Fine-scale current-driven regionalization of the Mediterranean pelagic seascape for biogeographical studies

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Changing seascapes

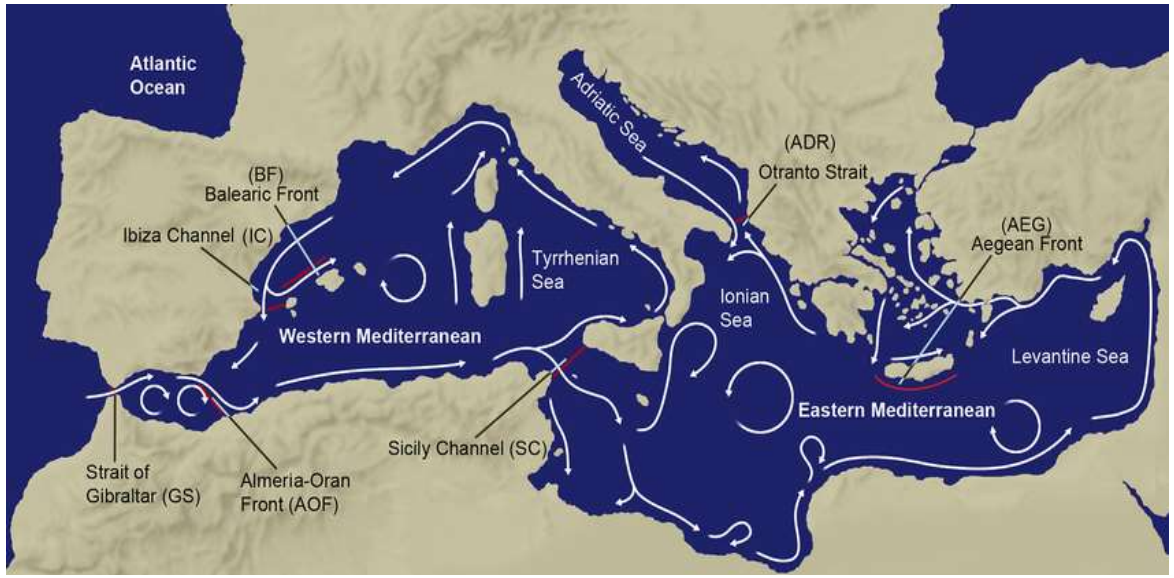
- Many areas of the global ocean are projected to experience different patterns of **biodiversity reorganization**, primarily caused by climate change.

[Blowes et al. 2019; Molinos et al. 2015; Pinsky et al. 2013]

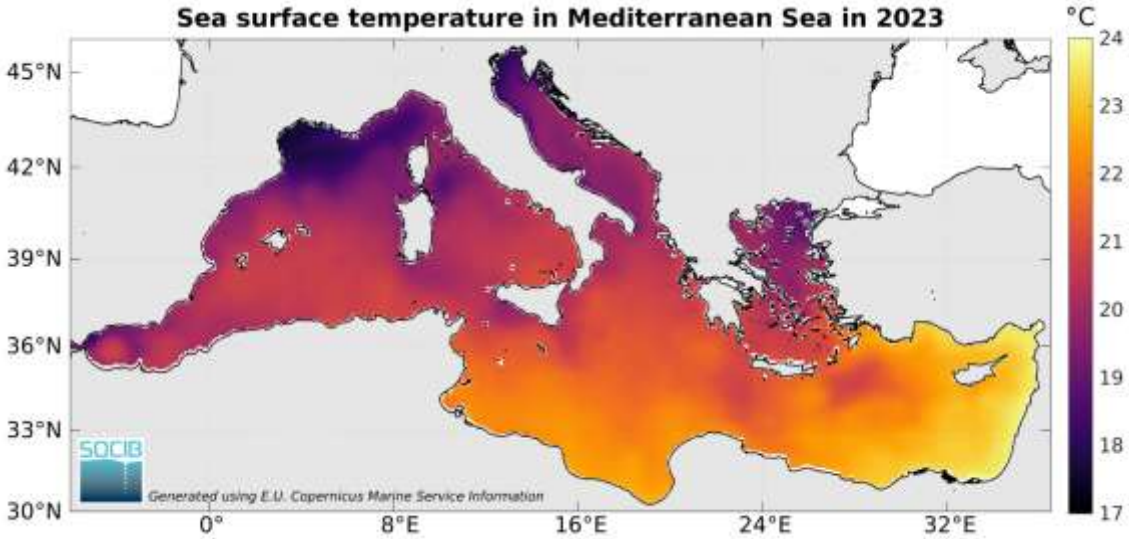
- Rapid modification of the three-dimensional (3D) habitats of many marine species.

