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Projected pH reductions by 2100 might put deep North Atlantic biodiversity at risk

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Supplement

Earth system models, model output: This study draws on standard CMIP5 output from the Program for Climate Model Diagnosis and Intercomparison (http://pcmdi3.llnl.gov/esgcet/home.htm). It uses models for which three-dimensional pH fields are available and that were part of a multi-model evaluation (Bopp et al., 2013). The complete set of RCPs is not available for all models. Individual models have been evaluated by the respective groups.

Table S1. Models used in this study and available RCP per model. References cite key papers for model validation. Esmfixclim2 = CMIP5 identifier for the simulation referred to as RCP4.5/fixclim in this study.

model name	available RCPs	piControl (years)	Ref.
CESM1-BGC	4.5, 8.5	500	Hurrell et al. (2013), Long et al. (2013)
GFDL-ESM2G	2.6, 4.5, 6.0, 8.5	500	Dunne et al. (2013)
GFDL-ESM2M	2.6, 4.5, 6.0, 8.5, esmfixclim2	500	Dunne et al. (2013)
IPSL-CM5A-LR	2.6, 4.5, 6.0, 8.5, esmfixclim2	1000	Séférian et al. (2013)
IPSL-CM5A-MR	2.6, 4.5, 8.5	300	Séférian et al. (2013)
MPI-ESM-MR	2.6, 4.5, 8.5	1000	Ilyina et al. (2013)
NorESM1-ME	2.6, 4.5, 6.0, 8.5	252	Tjiputra et al. (2013)

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Supporting Figures

Figure S1: pH of the waters over-lying the seafloor (top) and change in hydrogen ion concentration corresponding to a decrease in pH of 0.2 units (bottom). pH was calculated from GLODAP alkalinity and DIC, along with WOA nutrient data. The figure illustrates that waters having a low initial pH (e.g. deep waters) will experience the largest increase in $[H^+]$ or acidification for any given decrease in pH. Warm colours indicate high pH, respectively a low change in $[H^+]$.

