

Modeling At-Sea Density of Marine Birds to Support Atlantic Marine Renewable Energy Planning

Final Report



US Department of the Interior
Bureau of Ocean Energy Management
Office of Renewable Energy Programs



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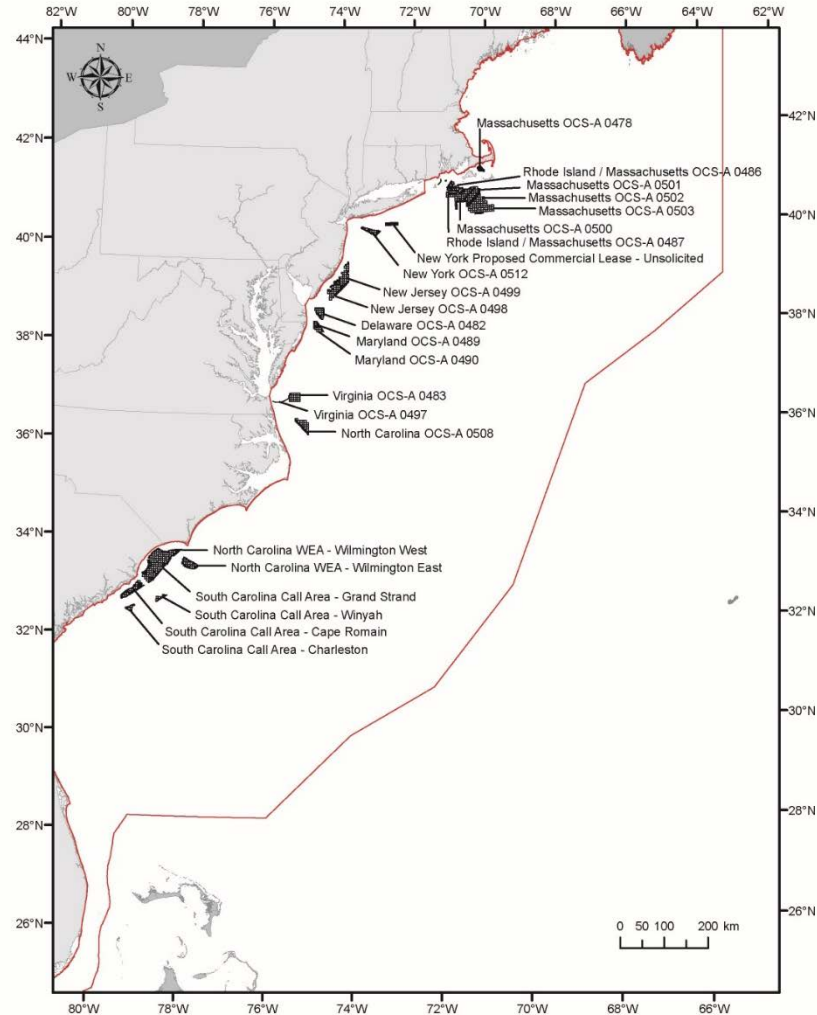
coastalscience.noaa.gov

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Atlantic offshore wind energy and marine birds



At-sea survey data

- Northwest Atlantic Seabird Catalog & Eastern Canada Seabirds at Sea
- Boat-based & aerial surveys
- Visual & digital video counts
- Strip transects
- Segmentation
- 47 species

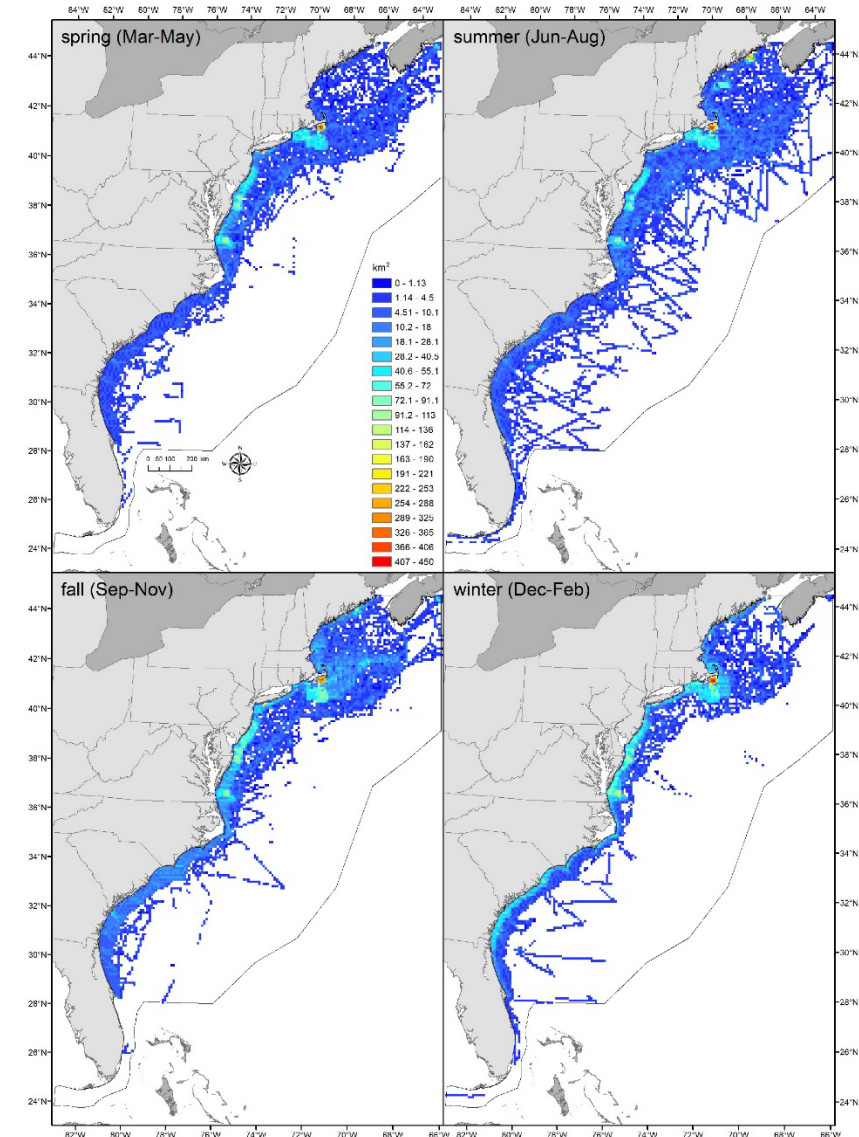


Figure 3. Total area surveyed each season within the study area, binned into 10 x 10 km cells. White areas represent no survey effort. See Appendix A for maps of individual survey effort.

