Can we identify Fish Essential Habitats with landings data ?

Application to the common sole of the Bay of Biscay

Baptiste Alglave, Youen Vermard, Marie-Pierre Etienne, Mathieu Woillez, Etienne Rivot

09/04/2021 - GdR Ecostats

Ifremer

UMR ESE Écologie et santé des écosystèmes

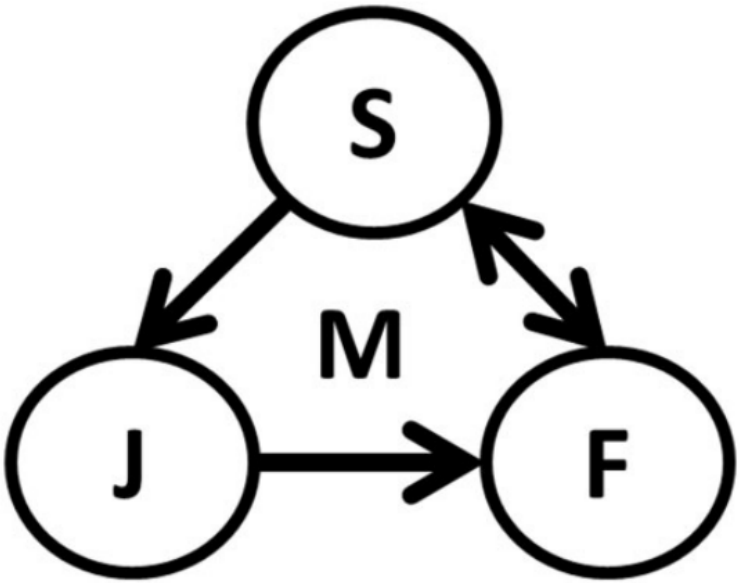
Essential Fish Habitats

Fishery ressources renewal highly rely on some key areas called **Essential Fish Habitats (EFH)** :

- Spawning and reproduction grounds
- Nursery grounds
- Migration routes

⇓

Identify and caracterise these areas ?



Conceptual diagram of common life-history stages of fish in coastal habitats: S = mature adults during spawning, J = immature juveniles, and F = feeding adults not in spawning. Arrows represent migrations (M).

(Brown *et al.*, 2018)

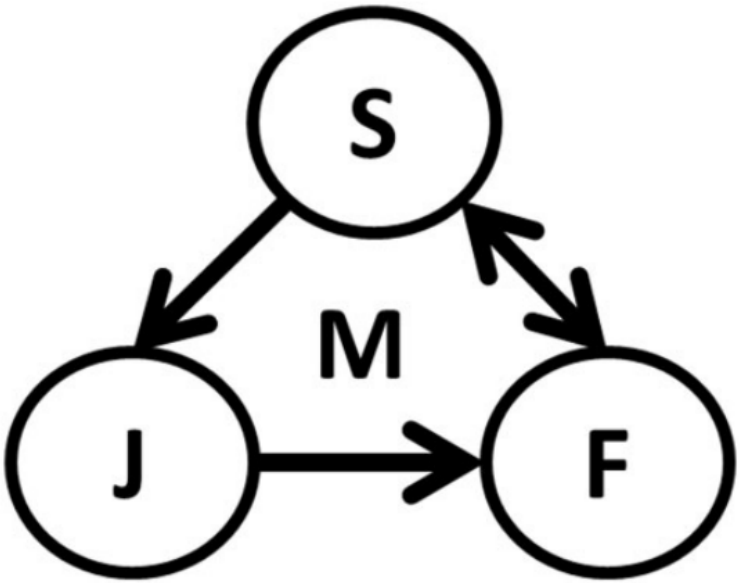
Essential Fish Habitats

Fishery ressources renewal highly rely on some key areas called **Essential Fish Habitats (EFH)** :

- Spawning and reproduction grounds
- Nursery grounds
- Migration routes

⇓

Identify and caracterise these areas ?



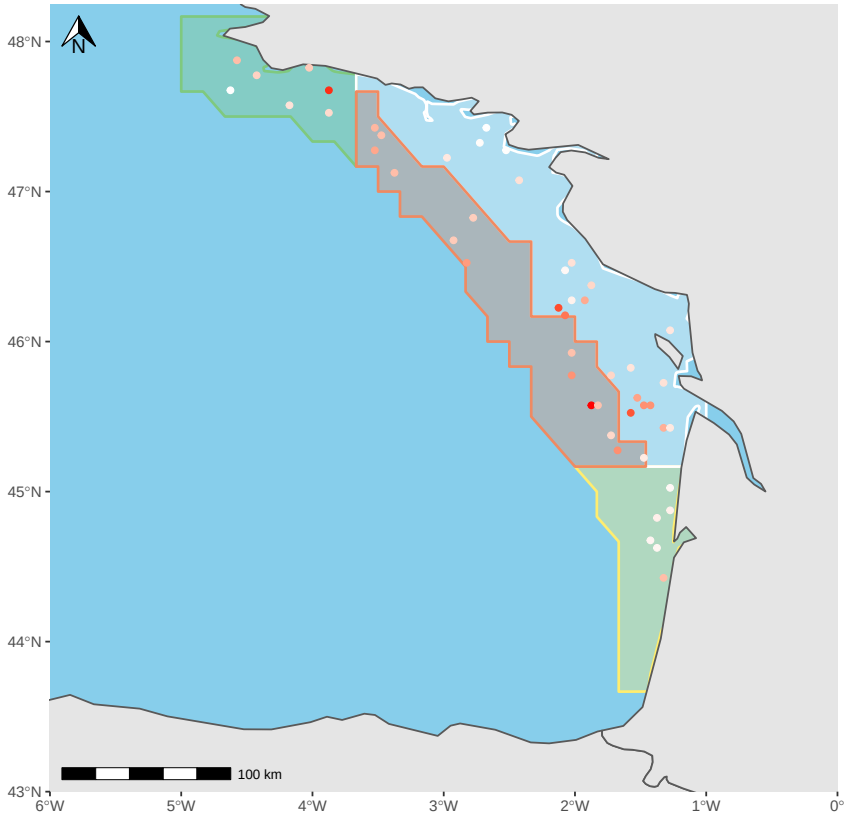
Conceptual diagram of common life-history stages of fish in coastal habitats: S = mature adults during spawning, J = immature juveniles, and F = feeding adults not in spawning. Arrows represent migrations (M).

