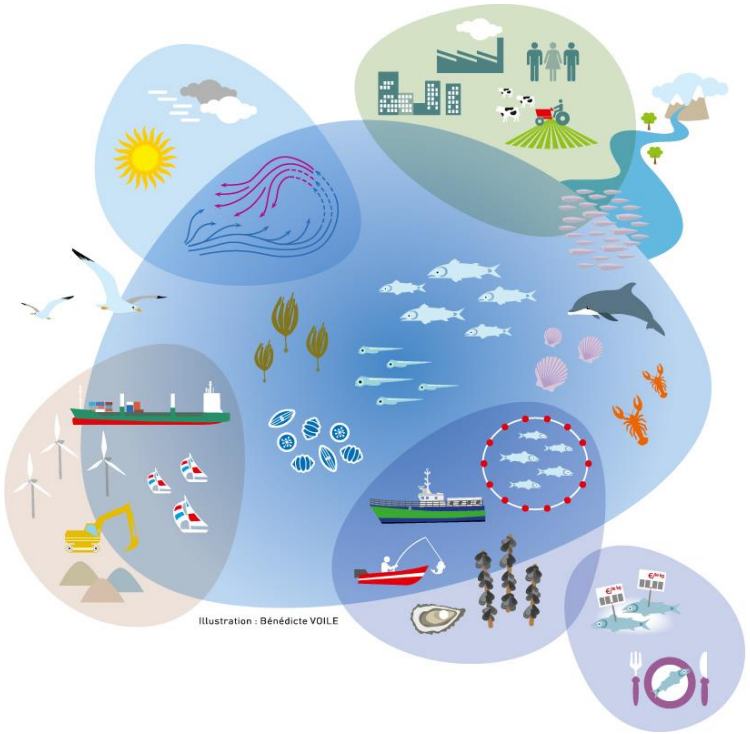
Can we trust commercial catch declarations data to map fish spatio-temporal distribution and identify fish essential habitats?

Baptiste Alglave

Supervision/contribution: Etienne Rivot, Youen Vermard, Mathieu Woillez, Marie-Pierre Etienne, James T. Thorson, Kasper Kristensen, Nicolas Bez

Context

Marine spatial planning

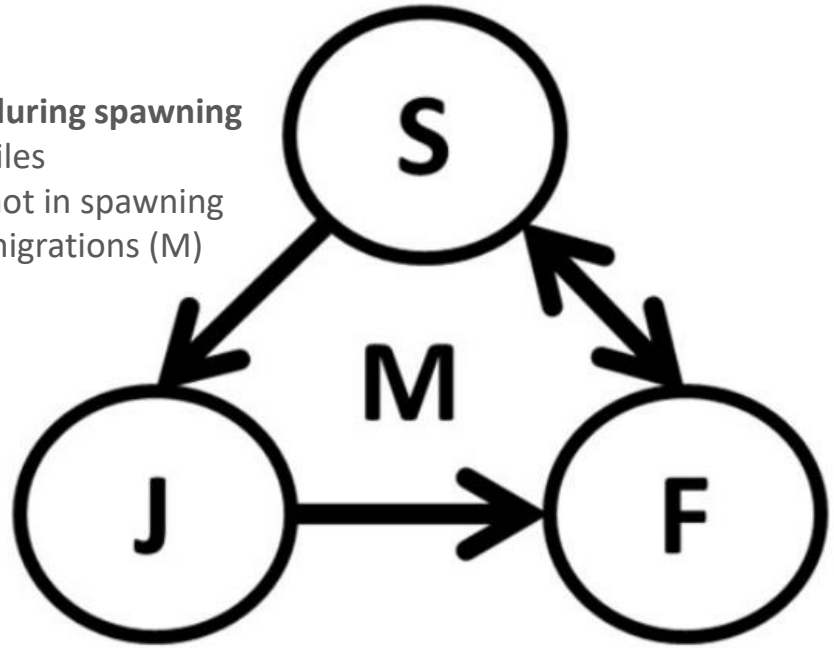


Lack of knowledge on:

Fish Essential habitats

Fish Spatio-temporal distribution
(at fine temporal scale – e.g. month)

S = mature adults during spawning
J = immature juveniles
F = feeding adults not in spawning
Arrows represent migrations (M)

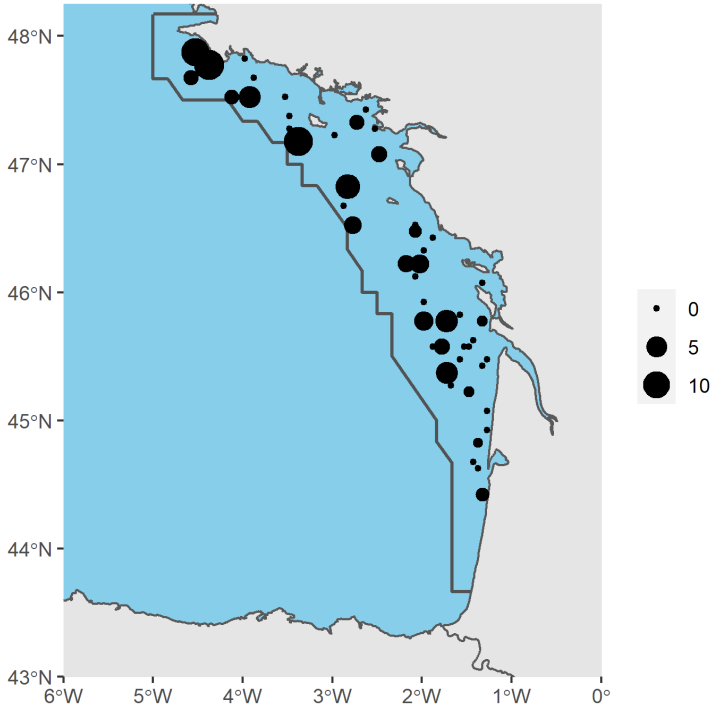


Common life-history stages of fish

Brown et al. (2018)

Data sources

Scientific survey data



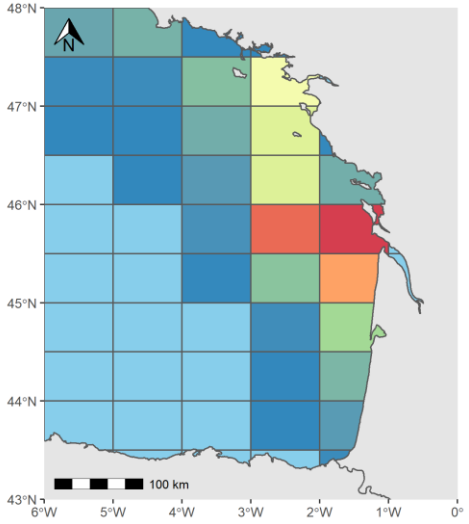
Orhago survey
(common sole)

+ Standardized high quality data

- Sparse sampling in space and/or time
Expensive

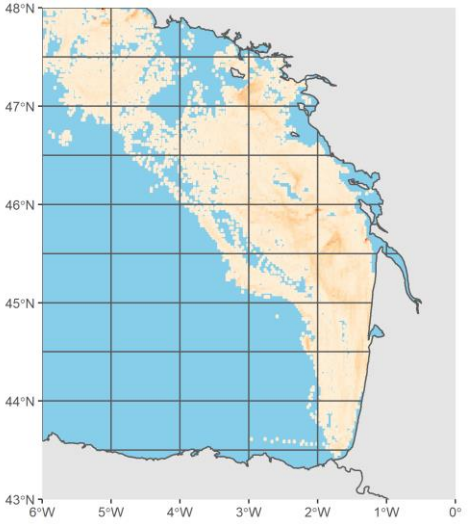
Commercial data

Logbook data
(landings)



