An Integrated Global-to-Regional Scale Workflow for Simulating Climate Change Impacts on Marine Ecosystems

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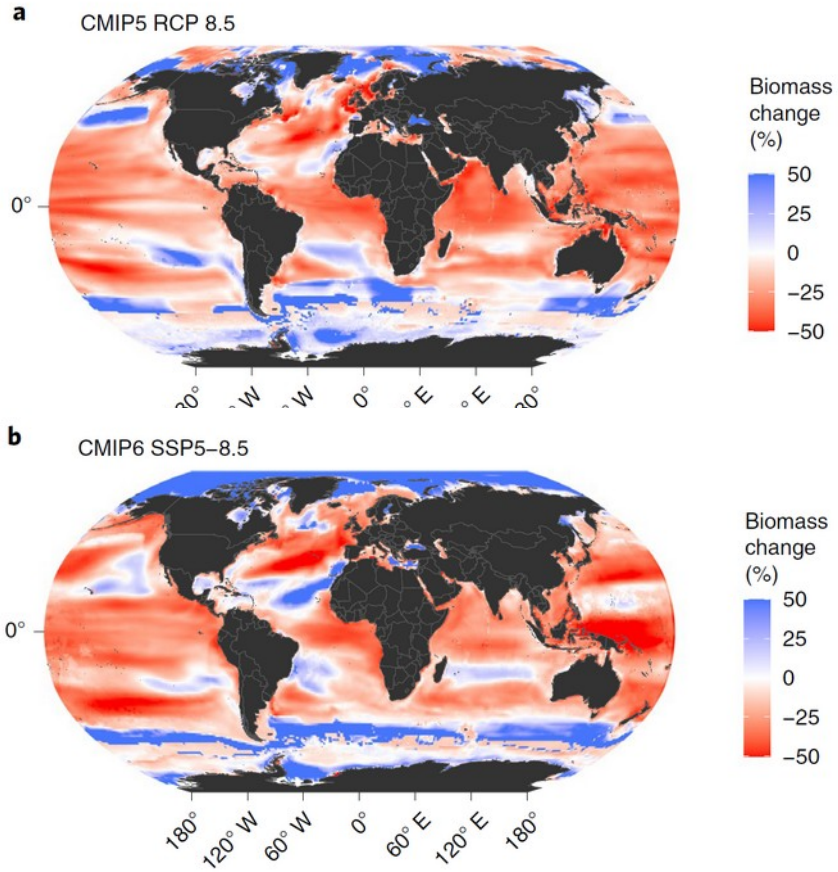
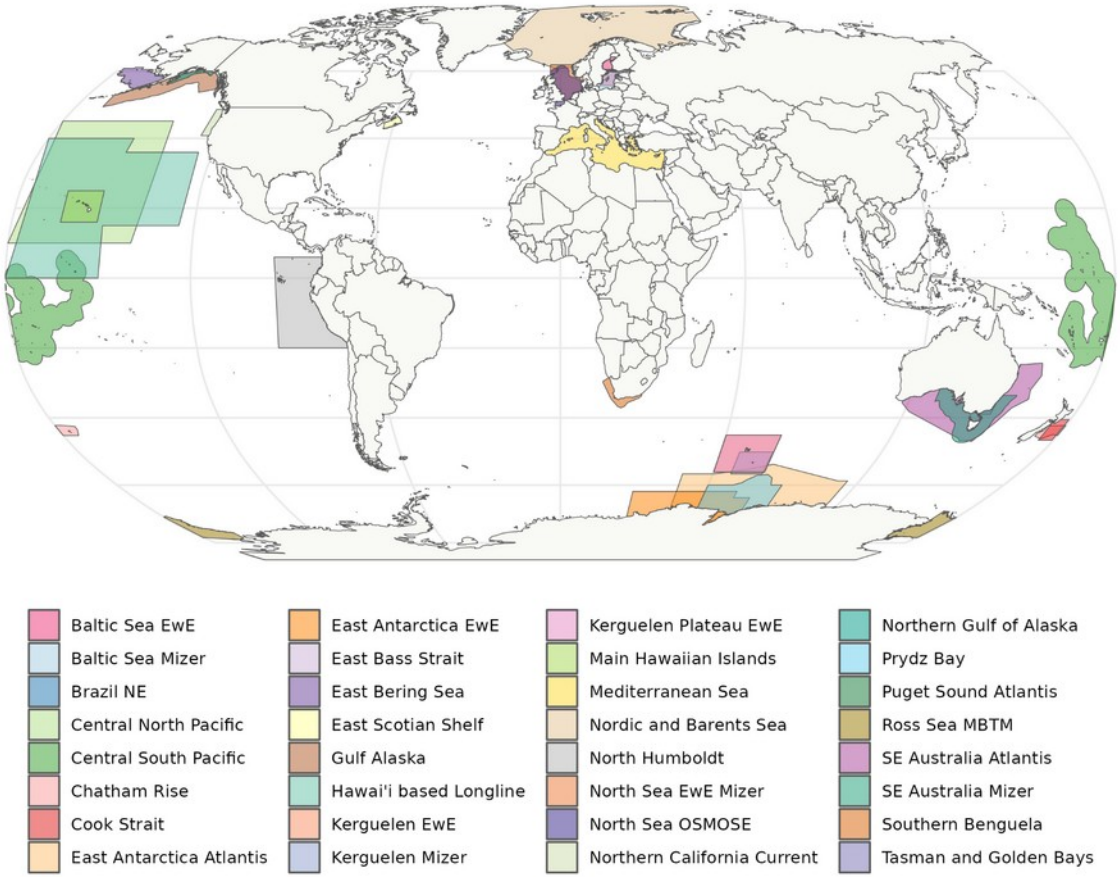
FishMIP
Fisheries & Marine Ecosystem Model Intercomparison Project

