## Basic Information

*This section contains basic information about the dataset, suitable for a minimal metadata entry.*

**Title:** Demersal (groundfish) community diversity and biomass metrics in the Northern and Southern shelf bioregions

**Dataset ID:** groundfish-community-diversity

**Status:** Completed

**Quality Control:** Completed

**Summary:** Conservation of marine biodiversity requires understanding the joint influence of ongoing environmental change and fishing pressure. Addressing this challenge requires robust biodiversity monitoring and analyses that jointly account for potential drivers of change. Here, we ask how demersal fish biodiversity in Canadian Pacific waters has changed since 2003 and assess the degree to which these changes can be explained by environmental change and commercial fishing. Using a spatiotemporal multispecies model based on fisheries independent data, we find that species density (number of species per area) and community biomass have increased during this period. Environmental changes during this period were associated with temporal fluctuations in the biomass of species and the community as a whole. However, environmental changes were less associated with changes in species' occurrence. Thus, the estimated increases in species density are not likely to be due to environmental change. Instead, our results are consistent with an ongoing recovery of the demersal fish community from a reduction in commercial fishing intensity from historical levels. These findings provide key insight into the drivers of biodiversity change that can inform ecosystem based management.

The layers provided represent three community metrics: 1) species density (i.e., species richness), 2) Hill-Shannon diversity, and 3) community biomass. All layers are provided at a 3 km resolution across the study domain for the period of 2003 to 2019. For each metric, we provide layers for three summary statistics: 1) the mean value in each grid cell over the temporal range, 2) the probability that the grid cell is a hotspot for that metric, and 3) the temporal coefficient of variation across all years.

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**Start Date:** 2003-01-01

**End Date:** 2019-12-31

## Contact Information

*This section contains contact information for the data creator and program manager.*

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## General

*General metadata compatible with the Canada Open Data metadata standard.*

**Topic Category:** Biota

**Date Completed:** 2021-01-01

**Date Published:** 2022-03-14

**Update Frequency:** Not Planned

**Dataset Level:** Dataset

**Keywords (GoC Thesaurus):** biodiversity, environmental planning, ecosystems, temperature, fishing resources, species diversity

## Science

*This section contains metadata specific to the Science branch at DFO.*

**Science Keywords:** species richness, community biomass, marine spatial planning, biodiversity change, environmental change, groundfish, ecosystem-based management, fisheries, species distribution models

**Theme:** Groundfish Survey

**Methods:** The analysis that produced these layers is presented in Thompson et al. (2022). Disentangling the impacts of environmental change and commercial fishing on demersal fish biodiversity in a northeast Pacific ecosystem (Thompson et al. 2022). The analysis uses data from the Groundfish Synoptic Bottom Trawl Research surveys in Queen Charlotte Sound, Hecate Strait, West Coast Vancouver Island, and West Coast Haida Gwaii from 2003 to 2019. Cartilaginous and bony fish species caught in DFO groundfish surveys that were present in at least 15% of all trawls over the depth range in which they were caught were included. This depth range was defined as that which included 95% of all trawls in which that species was present. The final dataset used in our analysis consisted of 57 species (Table S1 in Thompson et al. 2022).

The spatiotemporal dynamics of the demersal fish community were modeled using the Hierarchical Modeling of Species Communities (HMSC) framework and package (Tikhonov et al. 2021) in R. This framework uses Bayesian inference to fit a multivariate hierarchical generalized mixed model. We modeled community dynamics using a hurdle model, which consists of two sub models: a presence-absence model and a biomass model that is conditional on presence. Our list of environmental covariates included bottom depth, bathymetric position index (BPI), mean summer tidal speed, substrate muddiness, substrate rockiness, whether the trawl was inside or outside of the ecosystem-based trawling footprint, and survey region (QCS & HS vs. WCVI & WCHG)), mean summer near-bottom temperature deviation, mean summer near-bottom dissolved oxygen deviation, mean summer cross-shore and along-shore current velocities near the seafloor, mean summer depth-integrated primary production, and local-scale commercial fishing effort.