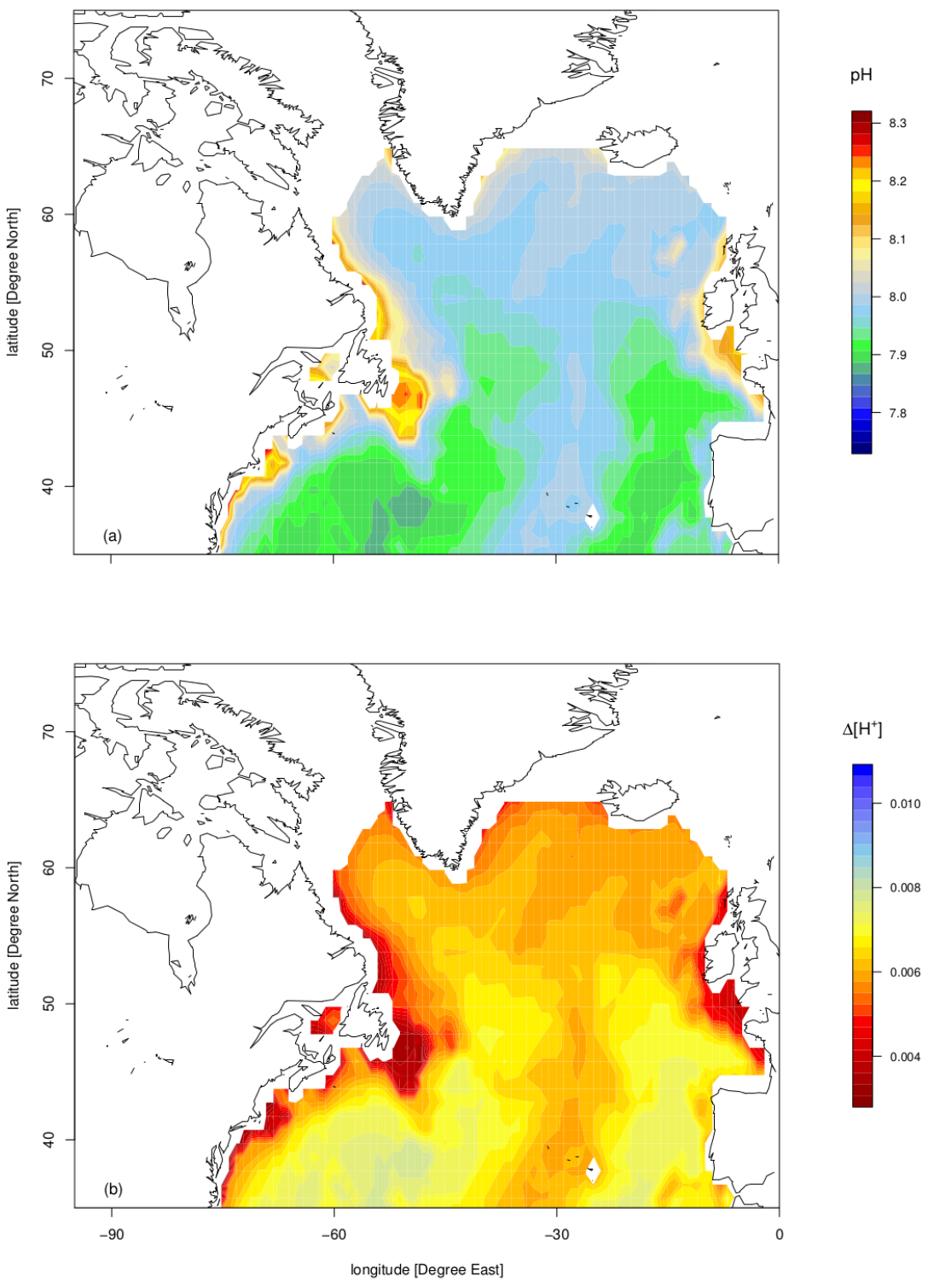
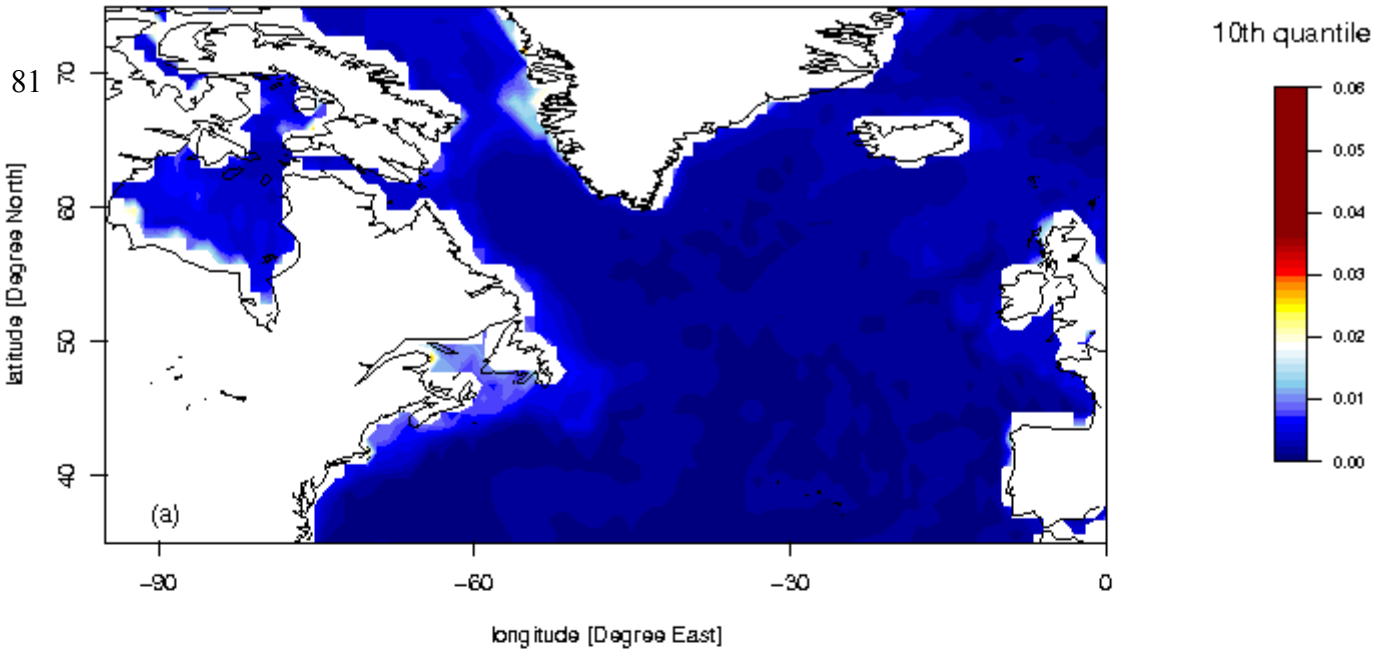
