Biogeography of tuna and billfish communities and the environmental forcing

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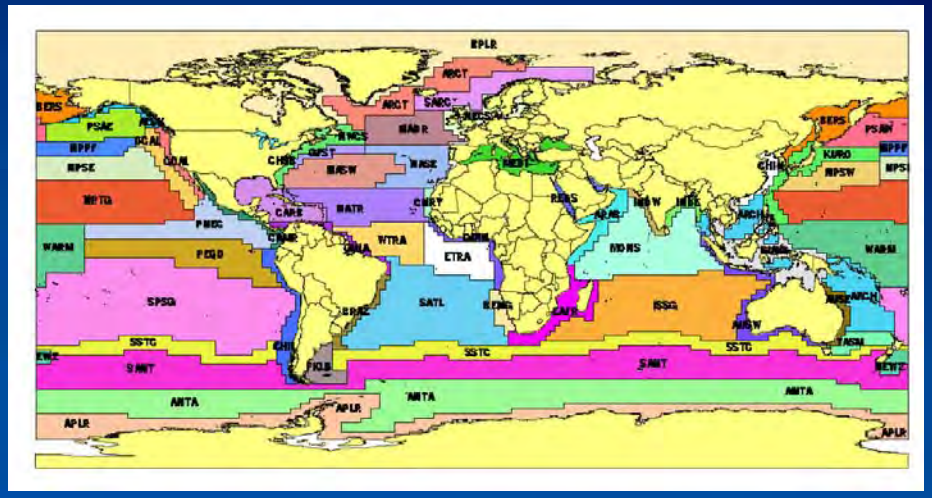
- Biogeography :

"Study of the spatial distributions of organisms… that vary across geographic gradients " Brown, 2005

- Biogeochemical provinces of Longhurst (1998, 2007):

- Based on remote sensing observations and biogeochemical variables
- Atlas of marine ecosystems



Pauly , 2000

Biogeochemical Provinces and trophic web:

- Abiotic parameters: in situ data (AMT) (Hooker et al., 2000)
- Biological observations:

Phytoplankton (Alvain et al., 2008; Sathyandranath et al.,1995)

Bacteria (Li et al., 2004)

Zooplankton (Beaugrand et al., 2002; Wood-Walker et al., 2002)

Benthic organism (Dales, 1985; Spalding et al., 2008)

What about top predator species …

- What is the biogeography of top predator communities ?
- Does the biogeography of top predator match with previous partitions ?
- How climate change will affect the biogeography of top predator?

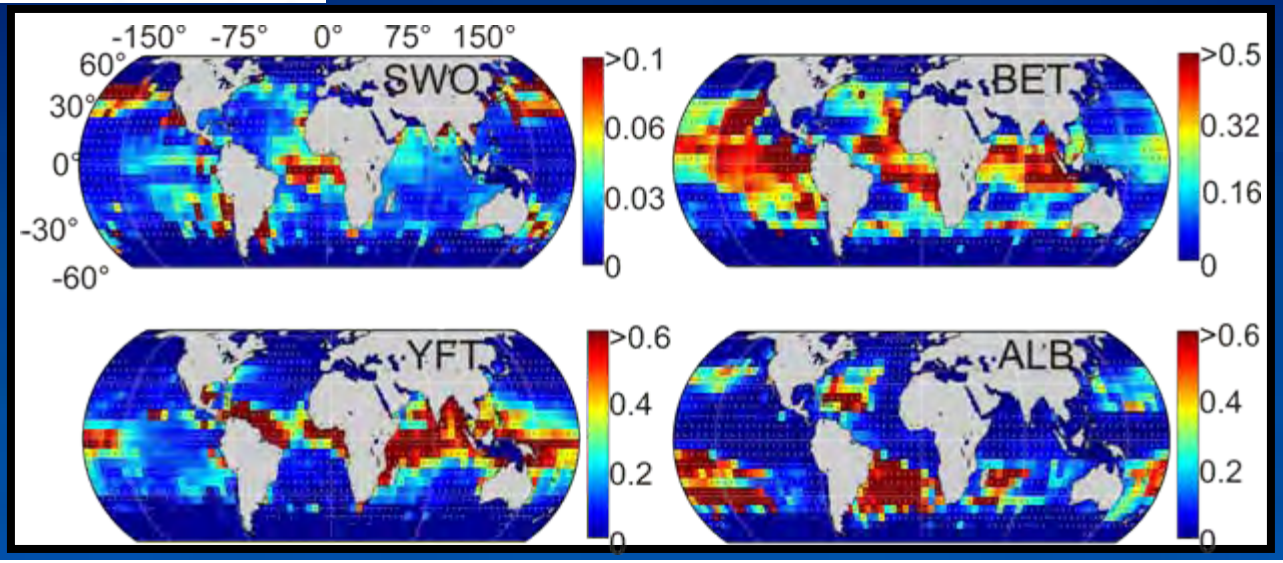
Fisheries data :

