Building a comprehensive framework to estimate bycatch risk in relation to fishing strategies

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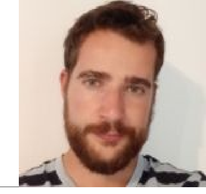
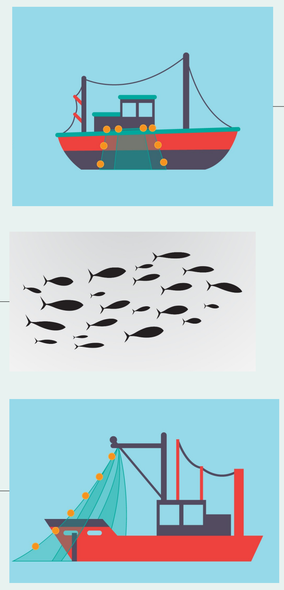


1) From fishing information (combination of catch profiles and effective fishing activity characteristics) to detailed yearly behaviours:

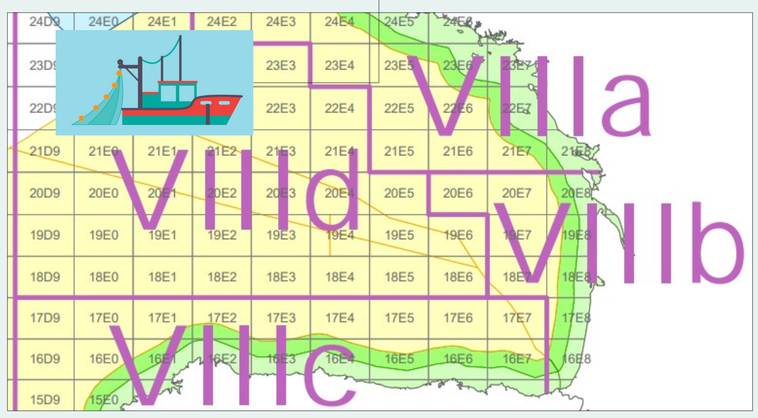
DATA

Landed taxa (sp, spp, family, order, isscaap code):
→ **fished taxa diversity** (richness, Simpson/Shannon index)
→ **weight and economic value of fished taxa** (altogether, most frequently associated taxa, and main taxa)
→ **main fished taxa** (also secondary/third taxa of importance when available) per fishing event occurrence, weight, economic value, fishing effort, productivity, **and their prevalence**
→ **main fishing stocks, and their prevalence**

Fishing gears:
→ **number of gears**
→ **main gear** (also main secondary gear when available) per fishing event occurrence, weight, economic value, fishing effort, productivity, **and its prevalence**
→ **weight, economic value, effort and productivity associated with the main gears**
→ **mesh size and gear dimensions** (when available, average or most dominant values, weighted by the same quantitative values as before)

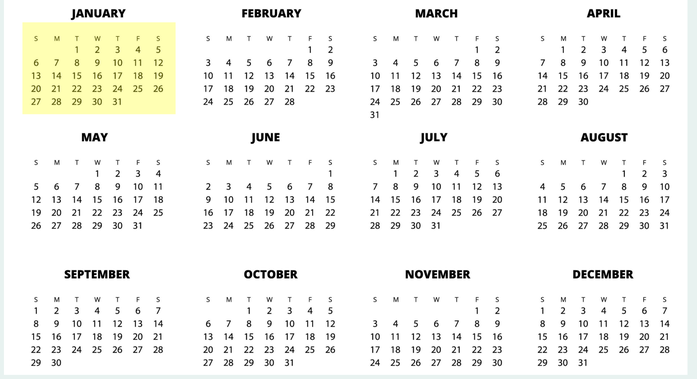


Vessel's characteristics:
→ **length**
→ **volume**
→ **power**
→ **age**
→ **flag**
→ **crew size**



Spatial activity (ZEE, ICES areas, statistic rectangles, distance to the coast):
→ **number of visited areas**
→ **main visited area** per fishing event occurrence, weight, economic value, fishing effort, productivity, **and its prevalence**
→ **weight, economic value, effort, and productivity associated with the main visited areas and the three main categories of distance to the coast** (i.e. coastal, offshore, or mixed activity)

Temporal activity (fishing effort, time at sea, main period of activity):
→ **number of fishing trips and fishing events**
→ **time spent fishing**
→ **time spent at sea** (cumulative time, day, month)
→ **main fishing month/trimester** per **fishing event occurrence, weight, economic value, fishing effort, productivity, and its prevalence**
→ **weight, economic value, effort, and productivity associated with each month and trimester**



Scales at which strategies (and how they vary) are considered:

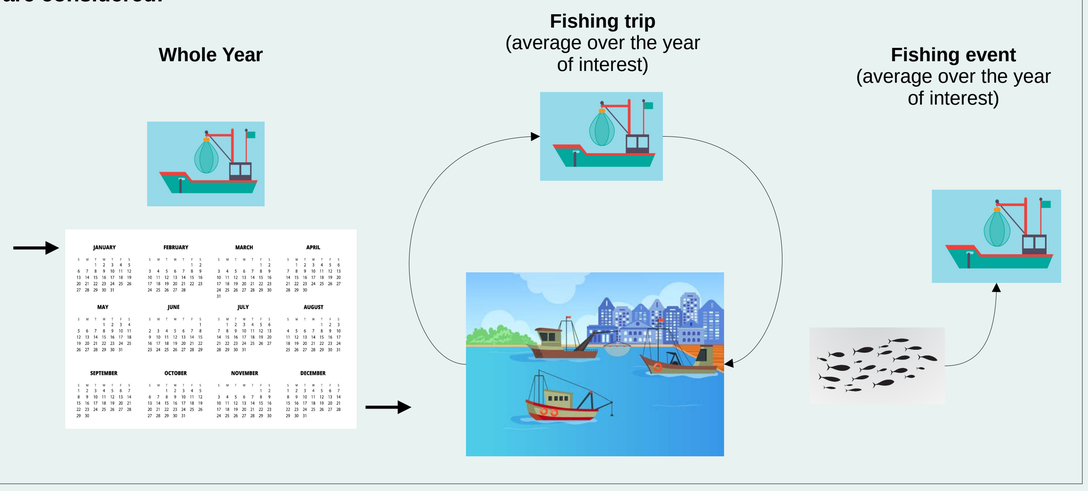


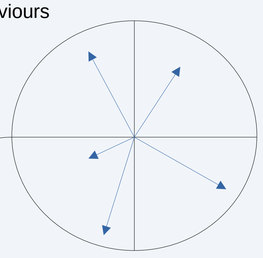
Image: Freepik.com

2) From detailed fishing behaviours to strategy clusters:

METHODS

Hierarchical Clustering on Principal Components (Lê et al. 2008), using previously computed strategy variables without missing value (we removed before that 1% of vessels with missing values for the most fundamental strategy variables):

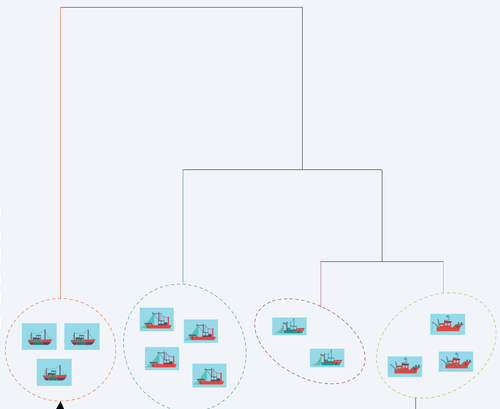
a) **Factor analysis of mixed data**, for synthesizing all information on fishing behaviours



Reduction of data dimension using only axes retaining the most of data variance (using Kaiser rule)

b) **Determining the optimal number of cluster**, using cluster stability metrics obtained through bootstrap (Fang and Wang, 2012, Hennig 2007, in "fpc" package)

c) **Hierarchical clustering** using Ward's criterion on the selected principal components, consolidation with **k-means** (initialized using hierarchical clustering results)



Clusters with homogeneous fishing behaviours: considered as fishing strategies

If clusterable, **the clustering method is applied recursively** on the strategy of interest to obtain **sub-strategy categories** (could be performed until obtaining a satisfying level of precision or until no more clusterability is reached)

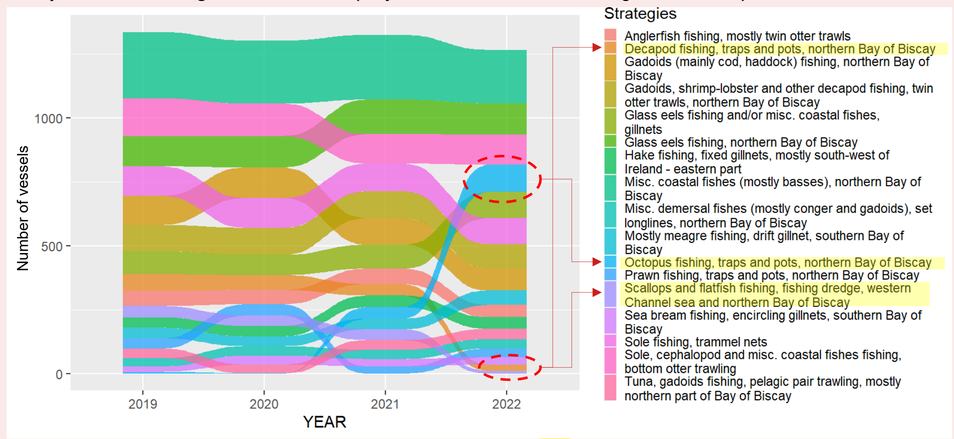
Testing for clusterability of this new dataset (Hopkin test / dip test depending on sample size >100 / <100 + Dudahart test for binary clusterization)

