Toward a new FishMIP protocol for projecting fisheries into the future using the Ocean System Pathways (OSPs) framework

Olivier Maury, Derek Tittensor, Tyler Eddy, Julia Blanchard, Camilla Novaglio and the FishMIP Scenario Working Group.

FISHERIES & MARINE ECOSYSTEM
FISH-MIP
MODEL INTERCOMPARISON PROJECT

FAO
FIAT PANIS

ISIMIP

Inter-Sectoral Impact Model Intercomparison Project

climate projections
RCP scenarios from CMIP & CORDEX archives

Socio-economic input
SSP scenarios

Impact models global & regional

agriculture	water
biomes	Forests
coastal infrastructure	health
fisheries	energy
agro-economics	permafrost

- Synthesis of impacts at different levels of global warming
- Quantification of uncertainties
- Model improvement
- Cross-sectoral interactions
- Cross-scale intercomparison
- Focus topics (e.g. extreme events, adaptation)

Agriculture Sector

Agro-economic Modelling

Terrestrial biodiversity

Permafrost

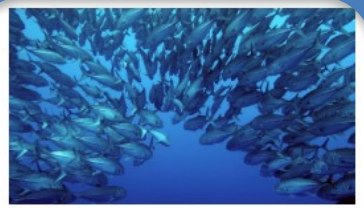
Coastal Infrastructure

Health

Lakes

Water (global)

Water (regional)



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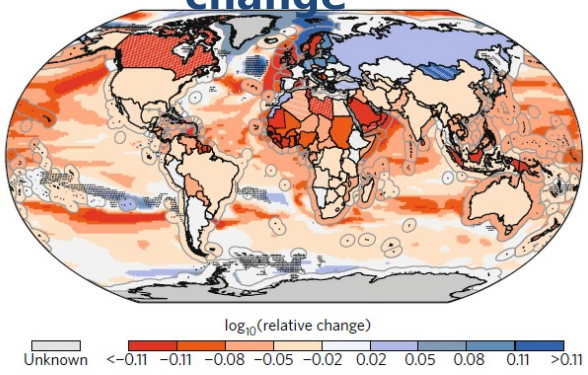
Energy Supply & Demand

Regional Forests

Global Biomes

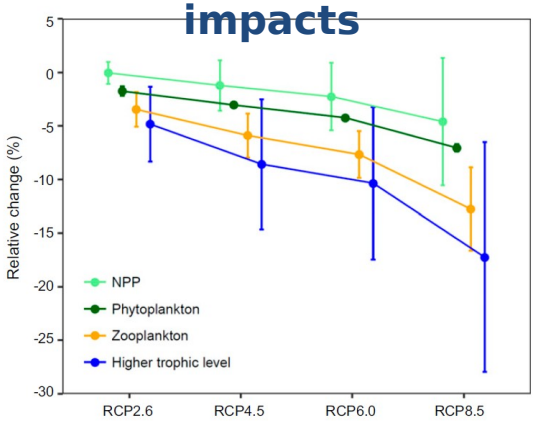
Contribution to IPCC & IPBES

Food security & climate change



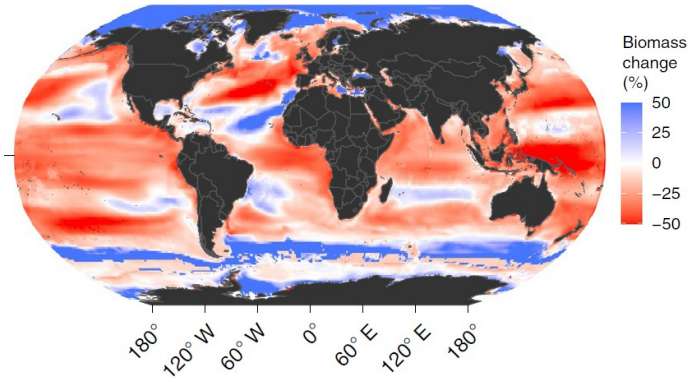
Blanchard et al. (2017), Nat. Ecol. Evol.

