

PICES/ICES/FAO
International Symposium on Small Pelagic Fish
(SPF-2026)
La Paz 4-8 May 2026

Topic Session 5. Spatiotemporal Dynamics of Small Pelagic Fishes in a Changing Ocean

Modelling the seasonal spatial distribution of European anchovy
(*Engraulis encrasicolus*) using Fishery-Dependent Data in two regions of
the Mediterranean Sea

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Scientific background

Fish species spatial distribution is basically investigated using scientific survey data

- ✚ Standardize Sampling Protocols
- Once Year Monitoring (low temporal resolution)

Small Pelagic Species
Mediterranean Sea - Spawning period



SPF in the Mediterranean area affected by strong seasonal variation in abundance and distribution

Objectives

↙ reduce knowledge gap

Investigate how environmental variability drives seasonal spatial changes in habitat suitability of European anchovy (*Engraulis encrasicolus*) in two Mediterranean areas.



most landed SPF species by the Italian fishing fleet

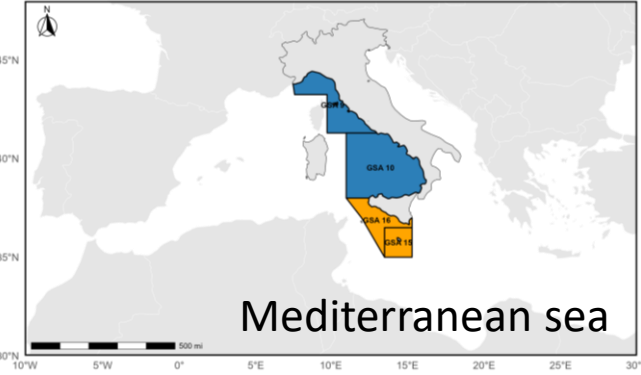
How:

apply presence/absence species distribution models using Fisheries Dependent Information

- ✚ Wide temporal resolution (*daily data all over the year*)
- Preferential Sampling (*autocorrelation*)

New data source

Material and Methods | Study Areas

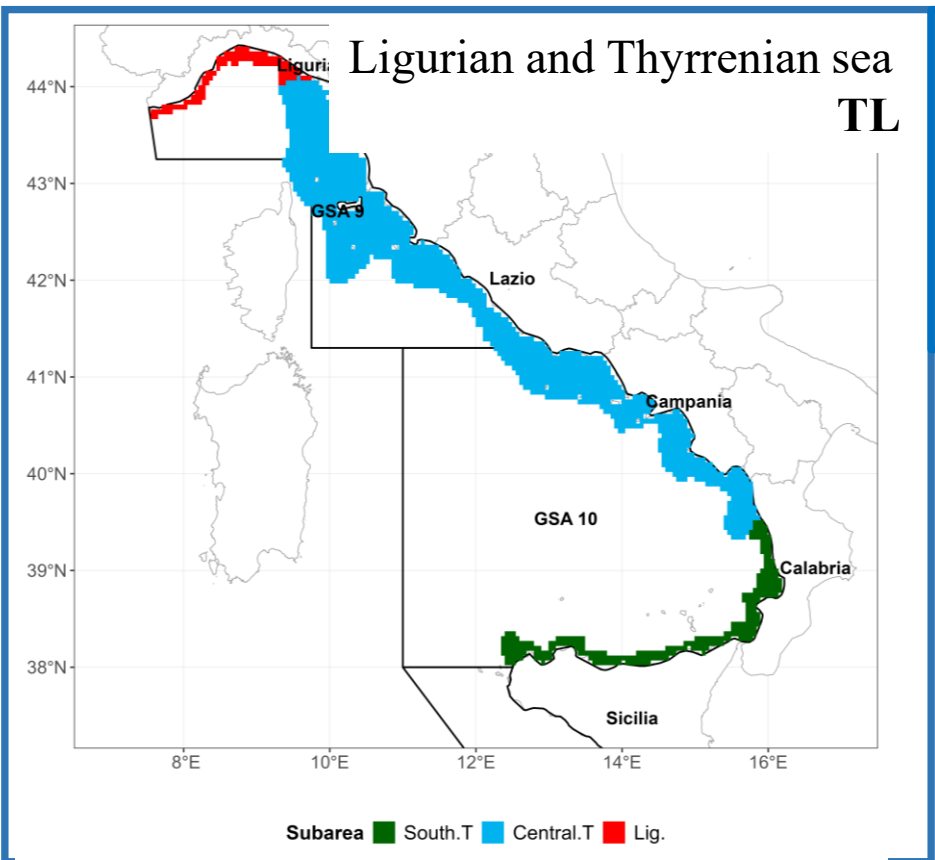


Study area 1 (*blue*): Ligurian and Tyrrhenian seas (GSA 9, GSA 10)

Study area 2 (*orange*): Sicily Strait (GSA 16, GSA 15)

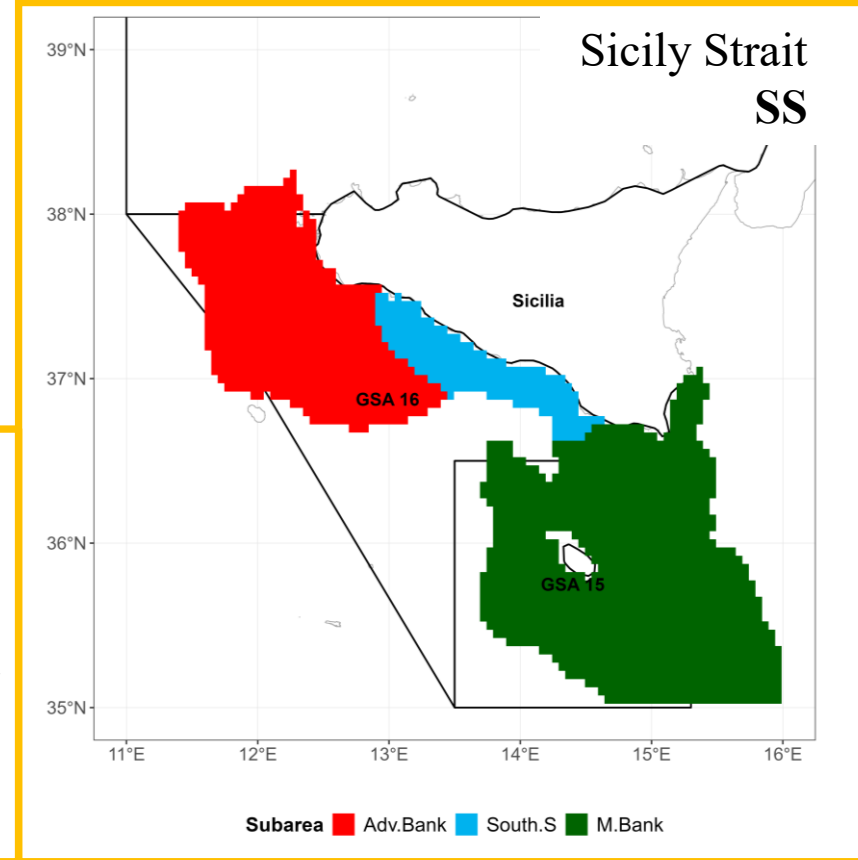
Spatial domain: considering portion of the study areas with a depth less than 1000 m

