Small pelagic fish symposium
4 – 9 May. La Paz, México

Living apart together

Spatial and isotopic niche differentiation between the pelagic fish species in the Gulf of Cádiz

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Pelagic Ecosystems: Functional Traits and Key Species

Source: Pienaar, J. (2019). Remote Lands Travelogues.

- **Fast-growing species** of the water column regulated and influenced by **environmental drivers**
- **Ecologically and economically vital species**
- **Critical energy vectors** linking lower to upper trophic levels

Small Pelagic Gulf of Cádiz species

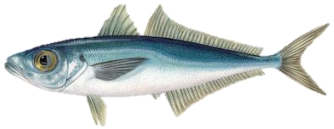
ANE
European anchovy
(Engraulis encrasicolus)

PIL
Sardine (*Sardina pilchardus*)

Medium-sized Gulf of Cádiz species

VMA
Chub mackerel *(Scomber colias)*

HOM
Atlantic horse mackerel
(Trachurus trachurus)

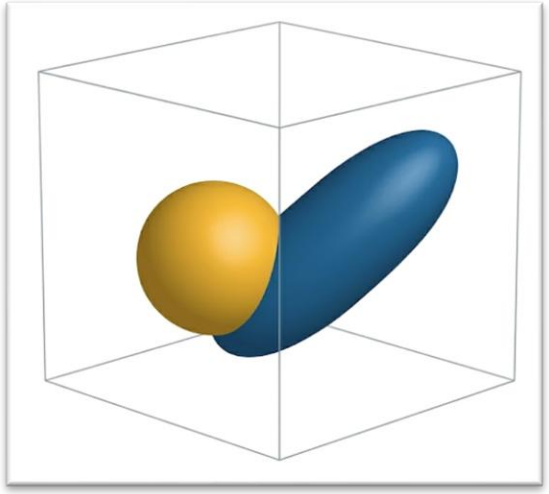


HMM
Mediterranean horse mackerel
(Trachurus mediterraneus)

Niche Concept: Multi-Dimensional Axes

The theory

The ecological niche
(Hutchinson G. E.1957)



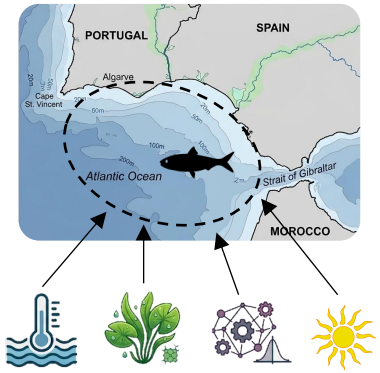
An n-dimensional hypervolume within which a species persists and interacts with its environment

The hypothesis

"Pelagic fish species reduce competition by differentiating their spatial and/or isotopic niches"

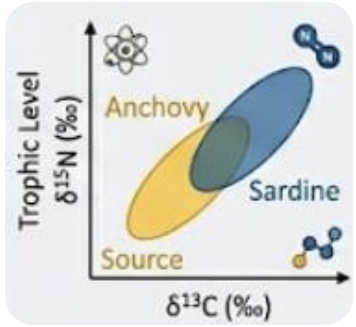
Our approach: Two niche axes

1. Spatial Niche



Influenced by enviroment

2. Isotopic Niche



Influenced by diet and resource source

The goals

Pelagic fish distributions and isotopic niche

Interspecific spatial and isotopic overlap

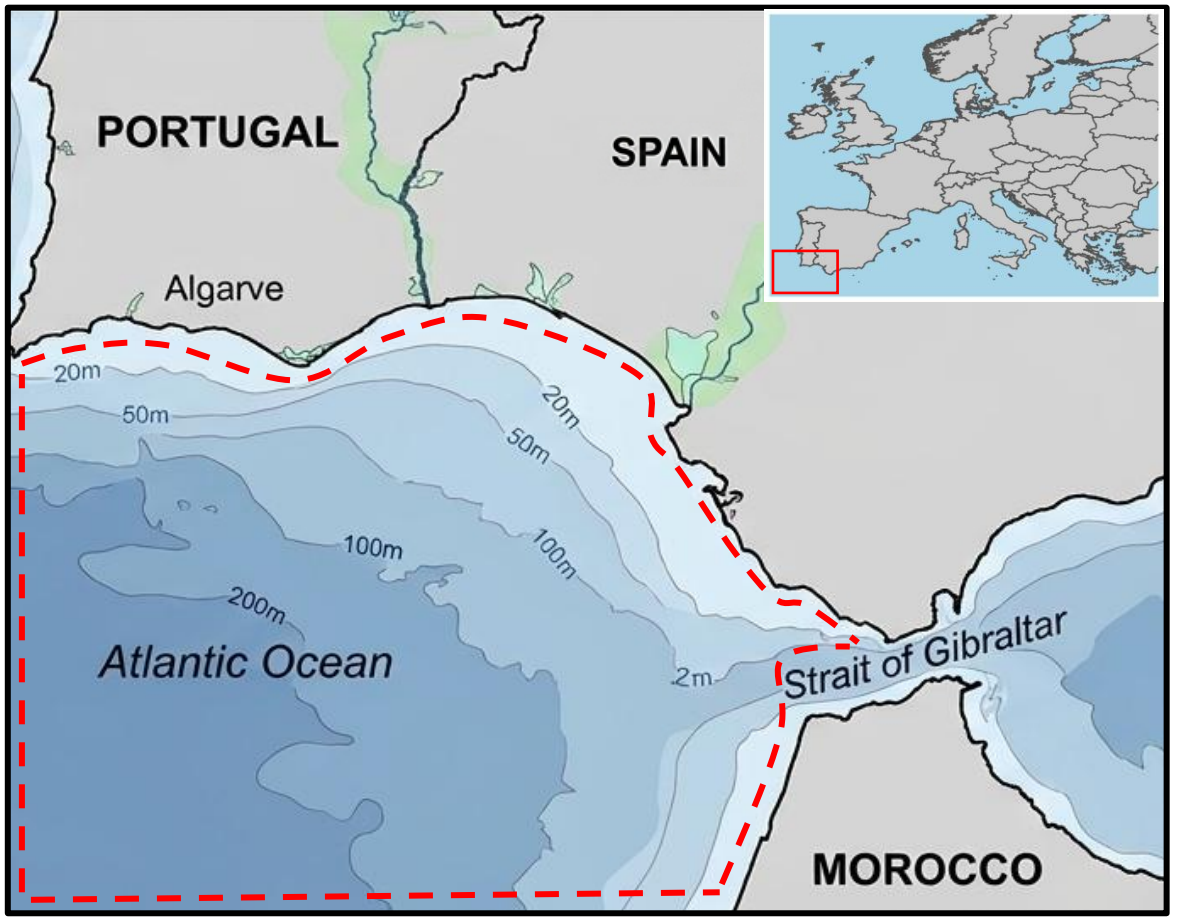
Competition or coexistence strategies among pelagic fish species in the Gulf of Cádiz

