Identifying biogeographical transition zones and nekton assemblages in the northern Humboldt Current System

Giancarlo Morón[1], Andrés Chipollini[1] and Miguel Romero[1]

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International Symposium: Understanding Changes in Transitional Areas of the Pacific

Background

- Biogeographical regions: Those primary divisions of the earths surface of approximately continental extent, which are characterised by distinct assemblages of animal types (Wallace, 1876)
  - An area has sub-areas: different scales of regionalization
  - Species assemblages: dominant and endemic species
- Biogeographical transition zone: The boundaries between biogeographical regions, representing areas of biotic overlap, which is promoted by historical and ecological changes that allow the mixture of taxa belonging to different biotic components. (Morrone, 2004).
  - It can occur at every hierarchical level of a biogeographical regionalization (Ferro and Morrone, 2014).
  - They may vary from narrow zones with strong changes to broad zones with gradual changes along their length (Ferro and Morrone, 2014).
- In recent years, there have been efforts to identify transition zones in terrestrial ecosystems

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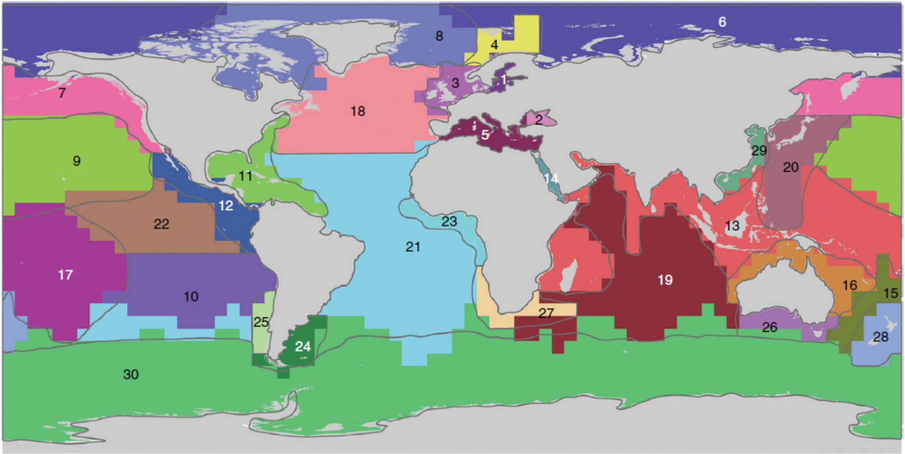

Costello et al. (2017)

Background

REVIEW ARTICLE

Biogeographical transition zones: a search for conceptual synthesis

IGNACIO FERRO and JUAN J. MORRONE*

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We revise concepts, definitions and examples of biogeographical transition zones to help develop a conceptual framework and differentiate them from other transitions that occur in the geographical space. A biogeographical transition zone is defined as a geographical area of overlap, with a gradient of replacement and partial segregation between biotic components (sets of taxa that share a similar geographical distribution as a product of a common history). It is an area where physical features, environmental conditions and ecological factors allow the mixture and the co-occurrence of two or more biotic components, but also constrain their distribution further into one another. The biogeographical affinities of the taxa are the most fundamental information to consider to analyse biogeographical transition zones accurately. By plotting the frequency of different distribution patterns on maps, gradual changes in their relative contribution to a given area can be perceived. Thus, the most heterogeneous places in terms of distributional patterns can be defined numerically on strictly geographical grounds. Biogeographical transition zones can occur at every hierarchical level of a biogeographical regionalization as long as different biotic components come into contact geographically. Ecological boundaries or ecotones when characterized only by differences in dominance of some species, life forms or sets of characteristic species (not endemic) are not biogeographical transition zones as defined herein. *Biological Journal of the Linnean Society*, 2014, **113**, 1–12.

ADDITIONAL KEYWORDS: biogeographical transitions – ecological boundaries – ecotones – evolutionary biogeography – regionalization.

Ferro and Morrone (2014)

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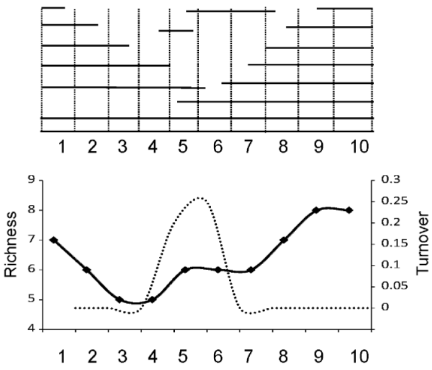