At-sea survey data

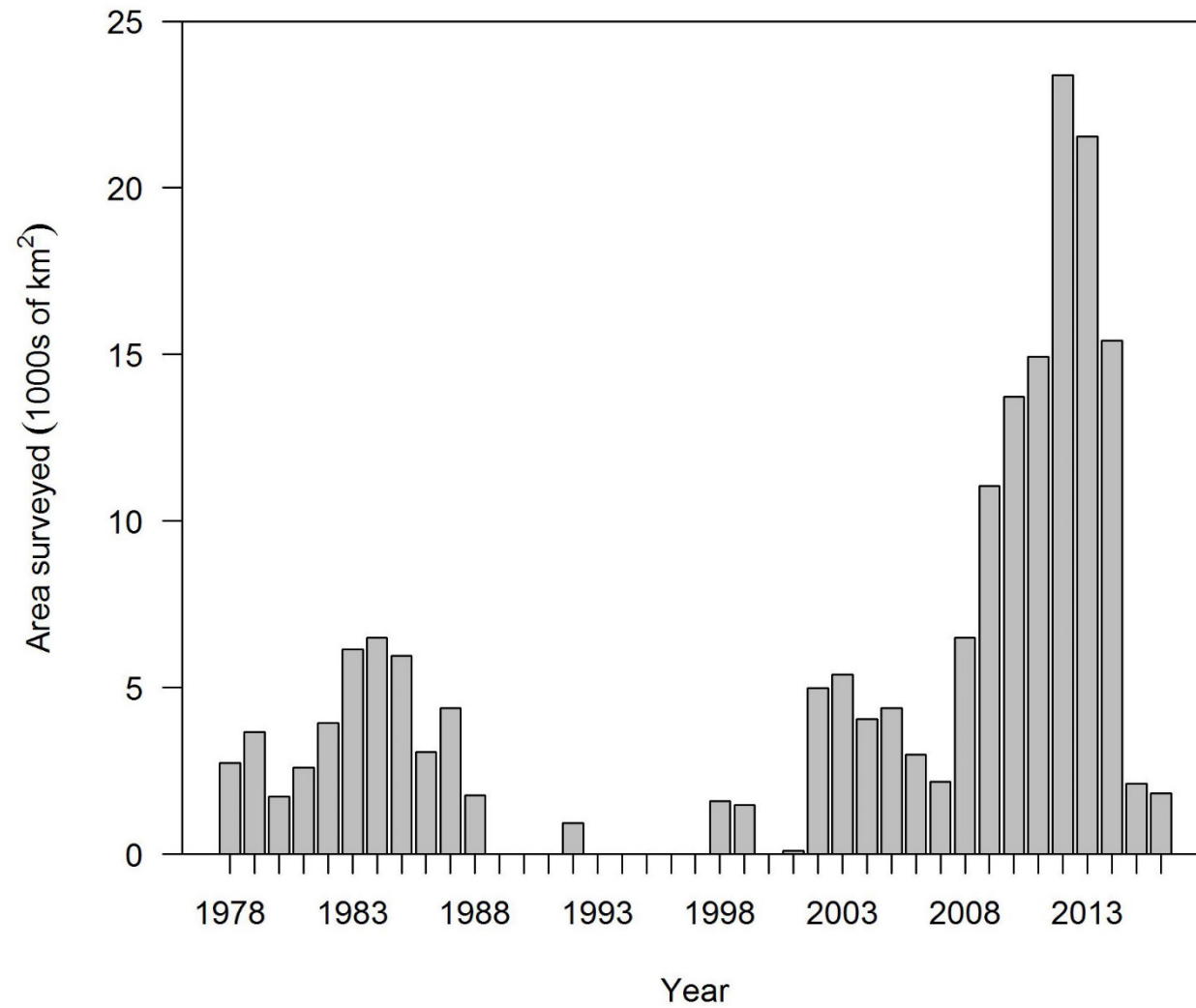
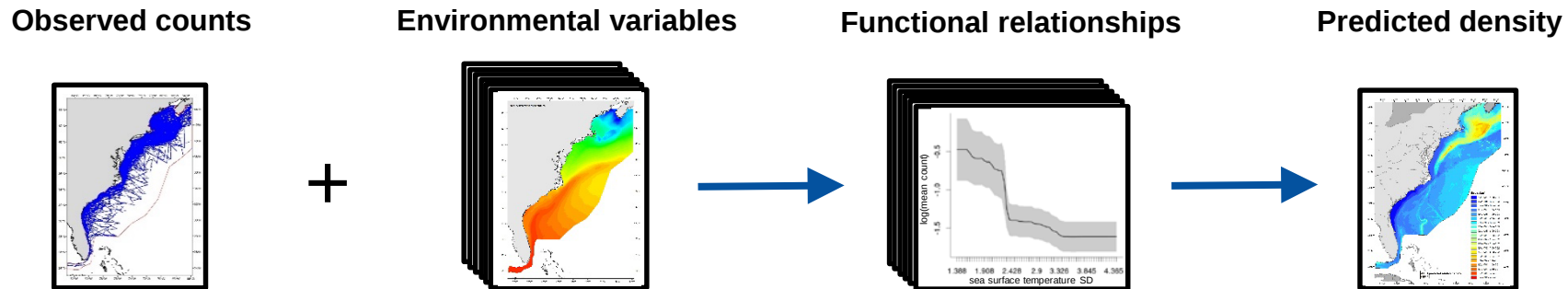


Figure 2. Area surveyed by year.

Spatial predictive modeling

- Survey coverage variable with gaps
- Comprehensive environmental datasets available
- Relate species counts to environmental variables
- Predict density across entire region



Adapted from Figure 4. Schematic overview of statistical modeling process.

Environmental predictor variables

Static (e.g., bathymetry)