Study Area: Gulf of Cádiz (GoC)

Southern and westernmost coast of the Iberian Peninsula

Continental shelf up to 37 km width.
Westward narrowing (~15 km) with abrupt slopes and submarine canyons

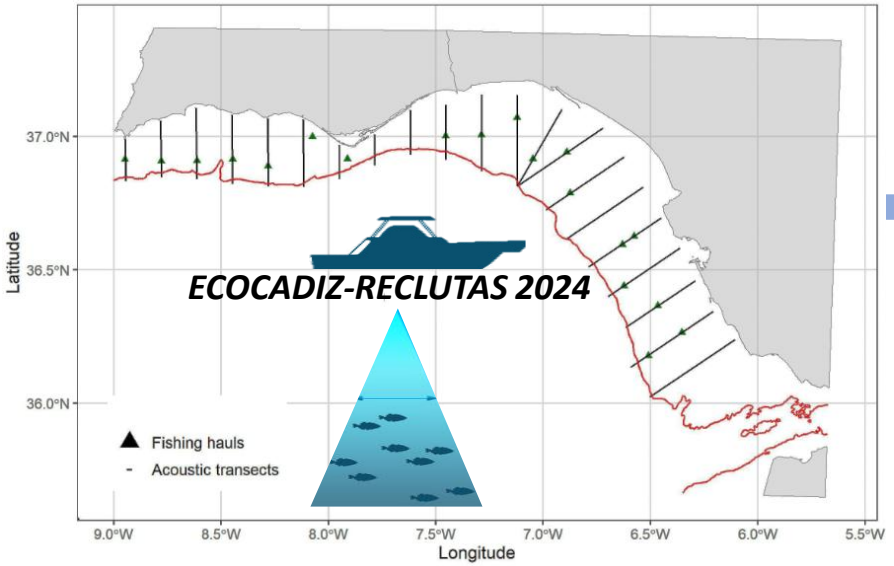
Continuous mixing of Atlantic and Mediterranean water masses.
Key driver for high primary production and diverse biological communities.



Study area, Gulf of Cádiz

Methodological Workflow

Spatial niche



Probability of presence (PP)

Presence (NASC>0.01)

Absence (NASC<0.01)

SST

SSC

SPDE

PAR

Density (D)

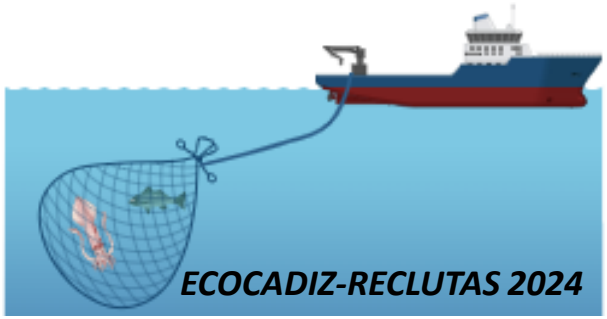
$$O_{ij} = \frac{(\sum_z (N_{iz} \times N_{jz})) \times m}{(\sum_z N_{iz} \times \sum N_{jz})}$$

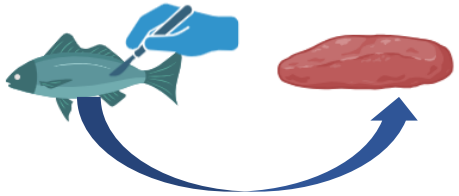
Williamson spatial overlap index
(Williamson 1993)

Graphical diagram of the methodology for niche and spatial overlap

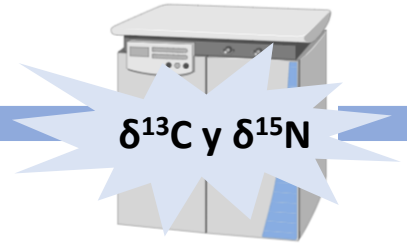
Methodological Workflow

Isotopic niche



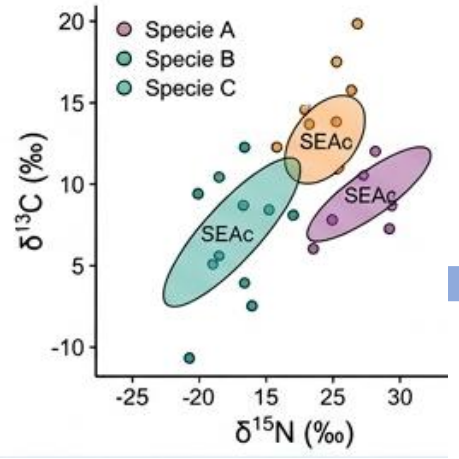


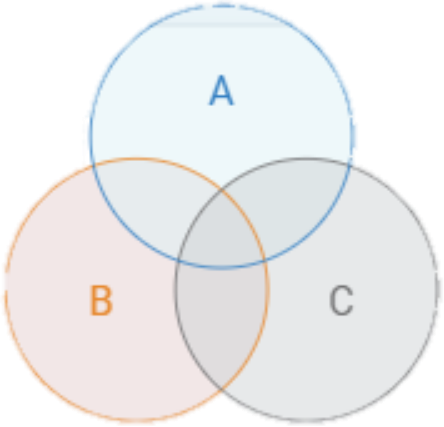
Dissection of white muscle sample



Isotopic ellipses "SIBER"
(Jackson et al. 2011)

