EGU24-7254, updated on 15 Sep 2024
https://doi.org/10.5194/egusphere-egu24-7254
EGU General Assembly 2024

Global marine ecosystem response to a strong AMOC weakening under low and high emission scenarios

Amber A. Boot[1], Jeroen Steenbeek[2], Marta Coll[2,3], Anna S. von der Heydt[1,4], and Henk A. Dijkstra[1,4]
[1]Institute for Marine and Atmospheric Research Utrecht, Utrecht University, Utrecht, Netherlands (a.a.boot@uu.nl)
[2]EcopathInternational Initiative (EII) Research Association, Barcelona, Spain
[3]Department of Marine Renewal Resources, Institute of Marine Science (ICM-CSIC), Barcelona, Spain
[4]Center for Complex Systems Studies, Utrecht University, Utrecht, the Netherlands

Marine ecosystems provide several important services for the Earth System and society in the form of, for example, carbon export, food and income. These ecosystems, and the functions they provide, are under threat from anthropogenic climate change, pollution and overfishing. Besides being a large risk for marine ecosystems, anthropogenic climate change might also lead to passing tipping points in the Earth System, leading to relatively fast and strong additional changes to the climate system. A tipping element in the Earth System is the Atlantic Meridional Overturning Circulation (AMOC). Tipping of the AMOC will disrupt the climate system and lead to changes in temperature, precipitation, wind fields, ocean circulation and the carbon cycle. In this study, we look at the effect of a strong AMOC weakening on global marine ecosystems. We do this by forcing a state-of-the-art model, the Community Earth System Model v2 (CESM2), with low (SSP1-2.6) and high (SSP5-8.5) emission scenarios, and with an additional freshwater flux in the North Atlantic from 2015 to 2100. Since the ecosystem component of the CESM2 is limited, we use the CESM2 output in a marine ecosystem model, EcoOcean v2. EcoOcean simulates 52 functional groups including mammals, birds, zooplankton, benthic species and fish on a 1° horizontal grid, and reconciles food web dynamics with a dynamic niche model. EcoOcean is forced with phytoplankton biomass and temperature fields from the CESM2 simulations and this enables us to determine the effect of the AMOC weakening in CESM2 on marine ecosystems. In CESM2, the weakening of the AMOC has a large impact on phytoplankton biomass and temperature fields through various mechanisms including changes in stratification and mixed layer depth, changes in sea-ice cover, and changes in upwelling velocities. Through these mechanisms, the three dimensional distribution of nutrients in the ocean is altered which directly affects the primary producers in CESM2. In EcoOcean, we see that almost all functional groups are negatively impacted by an AMOC weakening. The strongest net effect is seen in the high emission scenario, but the relative effect of the AMOC weakening is larger in the low emission scenario. There are some functional groups, e.g. pinnipeds, that show a strong decrease that closely follows the AMOC weakening. These results show that marine ecosystems will be under increased threat if the AMOC strongly weakens. Furthermore, the results show how tipping in the climate system can negatively impact marine ecosystems and thereby put an additional stress on socio-economic systems that are dependent on fishery industries as a food and income source.