Introduction

- FishMIP involves global and regional marine ecosystem models (MEMs) to make projections of ecosystem dynamics and functioning under different emissions scenarios.
- FishMIP's vision for regional models includes regional-global model comparisons and regional model ensembles.
- Priority: develop guidelines for regional MEM simulations that improve the workflow in modelling experiments.
- Not having clear workflow has led to some difficulties for regional ecosystem models to actually implement FishMIP runs.
- Goal: Translate the FishMIP protocol into practical steps for modelling groups.



Tittensor et al. 2021



FishMIP: 34 Regional MEMs

Regional MEM types

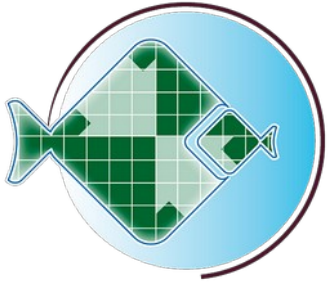
Atlantis

Ecopath, Ecosim and Ecospace

ECOTRAN

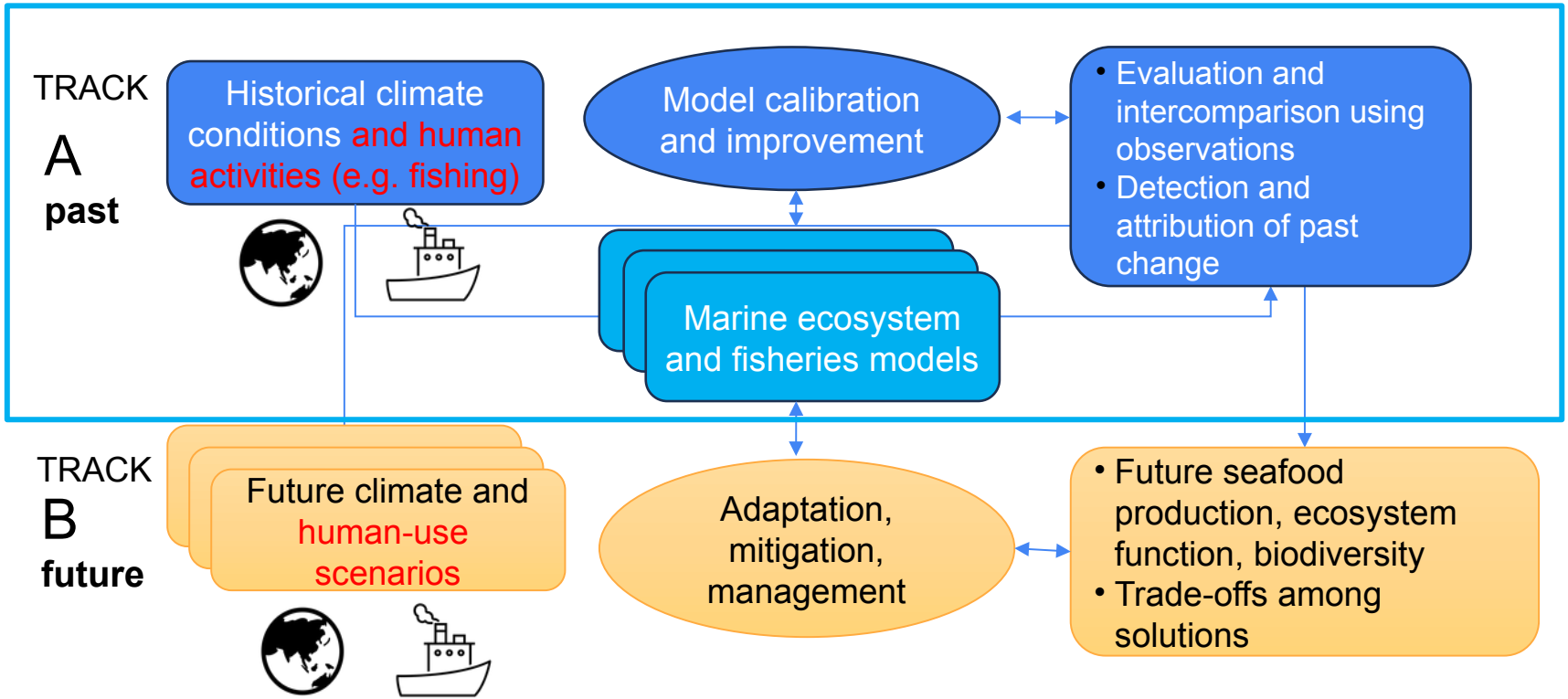
Model of Intermediate Complexity for Ecosystem Assessments (MICE)

