Projected change in global fisheries revenues and effort under climate change

Vicky W. Y. Lam

Nippon Foundation-Nereus Program & Sea Around Us, The University of British Columbia
v.lam@oceans.ubc.ca

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Outline:

Part 1: Projected changes in global fisheries revenues under climate change;

Part 2: Predicting fishing effort.
Mean percentage change in maximum catch potential (MCP) and revenues in the 2050s relative to current status under RCP 8.5 scenario

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>% change in MCP</td>
<td>-7.71</td>
<td>4.36</td>
</tr>
<tr>
<td>% change in revenues</td>
<td>-10.37</td>
<td>4.20</td>
</tr>
</tbody>
</table>

% change in revenues is 35% more than % change in MCP

Lam, Cheung, Reygondeau, Sumaila. (in revision)
### Price Scenarios (RCP 8.5)

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Brief descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Most plausible assumptions</td>
</tr>
<tr>
<td>Faster aquaculture expansion</td>
<td>The aquaculture output of the seafood commodities <strong>increased by 50%</strong> relative to baseline scenario</td>
</tr>
<tr>
<td>Lower China production</td>
<td>Income demand elasticities, production growth trends, and feed conversion ratios are <strong>adjusted downward</strong>.</td>
</tr>
<tr>
<td>Fishmeal and oil efficiency</td>
<td>Feed conversion efficiency for fishmeal and fish oil improves = 2 x baseline scenario</td>
</tr>
<tr>
<td>Slower aquaculture expansion</td>
<td>The aquaculture output of the seafood commodities <strong>decreased by 50%</strong> relative to baseline scenario</td>
</tr>
</tbody>
</table>
### Price Scenarios (RCP 8.5)

<table>
<thead>
<tr>
<th>Baseline</th>
<th>Faster aquaculture expansion</th>
<th>Lower China production</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Projected change in price (%)</strong></td>
<td><strong>Projected change in price (%)</strong></td>
<td><strong>Projected change in price (%)</strong></td>
</tr>
<tr>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
<td><img src="image3" alt="Graph" /></td>
</tr>
<tr>
<td>% change in revenue</td>
<td>13%</td>
<td>-15%</td>
</tr>
</tbody>
</table>

### Fishmeal & fish oil efficiency

<table>
<thead>
<tr>
<th>Fishmeal &amp; fish oil efficiency</th>
<th>Slower aquaculture expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Projected change in price (%)</strong></td>
<td><strong>Projected change in price (%)</strong></td>
</tr>
<tr>
<td><img src="image4" alt="Graph" /></td>
<td><img src="image5" alt="Graph" /></td>
</tr>
<tr>
<td>% change in revenue</td>
<td>11%</td>
</tr>
</tbody>
</table>
Latitudinal and regional patterns of impact on fisheries revenues

Latitudinal pattern

Change at different ocean basins

Lam, Cheung, Reygondeau, Sumaila. (in revision)
Are the impacts equally important in different countries?

Lam, Cheung, Reygondeau, Sumaila. (in revision)
Challenges

1. Price dynamics;

2. Degree of economic impact also depends on how people value the future (i.e., the discount rate);

3. Uncertainties (Model and structural uncertainties).
### Uncertainties

#### Model uncertainty

**% change in maximum catch potential**

<table>
<thead>
<tr>
<th>Model</th>
<th>GFDL</th>
<th>IPSL</th>
<th>MIP</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP 2.6</td>
<td>-1.66</td>
<td>-8.49</td>
<td>-2.03</td>
<td>-4.06</td>
<td>3.84</td>
</tr>
<tr>
<td>RCP 8.5</td>
<td>-4.44</td>
<td>-12.66</td>
<td>-6.02</td>
<td>-7.71</td>
<td>4.36</td>
</tr>
</tbody>
</table>

**% change in fisheries revenues**

<table>
<thead>
<tr>
<th>Model</th>
<th>GFDL</th>
<th>IPSL</th>
<th>MIP</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP 2.6</td>
<td>-5.07</td>
<td>-11.15</td>
<td>-5.12</td>
<td>-7.11</td>
<td>3.50</td>
</tr>
<tr>
<td>RCP 8.5</td>
<td>-6.88</td>
<td>-15.03</td>
<td>-9.21</td>
<td>-10.37</td>
<td>4.20</td>
</tr>
</tbody>
</table>