[Jorda et al. 2020; Brito-morales et al. 2020, Burrows et al. 2014]

=> Role of ocean transport and abiotic variability in structuring marine populations



Adapted from *Pascual et al. 2017*



Adapted from *Balearic Islands Coastal Observing and Forecasting System*

Research hypothesis:

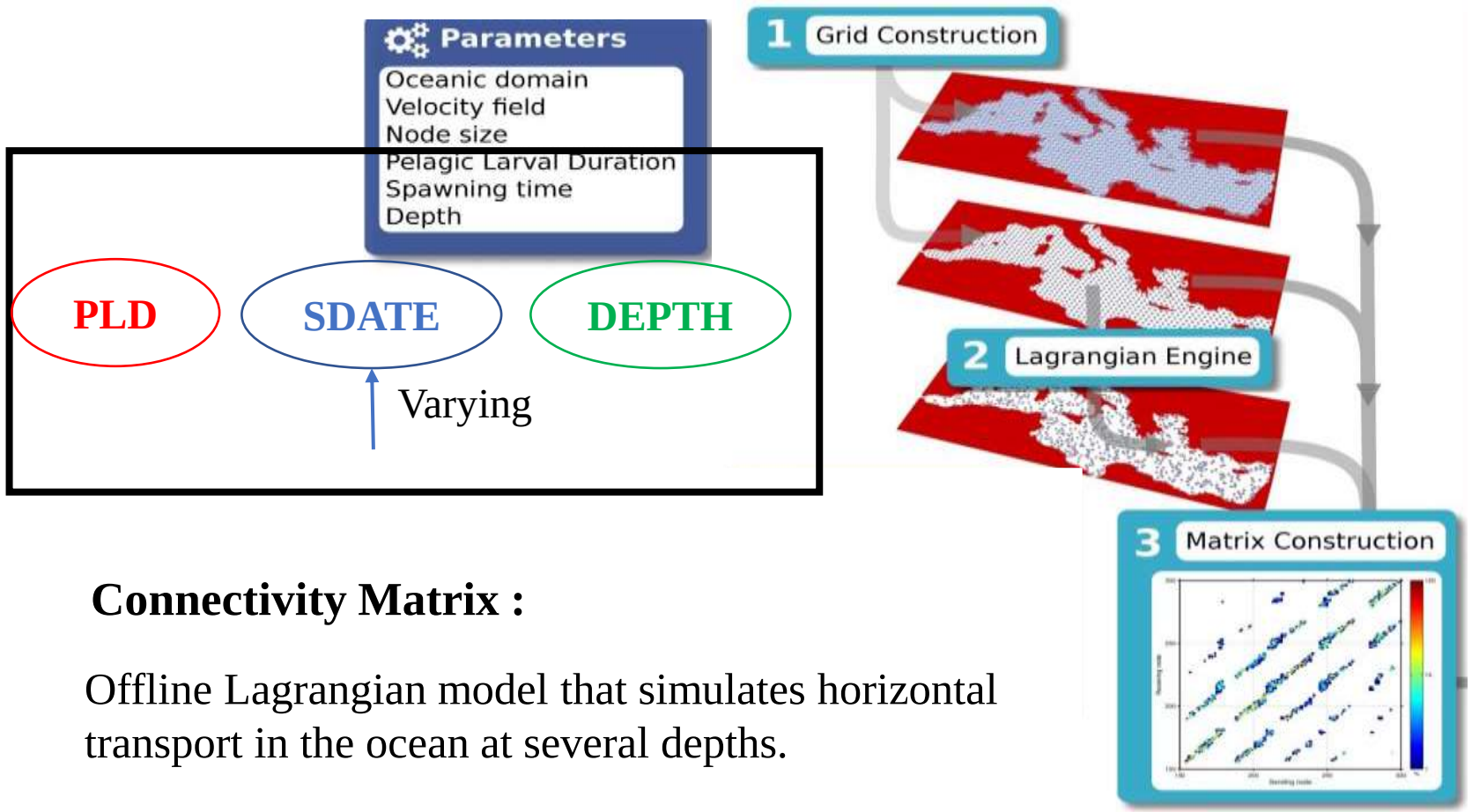
The biogeography of pelagic organisms is explained by the oceanic circulation.

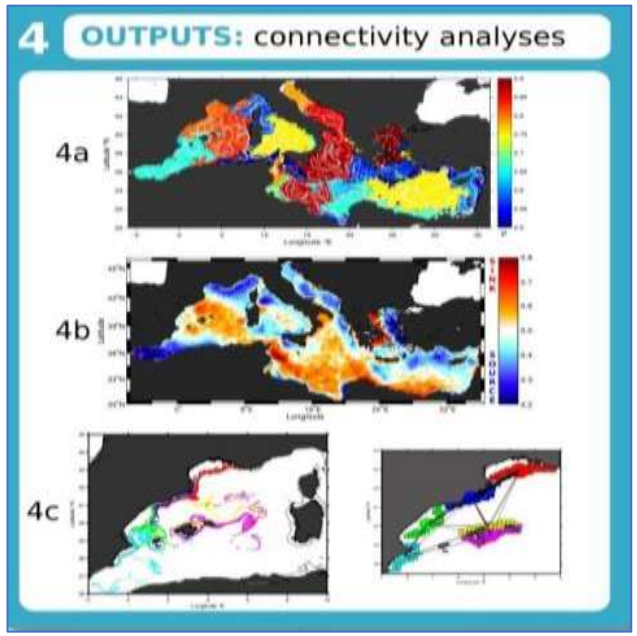
Work outline:

- Consider two target species with contrasted traits.
- Generate connectivity-based regionalization parametrized with their ecological traits.
- Investigate the relashionship between connectivity-based regionalizations and other biogeographical studies.