Mizer

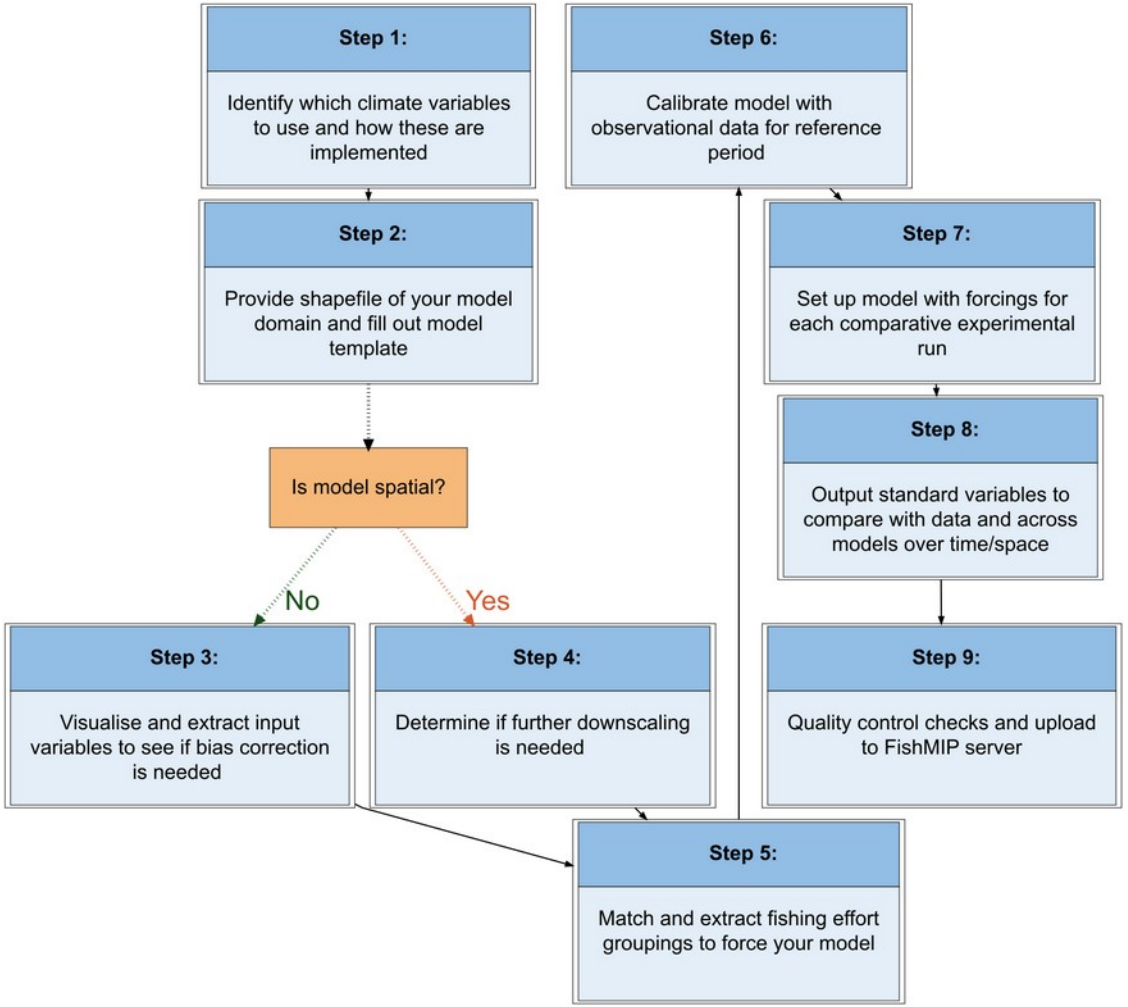


OSMOSE

FishMIP 2.0



Source: Blanchard et al. Under review



Workflow to implement protocol FishMIP 3a in regional MEMs

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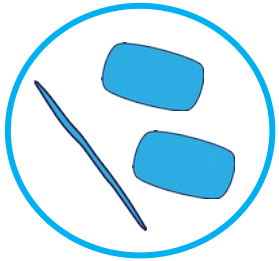
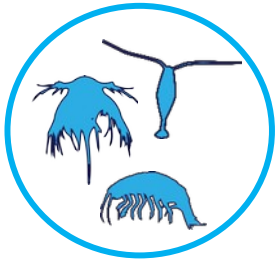
Step 1: Identify which climate model variables to use and how these are implemented

- Oceanic forcing data is derived from the coupled physical and biogeochemical ocean models Geophysical Fluid Dynamics Laboratory (GFDL), Modular Ocean Model (MOM6) and Carbon, Ocean Biogeochemistry and Lower Trophics (COBALTv2).

