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Fisheries in the AdriatIc Region - a Shared Ecosystem Approach

# Identifying priority areas for spatial management of fisheries in the Adriatic and North Western Ionian Sea using ensemble of species distribution models for 10 key demersal species

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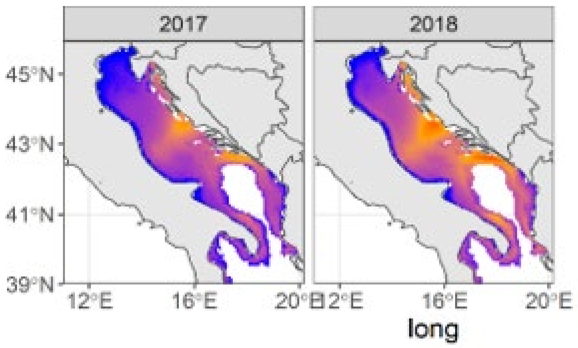
1 2 3 4 5 6 7 8 9

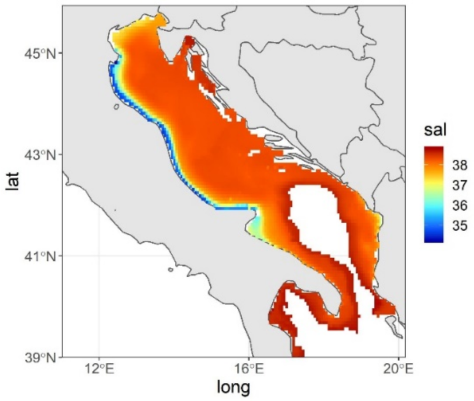
# Aim

- Contribution to the identification of areas of aggregation (hot spots) for juveniles and adults of demersal species (juv /ad) as potential best ecological areas for spatial management actions (e.g., Marine Protected Area, Fisheries restricted areas, other spatial management areas, etc)




## Additional objectives:

- Integration of oceanographic variables and identification of the role of environmental variables in species distribution
- Tool for exploring climatic possible effects




## Area of work:

- Adriatic and North-western Ionian sea (GSA17, 18 and 19)

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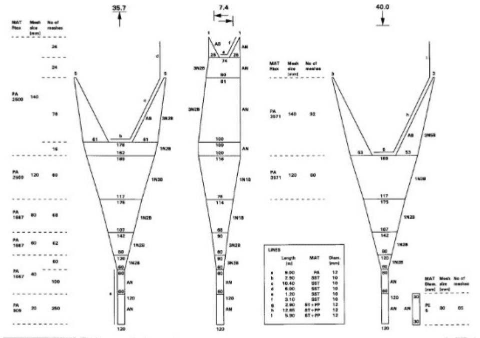
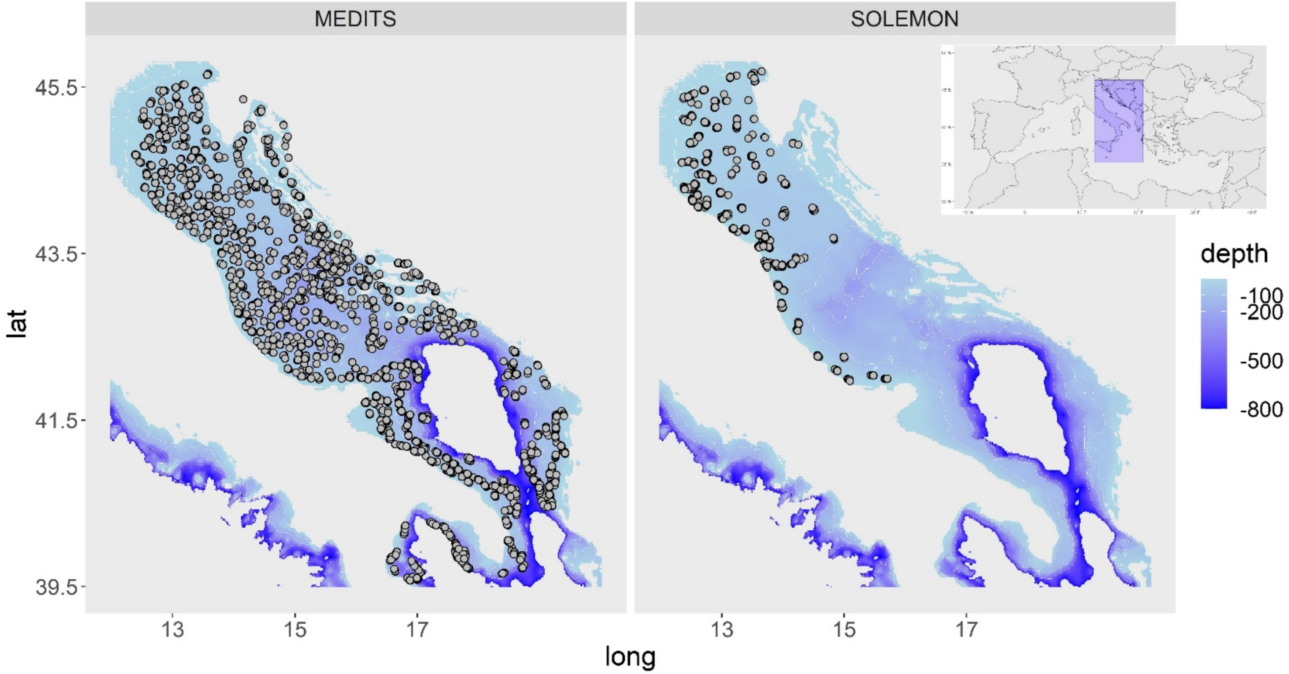
# Background information

Scientific trawl surveys are conducted in the area with a standardized protocol.






The MEDiterranean International Trawl Survey (MEDITS) programme 1994-ongoing

systematic otter trawl survey (OTB) of the demersal communities of the N Mediterranean sea. It was established in 1994 and it is now part of the Data Collection Framework. Consists, on the average, of **326 sampling sites per year** in GSA 17, 18 and 19.
(Spedicato et al., 2019)

Sole Monitoring (SOLEMON) programme 2005-ongoing

A survey conducted with beam trawl (rapido, TBB) in the northern Adriatic Sea since 2005 targeting benthic com of the entire Adriatic that is still ongoing, only in GSA 17.
It is now part of the Data Collection Framework.
consists, on the average, of **70 sampling sites per year in GSA 17**

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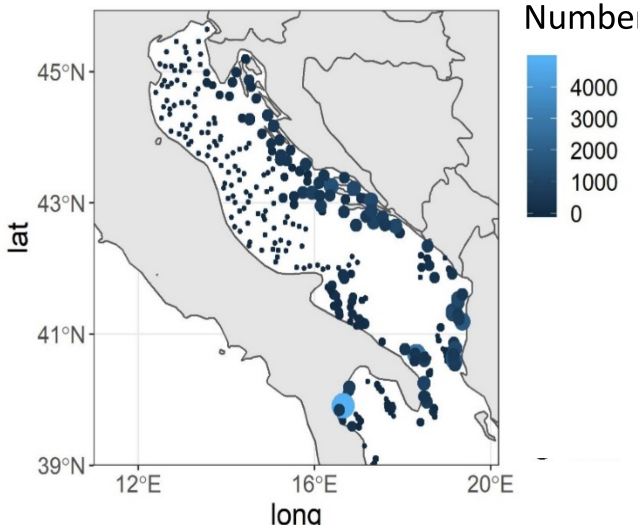
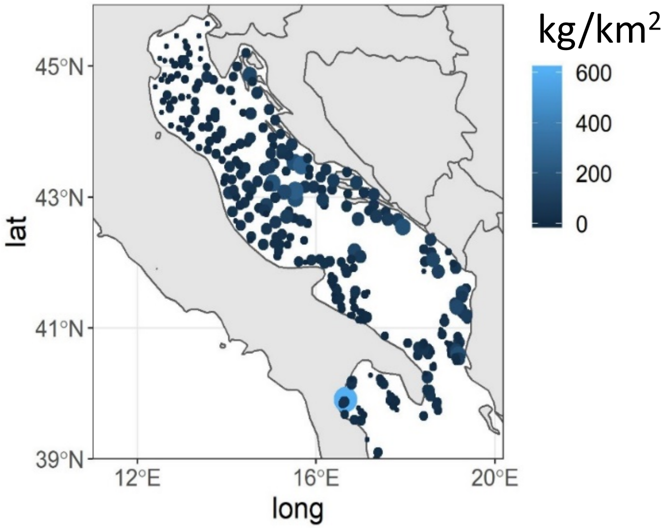
# Background

Trawl survey data from MEDITS and SOLEMON are important fishery-independent information on biomass and abundance of key species. We identified 10 key species: 7 from MEDITS and 3 from SOLEMON.