Standard ellipse area (SEA)
Total isotopic niche area (TA)





Isotopic Overlap

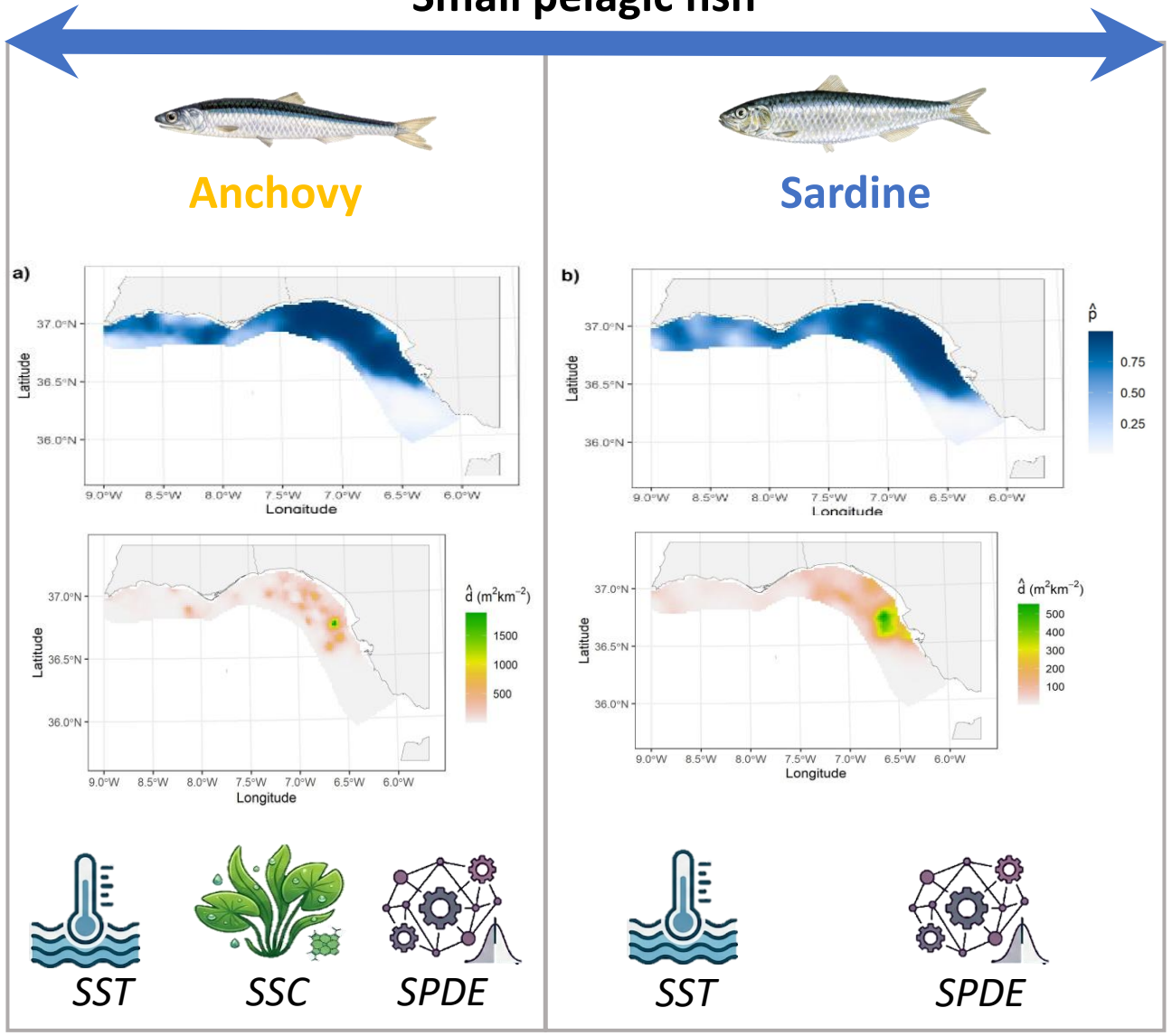
Graphical diagram of the methodology for niche and isotopic overlap