Oceanic transport and connectivity

[Rossi et al. 2014 GRL ; Ser-Giacomi et al. 2015 Chaos]





Connectivity Matrix :

Offline Lagrangian model that simulates horizontal transport in the ocean at several depths.

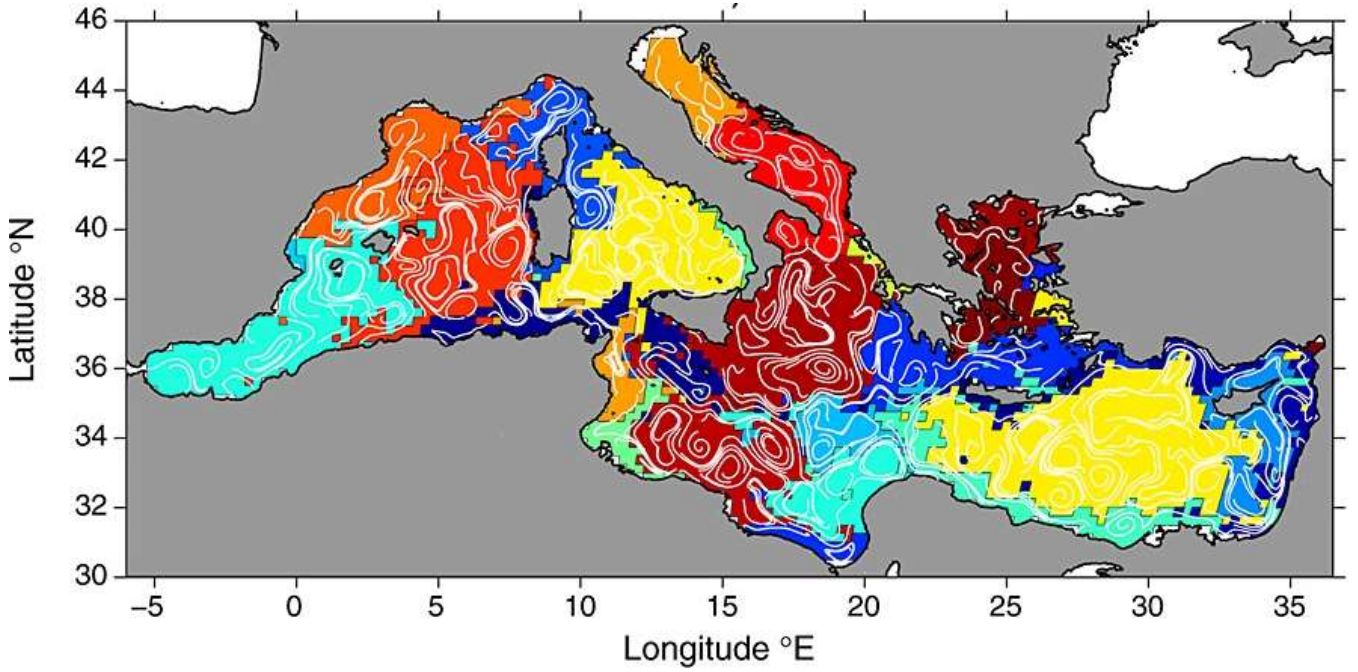
Application: Connectivity of marine populations using model reanalysis with a spatial resolution of 1/24 degree.

Community detection :

INFOMAP clustering Algorithm
[Rosvall and Bergstrom, 2008]

Identify well mixed oceanic regions which are relatively less connected with the surroundings.

Derive the so-called **hydrodynamical provinces**, revealing recurrent spatial patterns that match **multiscale oceanographic features**.



[Rossi et al. 2014 GRL]

Target species traits

Focus on early life stage of biphasic life cycle species

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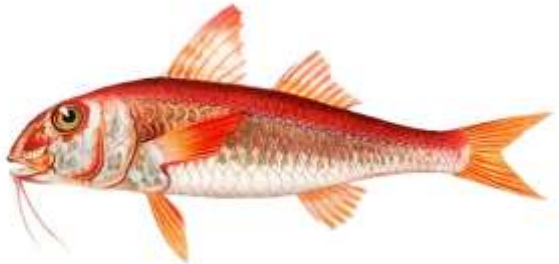


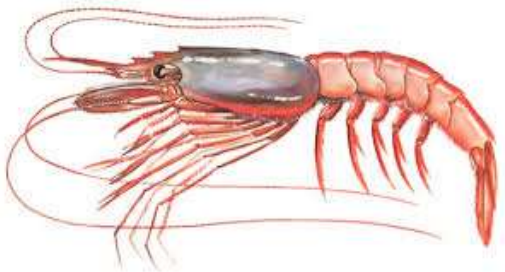
***Mullus barbatus* (red mullet)**

(Linnaeus, 1758)

Season: **June to july** *[Zarrad et al., 2013]*

Depth of abundance : 3-10 m *[Gargano et al. 2016]*, fixed at **6 m**

Pelagic Larval duration: 30-45 days *[Gargano et al. 2016]*, fixed at **30 days**