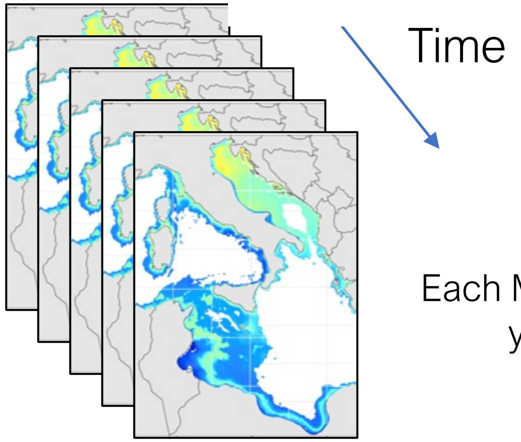

These information are collected once per year ( MEDITS, summer; SOLEMON, winter) but necessarily need to be:

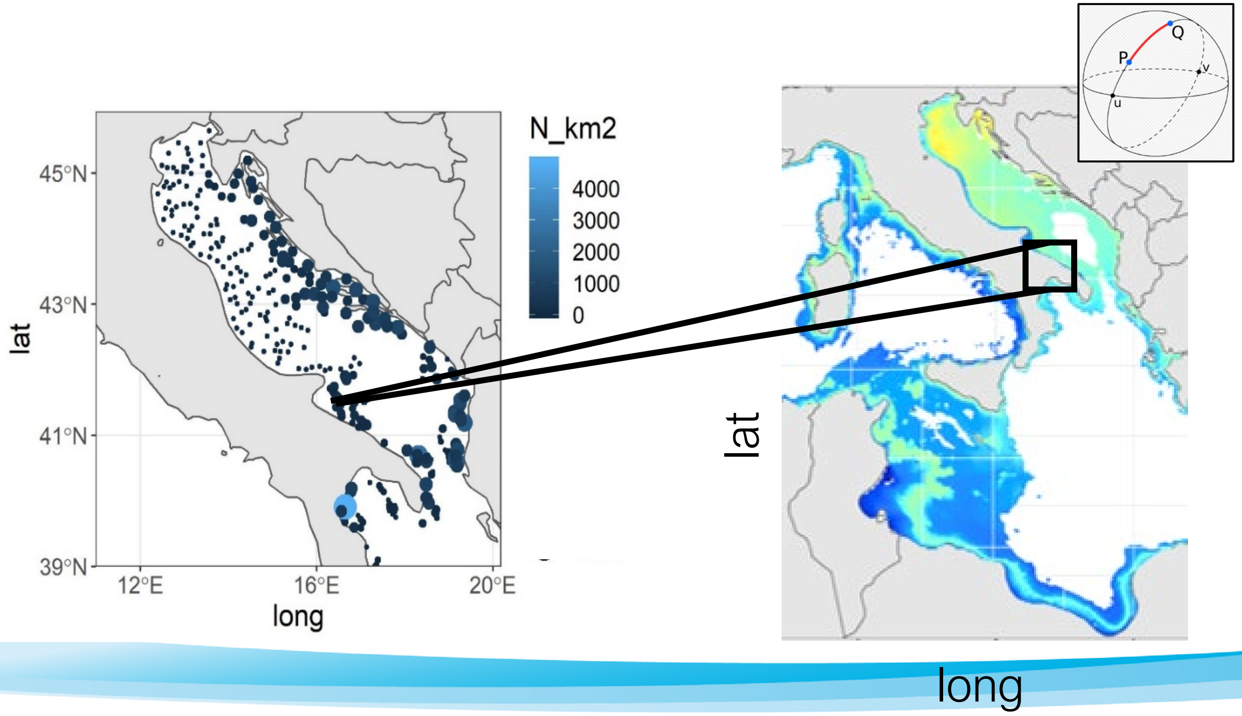
- Standardized for sampling variabilities among years
- Be extrapolated to the whole domain
- Extrapolation might consider factors important such as depth, but also environmental variables
- Use of different models (spatial distribution models)


# Oceanographic variables

Physical and biogeochemical datasets were developed within the Copernicus Marine Environment Monitoring Service (CMEMS, https://marine.copernicus.eu/access-data) and covered the available time series of data with a spatial resolution of 1/16° (approx. 6x6 km). These information are 3D!

Copernicus Grid:
For each
- month
- year
- Variable
- depth
- 1/16° (~6km)




- Chlorophyll (CHL): milligram m-3 (mean) *
- Temperature: surface (TMP_sst), **bottom (TMP_bot)** in degC
- Dissolved molecular oxygen (dox): millimol m-3: surface (dox.ss) **and bottom (dox.bot).**
- Nitrate (nit): millimol m-3 (mean)
- Phosphate (pho): millimol m-3 (mean)
- Salinity: 1e-3 (mean)
- pH (mean)
- Particulate Organic Carbon mg/m$^3$ (mean)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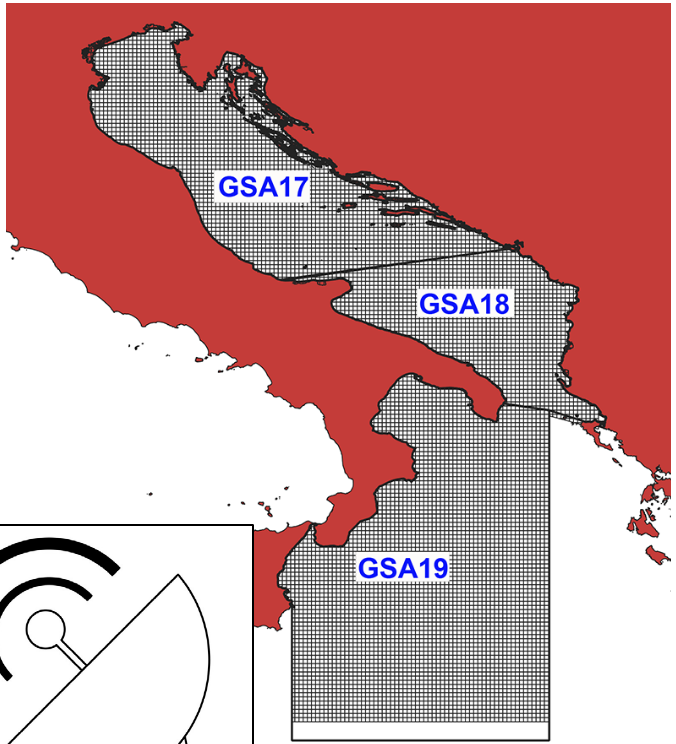
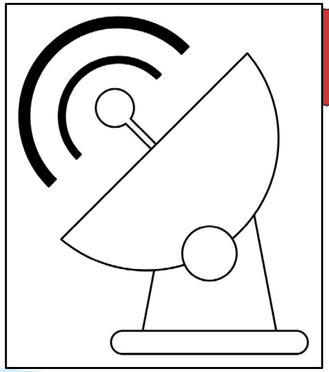
# Commercial Effort data

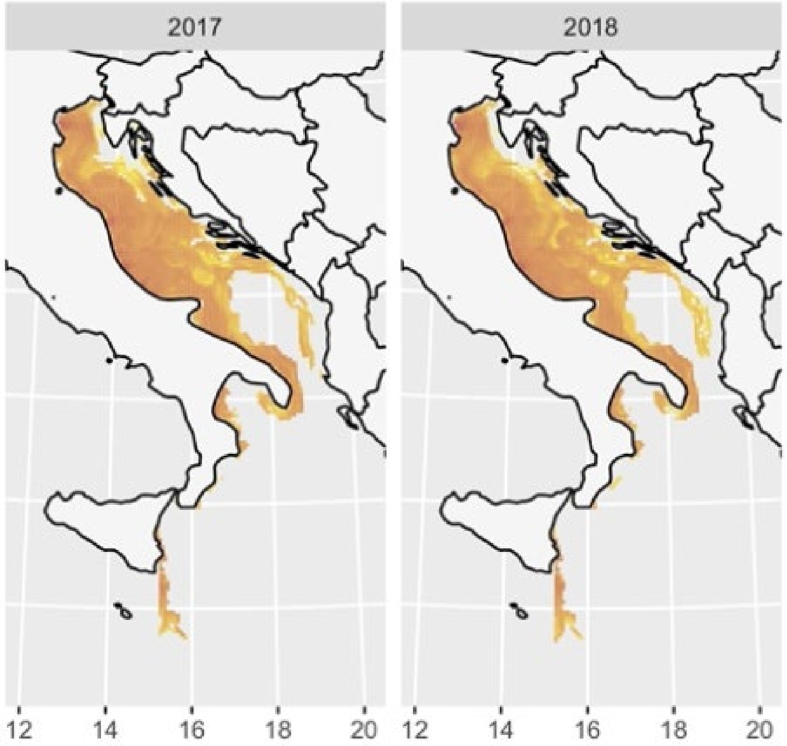


Effort data are used as additional variable supporting identification of presence of target species. Fishing effort was estimated by vessel/cell and aggregated at a yearly scale at same Copernicus grid for both OTB and TBB in the area.