Spatial distribution and environmental influence

Small pelagic fish

Anchovy

Sardine



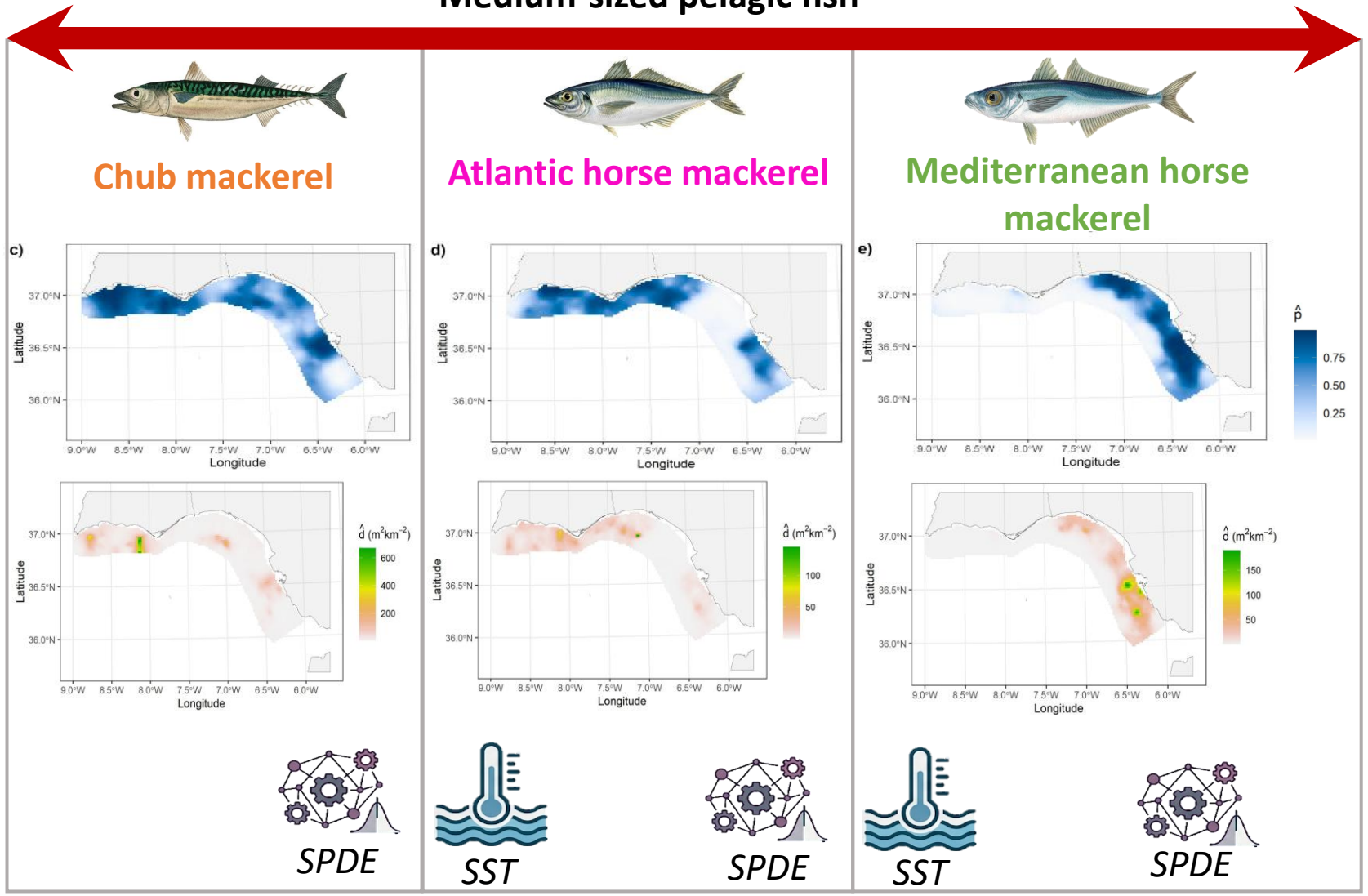
- ✓ High median PP (0.59)
- ✓ Highest PP in the central part of the GdC
- ✓ Largest median acoustic density (83.7)
- ✓ Sea surface temperature (SST), Spatial structure (SPDE) and Sea surface chlorophyll (SSC)

- ✓ Highest median probability of presence (0.64)
- ✓ Highest PP in the central part of the GdC
- ✓ Large median acoustic density (61.8)
- ✓ Sea surface temperature (SST) and Spatial structure (SPDE)

Results for small pelagic species: Probability of presence, predicted corrected density and significant environmental drivers.

Spatial distribution and environmental influence

Medium-sized pelagic fish



✓ High median PP (0.58)
✓ Highest PP in the western part of GdC
✓ Low median acoustic density (27.3)
✓ Spatial structure (SPDE)

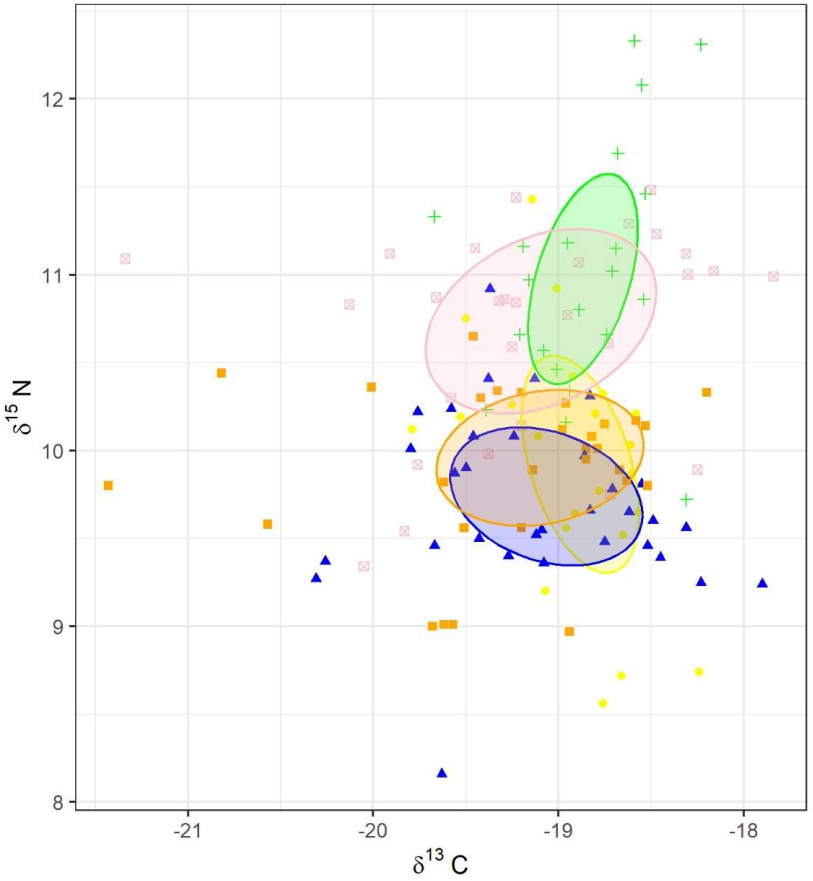
✓ Lowest median PP (0.34)
✓ Highest PP areas western and eastern of the GdC
✓ Lowest median acoustic density (6.2)
✓ Sea surface temperature (SST) and Spatial structure (SPDE)