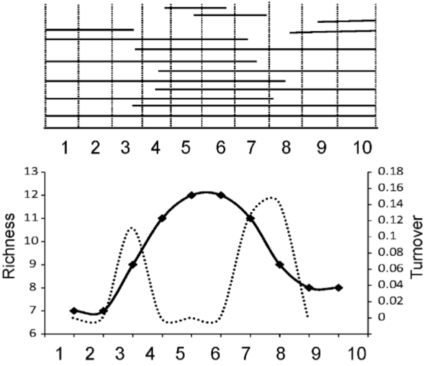

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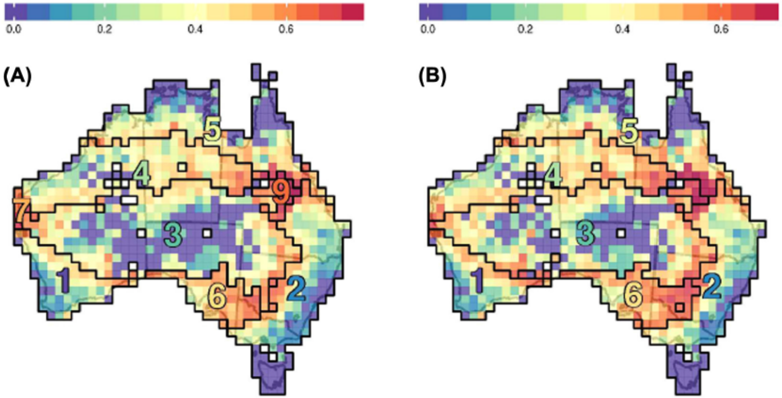

Bloomfield et al. (2018)

Goals

- Identify biogeographical areas of the epipelagic environment in the northern Humboldt Current System, based mostly on nekton taxa
- Compare the community structure between these regions
- Identify biogeographical transitional zones
- Determinate the influence of the shelf break and water masses on these transitional areas

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Data

- Location: northern Humboldt Current System
- 13 scientific surveys: parallel cross-shore transects of ∼100 nm long, with a ∼15 nm inter-transect spacing
- ∼200 midwater trawl sets per survey: mostly epipelagic nekton species
- 2613 trawl sets were used for this study
- Presence-absence data
- Spatial resolution: grid cell 15x15 nm

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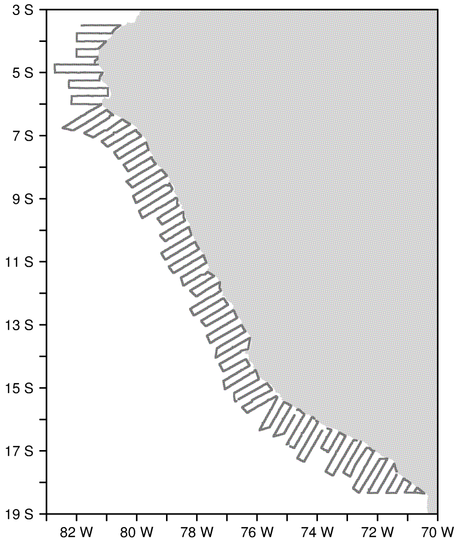

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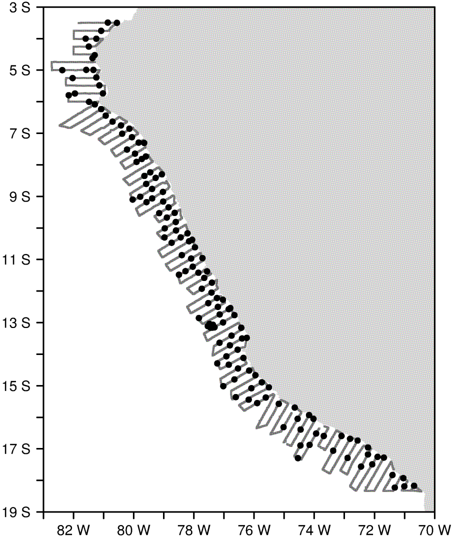

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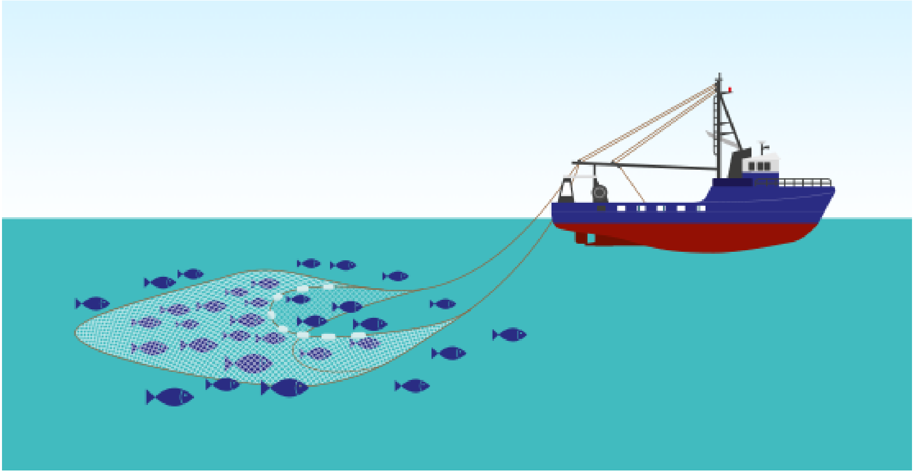