X

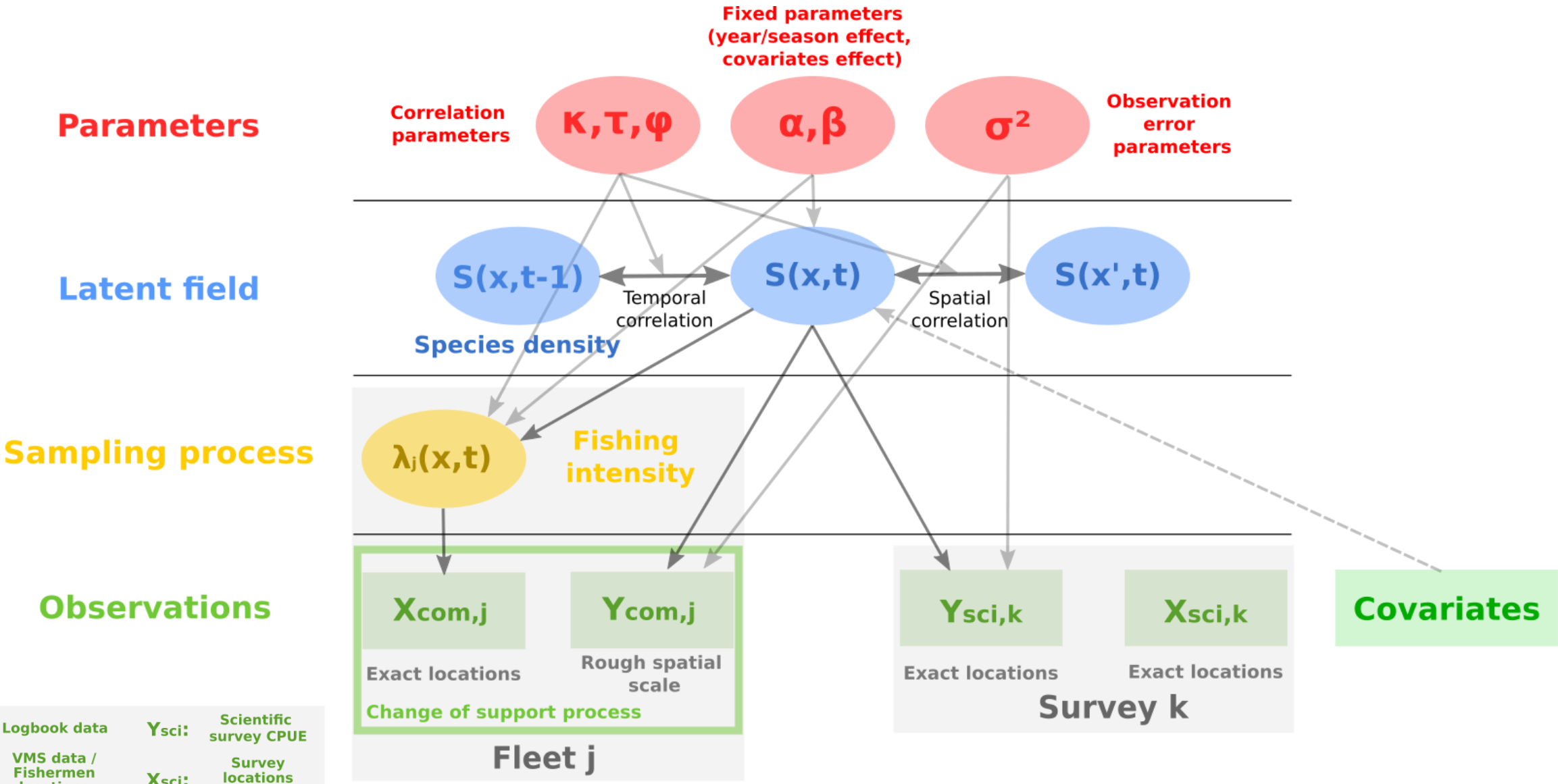
VMS data
(fishing locations)



+ Huge quantity of data
Full year coverage

- Preferential sampling
Non-homogeneous fleets
Rough spatial scale

Conceptual framework



Model biomass predictions

Scientific data

Commercial data

Spatio-temporal model

S(x,t)

Biomass predictions

Can we identify essential habitats from the model predictions?

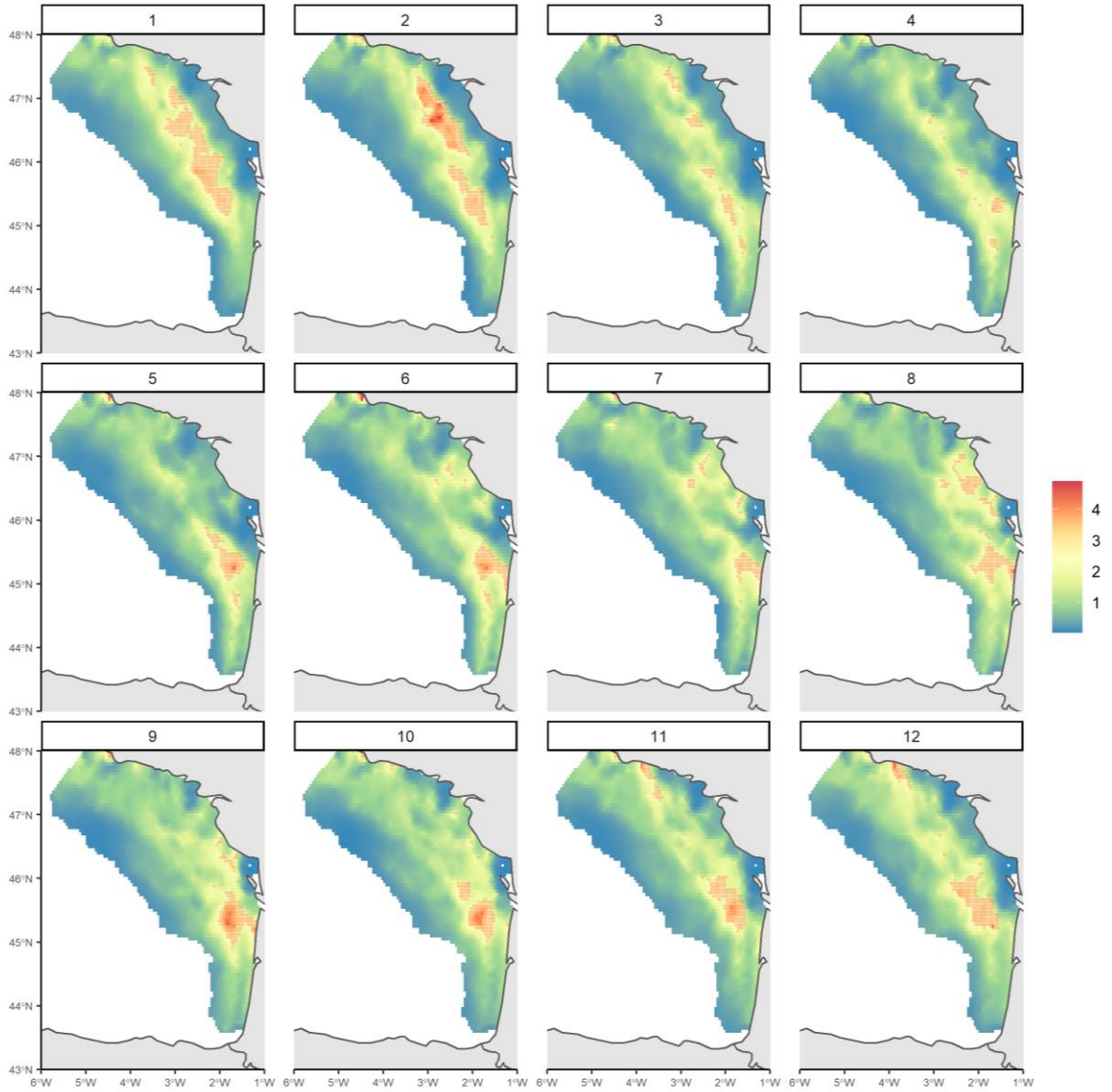
S(x,t)

