

Habitat scale model outputs Port Fourchon, LA during Fall 2022

Website: <https://www.bco-dmo.org/dataset/948167>

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Project

» [CAREER: Integrating Seascapes and Energy Flow: learning and teaching about energy, biodiversity, and ecosystem function on the frontlines of climate change](#) (Louisiana E-scapes)

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Abstract

This dataset and code form part of a broader analysis aimed at evaluating the relationship between habitat structure and species abundance across multiple spatial scales in a rapidly changing estuarine environment near Port Fourchon, Louisiana. Specifically, the code implements a Generalized Additive Modeling (GAM) approach to identify the optimal spatial scale at which habitat features—derived from satellite imagery—best explain the abundance of common estuarine species observed during the Fall 2022 drop sampling season. The data processing pipeline begins by merging species count data and environmental variables (salinity, temperature, site coordinates) with spatial habitat metrics, including percent edge habitat, mangrove edge length, and land-water ratio. These metrics are calculated at varying spatial scales, defined by buffer radii (20–600 m) and edge distances (1, 3, 5 m). The GAMs iteratively test combinations of predictors while excluding highly correlated variables to reduce multicollinearity. Models are ranked by Akaike Information Criterion (AIC), and the best models are selected based on performance across scales. The outputs include: AIC scores for all tested models across scales. Identification of the top model explaining white shrimp abundance. Evaluation of individual predictor significance and spatial autocorrelation in residuals. The results indicate that the relationship between habitat structure and estuarine species is often scale-dependent, with percent edge habitat and mangrove edge length emerging as significant predictors at specific scales. Outputs are saved in CSV files for model summaries and GAM diagnostics, while visualizations illustrate R^2 values across spatial scales, predictor significance, and observed vs. predicted species abundance. This pipeline provides a quantitative framework for identifying ecologically relevant spatial scales and assessing the effects of habitat change, such as mangrove encroachment, on species distributions. The findings contribute to a broader effort to model species-habitat relationships in coastal systems and inform management strategies in the face of climate-driven habitat change.

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Coverage

Location: Marshes surrounding Port Fourchon, Louisiana.

Spatial Extent: N:29.164671 E:-90.149744 S:29.092646 W:-90.269831

Temporal Extent: 2022-09-23 - 2022-09-29

Methods & Sampling

No raw data is included in this dataset. For collection methods of data used in this analysis, please refer to methods outlined in the linked datasets.

Data Processing Description

The data processing pipeline for this analysis begins with the preparation of input datasets, which include habitat data derived from satellite imagery and community composition data. The habitat data files, such as *google2022_edge[edge]_buf[buffer].csv*, contain spatial metrics including mangrove edge length, land-water ratios, and percent edge cover. The community composition data, *PtFouSept2022count_ns.csv*, provides site-specific counts for the target species (eg. *Litopenaeus setiferus*, abbreviated as PENSET) along with environmental variables like salinity, temperature, and geographic coordinates. These datasets are merged using a common identifier (*site_date_key*) to align spatial and ecological information.

Once merged, all predictor variables, such as % *mangrove edge* and % *land-water ratio*, are standardized by subtracting the mean and dividing by the standard deviation to ensure consistent scaling. A correlation matrix is computed to identify and exclude highly correlated predictor pairs (correlation > 0.8) to reduce multicollinearity in subsequent models. The core modeling process is conducted by the *model_compile* function, which iterates over combinations of buffer radii (100–600 m or *satscale*, 20–150 for *smallscale*) and edge distances (1, 3, 5 m) to assess species-habitat relationships. For each combination, spatial metrics are calculated, and generalized additive models (GAMs) are fitted using subsets of predictors. Knots for all GAM models were limited to $k=4$ to try and limit over fitting. Models with correlated variables are excluded, and the remaining models are ranked by Akaike Information Criterion (AIC). The best models within two AIC points of the top model are recorded, capturing their formula, AIC, buffer, and edge values.

The top model is then identified based on its frequency of selection across all scales and is saved for further analysis. Using this top model, the *univariate_edge* function evaluates individual predictor performance across scales. Residuals are examined for spatial autocorrelation using Moran's I test, and the significance of predictors, including their interactions (e.g., mangrove edge × land-water ratio), is assessed. These results are consolidated and saved in *outputs_over_scales.csv*.

Visualization and diagnostics follow, with R^2 values plotted across buffer sizes and edge distances to identify the habitat scale with the strongest explanatory power. Key predictors, such as mangrove edge and percent edge cover, are visualized in relation to species abundance, with significance indicated by custom point shapes (determined using threshold of $p < 0.05$). At the best scale, relationships between key variables and predicted species abundance are visualized, while residual and diagnostic plots (e.g., Cook's distance) are used to assess model fit. Predictions from the top model are compared to observed counts to validate performance.

The final outputs of this pipeline include several CSV files and visualizations. The *output_over_scales.csv* file summarizes model results across scales, including R^2 values, p-values, and significant predictors. The *species_aic.csv* file captures AIC scores for all tested models, and *topmodel.txt* records the formula of the top-selected model. Visualizations include plots of R^2 across scales and relationships between predictors and species abundance, as well as diagnostic plots for residuals and influential observations. This comprehensive pipeline rigorously evaluates the influence of spatial metrics on species abundance, identifying the optimal habitat scale for common in Port Fourchon, LA.