Subareas: different sectors with different continental shelf widths



TL:
 narrow continental shelf
 complex geomorphology
gulfs and archipelago
 oligotrophic area

SS:
 2 extended continental shelves
 highly hydrodynamic area
 complex oceanography
submesoscale processes
 Upwelling systems



Subarea ■ Adv. Bank ■ South.S ■ M. Bank

Material and Methods | Anchovy occurrences

Data input: Fisheries Dependent Information (FDI) of italian fleet

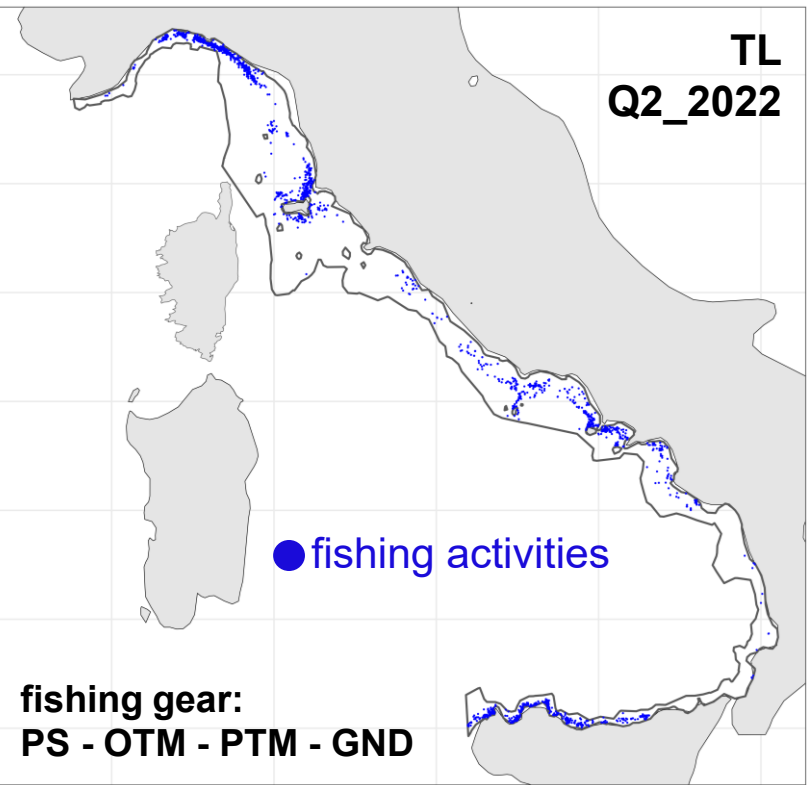
raw.data: **e-logbook 2020 - 2023**

Departure (**DEP**); Fishing activity report (**FAR**) - Return (**RTP**) - Landings activity (**LAN**)