| Temporal coverage | 2008 – 2018 |
|---|---|
| Data sources | VMS |
| Gears | OTB and TBB |
| Unit | Kw*hour/cell (Each year) |

OTB LOA 18-24

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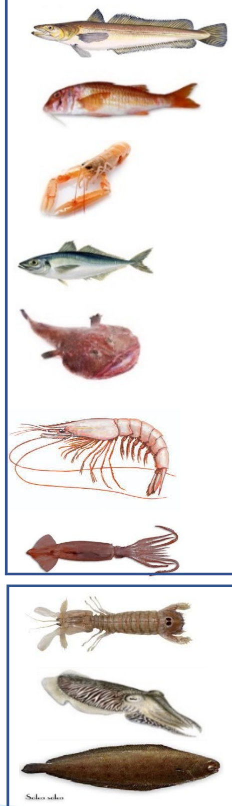
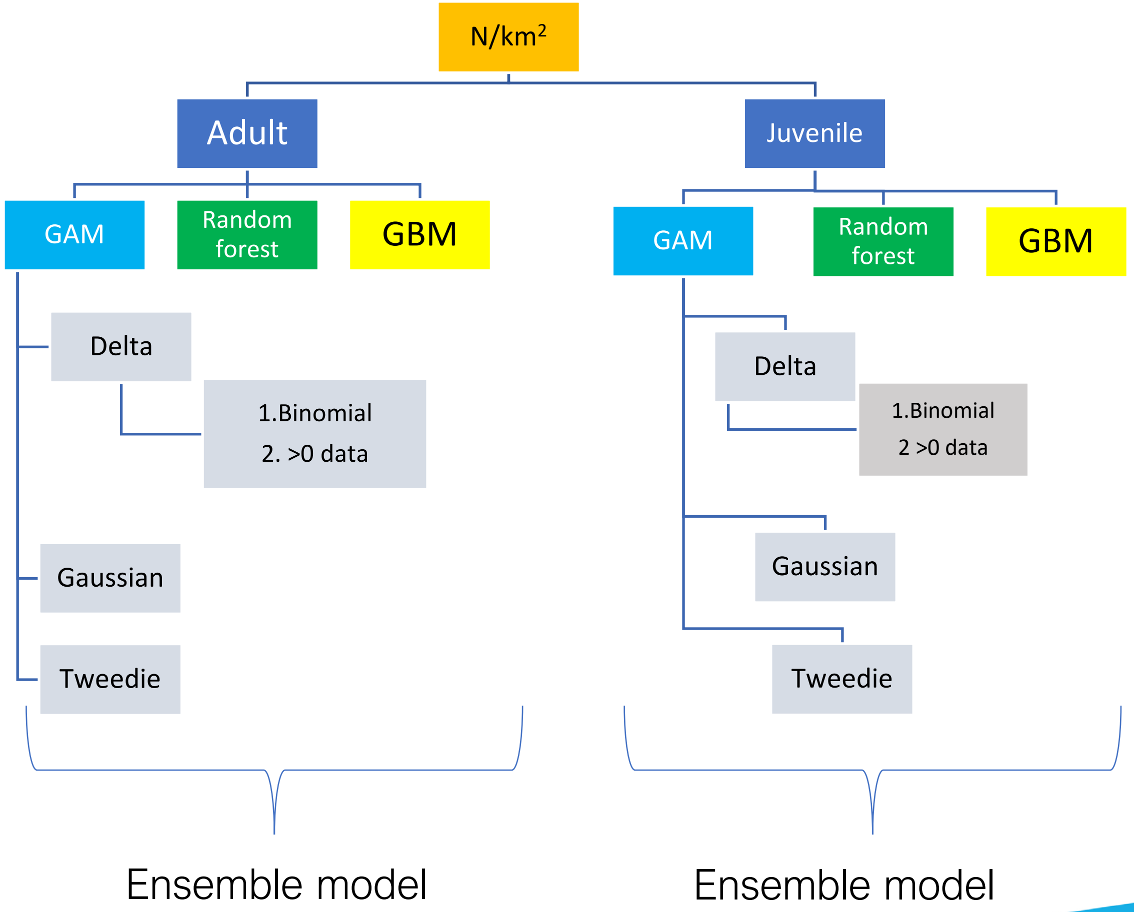
# MULTIMODEL APPROACH

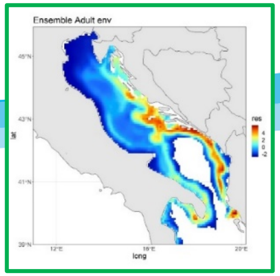
For each species and each size (adult and juveniles) a set of models were used to best integrate trawl survey, oceanographic variables and effort (training, testing, several times on random parts of the datasets). resulting in an ensamble of models (average weighted of models)



European hake
Red mullet
Norway lobster
European horse mackerel
Anglerfish
Deep rose shrimp
Shortfin squid

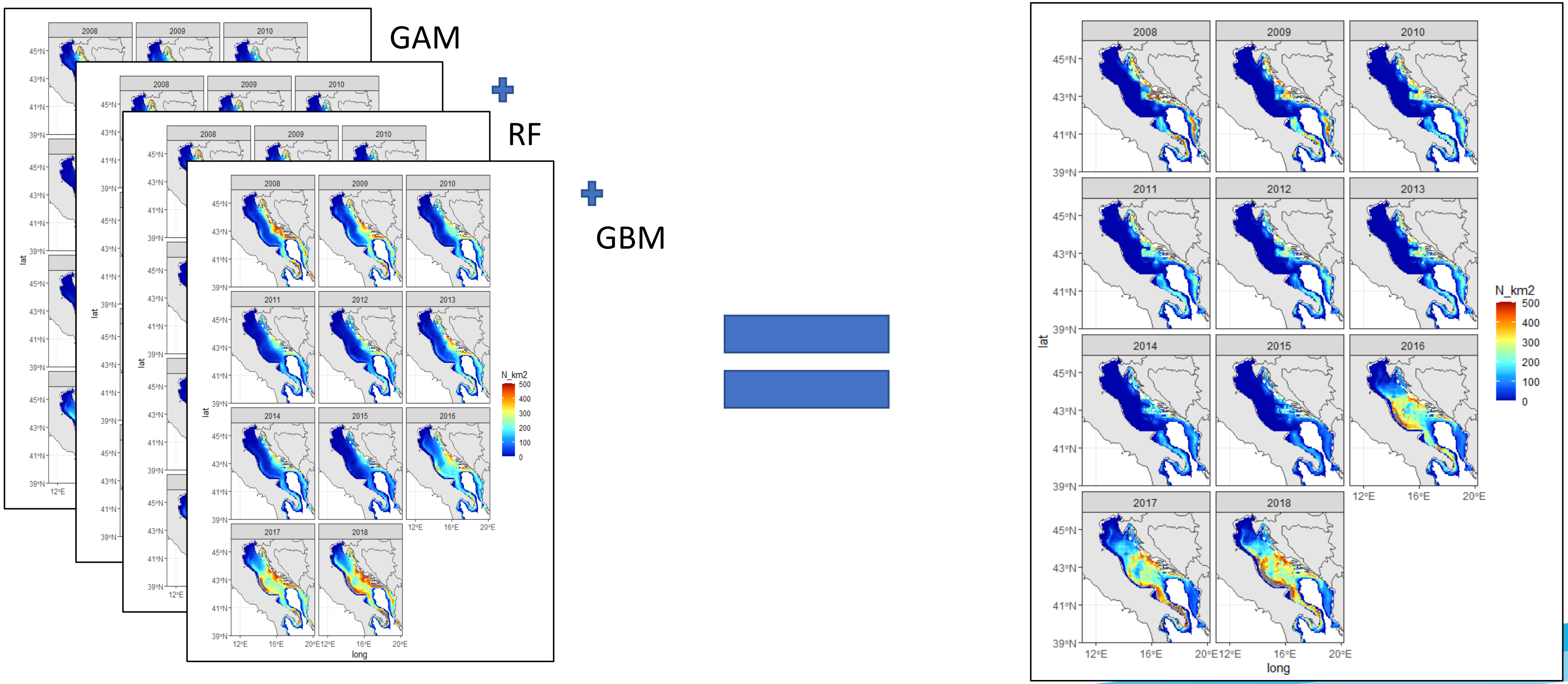
Mantis shrimp
Cuttlefish
Common sole




*Protocol is published in Panzeri et al., 2021 (IEEE Metrosea)*

# Distribution density map for each approach and ensemble model




The ensamble allows to obtain the best distribution of each year in the representative month for each stage and species