This analysis was performed in R version 4.3.2. Relevant packages in this analysis are as follows:

mgcv_1.9-0, *nlme_3.1-163*, *gam_1.22-4*, *foreach_1.5.2*, *spdep_1.3-5*, *sf_1.0-16*, *spData_2.3.1*, *lubridate_1.9.3*, *forcats_1.0.0*, *stringr_1.5.1*, *dplyr_1.1.4*, *purrr_1.0.2*, *readr_2.1.4*, *tidyr_1.3.0*, *tibble_3.2.1*, *ggplot2_3.5.1*, *tidyverse_2.0.0*, *scales_1.3.0*, *statmod_1.5.0*, *pscl_1.5.9*

loaded via a namespace (and not attached): *gtable_0.3.4*, *lattice_0.21-9*, *tzdb_0.4.0*, *vctr_0.6.5*, *tools_4.3.2*, *generics_0.1.3*, *proxy_0.4-27*, *fansi_1.0.5*, *pkgconfig_2.0.3*, *Matrix_1.6-1.1*, *KernSmooth_2.23-22*, *lifecycle_1.0.4*, *compiler_4.3.2*, *farver_2.1.1*, *deldir_2.0-4*, *munsell_0.5.0*, *codetools_0.2-19*, *class_7.3-22*, *pillar_1.9.0*, *crayon_1.5.2*, *MASS_7.3-60*, *classInt_0.4-10*, *wk_0.9.1*, *iterators_1.0.14*, *boot_1.3-28.1*, *tidyselect_1.2.1*, *stringi_1.8.2*, *labeling_0.4.3*, *grid_4.3.2*, *colorspace_2.1-0*, *cli_3.6.1*, *magrittr_2.0.3*, *utf8_1.2.4*, *e1071_1.7-14*, *withr_3.0.2*, *sp_2.1-3*, *timechange_0.2.0*, *hms_1.1.3*, *viridisLite_0.4.2*, *s2_1.1.6*, *rlang_1.1.2*, *Rcpp_1.0.11*, *glue_1.6.2*, *DBI_1.1.3*, *rstudioapi_0.15.0*, *R6_2.5.1*, *units_0.8-5*

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Parameters

Parameters for this dataset have not yet been identified

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Project Information

CAREER: Integrating Seascapes and Energy Flow: learning and teaching about energy, biodiversity, and ecosystem function on the frontlines of climate change (Louisiana E-scapes)

Website: <http://www.nelsonecolab.net/career>

Coverage: Saltmarsh ecosystem near Port Fourchon, LA

NSF Award Abstract:

Coastal marshes provide a suite of vital functions that support natural and human communities. Humans frequently take for granted and exploit these ecosystem services without fully understanding the ecological feedbacks, linkages, and interdependencies of these processes to the wider ecosystem. As demands on coastal ecosystem services have risen, marshes have experienced substantial loss due to direct and indirect impacts from human activity. The rapidly changing coastal ecosystems of Louisiana provide a natural experiment for understanding how coastal change alters ecosystem function. This project is developing new metrics and tools to assess food web variability and test hypotheses on biodiversity and ecosystem function in coastal Louisiana. The research is determining how changing habitat configuration alters the distribution of energy across the seascape in a multitrophic system. This work is engaging students from the University of Louisiana Lafayette and Dillard University in place-based learning by immersing them in the research and local restoration efforts to address land loss and preserve critical ecosystem services. Students are developing a deeper understanding of the complex issues facing coastal regions through formal course work, directed field work, and outreach. Students are interacting with stakeholders and managers who are currently battling coastal change. Their directed research projects are documenting changes in coastal habitat and coupling this knowledge with the consequences to ecosystems and the people who depend on them. By participating in the project students are emerging with knowledge and training that is making them into informed citizens and capable stewards of the future of our coastal ecosystems, while also preparing them for careers in STEM. The project is supporting two graduate students and a post-doc.

The transformation and movement of energy through a food web are key links between biodiversity and ecosystem function. A major hurdle to testing biodiversity ecosystem function theory is a limited ability to assess food web variability in space and time. This research is quantifying changing seascape structure, species diversity, and food web structure to better understand the relationship between biodiversity and energy flow through ecosystems. The project uses cutting edge tools and metrics to test hypotheses on how the distribution, abundance, and diversity of key species are altered by ecosystem change and how this affects function. The hypotheses driving the research are: 1) habitat is a more important indirect driver of trophic structure than a direct change to primary trophic pathways; and 2) horizontal and vertical diversity increases with habitat resource index. Stable isotope analysis is characterizing energy flow through the food web. Changes in horizontal and vertical diversity in a multitrophic system are being quantified using aerial surveys and field sampling. To assess the spatial and temporal change in food web resources, the project is combining results from stable isotope analysis and drone-based remote sensing technology to generate consumer specific energetic seascape maps (E-scapes) and trophic niche metrics. In combination these new metrics are providing insight into species' responses to changing food web function across the seascape and through time.

This project is jointly funded by Biological Oceanography and the Established Program to Stimulate Competitive Research (EPSCoR).

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using

the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2418012

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