Predicted probability of occupancy and abundance under a doubling of carbon dioxide using simulations from GFDL CM2.6

Website: https://www.bco-dmo.org/dataset/753188
Data Type: model results
Version: 1
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Project
» Adaptations of fish and fishing communities to rapid climate change (CC Fishery Adaptations)

Contributors	Affiliation	Role
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Abstract
Predicted probability of occupancy and abundance under a doubling of carbon dioxide using simulations from GFDL CM2.6. These data were published in Selden (2018).

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Coverage

Spatial Extent: **N**:44.25 **E**:-65.75 **S**:26 **W**:-75.75

Dataset Description

Predicted probability of occupancy and abundance under a doubling of carbon dioxide using simulations from GFDL CM2.6. These data were published in Selden (2018). The "Get Data" button on this page provides a tabular version of this dataset. These data are also available in the following R Datafile containing a DataFrame named “projected.” https://datadocs.bco-dmo.org/data/305/CC_Fishery_Adaptations/753188/1/da... Related dataset: "Observed and modeled presence 1968-2014": https://www.bco-dmo.org/dataset/753142

Methods & Sampling

To evaluate how future warming may affect species overlap, we examined projections of ocean temperature from experimental runs of CM2.6—a high-resolution global climate model developed by the National Oceanographic and Atmospheric Administration’s Geophysical Fluid Dynamics Laboratory. The climate model simulates an annual 1% increase in atmospheric CO_2 over the course of 80-years, reaching a doubling of CO_2 by year 70. Under the IPCC’s RCP 8.5 emissions scenario, CO_2 is predicted to approximately double by 2075 (van Vuuren et al., 2011). The CM2.6 model projects temperature as the change in temperature from the initial year, such that projections are in relative units (ΔºC). We use ΔºC projections for surface and bottom waters for the spring months of March, April and May. To convert projected temperature change (ΔºC) to absolute temperatures (ºC), projected temperature changes were added to the long-term mean climatology in each

0.25°latitude x 0.25°longitude grid cell. The fitted species distribution models were then projected with the CM2.6 sea bottom and sea surface temperatures for each simulated time step (t). Projections were made for each 0.25°latitude x 0.25°longitude grid cell j in the study region while holding species biomass constant at its overall mean and using the mean depth and substrate for each grid cell. Projections were also made with average biomass set equal to 50% and 150% of the historical mean to explore the effect of abundance on projected species occupancy.

Data Processing Description

Range size and species overlap were calculated using the R-file species_overlap_BCO.R available in the "Supplemental Documents" section on this page.

BCO-DMO data manager processing notes:
* exported RData as csv and imported into the BCO-DMO data system.
* periods in column names in the RData Frame changed to underscores in exported csv version to support import into the BCO-DMO data system.
* columns rounded to three decimal places during csv export:
"btemp","stemp","preds1","preds","se.fit","preds1.upr","preds1.lwr"

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Data Files

File
projected.csv(Comma Separated Values (.csv), 30.02 MB) MD5:50fbaf7ecbc66128376d04b2da58eb4a Primary data file for dataset ID 753188

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Supplemental Files

File	
species_overlap_BCO.R	(Octet Stream, 5.63 KB) MD5:c107c518ed26e5fe7f0958c7f034867e

This R-file uses R datafiles available from the following dataset landing pages:

"Observed and modeled presence 1968-2014": https://www.bco-dmo.org/dataset/753142

* historical.RData

"Projected species probability of occupancy and abundance under ocean warming": https://www.bco-dmo.org/dataset/753188

* projected.RData

Range size and species overlap

For each year, observations and predictions of historical species occupancy were aggregated to 0.5° latitude x 0.5° longitude grid cells by taking the average across hauls in each cell. Data in each year was further trimmed to the 113 grid cells that were observed in at least 30 years. Observed range size for species x in year y was calculated as the proportion of grid cells in the study region in which the species was present to account for differences in the intensity of sampling between years. The observed fraction of prey A's range occupied by predator B was defined as the number of sites occupied by both species relative to the total number of sites occupied by species A.

To calculate a species' predicted range extent from the species distribution models, we computed the average occupancy probability of that species across all sites in the region. To predict the fraction of prey A's range occupied by predator B, the cumulative joint probability of both species was divided by the cumulative probability for species A across all sites in the study region.