- Taiwanese and Japanese long liner Catch and effort associated
- 15 tuna and billfish species
- Monthly mean from 1957 to 2007
- Spatial grid of 5°x5° from 180°E to 180°W and 60°S to 65°N

Spatialized CPUE index:

$$CPUE_{i,j,f} = \frac{\Sigma_t C_{i,j,f\,s,t}}{\Sigma_t E_{i,j,f,t}}$$

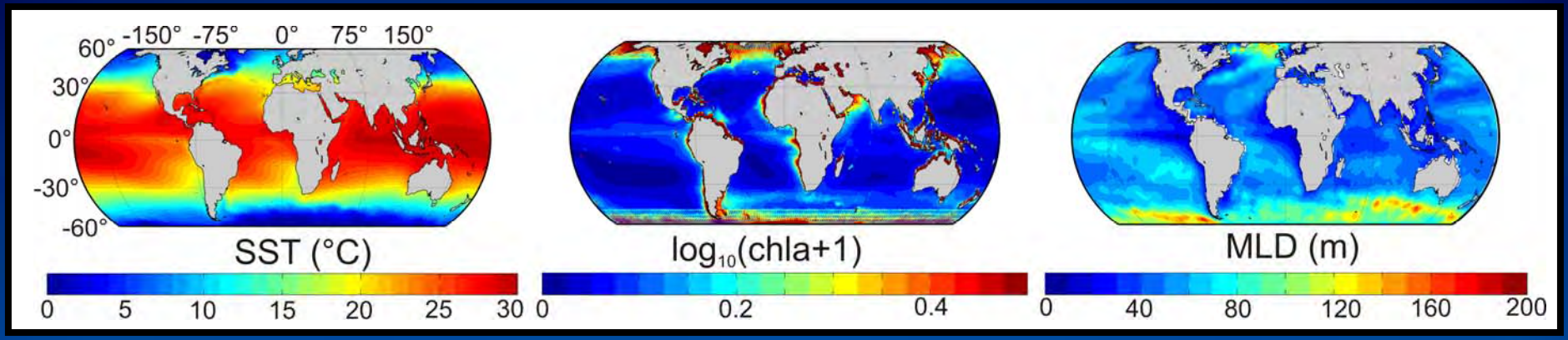
C= catch (tones) E= effort (number of hooks)
i= latitude j=longitude f=fleet s=species
t= time (month, year)



Environmental data:

Annual Climatologies for 14 variables :

- Sea Surface Temperature
- Sea Surface Salinity
- Nutrient: Nitrate, Phosphate, Silicate
- Oxygen : surface, at 100m
- Chlorophyll : mean, variance
- Stratification : thermocline and Mixed Layer Depth
- Bathymetry
- Ocean surface current.



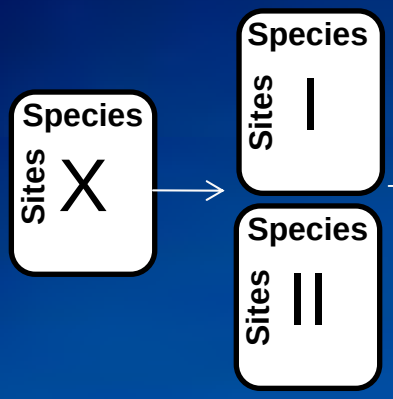
- Statistical methodology :

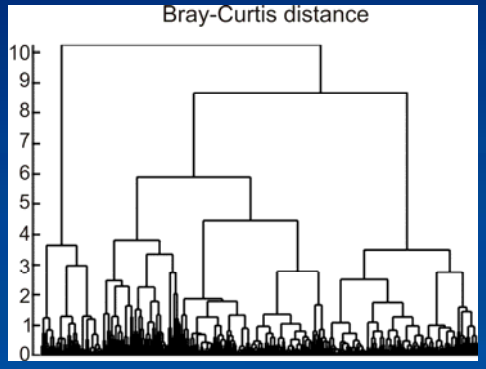
Step 1. Selection of dominant (I) and secondary species (II) (Souissi et al.,2001)

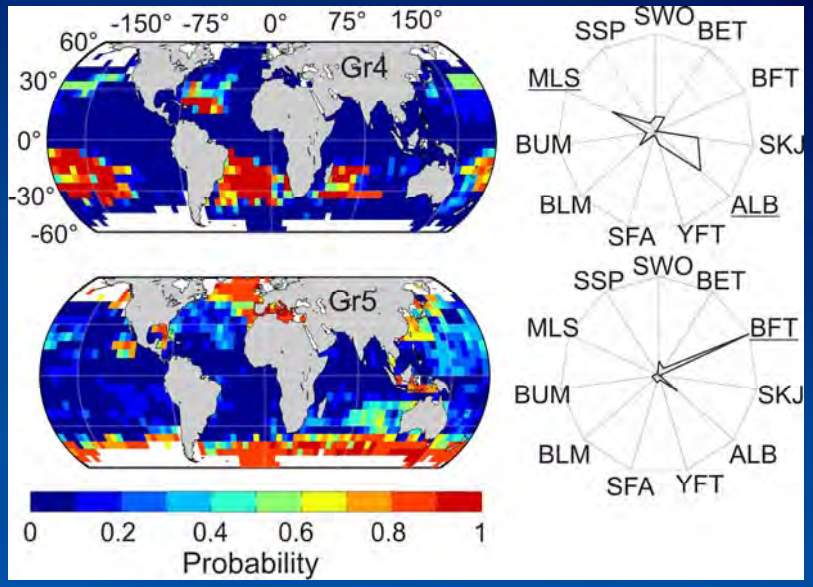
Step 2. Classification
Distance : Bray-Curtis
Linkage: flexible