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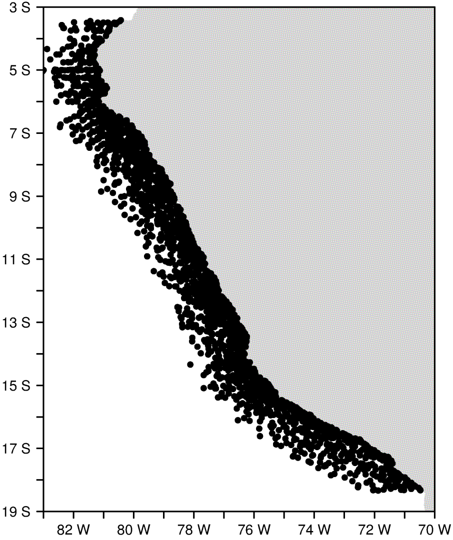

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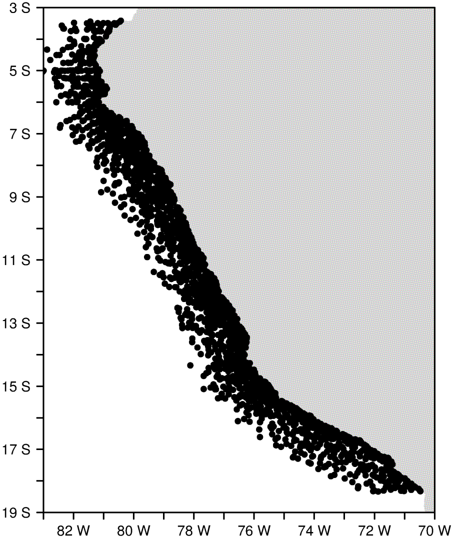

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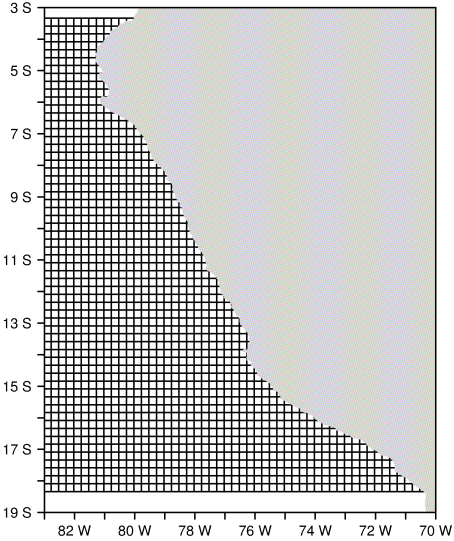

Methods

- A 'dissimilarity approach' instead of a modeling approach (e.g. SDM) (Vilhena and Antonelli, 2015)
- Beta diversity = species turnover + nestedness (Baselga, 2010)
- Hierarchical clustering - UPGMA (Kreft and Jetz, 2010): β_{sim} dissimilarity to quantify species turnover (Baselga, 2010). Optimal number of groups following Calinski and Harabasz (1974)
- Community structure: dominance plots, dominant and indicator species (De Caceres et al., 2012)
- Biogeographical transition zones: spatial variability in β_{sim}
- GAM analysis to assess the effect of shelf break on β_{sim} and richness
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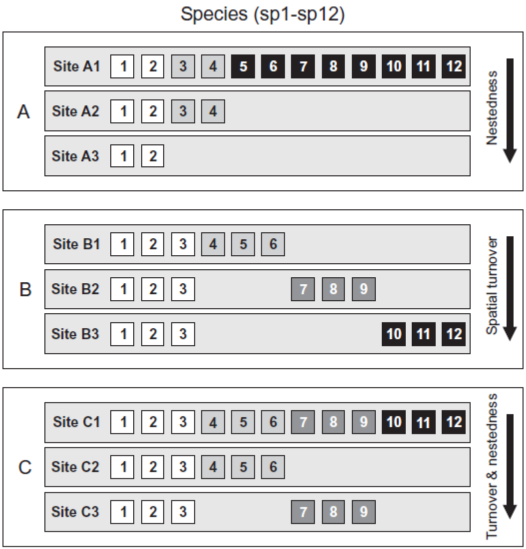

Species (sp1-sp12)
A
Site A1 1 2 3 4 5 6 7 8 9 10 11 12
Site A2 1 2 3 4
Site A3 1 2
Nestedness
B
Site B1 1 2 3 4 5 6
Site B2 1 2 3 7 8 9
Site B3 1 2 3 10 11 12
Spatial turnover
C
Site C1 1 2 3 4 5 6 7 8 9 10 11 12
Site C2 1 2 3 4 5 6
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Turnover & nestedness