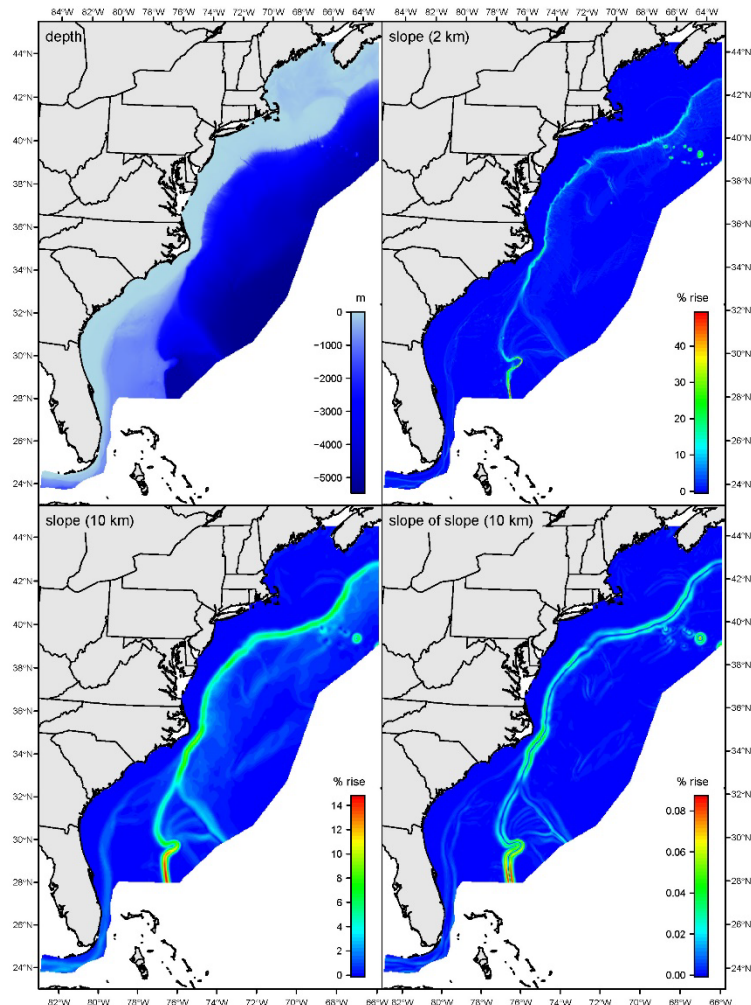


Figure B2. Predictor grids (2-km) for depth, slope (2-km and 10-km scales), and slope of slope (10-km scale). Data sources and details are listed in Table 3.

Dynamic (e.g., sea surface temperature)

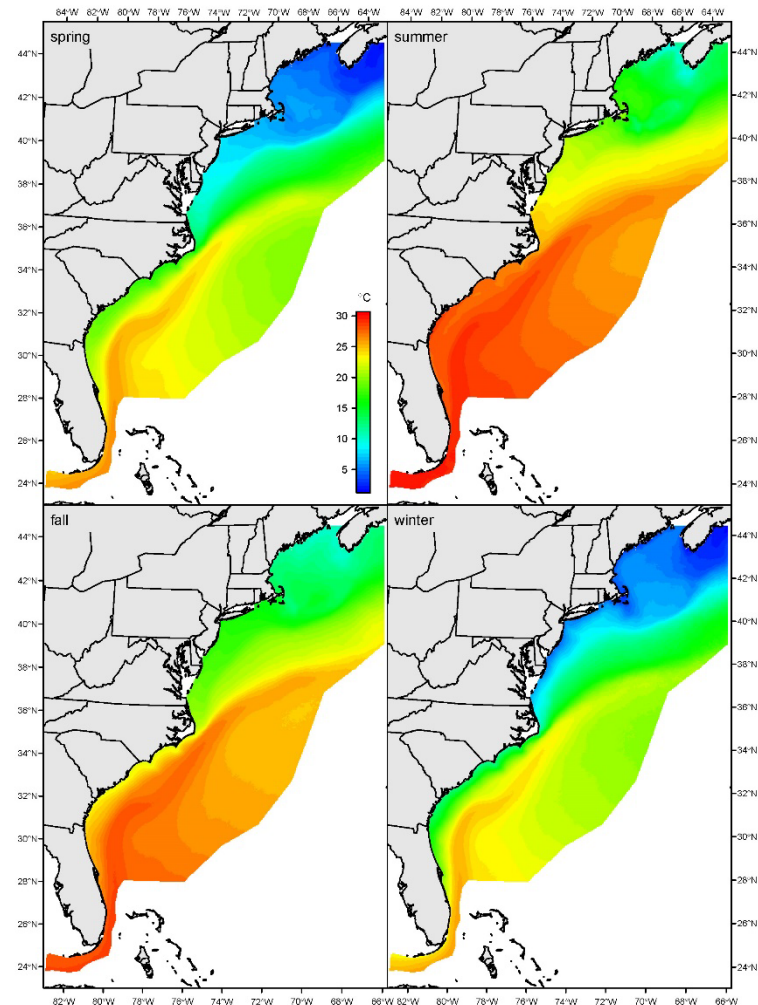


Figure B13. Seasonal predictor climatologies (2-km) for sea surface temperature. Data sources and details are listed in Table 3.

Spatial predictive modeling

- Boosted generalized additive models
- Zero-inflated likelihoods
- Effects of survey platform and transect
- Cross-validation to prevent over-fitting
- Bootstrapping to quantify uncertainty
- Model performance and selection