(Brown *et al.*, 2018)

Scientific data

- Standardized sampling plan

- Expensive
- Sparse and limited spatio-temporal coverage

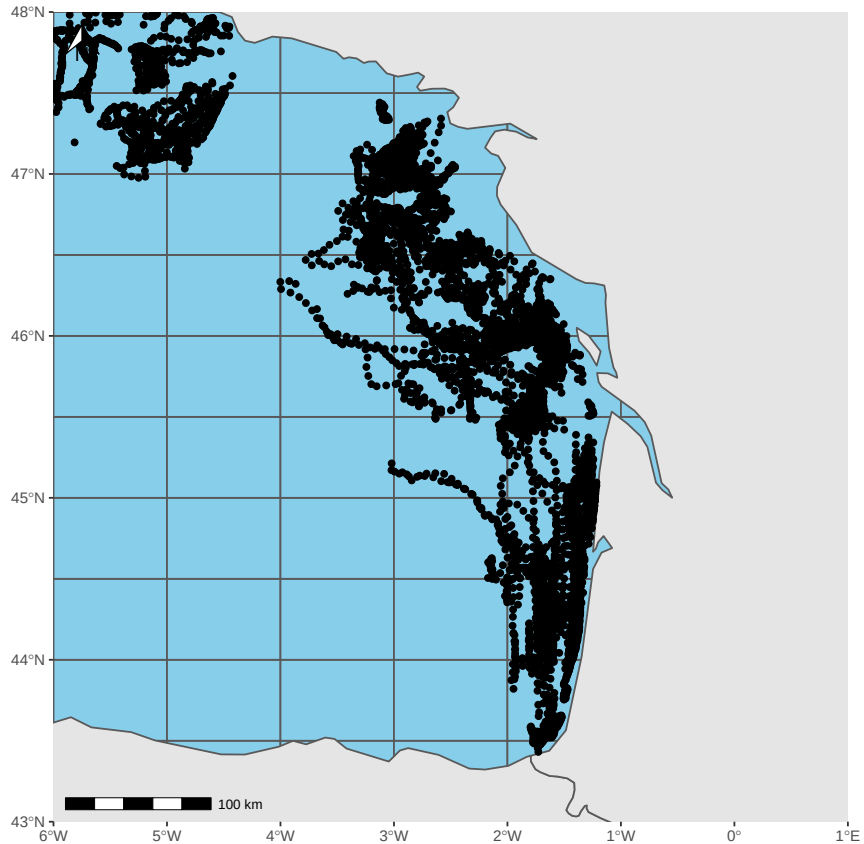


Orhago survey data - 2018

Commercial data (VMS x logbooks)

- Available data on the full year and dense coverage
- Costless (for scientists)

- Preferential behavior towards ressource
- Non-homogeneous fleets (varying catchability and targeting behavior)
- Reallocation of landings data on VMS pings



VMS data for otter trauls (OTB-DEF) - November 2018

Scientific question and objectives

Development of a hierarchical spatio-temporal model combining scientific and commercial data to infer fish spatial distribution

$\Rightarrow$ Identification of Essential Fish Habitats (with a focus on spawning grounds)

4 main dimensions :

Methodology **Ecology** **Fishery** **Management**

Scientific question and objectives

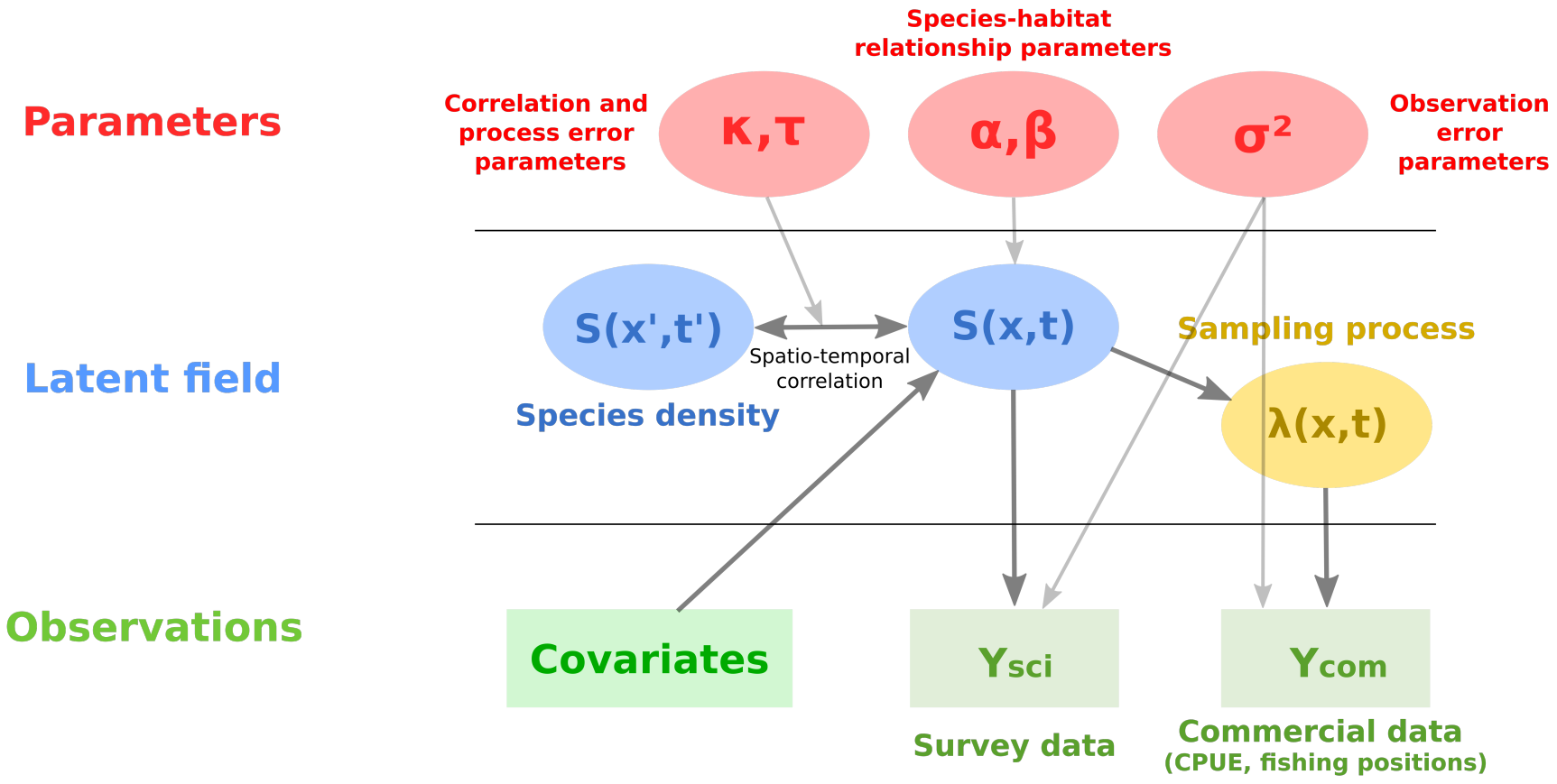
Development of a hierarchical spatio-temporal model combining scientific and commercial data to infer fish spatial distribution