✓ Lowest median PP (0.34)
✓ Restricted to the easternmost area
✓ Low median acoustic density (13.2)
✓ Sea surface temperature (SST) and Spatial structure (SPDE)

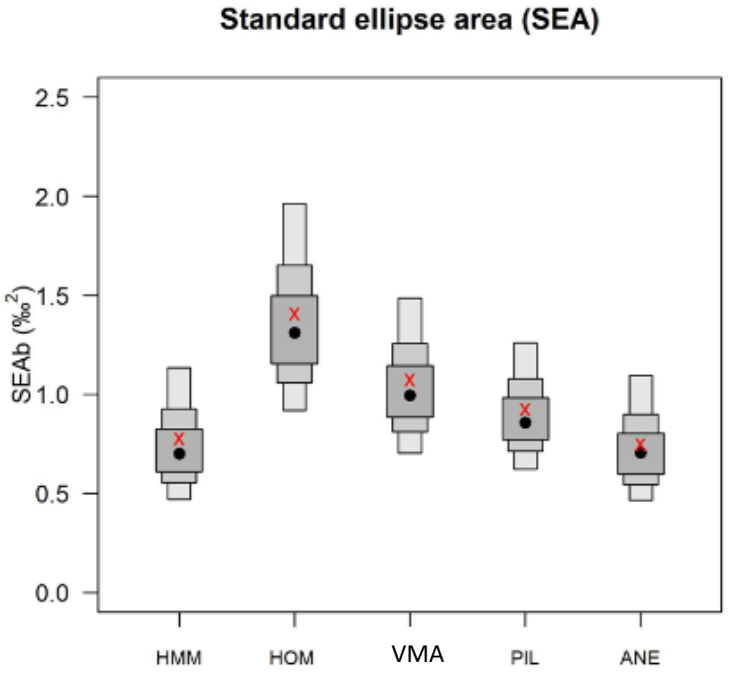
Results for medium-size pelagic species: Probability of presence, predicted corrected density and significant environmental drivers.

Isotopic Niche. The “trophic space” segregation

Carbon and Nitrogen stable isotopes represent the energy source ($\delta^{13}C$) and trophic axes ($\delta^{15}N$) in the isotopic space (Vander Zanden & Rasmussen 1999, Layman *et al.* 2007)



Anchovy (ANE)
Sardine (PIL)
Chub mackerel (VMA)
Mediterranean Horse Mackerel (HMM)
Atlantic Horse Mackerel (HOM)



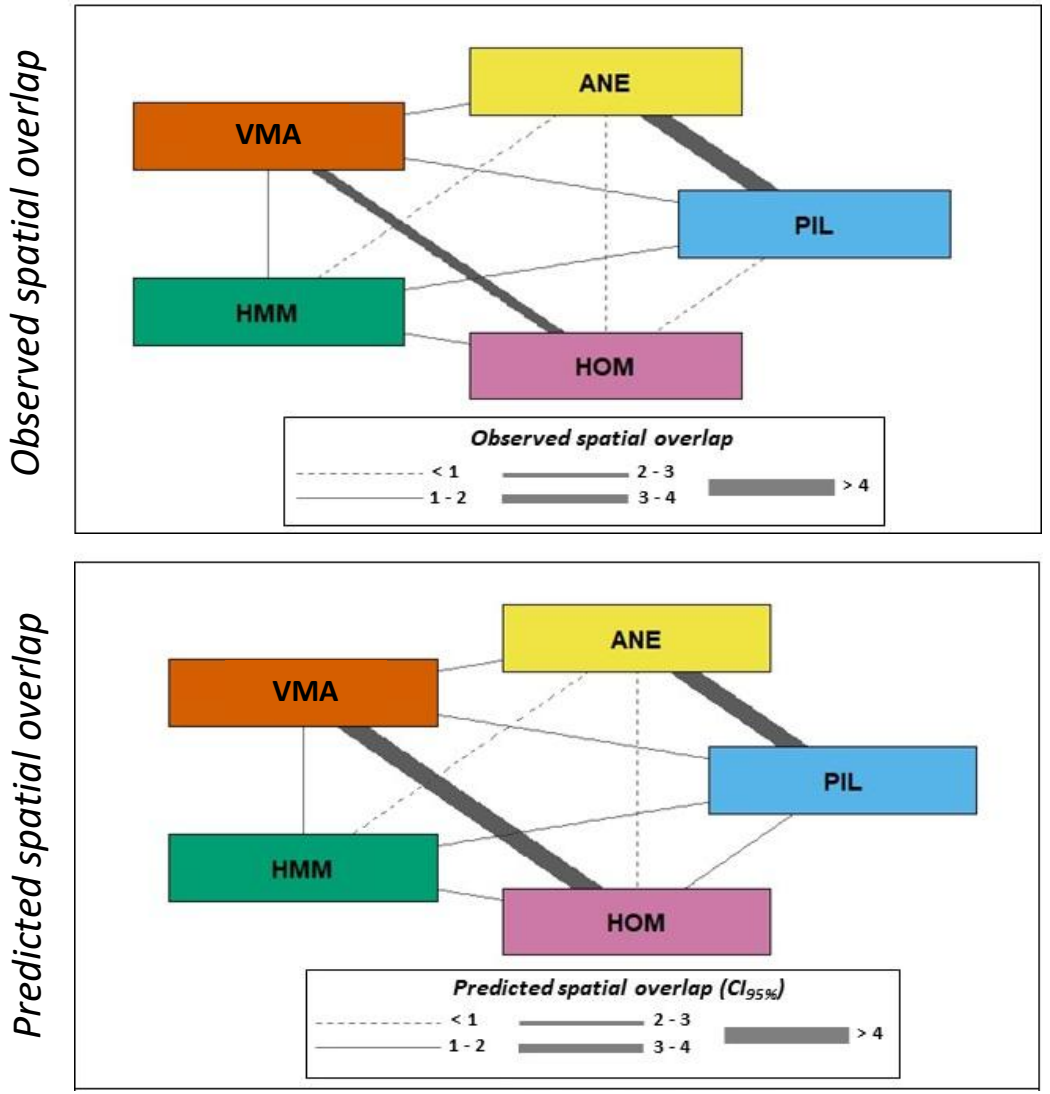
	HMM	HOM	VMA	PIL	ANE
SEA_b (95% CI)	**0.6** (0.4-1.1)	**1.1** (0.9-1.9)	**0.8** (0.7-1.4)	**0.7** (0.6-1.2)	**0.6** (0.4-1.0)