Sea Temperature



Primary production
Phytoplankton biomass



Zooplankton biomass

Step 2: Provide shapefile of your model domain and complete model templates

- Model spatial boundaries to extract all climate variables available in GFDL-MOM6-COBALTv2.
- Tools available at FishMIP GitHub repositories.
- Model templates requesting information about model set-up and calibration.

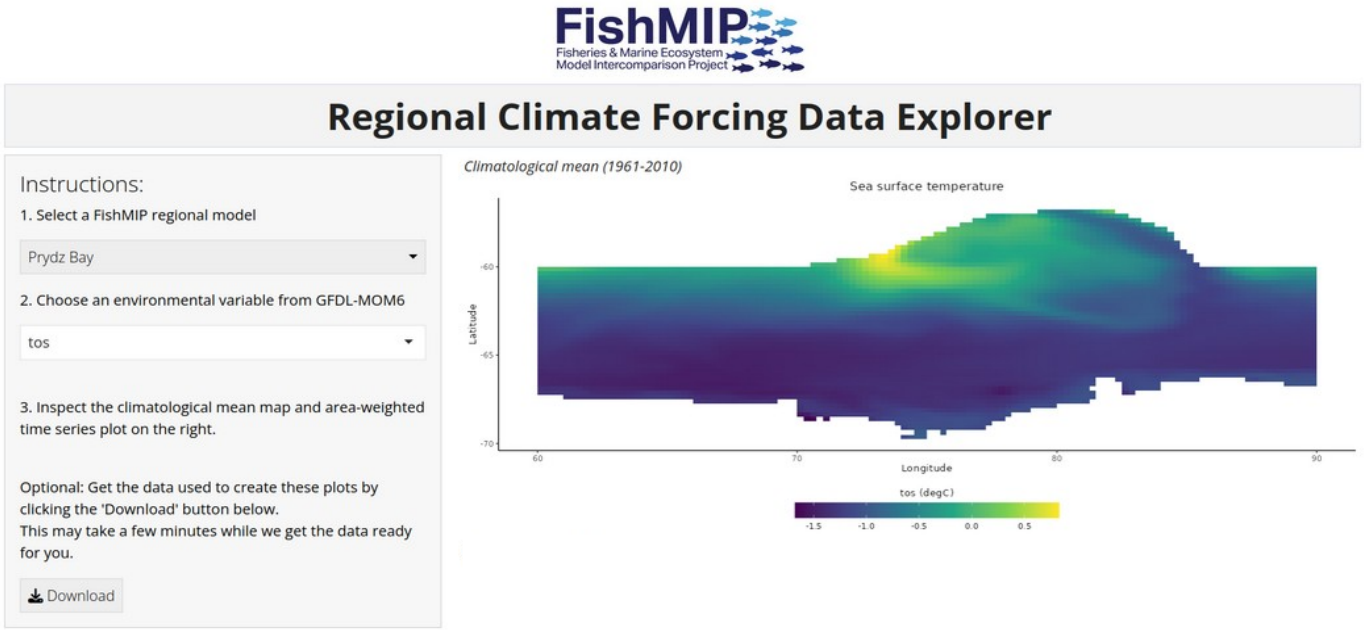
https://github.com/Fish-MIP/FishMIP2.0_TrackA_ISIMIP3a

Table 6. Climate forcing variables and units for FishMIP 3a simulations. All variables are available on a 0.25 and 1 degree horizontal grid, monthly and annual resolutions. Note: Some variables are available as specific layers extracted from vertically resolved data. Their variable names have been suffixed with -bot (ocean bottom, e.g. o2-bot), -surf (surface values, e.g. pH-surf) or -vint (vertically integrated, e.g. phyc-vint), respectively, or prefixed with int (vertically integrated, e.g. intpp). Temperature is suffixed with b or s for bottom (e.g. tob) or surface (e.g. tos) layers, respectively.

Variable	Specifier	Unit	Resolution	Datasets
Mass Concentration of Total Phytoplankton Expressed as Chlorophyll	**chl**	kg m-3	0.25° , 1° grid	GFDL-MOM6-COBALT2
Sea Floor Depth	**deptho**	m	0.25° , 1° grid	GFDL-MOM6-COBALT2
Downward Flux of Particulate Organic Carbon	**expc-bot**	mol m-2 s-1	0.25° , 1° grid	GFDL-MOM6-COBALT2
Particulate Organic Carbon Content	**intpoc**	kg m-2	0.25° , 1° grid	GFDL-MOM6-COBALT2
Primary Organic Carbon Production by All Types of Phytoplankton	**intpp**	mol m-2 s-1	0.25° , 1° grid	GFDL-MOM6-COBALT2
Net Primary Organic Carbon Production by Diatoms	**intppdiat**	mol m-2 s-1	0.25° , 1° grid	GFDL-MOM6-COBALT2
Net Primary Mole Productivity of Carbon by Diazotrophs	**intppdiaz**	mol m-2 s-1	0.25° , 1° grid	GFDL-MOM6-COBALT2
Net Primary Mole Productivity of Carbon by Picophytoplankton	**intpppico**	mol m-2 s-1	0.25° , 1° grid	GFDL-MOM6-COBALT2