Species maps: relative density

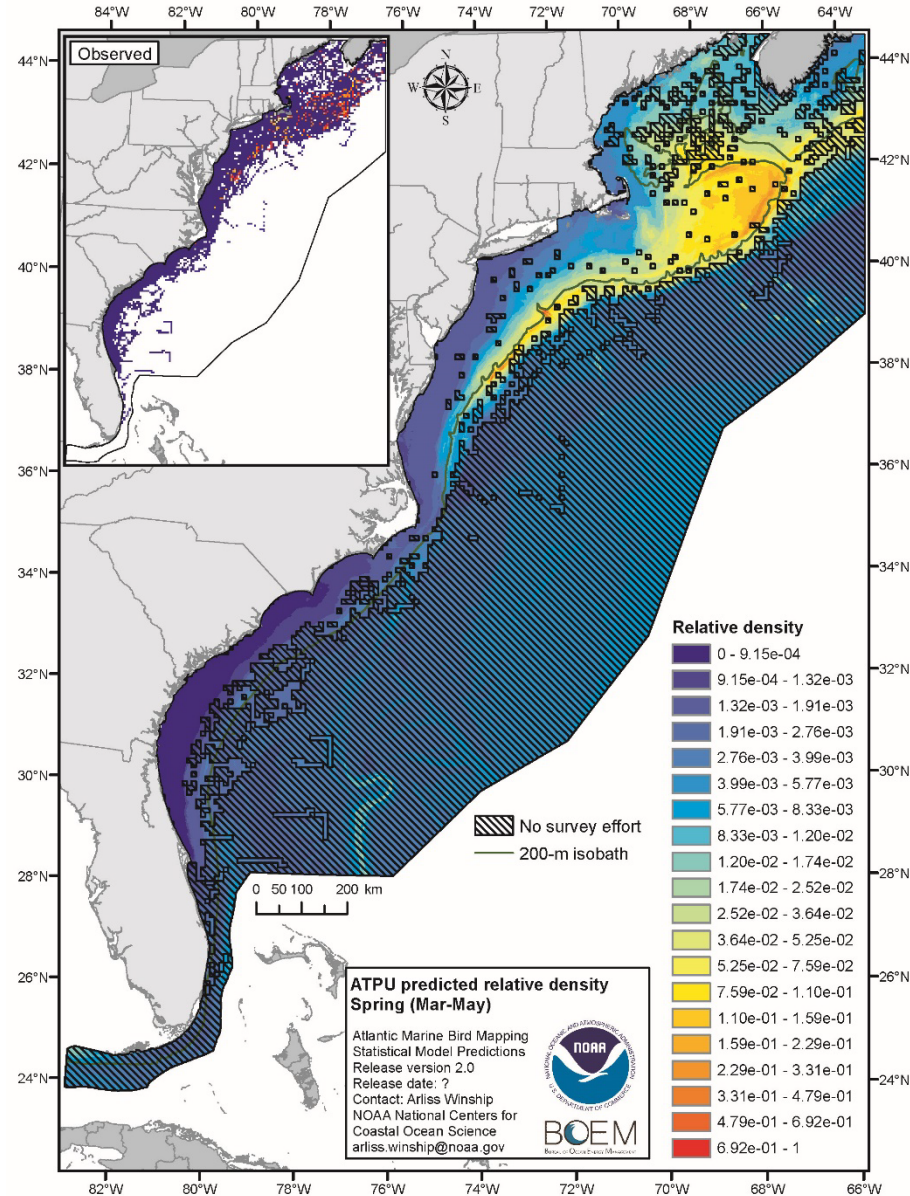


Figure 5. Example map of predicted relative density for one species (Atlantic Puffin) and season (spring).

Species maps: CV

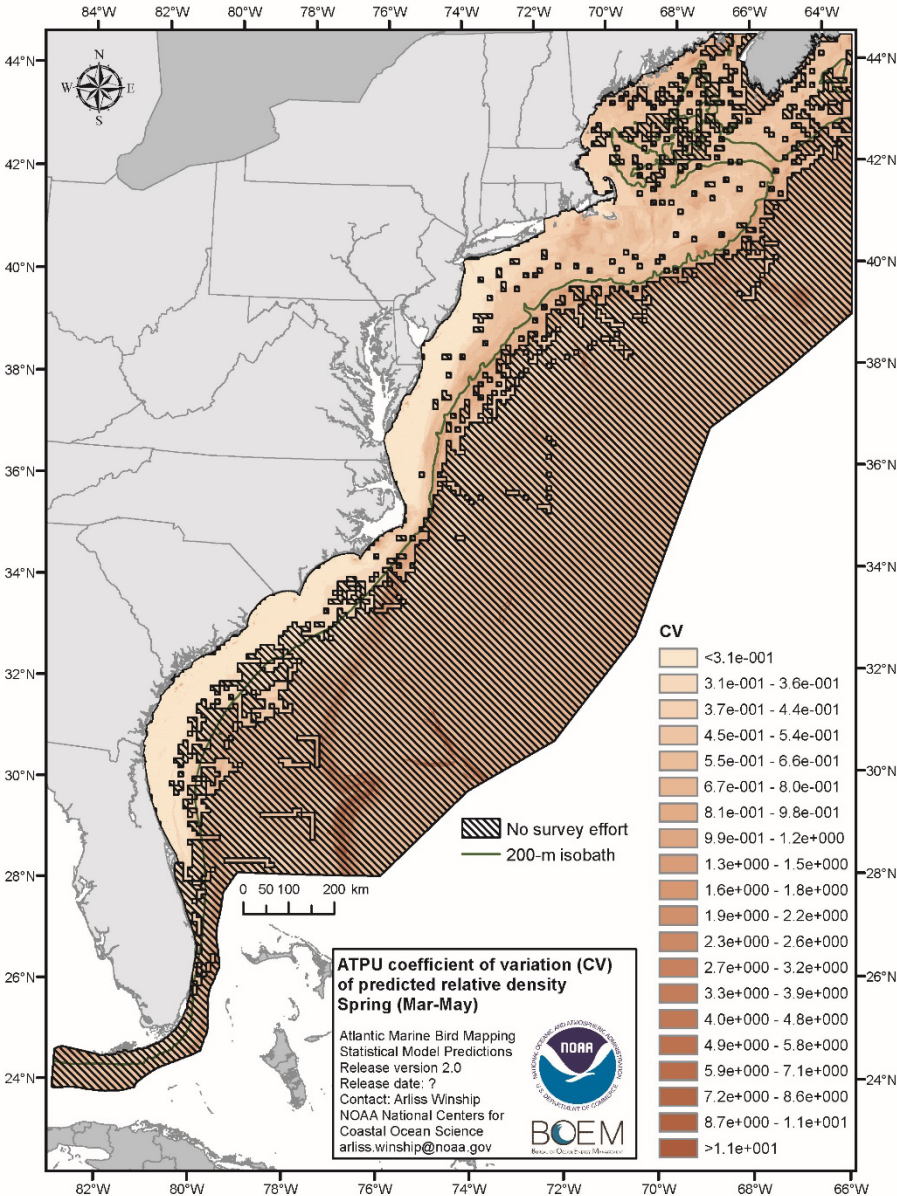
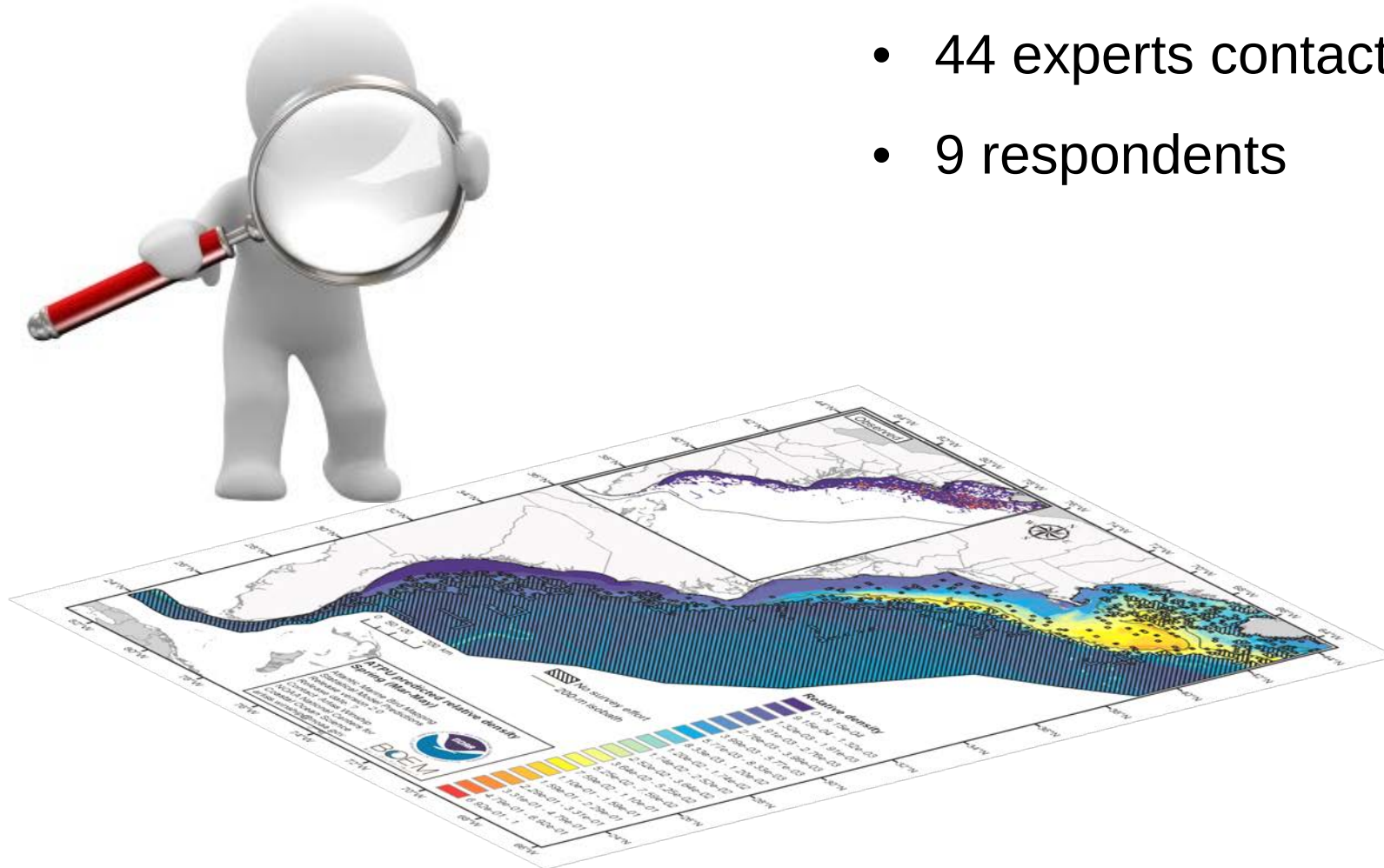