Left. *Isotopic niche illustrated by Bayesian ellipses.* ***Right***. Median predicted standard ellipse area (‰), 95% credibility intervals and the mode.

Multi-dimensional Overlap: Spatial

Where they are?

	Observed spatial overlap	Predicted spatial overlap ($CI_{95\%}$)
ANE-PIL	**4.02**	**4.81**
ANE-VMA	1.50	1.50
ANE-HMM	**0.77**	**0.53**
ANE- HOM	**0.81**	**0.65**
PIL-VMA	1.57	1.63
PIL-HMM	1.72	1.57
PIL-HOM	0.92	1.31
VMA-HMM	1.12	1.70
VMA-HOM	**3.78**	**4.51**
HMM-HOM	1.05	1.51

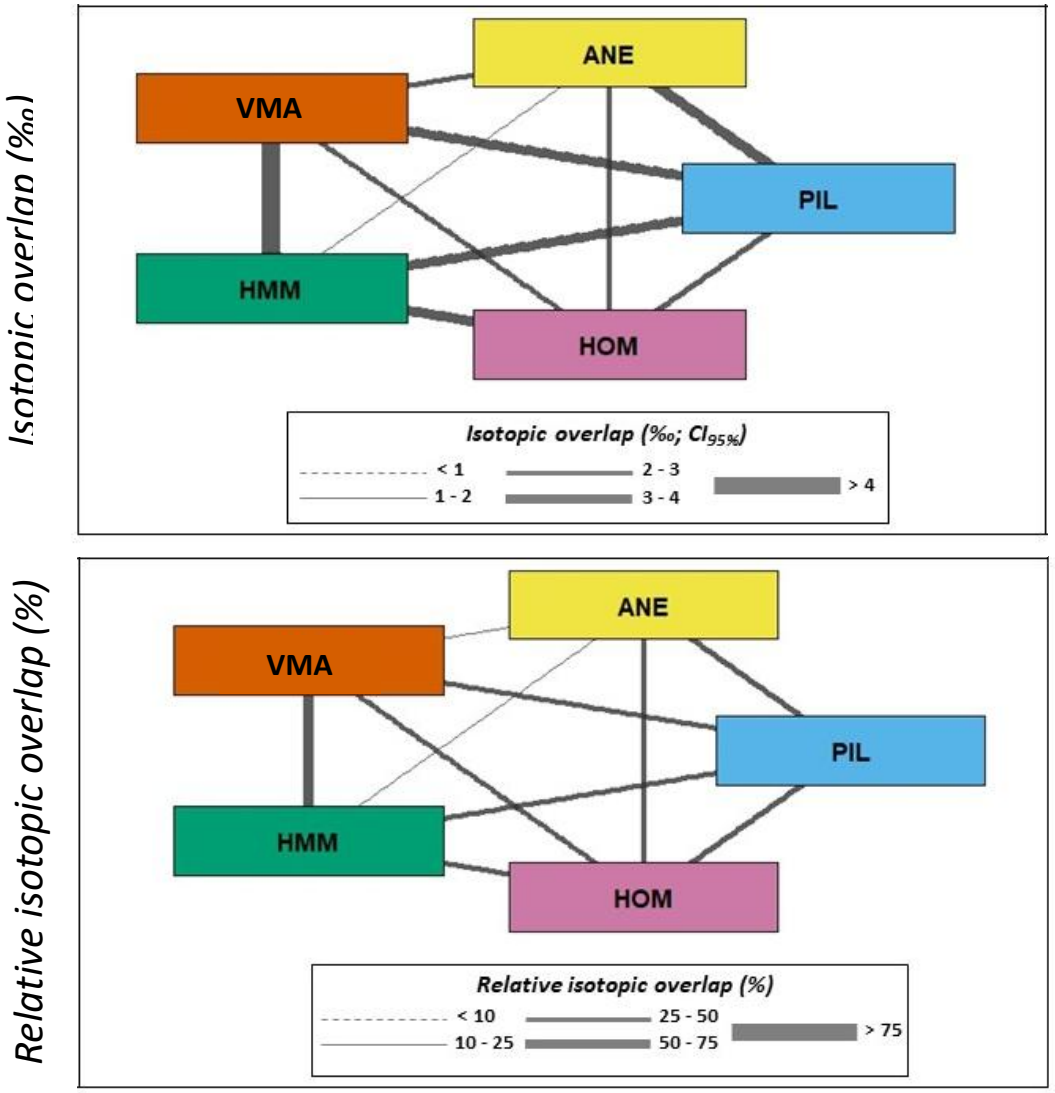


Left. Observed and predicted spatial overlap (CI: Credibility interval). ***Right.*** Flow diagram of spatial overlap results.