SSB

Mean monthly map of biomass

(sole, 2008 – 2018, fleets: OTB_DEF, OTB_DEF, OTT_DEF)

Red areas: 90% quantile



Identifying spawning grounds

S(x,t) — Biomass predictions

For each time step

Aggregation index (Getis & Ord)

Aggregation over time steps

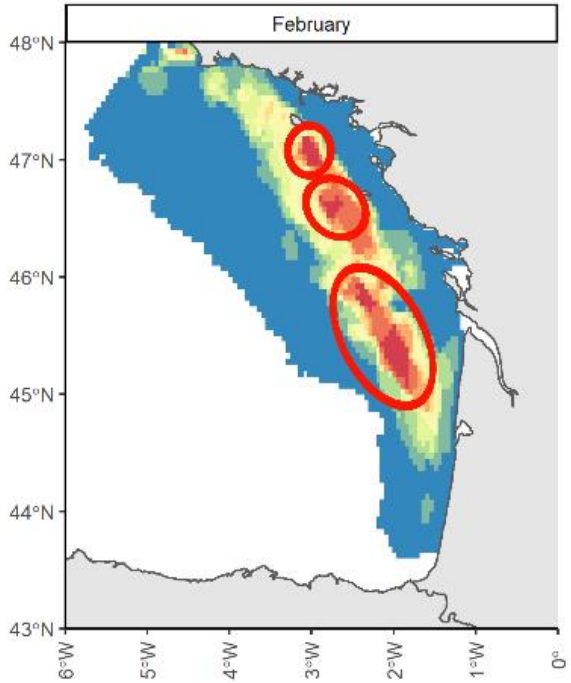
How often a cell is within an aggregation area ?

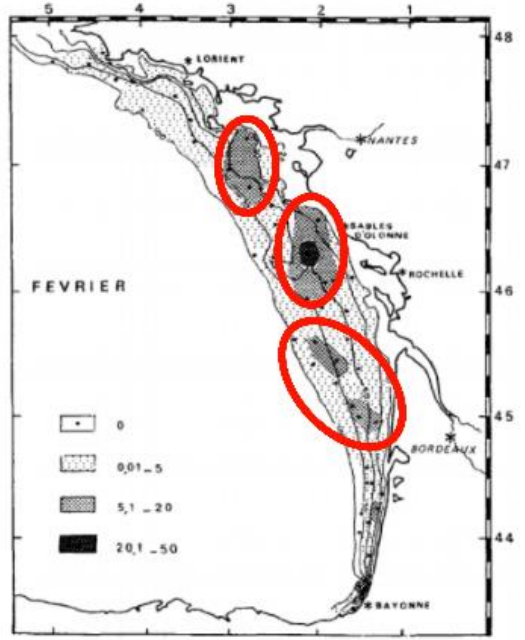
Focus on reproduction period

Knowledge on reproduction

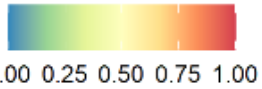
Egg and larvae survey available

Sole





Arbault et al. (1986)



Identifying spawning grounds

S(x,t) — Biomass predictions

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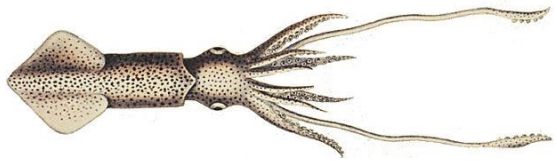
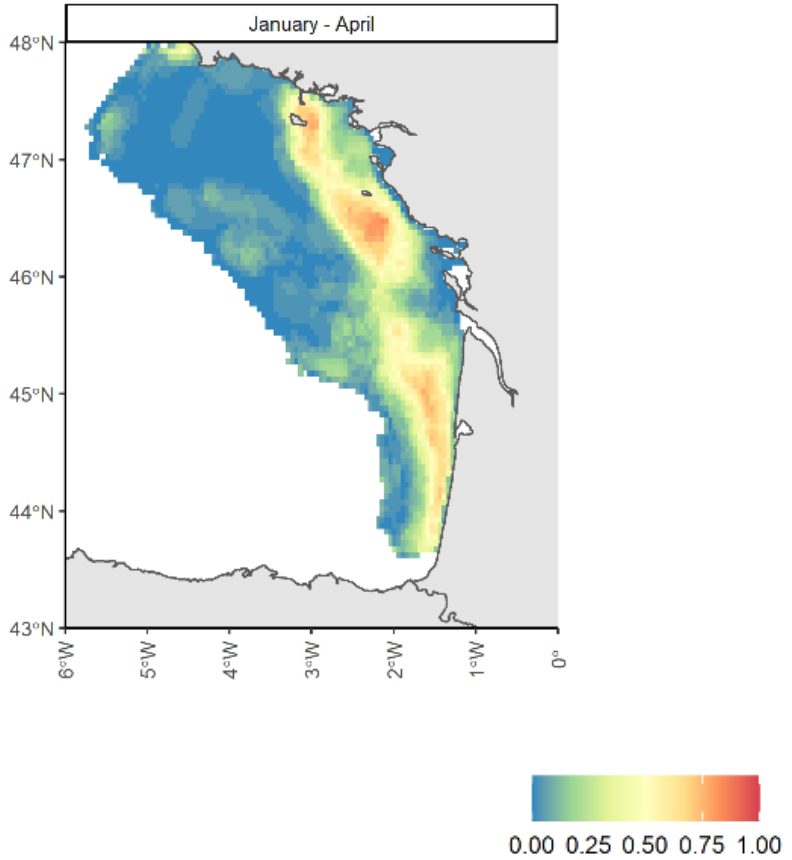


Knowledge on reproduction

Only information on the reproduction period

Squids



Spatio-temporal pattern analysis

⇒ What are the spatial patterns that structure the spatio-temporal distribution of fish?

⇒ Can we interpret these in regards to fish ecology?

Empirical Orthogonal Functions (EOF)

$$\vec{S}_t^{\,*} = \sum_{k=1}^{K} \alpha_k(t)\vec{p}^{\,k} + \vec{n}_t$$

- $\vec{S}_t^{\,*}$: Champ de biomasse Normalisé
- $\alpha_k(t)$: Indices temporels
- $\vec{p}^{\,k}$: Patrons spatiaux
- $\vec{n}_t$: Variabilité résiduelle

