Projected changes in habitat suitability for 33 marine species on the Northeast US shelf based on species distribution models fit to bottom trawl survey data from the NOAA Northeast Fisheries Science Center

Website: https://www.bco-dmo.org/dataset/765386
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
Projected changes in habitat suitability for 33 marine species on the Northeast US shelf. Changes in habitat suitability are calculated based on species distribution models fit to bottom trawl survey data from the NOAA Northeast Fisheries Science Center. Positive values indicate an increase in habitat suitability by 2040-2050 relative to historical (1963-2005). The spatial resolution of projections is 0.25 x 0.25 degrees.

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Coverage

Spatial Extent: **N**:44.875 **E**:-64.875 **S**:33.625 **W**:-76.875
Temporal Extent: 1963 - 2050

Dataset Description

Projected changes in habitat suitability for 33 marine species on the Northeast US shelf. Changes in habitat suitability are calculated based on species distribution models fit to bottom trawl survey data from the NOAA Northeast Fisheries Science Center. Positive values indicate an increase in habitat suitability by 2040-2050 relative to historical (1963-2005). The spatial resolution of projections is 0.25 x 0.25 degrees.

Methods & Sampling

The following methods are excerpted from Rogers et al. (in press):
Bottom trawl data from the NOAA Northeast Fisheries Science Center (NEFSC) fall (1963-2014) surveys were used to characterize the realized thermal niches of species. At each survey station, fish of each species were counted and weighed, and surface and bottom temperature measurements were taken. Correction factors were applied to standardize catch rates for changes in vessel and gear type. A total of 33 species were selected based on their near continuous presence in the survey as well as relative importance to commercial fisheries. For 4 species, data from 1972 onwards were used because observations were irregular prior to that year.

Generalized Additive Models were used to estimate the realized thermal niches of species. We restricted k (number of knots) to 4 or 6 for each of our covariates to ensure biologically meaningful responses. Our response variable was probability of occurrence in a trawl haul, and we used a binomial response with logit transform:

$p(occur_{y,j}) \sim \text{logit-1}\ (s(ST_{y,j})+s(BT_{y,j})+s(meanbiomass_{y})+s(rugosity_{j}))$

where $ST_{y,j}$ and $BT_{y,j}$ are sea surface temperature and bottom temperature measured at each haul location j in year y, and $meanbiomass_{y}$ is the average annual catch across all hauls to account for interannual changes in abundance due to, e.g., fishing. $Rugosity_{y}$ is a measure of benthic habitat roughness, measured as the Terrain Ruggedness Index, using the GEBCO 2014 30-arcsecond bathymetry data (downloaded 4 Feb 2015 from http://www.gebco.net/). The resulting estimated smooth functions describing the relationship between probability of occurrence and temperature can be interpreted as realized thermal niches.

For each species, the change in predicted probability of occurrence under future (2040-2050) projected climate conditions was compared to historical (1963-2005) conditions for each cell within a 0.25°x0.25° spatial grid. Because the modeled probability of occurrence included a component of catchability, values for each species were scaled by dividing by the maximum observed or predicted probability of occurrence across the study area. Positive values for a grid square indicated a projected increase in probability of occurrence, whereas negative values indicated a projected decrease in probability of occurrence.

See related dataset for NEFSC bottom trawl data: https://www.bco-dmo.org/dataset/753142 (doi: 10.1575/1912/bco-dmo.753142.1)

Data Processing Description

Data were processed using R version 3.4.4.

BCO-DMO Processing:
- replaced spaces with underscores in the column headers.

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Data Files

File	
projected_changes_habitat.csv	(Comma Separated Values (.csv), 137.82 KB) MD5:9e19330380f8ef8717c570ace36ef7c1
Primary data file for dataset ID 765386	

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Related Publications

Pinsky, M., & Selden, R. (2019). Trawl survey data and species distribution model predictions for presence, absence and abundance. Biological and Chemical Oceanography Data Management Office. doi:10.1575/1912/bco-dmo.753142.1

General

Rogers, L. A., Griffin, R., Young, T., Fuller, E., St. Martin, K., & Pinsky, M. L. (2019). Shifting habitats expose fishing communities to risk under climate change. Nature Climate Change, 9(7), 512–516. https://doi.org/10.1038/s41558-019-0503-z

Results

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Parameters

Parameter	Description	Units
brosme_brosme	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
centropristis_striata	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
gadus_morhua	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
glyptocephalus_cynoglossus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
hippoglossoides_platessoides	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
hippoglossus_hippoglossus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
leucoraja_ocellata	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
limanda_ferruginea	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless

lophius_americanus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
zoarces_americanus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
melanogrammus_aeglefinus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
merluccius_albidus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
merluccius_bilinearis	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
paralichthys_dentatus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
peprilus_triacanthus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
pollachius_virens	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
pseudopleuronectes_americanus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
scomber_scombrus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless

scophthalmus_aquosus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
sebastes_fasciatus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
squalus_acanthias	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
stenotomus_chrysops	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
urophycis_chuss	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
urophycis_tenuis	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
homarus_americanus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
placopecten_magellanicus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
loligo_pealeii	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
clupea_harengus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless

illex_illecebrosus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
menticirrhus_americanus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
pomatomus_saltatrix	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
cynoscion_regalis	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
micropogonias_undulatus	Change in habitat suitability for species. Positive values for a grid square indicate a projected increase in probability of occurrence by 2040-2050 relative to historical (1963-2005), whereas negative values indicate a projected decrease in probability of occurrence.	unitless
lon	Longitude	decimal degrees
lat	Latitude	decimal degrees

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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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