Multi-dimensional Overlap: Isotopic

What they do?

	Isotopic overlap (‰; $CI_{95\%}$)	Relative isotopic overlap (%)
ANE-PIL	**3.67**	**40.2**
ANE-VMA	2.17	24.6
ANE-HMM	**1.83**	**22.8**
ANE- HOM	2.32	34.0
PIL-VMA	4.00	38.1
PIL-HMM	3.21	30.5
PIL-HOM	2.96	29.5
VMA-HMM	**4.25**	**57.9**
VMA-HOM	**2.93**	**37.2**
HMM-HOM	**3.20**	**45.1**



Left. Isotopic overlap (‰) and relative isotopic overlap (%) (CI: Credibility interval). ***Right.*** Flow diagram of isotopic overlap results.

Multi-dimensional Overlap. Put all together.

How act the small pelagic fishes?

- ✓ High Spatial Overlap
- ✓ High Isotopic Overlap
- ✓ Divergent Niche Breadth (PIL wider)

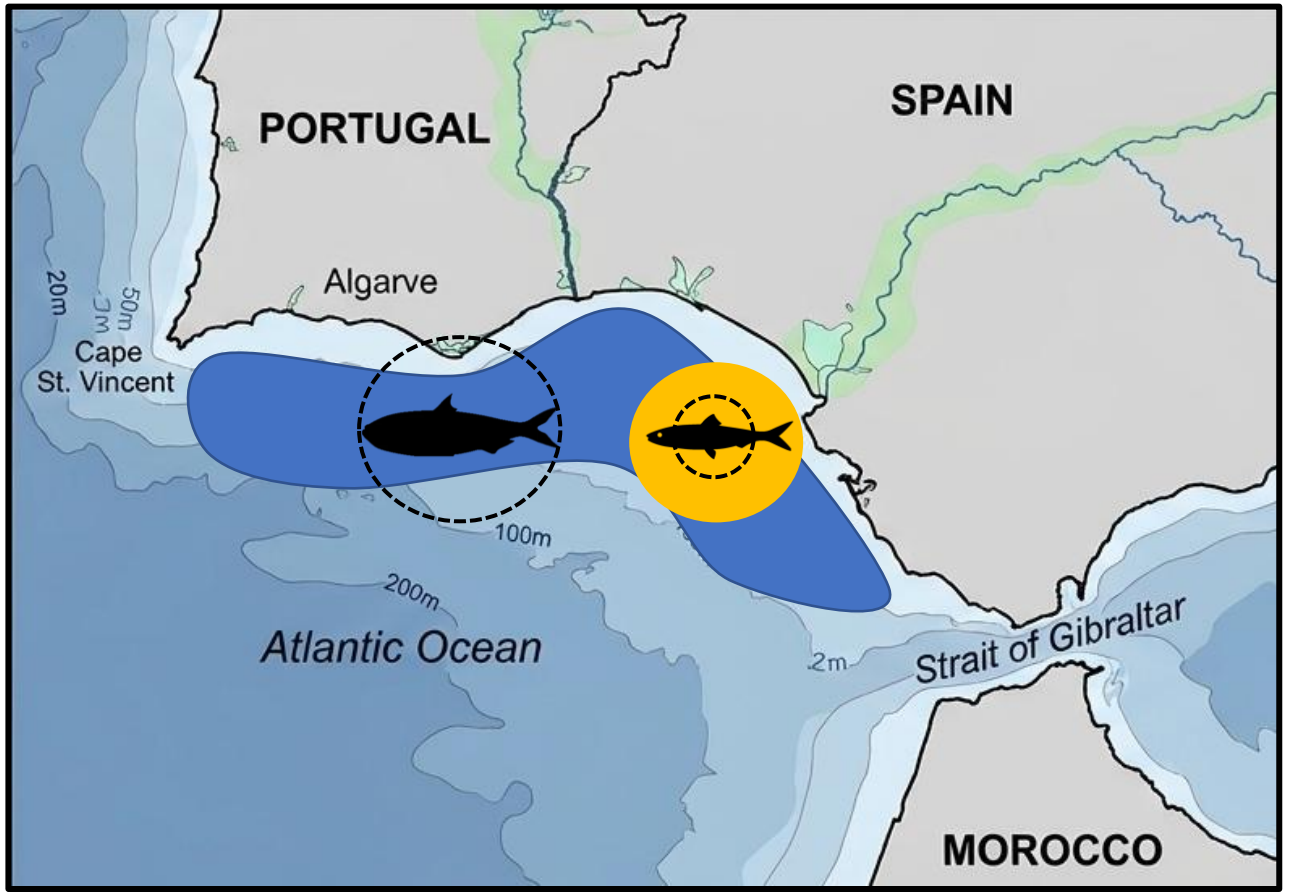
"Spread out to coexist"