Layers are provided for three community metrics: 1) species density/richness (# of species per area), 2) Hill-Shannon diversity, and 3) community biomass. All metrics should be interpreted as the value that would be expected in the catch from an average tow in the Groundfish Synoptic Bottom Trawl Research Surveys taken in a given 3 km grid cell. Species density (sometimes called species richness) should be interpreted as the number of the 57 species that would be caught in a trawl. Hill-Shannon diversity is a measure of diversity that gives greater weight to communities where biomass is spread equally across species. Community biomass is the total biomass across all 57 species that would be expected to be caught per square km in an average tow. Our analysis excludes species that are rarely caught in the research trawls and so our estimates would not include the occurrence or biomass of these rare species (see Thompson et al. 2022 for details).

All layers are provided at a 3 km resolution across the study domain for the period of 2003 to 2019. For each metric, we provide layers for three summary statistics: 1) the mean value in each grid cell for the period of 2003 to 2019, 2) the probability that the grid cell is a hotspot for that metric, and 3) the temporal coefficient of variation (i.e., standard deviation/mean) across all years from 2003 to 2019.

The hotspot probability is the proportion of posterior draws of the model that are greater than the threshold. This threshold is defined as the 80th percentile of the metric based on all mean values across all 3 km grid cells in the study domain. This is 15.4 for species density, 13.3 for Hill-Shannon diversity and 1400 kg/km2 for community biomass.

**Data Sources:**

Research data was provided by Pacific Science's Groundfish Data Unit for research surveys from the GFBio database between 2003 and 2019 that occurred in four regions: Queen Charlotte Sound, Hecate Strait, West Coast Haida Gwaii, and West Coast Vancouver Island. Rare species removed.
Commercial fishing data was accessed through a DFO R script detailed here: https://github.com/pbs-assess/gfdata. Local scale commercial fishing effort was calculated from this data.
The substrate layers were obtained from a substrate model (Gregr et al. 2021).
The oceanographic layers (bottom temperature, dissolved oxygen, tidal and circulation speeds, primary production) were obtained from a hindcast simulation of the British Columbia continental margin (BCCM) model (Peña et al. 2019).

**Scripts or Software Routines:** Code available from https://gitlab.com/dfo-msea/groundfish-multispecies-model, see Thompson et al. 2022 for details.

**Spatial Data Quality:** These analyses rely upon the quality of data collected by Groundfish Synoptic Bottom Research Trawl Surveys conducted by Fisheries and Oceans Canada (DFO) for stock assessment research. This data is collected by survey grade GPS in the field and is deemed to be reliable. Spatial data quality is also dependent on the quality of the environmental covariates and on the ability of the model to accurately estimate the spatial distribution of species.

The spatial scale of our environmental data were chosen to align with the spatial resolution of the trawl surveys and the time of year in which the surveys are conducted. However, it is likely that mismatches in the spatial scales of our fixed effects and the relevant ecological processes may have limited our ability to assess their influence on the community. Despite these caveats and limitations, our model should be well suited to capturing how the community is structured in space and how it is changing through time.

**Positional Accuracy:** Layers are provided at a 3 kilometer resolution.

**Attribute Accuracy:** NA

**Logical Consistency:** The model should provide a reliable estimate of the overall spatial and temporal patterns that are the focus of this inference.

**Completeness:** The dataset is complete in the four regions of study: Queen Charlotte Sound, Hecate Strait, West Coast Vancouver Island, and West Coast Haida Gwaii.

**Absence Data:** No Absence Data

**Uncertainties:** Species that are not well sampled by the trawl surveys may not be accurately estimated by our model. The model did not include spatiotemporal random effects, which likely underestimates spatiotemporal variability in the region. It is also important to underline covariate uncertainty and model uncertainty. The hotspot estimates provide one measure of model uncertainty/certainty.