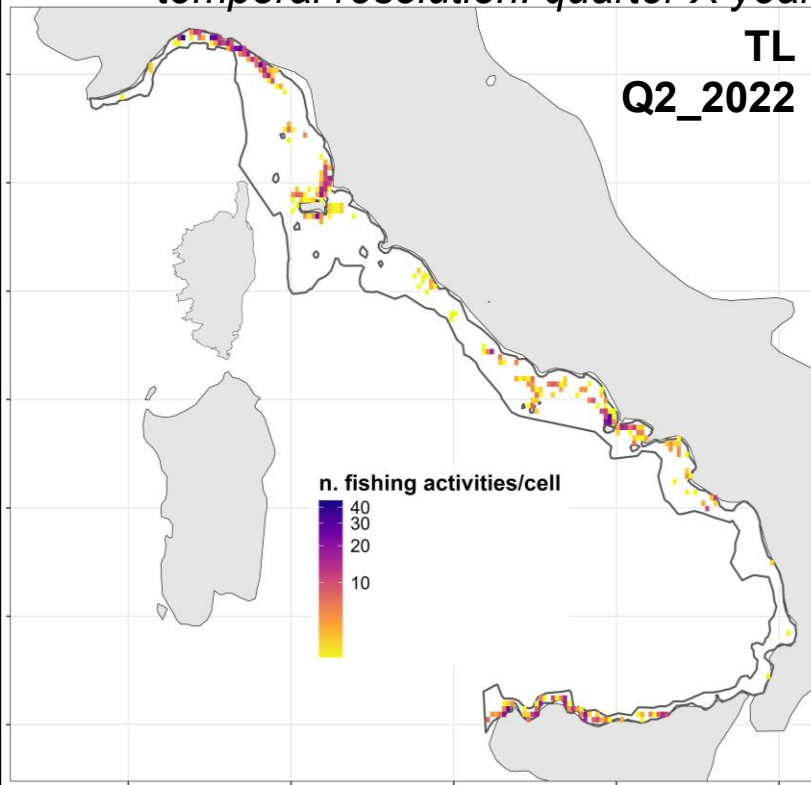
European Fisheries DCF



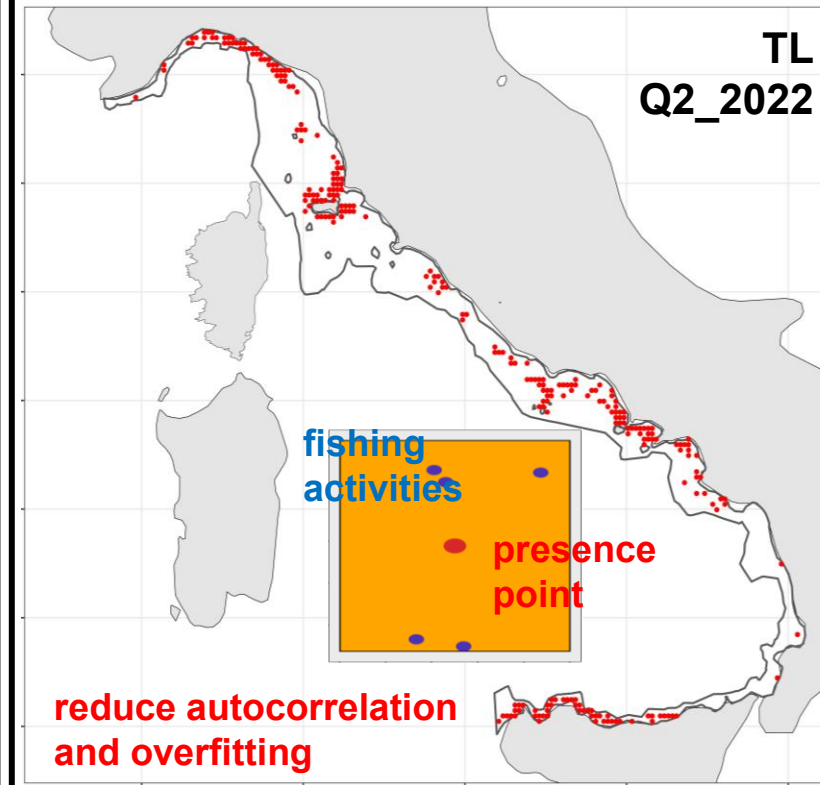
1 DEP + FAR + RTP + LAN
Fishing trips with Ea in catches
georeferenced fishing activities



2 Map fishing activities on grid
resolution $0.05^\circ \times 0.05^\circ$ cell
temporal resolution: quarter X year



3 Extract presence points
centroid of cells with fishing activities > 1



sources:



<https://marine.copernicus.eu>

Biogeochemical

MEDSEA_MULTIYEAR_BGC_006_008

nppv - Chl

Physical

MEDSEA_MULTIYEAR_PHY_006_004

Sal - Mlotst - Bottom T - Sst

monthly
 $0.042^\circ \times 0.042^\circ$



EMODnet

European Marine
Observation and
Data Network

EMODnet Digital

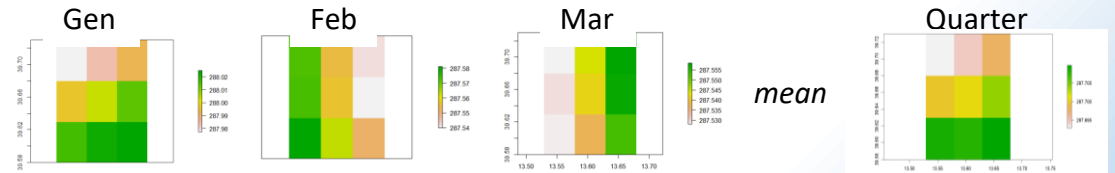
Bathymetry

(DTM 2016)

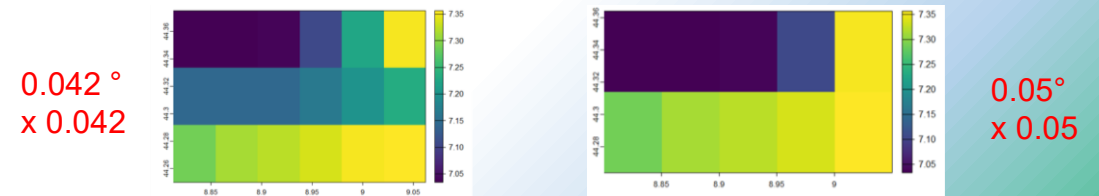
$250 \times 250 \text{ m}$

processing:

temporal resolution: *quarterly average*



Spatial resolution: *remapping covariates*
on the grid used for the fishing activities



output = grid with covariates and fishing
points at resolution $0.05^\circ \times 0.05^\circ$

True absences not deducible from e-logbook
 generation of **pseudoabsences**
 reverse niche approach → species multidimensional ecological space from presence points

1 ecological space

combination of discrete covariates values



discretize covariates
 Scoot rule (bin width)

| | | |
|--------|-----------------------------|---|
| nppv | 0.32 mg/m ³ /day | most significant predictors in bibliography on sdm Ea in the Mediterranean |
| Sal | 0.018 PSU | |
| Sst | 0.44 °C | |
| Mlosts | 2.57 m | |

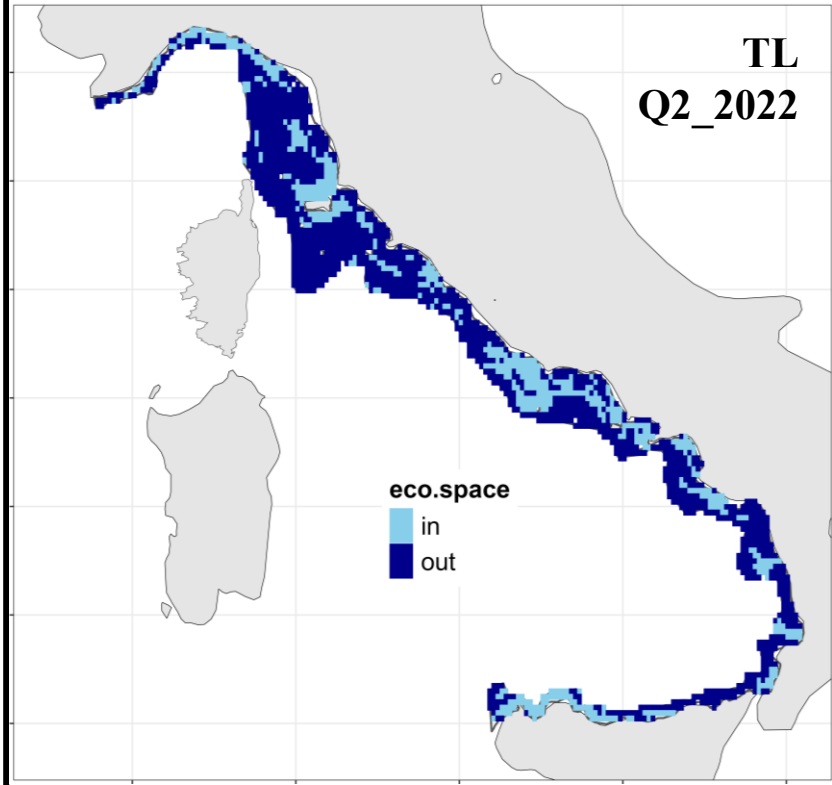


associate each cell of the grid to a combination of discretized covariates values

