Supplementary information

Differing marine animal biomass shifts under 21st century climate change between Canada's three oceans

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Table S1. Overview of marine ecosystem models included in the ensemble projections (modified from Tittensor et al. (2018a) and Bryndum-Buchholz et al. (2019)).

Marine ecosystem model	**Model description**	**Key ecological processes**	**Spatial and temporal scale for Fish-MIP simulations**	**Vertical resolution**	**Taxonomic scope**	**Reference**
BiOeconomic mArine Trophic Size-spectrum **(BOATS)**	Size-structure model. Combines marine biogeochemistry with size-based trophic theory and metabolic constraints to calculate the production of commercially-harvested fish across multiple size spectra.	Applies empirical parameterizations to describe phytoplankton community structure, trophic transfer of primary production from phytoplankton to fish, fish growth rates, and natural mortality of fish. No direct or passive movement of fish, larvae or eggs between grid cells.	1 x 1˚ grid Monthly mean timestep	None (2-dimensional domain). NPP is vertically-integrated through the water column. Temperature changes with SST.	3 size groups (small, medium, large) defined by their asymptotic mass of all commercial fish.	Carozza et al. (2016)
Macroecological Model	Static size-structure model. Uses minimal input parameters	Simple characterization of marine ecosystems in terms of body mass	1 x 1˚ grid Annual mean timestep	Single vertical (surface-integrated) layer.	180 body mass classes. Species are not resolved.	Jennings and Collingridge (2015)

	together with ecological and metabolic scaling theory to calculate mean size composition and abundance of marine animals (including fish).	distribution and marine animal abundance based on estimates of predator-prey mass ratios, transfer efficiency and changing metabolic demands with body mass and temperature. Animal movement is not included.				
Dynamic Pelagic Benthic Model **(DPBM)**	Dynamic size-and trait based model. Incorporates a pelagic predator size-spectrum with a benthic detritivore size-spectrum.	Individual processes of predation, food-dependent growth, natural mortality, and reproduction give rise to emergent size spectra for each functional group (pelagic predator and benthic detritivore).	1 x 1˚ grid Monthly mean timestep	2 vertical layers (sea surface and sea floor). No vertical transport or movement.	1 pelagic predator and 1 benthic detritivore size spectrum, with 100 size classes each.	Blanchard et al. (2012)
Dynamic Bioclimate Envelope Model **(DBEM)**	Species distribution model based on bioclimatic envelopes (niche) defined for each species. Simulates changes in species abundance and carrying capacity (as a function of the environment and species' habitat preferences) under environmental change.	Population dynamics are dependent of habitat suitability and movement of adult species driven by a gradient of habitat suitability and population density. Larval dispersal is driven by currents and temperature. Growth, reproduction, and natural mortality are	0.5 x 0.5˚ grid Annual mean ocean conditions	Vertical layers (sea surface and bottom) defined by species niche preferences.	892 commercial fish and invertebrate species.	Cheung et al. (2010)

		dependent on oxygen, pH, and temperature.				
EcoOcean	Trophodynamic model, based on species interactions and energy transfer across trophic levels. Ecosim-with-Ecopath (EwE) framework designed to evaluate the impacts of fisheries and climate change on marine resources and ecosystems.	Combines a food web model comprising a mass-balance component (Ecopath; input: biomass, production/biomass ratio, consumption/biomass ratio, diet composition, catches), a temporal dynamic predator-prey component (Ecosim), and a spatio-temporal dynamic component which is a function of grid cell specific habitat attributes i.e. pH, water depth, temperature, and bottom type (Ecospace).	1 x 1˚ grid Monthly mean timestep	Vertical layers defined by food web interactions and habitat preference patterns; vertical movement and transportation through the establishment of trophic links and the generation and consumption of dead organic matter linking pelagic organisms to demersal and benthic organisms.	51 trophic biomass groups; including all trophic level and taxonomic groups (marine mammals, birds, fish, invertebrates, primary producers and bacteria)	Christensen et al. (2015)
Apex Predators ECOSystem Model **(APECOSM)**	3D dynamic energy budget Eulerian model of size-structured marine populations and communities, based on individual environmentally driven bio-energetics, trophic interactions and behaviors, that are upscaled to populations and communities.	Size-based predation, food- and temperature-driven growth, reproduction and senescence. Includes environmental impacts on vertical and horizontal movements and schooling.	1 x 1˚ grid Monthly mean timestep	3D explicit vertical movement considered.	Explicit size-based communities including 3 communities (epipelagic, migratory, mesopelagic); 95 species length classes and 100 size classes	Maury (2010)

