Under pressure: Fisheries and climate change in a highly vulnerable marine ecosystem

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Juan Fernández Ridge Ecosystem
Location - Structure

- 1% Chilean Territory
- Approximately 97,166 km²
- Juan Fernández Archipelago
  - 1000 inhabitants (aprox.)
  - Robinson Crusoe - Santa Clara
  - Selkirk
Juan Fernández Ridge Ecosystem
JFRE as a VME

- 80% of endemism
- 60% historical extinctions
- 59% threatened or rare species
- Biosphere Reserve (1977)
- Highest Conservation Priority Chile
ECONOMY - Fisheries

Mainland

Archipelago
THE INDUSTRIAL FLEET

THE HISTORY OF A FAILURE

- Trawling fisheries
- Boom-and-Bust fishery
- Both currently closed
  - 2006 Orange roughy
  - 2012 Alfonsino
THE ARTISANAL FLEET
A FRAGILE SOCIO-ECONOMIC SYSTEM

- Tightly-knit fishing community
- Main economic income
  - 70% Lobster fishery
- Management
  - 3S type - Formal management
    - Size - Sex - Season
  - Internal code of conduct

Likely future increase in fishing effort
Climate Change

Expected changes in the JFRE

- Severe increase in aridity
  Karnauskas et al. 2016

- Increase in seawater temperature
**Climate Change**

**Impacts on resources**

- Unknown impact on fisheries
- No fish - no food and no money
- Important management problem
  - Fisheries
  - Political
  - Conservation
- Uncertain socio-ecological future
ASSESSING THE IMPACT OF CLIMATE CHANGE IN JFRE
ATLANTIS - SHORT DESCRIPTION

- Spatial explicit whole of ecosystem model
  - Physical drivers
    - Currents
    - Temperature
  - Bio-ecological processes
    - Growth
    - Reproduction
    - Trophic relation
  - Management and harvesting
    - Fishing mortality
    - Effort control
  - Social drivers
    - Revenues
    - Social impact
ASSESSING THE IMPACT OF CLIMATE CHANGE
Configuration: JFRE Atlantis model
ASSESSING THE IMPACT OF CLIMATE CHANGE
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Configuration: JFRE Atlantis model

[Graphs showing industrial and artisanal fleet data]

[Diagram of the Juan Fernández Ridge Model with geographic model (polygons), physics model, harvest model, and biological model]
## Including Climate Change

### Scenarios - Projections 2050

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Crustacean C</th>
<th>Finfish F</th>
<th>C. Change</th>
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</thead>
<tbody>
<tr>
<td>BAU</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>50%↑ C+F</td>
<td>↑</td>
<td>↑</td>
<td>✓</td>
</tr>
<tr>
<td>300%MIX</td>
<td>↓ 20%</td>
<td>↑</td>
<td>✓</td>
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</tbody>
</table>

(IMAS-CSIRO) Climate Change in VME
MODEL SKILL ASSESSMENT

Model Efficiency $\sim 1$
Correlation $\sim 0.9$
Trophic structure

**Trophic levels**

*JFRE Simulated Average Food-web*

- Highly dependent on local primary production
- The major component of the food web:
  - phytoplankton
  - zooplankton
  - mesopelagic fishes
TROPHIC LEVELS
HINDCAST MODEL

ARTISANAL
- High impact on Lobster
- Almost no impact on Finfish
- Increase on sea urchin

INDUSTRIAL
- High impact on Alfonsino
- Big impact on bycatch
- Impact highly localize
**TIME SERIES PROJECTIONS**

**Changes through time - since 2011**

- High Difference compared to 2011
- RCP 4.5 biggest impact
- Highest impact on primary producers
**COMPARE by FUNCTIONAL GROUPS**

**Average change (2005 - 2011) & (2040 - 2050)**

- RCP 4.5 biggest change
- Mayor impact on large phytoplankton
- Escalated effect
- Low effect on crustaceans
**Cumulative Effect**

**Base-scenario BAU**

- RCP 8.5 & 4.5 similar
- **50% Increase All**
  - ↓ Spiny lobster, golden crab and JF morwong biomass
- **Mix (-20% lobster)**
  - ↑ Spiny lobster biomass
  - ↓ Golden crab biomass
**COMPARE BAR-PLOTS**

**PROJECTED CATCH IN THE LONG RUN**

- RCP 8.5 & 4.5 similar
- **BAU**
  - ↑ small increase in all the catches
- 50% Both
  - ↓ Spiny lobster
  - ↑ Other Species
- MIX (-20% lobster)
  - ↑ Spiny Lobster
  - Golden Crab
**CONCLUSION**

**PROJECTED CATCH IN THE LONG RUN**

- Controlled by primary production
- Low impact from the artisanal fisheries
- Increase in the sea urchin population
- The ecosystem is not at optimal dynamical state
CONCLUSION
PROJECTED CATCH IN THE LONG RUN

- Controlled by primary production
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THOUGHTS FOR THE FUTURE

ALWAYS ABOUT DATA

Biology
- Biomass
- Recruitment
- Energetic costs

Modelling
- Bio-energetic
- Integrating CC stressors

Management
- New measures
- Foster diversification
In Chile today, nobody can seriously think about the future or development without addressing the environmental dimension. But not as a slogan, but with concrete actions, with participation, with public-private collaboration, hand in hand with society and science, looking at the world (Michelle Bachelet (Former President of Chile) during the signing of the Decree on the Creation of Marine Protected Areas in the Juan Fernandez Ridge Ecosystem.

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