considering quarter as temporal resolution for preferential conditions

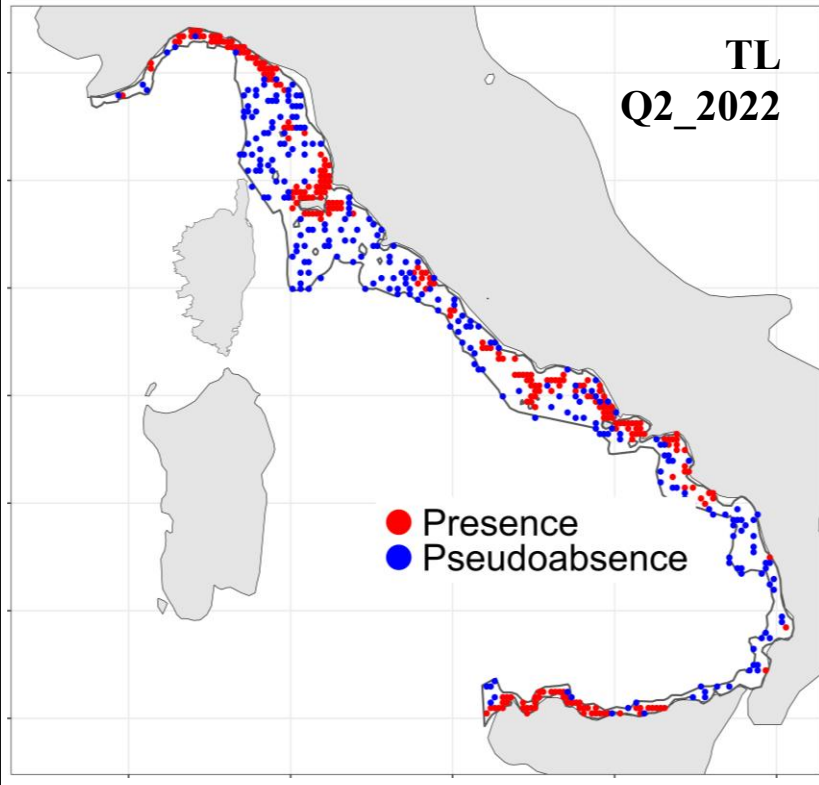
2 map preferential conditions

for each quarter and each year



3 generate pseudoabsence

Random select cell out the eco-space
 Prevalence = 1



Material and Methods | Modelling approach

Binomial Generalized Additive Models (logit link function)

spatio-temporal categorical factor

$$\text{logit}(\pi_i) = \log\left(\frac{\pi}{1 - \pi}\right) = \beta_0 + \underbrace{s_1(x_{1i}) + s_2(x_{2i}) + \dots + \beta_k z_k}_{\text{covariates}}$$

Model selection:

Predictor selection (simple models)
PA ~ s(Cov1) + s(Cov2)
PA ~ s(Cov1) + subarea

**Testing interactions
Testing stratification space/time**
PA ~ s(Cov1) + te(Cov2, Cov2)
PA ~ s(Cov1, by = quarter/subarea)

**Cross - validation
Temporal K - fold**
Test (3 years)
Validation (1 year)
AUC - ROC CURVE

deviance explained, AIC and predictors significance

Analysis of concurvity

Analysis of residuals (K-S test; Dispersion test - DHARMA)

Parsimony principle

Best fit model

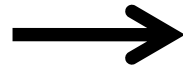
Seasonal habitat suitability maps

Results | Occurrences data

PS - Purse Seine
PTM - Midwater Pair Trawling

Processed e-logbook (2020-2023)

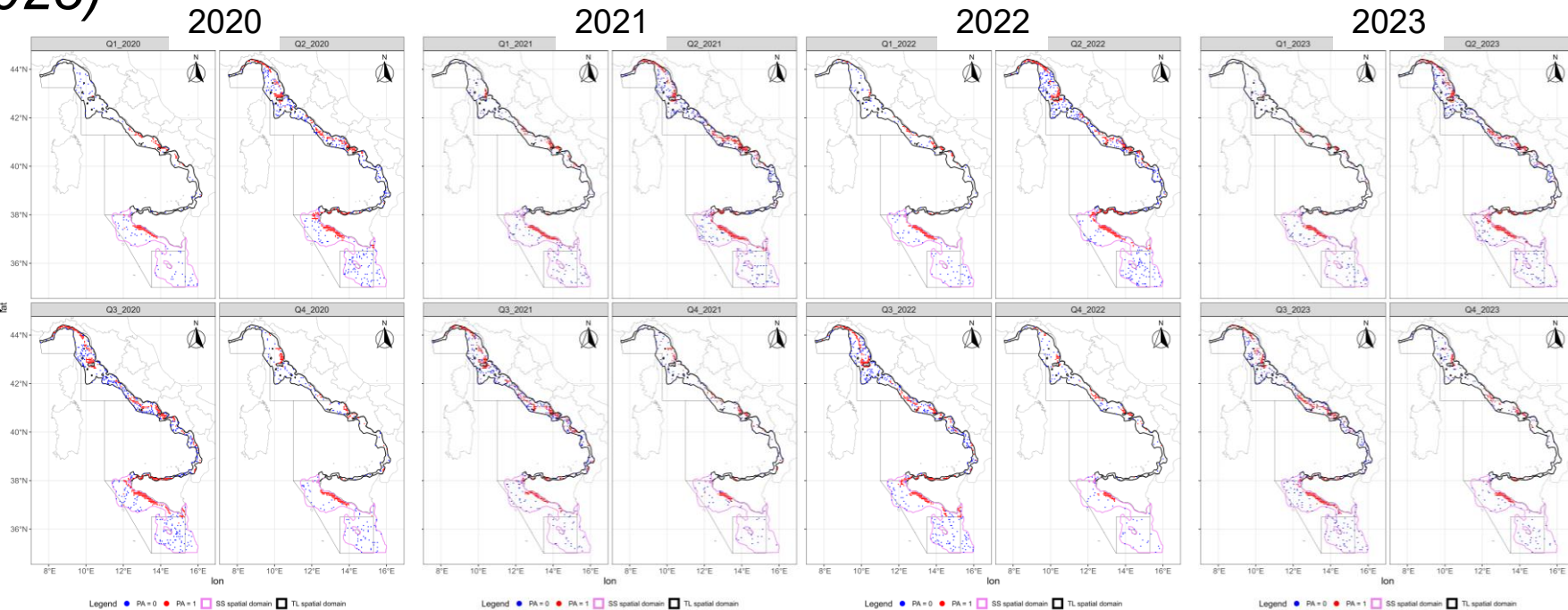
| | | |
|------------|-------|-------|
| | TL | SS |
| f.trips | 15468 | 11713 |
| main gears | PS | PTM |