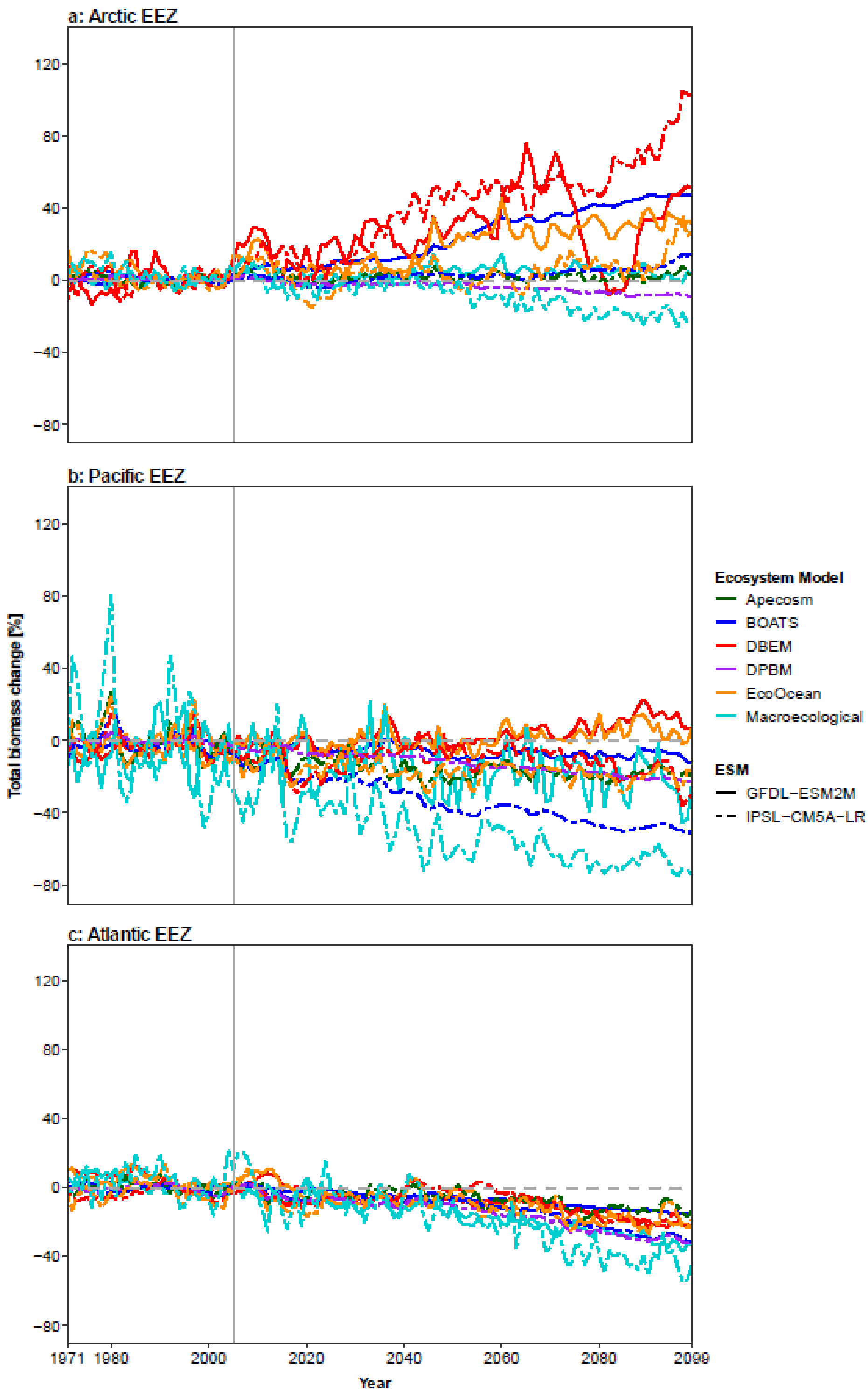

Fig. S1. Individual ecosystem model projections for GFDL-ESM2M and IPSL-CM5A-LR under RCP8.5 in Canada's three oceans. All trends are relative to 1990-1999. The vertical grey line indicates the separation of historical and future projections.