Step 3.
(a)Probability of each sites to belong to group at a cut off level c (Lenoir et al., 2010)

(b) Index of dominance (Legendre & Dufrêne, 1997)

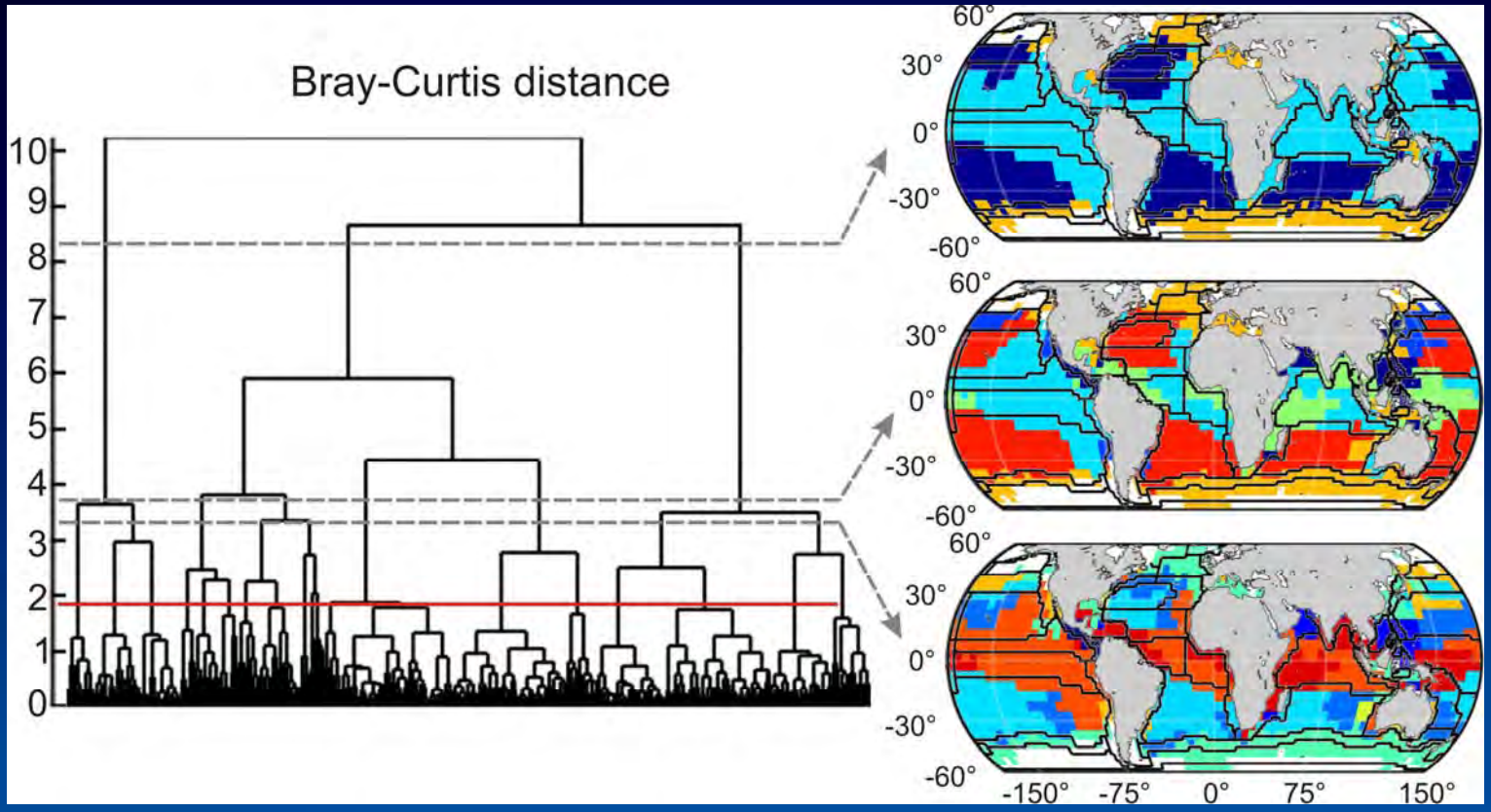






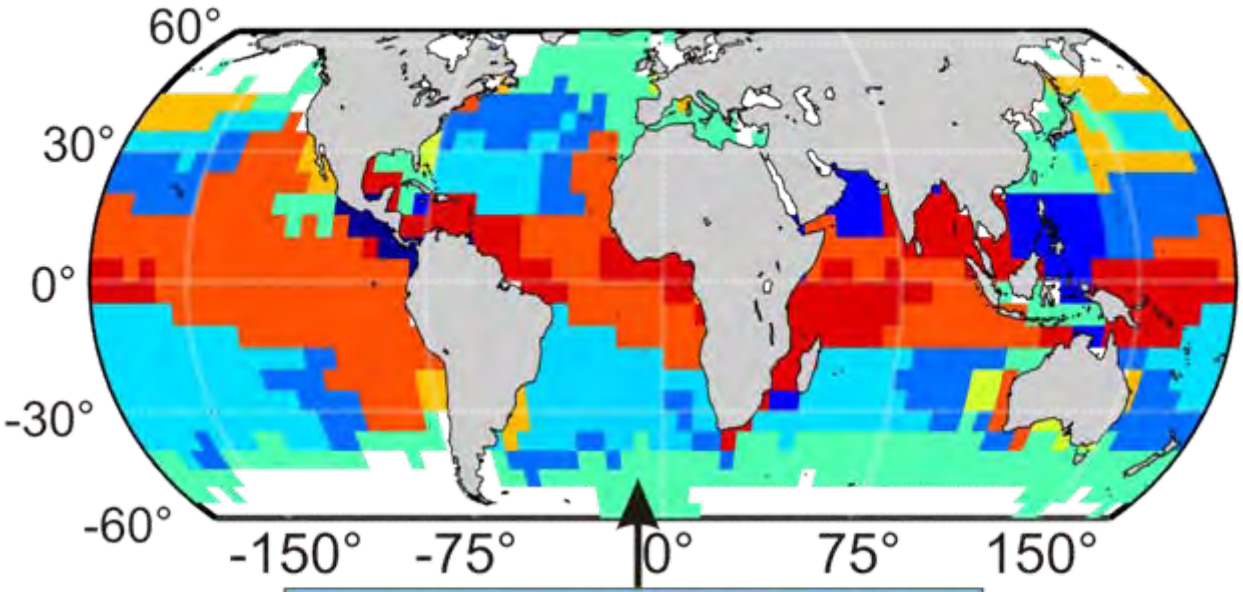
- Statistical methodology:

Step 4. Computation of the maximal probabilities for each site at each cut off level



Step 5. Characterisation of environmental forcing for each ecoregions (using Principal Component Analysis)

