Evaluation and characterisation of marine biodiversity under climate change

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Context

- The Ocean’s Contribution to Human Wellbeing

Ocean

- Biodiversity
- Ecosystems and functions

Ecosystem Services

HWB

- Social
- Economic

Direct and indirect drivers
• Has global marine biodiversity been previous evaluated?

• **2.2 Millions** eukaryotic species in the ocean (Mora et al., 2011)

• Observed distribution of biodiversity for > 10 000 species (Tittensor et al., 2010)

• Several **modelling** attempts
  -> exploited species (Cheung et al., 2009)
  -> theoritical (Beaugrand et al. 2015)
• Most of the studies on marine diversity have focused on **specific taxonomic group** (exploited species, coastal or copepods)

• Good comprehension on the terrestrial **Latitudinal Diversity Gradient**, the **mechanisms** driving the pattern of marine biodiversity remains unclear.

• Pattern of marine biodiversity is dependent on **thermal or space occupation strategies of species**?
Materials

• The NEREUS Biodiversity Database
  - Data from international website:
    - All occurrence (only) of individual:
      + Species level
      + with >10 different spatio/environmental observations
      + depth and time (month, year) of the sampling (optional)
    - Post database treatment has been processed:
      Removal of synonyms, replicas, misinformed data point, terrestrial/freshwater species
    - >103 000 species, >1\times 10^9 observations from protozoans to mammals
Sampling effort and species richness

Number of records (log10(x+1))

Number of species
Rarefaction curve

- Clear differences in the distribution of the sampling effort
- The vertical dimension...
- Asymptote reached in 4 of the 6 biomes
Observed biodiversity and distribution strategies

- Latitudinal diversity gradient: a complex composition
- The crucial contribution of widely distributed species
- Oceanic < Coastal: sampling Bias or real phenomenon
Biodiversity pattern may be driven by SST and thermal strategies of species or thermal strategies are products of species evolving to adapt to environment.
• Mean thermal niche: High differences between **Narrowly** and **Widely distributed** but same trends

• Breadth of the thermal niche: **loser** and **winners** of climate change
Thermal strategies

Protozoans    Flora    Animalia
To summarize ...

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Species Richness</th>
<th>% widely distributed</th>
<th>Mean Thermal niche</th>
<th>Breadth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polar</td>
<td>coastal</td>
<td></td>
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<tr>
<td></td>
<td>oceanic</td>
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Environmental niche model
Environmental data

• GFDL model (RCP 2.6 & 8.5) and observed climatological data (NASA, WOA):
  + Surface data: SST, SSS, OXY, pH, Zeu, MLD, NO3, PO4, SiO2, NPP, sea ice
  + Seafloor data: Temperature, salinity, oxygen, pH, sediment, NO3, PO4, SiO2

• Resolution:
  Yearly: exploited species (1950-2100) : 2080 species
  Decadal: non-exploited species (1950s-2090s) : 41 095

• ENM already computed:
  Exploited species: Maxent, BRT, NPPEN, BIOCLIM, ENFA
  Non-exploited species: BIOCLIM, ENFA
Some modeled distribution

- Emiliania huxleyi
- Calanus finmarchicus
- Cotylorhiza tuberculata
- Latimeria chalumnae
- Gadus morhua
- Thunnus Thynnus
- Physeter macrocephalus
• Correlation rate with Tittensor et al. (2010) = 0.9233
• Species Richness spatial patterns:
  Sub tropical peaks are retrieved as well as LDG in oceanic and coastal regions
Change in marine biodiversity

<table>
<thead>
<tr>
<th>Year</th>
<th>RCP 2.6</th>
<th>RCP 8.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2050</td>
<td><img src="map2050_r2.6.png" alt="Map" /></td>
<td><img src="map2050_r8.5.png" alt="Map" /></td>
</tr>
<tr>
<td>2100</td>
<td><img src="map2100_r2.6.png" alt="Map" /></td>
<td><img src="map2100_r8.5.png" alt="Map" /></td>
</tr>
</tbody>
</table>

The color scale represents the percentage of change in species richness:
- Blue: >30%
- Green: 15-30%
- Yellow: 5-15%
- Orange: -5-15%
- Red: <-50%
Some preliminary conclusions and perspective

- **Observed biodiversity**
  + Evaluation of the present sampling and knowledge on species richness
  + LDG is structured by the different distribution and thermal strategies
  + Thermal niche: Loser and winners.. some surprise.

- **Modelled biodiversity**
  + Spatial gradient are retrieved
  + A critical loss of SR at a global level that could be minimized
  + Several indicator are needed to better understand these changes

! NPPEN, BRT, ENFA, Maxent need to be run for GFDL
! IPSL and MPI model will be used to compute uncertainties
Study in perspective

- How Interactions between exploited species will be modified?

Consequence for the ecosystem trophodynamic at a global level
(Camille Albouy, ETH Zurich)
Study in perspective

- What are the missing species?
  (with Gregory Beaugrand, SMW, france)

Our estimations

Theory

Sampling

- What are the difference between observed and theoritical model
- Does the missing species are caused:
  -> sampling?
  -> Niche vacation?
Study in perspective

• Biodiversity and Catch (/potential Catch)

SR observations

Catch

Environment

• Is there a relation between Species richness, environment and global catch?
• Does this relation varies in space (LME)?
• Anthropogenic effects?
Acknowledgement:

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Thank you for your attention.
The Ocean’s Contribution to Human Wellbeing

Ocean Health Index vs. Fragile state index