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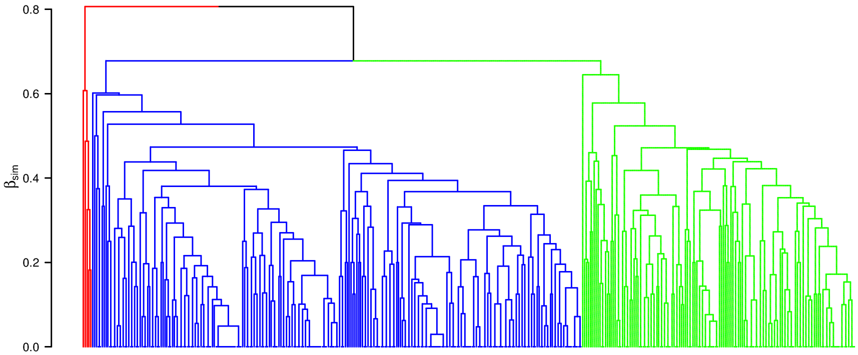
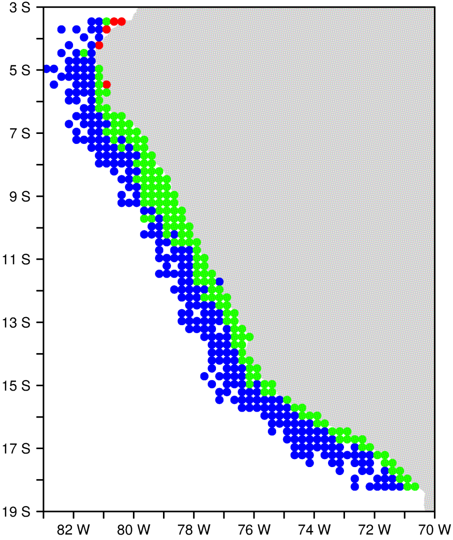
Results



- Three optimal groups: Zone 1 (red), Zone 2 (blue) and Zone 3 (green)

Results

- Three main biogeographic areas:
  - Zone 1: High influence from Tropical Pacific (Costello et al., 2017)
  - Zone 2: Influence from South-east Pacific (Costello et al., 2017)
  - Zone 3: A coastal area



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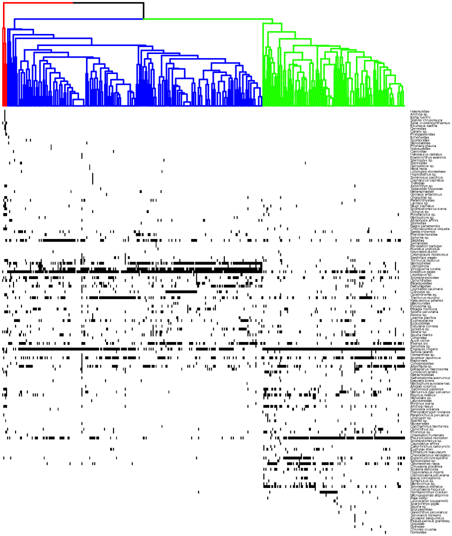
- Differences in community structure: dominance plots



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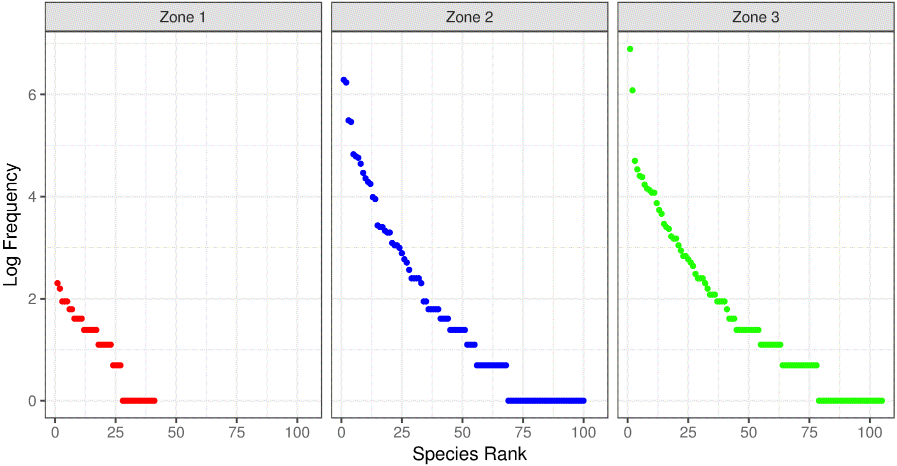

Results

Dominant species		
Zone	Rank	Species
1	1	Trachinotus paitensis
	2	Anchoa nasus
	3	Opisthonema sp.
	4	Oligoplites sp.
	5	Selene sp.
2	1	Dosidicus gigas
	2	Engraulis ringens
	3	Vinciguerria lucetia
	4	Myctophidae
	5	Psenes sio
3	1	Engraulis ringens
	2	Pleuroncodes monodon
	3	Odontesthes regia
	4	Scomber japonicus
	5	Argonauta sp.