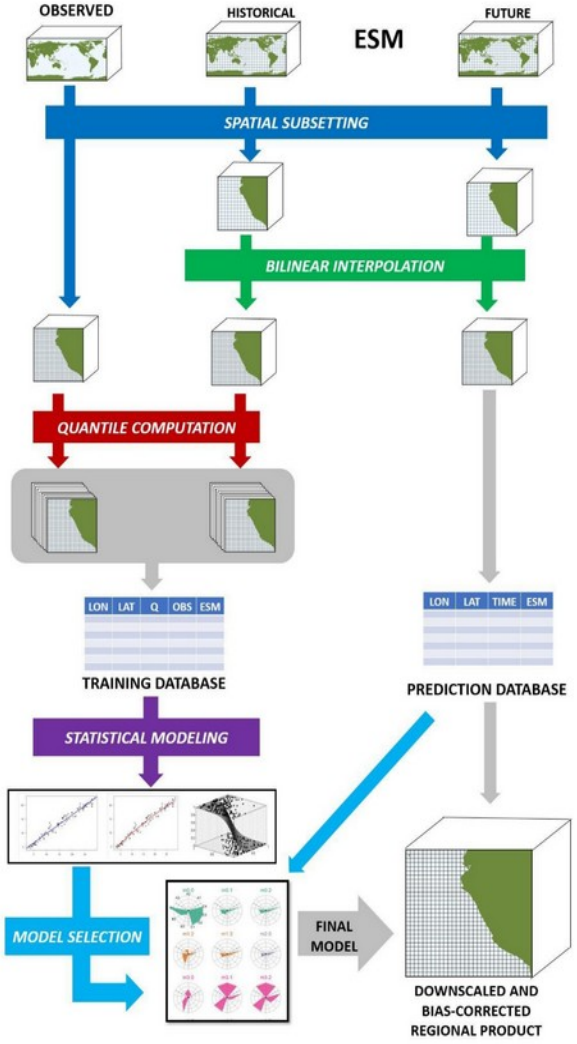
Step 3: Visualize and extract input variables to see if bias correction is needed

- Delta method: Bias correction using the Word Ocean Atlas 18 (Garcia et al., 2019; Locarnini et al., 2018).
- For plankton biomass and primary productivity, different approaches have been used.



Step 4: If spatial: determine if further downscaling is needed

- OSMOSE-Northern Humboldt.
- Oliveros-Ramos et al. (2023) evaluated 19 nested statistical downscaling models and found that model performance varied across regions.
- The ‘Gridded time series analysis’ R package is open-source and can be found on GitHub (https://github.com/roliveros-ramos/gts).
- Statistical downscaling approach to be used as part of this protocol has not yet been standardized.



Source: Oliveros-Ramos et al. (2023)

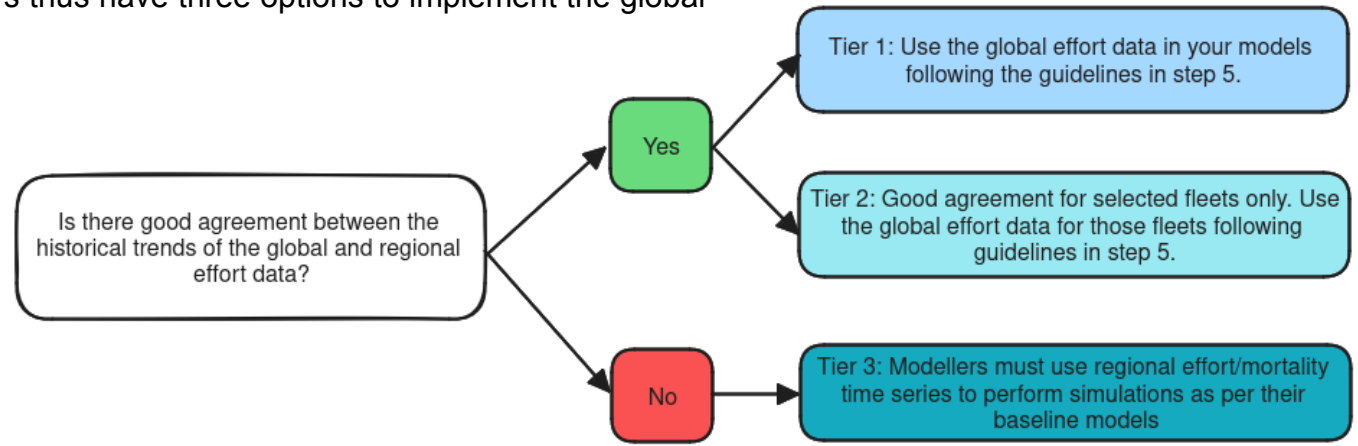
Step 5: Match and extract fishing effort groupings to force your model