*Month of July

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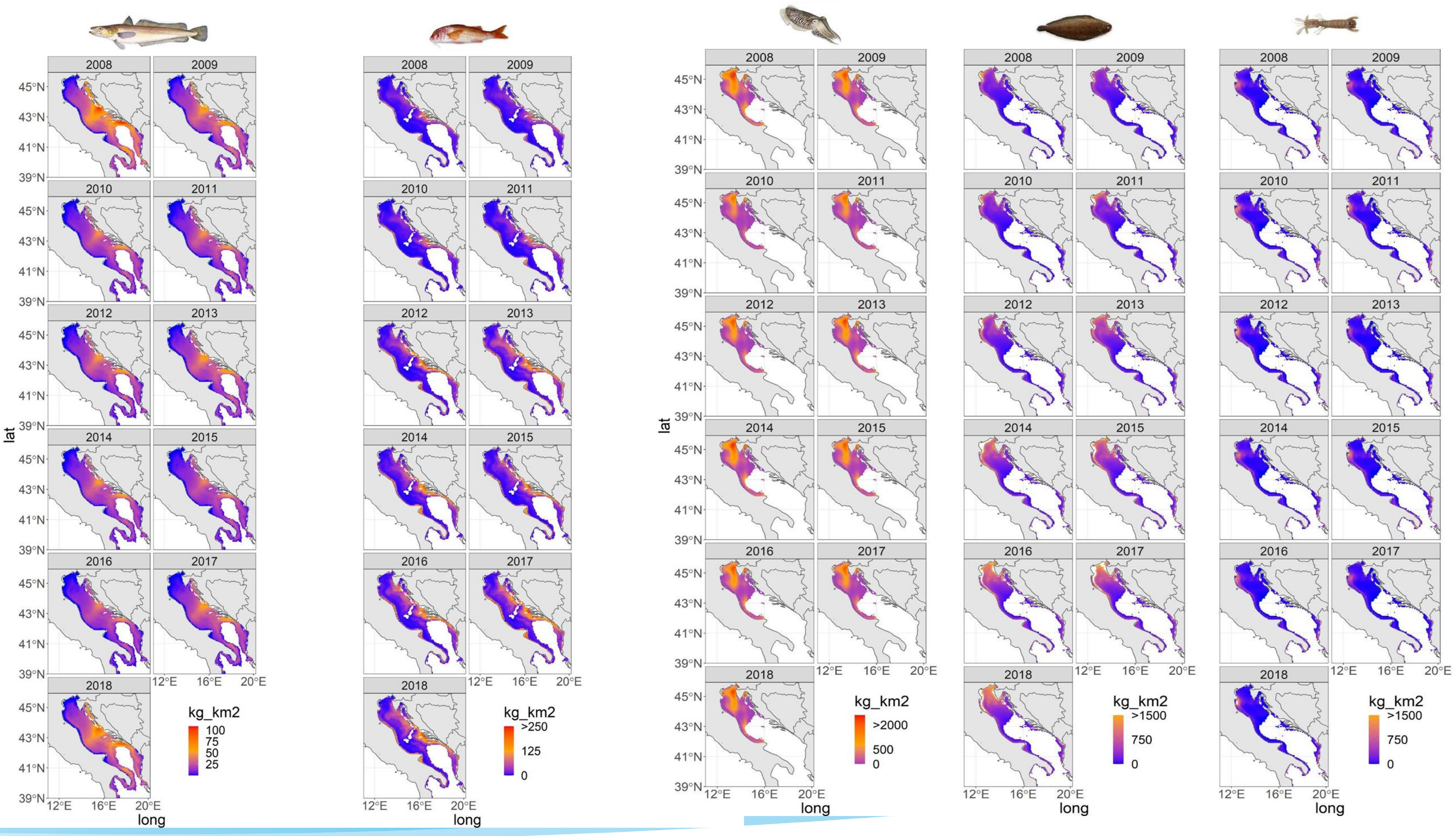
Examples of best distribution and biomass of demersal resources over years

For MEDITS and SOLEMON species

(bluish low density, redish high density)




*Panzeri et al., 2021 (Ocean State Report 5)*

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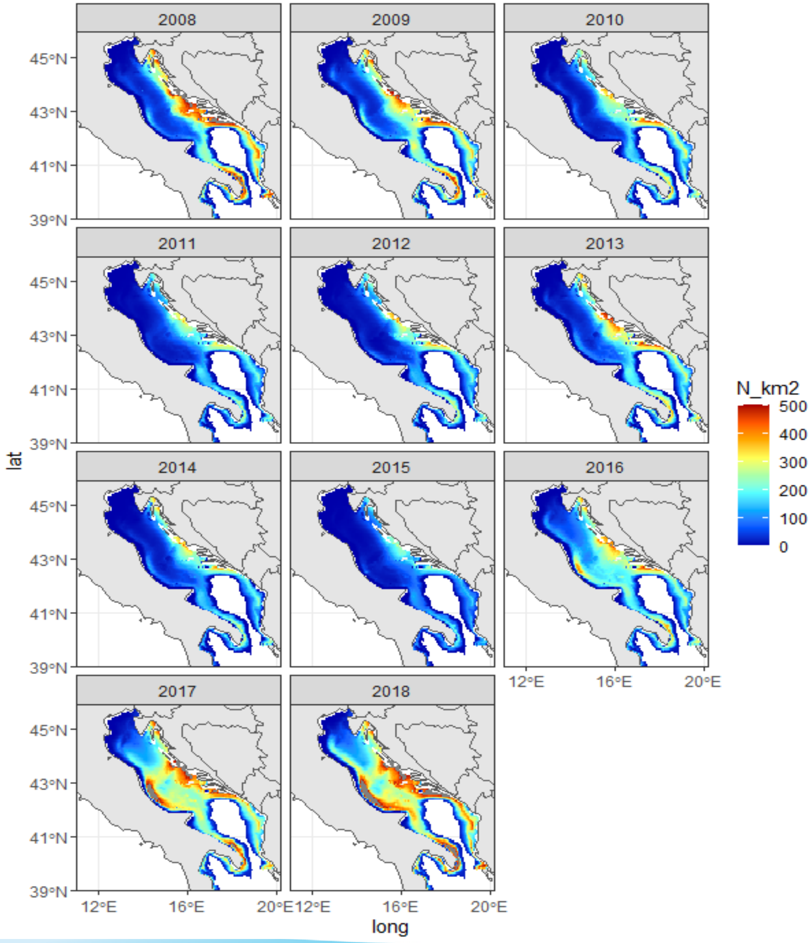
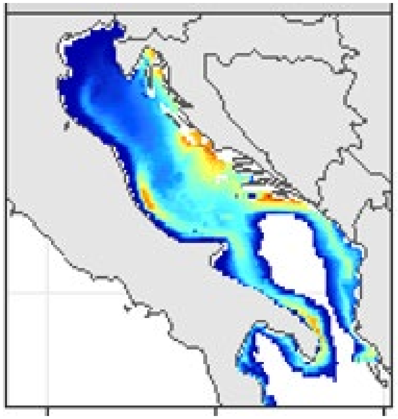
# Hot spot detection