Results

Indicator species			
Zone	Species	Statistic	p-value
1	Chloroscombrus orqueta	0.88	< 0.01
	Polydactylus sp.	0.88	< 0.01
	Trachinotus paitensis	0.81	< 0.01
	Anchoa nasus	0.78	< 0.01
	and others 25 species!		
2	Vinciguerria lucetia	0.8	< 0.01
	Myctophidae	0.76	< 0.01
	Bathylagidae	0.48	0.04
3	Pleuroncodes monodon	0.83	< 0.01
	Odontesthes regia	0.62	0.03
	Stromateus stellatus	0.57	0.01
	Sciaena deliciosa	0.4	0.03
	Normanichthys crockeri	0.38	0.02
1+2	Dosidicus gigas	0.86	< 0.01
1+3	Diplectrum conceptione	0.54	< 0.02

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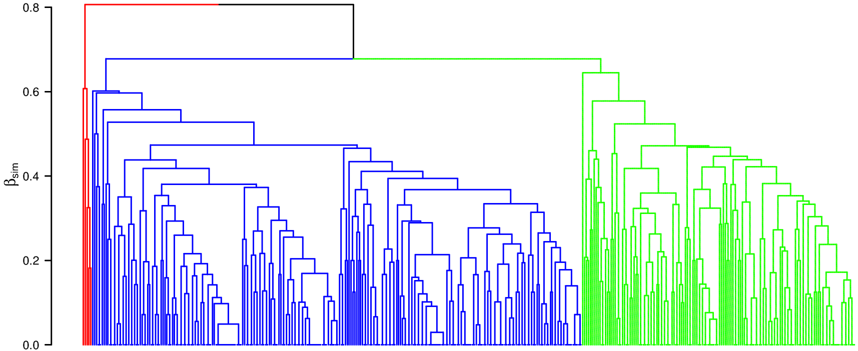

- Five groups: Zone 1 (red), Zone 2-1 (orange), Zone 2-2 (skyblue), Zone 2-3 (darkblue) and Zone 3 (green)

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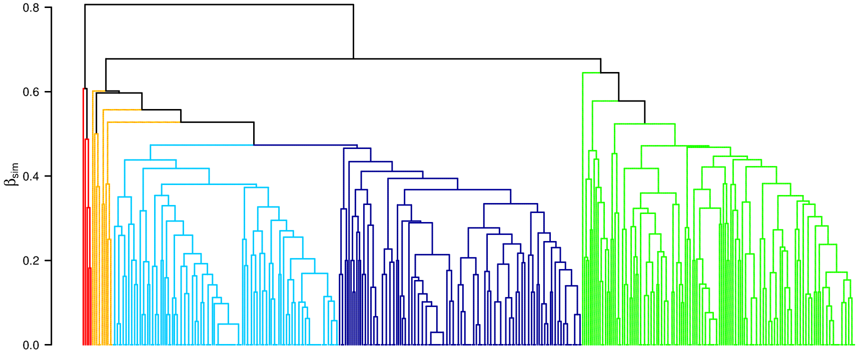

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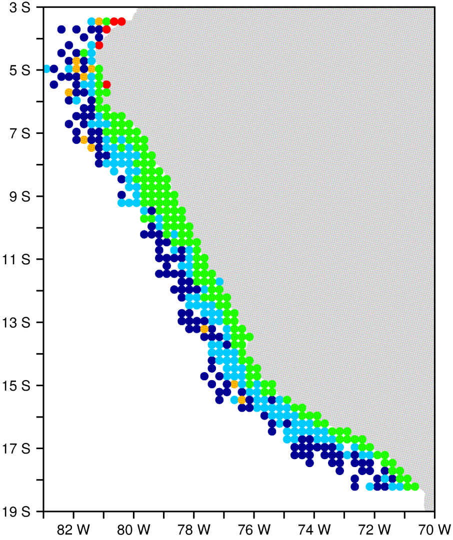
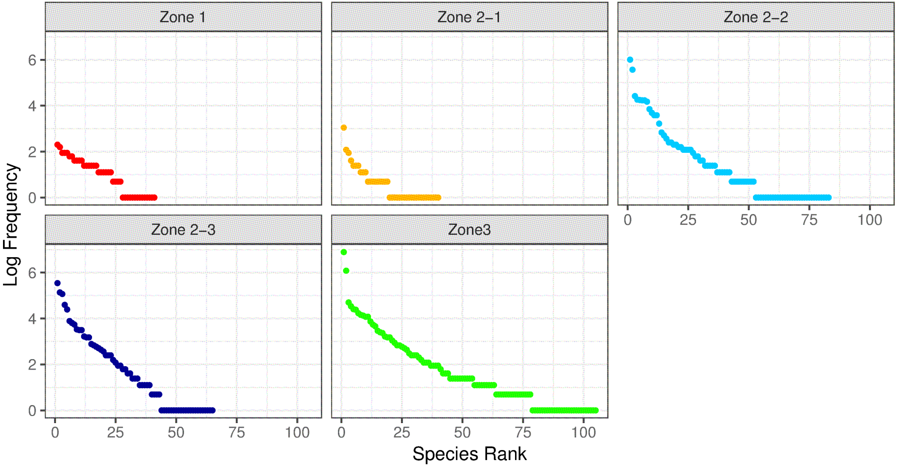
Results