- Results: main ecoregions identified



Temperate & Sub-Polar

Bluefin tuna

Westerlies & Polar biome

Parameters :

- SST

+Oxygen Surface

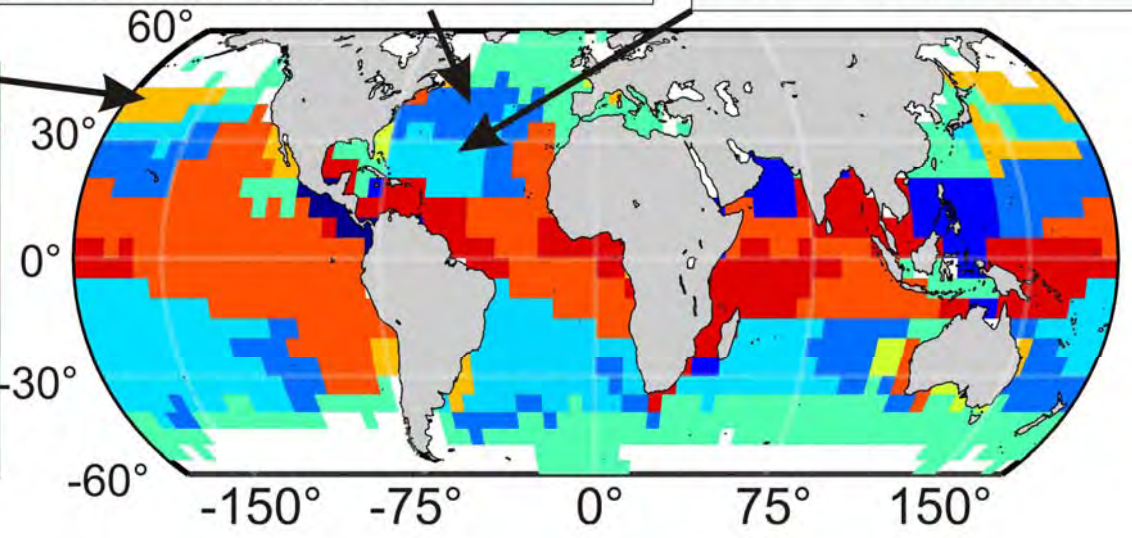
+Mean Chlorophyl & std

- Results: main ecoregions identified

Seasonal extent of Gyre
Albacore tuna
Westerlies biome
Parameters:
+ SST & SSS
- Strafication (IT and ZT)
+ Mean chlorophyl