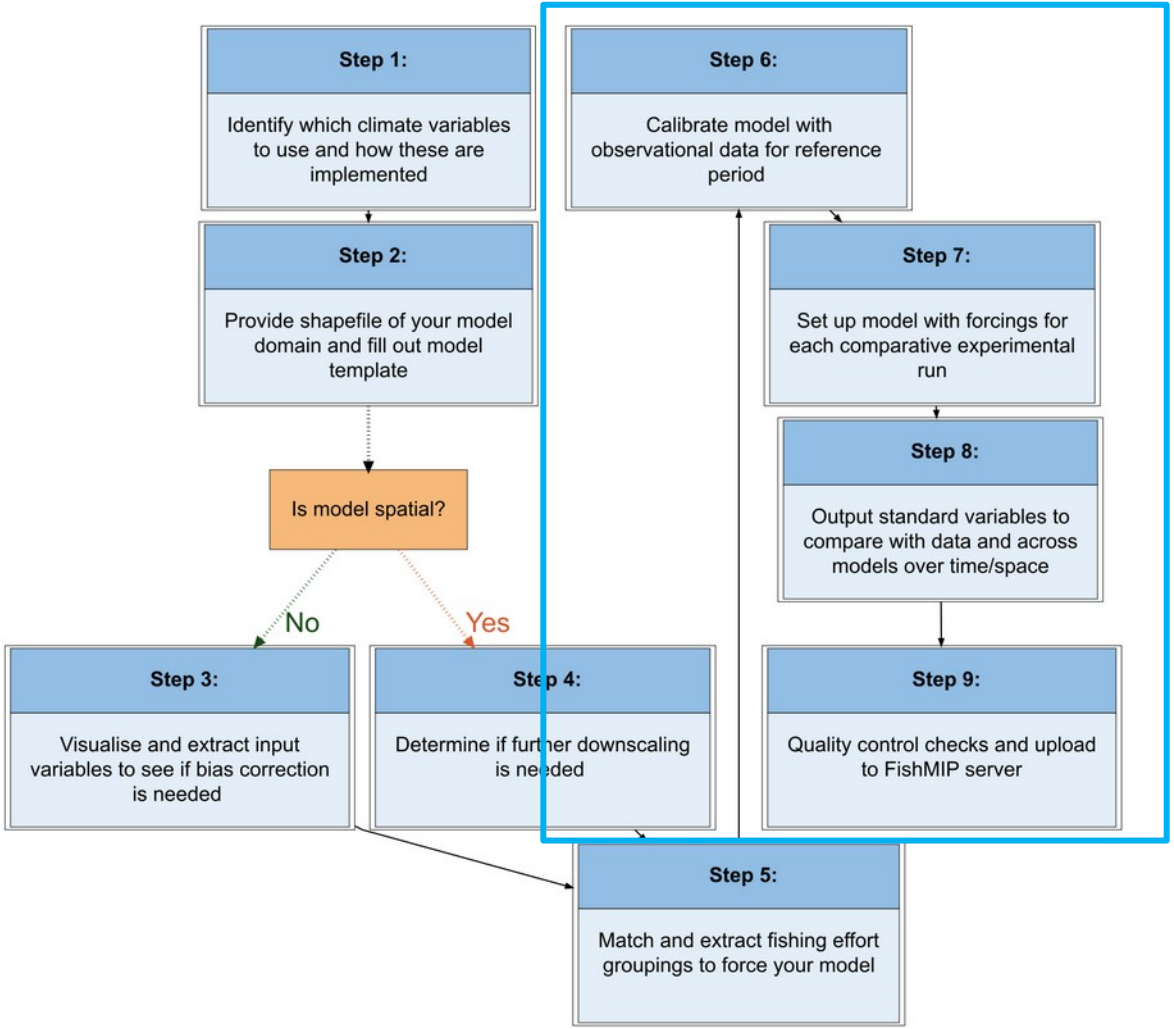
- Global fishing effort forcing (Rousseau et al. 2024). Assumptions on how to split the global effort by fleet and catch to account for the taxonomic resolution required by some regional models.

Fishing effort data: "effort_histsoc_1841_2010_regional_models.csv"
Catch time series:"calibration_catch_histsoc_1850_2004_regional_models.csv"

http://portal.sf.utas.edu.au/thredds/catalog/gem/fishmip/ISIMIP3a/InputData/fishing/histsoc/catalog.html

- Modellers thus have three options to implement the global data.





