Rebuilding in the face of climate change

Richard J. Bell^{*,1,4}, Anthony Wood^{3,5}, Jonathan Hare^{1,6,10},
David Richardson^{1,7}, John Manderson^{2,8} and Timothy Miller^{3,9}

¹Northeast Fisheries Science Center, National Marine Fisheries
Service, Narragansett, RI 02882

²Northeast Fisheries Science Center, National Marine Fisheries
Service, Sandy Hook, NJ 07732

³Northeast Fisheries Science Center, National Marine Fisheries
Service, Woods Hole, MA 02543

⁴Current address: The Nature Conservancy, Narragansett, RI
02882

¹⁰Current address: Northeast Fisheries Science Center,
National Marine Fisheries Service, Woods Hole, MA 02543

⁵anthony.wood@noaa.gov

⁶jon.hare@noaa.gov

⁷david.richardson@noaa.gov

⁸john.manderson@noaa.gov

⁹timothy.j.miller@noaa.gov

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*Corresponding author

E-mail: rich.bell@tnc.org

Phone: 401-874-6511

Supplemental material

IPCC Model	Model file
Community Climate System Model Version 4	tas_Amon_CCSM4_rcp85_r1i1p1_200601-210012.nc
Centre National de Recherches Mtorologiques	tas_Amon_CNRM-CM5_rcp85_r1i1p1_2006-209911.nc
Commonwealth Scientific and Industrial Research Organization	tas_Amon_CSIRO-Mk3-6-0_rcp85_r1i1p1_2006-209911.nc
Canadian Earth System Model	tas_Amon_CanESM2_rcp85_r1i1p1_200601-210012.nc
Flexible Global Ocean-Atmosphere-Land System Model: Grid-point Version 2	tas_Amon_FGOALS-g2_rcp85_r1i1p1_2006-209911.nc
GFDL Coupled Physical Model	tas_Amon_GFDL-CM3_rcp85_r1i1p1_2006-209911.nc
NASA Goddard Institute for Space Studies	tas_Amon_GISS-E2-H_rcp85_r1i1p1_2006-209911.nc
Met Office Hadley Centre	tas_Amon_HadGEM2-CC_rcp85_r1i1p1_2006-209911.nc
Institute Pierre Simon Laplace	tas_Amon_IPSL-CM5A-MR_rcp85_r1i1p1_2006-209911.nc
Model for Interdisciplinary Research on Climate	tas_Amon_MIROC5_rcp85_r1i1p1_2006-209911.nc
Max-Planck-Institut fr Meteorologie	tas_Amon_MPI-ESM-MR_rcp85_r1i1p1_2006-209911.nc
Meteorological Research Institute	tas_Amon_MRI-CGCM3_rcp85_r1i1p1_2006-209911.nc
Beijing Climate Center Climate System Model	tas_Amon_bcc-csm1-1_rcp85_r1i1p1_200601-209912.nc
Russian Institute for Numerical Mathematics Climate Model Version 4	tas_Amon_inmcm4_rcp85_r1i1p1_2006-209911.nc

Table S1: The IPCC AR5 models used to develop the ensemble temperature projection from the Coupled Model Intercomparison Project Phase 5 (CMIP 2017).

Figure S1: The probability of selecting the estimated recruitment from a given year for the ENVIRON projection.

Bootstrap runs

Bootstrapped model runs were conducted to evaluate the difference among the estimated values (e.g. SSB, Fishing) from the three different model formulations. Because the different models were based on the same underlying data, the outputs were not independent and could not be compared with simple probability intervals. We followed the method of Miller and Legault (2017) utilizing parametric bootstrap runs. Distributions were constructed for the catch, survey indices and age composition data with the mean set to the observed values and dispersion based on the coefficient of variation. Five hundred data sets were created and run through the three different model formulations producing fifteen hundred sets of estimated values. The three different models were each fit to the same bootstrapped data set and compared. The difference in the quantities of interest (e.g. SSB, Fishing) across the different models was then sorted to produce 95% intervals.

The outputs were similar across the three models, but were consistently different after 1994 (Figures S2 & S3). While the patterns were the same, the standard model always had the highest SSB and lowest fishing mortality while the environmental model with $cv = 0.2$ had the lowest SSB and highest fishing mortality. The environmental model with $cv = 0.5$ was in the middle. After 1994, the intervals consistently did not cross zero indicating the outputs were different among the three model formulations (Figure S4).

Figure S2: Estimated spawning stock biomass (SSB) for all three models across all bootstrap runs. The estimated SSB for a single bootstrap run and the difference among the estimated SSB for the particular bootstrap run.

Figure S3: Estimated fishing mortality for all three models across all bootstrap runs. The estimated fishing mortality for a single bootstrap run and the difference among the estimated fishing mortality for the particular bootstrap run.

Figure S4: Estimated 95% probability intervals and median for the difference among the three models from the parametric bootstraps. After 1994, the intervals consistently do not cross zero.

References

- CMIP 2017. <http://cmip-pcmdi.llnl.gov/index.html?submenuheader=0>.
- Miller, T. and Legault, C. 2017. Statistical behavior of retrospective patterns and their effects on estimation of stock and harvest status. *Fisheries Research* **186**(1): 109–120.