Trophic amplification of impacts



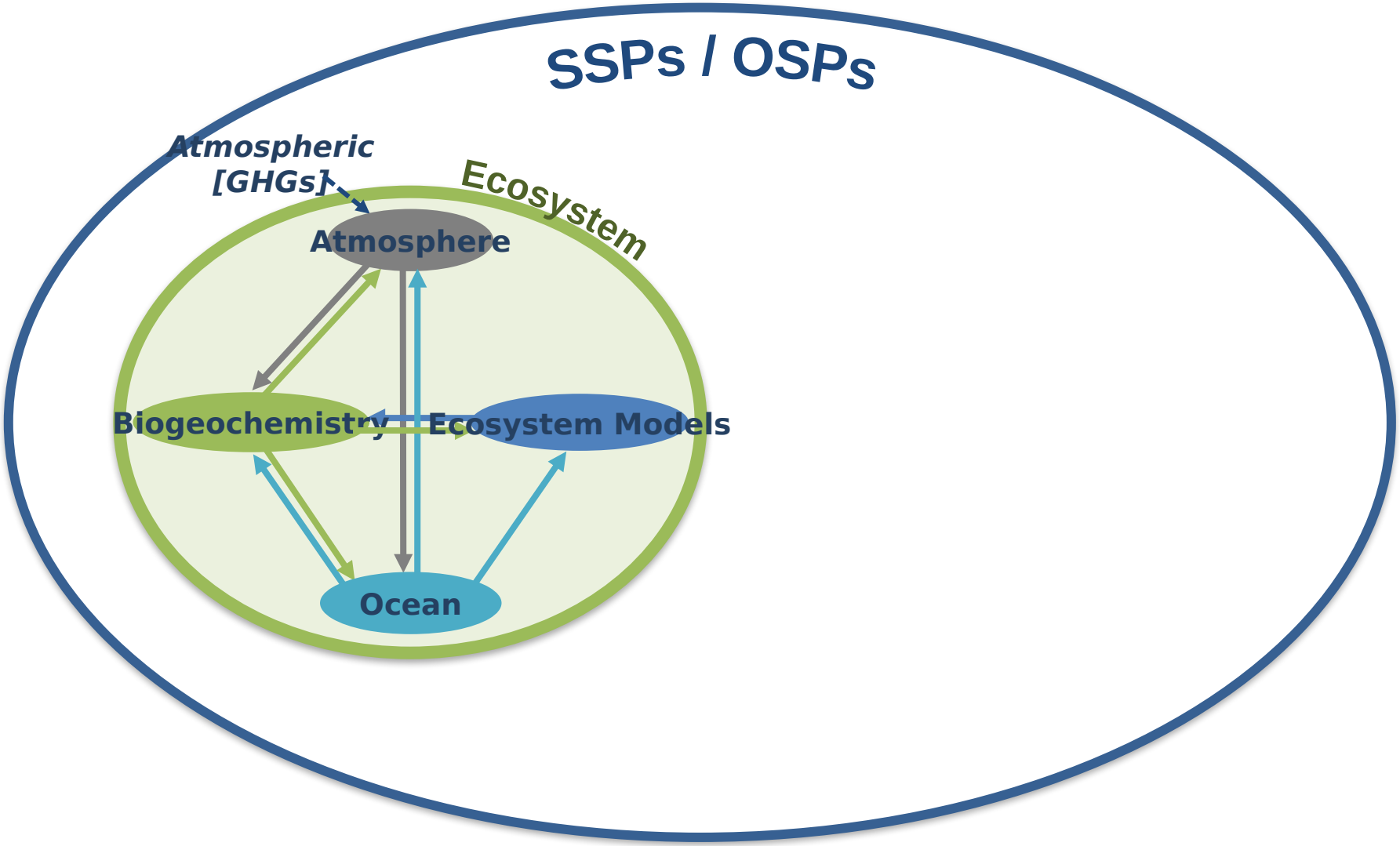
Lotze et al. (2019), PNAS

Climate risks for ecosystems

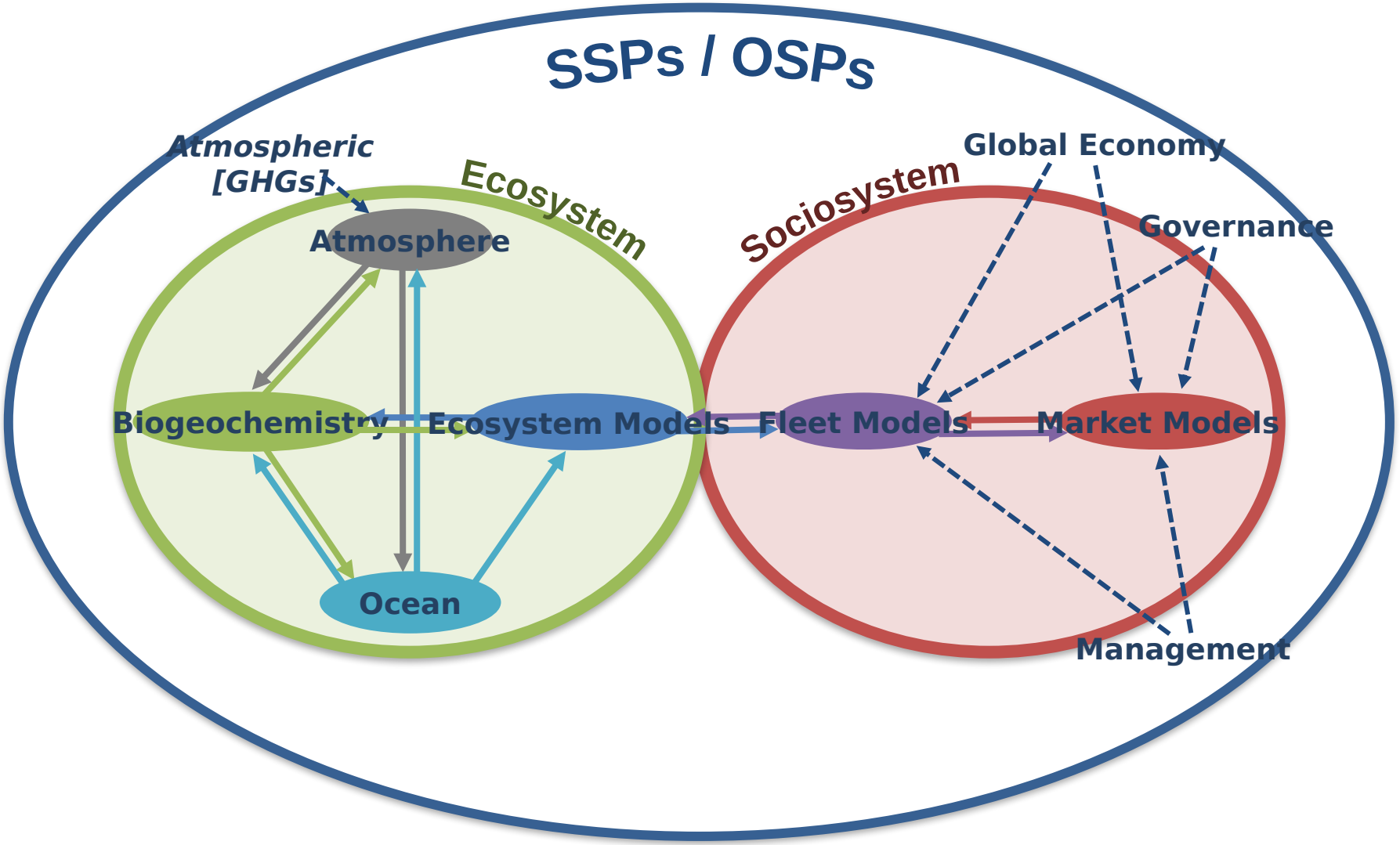


Tittensor et al. (2021), Nat. Clim. Change

*Projecting fisheries requires moving from **Ecosystems***



*Projecting fisheries requires moving from Ecosystem to **Socio-ecosystems** scenarios & models*



The Ocean System Pathways OSP

- Extend & contextualize the SSP storylines to oceanic fisheries: 1st workshop, UNESCO-IOC (Nov. 2013)
  - Scientists from various fields,
  - Representatives from the European fishing industry,
  - International organizations

United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

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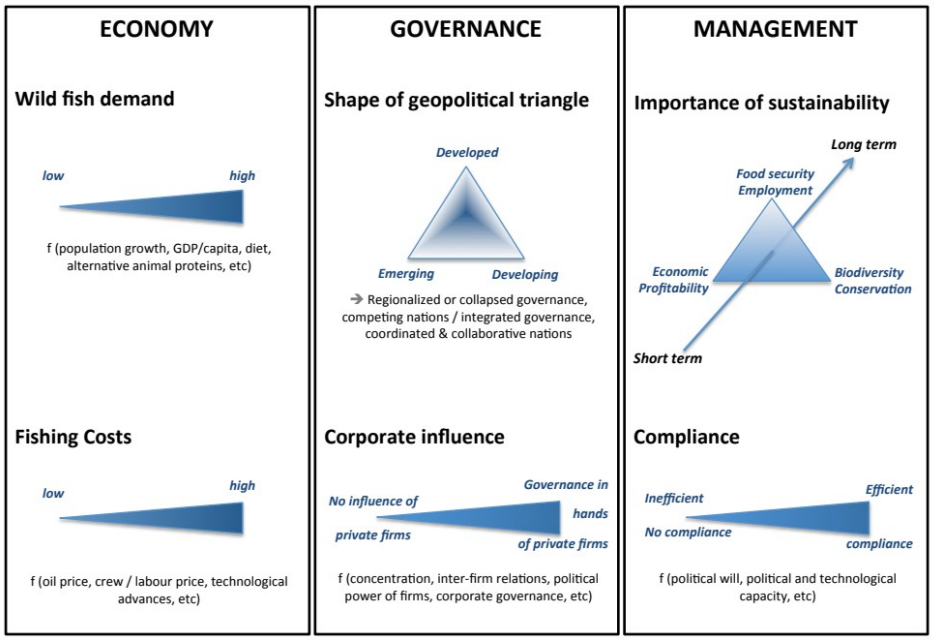
From shared socio-economic pathways (SSPs) to oceanic system pathways (OSPs): Building policy-relevant scenarios for global oceanic ecosystems and fisheries

O. Maury[a,b,*], L. Campling[c], H. Arrizabalaga[d], O. Aumont[e], L. Bopp[f,g], G. Merino[d], D. Squires[h], W. Cheung[i], M. Goujon[j], C. Guivarch[k], S. Lefort[f], F. Marsac[a,b], P. Monteagudo[l], R. Murtugudde[m], H. Österblom[n], J.F. Pulvenis[o], Y. Ye[p], B.J. van Ruijven[q]