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Related Publications

Saba, V. S., Griffies, S. M., Anderson, W. G., Winton, M., Alexander, M. A., Delworth, T. L., Hare, J. A., Harrison, M. J., Rosati, A., Vecchi, G. A., & Zhang, R. (2016). Enhanced warming of the N orthwest A tlantic O cean under climate change. In Journal of Geophysical Research: Oceans (Vol. 121, Issue 1, pp. 118–132). American

Geophysical Union (AGU). https://doi.org/10.1002/2015jc011346 https://doi.org/10.1002/2015JC011346
Methods

Selden, R. L., Batt, R. D., Saba, V. S., & Pinsky, M. L. (2017). Diversity in thermal affinity among key piscivores buffers impacts of ocean warming on predator-prey interactions. Global Change Biology, 24(1), 117–131. doi:10.1111/gcb.13838
Results

Van Vuuren, D. P., Edmonds, J., Kainuma, M., Riahi, K., Thomson, A., Hibbard, K., … Rose, S. K. (2011). The representative concentration pathways: an overview. Climatic Change, 109(1-2), 5–31. doi:10.1007/s10584-011-0148-z
Methods

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Parameters

Parameter	Description	Units
spp	species scientific name	unitless
lon_deg	longitude of grid cell	decimal degrees (DD)
lat_deg	latitude of grid cell	decimal degrees (DD)
scen	year from GFDL simulation. CO2 increases 1% per year over 80 years, doubling from initial levels at year 70 (see Saba et al. 2016 for details)	unitless
btemp	predicted bottom temperature from GFDL simulation	degrees Celsius
stemp	predicted surface temperature from GFDL simulation	degrees Celsius
preds1	predicted probability of occurrence (0-1)	dimensionless
preds	predicted biomass	kilograms (kg)
se_fit	standard error of prediction for probability of occurrence	kilograms (kg)
preds1_upr	upper bound of predicted probability of occurrence (fit + 2SE)	dimensionless
preds1_lwr	lower bound of predicted probability of occurrence (fit -2SE)	dimensionless

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Project Information

Adaptations of fish and fishing communities to rapid climate change (CC Fishery Adaptations)

Coverage: Northeast US Continental Shelf Large Marine Ecosystem

Description from NSF award abstract:
Climate change presents a profound challenge to the sustainability of coastal systems. Most research has overlooked the important coupling between human responses to climate effects and the cumulative impacts of these responses on ecosystems. Fisheries are a prime example of this feedback: climate changes cause shifts in species distributions and abundances, and fisheries adapt to these shifts. However, changes in the location and intensity of fishing also have major ecosystem impacts. This project's goal is to understand how climate and fishing interact to affect the long-term sustainability of marine populations and the ecosystem services they support. In addition, the project will explore how to design fisheries management and other institutions

that are robust to climate-driven shifts in species distributions. The project focuses on fisheries for summer flounder and hake on the northeast U.S. continental shelf, which target some of the most rapidly shifting species in North America. By focusing on factors affecting the adaptation of fish, fisheries, fishing communities, and management institutions to the impacts of climate change, this project will have direct application to coastal sustainability. The project involves close collaboration with the National Oceanic and Atmospheric Administration, and researchers will conduct regular presentations for and maintain frequent dialogue with the Mid-Atlantic and New England Fisheries Management Councils in charge of the summer flounder and hake fisheries. To enhance undergraduate education, project participants will design a new online laboratory investigation to explore the impacts of climate change on fisheries, complete with visualization tools that allow students to explore inquiry-driven problems and that highlight the benefits of teaching with authentic data. This project is supported as part of the National Science Foundation's Coastal Science, Engineering, and Education for Sustainability program - Coastal SEES.

The project will address three questions:
1) How do the interacting impacts of fishing and climate change affect the persistence, abundance, and distribution of marine fishes?
2) How do fishers and fishing communities adapt to species range shifts and related changes in abundance? and
3) Which institutions create incentives that sustain or maximize the value of natural capital and comprehensive social wealth in the face of rapid climate change?

An interdisciplinary team of scientists will use dynamic range and statistical models with four decades of geo-referenced data on fisheries catch and fish biogeography to determine how fish populations are affected by the cumulative impacts of fishing, climate, and changing species interactions. The group will then use comprehensive information on changes in fisher behavior to understand how fishers respond to changes in species distribution and abundance. Interviews will explore the social, regulatory, and economic factors that shape these strategies. Finally, a bioeconomic model for summer flounder and hake fisheries will examine how spatial distribution of regulatory authority, social feedbacks within human communities, and uncertainty affect society's ability to maintain natural and social capital.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1426891

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