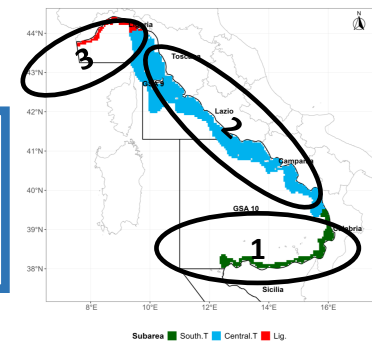
- fishing trips duration less than 1 day
- mostly a single fishing activity for PS
- more fishing activities for PTM
- consistent spatial pattern over the years
- strong seasonality for PS, less for PTM

Presence points (2020-2023)

| | | |
|----|------|------|
| | TL | SS |
| Q1 | 254 | 285 |
| Q2 | 907 | 441 |
| Q3 | 952 | 408 |
| Q4 | 307 | 212 |
| | 2420 | 1346 |

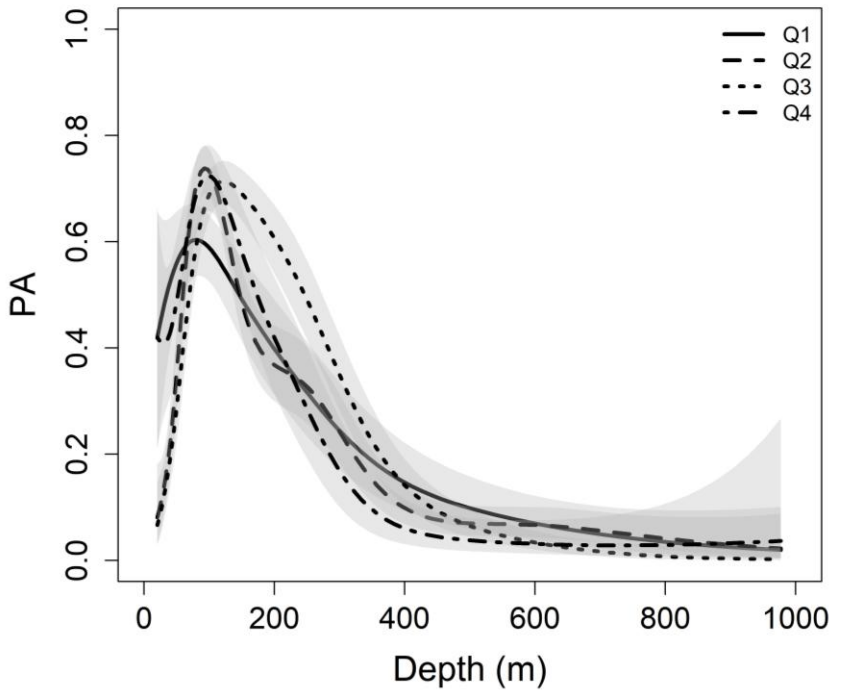


Results | Anchovy seasonal habitat suitability TL



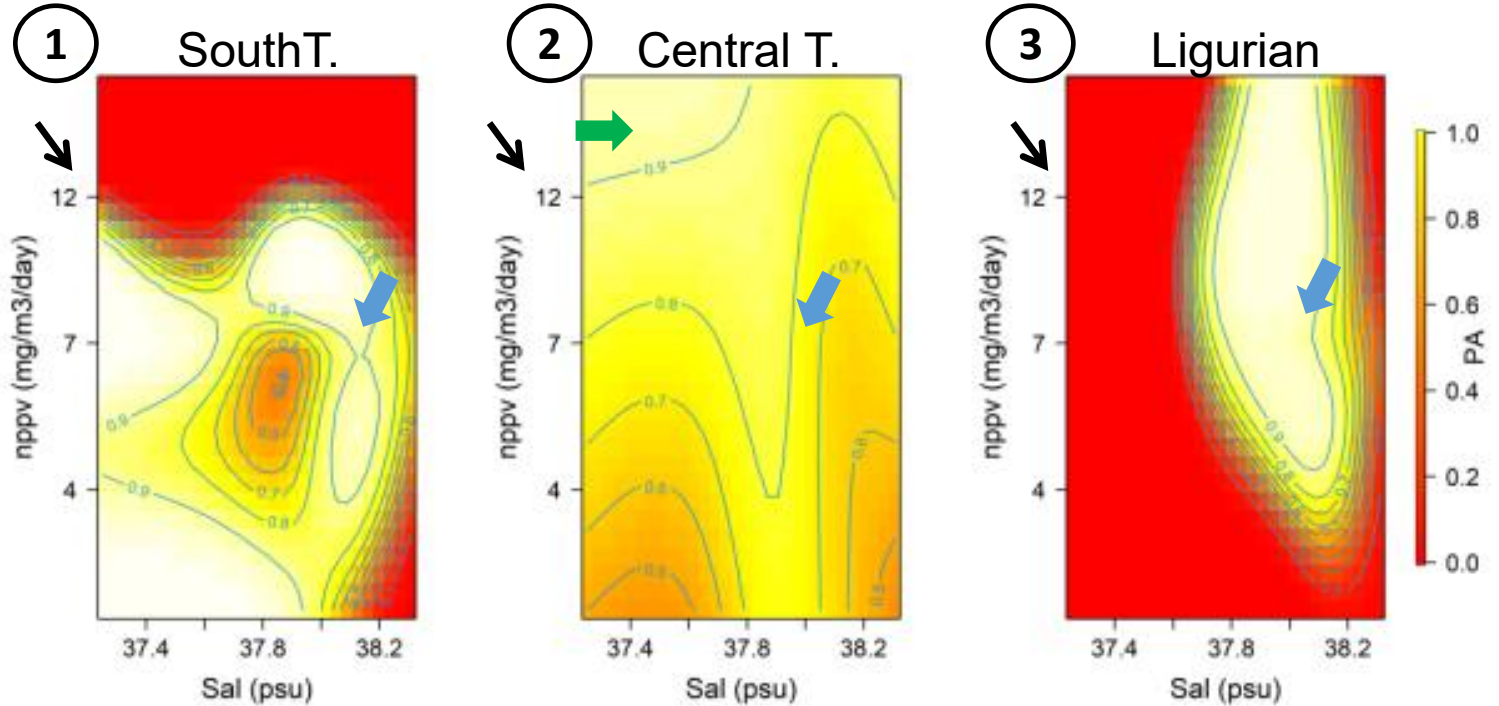
| formula | dev.exp | AIC | AUC |
|---|---------|------|------|
| $PA \sim s(\text{depth}^{1/3}, \text{by} = \text{quarter}) + \text{te}(\text{Sal}, \ln(\text{nppv}), \text{by} = \text{subarea})$ | 29.8 | 4843 | 0.84 |