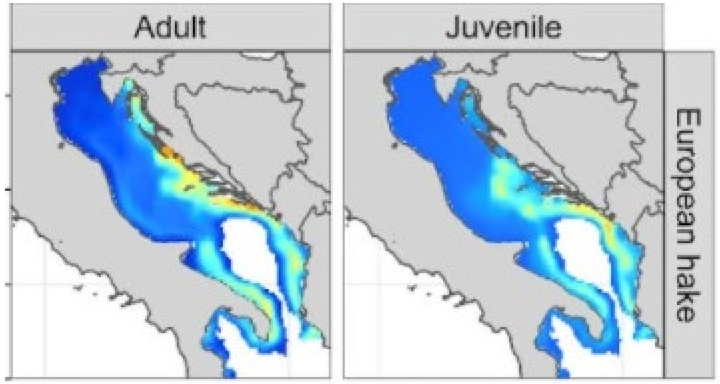
Ensemble model




Mean over years



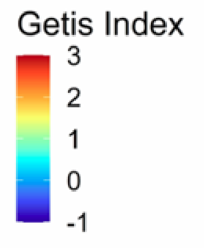
**Getis index old-Gi***
**Hot spot**

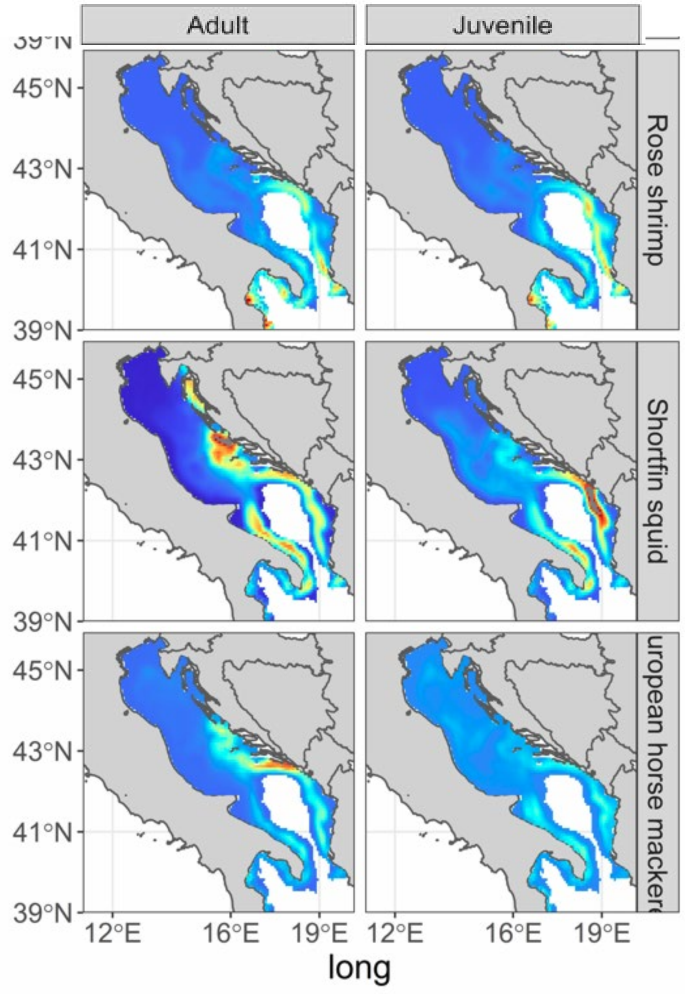


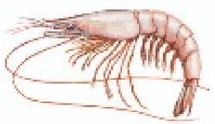

From the best ensamble of model results it is possible to determine the areas of aggregation (hot spots) using opportune spatial indicators of aggregation (Getis).
Results are maps of aggregation of juveniles and adults.

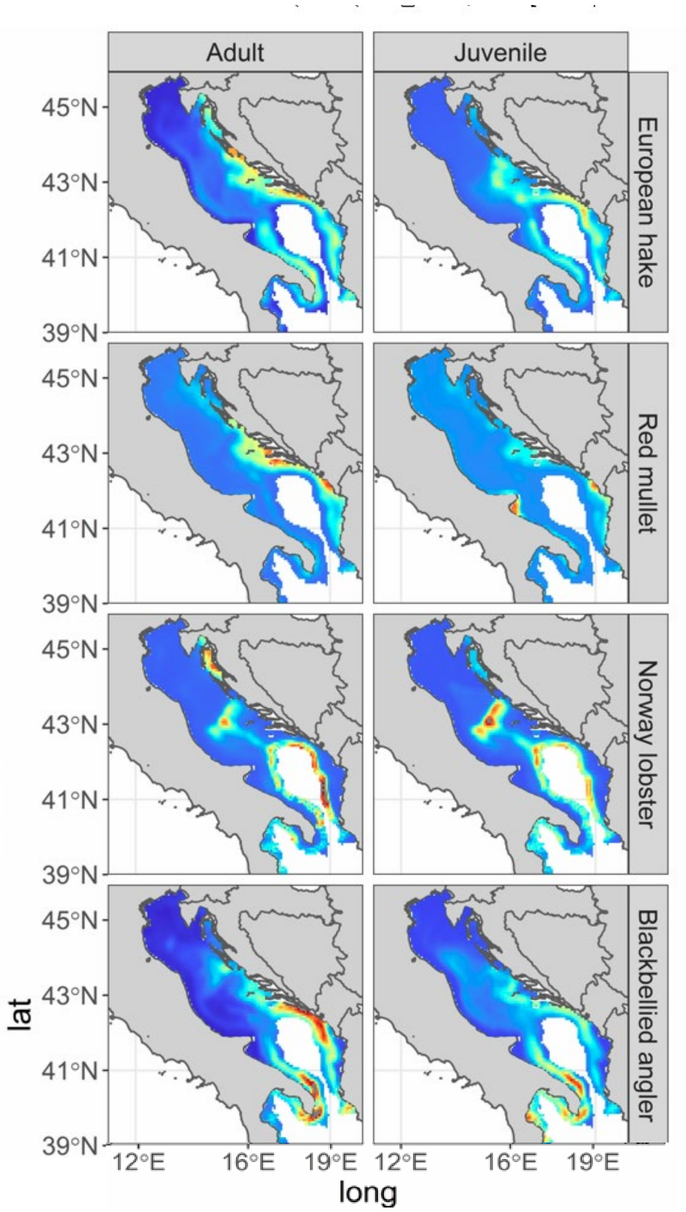
# Hot spots «Medits species»

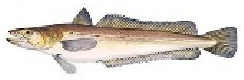
For each stage and each species it was thus determined the most relevant areas of aggregation, as areas preferred by species





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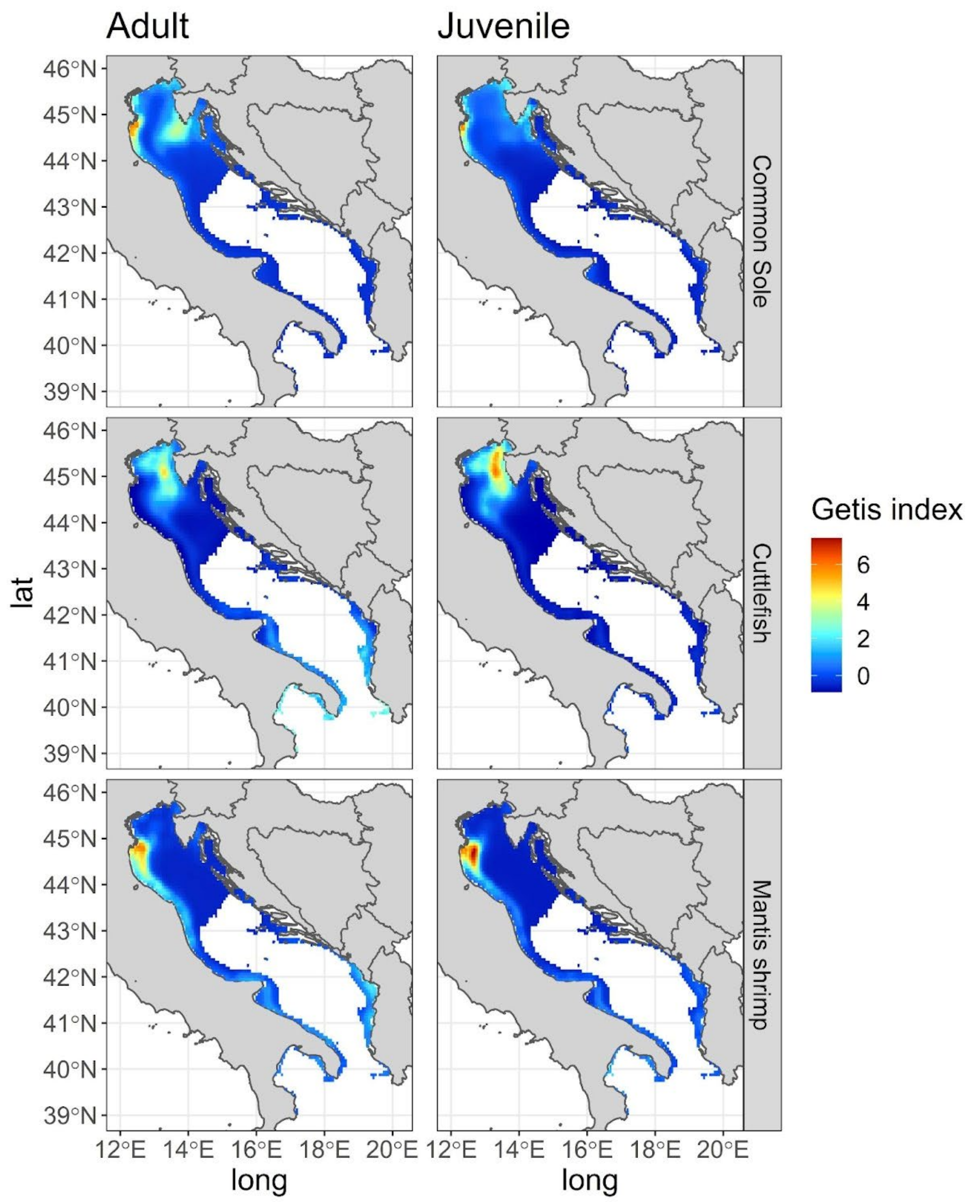
*Panzeri et al., 2022 in preparation*

