Changes in groundfish fishing communities in the northeast US from 1997-2014 as captured in the vessel trip report (VTR) data collected by the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA-NMFS-NEFSC)

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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
This dataset describes changes in groundfish fishing communities in the northeast US from 1997-2014 as captured in the vessel trip report (VTR) data collected by the National Oceanic and Atmospheric Administration National Marine Fisheries Service Northeast Fisheries Science Center (NOAA-NMFS-NEFSC).

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Dataset Description

This dataset describes changes in groundfish fishing communities in the northeast US from 1997-2014 as captured in the vessel trip report (VTR) data collected by the National Oceanic and Atmospheric Administration National Marine Fisheries Service Northeast Fisheries Science Center (NOAA-NMFS-NEFSC), including:
- annual latitudinal shift in fishing location;
- whether the community is still extant in the dataset (and if not, the year it disappeared from the dataset);
- mean shannon-wiener diversity metric of species composition of catch;
- percentage of species composing 90% of catch.

Methods & Sampling

We used the Communities-at-Sea framework developed by St. Martin and colleagues (St Martin and Hall-Arber, 2008 (Human Ecology Review); St Martin and Hall-Arber, 2008 (Marine Policy); St Martin and Olson, 2017) to define fishing communities. This approach aggregates peer groups of vessels into community-based fleets, each defined as a unique combination of port, gear, and vessel size. We used two categories of vessel size: vessels that are longer than or equal to 65’, and those that are shorter. Each trip in the vessel trip report (VTR) trawl data was grouped into a community fleet by the port of landing and vessel size, as long as at least one of the following two conditions were met: (1) the vessel landed at least 50% of its trips that year at that port, or (2) the vessel reported that landing port as its home port or principal port on its permit. Trips that landed at a port that did not meet either category were not included in this analysis. To ensure confidentiality of harvester information, we only analyzed community fleets that included at least three vessels in a given year.

For each community fleet in a given year (a "fleet-year"), we estimated an annual geographic effort-weighted centroid of fishing activity using a bootstrapping approach. We first used DePiper's (2014) model to calculate a 90% confidence interval for each individual fishing trip. Then, using that confidence interval as a radius around the reported trip location and assuming a uniform distribution, we chose a random point within that area to represent the trip location. For each fleet-year, we used all estimated trip locations to calculate a weighted geographic centroid. Each centroid was weighted by crew size multiplied by trip length to represent a measure of labor time and investment (St Martin and Olson, 2017). We repeated this process 1000 times to generate a distribution of centroids for each community-year. See script: bootstrap_centroid.R (input: Communities-at-Sea table, output: centroids table).

We used an inverse weighted regression analysis to assess if and to what degree the annual fishing center for each community fleet shifted significantly over time. For each community fleet, we fit a linear regression of latitude against year for each set of bootstrap-replicated centroids described above. We weighted each centroid by the inverse variance of the trip latitudes used to calculate that centroid. This approach weights a centroid with tightly clustered trips more heavily than one with more dispersed trips. We used the mean effect strength from those 1000 regressions as the rate of change in latitude for each fleet. To ensure sufficient data for analysis over time, we restricted this analysis to only community fleets with at least seven years of trip data. See script: build_delta_gf.R (input: Communites-at-Sea table, output: delta_gf table).

We summarized the delta_gf table in a results table. See script: build_results_table.R (input: delta_gf table, output: results_table.csv (this dataset; use "Get Data" button). Also see Table S1 of Young et al. (2018).

In order to assess the effect of factors correlated with changes in fishing latitude, we fit a series of multiple linear regressions between the rate of latitudinal change and five explanatory variables:
(1) Vessel size,
(2) Species diversity of catch,
(3) Change in composition of catch species,
(4) Change in depth of fishing location. In order to estimate change in depth of fishing location for each community, we first found the nearest depth recording for each trip using a U.S. coastal relief model (NOAA National Centers for Environmental Information, U.S. Coastal Relief Model, n.d.), and calculated an effort-weighted average depth for all the trips in a community year. As above, we then regressed depth against year and used the resulting slope as the covariate.
(5) Port latitude. Species diversity of catch was correlated with port latitude (fleets from more northern ports had greater catch diversity), so we also included latitude of port as a covariate so that we could assess the separate effects of catch diversity and port latitude.