$s(\text{depth}^{1/3}, \text{by} = \text{quarter})$



winter < 100 m
 spring and autumn < 150 m
 summer < 250 m

$\text{te}(\text{Sal}, \ln(\text{nppv}), \text{by} = \text{subarea})$



↘ Positive effect: highest nppv in all subareas
 → In the Central T. main positive at low salinity values
 ↙ Positive effect at decreasing gradient in nppv at high salinity

Results | Anchovy seasonal habitat suitability TL

Proportion of cells with $P > 0.6$

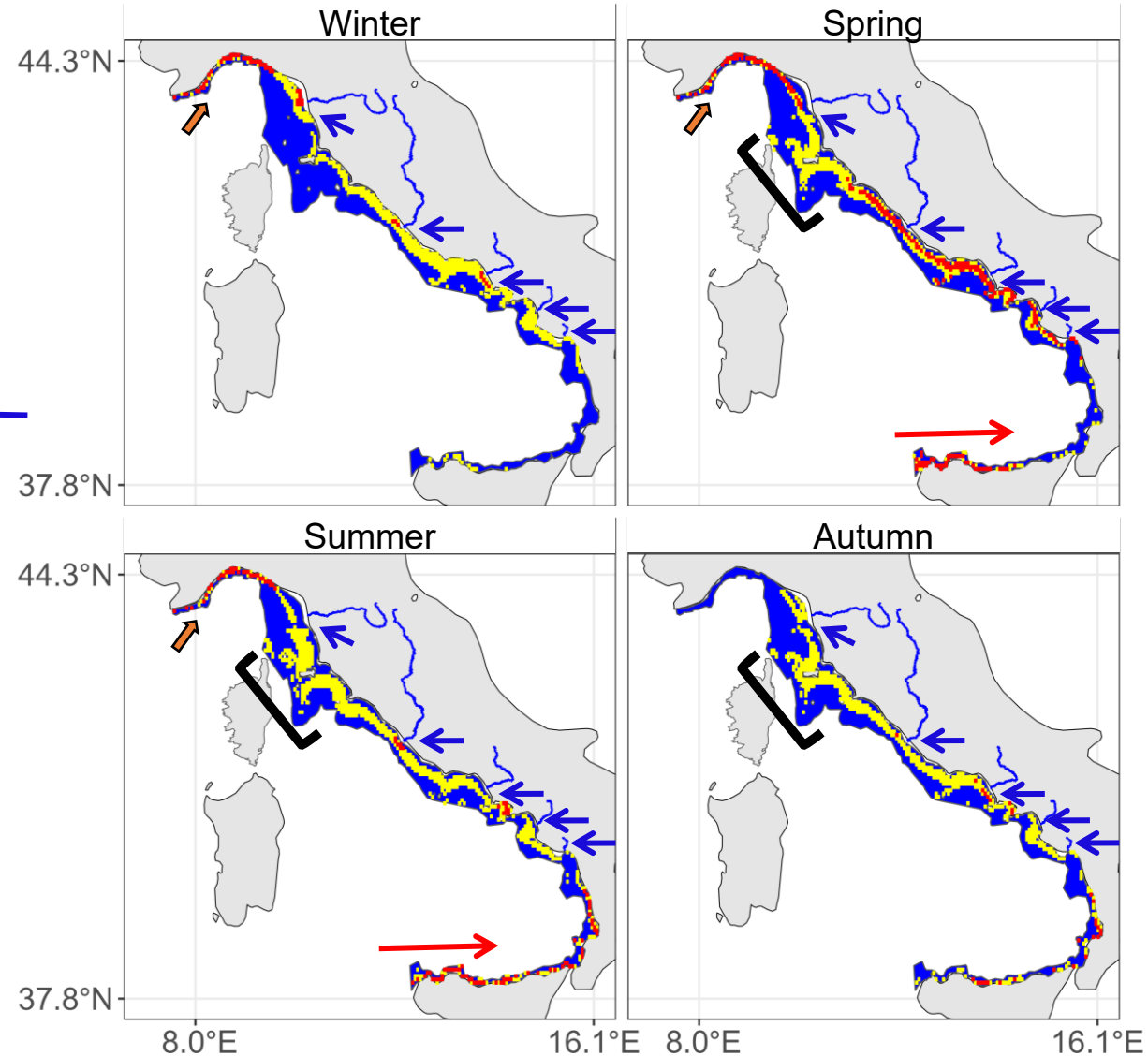
| Subarea | Q1 | Q2 | Q3 | Q4 |
|-----------|-------|-------|-------|-------|
| Central.T | 28.27 | 31.48 | 32.02 | 26.74 |
| Lig | 46.96 | 47.41 | 44.86 | 6.7 |
| South.T | 8.62 | 31.36 | 38.1 | 23.37 |
| total TL | 26.26 | 32.28 | 33.60 | 25.19 |

