koeck)

Connectivity & Identification of preferred habitats installation

## Inputs

**Scenari 1: Theoretical**  
PLD, release in MPA area

**Scenari 2: Empirical**  
Stella Mare predicted  
distribution of larvae

Definition  
« **real release zone** »  
of larvae

Hydrodynamic  
Corse 400 m  
Model

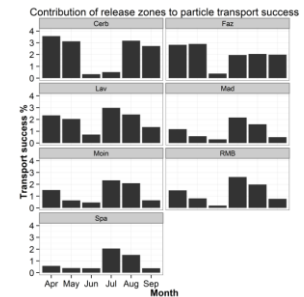
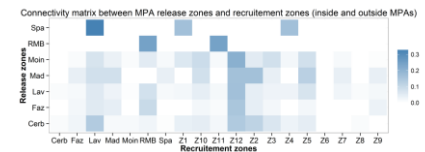
+



Individual Based  
Model

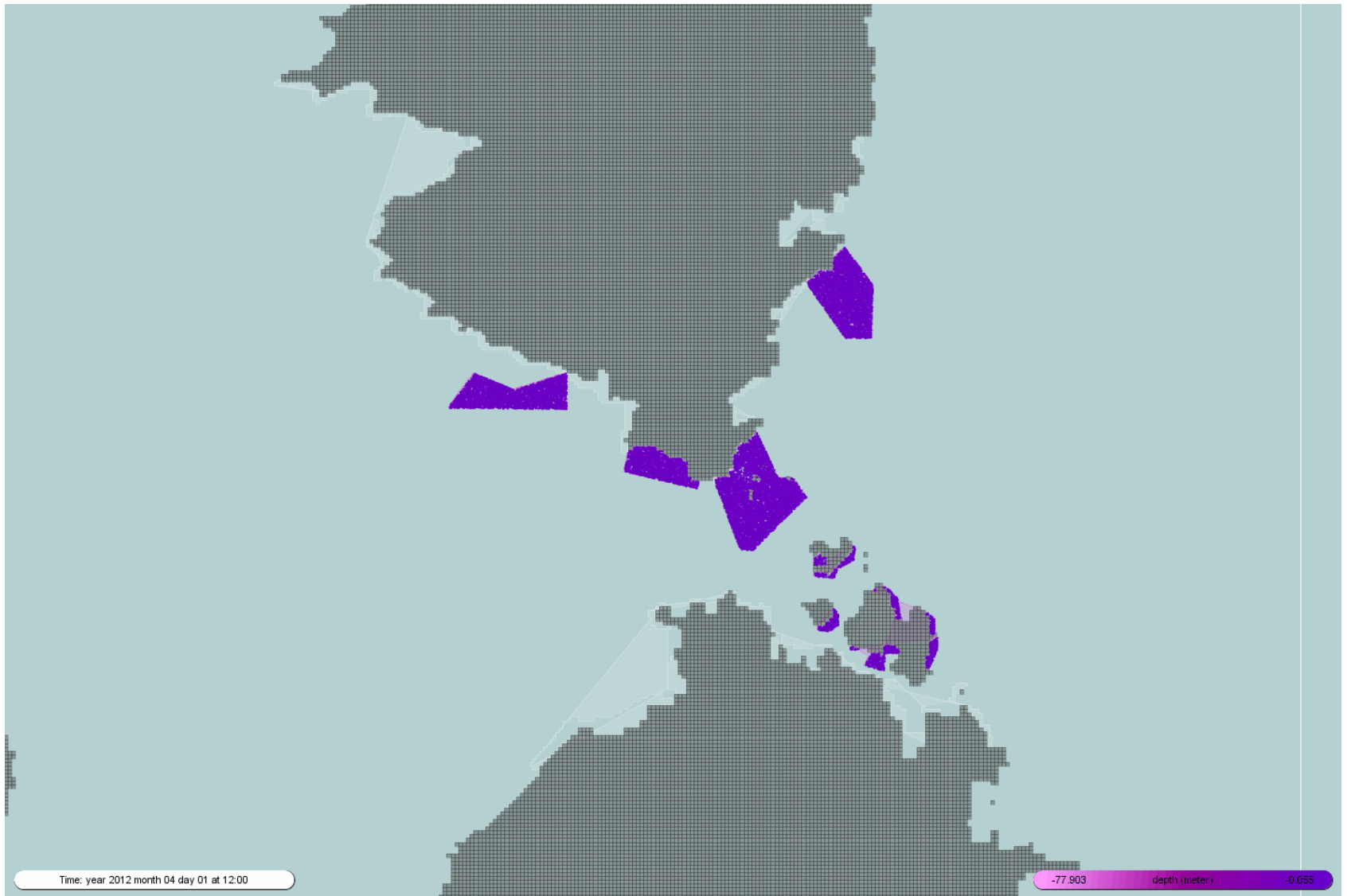
## Outputs

- Transport success
- Recruitment success
- Matrix of connectivity



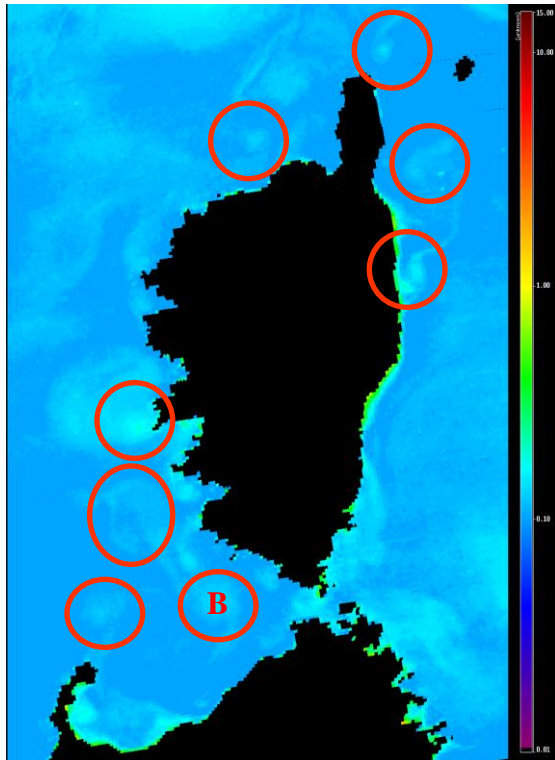


# Application: Larval dispersion (Gérigny and Koeck)



# Application: Chlorophyll A concentrations (Lapucci, G erigny )

08/2012



ChlA data (mg/m<sup>3</sup>) in oligotrophic conditions :

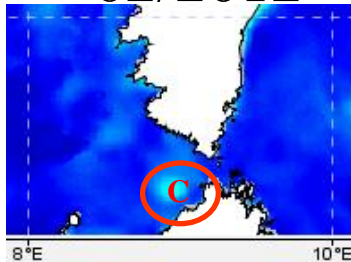
- obtained by MODIS satellite (spatial resolution 1km)
- treated by OC5 algorithm – IFREMER / LAMMA

Lapucci C. and al., *Evaluation of empirical and semi-analytical chlorophyll algorithms in the Ligurian and North Tyrrhenian Seas*, J. Appl. Remote Sens. 6 (1), 063565 (September 21, 2012).

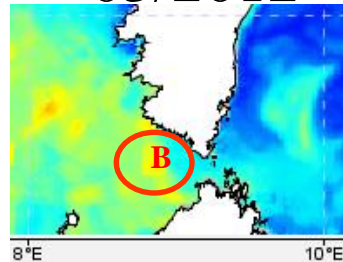
=> During summer 2012,  
higher concentrations in ChlA in eddy structures

=> Long term and pluri-annual recurrence of  
eddies is confirmed on other periods