Figure 5. Example map of coefficient of variation (CV) for one species (Atlantic Puffin) and season (spring).

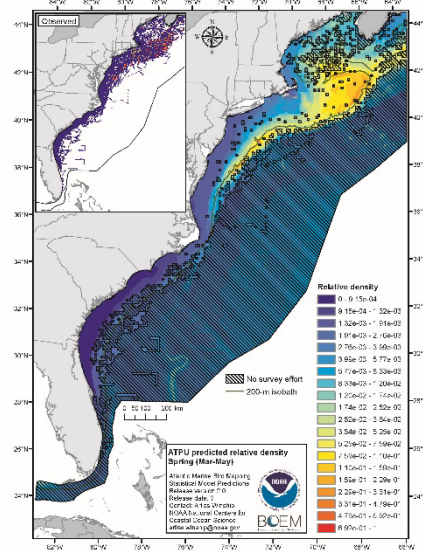
Expert review of maps

- 44 experts contacted
- 9 respondents

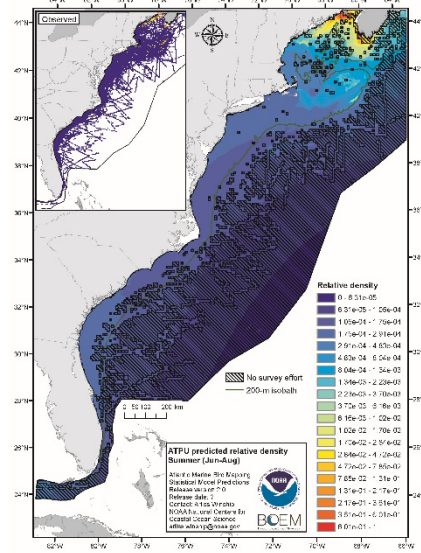


Combining seasonal maps: annual

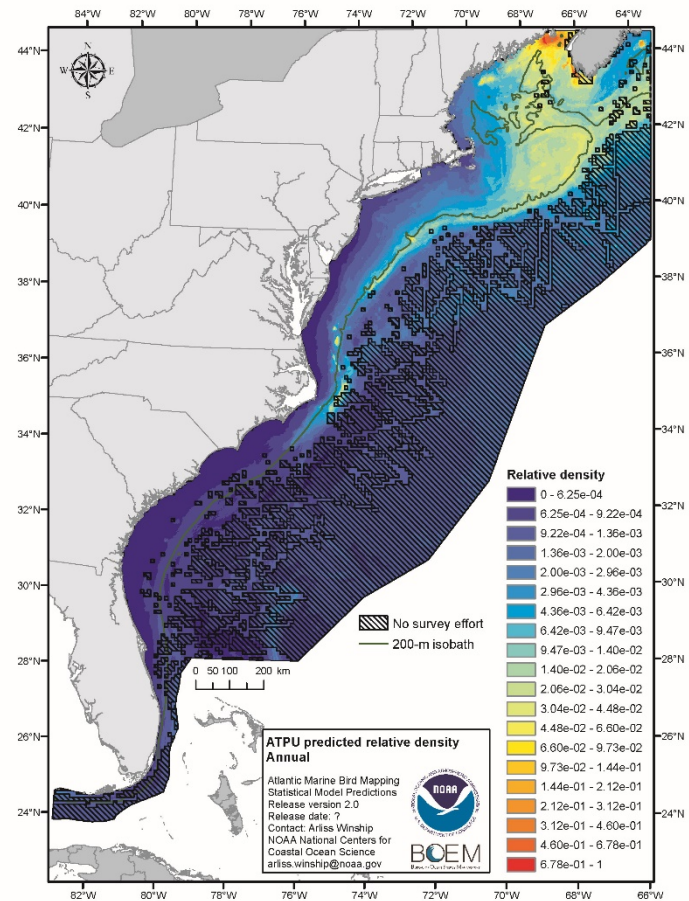
spring



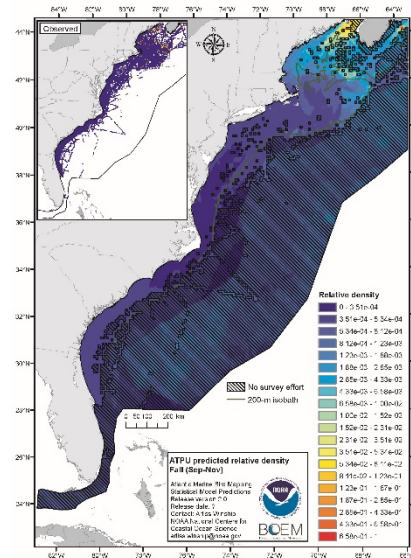
summer



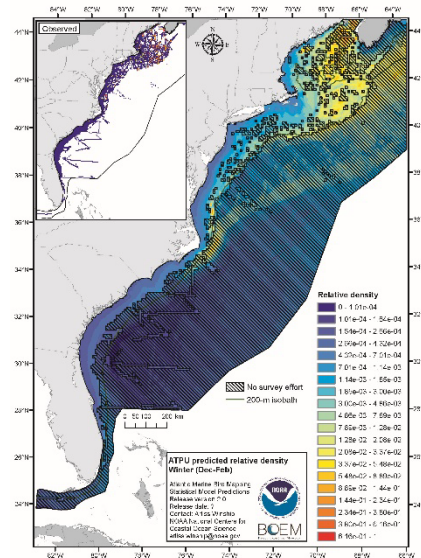
annual



fall



winter



Combining seasonal maps: multi-species



Photo: Peter Massas



Photo: Don Faulkner



Photo: Peter Massas

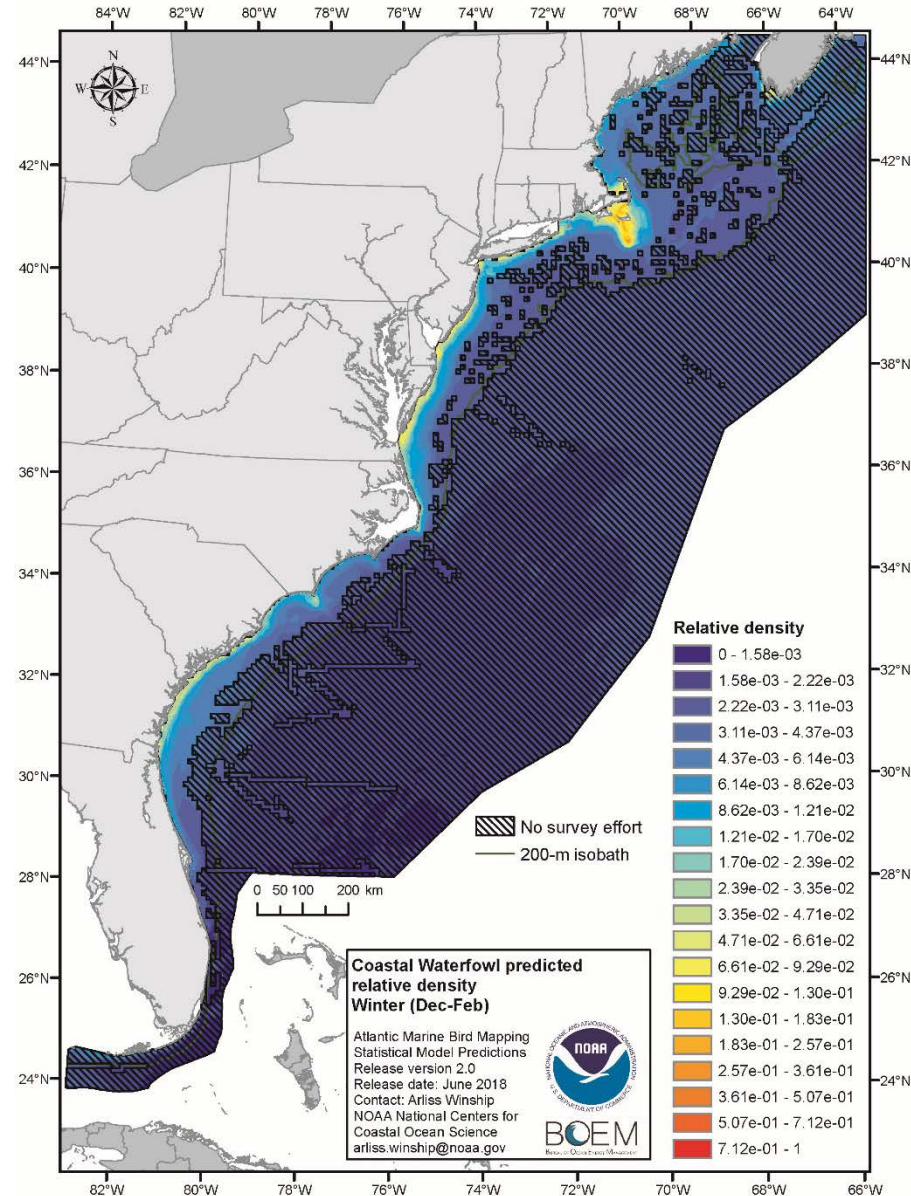


Photo: Emily Willoughby

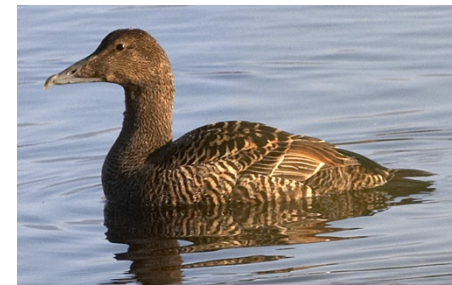


Photo: Wikipedia

Figure 8. Example map of predicted relative density for Coastal Waterfowl species group during winter. Coastal Waterfowl included Black Scoter, Common Eider, Common Loon, Long-tailed Duck, Red-throated Loon, Surf Scoter, and White-winged Scoter.