$\Rightarrow$ Identification of Essential Fish Habitats (with a focus on spawning grounds)

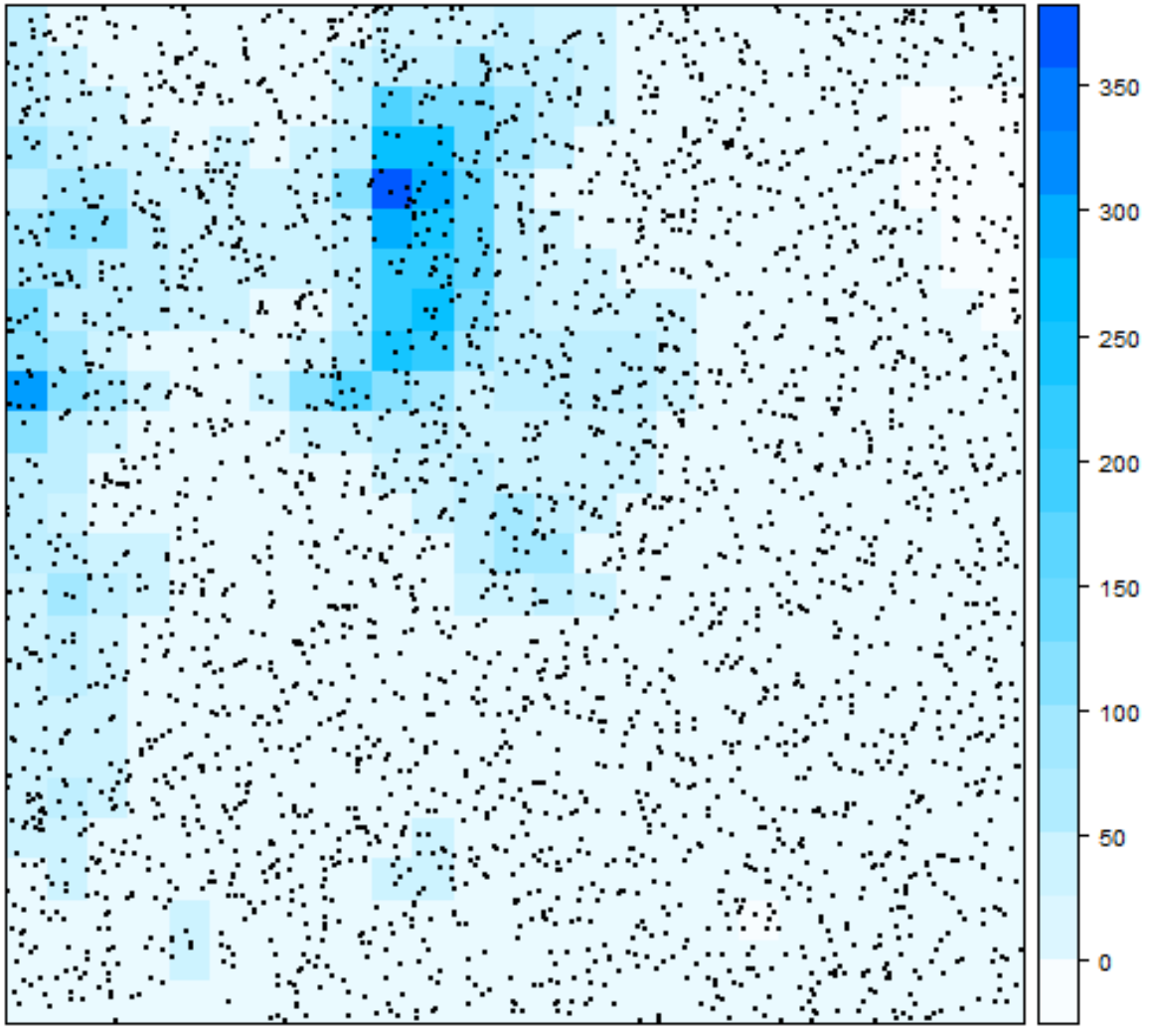
4 main dimensions :