- Three sub-areas of the Zone 2:
  - Zone 2-1: Most of the grids in the north
  - Zone 2-2: Transition between Zone 1 and the oceanic area
  - Zone 2-3: An oceanic area



Results

- Differences in community structure: dominance plots



Results

Dominant species		
Zone	Rank	Species
2-1	1	Dosidicus gigas
	2	Myctophidae
	3	Engraulis ringens
	4	Ophichthidae
	5	Selene peruviana
2-2	1	Engraulis ringens
	2	Dosidicus gigas
	3	Trachurus murphyi
	4	Vinciguerria lucetia
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	5	Psenes sio

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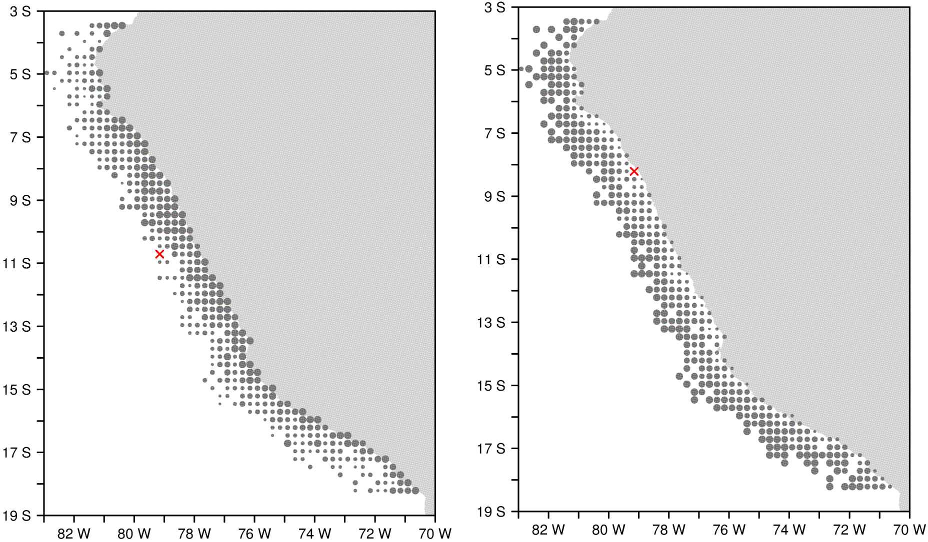
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5 S
7 S
9 S
11 S
13 S
15 S
17 S
19 S
82 W
80 W
78 W
76 W
74 W
72 W
70 W
3 S
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70 W

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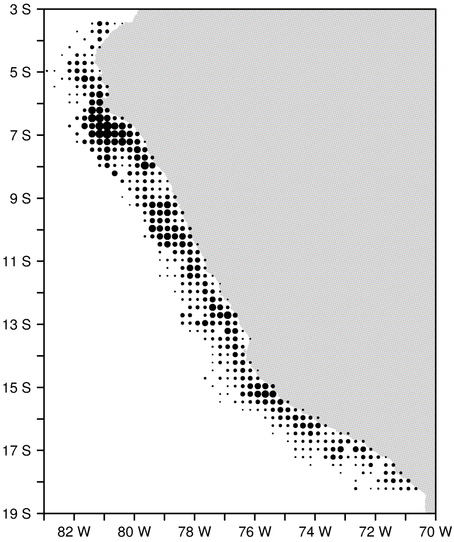

- β_{SIM} index to find spatial turnover for each gird
- An area of high species turnover in the north of the study area
- The highest species turnover on the shelf break
- An area of high species density in the north of the study area
- More species density in the coastal area

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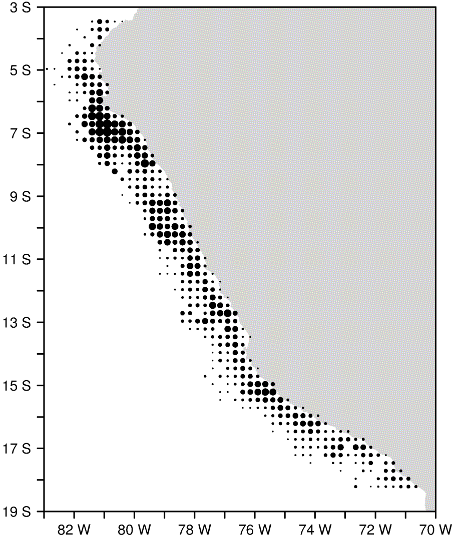

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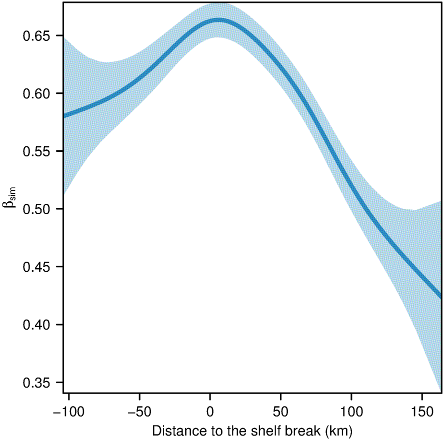