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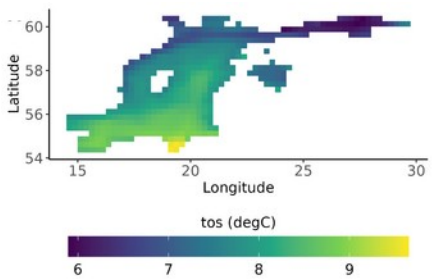
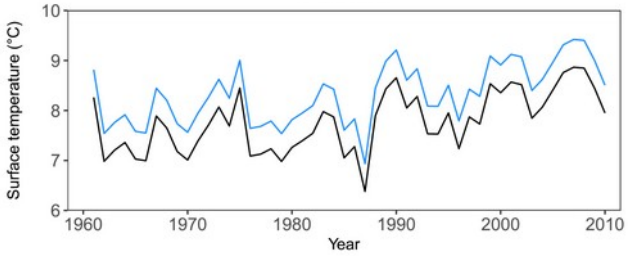
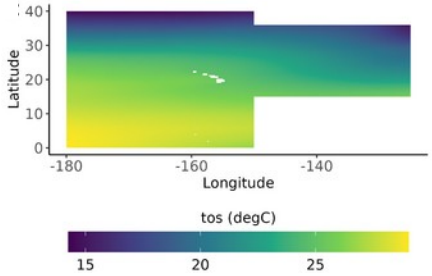
Case study 1: Climate forcing intermodel comparison

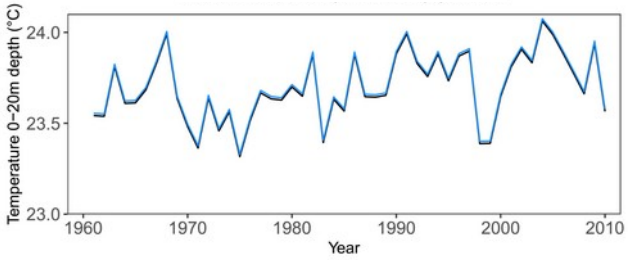
Baltic Sea - Mizer model



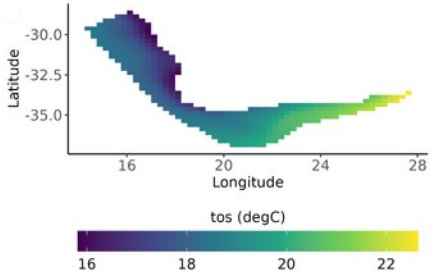


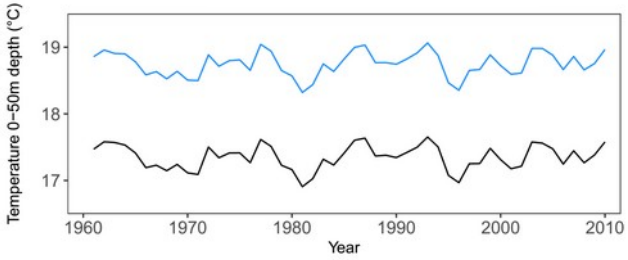
Hawai'i based longline fishery - (ther) Mizer model