Predictor variable importance

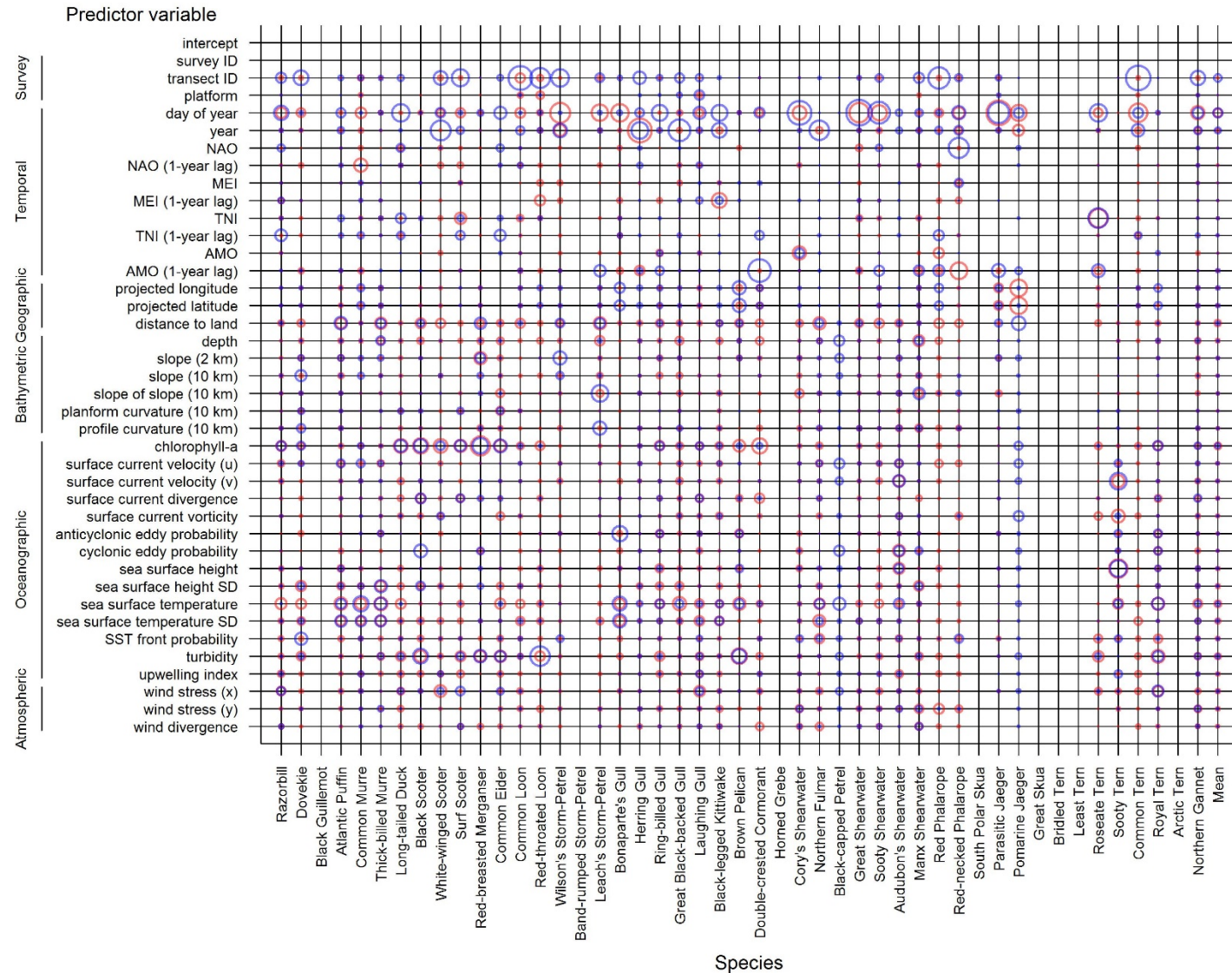


Figure 6a. Relative importance of predictor variables for p (red) and μ (blue) components of best spring (March-May) models. Areas of circles are proportional to importance.

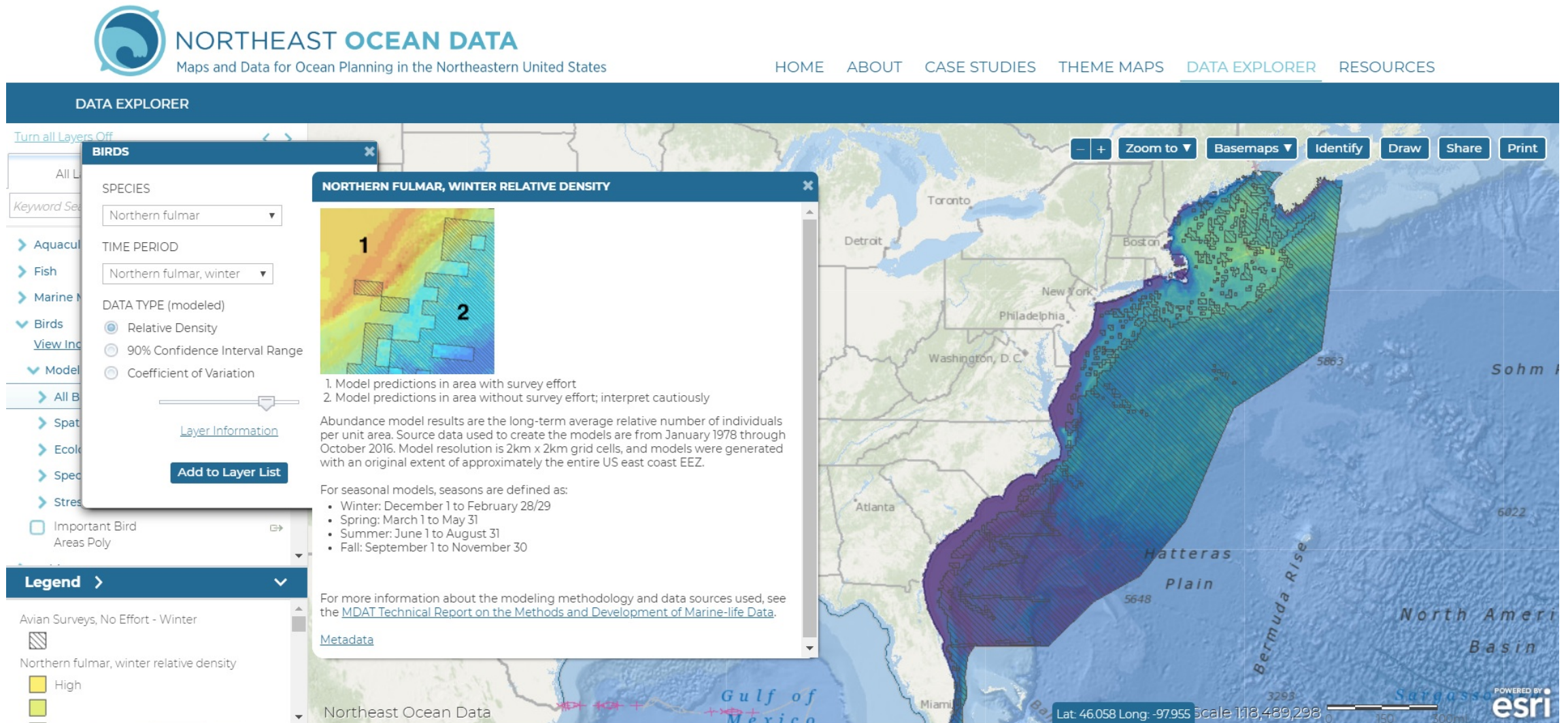
Applications

- BOEM: call areas, NEPA analyses, EISs, and ESA consultations
- Northeast Ocean Plan & Mid-Atlantic Ocean Action Plan
(Marine-life Data Analysis Team)

