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ESTUARINE BENTHO-DEMERSAL FISH DYNAMICS IN RESPONSE TO ENVIRONMENTAL PRESSURES: THE CASE OF MARINISATION OF THE LOIRE ESTUARY



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Context of estuarine marination

Anthropogenic coastal pressures [1]

Banks damming and channel dredging

Drop in sub-tropical rainfalls [2]

Loire river floods flow rate decrease

Saltwater intrusion in the upper estuarine reaches eased by a linearised riverbed and less fluvial discharge against tidal waves

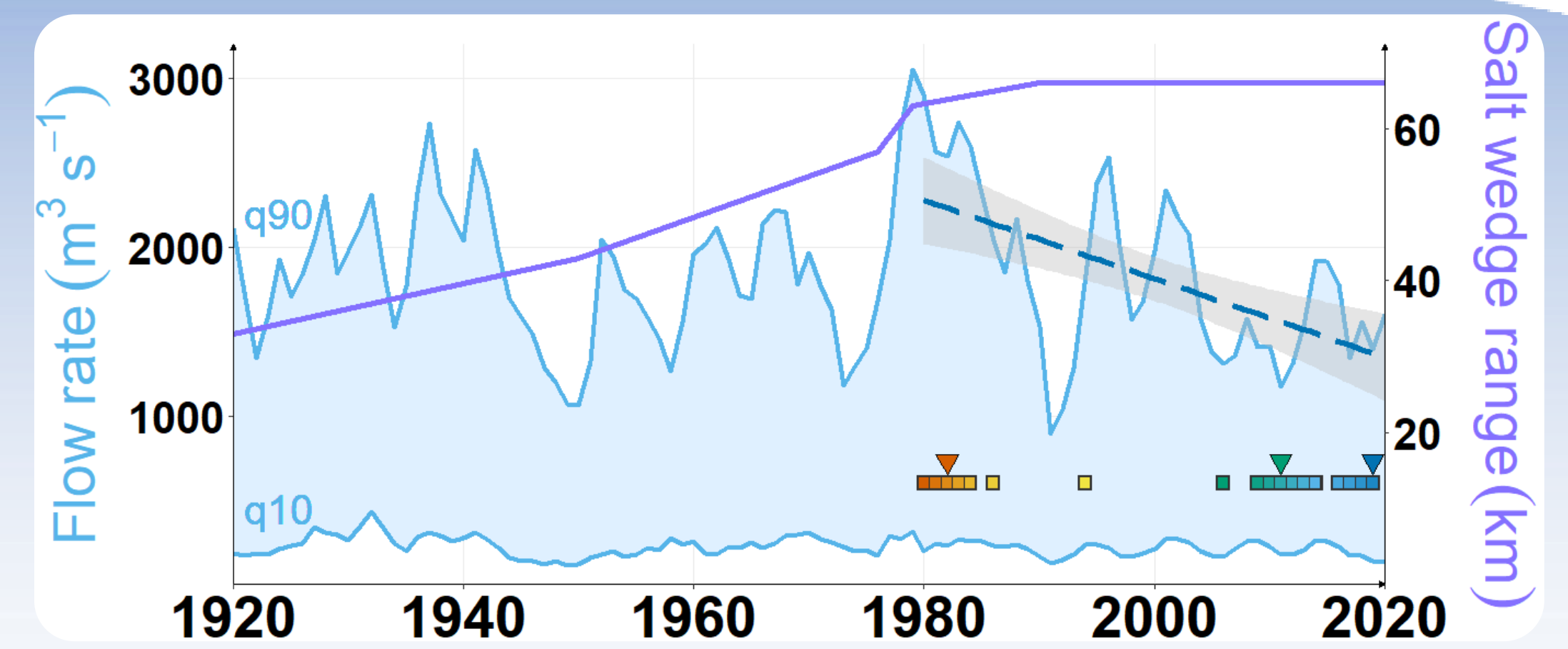


FIGURE 1: Loire estuary salt wedge intrusion (violet line), river flow range (lightblue) and recent decreasing trend (blue dashed line, $-23 \text{ m}^3 \cdot \text{s}^{-1} \cdot \text{yr}^{-1}$). Coloured squares and arrowheads show yearly and monthly data sampling time.

What modifications did fish community experience since 1980 in a marination setting?