low seasonality

strong seasonality

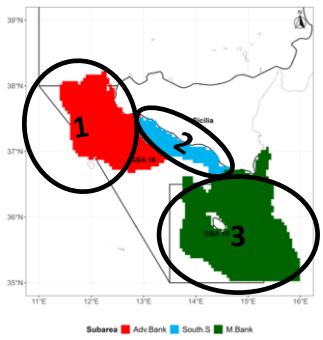
Habitat suitability

$0.8 < P \leq 1$ persistency $0.6 < P \leq 0.8$ preferential



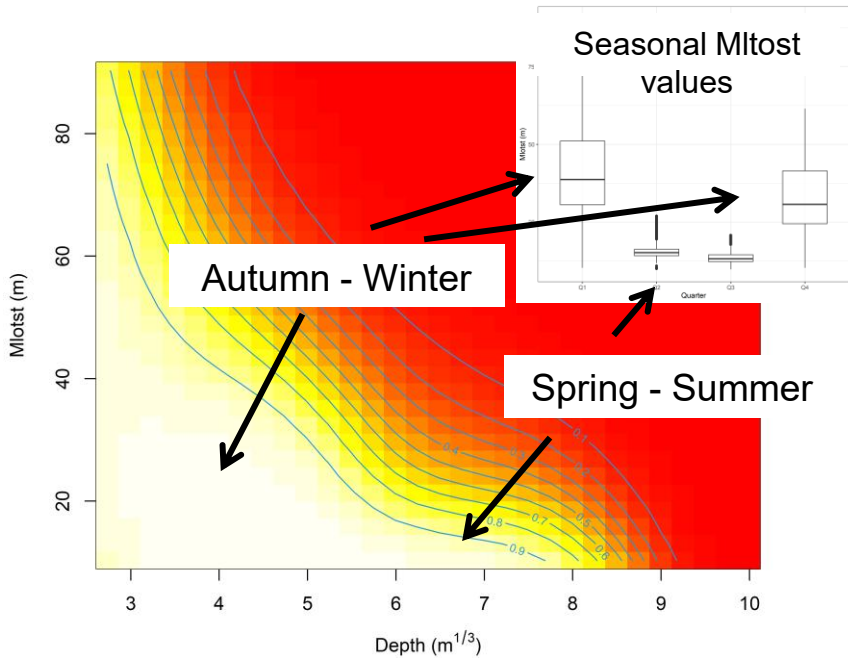
- persisten habitats related to the river mouths in Central T. \leftarrow
river runoff effect \rightarrow high nppv vs low salinity
- Ligurian suitable conditions from winter to summer \rightarrow
wind driven upwelling \rightarrow winter
- spring-summer expansion in Central T. $\left\{$
Tuscany archipelago \rightarrow highly productivity from spring
- spring - summer eastern expansion in South T. \rightarrow
- positive effect in summer at \uparrow salinity \downarrow nppv
evaporation and food consumptions after spring bloom

Anchovy seasonal habitat suitability SS



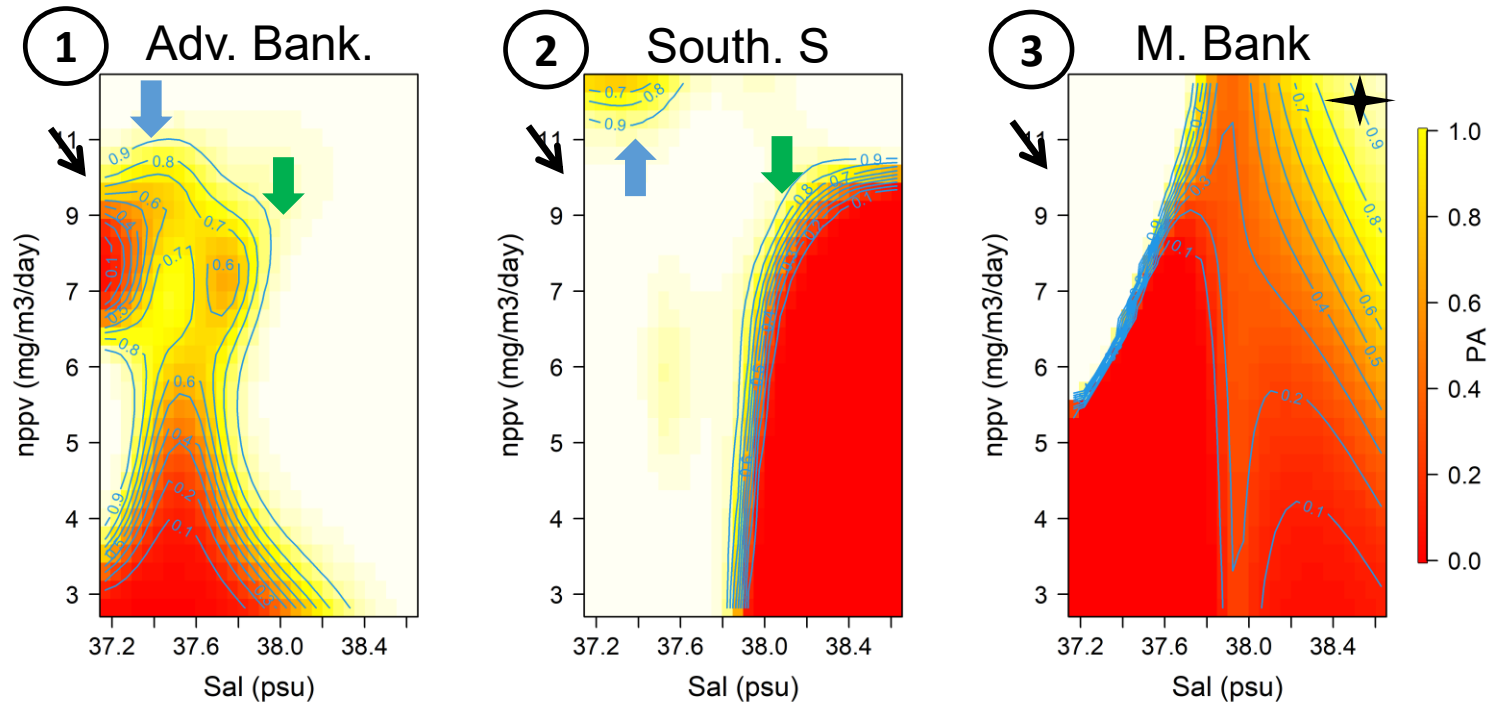
| formula | dev.exp | AIC | AUC |
|---|-------------|-------------|-------------|
| PA ~ te(depth^{1/3}, Mlotst) + te(Sal, ln(nppv), by = subarea) | 71.3 | 1138 | 0.97 |

te(depth^{1/3}, Mlotst)



depth increases Mlotst reduces typical warmer season - stratification
 spring-summer expansion of suitable habitat

te(Sal, ln(nppv), by = subarea)