FISHERIES & MARINE ECOSYSTEM
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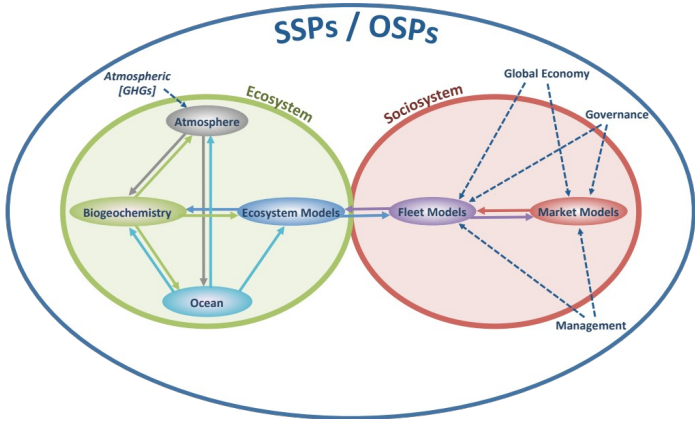
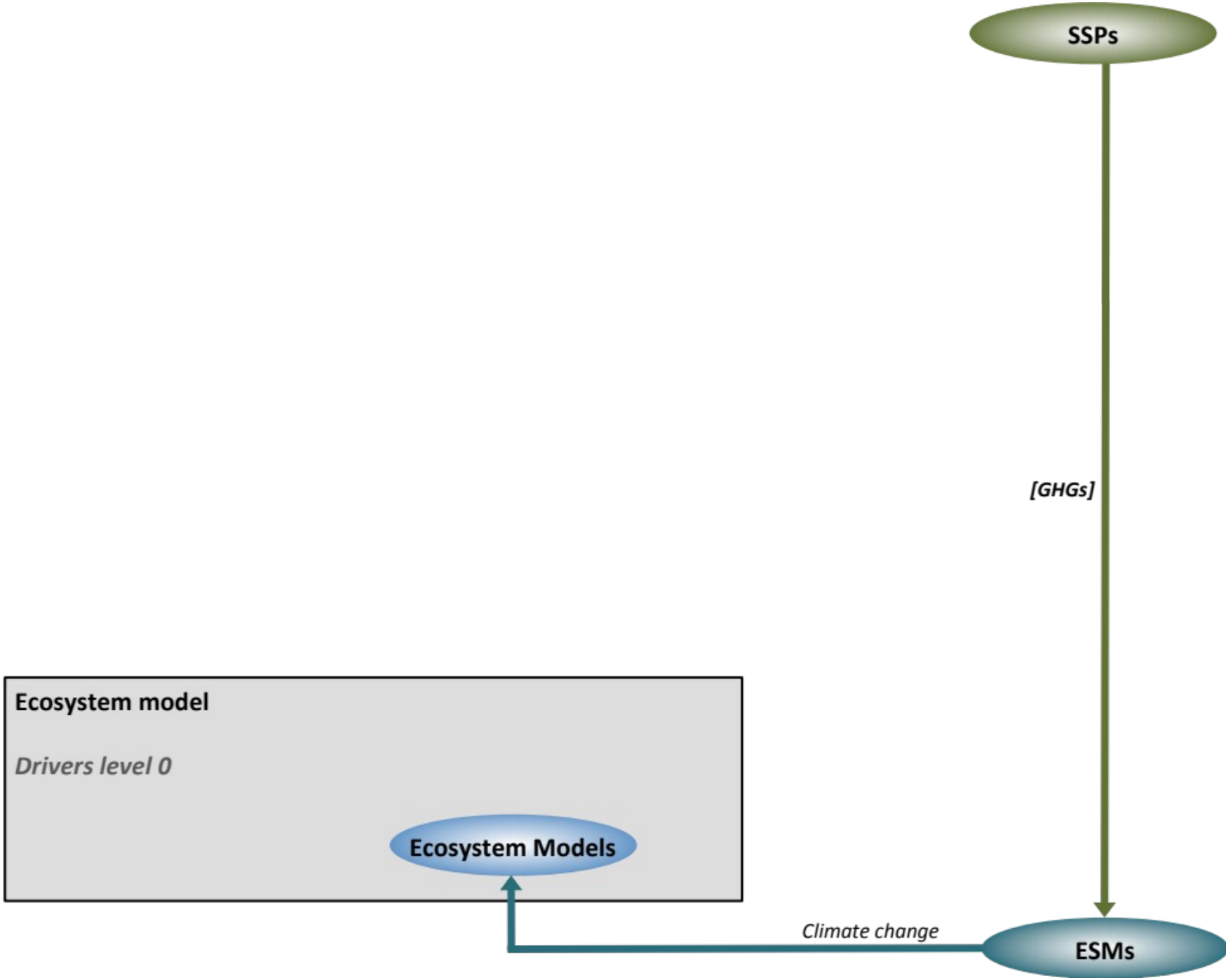
- Extend the OSP to **global fisheries** (2nd workshop October 2019, **FishMIP SWG**)
  - *Oceanic fisheries*
  - *Demersal & benthic fisheries*
  - *Small pelagic fisheries*
  - *Emerging fisheries*
  - *Aquaculture*
- OSPs consider both artisanal & industrial fleet

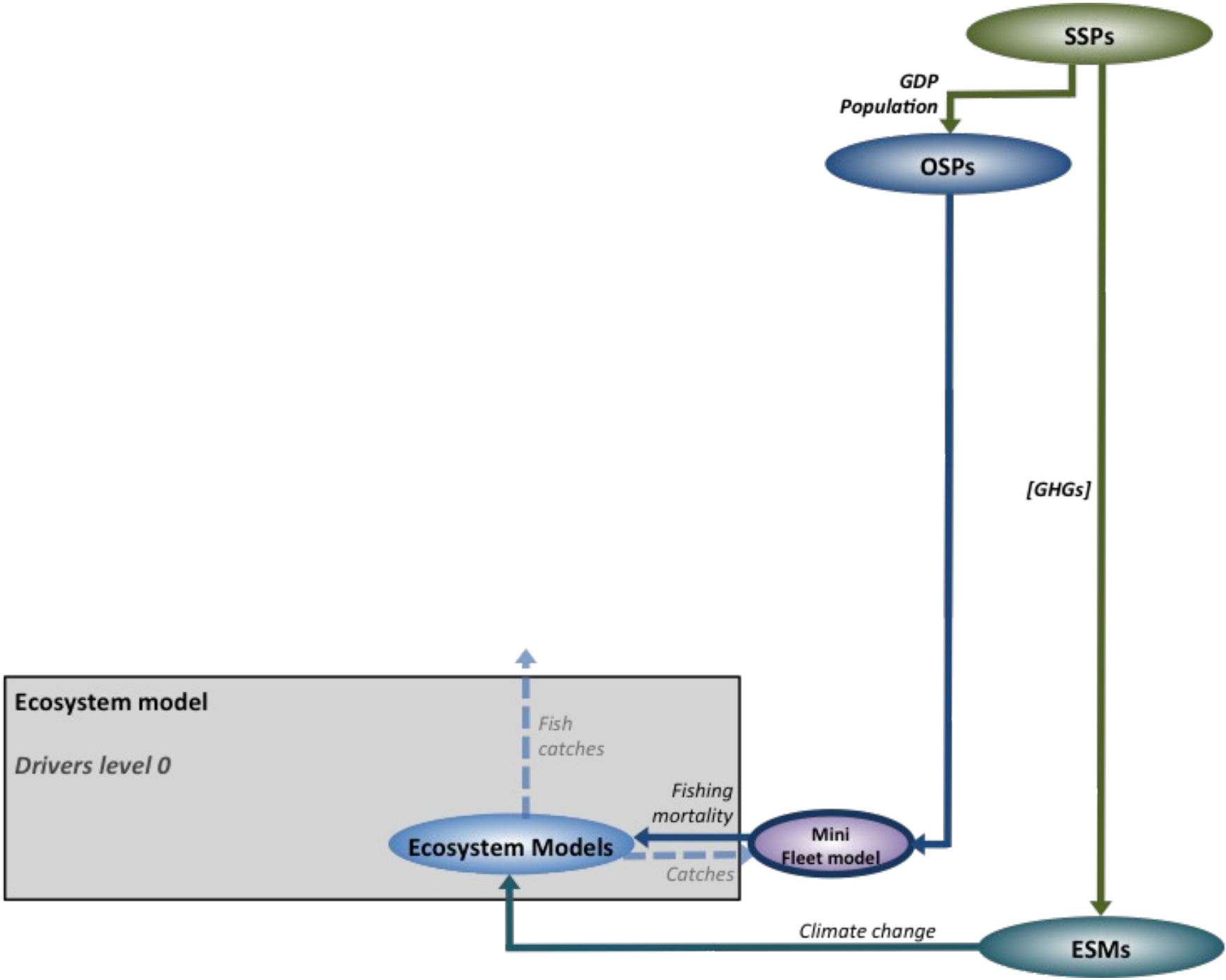
- *Articulate national, sub-regional, regional and global scales*