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***Aristeus antennatus* (red shrimp)**

(Risso, 1816)

Season: **May to september** *[Carbonell, 1994]*

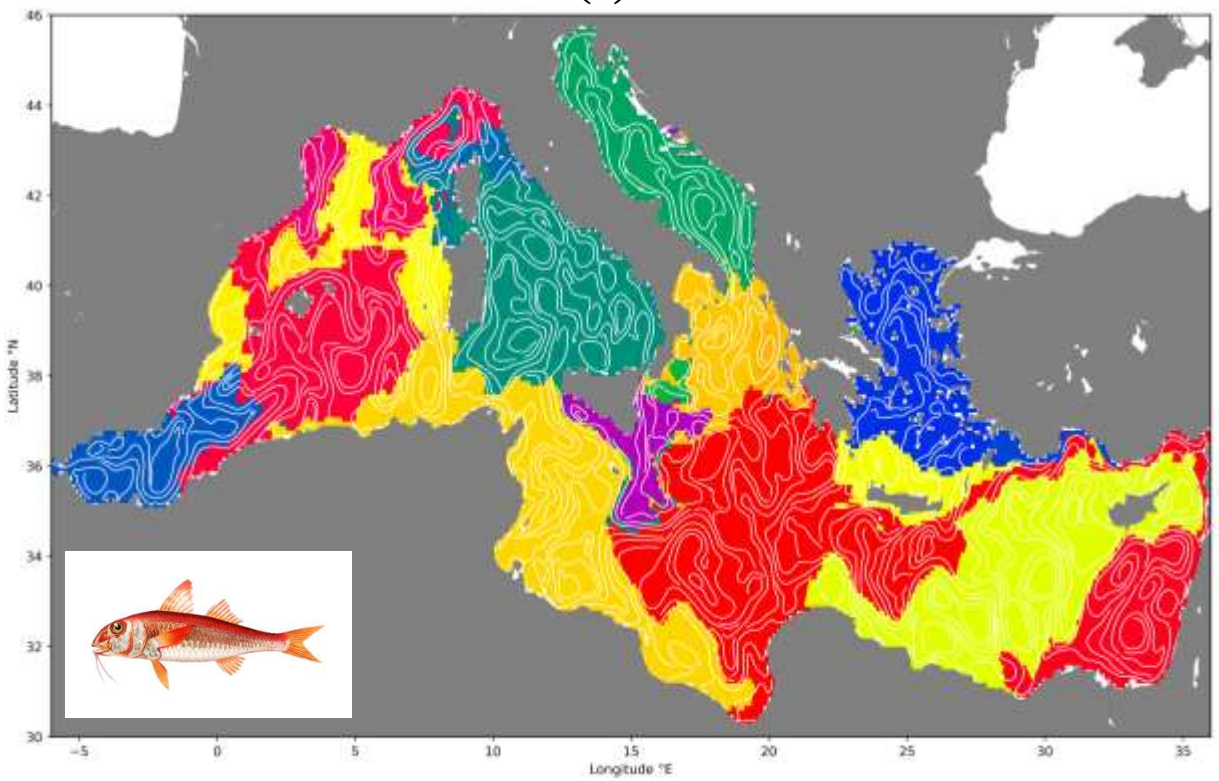
Depth of abundance: 100 -2200 m *[Sarda and Cartes, 1993]*, fixed at **600 m**

Pelagic Larval duration : 17-25 *days [Carretón et al 2021]*, fixed at **22 days**