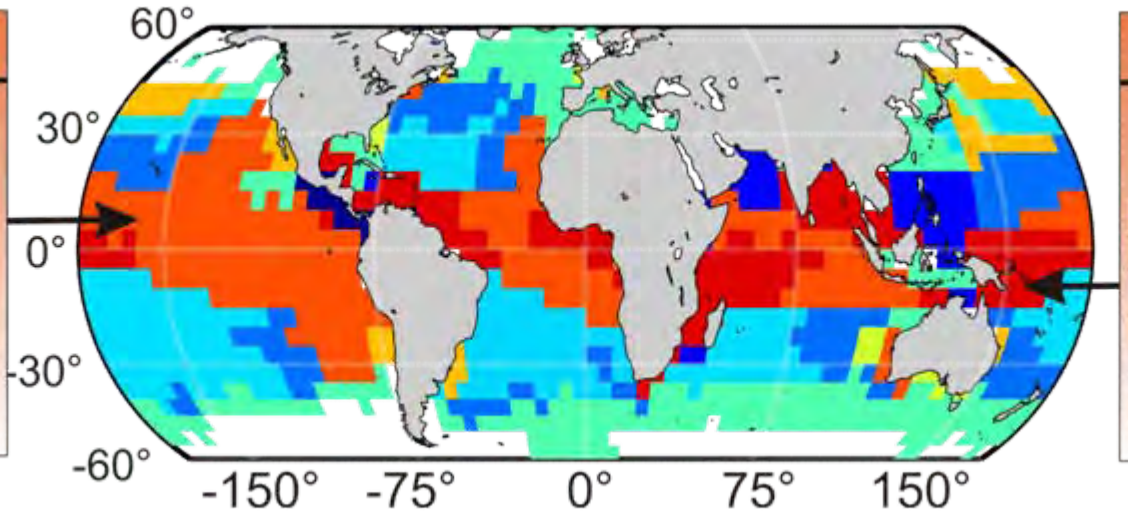
Core of Gyre
Albacore tuna
Westerlies biome
Parameters :
+ SST & SSS
- Stratification (MLD)
- Mean chlorophyl

Transition Zone
Swordfish
Westerlies biome
Parameters:
- SST
+Oxygen surface
+Chlorophyl std



- Results: main ecoregions identified

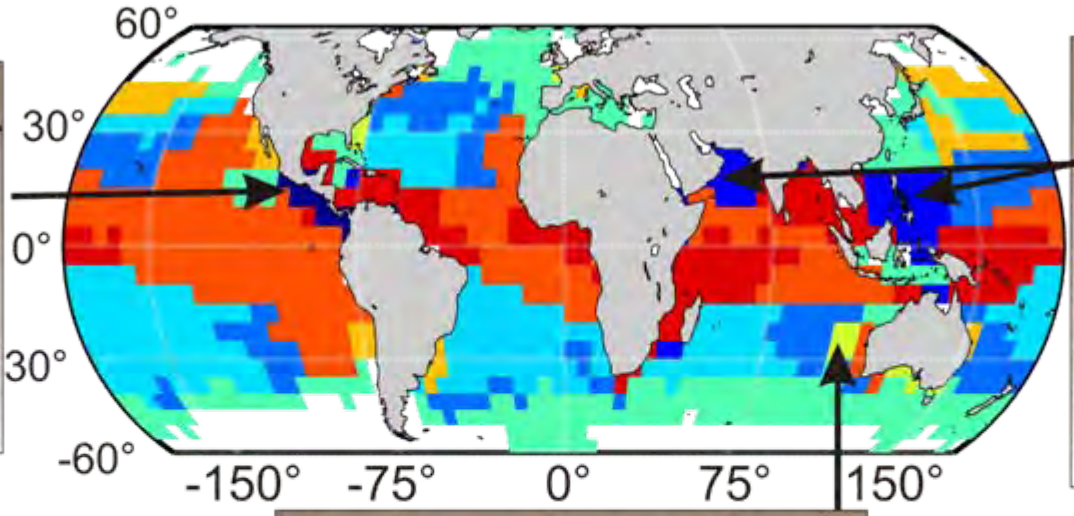
Tropical I
Bigeye tuna
Tropical biome
Parameters:
+SST
+Stratification (IT)
+Stream speed
- Oxygen 100m



Tropical II
Yellowfin tuna
Tropical biome
Parameters:
+SST
+Chlorophyl µ
- Stratification (ZT)
+Salinity