Methods

Inter-annual analysis of benthic-demersal fish abundance

Structural diversity

Hill diversity number [3]

$$qD = \left(\sum_i p_i^q \right)^{1/(1-q)}$$

q : order of sensitivity to common species
 p_i : proportion of species i

Species composition

Freshwater	Estuarine	Marine
<i>A. brama</i>	<i>P. flesus</i>	<i>S. solea</i>
<i>S. lucioperca</i>	<i>O. eperlanus</i>	<i>Pomatoschistus spp.</i>
Others (n = 3)	Others (n = 3)	<i>D. labrax</i>
		<i>T. luscus</i>
		<i>C. lyra</i>
		<i>A. minuta</i>
		<i>M. merlangus</i>
		Others (n = 13)

Monthly trajectories

Community trajectory analysis [4]

- Pairwise Hellinger distance
- Ordination and classification
- Consecutive states linkage

Geometric indices

- Ellipses: amplitude of variability among months
- Lengths: speed of change between months

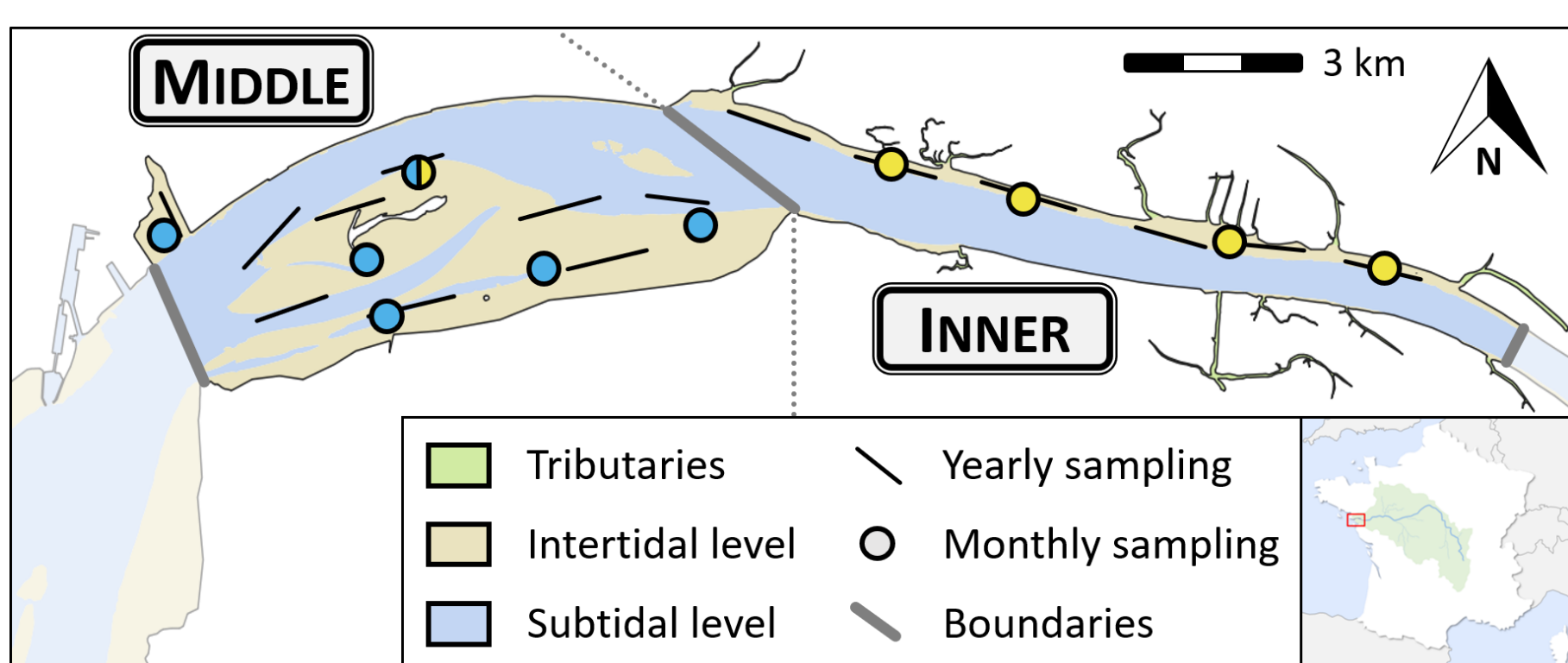


FIGURE 2: Loire estuary studied spatial extent and morphological segmentation. **Middle** sector features vast intertidal mudflats whereas **Inner** sector connects numerous freshwater tributaries. Monthly sampling points are clustered (colours) based on ecological trajectory dissimilarity.