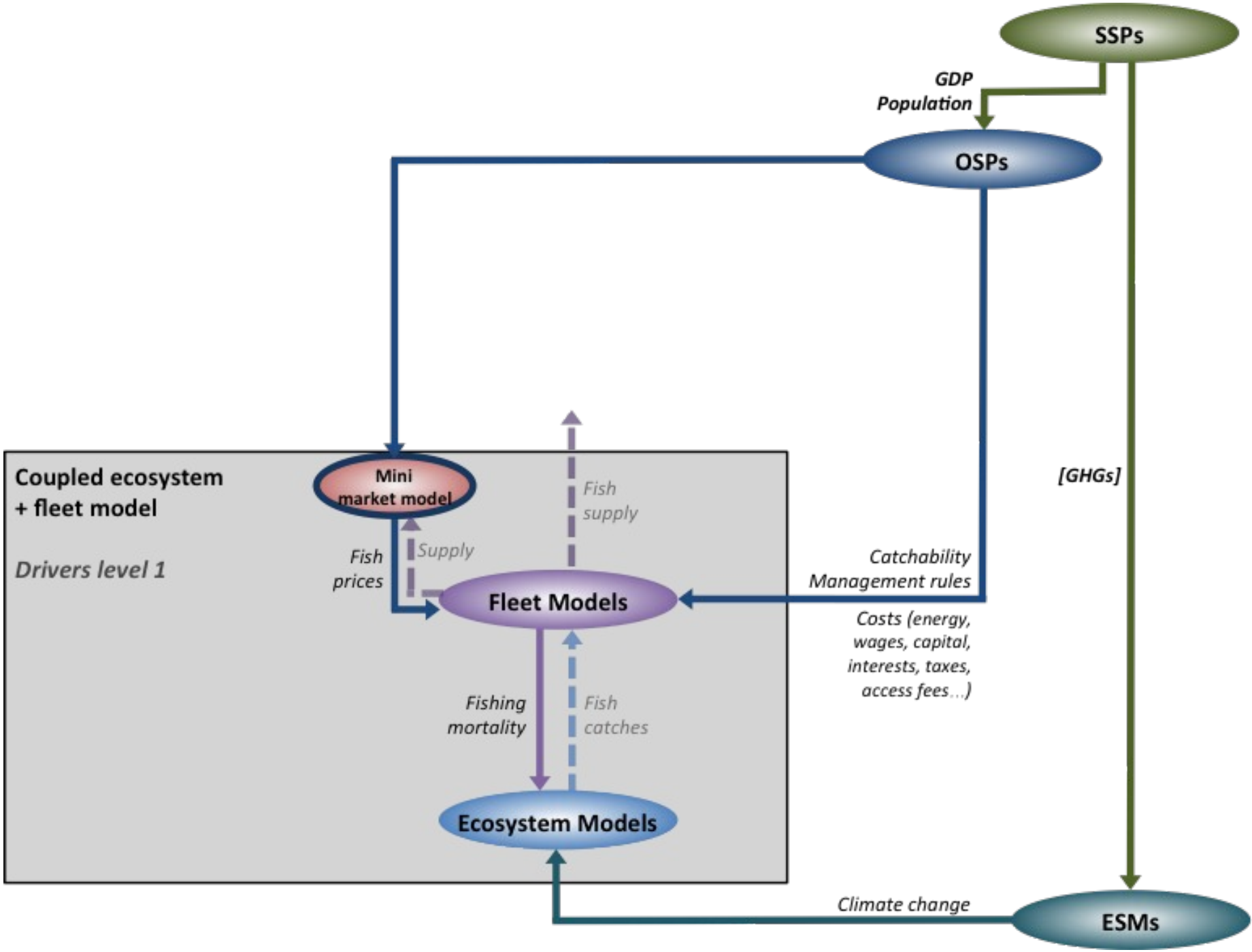
- Turn the storylines into quantitative drivers pathways for the FishMIP coupled marine ecosystem & fisheries models