**Use Restrictions:** Data is restricted to DFO Science for spatial analysis only.

**Temporal Coverage:** The surveys are conducted between May and September in 4 regions: Queen Charlotte Sound (QCS), Hecate Straight (HS), West Coast Haida Gwaii (WCHG), and West Coast Vancouver Island (WCVI). Sampling was conducted in odd years since 2003 in QCS and 2005 in HS. QCS was also sampled in 2004. Sampling was conducted in even years starting in 2004 in WCVI and 2006 in WCHG. WCHG was also sampled in 2007. This analysis includes all survey years until 2019.

**Species Data:**

| Code and Name | Age Data | Obs Type |
|---|---|---|
| 602 - ATHERESTHES STOMIAS (ARROWTOOTH FLOUNDER) | False | Targeted |
| 056 - BERINGRAJA BINOCULATA (BIG SKATE) | False | Targeted |
| 233 - LYCODES CORTEZIANUS (BIGFIN EELPOUT) | False | Targeted |
| 245 - LYCODES PACIFICUS (BLACKBELLY EELPOUT) | False | Targeted |
| 435 - SEBASTES PAUCISPINIS (BOCACCIO) | False | Targeted |
| 038 - APRISTURUS BRUNNEUS (BROWN CAT SHARK) | False | Targeted |
| 619 - ISOPSETTA ISOLEPIS (BUTTER SOLE) | False | Targeted |

| Code and Name | Age Data | Obs Type |
|---|---|---|
| 437 - SEBASTES PINNIGER (CANARY ROCKFISH) | False | Targeted |
| 635 - PLEURONICHTHYS DECURRENS (CURLFIN SOLE) | False | Targeted |
| 410 - SEBASTES CRAMERI (DARKBLOTCHED ROCKFISH) | False | Targeted |
| 605 - EMBASSICHTHYS BATHYBIUS (DEEPSEA SOLE) | False | Targeted |
| 626 - MICROSTOMUS PACIFICUS (DOVER SOLE) | False | Targeted |
| 628 - PAROPHRYS VETULUS (ENGLISH SOLE) | False | Targeted |
| 148 - THALEICHTHYS PACIFICUS (EULACHON) | False | Targeted |
| 612 - HIPPOGLOSSOIDES ELASSODON (FLATHEAD SOLE) | False | Targeted |
| 256 - ALBATROSSIA PECTORALIS (GIANT GRENADIER) | False | Targeted |
| 414 - SEBASTES ELONGATUS (GREENSTRIPED ROCKFISH) | False | Targeted |
| 461 - HEXAGRAMMOS DECAGRAMMUS (KELP GREENLING) | False | Targeted |
| 467 - OPHIODON ELONGATUS (LINGCOD) | False | Targeted |
| 059 - RAJA RHINA (LONGNOSE SKATE) | False | Targeted |
| 453 - SEBASTOLOBUS ALTIVELIS (LONGSPINE THORNYHEAD) | False | Targeted |
| 044 - SQUALUS SUCKLEYI (NORTH PACIFIC SPINY DOGFISH) | False | Targeted |
| 222 - GADUS MACROCEPHALUS (PACIFIC COD) | False | Targeted |
| 220 - ANTIMORA MICROLEPIS (PACIFIC FLATNOSE) | False | Targeted |
| 251 - CORYPHAENOIDES ACROLEPIS (PACIFIC GRENADIER) | False | Targeted |
| 225 - MERLUCCIUS PRODUCTUS (PACIFIC HAKE) | False | Targeted |
| 614 - HIPPOGLOSSUS STENOLEPIS (PACIFIC HALIBUT) | False | Targeted |
| 096 - CLUPEA PALLASII (PACIFIC HERRING) | False | Targeted |
| 396 - SEBASTES ALUTUS (PACIFIC OCEAN PERCH) | False | Targeted |
| 361 - AMMODYTES PERSONATUS (PACIFIC SAND LANCE) | False | Targeted |

