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

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

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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

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 Littorale Aquaculture and Marine Research (Stellamare) project, to study the distribution of larvae communities.


- Lamma consortium (Italia): to monitor coastal water (Inter-regional project SICOMAR), founded by Europe.
Materials and Methods - 1. Systemic approach in a MPA

Structures identification

Oceanic Model

• Atmospheric forcing
• Regional Corsica model

Hydrodynamic Processes

• Currentology (ADCP)
• Hydrology (CTD)
• Meteorology (local station)

Validation

Larval dispersion

• Recruitment
• Connectivity
• Management

Microparticle Chlorophyll

• Concentration
• Dispersion

Systemic approach

ChlA gives model for larval distribution

Lagrangian transport estimation

Structures observation by satellite & in-situ syst.
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
**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 3meters 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.
Materials and Methods – 5. Larval and microparticles data

36 sampling stations

Microparticles

Plankton

Bongo net (200 & 500 µm)
Zooplankton & Ichtyoplankton

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

\[ p_2 \quad v_2 \]

⇒ 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
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)
Results – 3. Currentology: process analysis by ADCP

Mesoscale system observed in the west part of the strait

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.

- 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: Theorical**
  - PLD, release in MPA area

- **Scenari 2: Empirical**
  - Stella Mare predicted distribution of larvae
  - **Definition**
    - « real release zone » of larvae

**Outputs**

- **Hydrodynamic Corse400 m Model**
- **Individual Based Model**
  - **Inputs**
  - **Outputs**
    - Transport sucess
    - Recruitment sucess
    - **Matrix of connectivity**

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Application: Larval dispersion (Gérigny and Koeck)
**Application: Chlorophyll A concentrations (Lapucci, Gérignon)**

08/2012

ChlA data (mg/m3) in oligotrophic conditions:

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


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

=> Long term and pluri-annual recurrence of eddies is confirmed on other periods
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 marco marinelitter => localisation of vortex
Mesoscale (~10 km) Structures identified thanks to the model

Validation

Larval dispersion
Chl A images
Marine litter counting

Approximation

Check the presence of these structures with coupled measurements

Verification
Conclusion

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 Areas
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