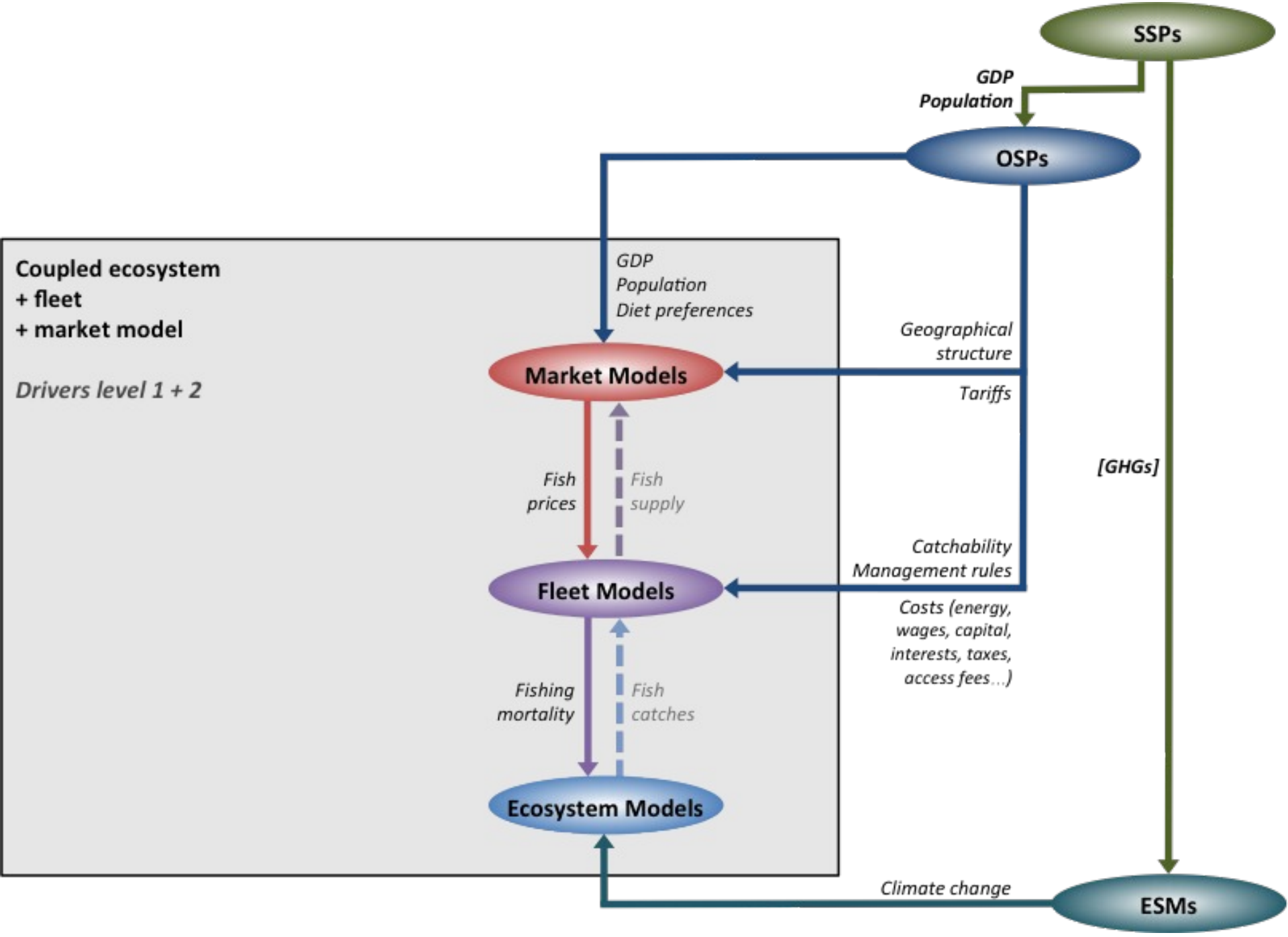


- Derive scenario-based model envelope

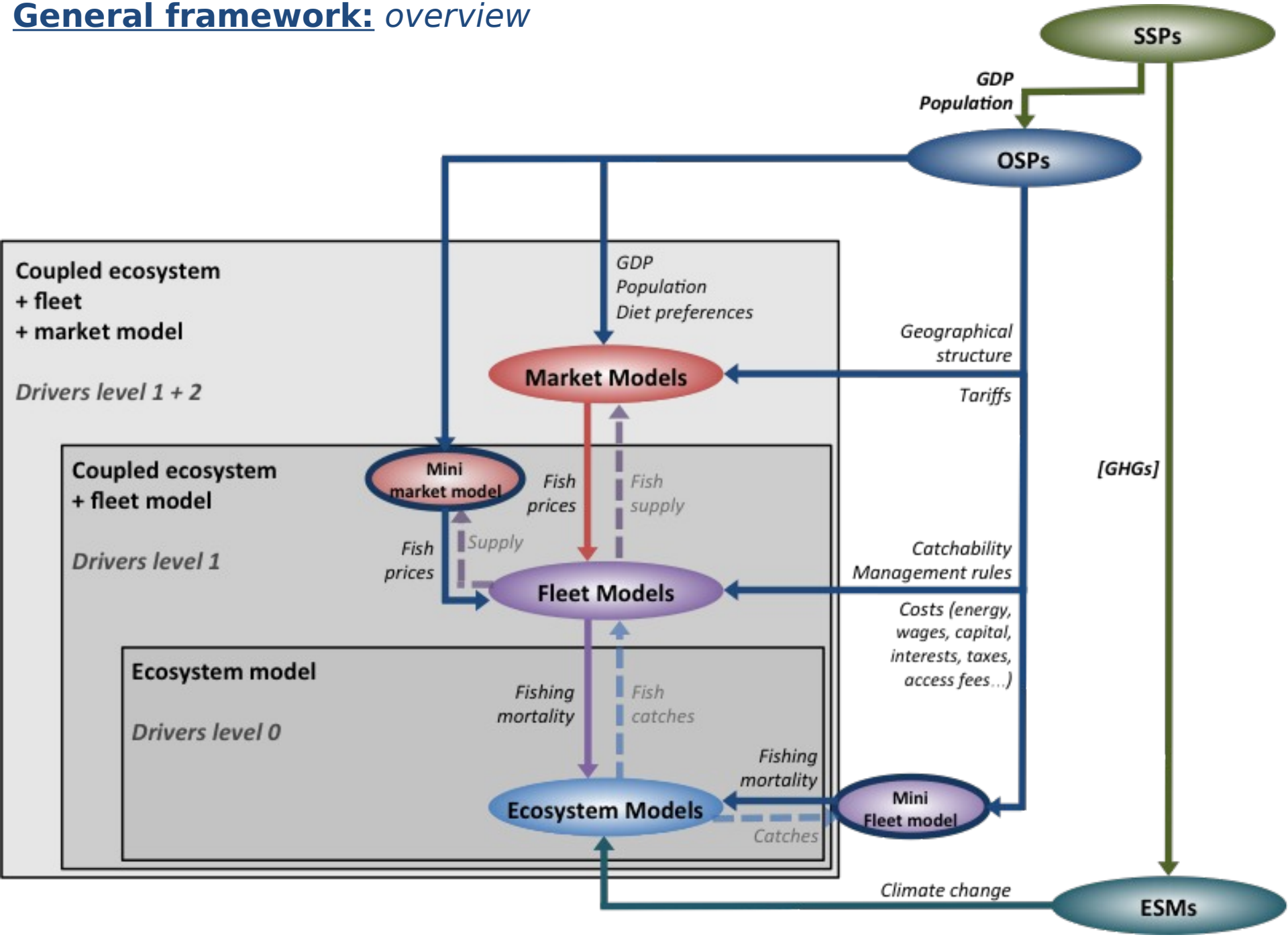

SSPs
[GHGs]
Ecosystem model
Drivers level 0
Ecosystem Models
Climate change
ESMs


SSPs
GDP
Population
OSPs
[GHGs]
Ecosystem model
Drivers level 0
Fish
catches
Fishing
mortality
Ecosystem Models
Mini
Fleet model
Catches
Climate change
ESMs

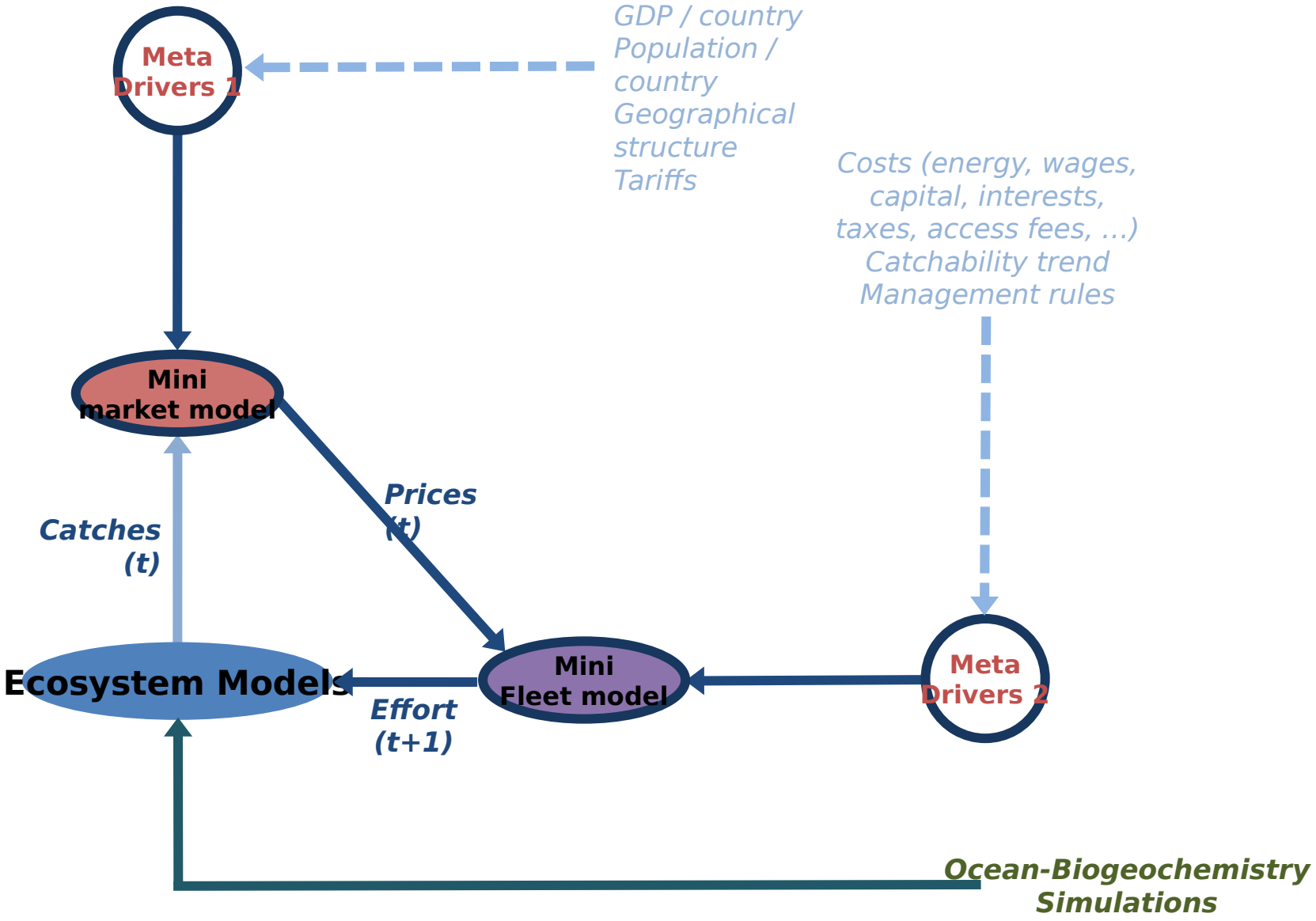

SSPs
GDP
Population
OSPs
[GHGs]
Coupled ecosystem
+ fleet model
Drivers level 1
Mini
market model
Fish
supply
Fish
prices
Supply
Catchability
Management rules
Fleet Models
Costs (energy,
wages, capital,
interests, taxes,
access fees…)
Fishing
mortality
Fish
catches
Ecosystem Models
Climate change
ESMs