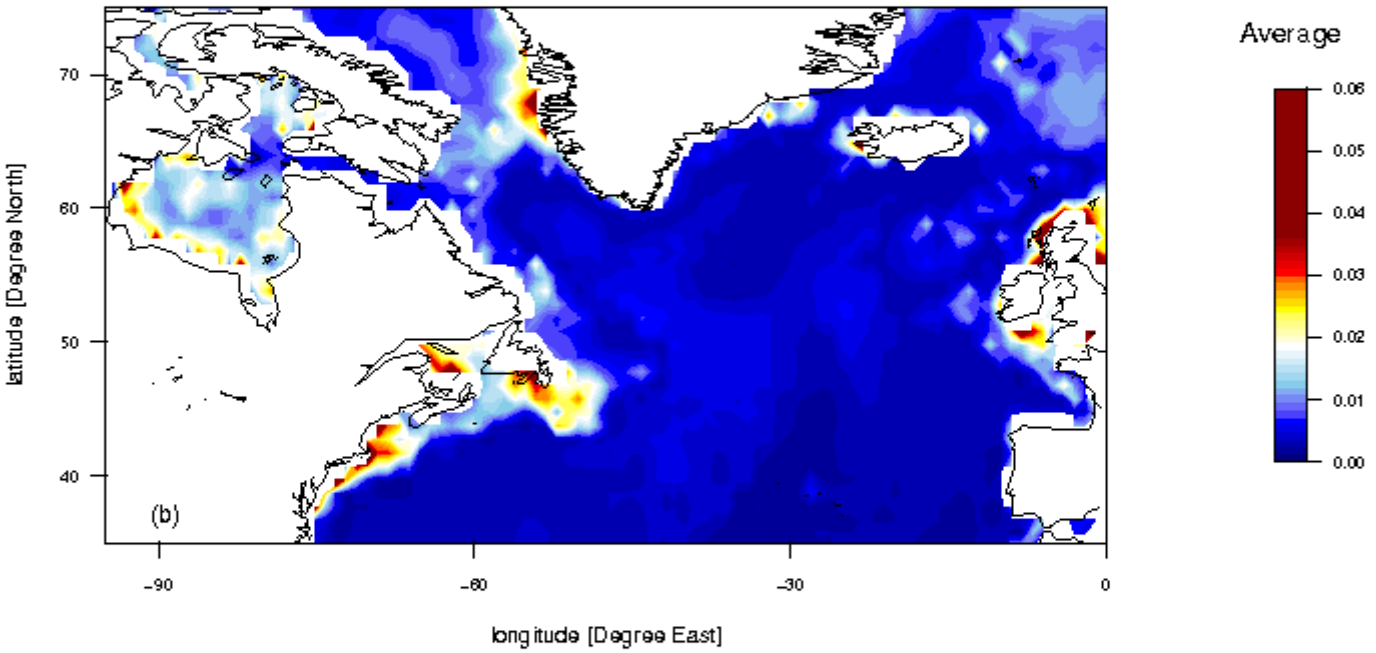


