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Evaluating multiple sources of uncertainty in a global marine ecosystem model from a regional (Southern Ocean) perspective

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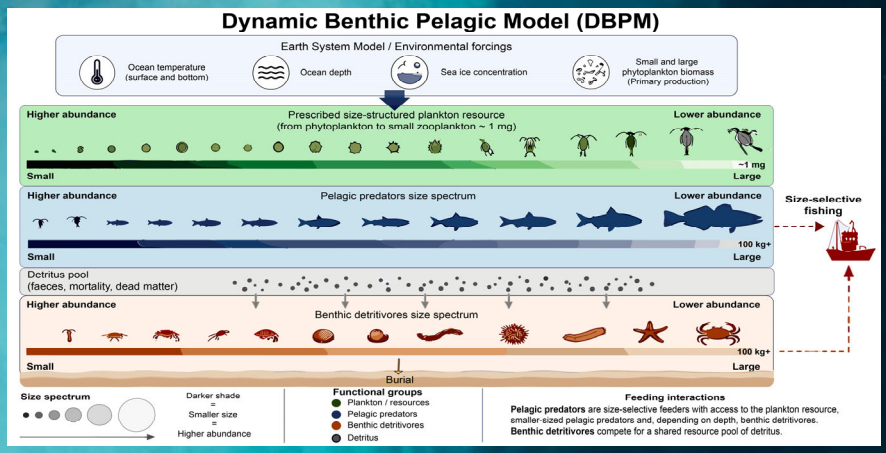
Including a sea ice mask to more realistically distribute fishing effort across space improves historical fishing catches simulated by a global marine ecosystem model for the Southern Ocean, but limited high-quality fishing effort data hinders further model skill improvement.

- Global marine ecosystem models (MEMs) are increasingly being used for assessing climate impacts at various spatial scales (global, regional, national, etc.), but their outputs are influenced by uncertainties linked to the forcings (ocean model outputs and fisheries data).
- We run simulations following Track A of the Fisheries and Marine Ecosystem Model Intercomparison Project 2.0 using the Dynamic Benthic Pelagic Model (DBPM).
- We evaluated the impact of three sources of uncertainty influencing the accuracy of simulated fishing catches in the Southern Ocean (1961–2010): (1) coarsening horizontal resolution of environmental forcings (from 0.25° to 1°), (2) restricting spatial distribution of fishing effort using a sea ice mask, and (3) using regional versus global fishing effort forcing data.

Dynamic Benthic Pelagic Model (DBPM)

Global dynamic size-structured food web model that includes a size-structured resource (i.e., plankton) and two sized-structured consumer communities (pelagic predators and benthic detritivores). Consumer communities are linked to one another via predation and an unstructured detritus resource pool.

DBPM does not require extensive knowledge of individual species as predation, growth, mortality, and reproduction depend on the body size of an organism.



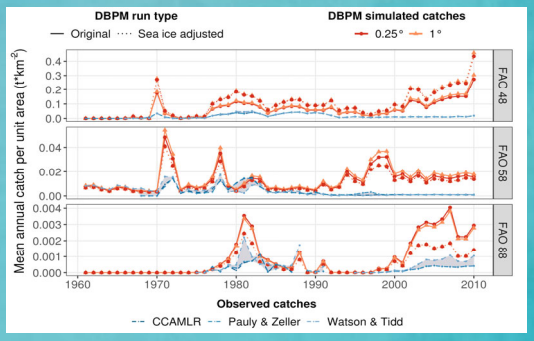


Fig 1. Mean annual catches per unit area between 1961 and 2010 estimated by original DBPM runs (continuous lines) and sea ice corrected spread of fishing effort (dotted lines). Dotted blue lines show the reconstructed ('observed') catches from three sources, with spread of the reconstructed catches shown in grey shaded area.

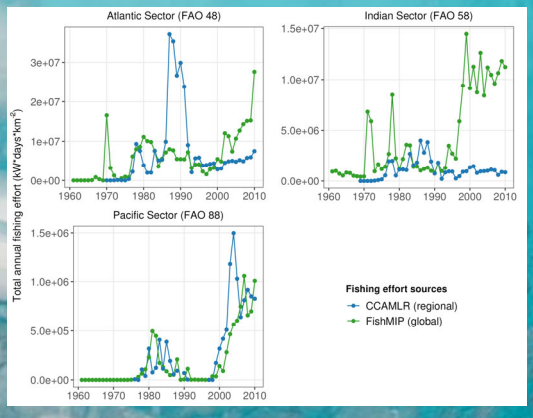


Fig 2. Annual fishing effort for the Southern Ocean between 1961 and 2010. The green line shows the global fishing effort dataset (FishMIP) used as the standard forcing in the FishMIP protocol 3A. The blue line shows the regional fishing effort dataset from CCAMLR.

Main results

- DBPM overestimated fishing catches for entire simulation, but captured well observed temporal trends prior to the 1990s, with minimal differences between forcing resolutions (Fig 1).
- The inclusion of a sea ice mask that restricted fishing effort distribution decreased overestimation by ~15% in the Indian (FAO 58) and Pacific sectors (FAO 88). Overestimation in the Atlantic sectors (FAO 48) grew larger (~55%) as effort was concentrated in highly productive areas after the inclusion of sea ice (Fig 1).
- Spatial distribution of observed fishing catches showed good agreement with observations when sea ice was considered (Fig 3).
- From the mid-1990s overestimation of catches worsen and it appears to be linked to biases in underlying fishing effort forcing data (Fig 2).

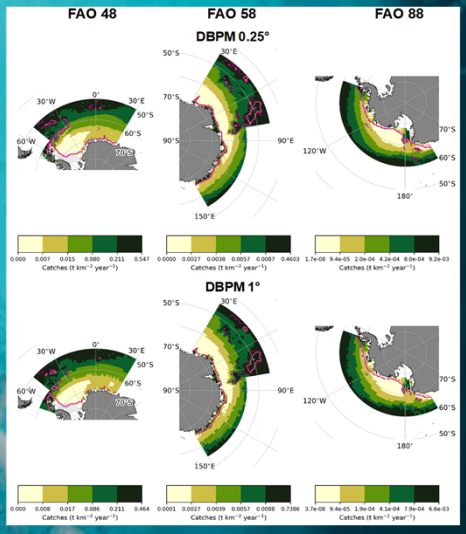


Fig 3. Mean annual catches per unit area estimated by sea ice corrected DBPM at two resolutions 0.25◦ (upper row) and 1◦ (lower row) over simulation period (1961-2010). Colour bars divide simulated catches for each region into quintiles, with each colour bin representing 20% of the data for that region. Pink contours darken with depth and identify the 1,000 m and 2,000 m isobaths.

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