Methodology **Ecology** **Fishery** **Management**

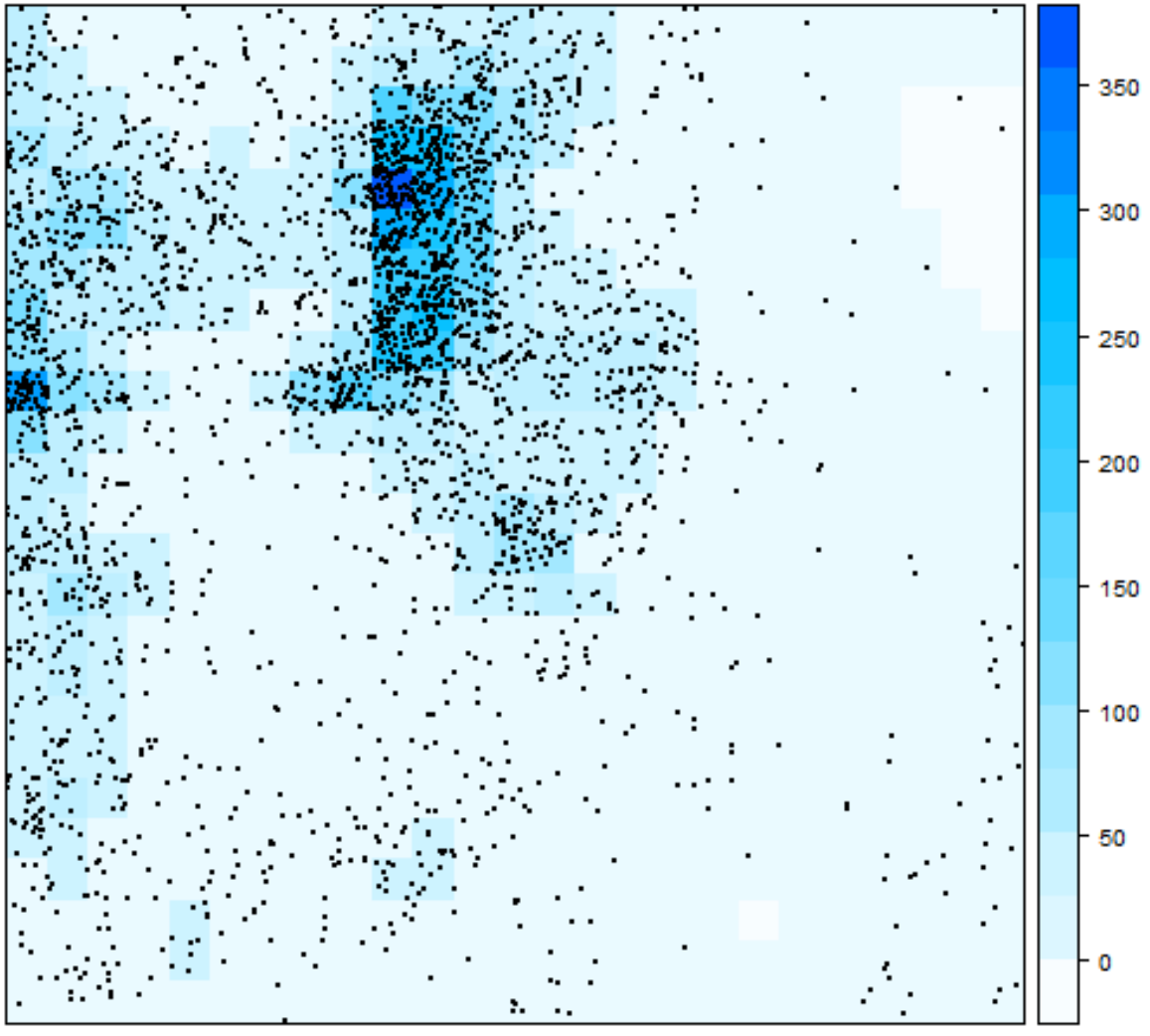
Spatio-temporal model



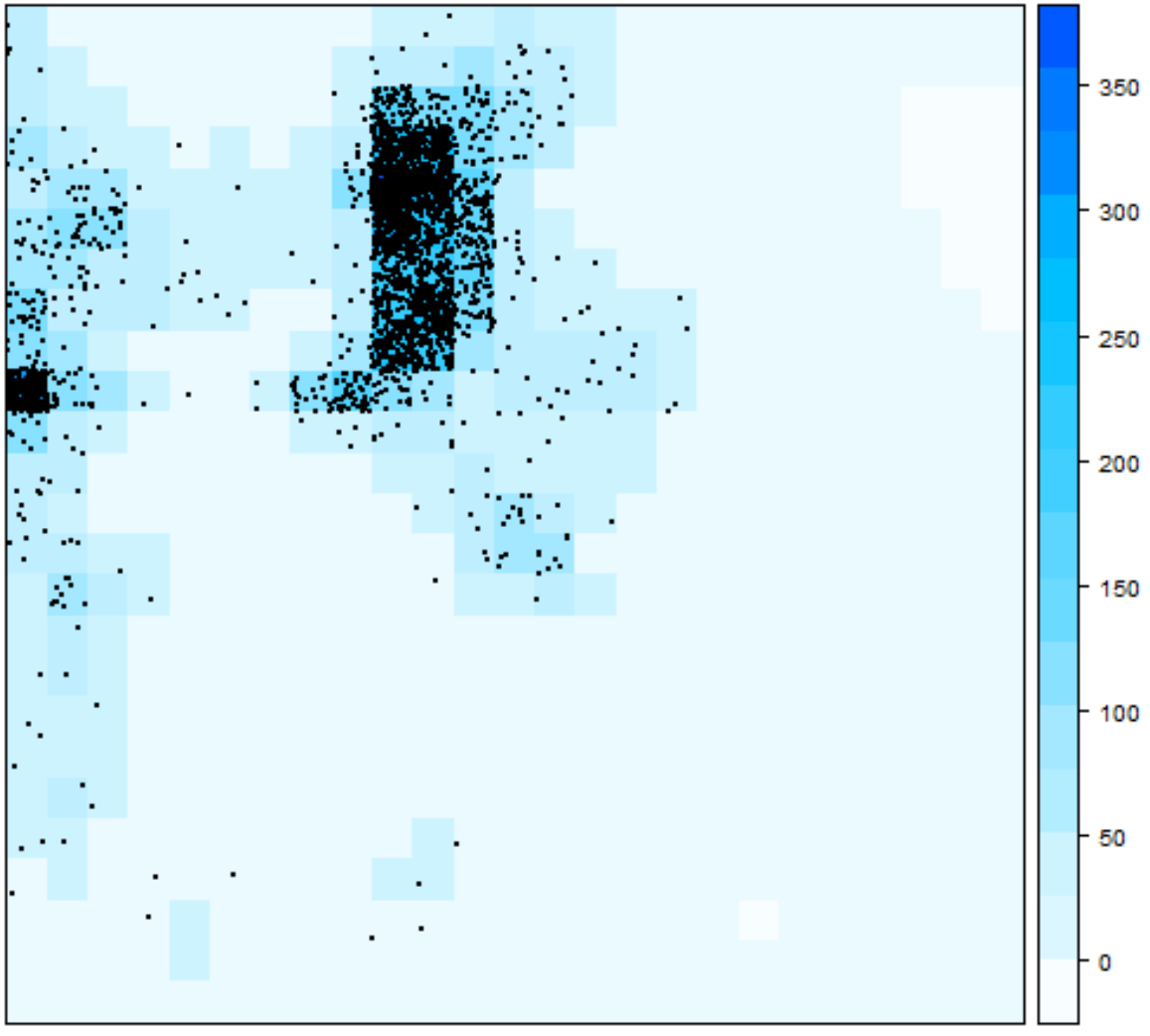
Basic ideas of the spatio-temporal model