Dans une EOF, les indices α_k et les patterns p^k sont construits tel que

- la variance résiduelle n_t soit minimale
- les patrons p^k soient orthogonaux

≡ ACP

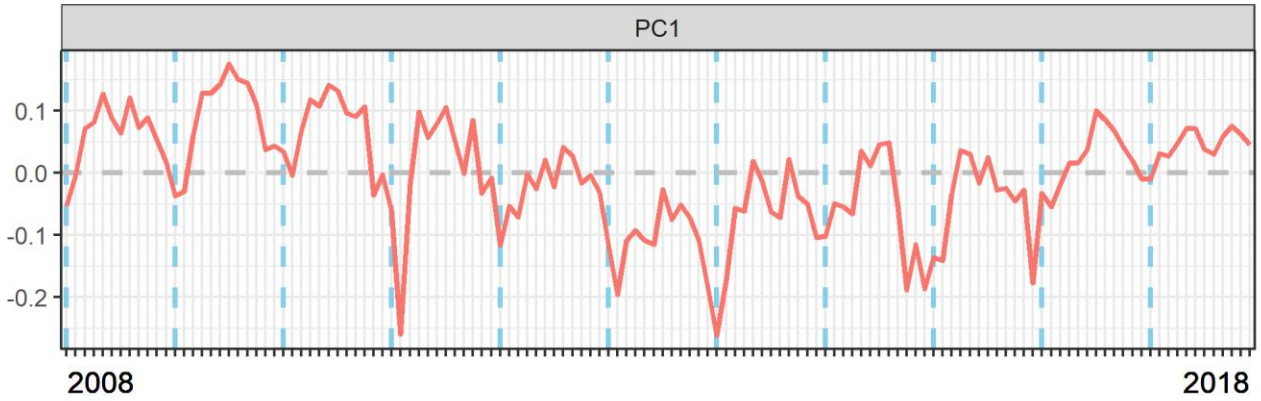
Sole

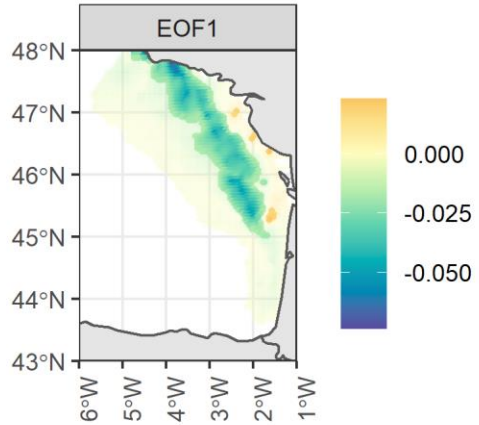
Hake

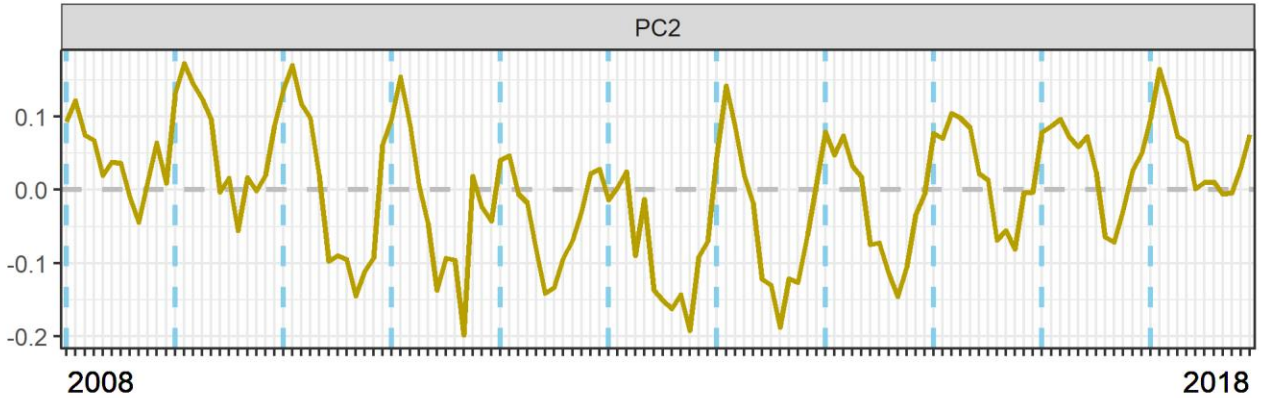
Sea bass

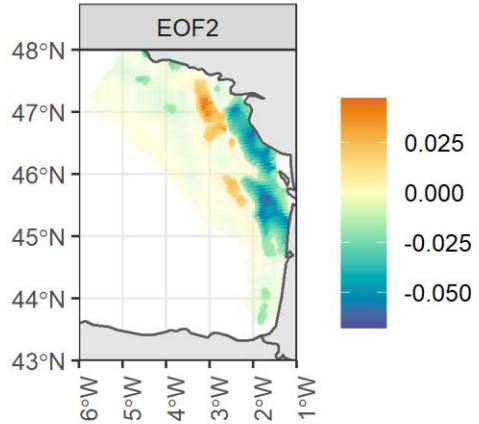
Spatio-temporal pattern analysis

Sole







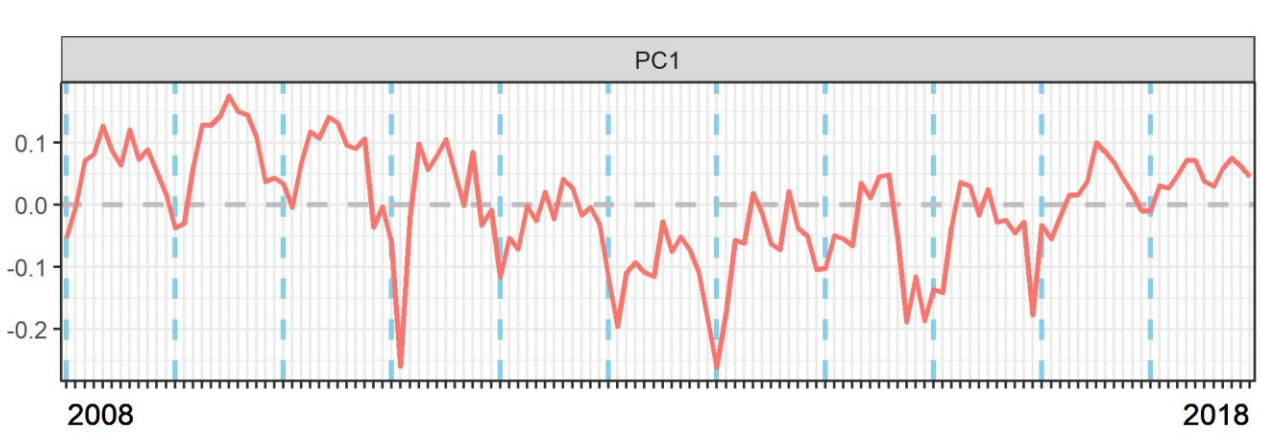