Sardine

- ✓ **Spatial generalist**
- ✓ **Dietary plasticity**

Anchovy

- ✓ **Habitat specialist**
- ✓ **River delta**

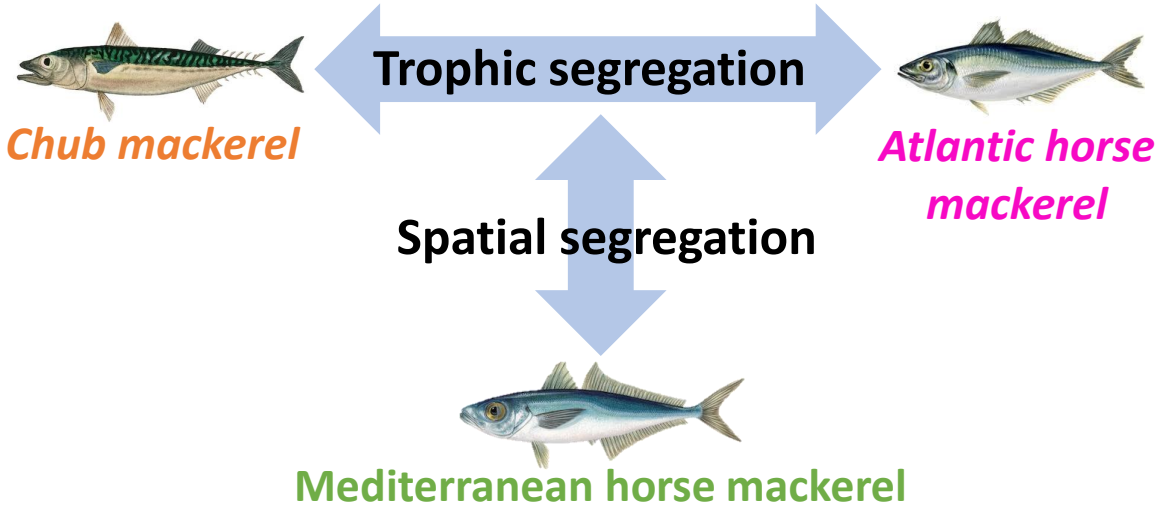


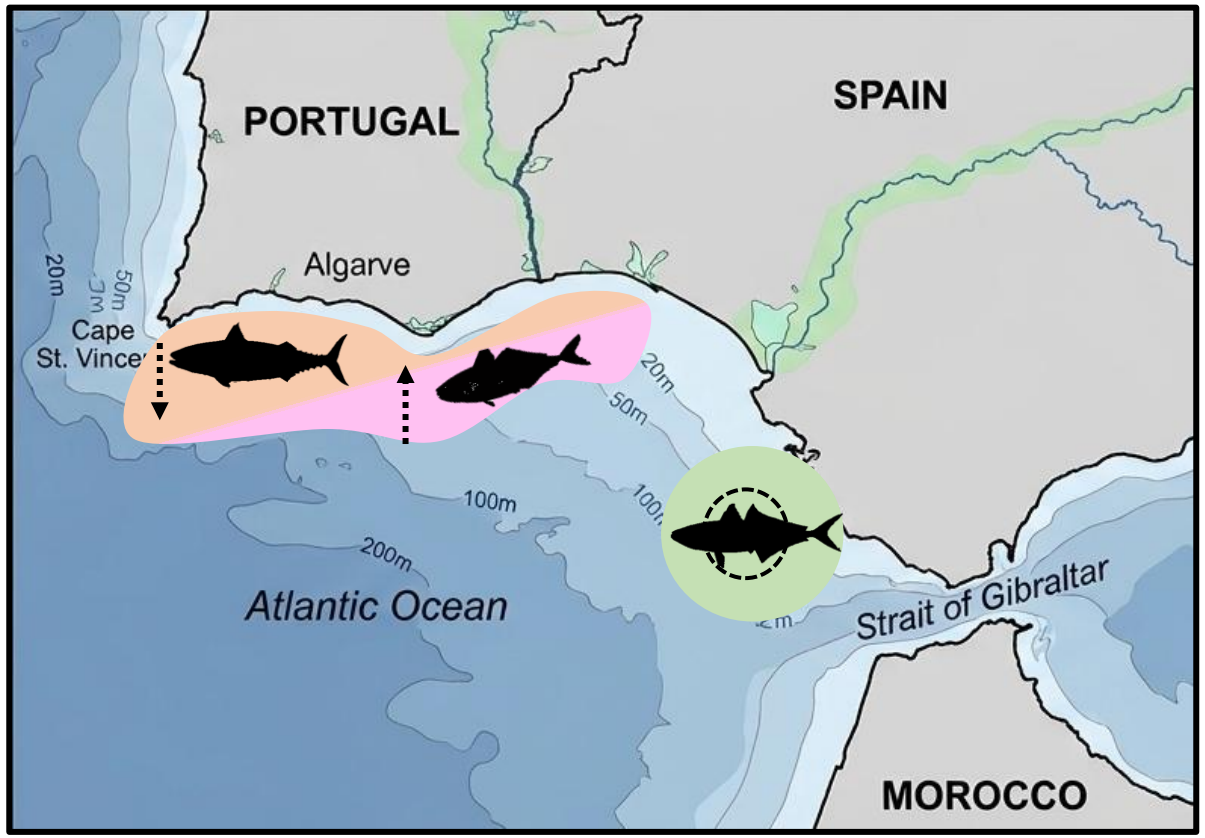
Multi-dimensional Overlap. Put all together.

And the medium-sized pelagic fishes?

- ✓ Low Spatial Overlap. Except between VMA-HOM
- ✓ High Isotopic Overlap. Weaker between VMA-HOM
- ✓ Divergent Niche Breadth (HOM wider)

"Spread out and expand the menu to coexist"





To take home…

Successfully defined the spatial and isotopic niche dimensions for our main pelagic fish species

Differences in the spatial distribution of small pelagic fishes, potentially related to environmental variables influence, allow both species to coexist within the Gulf of Cádiz

For medium-sized pelagic fishes the spatial and trophic segregation likely reduces competition within the Gulf of Cádiz

This study provides novel evidence on pelagic fish niche axes and their role in shaping species interactions within the Gulf of Cádiz ecosystem

Future steps…

- Analysis and interpretation of spatial niche and isotopic niche relationship
- Analysis and interpretation of the overlap between small and medium-sized pelagic species
- Stomach Content Analysis (SCA) and Eye lens stable isotope analysis (ELSIA)

Thank you for your attention

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Partly supported by Ices Travel Grant