# Hot spots «SOLEMON species»

For each stage and each species it was thus determined the most relevant areas of aggregation, as areas preferred by species

For the GSA17, also extrapolated to GSA18 and 19

These information allows to identify key ECOLOGICAL areas such as nursery and spawning and feeding grounds useful for spatial fisheries management




*Panzeri et al., 2022 in preparation*



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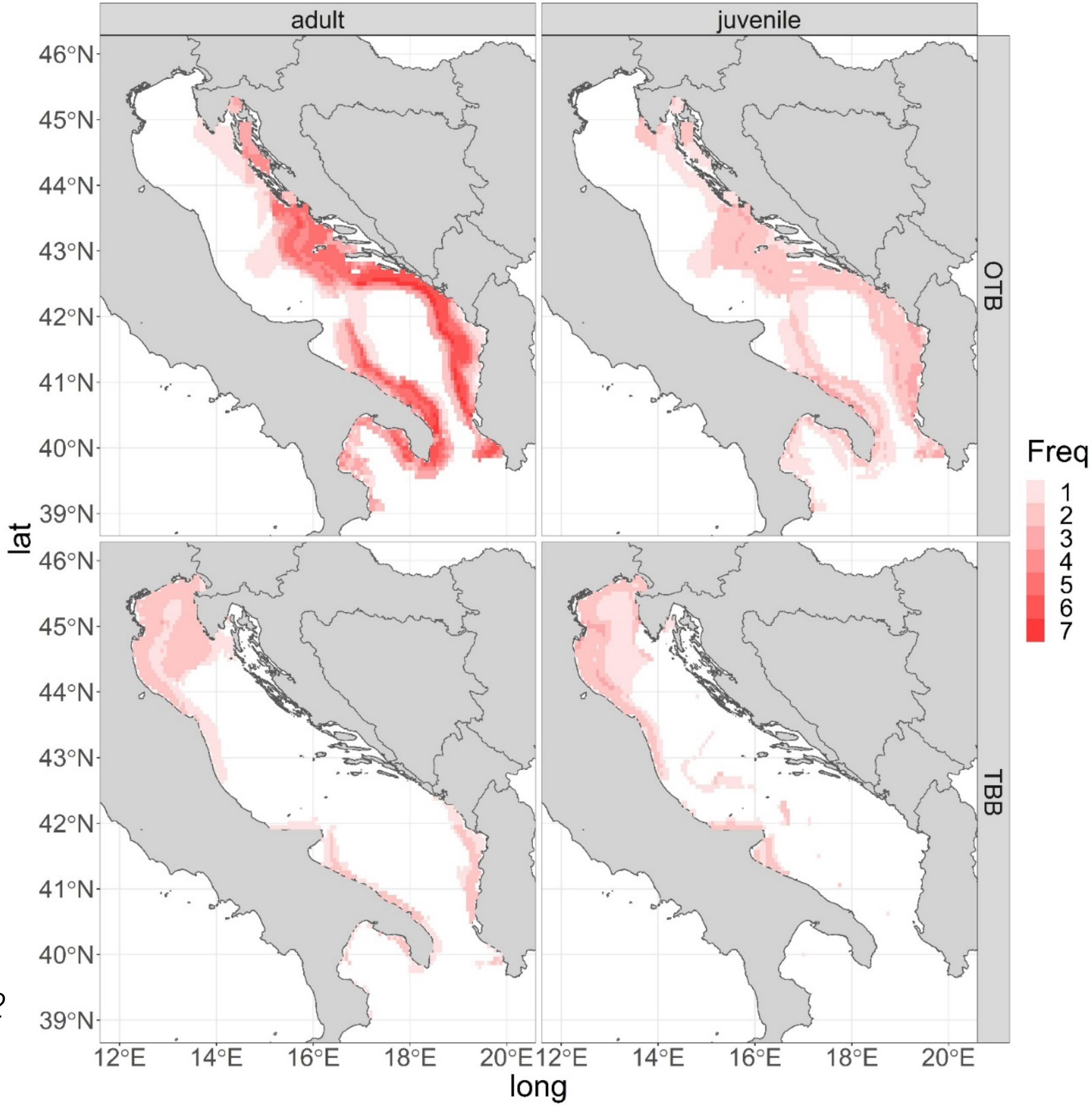
# Overlapping hot spots

It is possible to look at areas where more species have their hotspots.

Values in the figures refer to the number of species having their hot spot in the grid cell (6x6km).

Hot spot considered: Getis index greater than a threshold (the third quartile in each grid).

Resulting maps are distinguished by OTB targeted species and TBB targeted species and could be used to OPTIMIZE spatial fisheries management




*Panzeri et al., 2022 in preparation*

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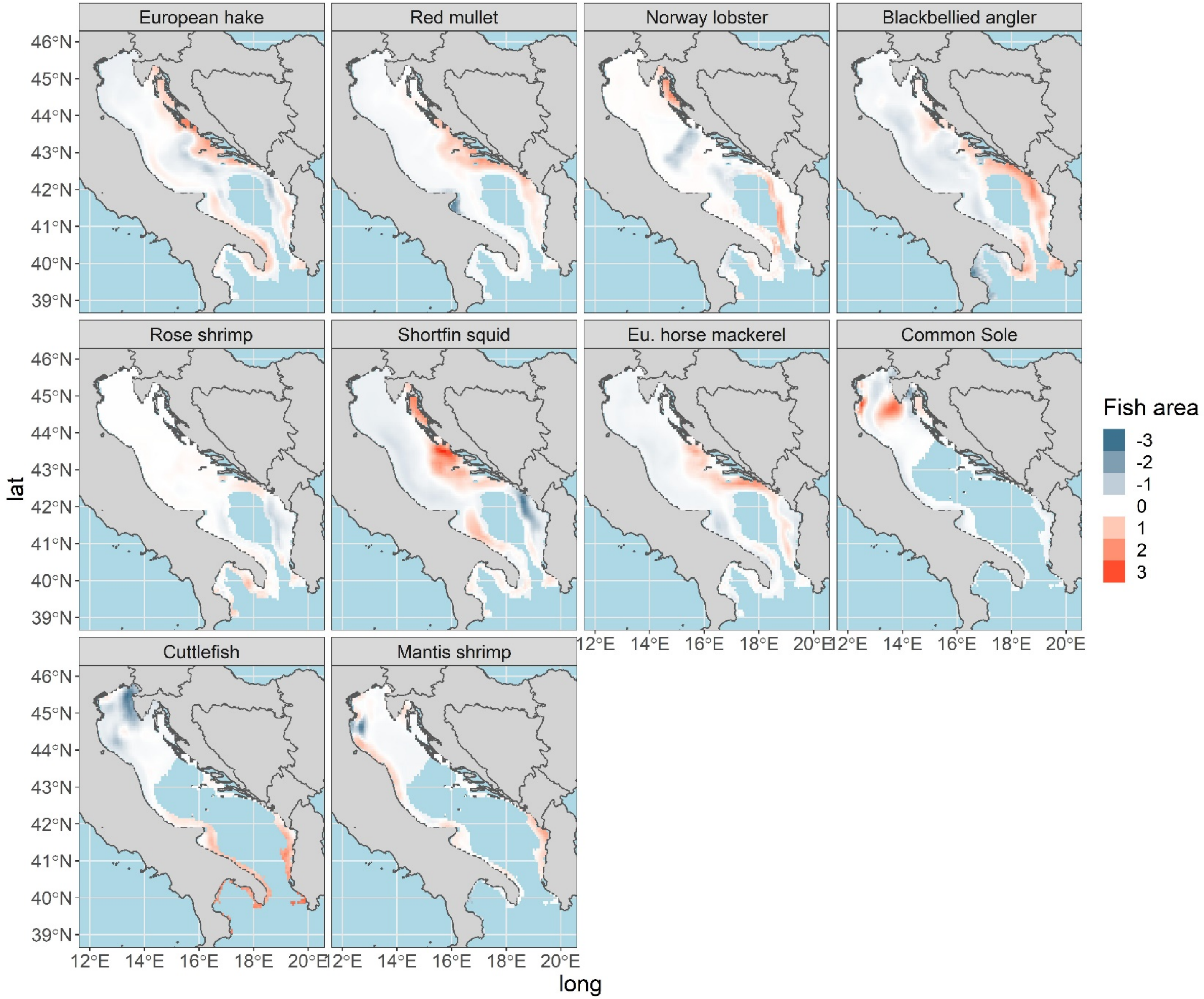
# Match-mismatch between juveniles and adults

In order to increase fisheries selectivity the results can also be considered in terms of mismatch between adult aggregation and juvenile aggregation.