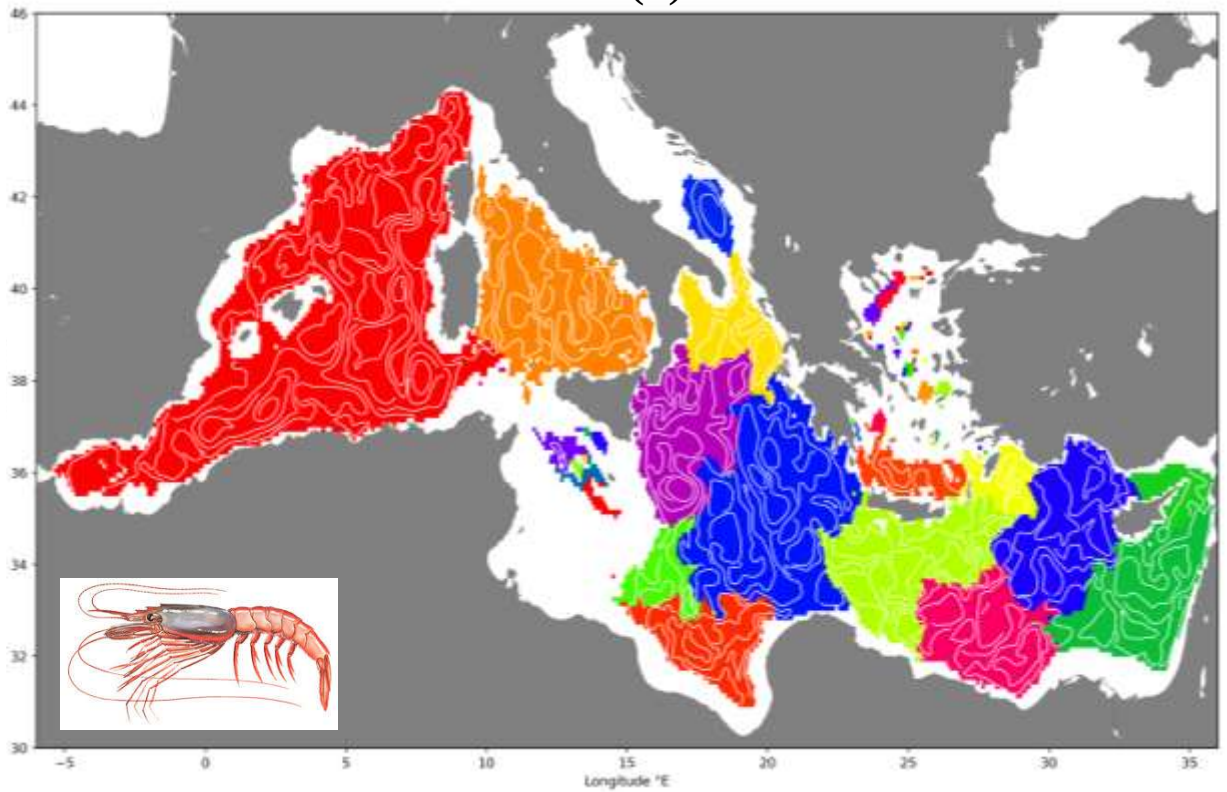
Preliminary results

Hydrodynamical provinces

(a)



(b)

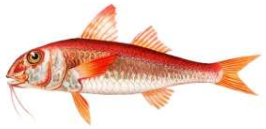


Summer 2016 (sdate = 1 june), using a PLD of 30 days and at depth = 6 meters.
Total of 33 provinces.

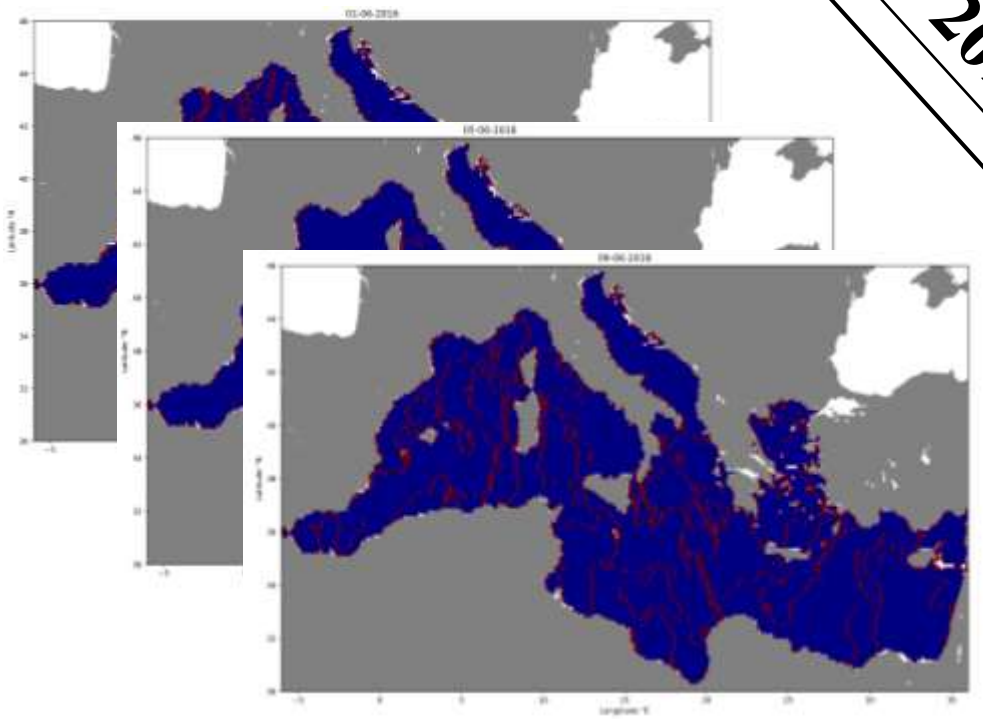
Mid-spring 2016 (sdate = 1 may), using a PLD of 22 days and at depth = 600 meters.
Total of 50 provinces.

Each province is colored according to its index.
White streamlines represent the flow averaged over the period of integration (Figure (a) for 1-30 june 2016, figure (b) for 1-22 may 2016.