Uniform sampling



Moderate preferential sampling

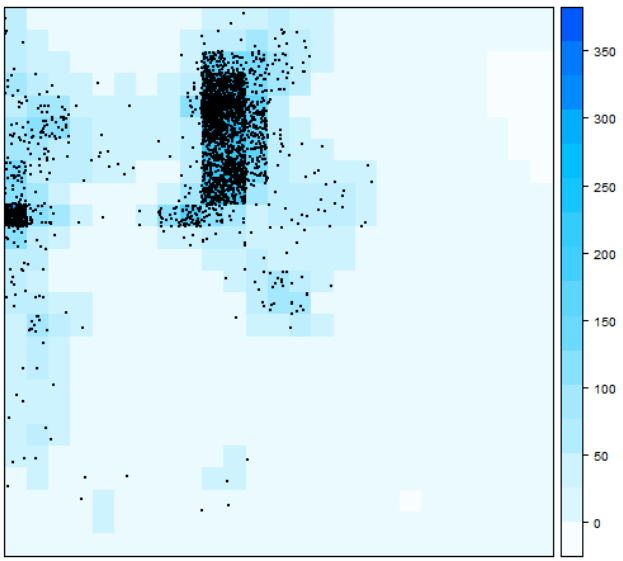


Strong preferential sampling

$$X_{com\,f} \sim \mathcal{IPP}(\lambda_f(x,t))$$

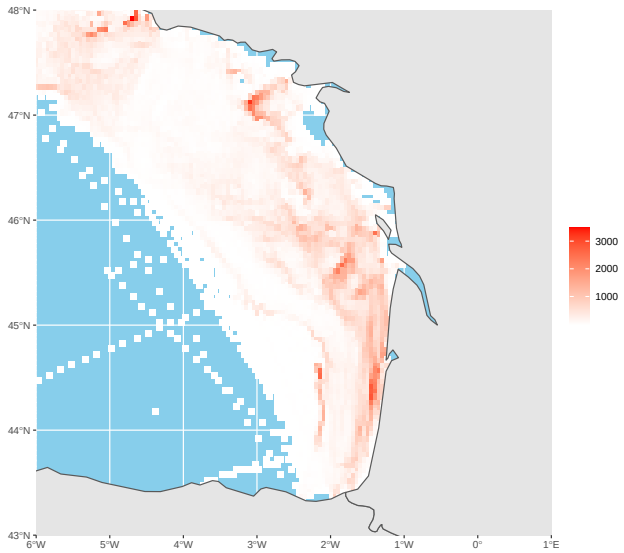
$$log(\lambda_f(x,t)) = \alpha_{X\,f}(t) + b_f(t).\log(S(x,t)) + \eta_f(x,t)$$

- $X_{com\,f}$: inhomogeneous point process
- $\lambda_f(x,t)$: commercial sampling intensity
- $\alpha_{X\,f}(t)$: intercept (seasonnal and yearly variation)
- $b_f(t)$: targeting parameter
- $S(x,t)$: biomass field
- $\eta(x,t) \sim N(0, Q_S^{-1})$
- f : fleet