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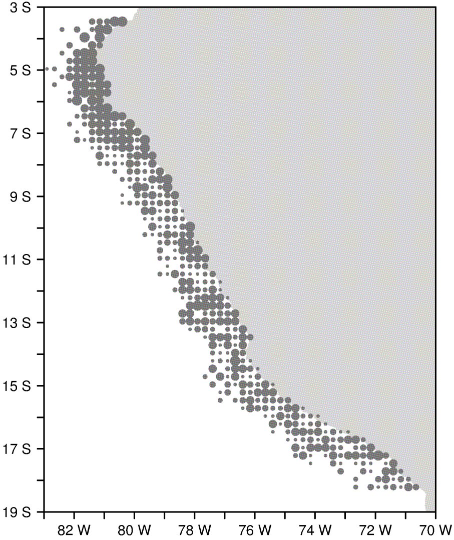

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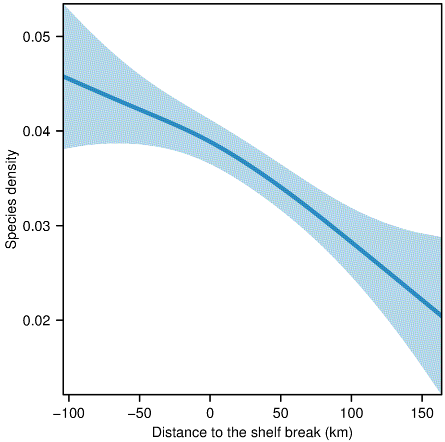

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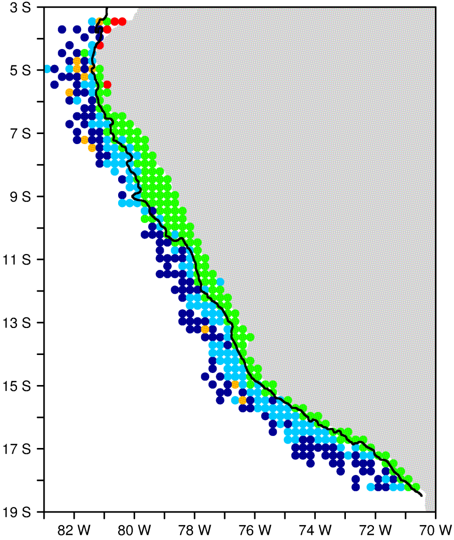
- An area of high species density in the north of the study area
- More species density in the coastal area

Results



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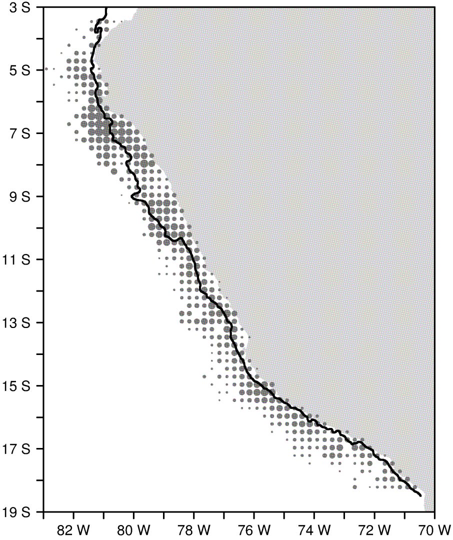

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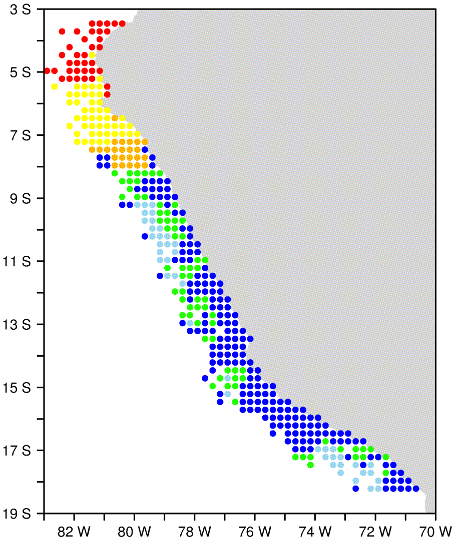
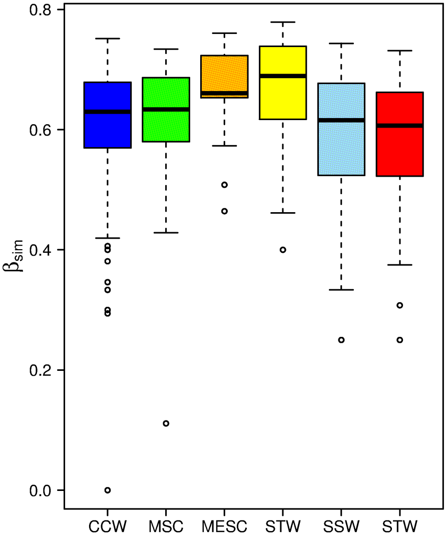