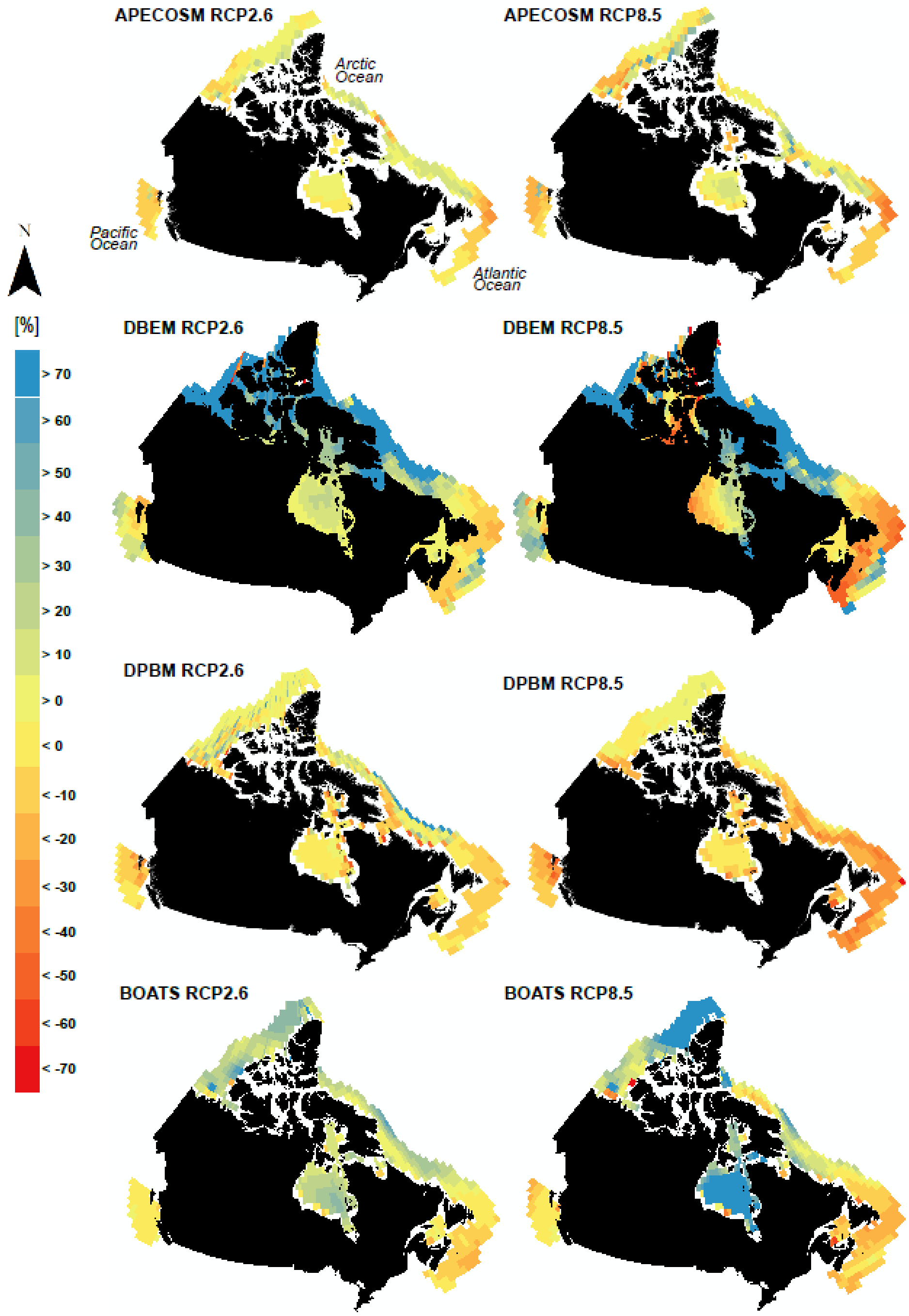

Fig. S2. Spatial patterns of APECOSM, DBEM, DPBM, and BOATS projections of total marine animal biomass under RCP2.6 (left) and RCP8.5 (right) in Canada's three oceans. For better visualization of patterns, percent biomass change values were capped at +/-75%. Country shapefile retrieved from www.diva-gis.org. EEZ outline modified from Flanders Marine Institute (2018).