| Code and Name | Age Data | Obs Type |
|---|---|---|
| 596 - CITHARICHTHYS SORDIDUS (PACIFIC SANDDAB) | False | Targeted |
| 226 - MICROGADUS PROXIMUS (PACIFIC TOMCOD) | False | Targeted |
| 607 - EOPSETTA JORDANI (PETRALE SOLE) | False | Targeted |
| 250 - CORYPHAENOIDES CINEREUS (POPEYE) | False | Targeted |
| 424 - SEBASTES MALIGER (QUILLBACK ROCKFISH) | False | Targeted |
| 401 - SEBASTES BABCOCKI (REDBANDED ROCKFISH) | False | Targeted |
| 439 - SEBASTES PRORIGER (REDSTRIPE ROCKFISH) | False | Targeted |
| 610 - GLYPTOCEPHALUS ZACHIRUS (REX SOLE) | False | Targeted |
| 421 - SEBASTES HELVOMACULATUS (ROSETHORN ROCKFISH) | False | Targeted |
| 009 - SEBASTES ALEUTIANUS (ROUGHEYE ROCKFISH) | False | Targeted |
| 455 - ANOPLOPOMA FIMBRIA (SABLEFISH) | False | Targeted |
| 636 - PSETTICHTHYS MELANOSTICTUS (SAND SOLE) | False | Targeted |
| 450 - SEBASTES ZACENTRUS (SHARPCHIN ROCKFISH) | False | Targeted |
| 403 - SEBASTES BOREALIS (SHORTRAKER ROCKFISH) | False | Targeted |
| 451 - SEBASTOLOBUS ALASCANUS (SHORTSPINE THORNYHEAD) | False | Targeted |
| 405 - SEBASTES BREVISPINIS (SILVERGRAY ROCKFISH) | False | Targeted |
| 625 - LYOPSETTA EXILIS (SLENDER SOLE) | False | Targeted |
| 621 - LEPIDOPSETTA BILINEATA (SOUTHERN ROCK SOLE) | False | Targeted |
| 412 - SEBASTES DIPLOPROA (SPLITNOSE ROCKFISH) | False | Targeted |
| 066 - HYDROLAGUS COLLIEI (SPOTTED RATFISH) | False | Targeted |
| 550 - PODOTHECUS ACCIPENSERINUS (STURGEON POACHER) | False | Targeted |

| Code and Name | Age Data | Obs Type |
|---|---|---|
| 235 - BOTHROCARA BRUNNEUM (TWOLINE EELPOUT) | False | Targeted |
| 228 - GADUS CHALCOGRAMMUS (WALLEYE POLLOCK) | False | Targeted |
| 442 - SEBASTES RUBERRIMUS (YELLOWEYE ROCKFISH) | False | Targeted |
| 440 - SEBASTES REEDI (YELLOWMOUTH ROCKFISH) | False | Targeted |
| 418 - SEBASTES FLAVIDUS (YELLOWTAIL ROCKFISH) | False | Targeted |

**References:**

Thompson P. L., S. C. Anderson, J. Nephin, D.R. Haggarty, M.A. Peña, P.A. English, K.S.P. Gale, and E. Rubidge (2022). Disentangling the impacts of environmental change and commercial fishing on demersal fish biodiversity in a northeast Pacific ecosystem. Marine Ecology Progress Series. DOI:10.3354/meps14034.

Gregr, E. J., D. R. Haggarty, S. C. Davies, C. Fields and J. Lessard. (2021). Comprehensive Marine Substrate Classification Applied to Canada's Pacific Shelf. PLoS ONE 16:e0259156.

Peña, M. A., I. Fine and W. Callendar (2019). Interannual Variability in Primary Production and Shelf-Offshore Transport of Nutrients Along the Northeast Pacific Ocean Margin. Deep Sea Research Part II: Topical Studies in Oceanography 169–170:104637.

**Collaboration:** No collaboration outside of DFO.

**Confidentiality:** Not Protected