Figure S2. Simulated natural variability of deep-water pH from seven Earth system models. The standard deviation (sdv) of pH is computed for each individual model for the pre-industrial simulation piControl with the multi-model mean sdv shown on panel (b) and the multi-model range in sdv as defined by the 10% (a), respectively 90%(c) quantiles.


10th quantile
0.06
0.05
0.04
0.03
0.02
0.01
0.00
latitude [Degree North]
70
60
50
40
(a)
−90
−60
−30
0
longitude [Degree East]


Average
0.06
0.05
0.04
0.03
0.02
0.01
0.00
latitude [Degree North]
70
60
50
40
(b)
−90
−60
−30
0
longitude [Degree East]

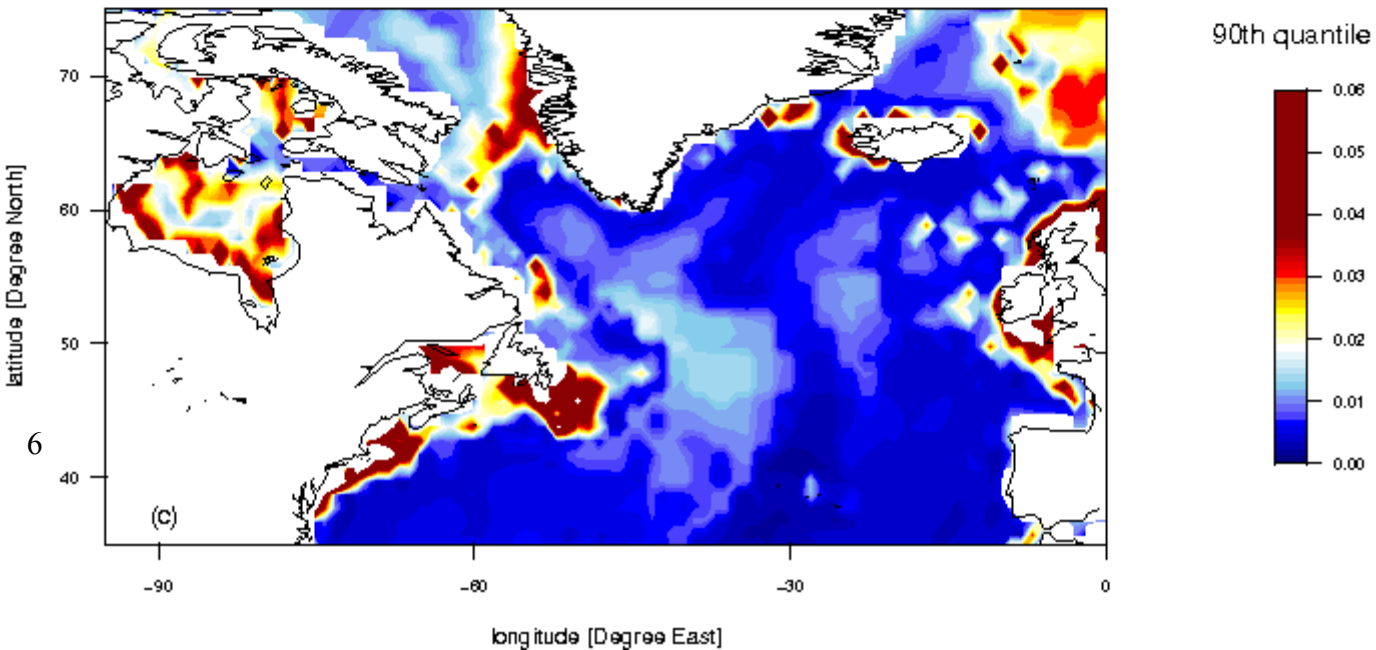

90th quantile
0.06
0.05
0.04
0.03
0.02
0.01
0.00
latitude [Degree North]
70
60
50
40
(c)
−90
−60
−30
0
longitude [Degree East]

Figure S3. Projected changes in deep ocean pH between pre-industrial and the two IPCC scenarios RCP2.6 and RCP6.0 by 2100. The panels represent the difference in mean pH between the pre-industrial and the 2090-2100 average for (a) RCP2.6 and (b) RCP6.0. Locations of deep-sea canyons and seamounts are indicated as red and black symbols, respectively. The -0.2 pH contour line is plotted to delineate areas experiencing pH reductions beyond this threshold.