We evaluated models with all possible combinations of main effects as well as three interactions: vessel size and port latitude, vessel size and catch species diversity, and catch species diversity and change in catch species composition. We calculated the corrected Akaike Information Criterion (AICc) for each model and the Relative Variable Importance (RVI) for each variable and interaction included in the model. See script: lat_shift_model.R (input: delta_gf table).

In order to assess factors mediating changes in community size, we fit a series of regressions to assess the effect on rate of change in community size (change in number of unique permits over time; linear) and community disappearance (fewer than 3 permits by 2014; logistic) of three predictor variables: (1) vessel size, (2) species diversity of catch, and (3) port latitude. We evaluated models with all possible combinations of main effects as well as interactions, and calculated AICc and RVI as described above. We used the number of unique fishing permits in a community as a proxy for community fleet size. See script: community_decline_model.R (input: delta_gf table).

Additional details and references can be found in Young et al. (2018).

Data Processing Description

Data were processed in R 3.4.4.

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Data Files

File
results_table.csv (Comma Separated Values (.csv), 12.77 KB) MD5:f3b59ef43ca7497e59ca53066bea7b40 Primary data file for dataset ID 752624

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Supplemental Files

File
bootstrap_centroid R script filename: bootstrap_centroid.R (R Script, 5.02 KB) MD5:bde787fde9198c90c950c99f162cd553 R script used to estimate an annual geographic effort-weighted centroid of fishing activity using a bootstrapping approach
build_delta_gf R script filename: build_delta_gf.R (R Script, 7.80 KB) MD5:cc3a3f0006ec4b42b67f20eb972cb265 R script used in an inverse weighted regression analysis to assess if and to what degree the annual fishing center for each community fleet shifted significantly over time
build_results_table R script filename: build_results_table.R (R Script, 2.33 KB) MD5:df5fa0f9c6964015c8ddefd205e47e94 R script used to build the results file, "results_table.csv" (dataset available through the "Get Data" button)
community_decline_model R script filename: community_decline_model.R (R Script, 3.05 KB) MD5:6b6546855a17e5089e5bd340eb03b6fd R script used in assessing various factors mediating changes in community size
lat_shift_model R script filename: lat_shift_model.R (R Script, 1.26 KB) MD5:04d3af3959a07505ab3c5e0ad66518db R script used in assessing the effect of different factors correlated with changes in fishing latitude

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Related Publications

DePiper G. S. (2014). Statistically assessing the precision of self-reported VTR fishing locations. Technical Memorandum NMFS-NE-229. NOAA/National Marine Fisheries Service. Technical Memorandum NMFS-NE-229. 22. pp. https://repository.library.noaa.gov/view/noaa/4806
Methods

NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. 1998. NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. https://www.ngdc.noaa.gov/mgg/coastal/crm.html
Methods

St. Martin K., Hall-Arber M. (2008). Creating a place for 'community' in New England fisheries. Human Ecology Review , 15: 161–170.
Methods

St. Martin, K., & Hall-Arber, M. (2008). The missing layer: Geo-technologies, communities, and implications for marine spatial planning. Marine Policy, 32(5), 779–786. doi:10.1016/j.marpol.2008.03.015
Methods

St. Martin, K., & Olson, J. (2017). Creating Space for Community in Marine Conservation and Management.

Conservation for the Anthropocene Ocean, 123–141. doi:10.1016/b978-0-12-805375-1.00007-6
https://doi.org/10.1016/B978-0-12-805375-1.00007-6
Methods

Young, T., Fuller, E. C., Provost, M. M., Coleman, K. E., St. Martin, K., … McCay, B. J. (2018). Adaptation strategies of coastal fishing communities as species shift poleward. ICES Journal of Marine Science. doi:10.1093/icesjms/fsy140
Results

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Parameters

Parameter	Description	Units
community	Fishing community based on port, gear, and vessel size (greater than or smaller than 65'), categorized using Communities-At-Sea methodology. In this case all communities use trawls targeting groundfish. (See Young et al. 2018 for additional details.)	unitless
size	Vessel length: large (>=65') or small (	unitless
km_shift	Annual latitudinal shift in km (degrees * 110.57)	kilometers (km)
still_extant	Whether the community is still in the data set at the end (2014). 0 = no, 1 = yes.	unitless
last_year	Year the community disappeared from the dataset	unitless
sw_mean	Mean Shannon-Wiener diversity index of catch composition across all years	unitless
species_percent	Percentages of species contributing to 90% in catch across all years	unitless

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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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