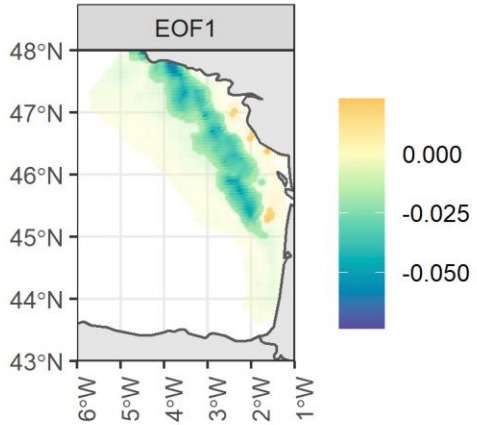
Blue dashed line: January

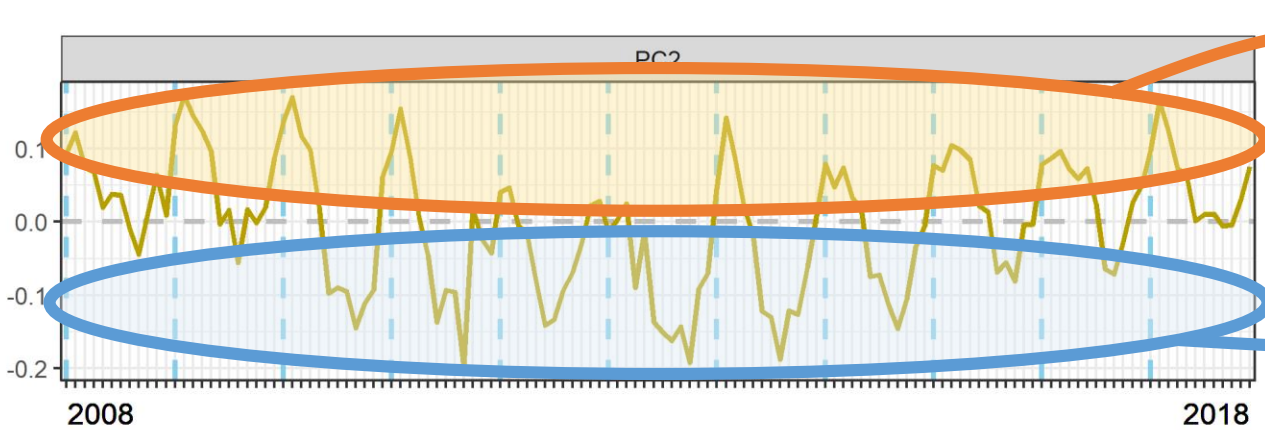
EOF

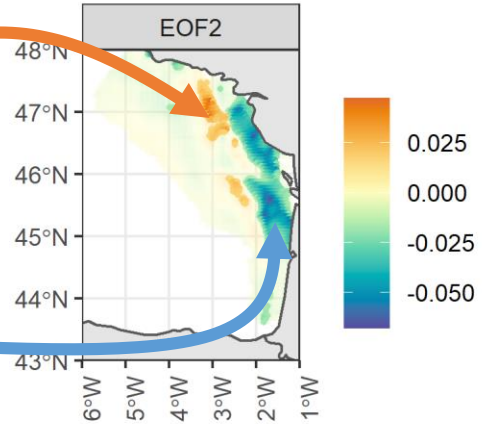
Spatio-temporal pattern analysis

Sole









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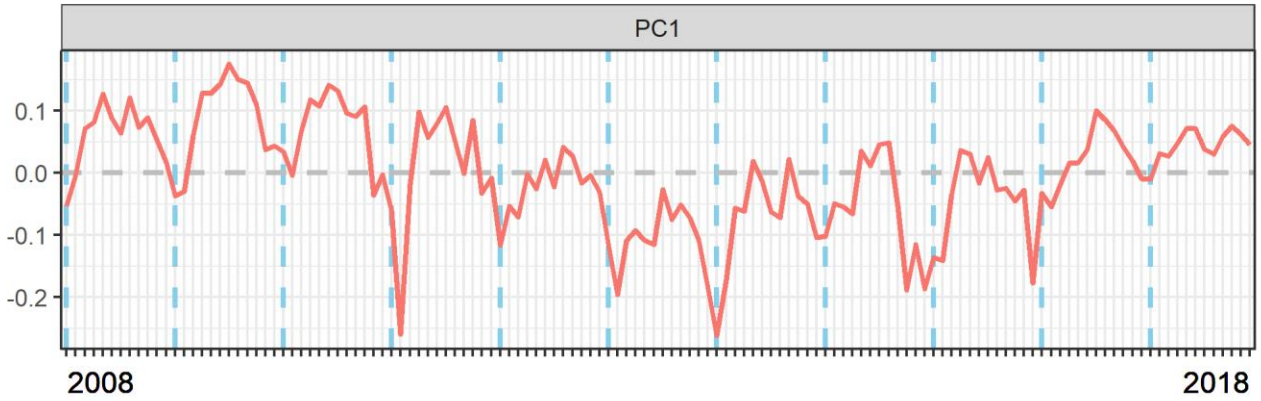
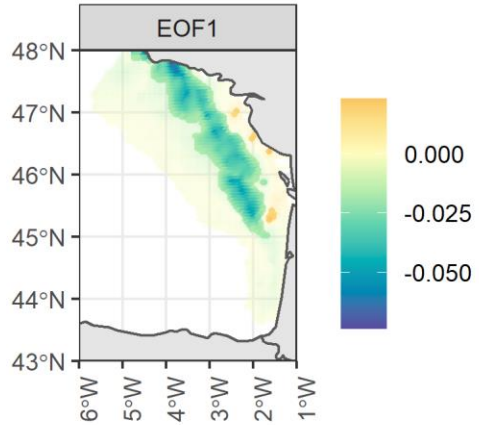
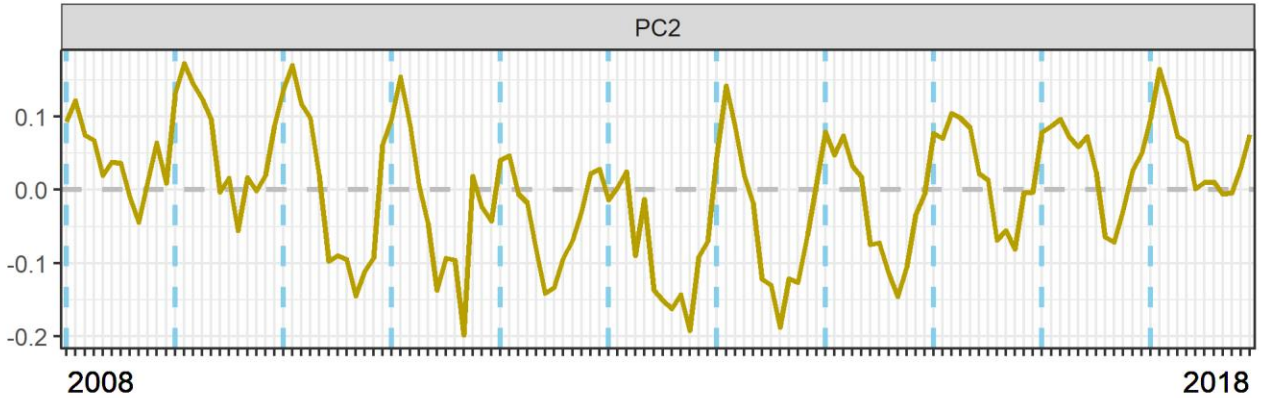
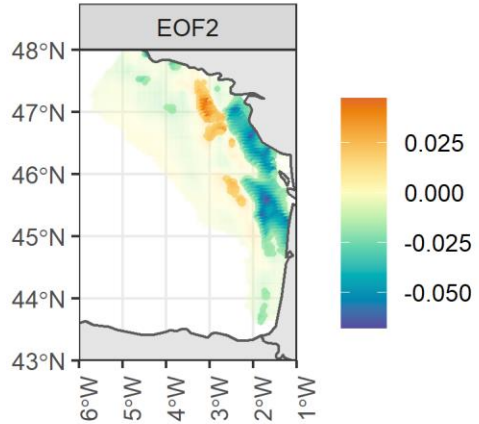
Spatio-temporal pattern analysis

