Getting the big picture in focus
Assessing climate and human factors with global human-ocean models

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Warming
Deoxygenation
Acidification
Plastics
Deep Sea Mining
Coastal Pollution
Fisheries
Invasive Species
Nutrient supply
Primary production
Ocean currents
Acidification
Food web structure
What the heck is happening

What might happen in the long-term future

Models as synthesis tools
Why a global perspectives is necessary

• We are throwing a global party and 10 billion people are invited

• Will we all have enough to eat? How can we maintain healthy ecosystems and prevent widespread extinctions?

Gerland et al., Science 2014
Why a global perspectives is necessary

• Addresses possible location-bias of local changes
• Provides context for local changes
• Can help to illuminate universal processes
• Climate and the oceans both require global policy
Climate model approach

- Strives for fundamental basis
- Test models against past observations
- Can provide future projections on long timescales
Natural-Social Science Gap

Physics
Chemistry
Biology

Well-being
Values
Behaviour
Fish Models

Climate Physics → Fish

Cheung et al., Global Change Biology 2010
Diverse modeling approaches

- Ecopath/Ecosim
- Atlantis
- OSMOSE
- DBEM
- APECOSM
- Madingly
- EcoOcean
- Macroecological
- POEM
- BOATS
Projected fish biomass

Tittensor et al., GMD 2018

Blanchard et al., Nature Ecology and Evolution 2017
Why do the global models predict that climate change reduces fish biomass?
Body size as a master organizing variable
Parameter optimization

- Randomly generate a combination of 13 parameter values from the prescribed probability distributions
- Run a transient simulation with 5% y⁻¹ increasing catchability and constant environmental boundary conditions
- Save output

Monte Carlo loop

- Repeat 10,000 simulations

Ensemble selection

- Optimize ensemble
- Remove simulations with too-large or too-small global LME peak harvests
- Remove simulations with unrealistic size structure of catch
- Remove simulations with unrealistically large H:B ratios
- Rank simulations based on correlation of LME peak harvests

Carozza et al., PLoS One 2017
Carozza et al., *Global Ecology and Biogeography*, in review
Integrated global impact in BOATS

Carozza et al., *Global Ecology and Biogeography*, in review
Large model uncertainties

- Simple, mostly linear behaviour
- No tipping points
- Missing many processes
- Need more close collaboration between modelers and observationalists
Hindcasts: can we predict the past?
World fish catch

(a) CMIP3
CMIP5
observations

Year
1860 1880 1900 1920 1940 1960 1980 2000

Temperature anomaly (°C)
0.0
0.5
1.0
1.5

Effective radiative forcing (W m⁻²)
0
-0.5
-1.0
-1.5

Year
1860 1880 1900 1920 1940 1960 1980 2000

(e)

(f)
Technology was the main driving force in the global fishery during the 21st century.
Perfect ability to harvest & govern

Technology-driven change (no regulation)

Galbraith et al., *Nature Communications*, 2017
Perfect ability to harvest & govern preindustrial climate change technology & socio-economics

Technology-driven change (no regulation)

Galbraith et al., *Nature Communications*, 2017
Perfect ability to harvest & govern preindustrial climate change

Technology-driven change (no regulation)

Galbraith et al., *Nature Communications*, 2017
Perfect ability to harvest & govern preindustrial climate change

Technology-driven change (no regulation)

Climate & socio-economics

Galbraith et al., *Nature Communications*, 2017
Perfect ability to harvest & govern preindustrial climate change.

Technology-driven change (no regulation).

Large scope for improvement through regulation.

Deployment of existing technology

Fish forecasts

Robot fishermen
Dynamic regulation (constant climate)

No regulation | Some regulation | Perfect regulation

PhD student Kim Scherrer, in preparation
Summary

• We need global predictive models to envision and quantify possible futures.

• Existing global fish models unanimously predict a decrease of fish biomass due to climate change in 21st century, but processes remain highly uncertain, models lack tipping points.

• Non-climate human factors are of comparable or potentially greater importance (e.g. technology).

• Can counter climate change impacts with improved fishery regulation.

• Need more work on natural-social science integration.

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