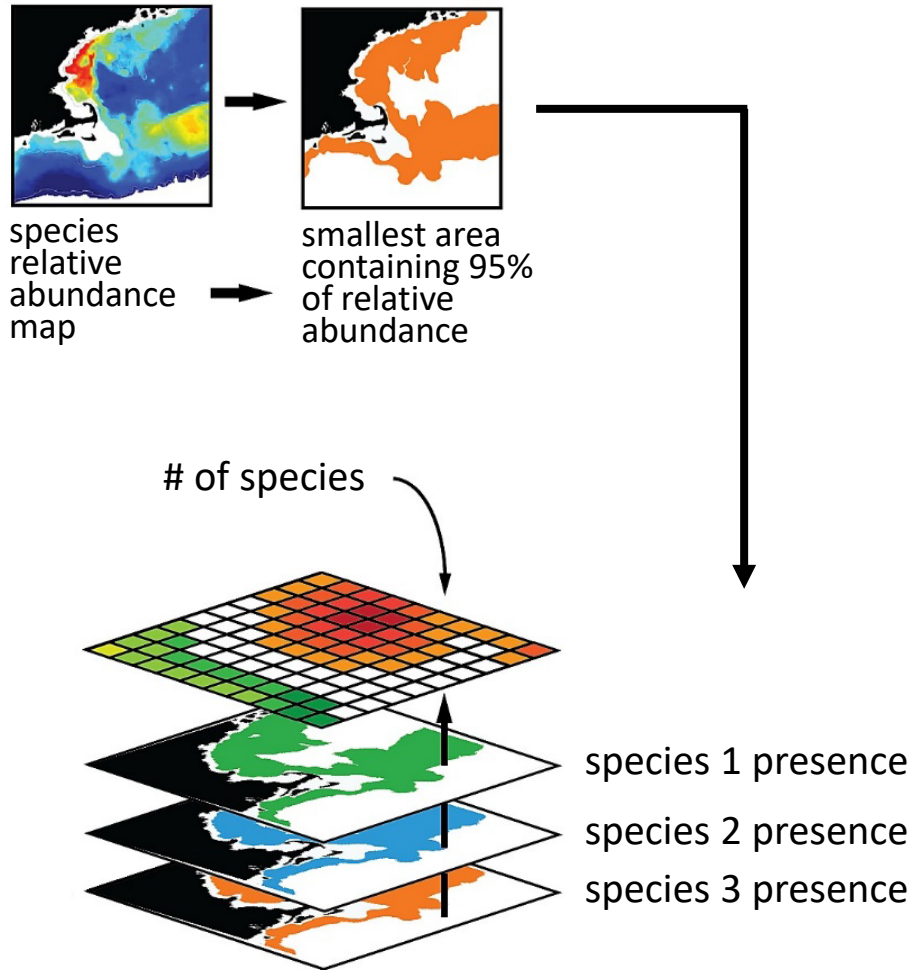


Regional Ocean Data Portals

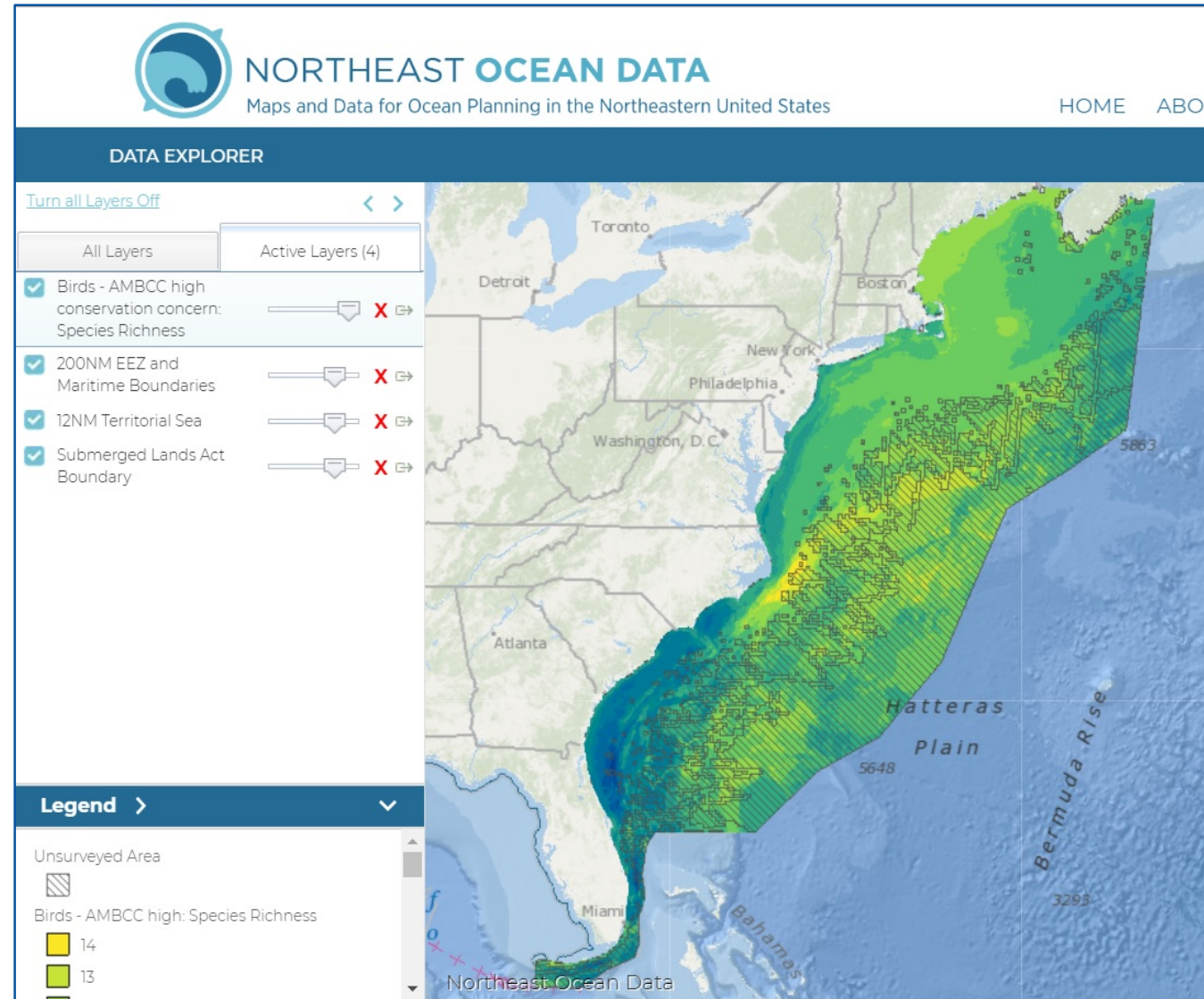
Northeast Ocean Data - <https://www.northeastoceandata.org/data-explorer/>



Species Richness



Conservation priority species group (AMBC high concern)



Thank you very much for your time!



<https://coastalscience.noaa.gov/project/statistical-modeling-marine-bird-distributions/>



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