Sole









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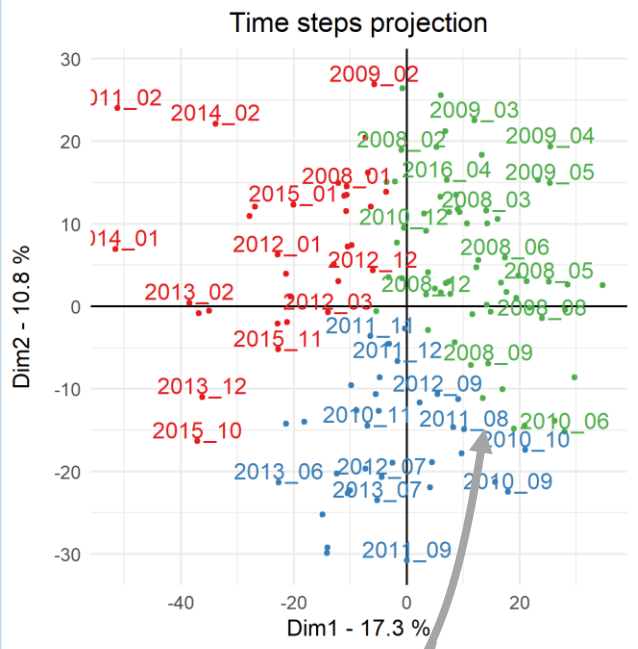
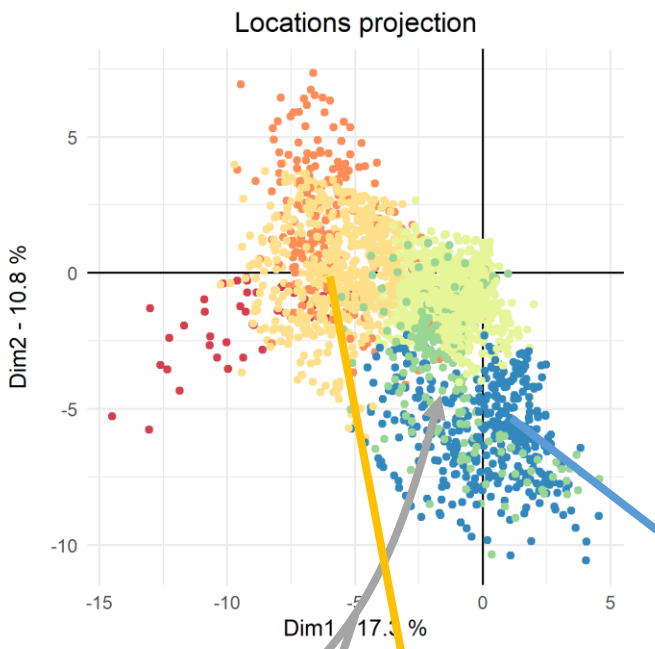
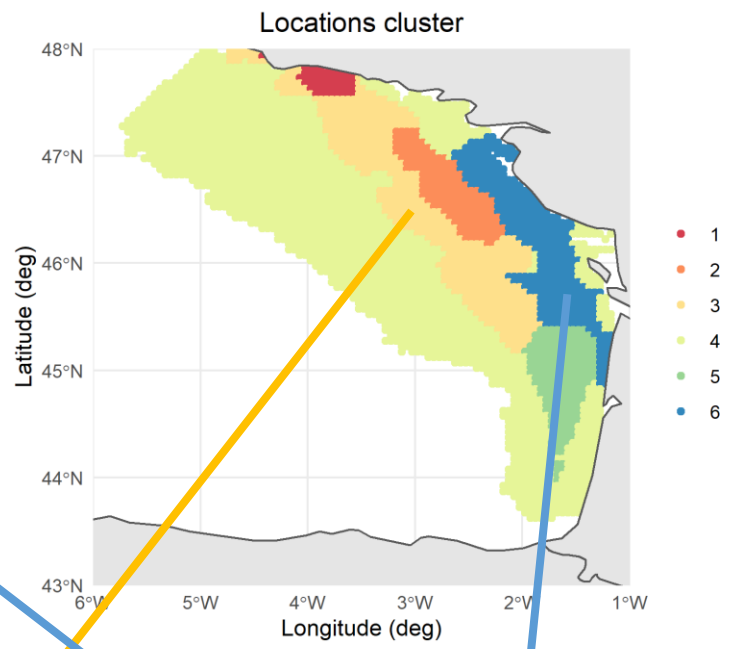
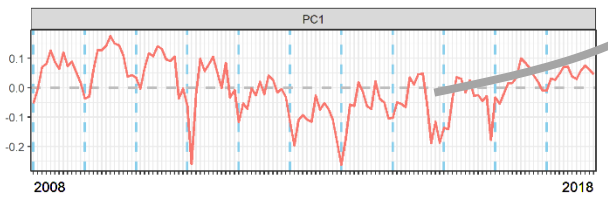
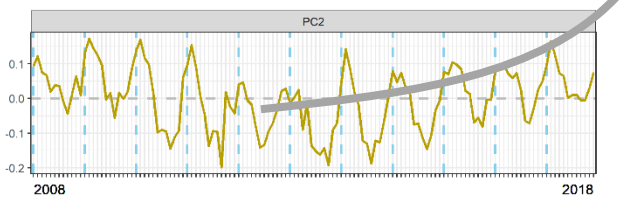
Spatio-temporal pattern analysis

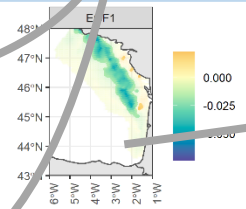


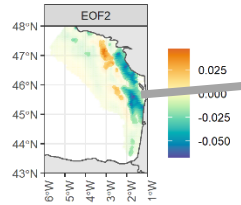












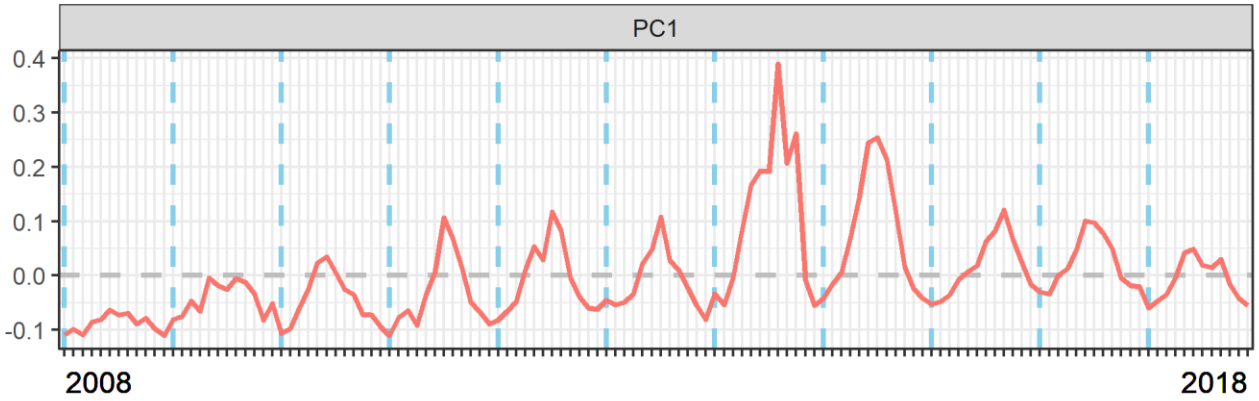
Winter habitat (reproduction area)

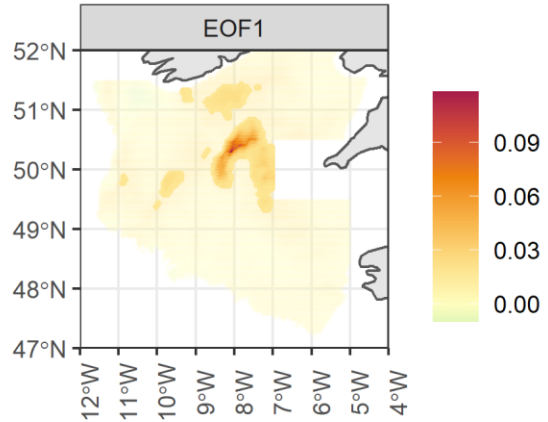
Summer habitat (feeding area?)