Southern Benguela - Atlantis model





GFDL-MOM6-COBALT2

Bias-corrrected

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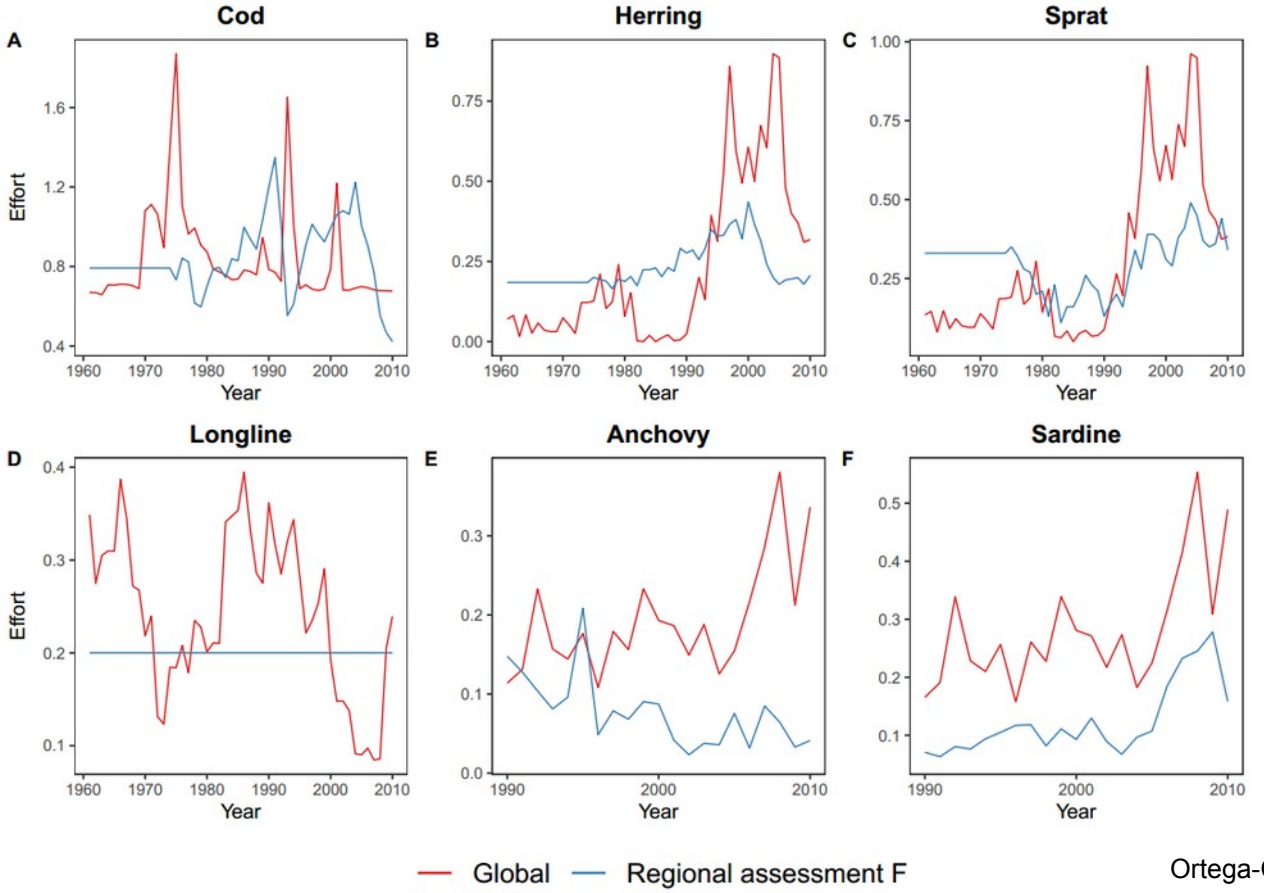
Case study 2: Fishing effort forcing intermodel comparison



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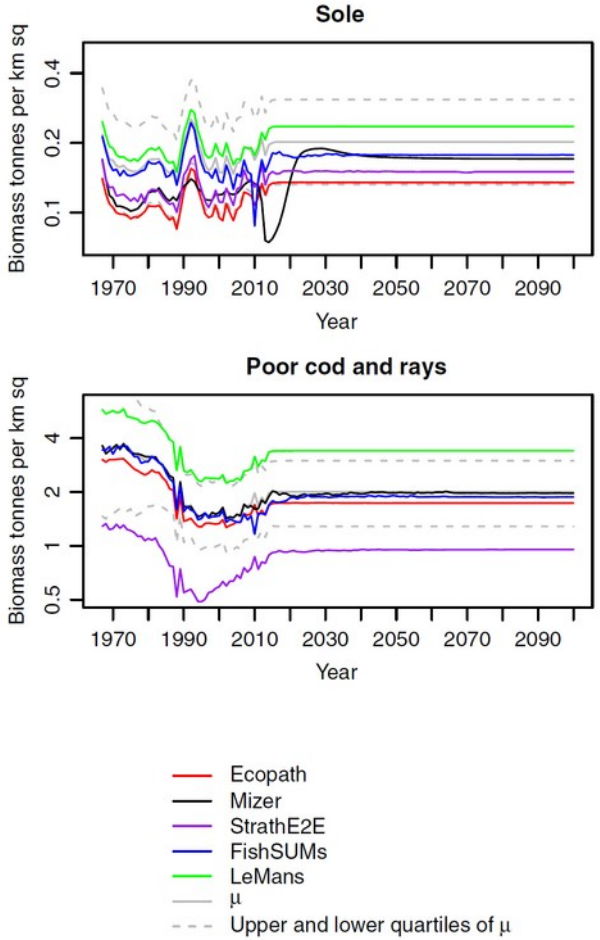
Conclusions

- Integrated approach for setting up regional MEMs for climate hindcasts or projections.
- Regional Climate Forcing Data Explorer.
- Flexible workflow.
- Harmonized downscaling approach.
- Facilitate future research on MEM ensemble development and applications:

  1) model evaluation and benchmarking (across multiple models/regions)

  2) global-regional model intercomparison for regions

  3) regional MEM ensembles.



Spence et al., 2018

Thank you for your attention!

More info: www.fishmip.org
Contact: fishmip.coordinators@gmail.com

README

FishMIP_2022_3a_Protocol

Contents

Goal

The goal of the FishMIP Model Evaluation Protocol is to understand and reduce uncertainty associated with FishMIP models through model evaluation under historical climate and fishing effort forcings.

This information will allow FishMIP to better target policy initiatives such as IPCC and IPBES by providing more robust uncertainty assessment, as well as advancing the state of FishMIP models for informing vulnerability, impact, and adaptation plans of coastal sea ecosystems and fisheries (requested by the FAO). It will also help move towards a detection and attribution framework.

FishMIP 3a protocol

https://github.com/Fish-MIP/FishMIP2.0_TrackA_ISIMIP3a