#### Different Earth System Models (ESMs)

#### Different structure of fish models

**% change in global fisheries revenues in the 2050s from the current status (2000s)**

<table>
<thead>
<tr>
<th>Earth System Model</th>
<th>GFDL</th>
<th>Spatial distribution models</th>
<th>Basic</th>
<th>AquaMaps</th>
<th>Maxent</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum catch potential</td>
<td></td>
<td></td>
<td>-5.8</td>
<td>-8.2</td>
<td>-3.6</td>
<td>-5.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Fisheries revenues</td>
<td></td>
<td></td>
<td>-10.1</td>
<td>-9.6</td>
<td>-4.1</td>
<td>-7.9</td>
<td>3.4</td>
</tr>
</tbody>
</table>
Future studies

1. Should include other metrics such as monetized utility (e.g., consumer surplus) and resource rents (e.g., producer surplus);

2. Actual catch may not equal to MCP. Future studies should consider the influence of different policies;

3. Other human and socio-economic responses to climate change should also be considered e.g., adaptation responses.
Outline:

Part 1: Projected changes in global fisheries revenues under climate change;

Part 2: Predicting fishing effort.
However, the earlier version DBEM did not include:

- Δ the catch amount and profit → the investment → the fishing effort;

- Δ effort → biomass and catches.

(Nereus workshop on effort dynamic in 2015)
Predicting fishing fleet dynamics using a simple bioeconomic model

**Assumption:** that active effort will seek to maximize profits from a fishery given yearly price and cost information.

- Within a given year, enter a fishery vs remain at the dock;
- Over longer time spans, the total fleet size will change depending on the profitability of the fishery;
Parameters and variables in the effort dynamic model

**Biology**
- Biomass
- Carrying capacity
- Intrinsic population growth rate
- Density-dependent distribution

**Economics**
- Ex-vessel price
- Unit cost of fishing
- Cost of each new vessel
- Reinvestment ratio

**Fisheries**
- Initial fleet size and active effort
- Number of new vessel
- Effort response to catch
- Capital depreciation
- Catchability
## Source of parameters

**Some examples:**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sources</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active fishing effort, $E$</td>
<td>SAU fishing effort database</td>
<td>The fishing effort data is by country, year, sector and gear type (not by spp and no spatial information)</td>
</tr>
<tr>
<td>Ex-vessel price, $p$</td>
<td>SAU price database</td>
<td>Assume the price keep constant after 2010</td>
</tr>
<tr>
<td>Unit cost of fishing, $c$</td>
<td>Global fishing cost dB (Lam et al. 2011)</td>
<td>No time series data</td>
</tr>
<tr>
<td>Effort response to profit, $p$</td>
<td>Assumed</td>
<td></td>
</tr>
<tr>
<td>Reinvestment ratio, $I$</td>
<td>Assumed</td>
<td>Proportion of profit reinvested into fishery</td>
</tr>
<tr>
<td>Catchability, $q$</td>
<td>Estimated from the current values</td>
<td></td>
</tr>
</tbody>
</table>
Overview of the DBEM with effort dynamic model

Global climate change projections

Predicted future species distribution

Species composition in each EEZ

Catch

Fishing cost

Land value

Fishing effort

Last year?

Profit > 0?

Yes

Yes

New Investment

No effort

Output projected catch potential & landed value

No

Yes

Dynamic Bioclimatic Envelope Model (DBEM)
Spatial distribution of fishing effort (Gravity Model)

\[ \hat{c} = \sum_{i=1}^{n} h_i p_i \text{Prop} / \sum_{i=1}^{n} D_i \]

- \( \hat{c} \) is the average fishing cost per km;
- \( \text{Prop} \) is the proportion of operational cost to the total landed value of a sector.

In each cell:

\[ G_i = K \sum_{j=1}^{n} (p_{ij} \times q_{ij} \times B_{ij}) / c_i \]

- \( G \) is the weighted “attractiveness” of a cell to fleet;
- \( K = \) if cell is open to that fleet, then 1, otherwise 0;
- \( c_i = \) fishing cost = \( \hat{c} \times D_i \);

\[ F_i = F_T \times G_i / \sum_{i=1}^{n} G_i \]

- \( F_T \) is the total fishing effort in a EEZ.
Way forward

• Testing model implementation of the linkages between DBEM and fishing dynamic model;

• Application of case studies e.g., Bangladesh, Solomon Islands, with the focus on nutritional security;

• Linkages to macro-economic model (University of Akansas).
Conclusions

1. Global revenues could drop by 35% more than the projected decrease in catches by 2050 under RCP8.5;

2. Projected increase in fish catch in high latitude countries may not translate into increase in revenues;

3. Most developing countries (low HDI) with high fisheries dependency are negatively impacted;

4. These results provide further justification for the need to begin to decarbonize the global economy by implementing the Paris Agreement;

5. The inclusion of fishing effort dynamic into the DBEM allows us to project the future MCP and revenues in a more realistic way.
Acknowledgement

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Contact: v.lam@oceans.ubc.ca

Source: FERU website (http://www.feru.org)