The effects of climate change and the collapse of the shrimp fishery on fish communities’ diversity and ecological functions in a tropical context: The case of the continental shelf off French Guiana

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Local context

A high fish diversity between 400 and 500 species
• An increasing SST (sea surface temperature)
• An increasing SST (sea surface temperature)

• A collapsing fishing pressure by bottom trawling (shrimp fishery)
Objectives and interests

→ Describe the effects of climate change and a decreasing fishing pressure on tropical fish communities

→ Provide a better understanding of the tropical fish communities’ functioning in order to plan how they could respond to future climatic and fishing scenarios

→ Set up future ecological and economic implementations
Samplings

1993 - 2017

RESUBGUY

CHALOUPE

STUDY

10 m

33 stations

60 m

1993 → 2017
Samplings

RESUBGUY

1993

1994

CHALOUPE

2006

2007

2009

STUDY

2016

2014

2017

1990’s

2000’s

2010’s
Functional diversity: the traits based approach

Functional Richness (\textbf{FRic}), Functional Dispersion (\textbf{FDis}) Functional Specialization (\textbf{FSpe})

\textbf{14 morphological traits}

\textbf{2 ecological traits}

- Trophic group
  - planktivorous
  - invertivorous
  - piscivorous
  - omnivorous

- Habitat
  - benthic
  - demersal
  - pelagic

Measured from 1 to 10 collected individuals for 174 species

Modified from Villéger et al., 2010
Functional indices

Functional richness (FRic)

FRic = the portion of the functional space filled by a species assemblage

Convex hull = FRic
Functional indices

Functional richness (FRic)

FRic = the portion of the functional space filled by a species assemblage

FRic of one decade

FRic of the last three decades
Functional indices

Functional richness (FRic)

FRic = the portion of the functional space filled by a species assemblage

Rare species with an extreme combination of traits
Functional indices

**Functional richness (FRic)**

\[ \text{FRic} = \text{abundance weighted deviation of species trait values from the center of the functional space filled by the community} \]

**Functional Dispersion (FDis)**

\[ \text{FDis} = \text{abundance weighted deviation of species trait values from the center of the functional space filled by the community} \]
Taxonomic indices

Species richness (S)

Shannon exponential (H’)

1990’s

2000’s

2010’s

***

***

***

* ns

***

ns
The same trend is observed for the functional specialization (FSpe)
Morpho-ecological groups

- Benthic fish
- Demersal fish
- Rays
- Pelagic fish
- Reef fish
Morpho-ecological groups

- Reef fish
- Demersal fish
- Pelagic fish
- Rays
- Benthic fish

Total Biomass

Biomass (kg)

- 1990’s
- 2000’s
- 2010’s

Graph showing changes in biomass from 1995 to 2015 for different morpho-ecological groups.
Morpho-ecological groups

- Reef fish
- Demersal fish
- Pelagic fish
- Rays
- Benthic fish

Total Biomass

Effects of the decreasing fishing pressure

Biomass (kg)

1990’s 2000’s 2010’s
Size Spectra Slope (SSS)

Size spectra slope

log (abundance)

log (size class median)

1990’s

2010’s
Mean Temperature of the Survey Community (MTSC)

Mean annual SST

\[ MTC_{yr} = \frac{\sum_{i}^{n} T_{i}C_{i, yr}}{\sum_{i}^{n} C_{i, yr}} \]

Cheung et al., 2013
Mean Temperature of the Survey Community (MTSC)

- Mean annual SST
- MTSC

\[ MTC_{yr} = \frac{\sum_{i}^{n} T_i C_{i,yr}}{\sum_{i}^{n} C_{i,yr}} \]

Cheung et al., 2013

<table>
<thead>
<tr>
<th>1990’s</th>
<th>2000’s</th>
<th>2010’s</th>
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<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td>Mean B = 2 t</td>
<td>Mean B = 2.57 t</td>
<td>Mean B = 2.86 t</td>
</tr>
<tr>
<td>60%</td>
<td>39%</td>
<td>34%</td>
</tr>
<tr>
<td>Tropical species</td>
<td>Sub-tropical species</td>
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</tbody>
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- 1990’s: Mean B = 2 t, 60%
- 2000’s: Mean B = 2.57 t, 39%
- 2010’s: Mean B = 2.86 t, 34%
The Rays group

Biomass (kg)

<table>
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<th></th>
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<tbody>
<tr>
<td>H. americanus</td>
<td>90%</td>
<td>4%</td>
<td>0.5%</td>
</tr>
<tr>
<td>H. guttatus</td>
<td>0%</td>
<td>41%</td>
<td>53%</td>
</tr>
<tr>
<td>F. geijskesi</td>
<td>0%</td>
<td>47%</td>
<td>38%</td>
</tr>
</tbody>
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Sub-tropical species
Tropical species
Restructuring of the fish communities so far but until when?
What’s next about SST?
What’s next about SST?
What’s next about SST?
What’s next about SST?
What’s next about SST?
What’s next about SST?

Mean SST of the 1990's
Mean SST of the 2010's
Estimated mean SST for 2050 (30°C?)

Species rank

T (°C)

15
Conclusions

→ Biodiversity in tropical regions is likely to be impacted by higher rate of local extinction due to warming waters

→ In French Guiana, positive effects of the decreasing fishing pressure on the fish communities’ dynamics dominates over the climate change so far
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→ Biodiversity in tropical regions is likely to be impacted by higher rate of local extinction due to warming waters

→ In French Guiana, positive effects of the decreasing fishing pressure on the fish communities’ dynamics dominates over the climate change so far

→ Ecosystem approach to fisheries management

→ Mechanistic approaches to evaluate impacts of future scenarios on fish communities
Thank you!

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