Results of difference for each species (adult minus juvenile) derived from Getis index

Mismatch areas with greater presence of adults (red) are those considered “more selective for fisheries

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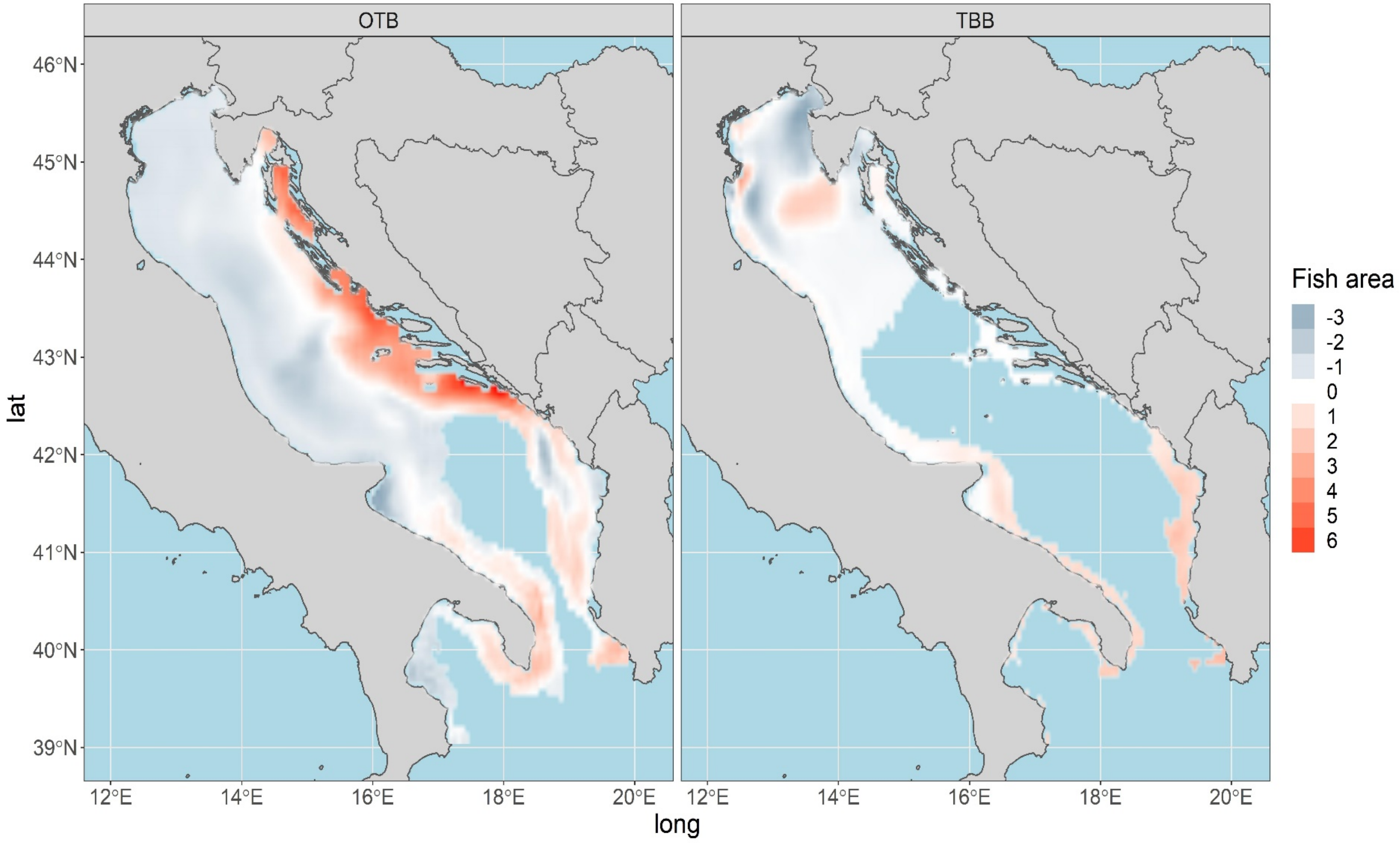
# Match-mismatch between juveniles and adults

Mismatch areas for portfolio of species is reconstructed for OTB and TBB species and can be used to optimize fisheries selectivity



# Conclusions

- The approach per mits integrating fishery dependent, independent and oceanographic variables for best description of species distribution of demersal species also through ensamble of different models

- The results permit identification of «hot spots» of aggregation of ecological significance and can be used to optimize defintion of spatial fisheries management measures

- Limitations are mainly related to capability of the approach to grasp main changes across the year for each species (difficult to consider migrations). Results for Red mullet for example are to be considered with care.

- For setting optimal spatial management areas (in the light of 30% by 2030 for instance) othersocio economic factors are also to be considered.

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# Thank you!

## Acknowledgements

This work results from activities of the project FAIRSEA (Fisheries in the Adriatic Region – a Shared Ecosystem Approach) funded by the 2014–2020 Interreg V-A Italy – Croatia CBC Programme [Standard project ID 10046951].

The Ministries of Agriculture of Member States of Italy and Croatia and the FAO AdriaMed Project are thankfully acknowledged for sharing information on VMS used in this work.

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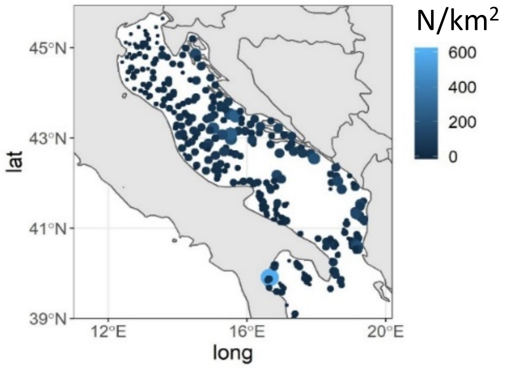
# Work flow