- Results: main ecoregions identified

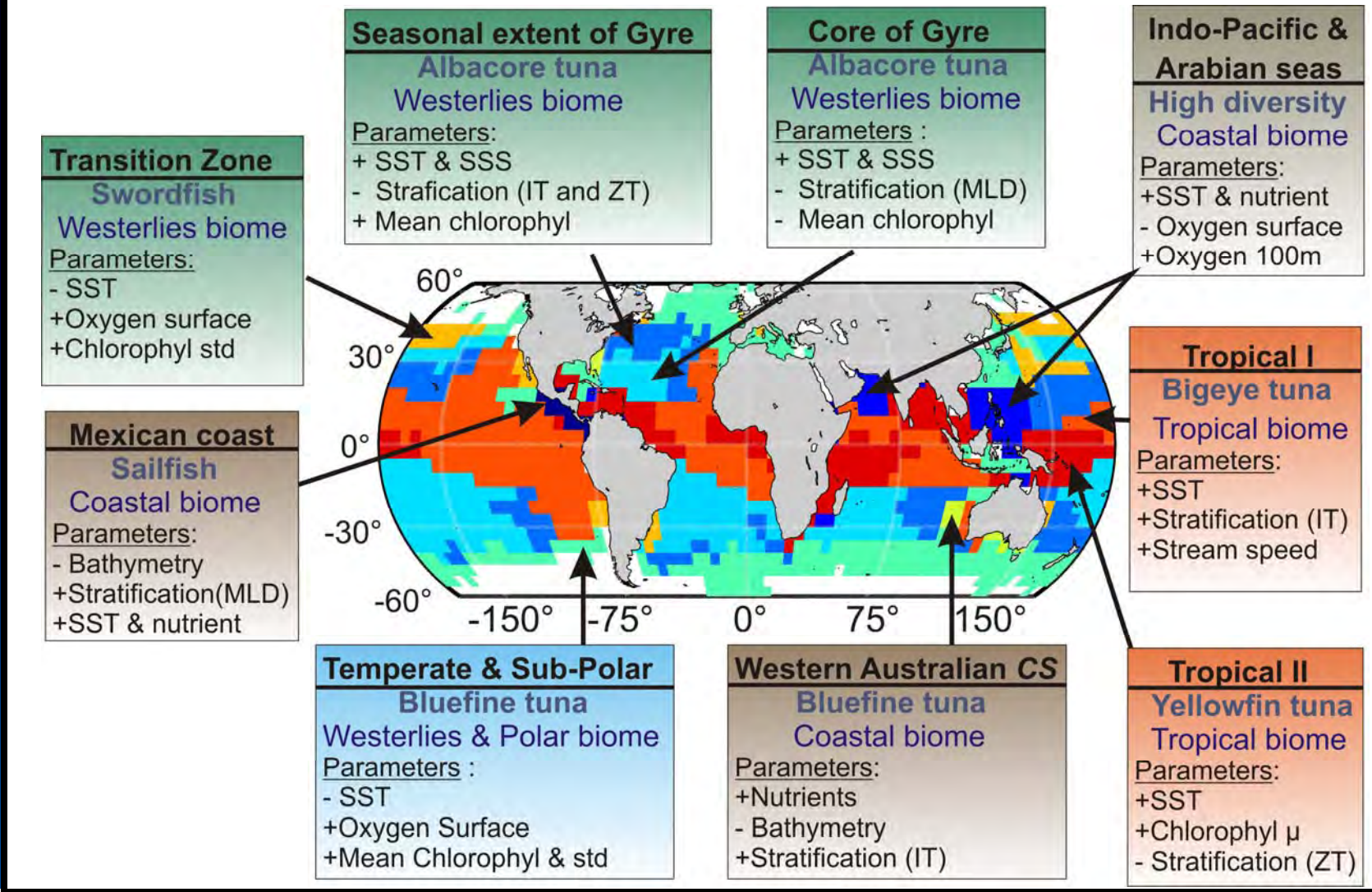
Mexican coast
Sailfish
Coastal biome
Parameters:
- Bathymetry
+Stratification(MLD)
+SST & nutrient