SSPs
GDP
Population
OSPs
Coupled ecosystem
+ fleet
+ market model
Drivers level 1 + 2
GDP
Population
Diet preferences
Market Models
Geographical
structure
Tariffs
[GHGs]
Fish
prices
Fish
supply
Catchability
Management rules
Fleet Models
Costs (energy,
wages, capital,
interests, taxes,
access fees…)
Fishing
mortality
Fish
catches
Ecosystem Models
Climate change
ESMs

General framework: *overview*

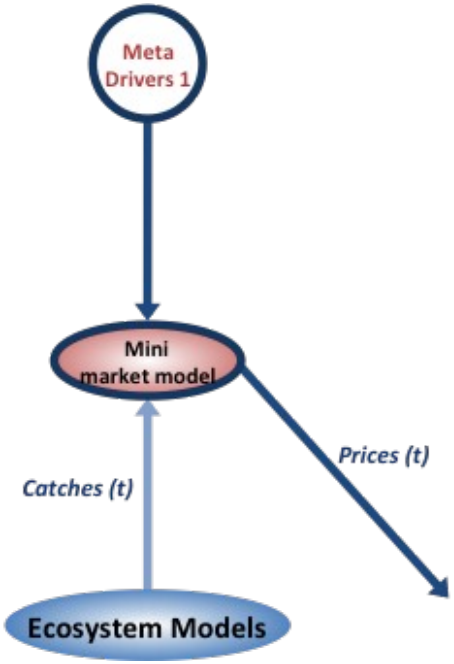


General framework: *2 "mini-models"*



What is the mini-market model?

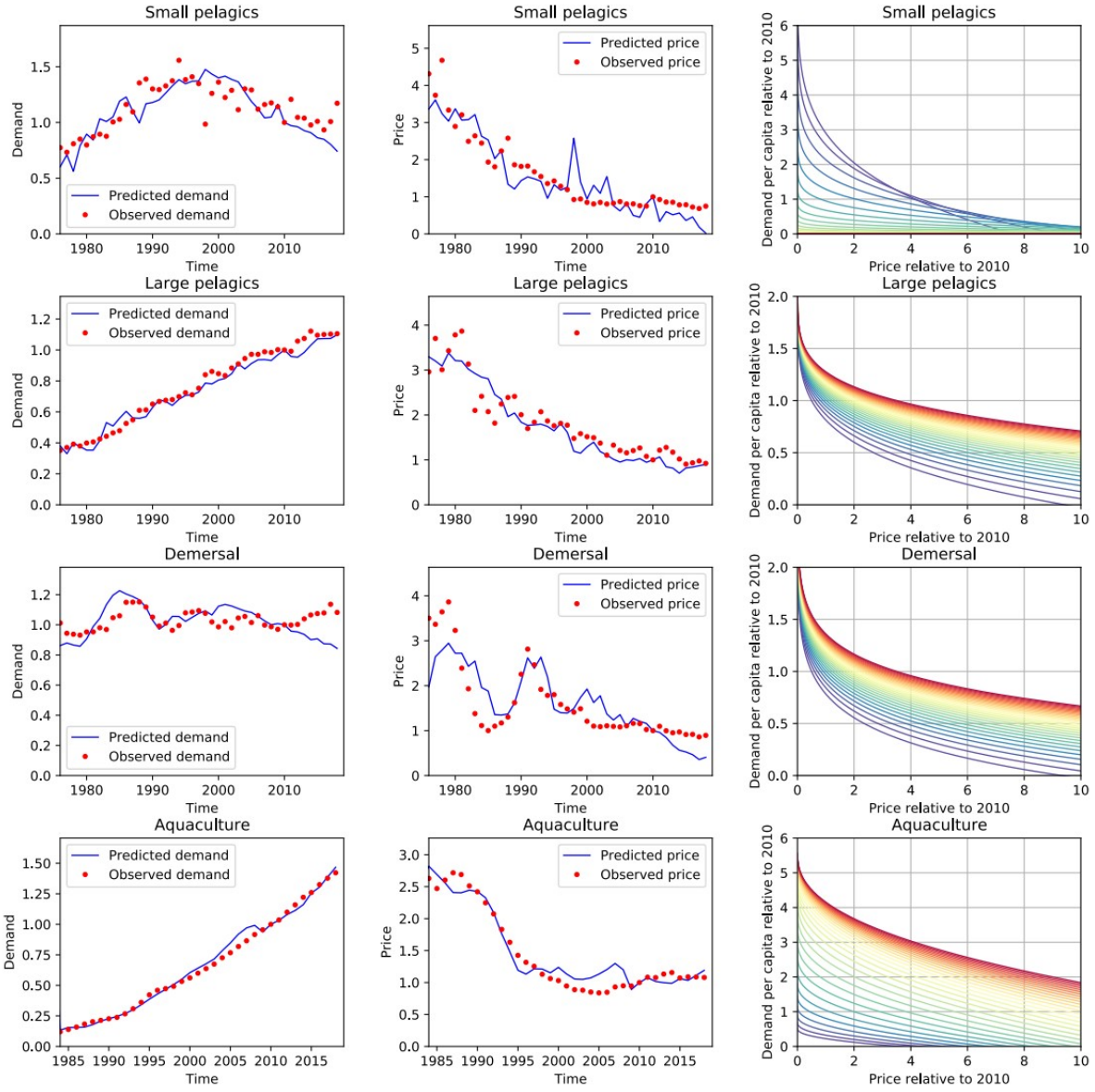
➥ An OSP-driven demand function:



$$P_{i,r,t} = \left(\frac{X_{i,r,t} - Q_{i,r,t}}{W_{i,r,t}} \right)^{1/\varepsilon_i}$$

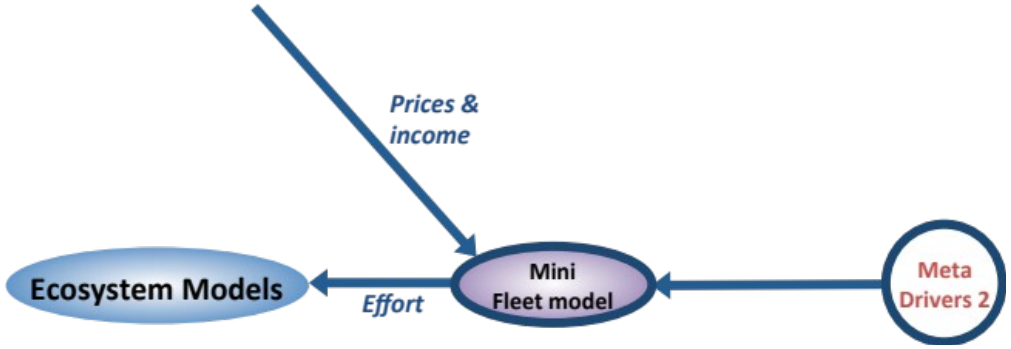
$$X_{i,r,t} = pop_{r,t} \frac{\overline{Q}}{1 + e^{\varrho_i \left(GDP^{cap}_{r,t} - \eta_i \right)}}$$

$$W_{i,r,t} = X_{i,r,t} \left(\varsigma_i GDP^{cap}_{r,t} \right)^{-\varepsilon_i}$$



What is the mini-fleet model?