Merge data

Survey dataset

Copernicus dataset

Complete data set

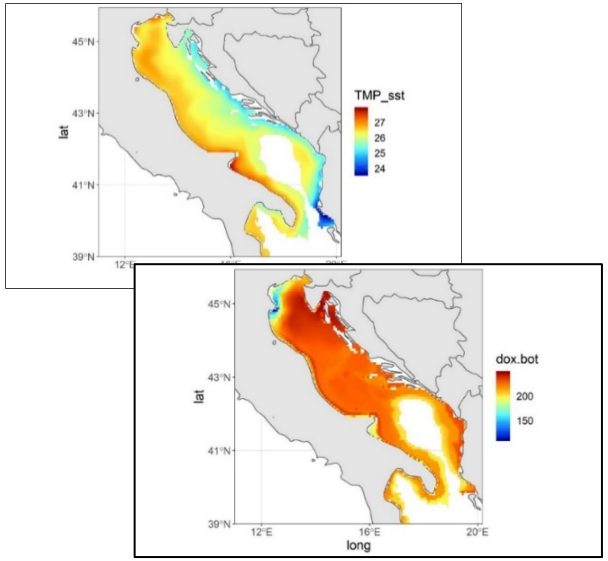
VIF

A — Spatial training and test datasets: stepwise approach

B — Choose best model

C — Applied to entire data
Look diagnostic

D — Use the model to predict on grid




E — Hot Spot detection

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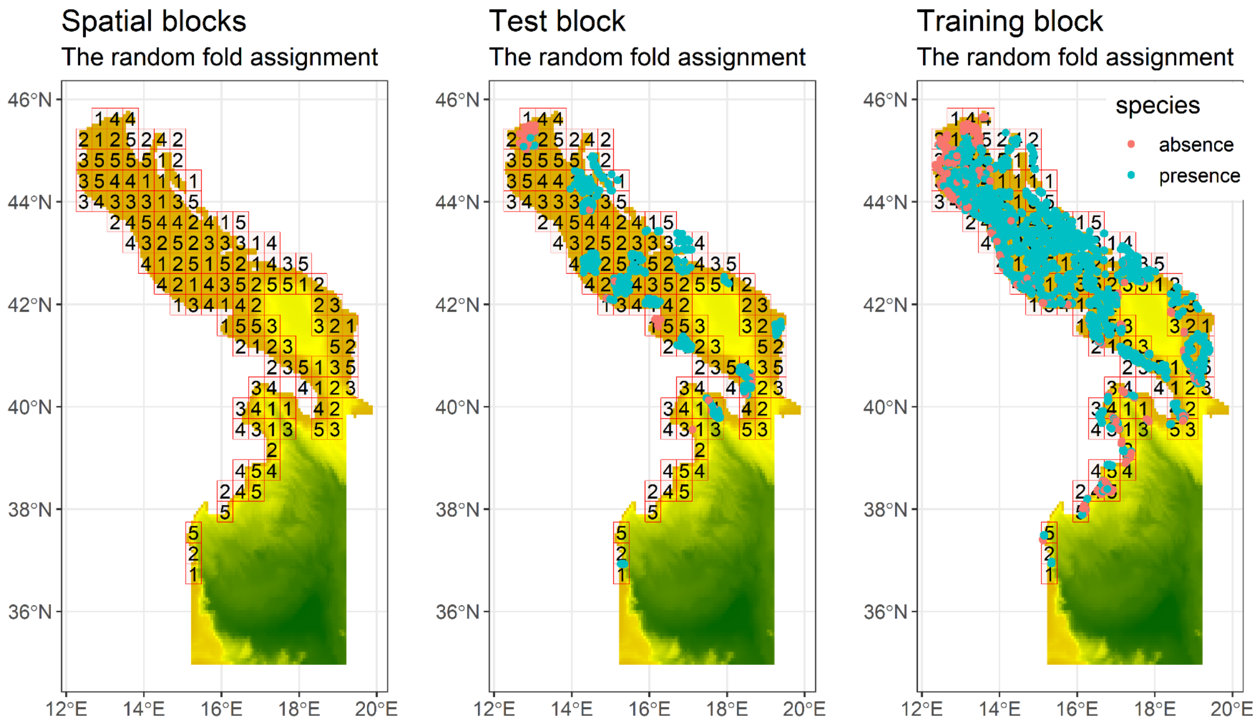
# Spatial training and test datasets

A



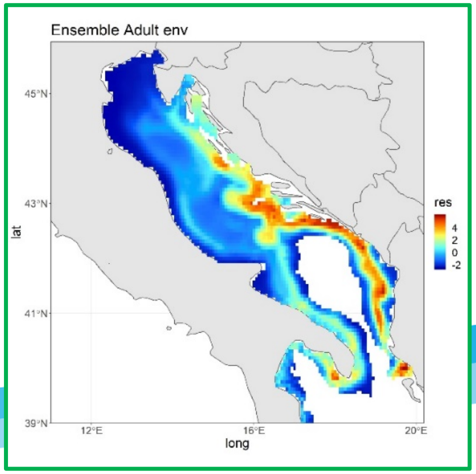

- Selected covariates after collinearity analysis (VIF-Variance Inflation Factor) → $VIF_j = \frac{1}{1-R_j^2}$ (< 5)
- Spatial training and test data set
- Fit the model on train
- Predict on test
- Several models

```
A <- log.N_km2 ~  s(X,Y)+s(year)+ s(depth,k=6,bs='cr')
B <- log.N_km2 ~  s(X,Y)+s(year)+ s(depth,k=6,bs='cr')+s(TMP_bot,k=3,bs='cr')
C <- log.N_km2 ~  s(X,Y)+s(year)+ s(depth,k=6,bs='cr')+s(dox.bot,k=3,bs='cr')
D <- log.N_km2 ~  s(X,Y)+s(year)+ s(depth,k=6,bs='cr')+s(TMP_bot,k=3,bs='cr')+s(eff_OTB,bs='cr',k=3)
E <- log.N_km2 ~  s(X,Y)+s(year)+ s(depth,k=3,bs='cr')+s(dox.bot,k=6,bs='cr')+s(eff_OTB,bs='cr',k=3)
F <- .....
G ....
```

# How?

Models approach:

- Predictive capacity with **environmental variables (Copernicus products from HYDRO, BGC modules)**
- **Including effort from VMS/AIS as covariate (EFFORT)**
- Comparison between **models**
- Increase knowledge on species distribution and aggregation areas
- Future scenario



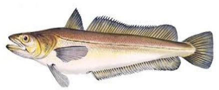

Information useful for fisheries management?

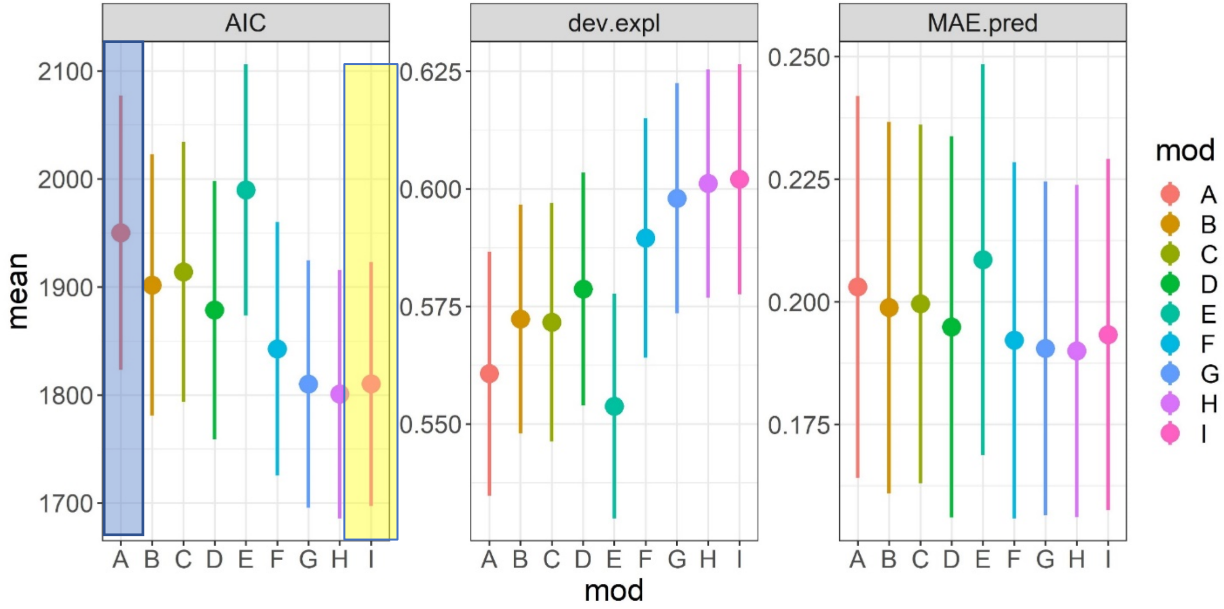
# Choose best model using different diagnostics

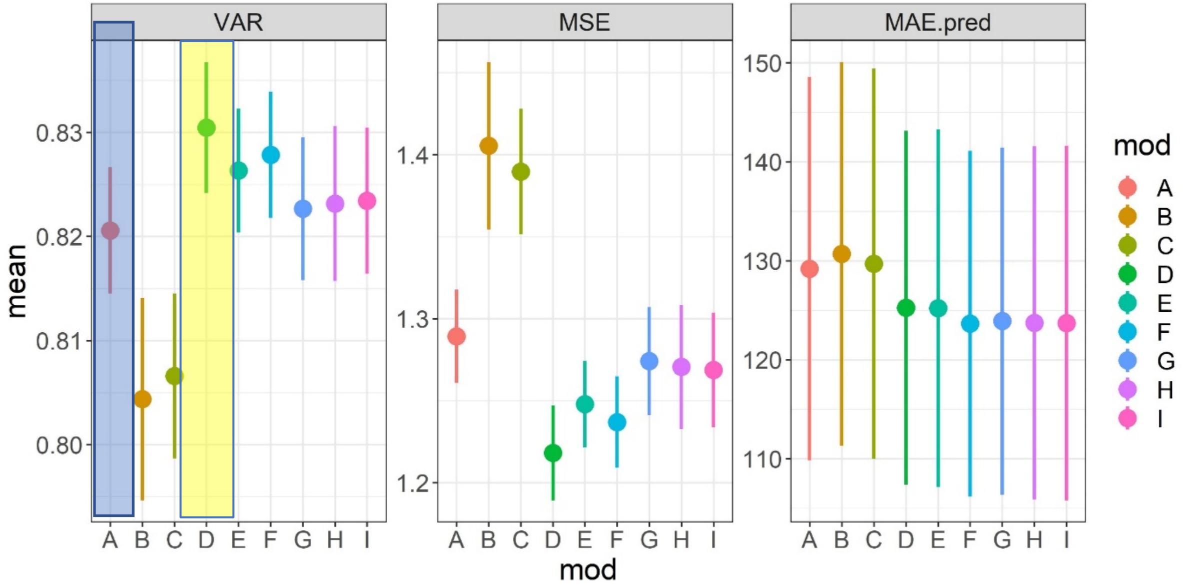
B

Binomial

Random forest






10 model for each approach:

- A: model spatiotemporal
- B-L: spatiotemporal + environmental

ST

ST + Env

Different diagnostic

- AIC & dev. Expl on training
- MAE

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