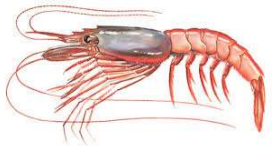
Large spatio-temporal variability



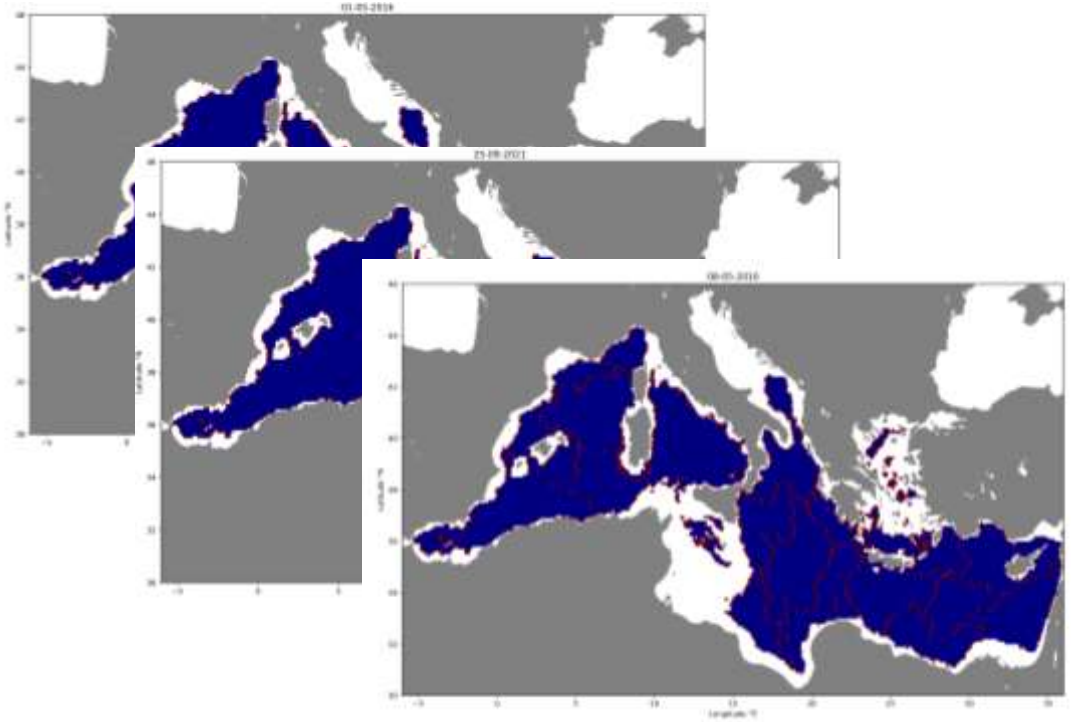
6 m of depth



2016 - 2024