1. Variability in fish structural diversity and species composition

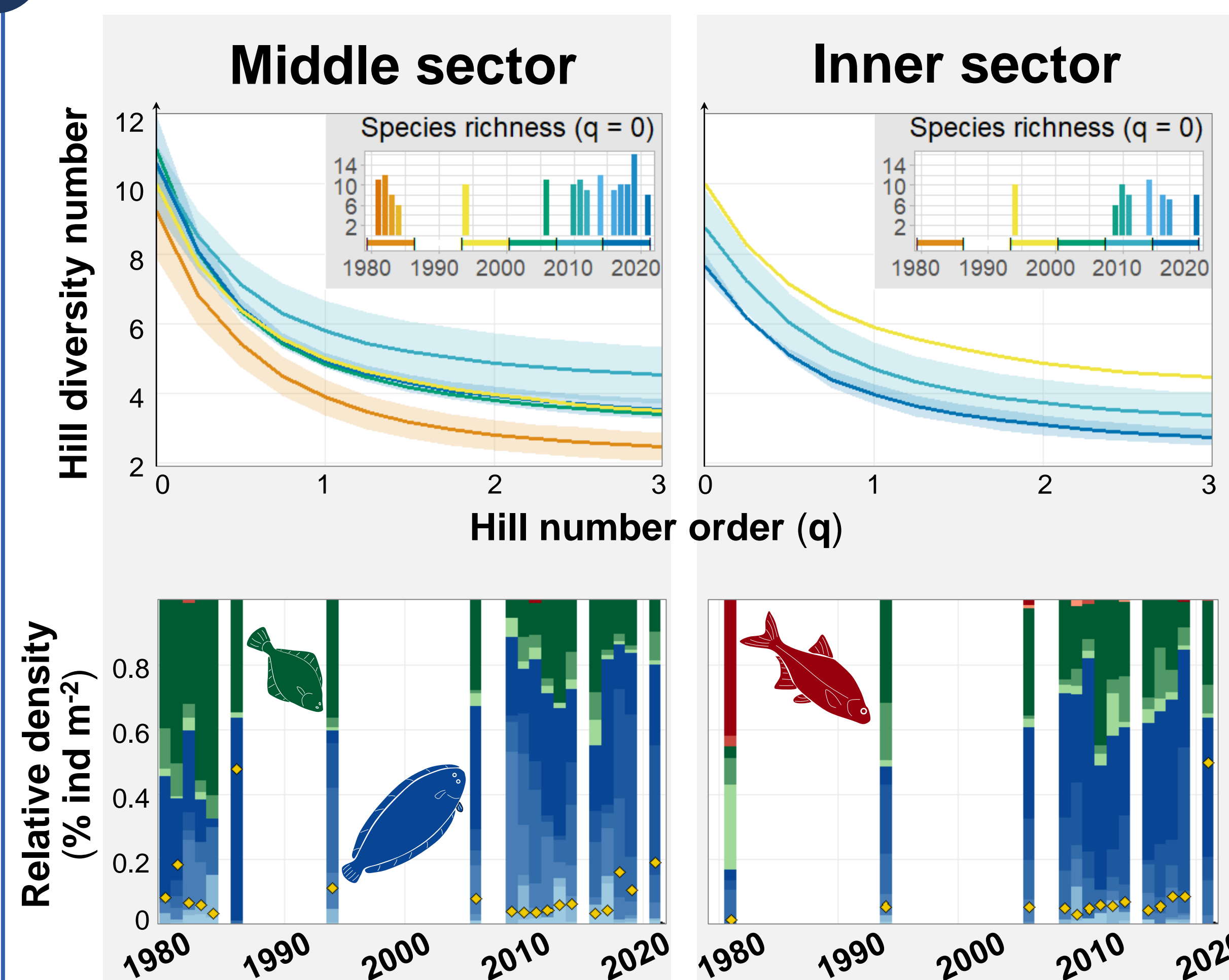


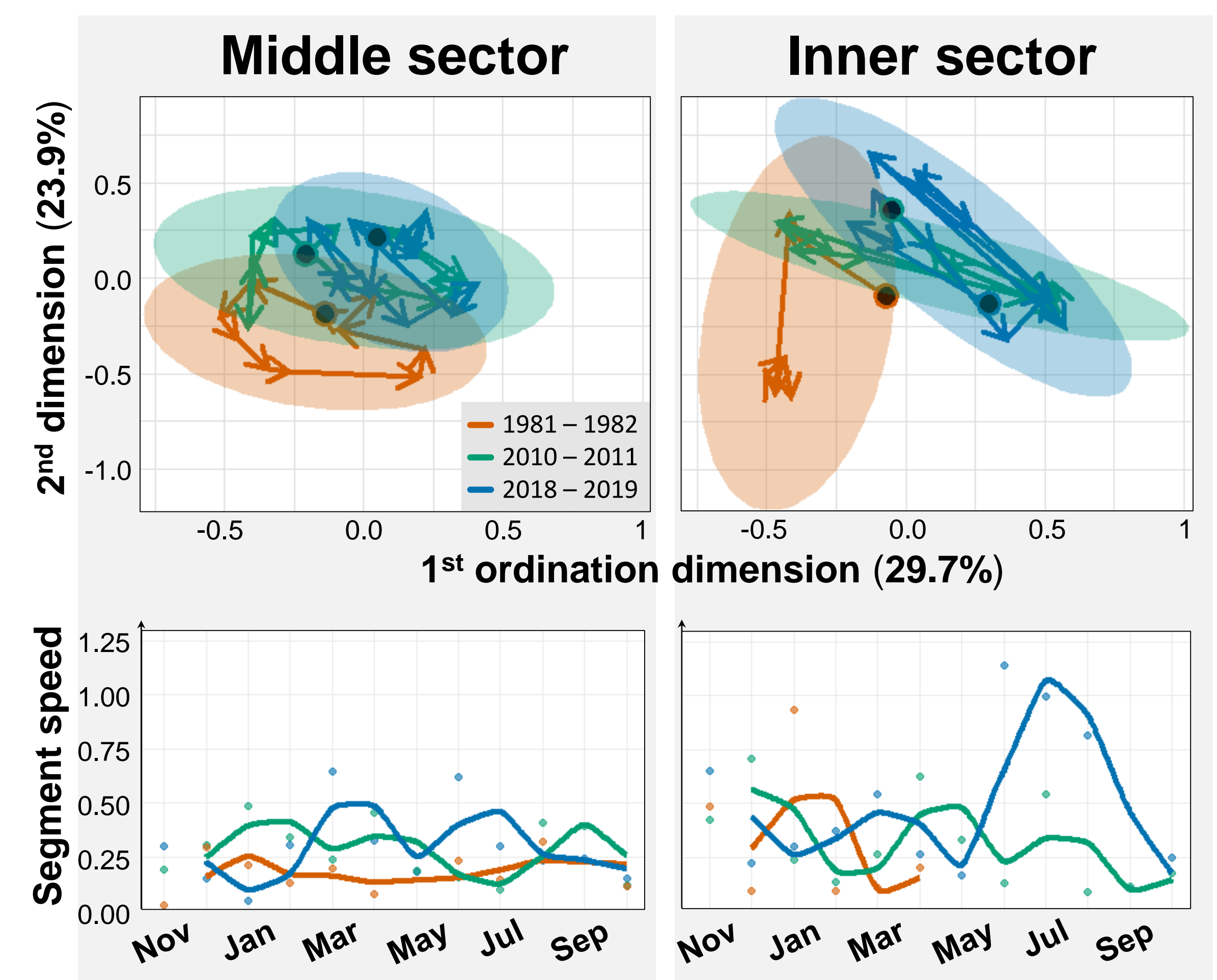
FIGURE 3: Top: median diversity profiles per six-year ranges with 10th-90th interpercentile shade. Inset: yearly species richness ($q = 0$). Bottom: proportion of fish species grouped by salinity tolerance. Qualitative mean density as yellow diamonds.

- Middle diversity:** 1980-86 < 2015-21 < 2008-14
Shift in dominance:
pre - 2000 → estuarine fish
post - 2000 → marine fish
- Inner diversity:** 2015-21 < 2008-14 < 94-2000
Freshwater fish: strong decrease

2. Spatial patterns of fish community monthly trajectories

FIGURE 4: Top: mean ecological trajectories and 95% confidence ellipses. Bottom: length of successive trajectory segments (two-month smoothing).

- 2011 and 2019 trajectories overlap and partially differ from 1982
- Amplitude: **Middle** sector < **Inner** sector
- Variability: **Middle** sector < **Inner** sector
- Middle** sector variability:
1982 < 2011 < 2019



Consequences of marination

- Increasing diversity in **Middle** sector: marine fish species replacing poorly diverse estuarine species
- Higher monthly dynamics variability: modifications in seasonal composition and greater disturbances

Regional broad-scale viewpoint

- Comparable marination effects in Gironde estuary with increase in marine fish proportion [5]
- Similar pattern in the Seine estuary for supra-benthic invertebrates [6]

Research prospects

- Study of annual evolution in seasonal patterns
- Investigating inter-annual dynamics of benthic macroinvertebrates over the same period
- Relationship with estuarine abiotic drivers

[1] Williams *et al.* (2022). Conservation Biology 36: e13874. [2] Sanderson *et al.* (2011). Phil. Trans. R. Soc. A 369: 85-98. [3] Hill (1973). Ecology 54 (2): 427-432. [4] De Cáceres *et al.* (2019). Ecological Monographs 89: e01350. [5] Chevillot *et al.* (2016). Mar. Ecol. Prog. Ser. 549: 137-151. [6] Dauvin & Pezy (2013). J. Exp. Mar. Biol. Ecol. 448: 93-103.

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