Case study

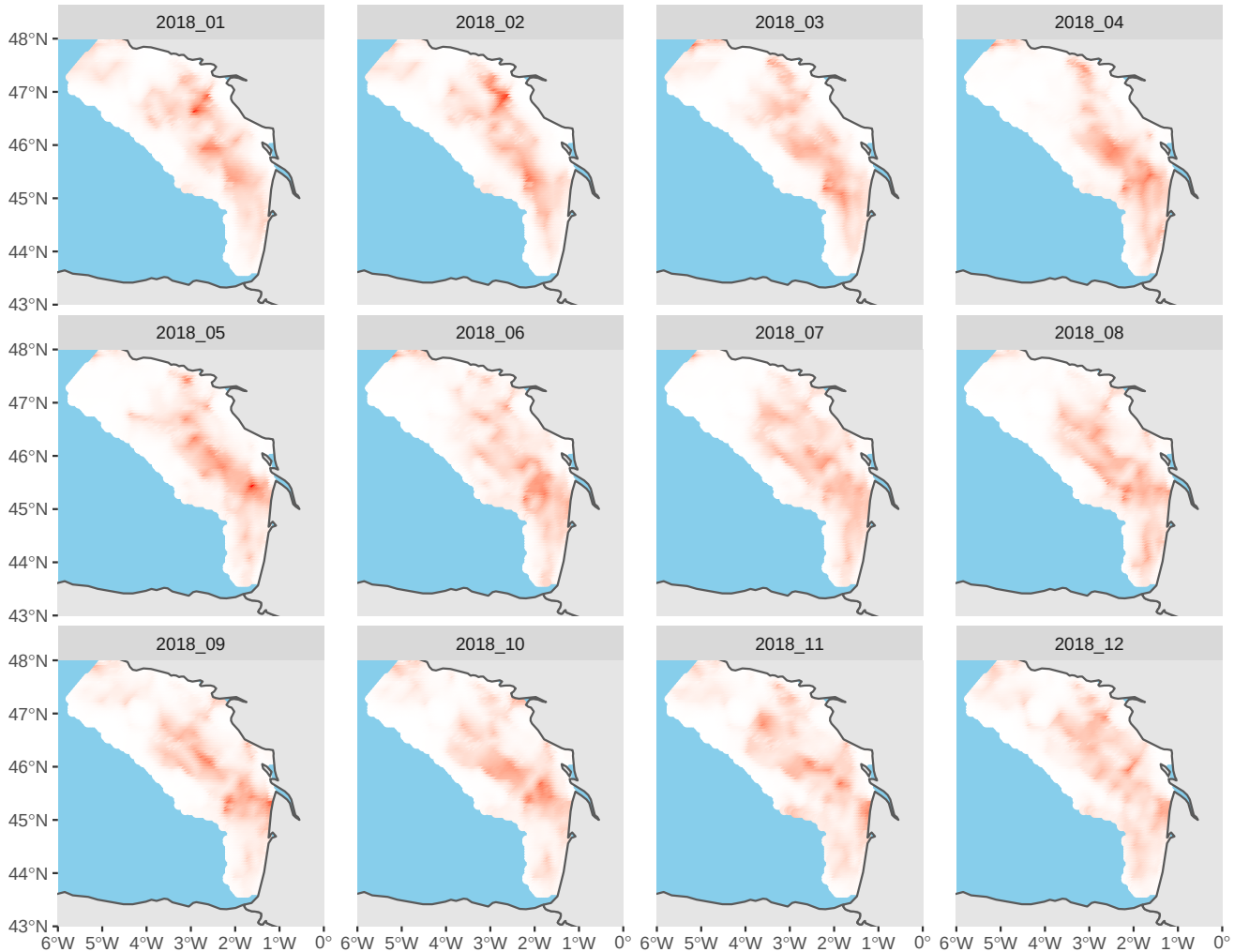
- Bay of Biscay common sole (catch = landings, well-known ecology, commercial interest)
- Commercial data from otter trawls targeting demersal species (fishing time as proxy of effort, good coverage of the area, relatively homogeneous catchability and targeting behavior)
- Filter mature fraction of landings
- Period : 2008 - 2018, monthly time step (132 time steps)



Map of effort in fishing hours - Otter trawls targeting demersal fish (OTB-DEF) - Agregated data from 2008 to 2018.

Solea solea (Linnaeus, 1758)

Predictions of the relative biomass random field



Monthly relative distribution of sole for the year 2018

Spatial patterns (EOF)

How to summarize the information of 132 maps and extract the main distribution patterns ?

$\Rightarrow$ **Empirical Orthogonal Functions (EOF)**

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

- $\overrightarrow{\mathbf{S}}_t^*$: normalized biomass field.
- $\vec{p}^k$: maps (or spatial patterns) which capture best the variance of $\overrightarrow{\mathbf{S}}_t^*$.
- $\alpha_k(t)$: temporal index informing when $\overrightarrow{\mathbf{S}}_t^*$ is distributed following the spatial pattern $\vec{p}^k$.
- $\vec{n}_t$: noise (or none relevant variation of the variable of interest).

von Storch (1999); Wikle *et al.* (2019)

Spatial patterns (EOF)

How to summarize the information of 132 maps and extract the main distribution patterns ?

$\Rightarrow$ **Empirical Orthogonal Functions (EOF)**

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

- $\overrightarrow{S}^*_t$: normalized biomass field.
- $\vec{p}^k$: maps (or spatial patterns) which capture best the variance of $\overrightarrow{S}^*_t$.
- $\alpha_k(t)$: temporal index informing when $\overrightarrow{S}^*_t$ is distributed following the spatial pattern $\vec{p}^k$.
- $\vec{n}_t$: noise (or none relevant variation of the variable of interest).

von Storch (1999); Wikle *et al.* (2019)

Spatial patterns (EOF)

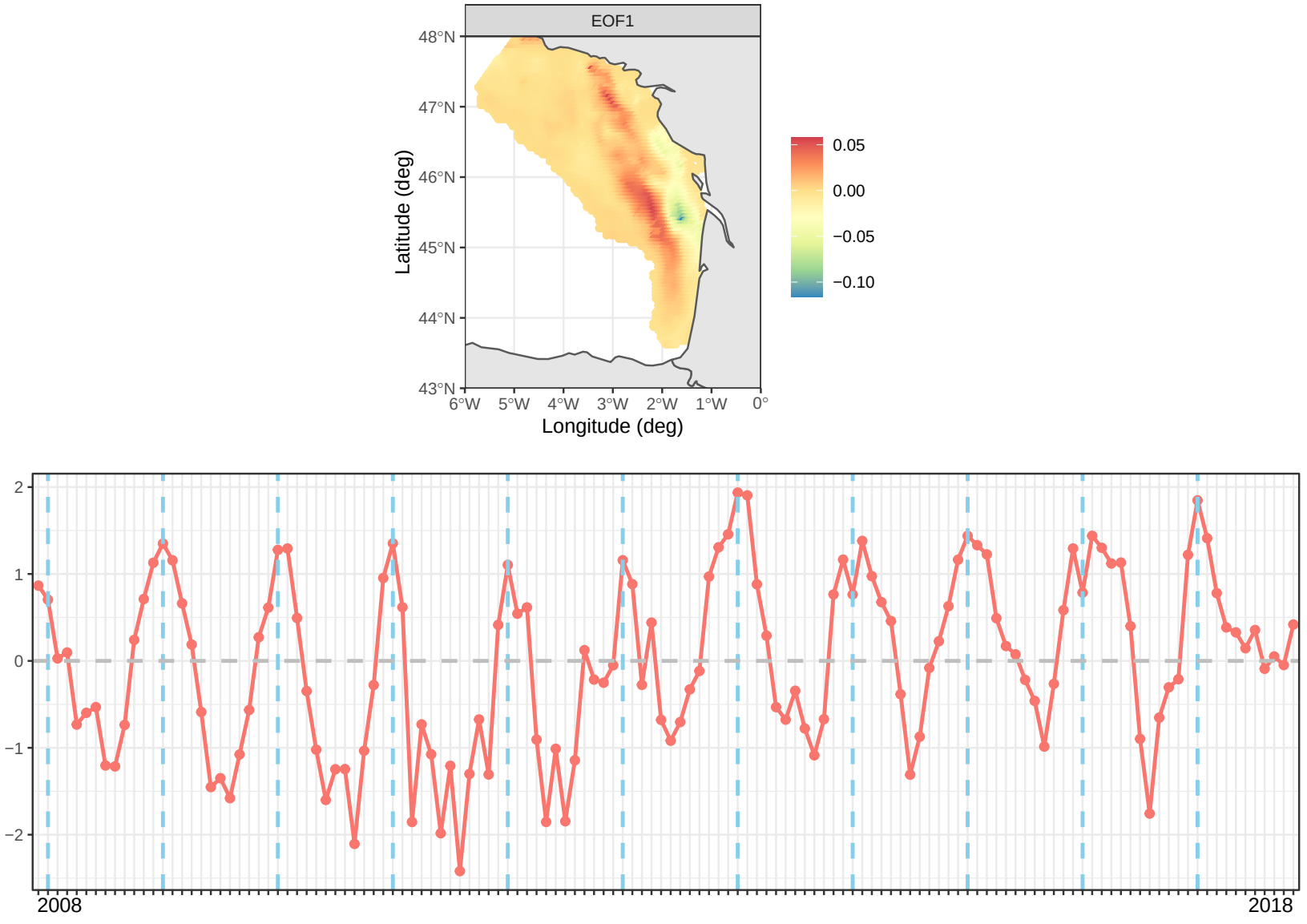
How to summarize the information of 132 maps and extract the main distribution patterns ?