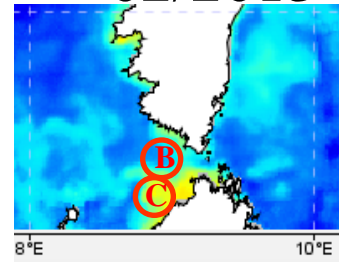
02/2012



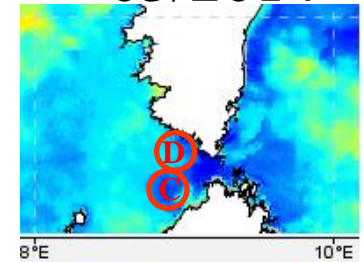
03/2012



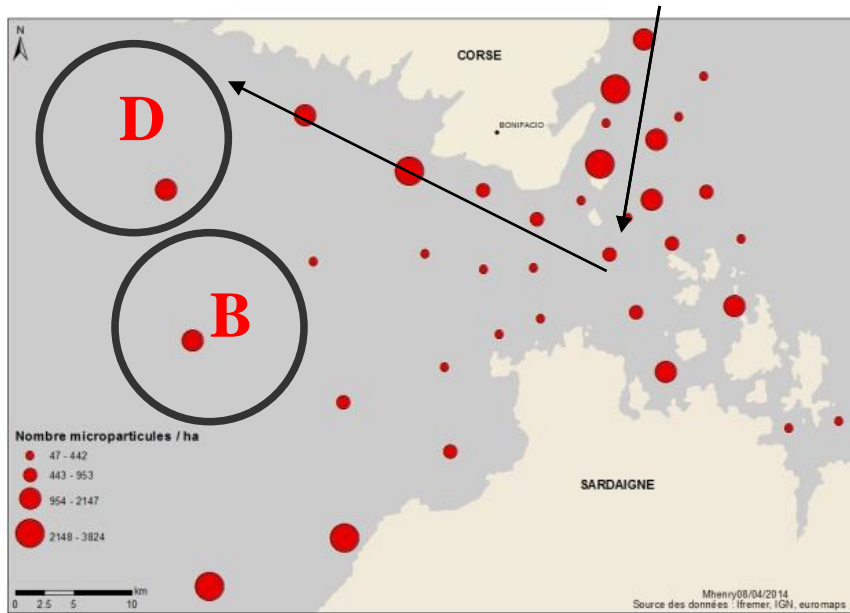
02/2013



03/2014



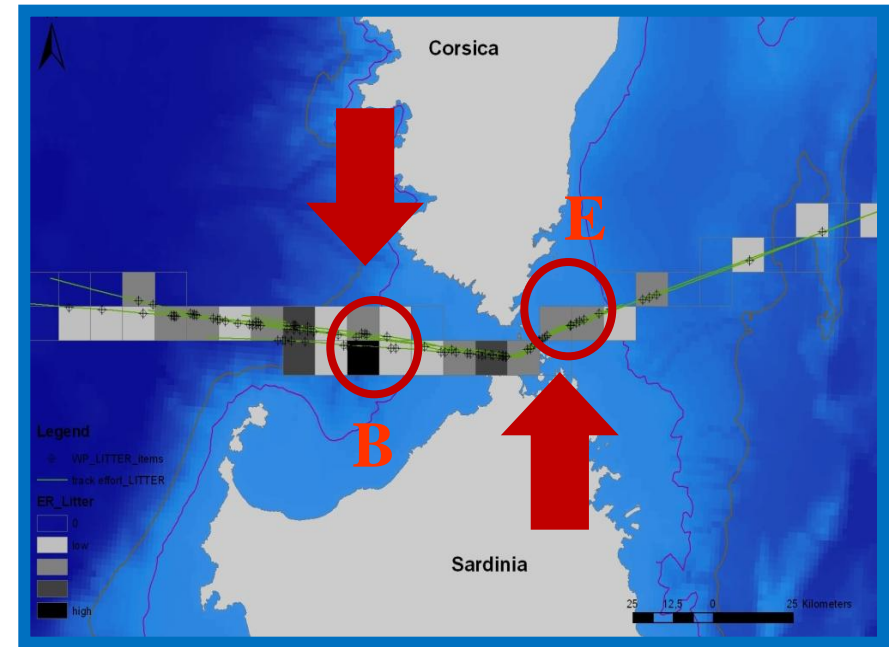
# Application : Marine Litter (O.Gérigny, F.Galgani, M.Henry)



## StellaMare cruise results :

Marine litter distribution obtained after microparticles counting

Concentrations are higher along the path of the main current.