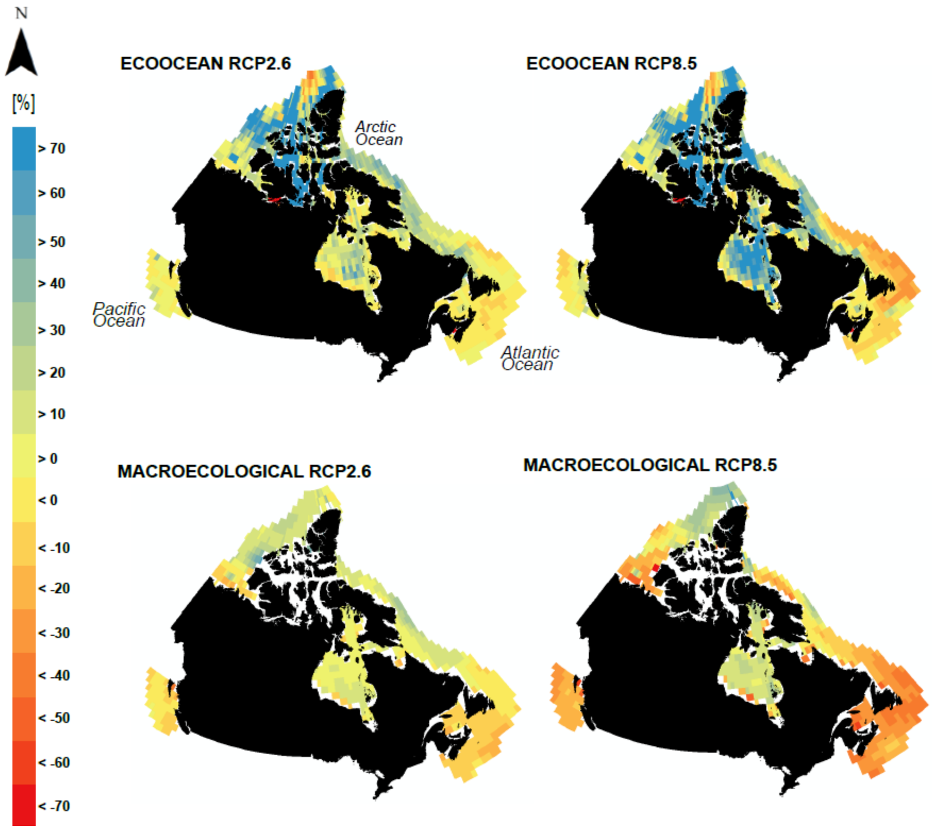

Fig. S3. Spatial patterns EcoOcean and Macroecological projections of total marine animal biomass RCP2.6 (left) and RCP8.5 (right) in Canada's three oceans. For better visualization of patterns, percent biomass change values were capped at +/-75%. Country shapefile retrieved from www.diva-gis.org. EEZ outline modified from Flanders Marine Institute (2018).