- Average distribution of water masses in the northern Humboldt Current System
- Species turnover is higher in mixing waters and warmer water
- A higher species density in warmer waters

Results



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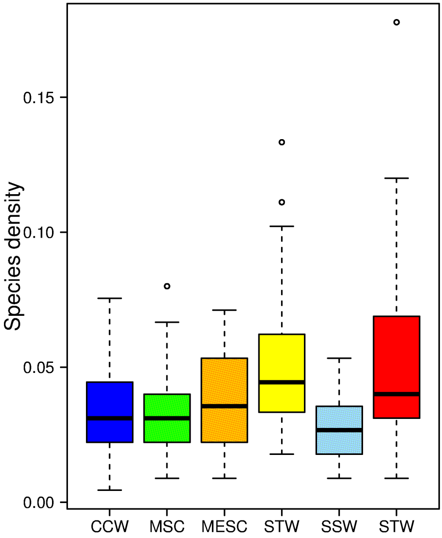

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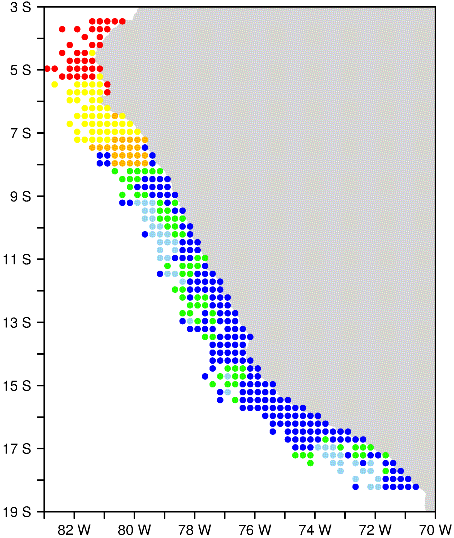

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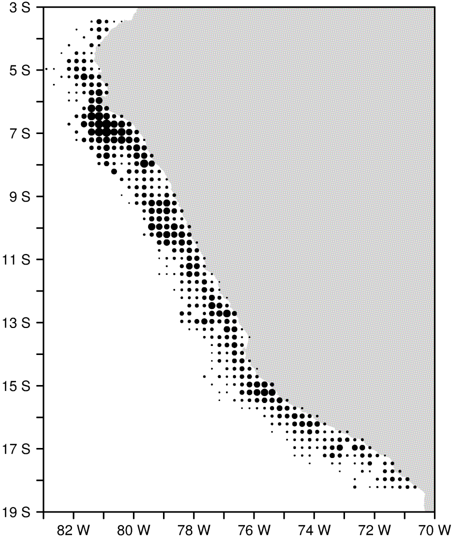

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Conclusions

- Data from scientific surveys is useful to identify spatial patterns in the community structure
- Three biogeographical areas, mainly influenced by the shelf break
- Species associated to warm environments (from the equator) have a limited range distribution
- We identified a biogeographical transition zone between the neritic and oceanic environment: high influence to species with vertical migrations
- In general, the transition from a neritic to a oceanic zone is gradual

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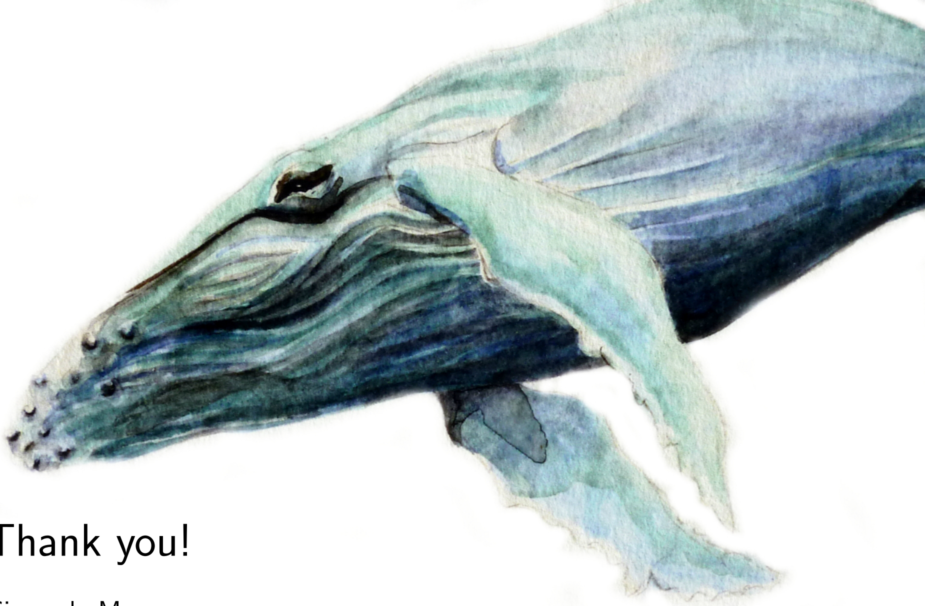

Thank you!

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Picture from ellaquaint