➥ An OSP-driven bio-economic model based on incomes & costs:



$$\frac{df_{i,r,t}}{dt} = \mathcal{M}_{i,r,t} Y_{i,r,t} P_{i,r,t} U_{i,t,r} - \left(\mathcal{M}_{i,r,t} V_{i,t,r} + M_{i,t}\right) f_{i,r,t}$$

$$U_{i,t,r} = \frac{\alpha\left(1 - \left(c^{1,t}_{i,t,r} + c^{1,a}_{i,t,r}\right)\left(\frac{1 - s^{1,i}_{r,t}}{1 - c^{1,i}_{i,t,r}}\right)\right)}{p^{1,k}_{i,t,r}\left(1 + c^{1,i}_{i,t,r}\right)^{t}}$$

$$V_{i,t,r} = \frac{\alpha\left(c^{2,e}_{i,t,r} + c^{2,m}_{i,t,r}\right)\left(\frac{1 - s^{1,i}_{r,t}}{1 - c^{1,i}_{i,t,r}}\right)}{c^{1,k}_{i,t,r}\left(1 + c^{1,i}_{i,t,r}\right)^{t}}$$

$$\mathcal{M}_{i,r,t} = 1 - o_{i,r,t}\mathrm{H}\left(f_{i,r,t} - \rho^{target}_{i,r,t} f^{MSY/MEY}_{i,r,t}\right)$$

Spatial structure of the OSPs framework

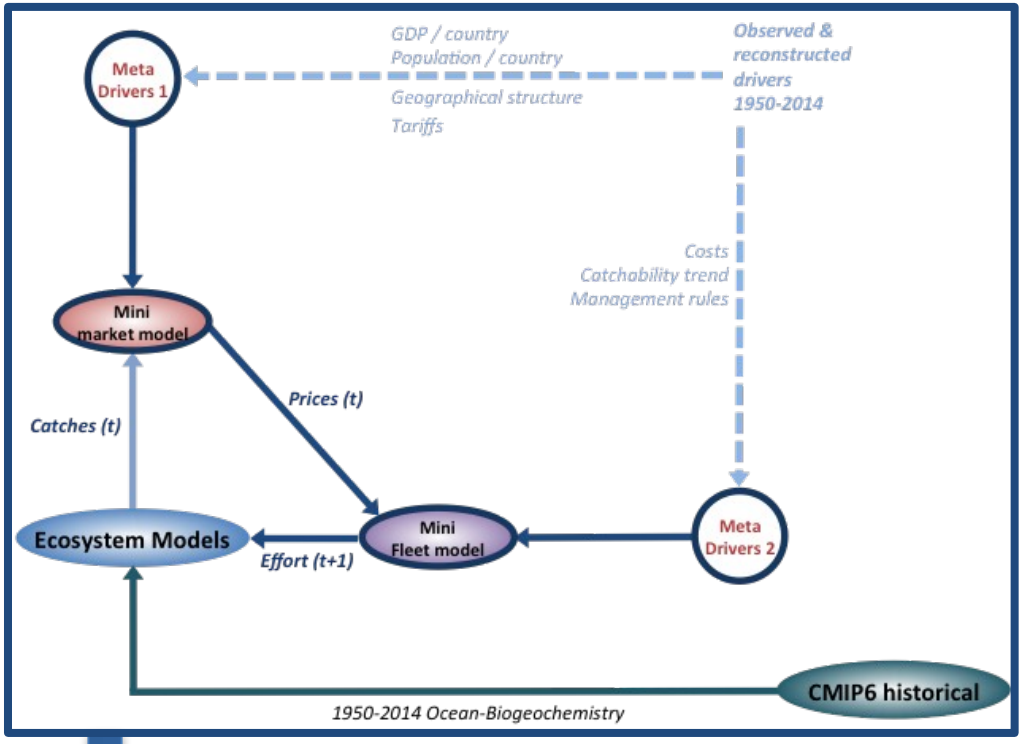
➥ Articulates national, sub-regional, regional and global scales

- *Prices can be formed at any scale (depend on the level of geographic aggregation of markets specified in each OSP),*
- *Effort (□ catch) dynamics can be calculated at any scale,*

➥ The quantity consumed can be back-calculated for every country worldwide

Proposed 2-phases protocol:

1- Historical calibration & model evaluation 1960-2014



Yannick Rousseau's reconstructions

1960-2014 Simulated catches & efforts

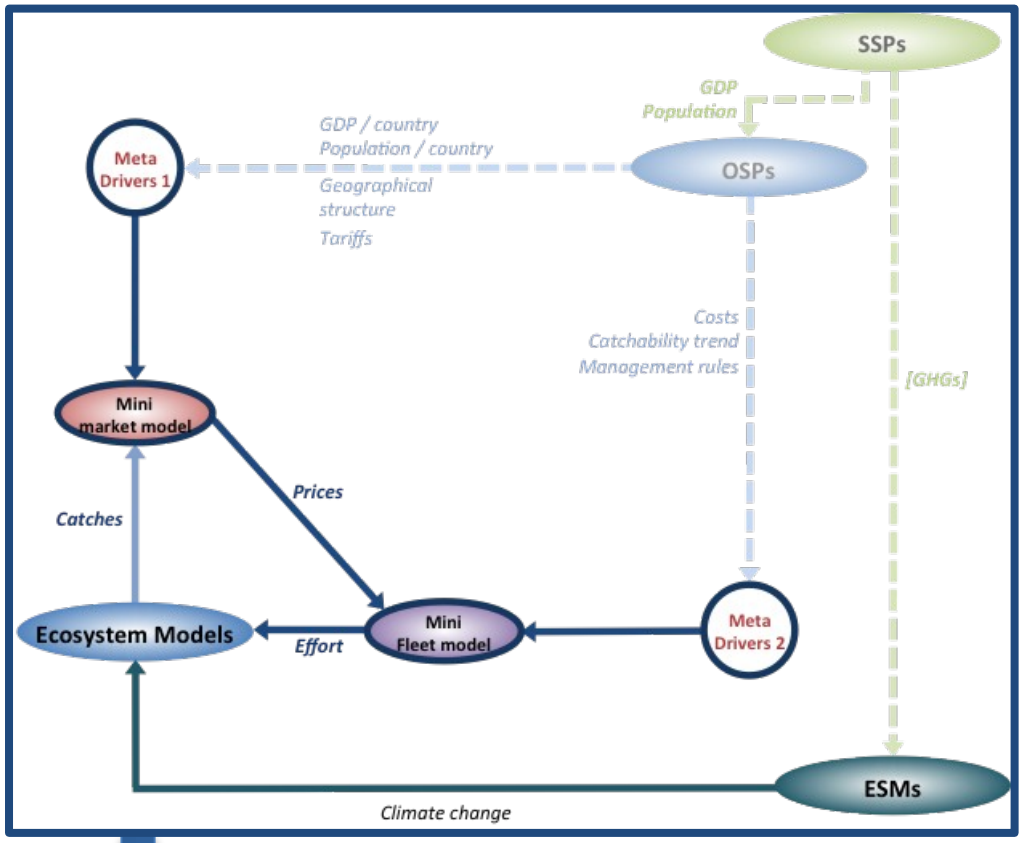
Compared to

1960-2014 Reconstructed catches & efforts

alibration & skills assessment of the fisheries simulation framework

Proposed 2-phases protocol:

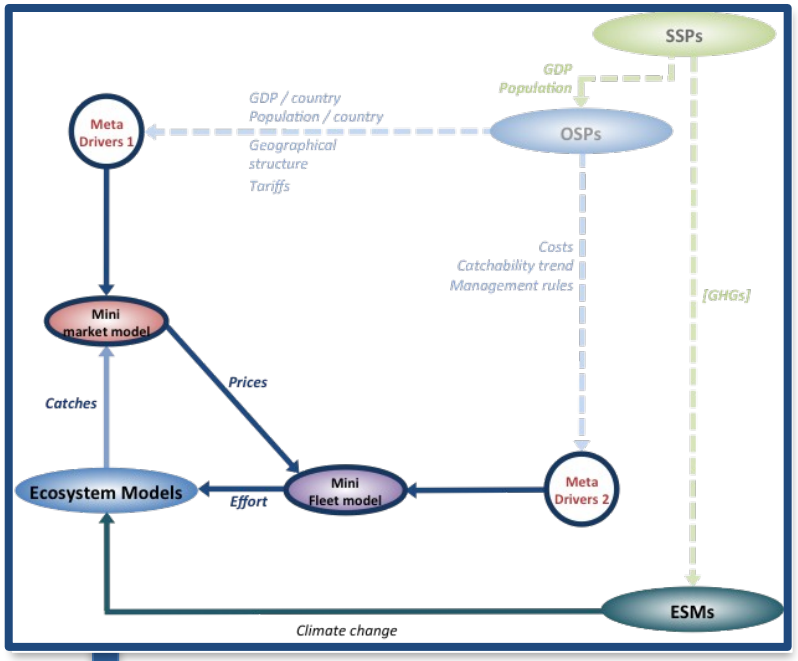
2- Future projections 2023-2100



2015-2100 Catches & efforts projections

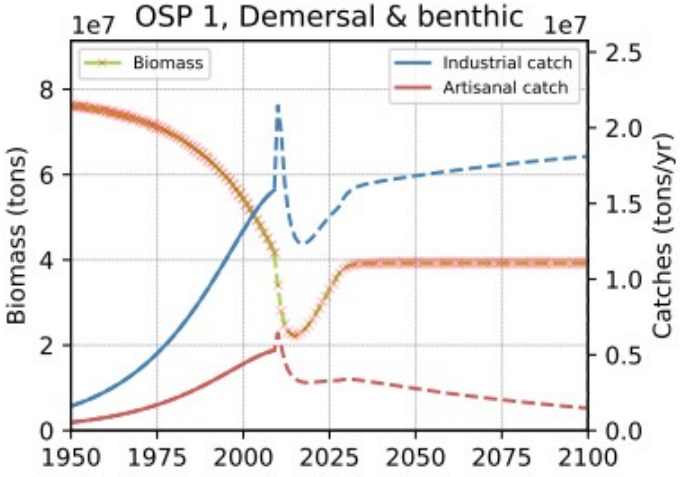
OSP-based multi-model projection ensembles

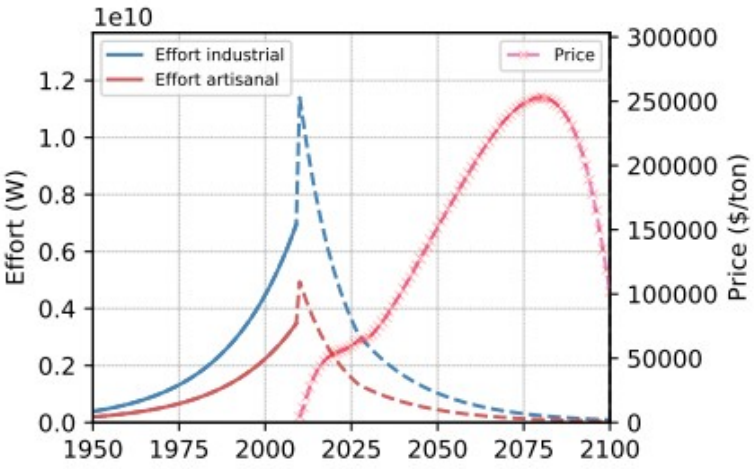
Proposed 2-phases protocol:



1960-2014
Catches, efforts & pr
Historical simulations

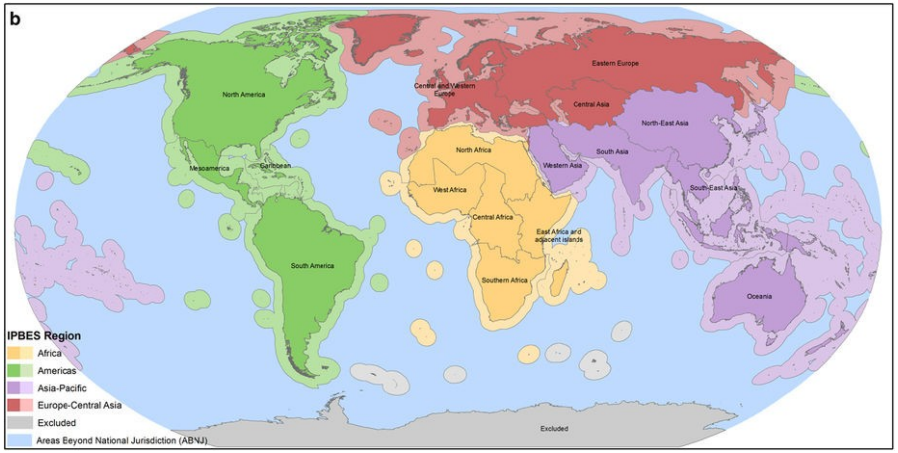
2015-2100
Catches, efforts & prices
OSP-based projections





Proposed structure of global simulations:

- ***Oceanic fisheries***
  - *1 global DWFN*
- ***Demersal & benthic fisheries***
  - *National EEZs: industrial / artisanal*
- ***Small pelagic fisheries***
  - *National EEZs: industrial / artisanal*
- ***Aquaculture***
  - *1 global*

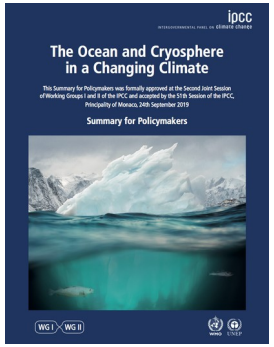


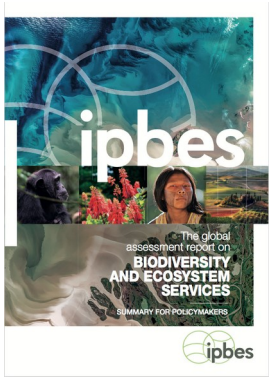
Proposed timeline

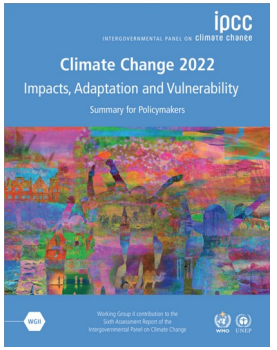
- **Launch of 3b OSP round of simulations**: online early Dec. 2023
  - Draft protocol released in the community for discussion
- **OSP technical meeting (1)** : Sète + online/parallel? February 2024
  - ➔ Mini-models implementation in global & regional models
  - ➔ Start tuning historical simulations
- **OSP technical meeting (2)** : Sète, June 2024
  - Assess models' skills against historical C & f reconstructions (one paper)
  - Launch scenario projections
- **1st 3b OSP writing meeting** : FAO Rome, Early 2025
  - Analyse ensemble projections
  - ➔ Start writing collective papers

Conclusion

- FishMIP has coordinated global **MEMs intercomparisons**
  - **Process** studies
  - **Projection** ensembles
  - Contributions to **IPCC & IPBES** reports







- We now extend these SSP-based ecosystem projections to include fisheries **OSP scenarios**
  - **Storylines**, quantitative **drivers** & **mini-models**
  - From **national to global** scale
  - Oceanic, demersal & small pelagic **fisheries +**
  - **Artisanal & industrial** fisheries
  - **Economy, governance & management**

- **To come in 2024-2025:** OSP-driven fisheries projection envelopes

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