$\Rightarrow$ **Empirical Orthogonal Functions (EOF)**

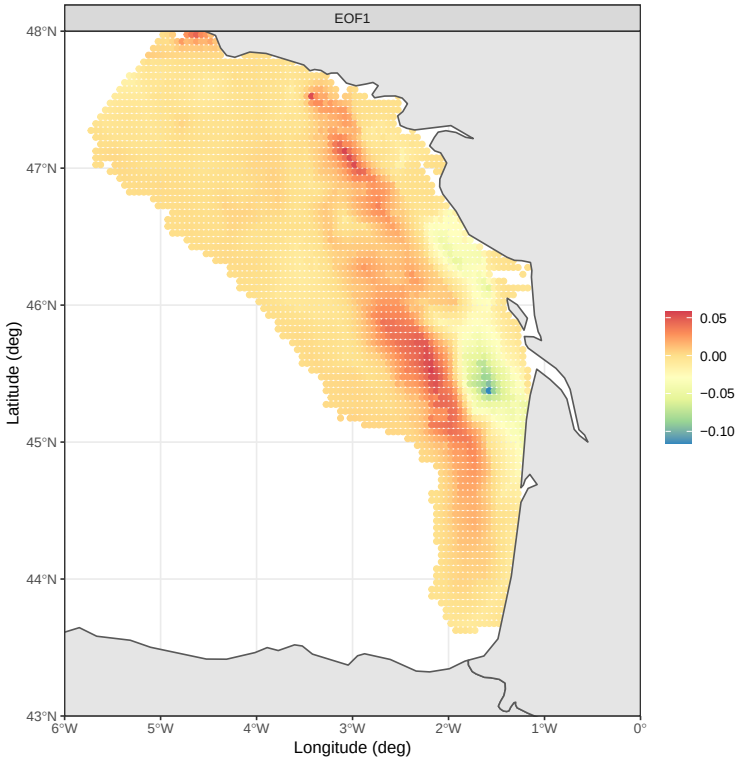
$$\overrightarrow{\mathbf{S}}_t^* = \sum_{k=1}^{K} \alpha_k(t)\vec{p}^k + \vec{n}_t$$

- $\overrightarrow{\mathbf{S}}_t^*$: normalized biomass field.
- $\vec{p}^k$: maps (or spatial patterns) which capture best the variance of $\overrightarrow{\mathbf{S}}_t^*$.
- $\alpha_k(t)$: temporal index informing when $\overrightarrow{\mathbf{S}}_t^*$ is distributed following the spatial pattern $\vec{p}^k$.
- $\vec{n}_t$: noise (or none relevant variation of the variable of interest).

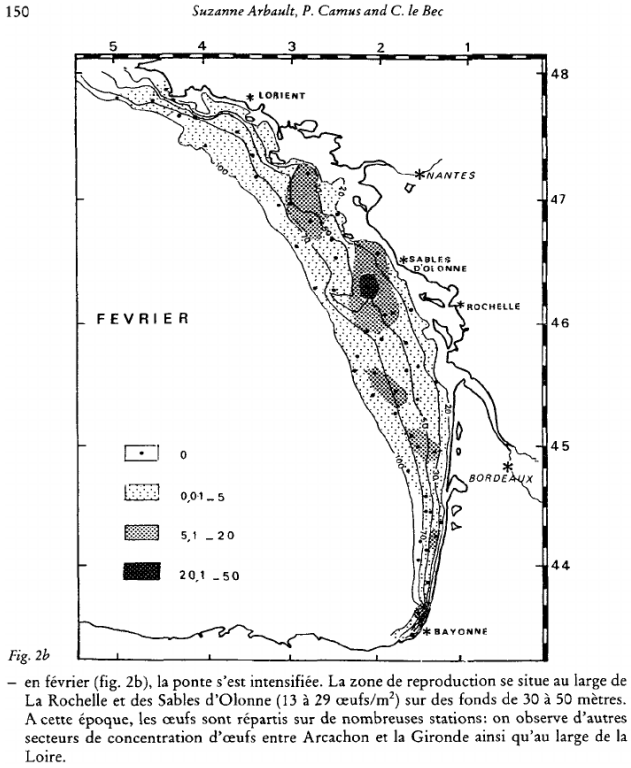
von Storch (1999); Wikle *et al.* (2019)



First EOF map (up) and related principal component (down). Blue line : February (reproduction period).