Re-attribution of behavioural variables available for the cluster of interest

3) Strategies' distribution and dynamic, the Bay of Biscay example (2019-2022):

→ Focus on the vessels operating in the french part of the Bay of Biscay (27.8.a and 27.8.b ICES areas), selection of all vessels with at least one fishing operation in these areas (N~6000)

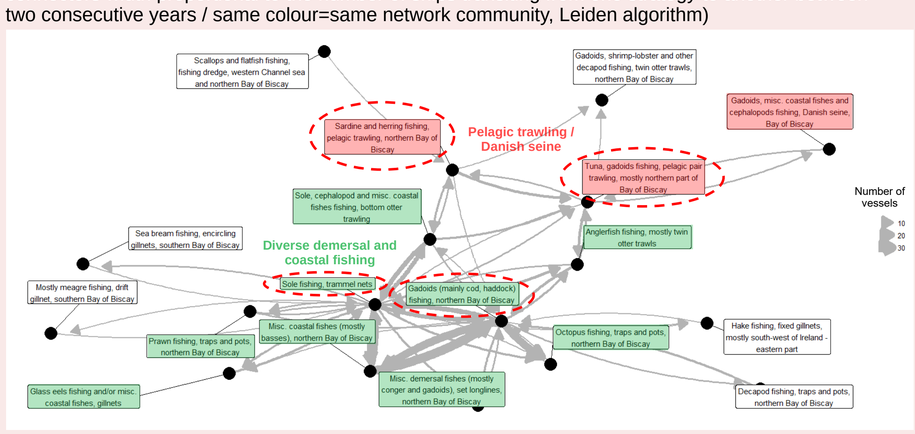
Bump chart of strategies distribution (only the most numerous strategies: first third)



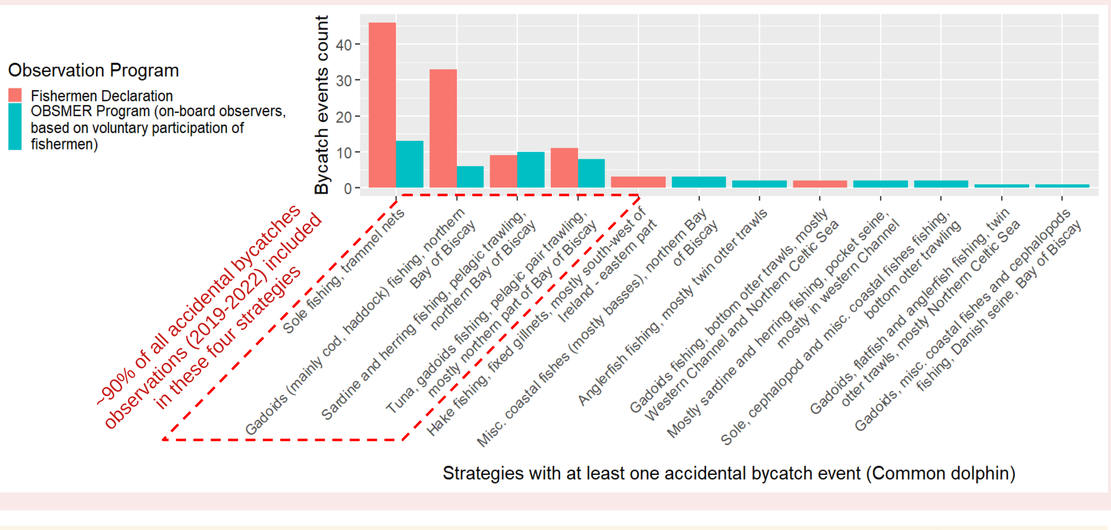
: Strategies whose distribution significantly increases or decreases throughout years (multinomial glm)

→ Strategies are designated by the fishing behaviours statistically predominant within the group, but the presence of multiple behaviours within the same strategy does not imply that all vessels conform to each of these behaviours.
Please note that the descriptions provided are simplified for clarity and may not fully capture the intricate complexity of the observed strategies.