- ↘ Positive effect: highest nppv in all subareas
- ↓ Adv. Bank and South S. positive effect at high nppv and high sal
- ↑ Adv. Bank and South S. positive effect at high nppv and low sal
- ★ in M. Bank positive effect at high sal and high nppv values

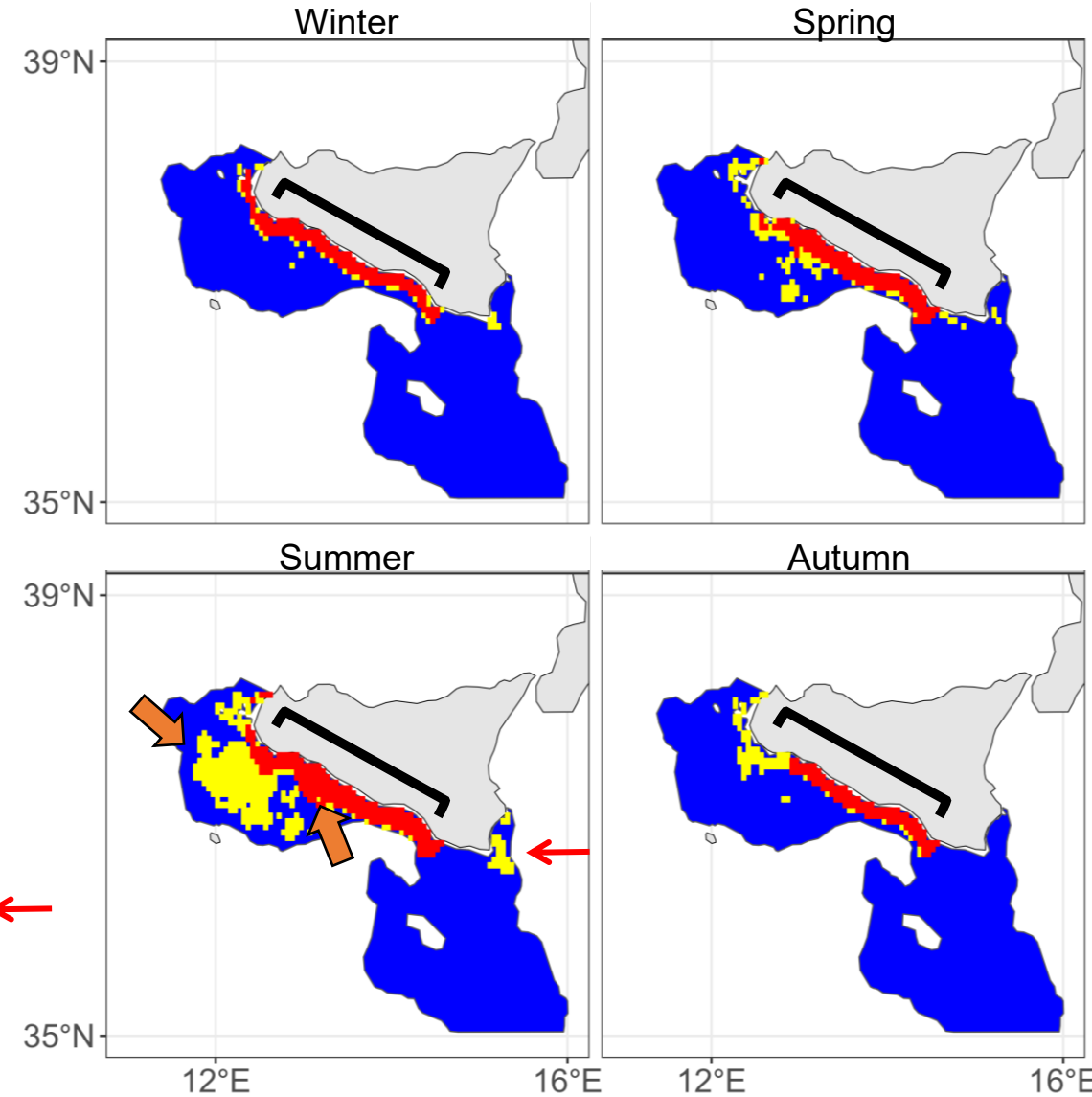
Anchovy seasonal habitat suitability Sicily Strait

Proportion of cell with $P > 0.6$

| Subarea | Q1 | Q2 | Q3 | Q4 |
|----------|-------|-------|-------|-------|
| Adv.Bank | 7.84 | 12.91 | 39.14 | 11.86 |
| South.S | 58.74 | 73.11 | 78.16 | 58.22 |
| M.Bank | 1.24 | 2.46 | 2.86 | 0 |
| SS | 8.59 | 12.73 | 22.52 | 8.91 |

strong seasonality
medium seasonality
low suitable area

Habitat suitability
 $0.8 < P \leq 1$ persistency $0.6 < P \leq 0.8$ preferential



□ persisten habitats are located along the southen coast of Sicily in the subareas Adv.Bank and South S.
high nppv and high sal → winds driven coastal upwelling

□ suitable habitat extend in summer, offshore the South S. and in the core of Adv.Bank
Atlantic Ionian Stram (AIS) → seasonal upwelling system

□ north est portion of Malta Bank suitable condition in summer
effect of the AIS and well know spawning grounds

Conclusions

- ❖ **Fisheries-dependent information** (e-logbook data), are valuable data source for assessing **seasonal habitat suitability** of fish species.
- ❖ European Anchovy suitable habitat along the two study areas is strongly associated with **nutrient enrichment processes (ocean triads!!!!)** in coastal waters.
- ❖ Distinct oceanographic processes **across and within the two areas** generate these conditions, with **local spatio-temporal variability**.
- ❖ **Intrannual spatio-temporal maps** identify key areas, supporting **spatial management strategies**.
- ❖ In both study areas there is a **summer expansion of suitable conditions** that occur during the peak of the spawning: **match-mismatch ipotesis**.

➤ Anchovy spatial distribution shows strong intra-annual variability, driven by dynamic, locally modulated oceanographic processes. Incorporating local-scale dynamics improves models and climate-change impact assessments on anchovy populations.

Thanks for the attention.

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