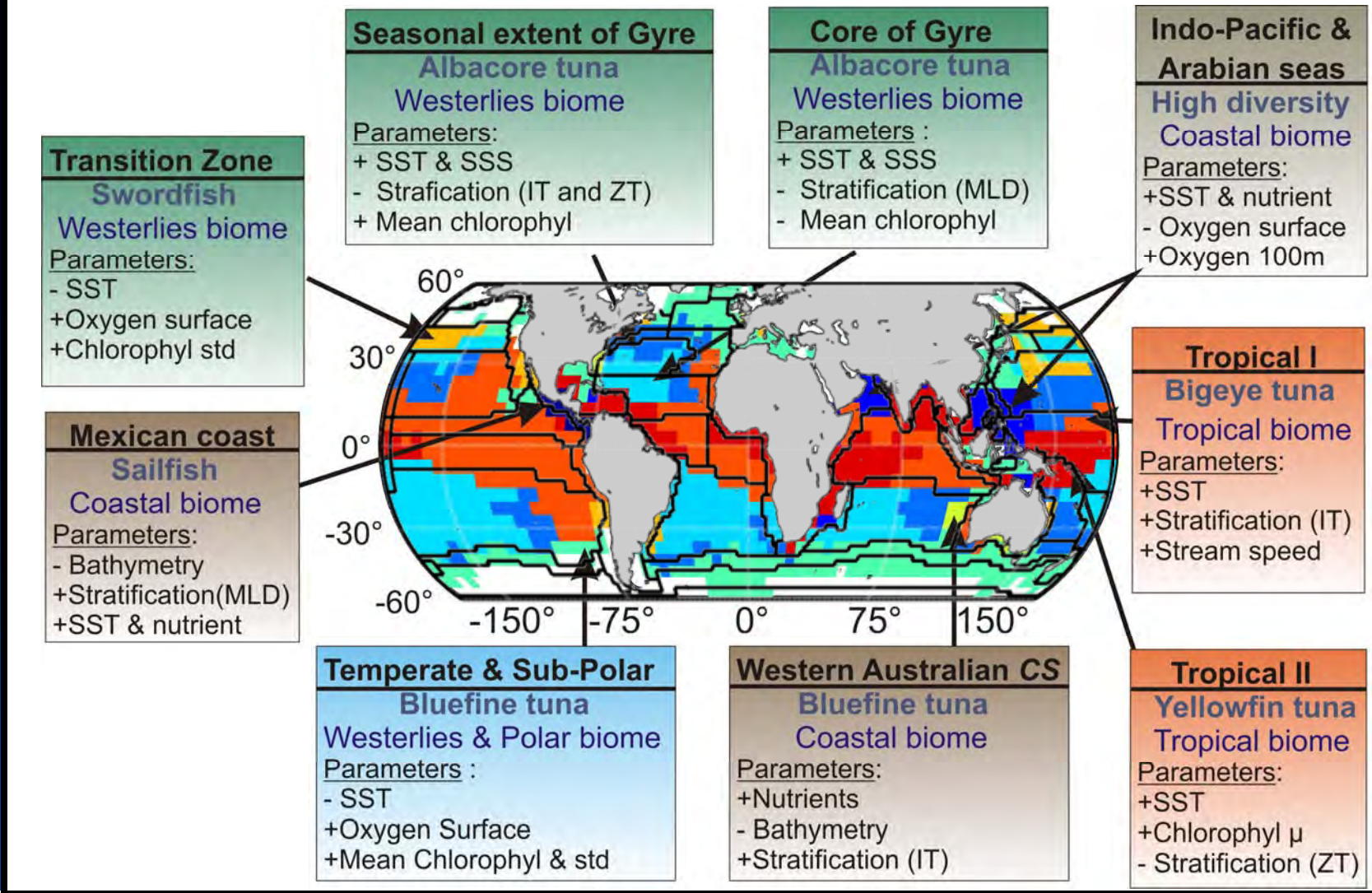
Indo-Pacific & Arabian seas
High diversity
Coastal biome
Parameters:
+SST & nutrient
- Oxygen surface
+Oxygen 100m

Western Australian *CS*
Bluefine tuna
Coastal biome
Parameters:
+Nutrients
- Bathymetry
+Stratification (IT)

- Results: main ecoregions identified



- Results: main ecoregions identified



Trends in the environment of the ecoregions

Time series :

- Sea surface temperature : Icoads (1970-2007)
- Stratification : World ocean database (1980-2007)
- Chlorophyll : Seawifs (1998-2008)
- Oxygen : World ocean database (1977-2007)
- Salinity: World ocean database (1977-2007)

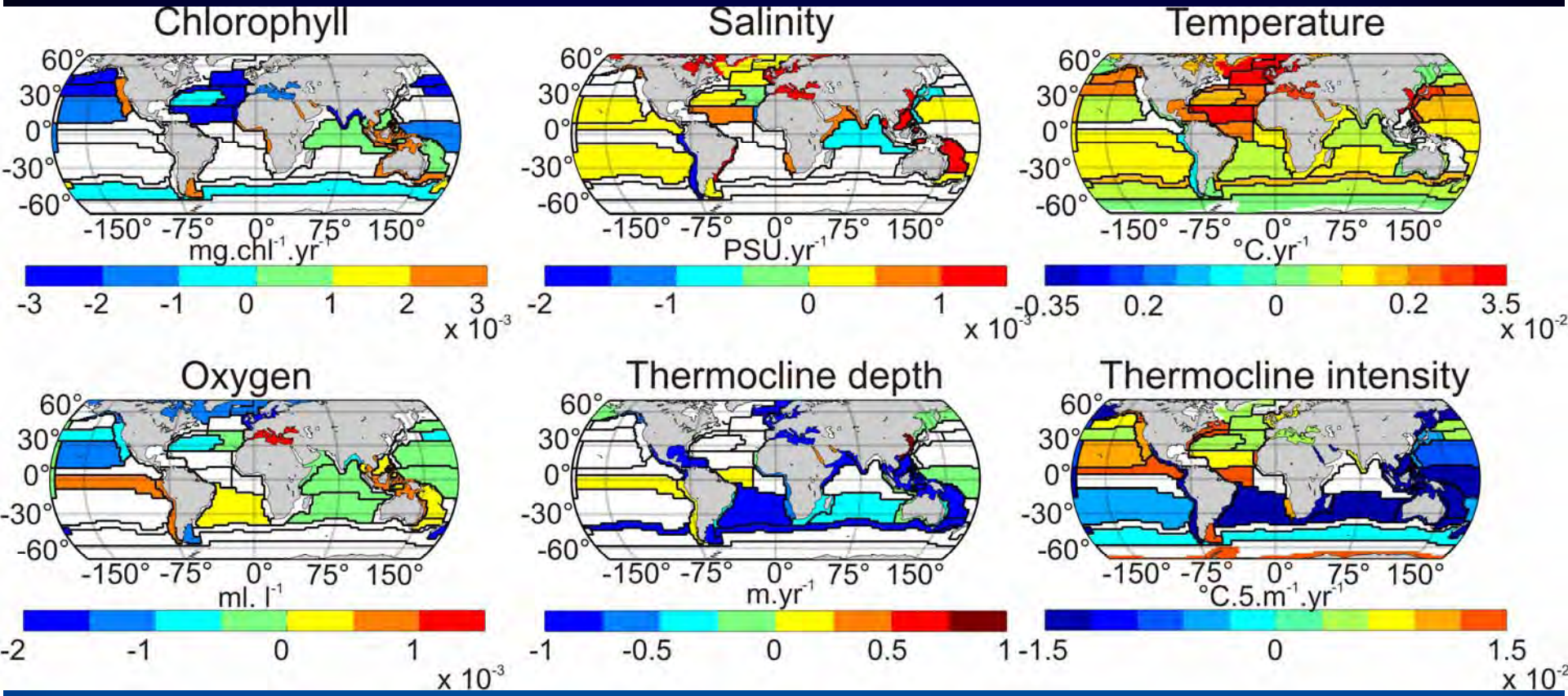
Spatial Referential:

- Aggregation on the Biogeochemical provinces of Longhurst (1998)

Methodology

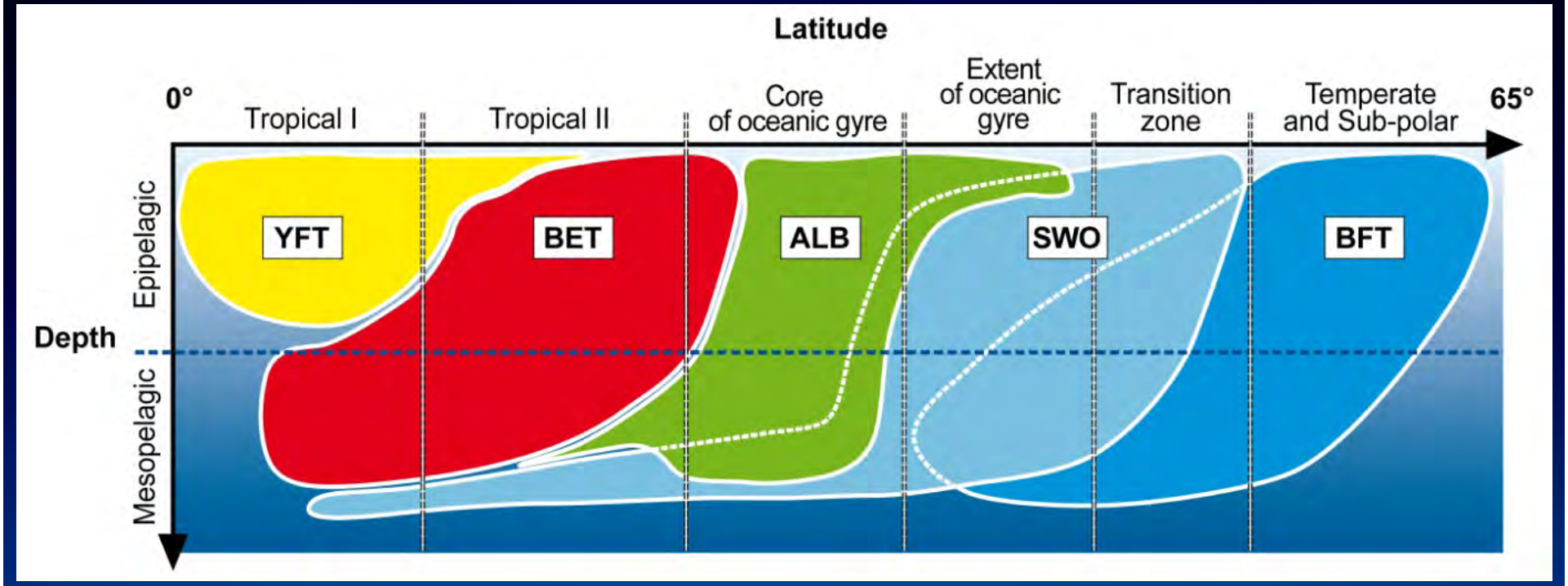
- Filtration by Wavelet analysis of seasonal and inter annual variability
- Quantification of the remaining trends by linear regression

Statistiscal significative slope of the trend in the environment



Drastic changes are observed

Top predator matches the provinces of Longhurst



Top predator fit with the provinces of Longhurst

Effect of Global climate change

Spatial change of the environmental structure of the ecoregion

o Spatial shift of the communities

o Reorganisation of species composition and inter-specific relationships

Top predator fit with the provinces of Longhurst

Effect of Global climate change

Identifying key environmental factors and species composition of top predators ecoregions will help to understand and detect further spatial or temporal changes

Thank you for your attention

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