600 m of depth

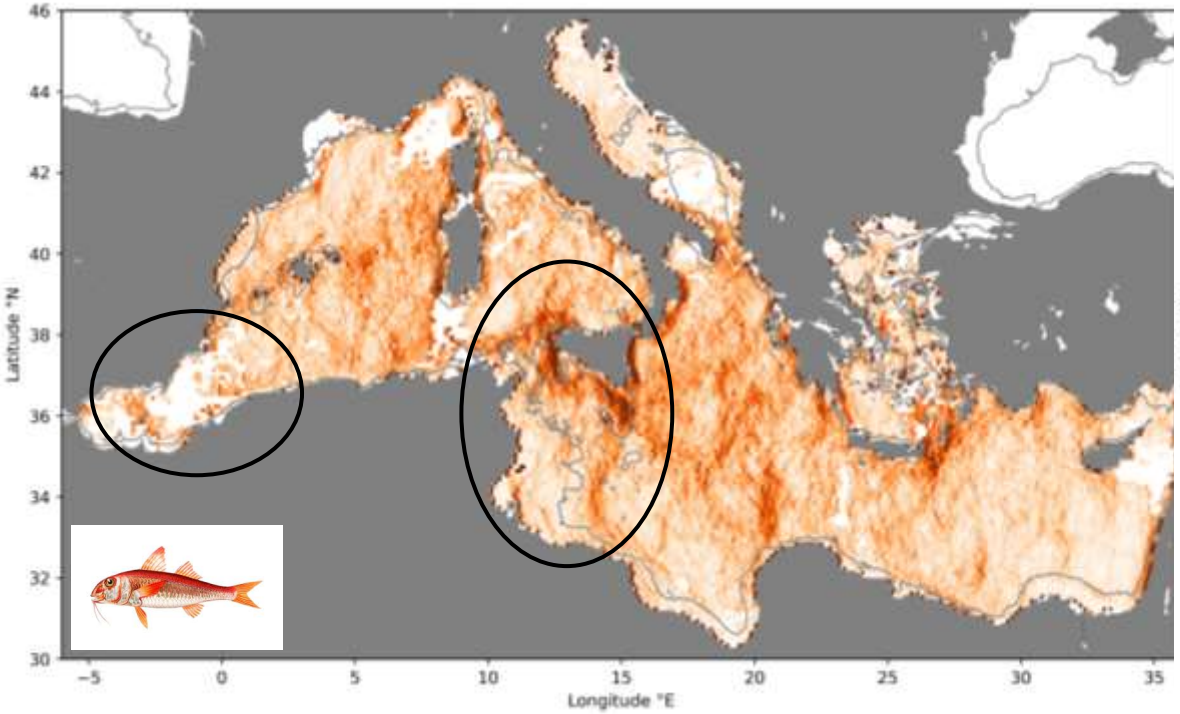


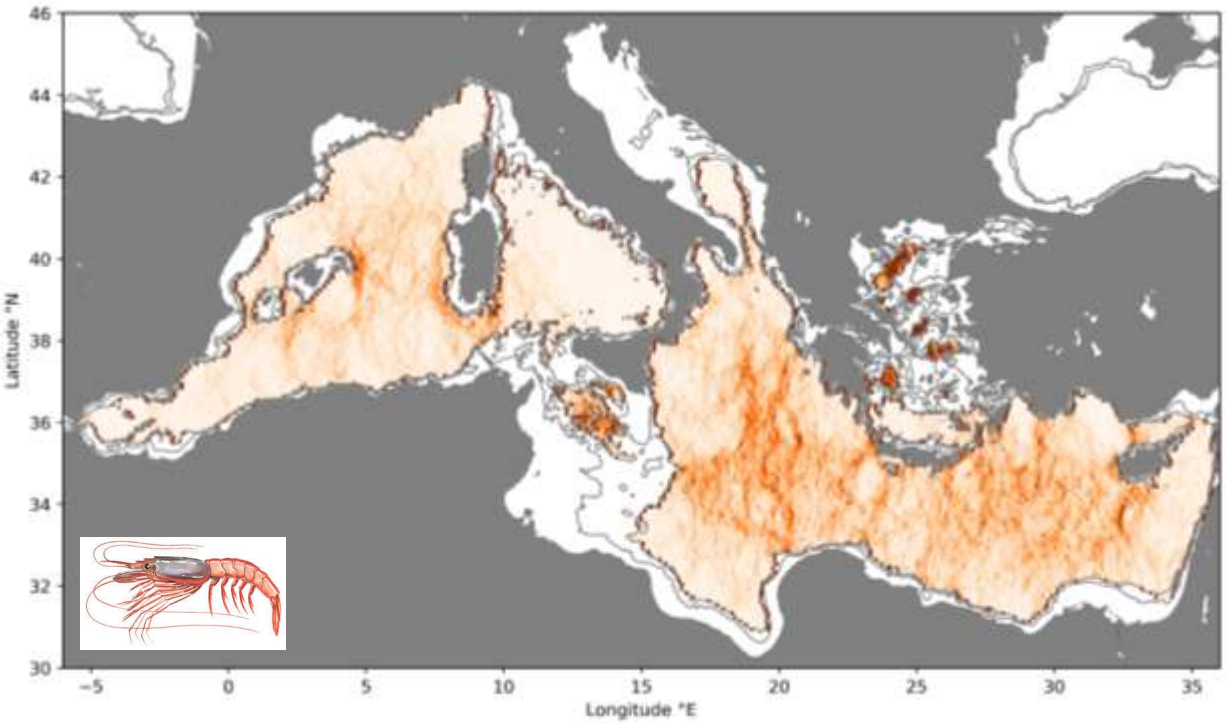
Province boundaries at each ocean node.