Strategy network (only the strategies connected to the ones associated with most of bycatch events / connectors width proportional to the number of ships transiting from one strategy to another between two consecutive years / same colour=same network community, Leiden algorithm)

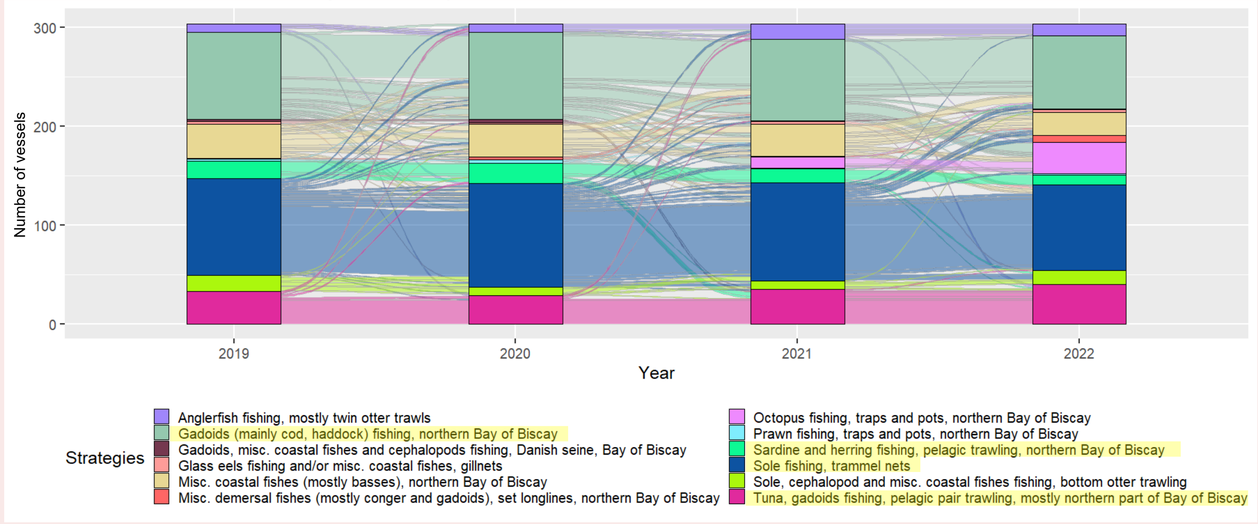


Common dolphin bycatch distribution among strategies



RESULTS

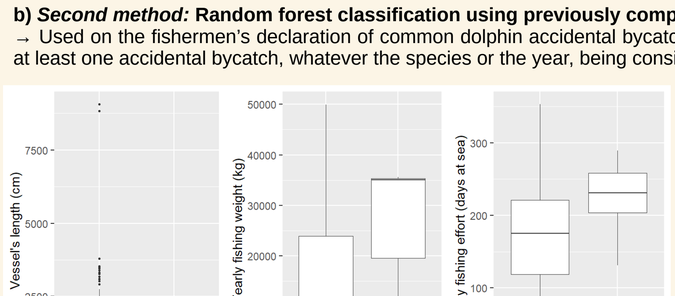
Alluvial plot of strategies transitions (only strategies connected to the ones associated with most of bycatch events)

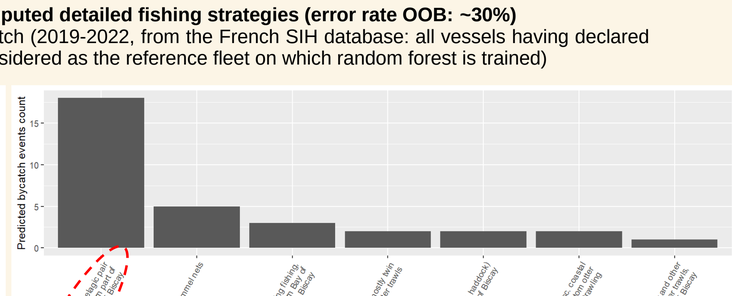


4) Estimating bycatch within defined strategies:

a) *First method:* Estimating Bycatch From Non-representative Samples: Simulation Study With Regularized Multilevel Regression and Post-stratification (Authier et al. 2021)
→ Used on the French ObsMer program (external observers on fishing vessels, volunteer-based), with a focus on pair trawlers and common dolphins in the Bay of Biscay (Rouby et al. 2022)

b) *Second method:* Random forest classification using previously computed detailed fishing strategies (error rate OOB: ~30%)
→ Used on the fishermen's declaration of common dolphin accidental bycatch (2019-2022, from the French SIH database: all vessels having declared at least one accidental bycatch, whatever the species or the year, being considered as the reference fleet on which random forest is trained)





DEVELOPMENTS

QR code to personal GitHub
→ Access to source codes (R) on all previously considered analyses and in-progress developments (no data available and no update upcoming on this specific repository for confidentiality reasons)

SCAN ME

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