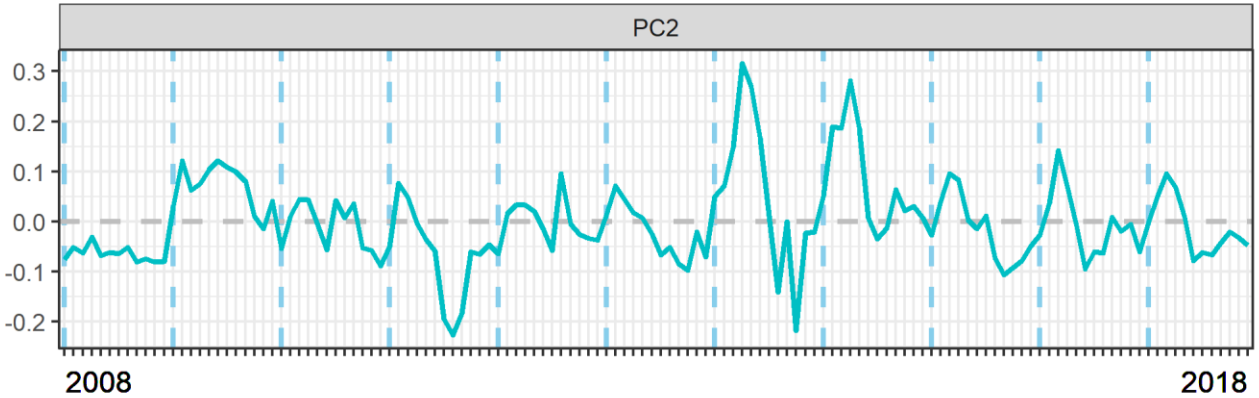
EOF x Clustering

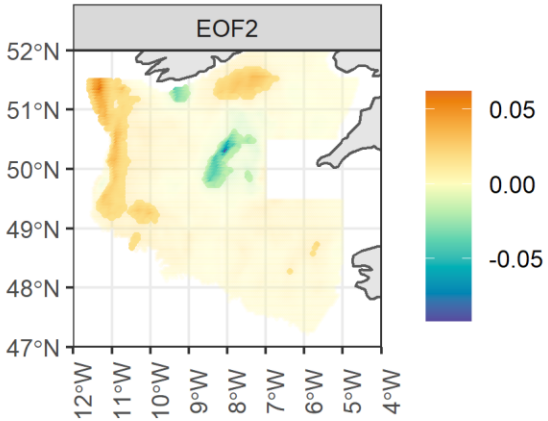
Spatio-temporal pattern analysis

Hake – Celtic Sea







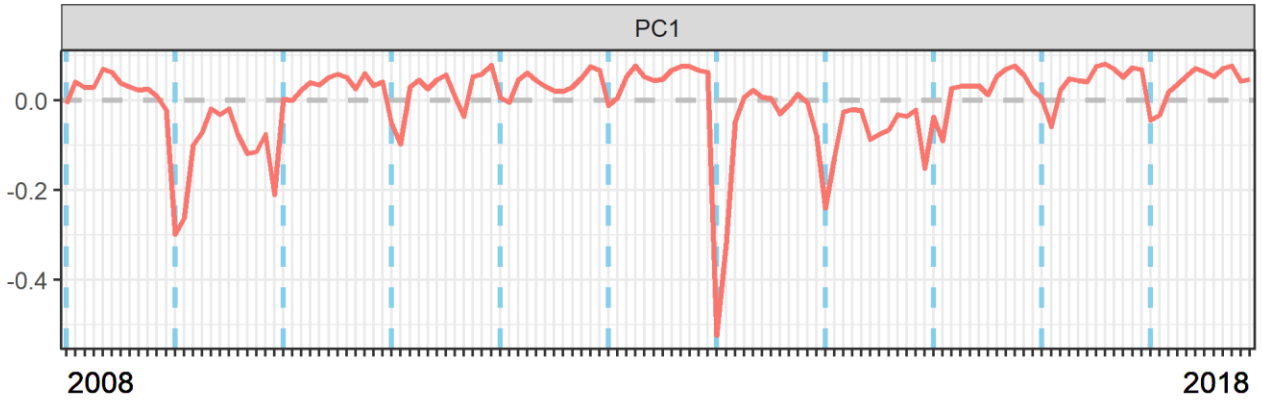


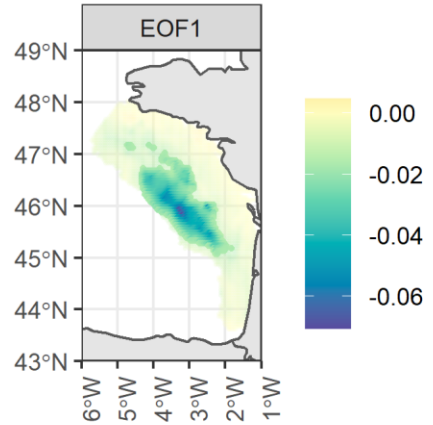
Blue dashed line: January

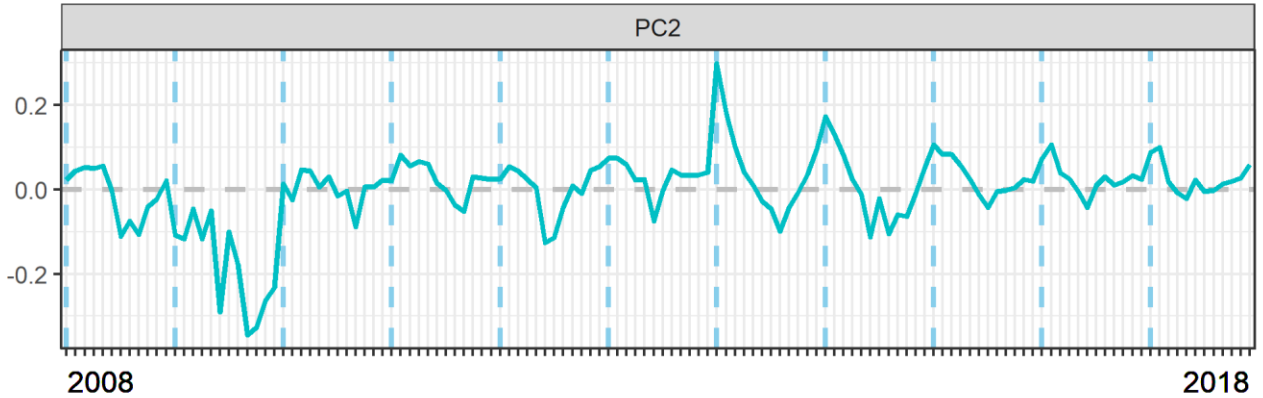
EOF

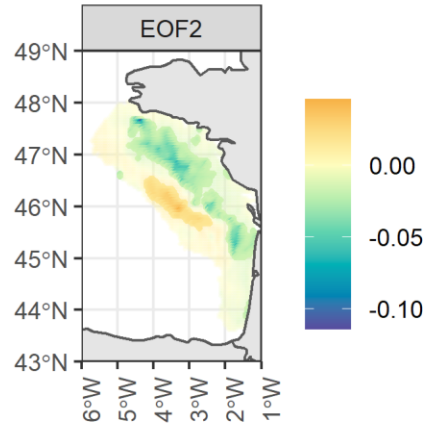
Spatio-temporal pattern analysis

Hake – Bay of Biscay







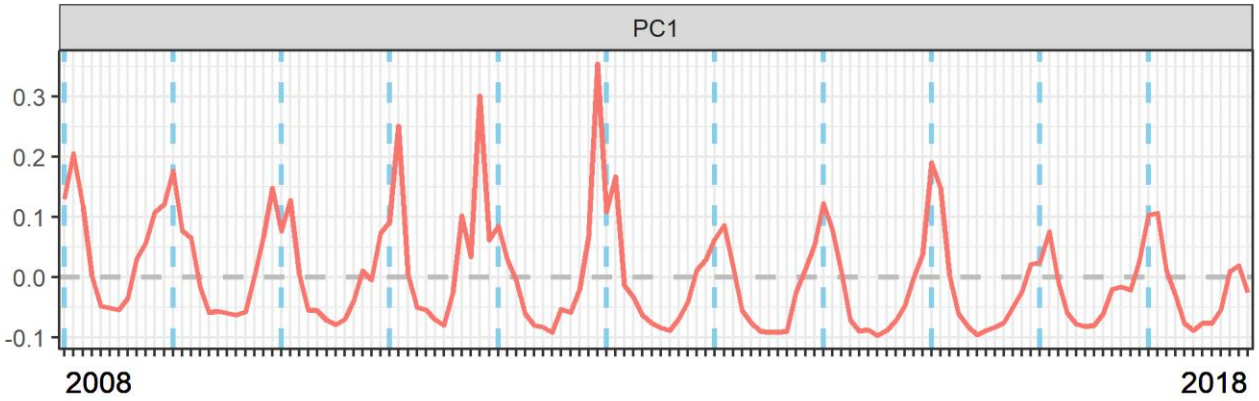


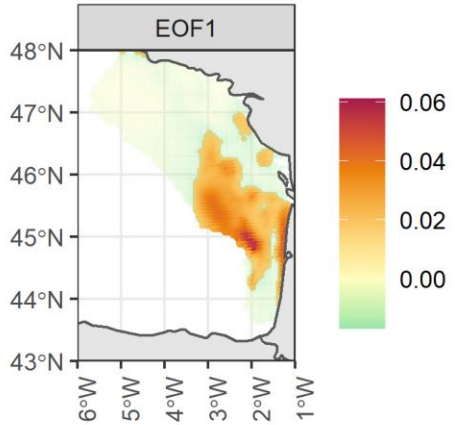
Blue dashed line: January

EOF

Spatio-temporal pattern analysis

Sea bass





⇒ Seasonnal pattern that coincides with the ecology of reproduction of the species