First EOF map - Main spatial pattern



Eggs and Larvae distribution

(Arbault *et al.*, 1986)

Targeting parameter

Parameters $b_f(t)$

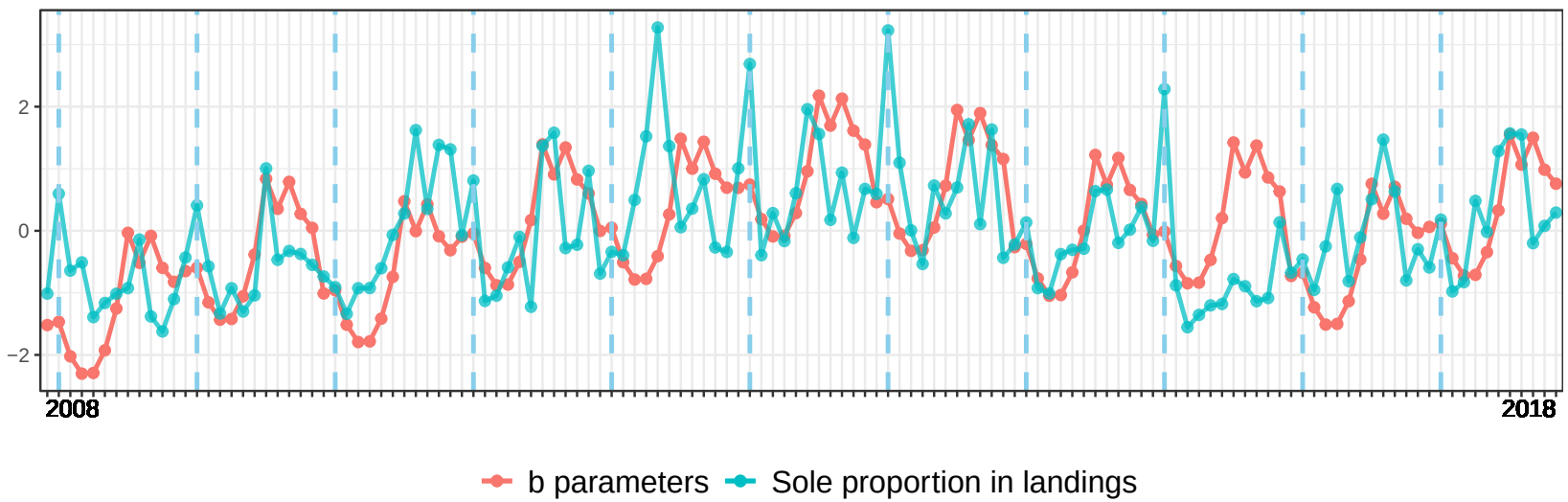
[0.8 ; 1.2]

vs.

Proportion of sole in landings

Alternative targeting indicator

[2,5 % ; 7.5 %]



Variables have been normalized

Conlusions

Approach with the potential to :

- capture main spatial patterns of the exploited fraction of the population $\Leftrightarrow$ **reproduction ecology of sole**
- estimate the strength of targeting towards the species of interest and its evolution in time

$\Rightarrow$ **Need for expert validation and additional applications**

Conlusions

Approach with the potential to :

- capture main spatial patterns of the exploited fraction of the population $\Leftrightarrow$ **reproduction ecology of sole**
- estimate the strength of targeting towards the species of interest and its evolution in time

$\Rightarrow$ **Need for expert validation and additional applications**

Conlusions

Approach with the potential to :

- capture main spatial patterns of the exploited fraction of the population $\Leftrightarrow$ **reproduction ecology of sole**
- estimate the strength of targeting towards the species of interest and its evolution in time

$\Rightarrow$ **Need for expert validation and additional applications**

Conlusions

Approach with the potential to :

- capture main spatial patterns of the exploited fraction of the population $\Leftrightarrow$ **reproduction ecology of sole**
- estimate the strength of targeting towards the species of interest and its evolution in time

$\Rightarrow$ **Need for expert validation and additional applications**

Perspectives

- Application to other case studies / other geographic areas

Hake

Sea bass

Anglerfish

Pilchard

- Extension of the model to include a multispecific targeting component and other drivers of targeting (tradition, management, etc.)

- Effect of landings reallocation on vessel GPS positions ? How does it affect model outputs ? How to account for reallocation in the modelling approach ?

Perspectives

- Application to other case studies / other geographic areas

Hake

Sea bass

Anglerfish

Pilchard

- Extension of the model to include a multispecific targeting component and other drivers of targeting (tradition, management, etc.)

- Effect of landings reallocation on vessel GPS positions ? How does it affect model outputs ? How to account for reallocation in the modelling approach ?

Perspectives

- Application to other case studies / other geographic areas

Hake

Sea bass

Anglerfish

Pilchard

- Extension of the model to include a multispecific targeting component and other drivers of targeting (tradition, management, etc.)

- Effect of landings reallocation on vessel GPS positions ? How does it affect model outputs ? How to account for reallocation in the modelling approach ?

Thank you for your attention!

Bibliography

Arbault, P. S., Camus, P., and Bec, C. le. 1986. Estimation du stock de sole (Solea vulgaris, Quensel 1806) dans le Golfe de Gascogne à partir de la production d'œufs. Journal of Applied Ichthyology, 2: 145–156. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1439-0426.1986.tb00656.x (Accessed 29 October 2020).

Brown, E. J., Vasconcelos, R. P., Wennhage, H., Bergström, U., Støttrup, J. G., van de Wolfshaar, K., and Millisenda, G. *et al.* 2018. Conflicts in the coastal zone: Human impacts on commercially important fish species utilizing coastal habitat. ICES Journal of Marine Science, 75: 1203–1213. Oxford University Press.

von Storch, H. 1999. Spatial patterns: EOFs and CCA. *In* Analysis of climate variability, pp. 231–263. Springer.

Wikle, C. K., Zammit-Mangion, A., and Cressie, N. 2019. Spatio-temporal Statistics with R. CRC Press.