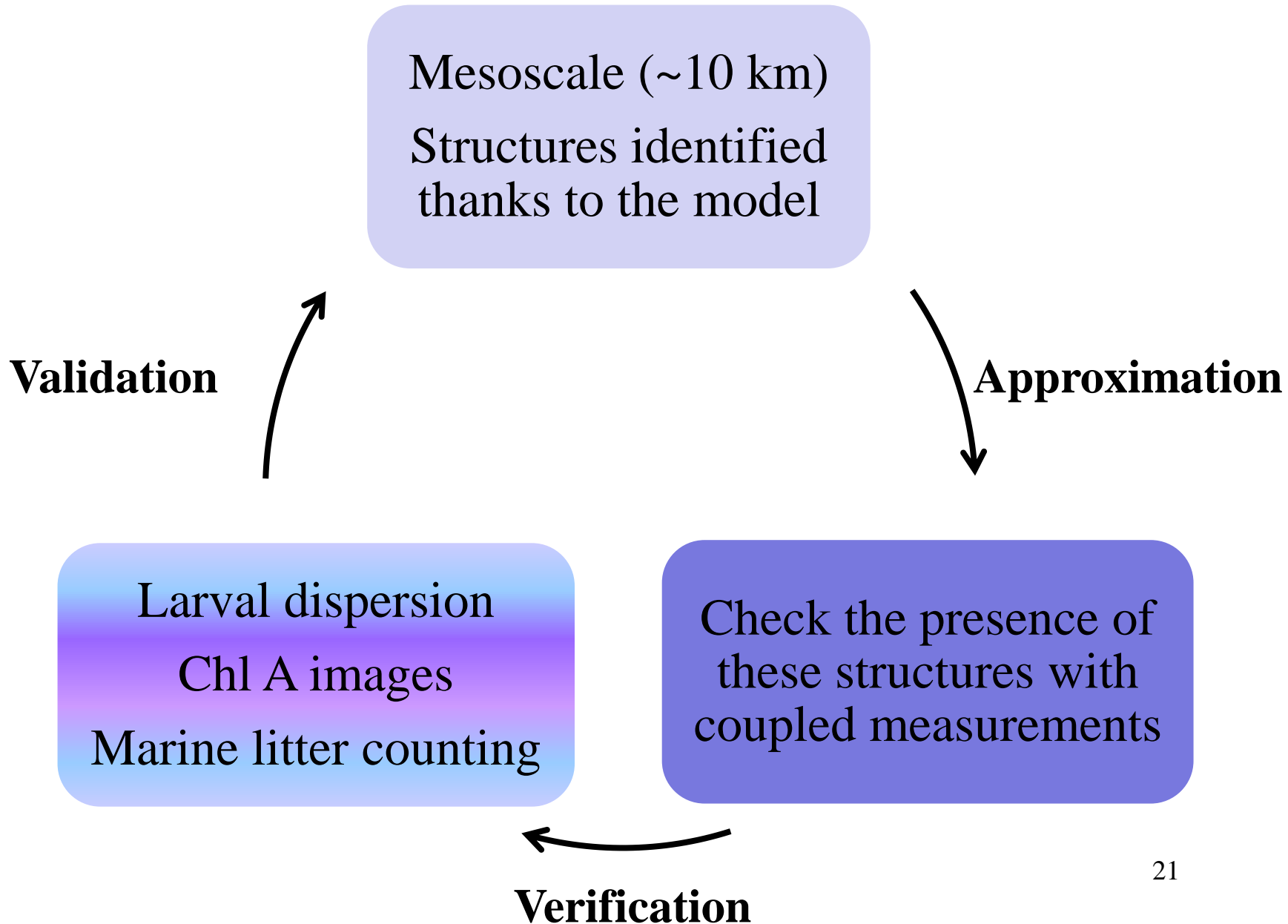


## Accademia leviatano (italy) results:

Observation made from the ferry, averaged data on one year

Higher concentration of marine litter => localisation of vortex

# Conclusion : Systemic approach





# Conclusion

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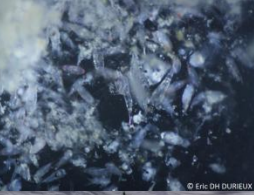
## Main goals have been reached:

### **Hydrodynamic model :**

- Data recorded during campaign at sea give us a good validation of our hypothesis
- Knowledge of the circulation is now more accurate

### **Larval dispersion :**

- Connected to Ichtyop, the tool can be operated for new scenarii
- New applications can be developed to support Marine Protected Area



Thank you for your attention !!!!!



# Conclusion : Further work



**WaveGlider trials =>**



- Low cost and more flexible ADCP transects
- Wider grids
- Litter counting by subsurface video



**ESA Sentinel Satellites =>** launched 04/2014, 2015, 2016

- More accurate images (SST, roughness, water colour )



**Larval dispersion =>** Refine our process knowledge and get more data as input for biological simulation