Blue dashed line: January

EOF

Discussion

- **A framework**:

Combining **scientific survey data** and **commercial catch declarations** data

To infer **fish spatio-temporal distribution** at a monthly time step

- **Can we identify essential habitats from the model outputs?**

Persistent aggregation areas

⇒ **Match with the literature** knowledge of spawning areas
⇒ Requires to have an **a priori on the spawning season**

Spatio-temporal pattern analysis

⇒ **Seasonnality** of spatial patterns
⇒ **Identification of specific areas** that can be interpreted as essential habitats

- **Limits:**

Only indirect observations of spawning areas / habitats

⇒ **Need for additionnal information to interpret the model outputs**
(expert knowledge, on-field data)

Logbook data limits
No discards / species aggregation (e.g. anglerfish)

⇒ **Integrate obsmer data to provide the missing part of information**

Perspectives

MACCO project

Application to data-poor species



Bay of Biscay




Med. Sea

CSTEP WG
Closure areas

Identification of potential closure areas
+
Model parameterization to assess these closure areas

ISIS-fish

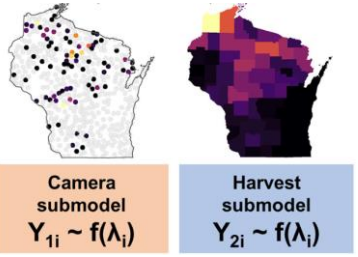
MARXAN conservation solutions

Use for marine spatial planning

Other fields of application

Terrestrial ecology

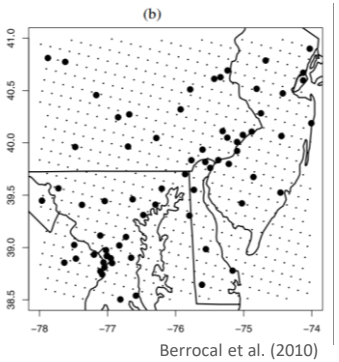
Harvest records
(declarations data)
x
Camera-trap data
(scientific data)



Gilbert et al. (2021)

Air pollution

Outputs of numerical model
(massive rough data)
x
Monitoring networks data
(spase high quality data)



Berrocal et al. (2010)

And others: epidemiology, climate science, etc.

For more details on the framework

Alglave, B., Rivot, E., Etienne, M. P., Woillez, M., Thorson, J. T., & Vermard, Y. (2022). Combining scientific survey and commercial catch data to map fish distribution. *ICES Journal of Marine Science*, *79*(4), 1133-1149.

Alglave, B., Vermard, Y., Rivot, E., Etienne, M. P., & Woillez, M. (*under review*). Identifying fish spawning grounds by combining catch declarations and scientific survey data.

Thank you for your attention!

If any question/suggestion/proposition: Baptiste.alglave@agrocampus-ouest.fr

References

Berrocal, V. J., Gelfand, A. E., & Holland, D. M. (2010). A spatio-temporal downscaler for output from numerical models. *Journal of agricultural, biological, and environmental statistics*, *15*(2), 176-197.

Brown, E. J., Vasconcelos, R. P., Wennhage, H., Bergström, U., Støttrup, J. G., van de Wolfshaar, K., ... & Le Pape, O. (2018). Conflicts in the coastal zone: human impacts on commercially important fish species utilizing coastal habitat. ICES Journal of Marine Science, 75(4) , 1203-1213.

Gilbert, N. A., Pease, B. S., Anhalt-Depies, C. M., Clare, J. D., Stenglein, J. L., Townsend, P. A., ... & Zuckerberg, B. (2021). Integrating harvest and camera trap data in species distribution models. Biological Conservation, 258, 109147.

Appendix

Identifying spawning grounds

S(x,t) — Biomass predictions

For each time step

Aggregation index (Getis & Ord)

Aggregation over time steps

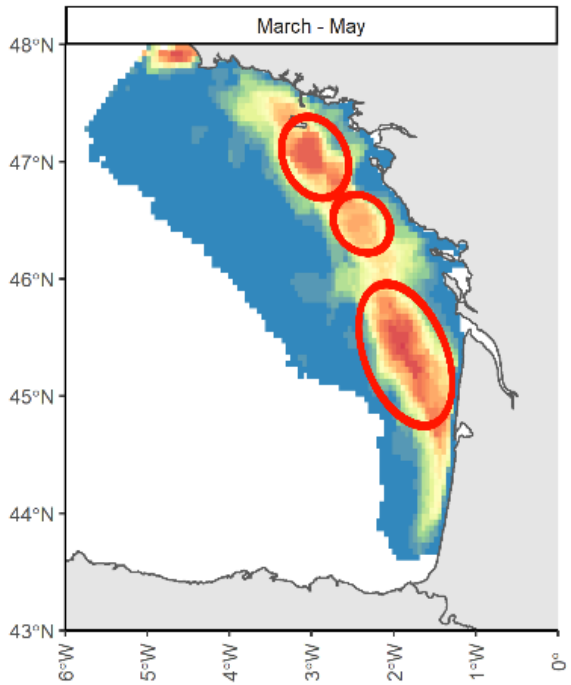
How often a cell is within an aggregation area ?

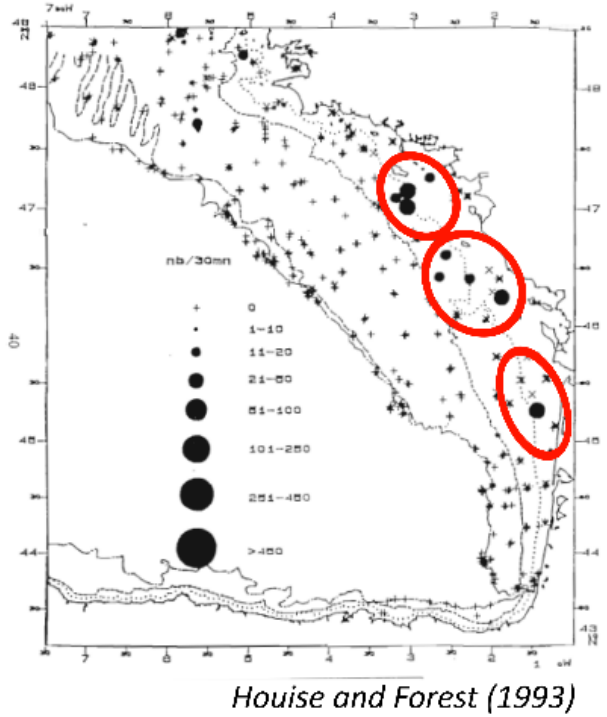
Focus on reproduction period

Knowledge on reproduction

Trawl survey of mature individuals

Whiting





Houise and Forest (1993)