Preliminary results

Mean hydrodynamical provinces

Frequency of occurrence of province boundaries

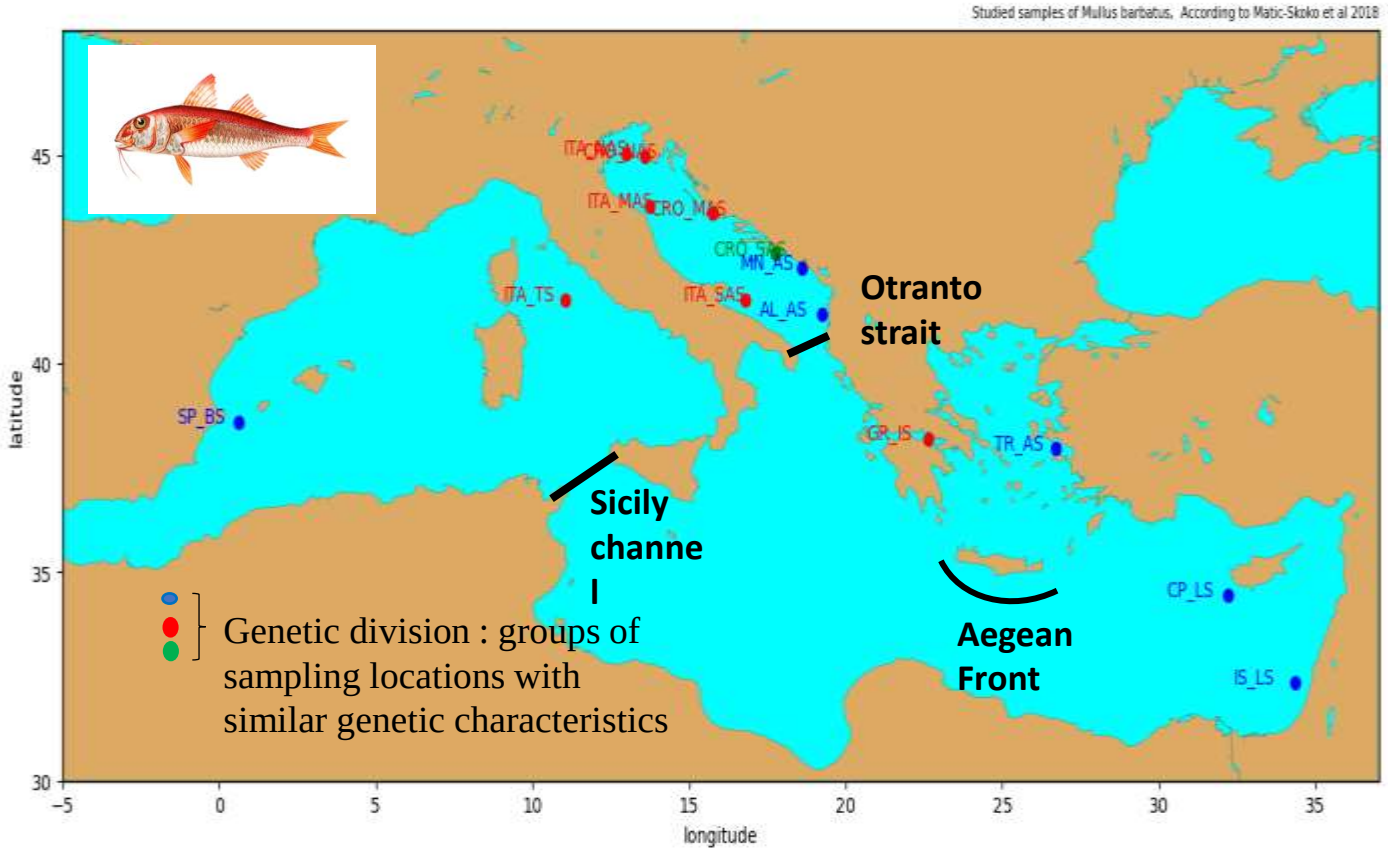


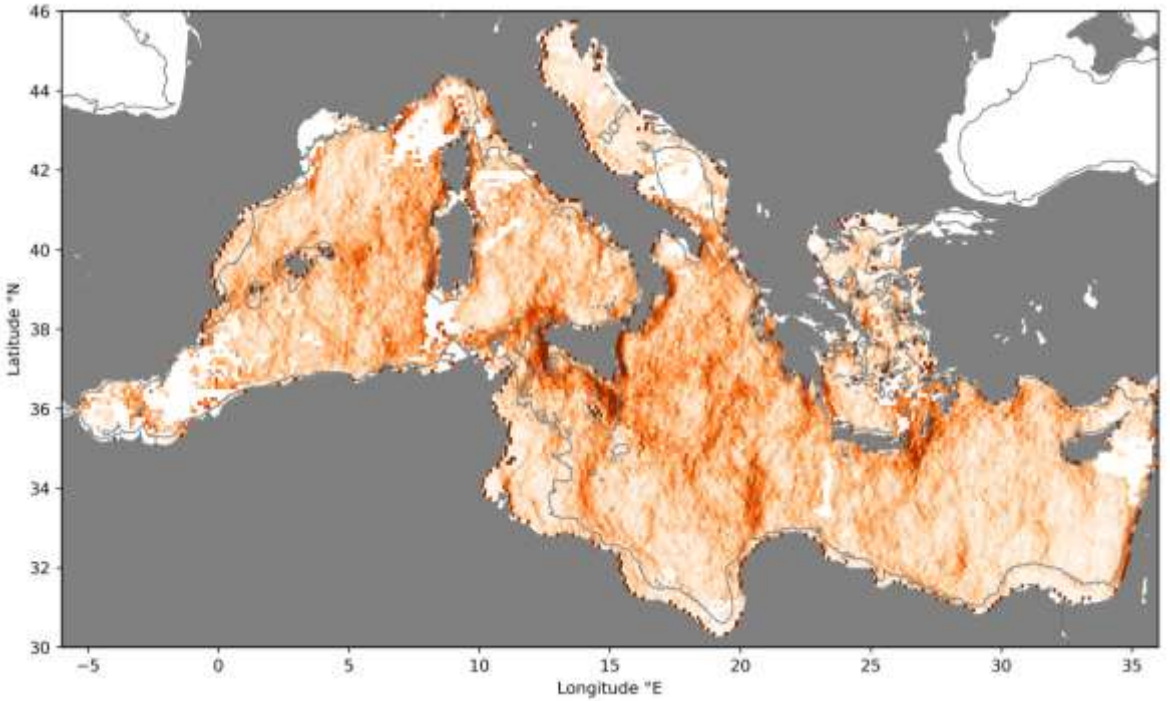


Averaged over 92 experiments (from june to july of 2016-2021),
Depth = 6 meters,
PLD = 30 days

Averaged over 138 experiments (From may to september of 2016-2021),
Depth = 600 meters,
PLD = 22 days

Genetic-based & Current-based biogeagraphy





Clustering of Mullus barbatus's microsatellite genotypes [Matić-Skoko et al 2018]

Preliminary conclusions

- Different patterns emerge for the epipelagic and mesopelagic layers.
- Matches & mismatches among independent biogeographical studies.
- Current-based regionalisations seem to partly explain biogeography.

Perspectives

- Compare with clustered environmental variables (temperature, salinity, Chl-a ...)
- Compile more independent « observed biogeographical studies » for further comparison.
- More statistics of hydrodynamical provinces; apply other flow fields (satellite-derived 4DMED, AMOR3D).
- Extend to other pelagic and benthic species.

Thank you for your attention!

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