The SECAS Third Thursday Web Forum

Predicting the distribution and biodiversity of deep-sea corals at regional scales using hierarchical community occupancy models

3-21-2024

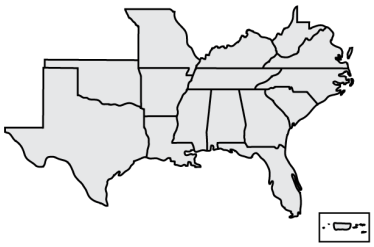
Agenda

- Introduction
- Monthly topic
- Q&A and discussion
- Preview of next webinar
- Staff updates

Predicting the distribution and biodiversity of deep-sea corals at regional scales using hierarchical community occupancy models

Matt Poti, NOAA National Centers for Coastal Ocean Science

3-21-2024



Next Third Thursday Web Forum

4-18-2024

10:00 am ET

Patrick Bixler, University of Texas

Shawn Johnson, University of Montana

Collaborative complexity in the Southeast: A Blueprint for regional interorganizational capacity

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Predicting the Distribution and Biodiversity of Deep-Sea Corals at Regional Scales using Hierarchical Community Occupancy Models

Matthew Poti[1], Holly F. Goyert[2], Arliss Winship[2], Enrique J. Salgado[2], Rachel Bassett[2], Janessy Frometa[2], Michael Coyne[2], Thomas F. Hourigan[3], Heather Coleman[3]

1. NOAA, NOS, National Centers for Coastal Ocean Science (NCCOS)
2. CSS, Inc. under contract to NOAA NCCOS
3. NOAA, NMFS, Deep Sea Coral Research and Technology Program

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BOEM Bureau of Ocean Energy Management

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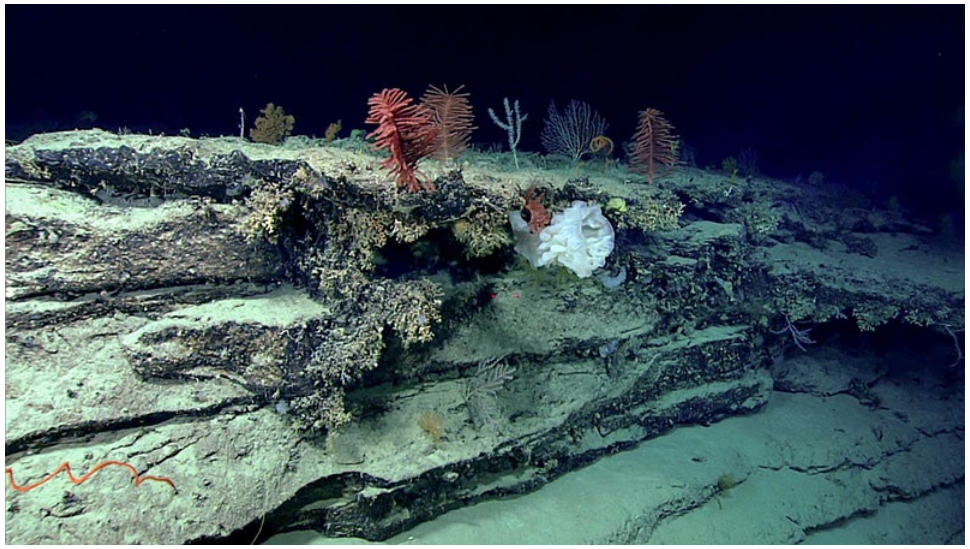
Background

- Deep-sea corals (DSCs) can form complex 3-D structures that increase local biodiversity by providing microhabitats for other organisms

Credit: NOAA OER

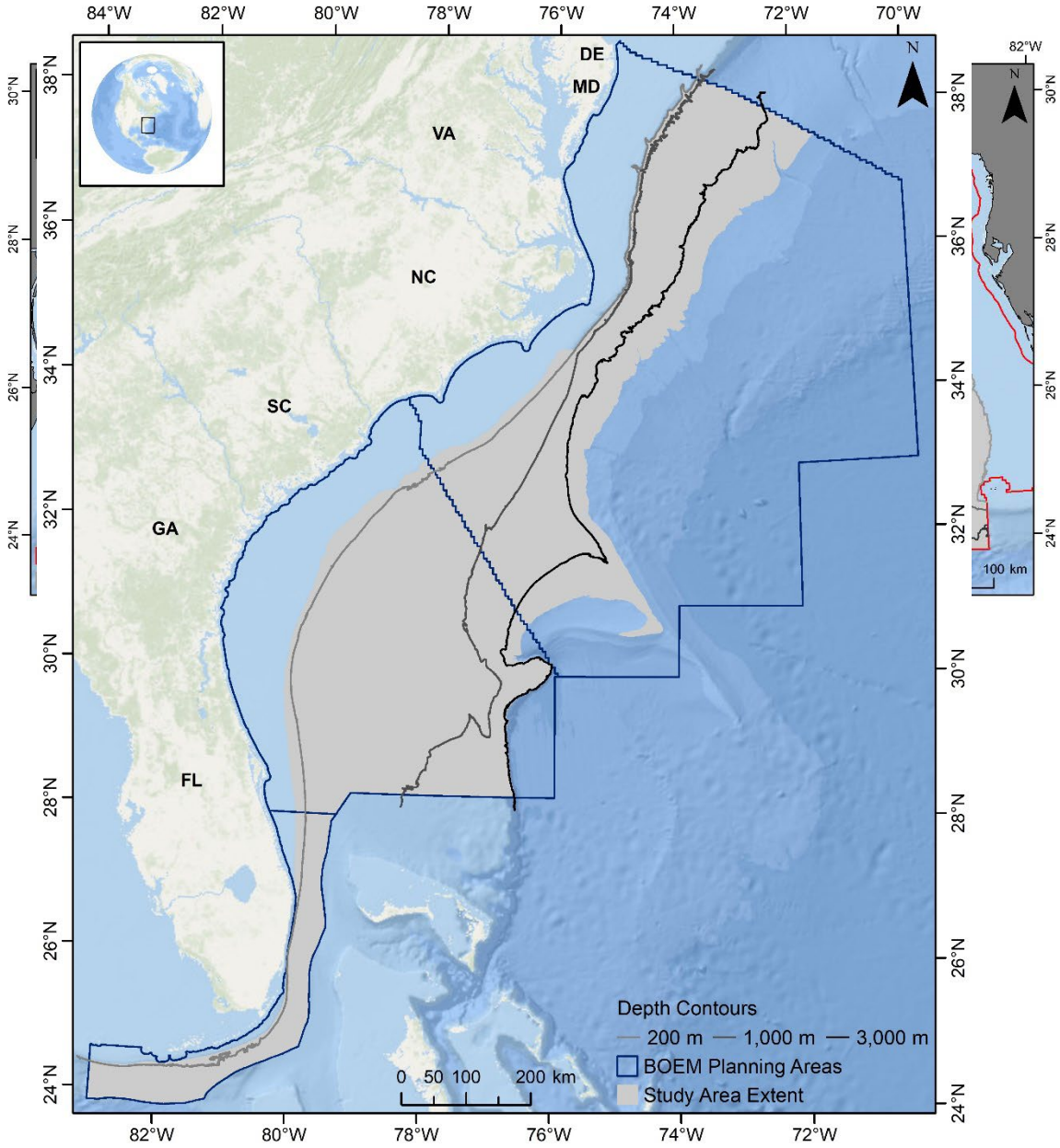
- Exposed hard substrate provides surface for attachment of sessile invertebrates and may be associated with increased diversity and abundance of large fish



Credit: NOAA OER

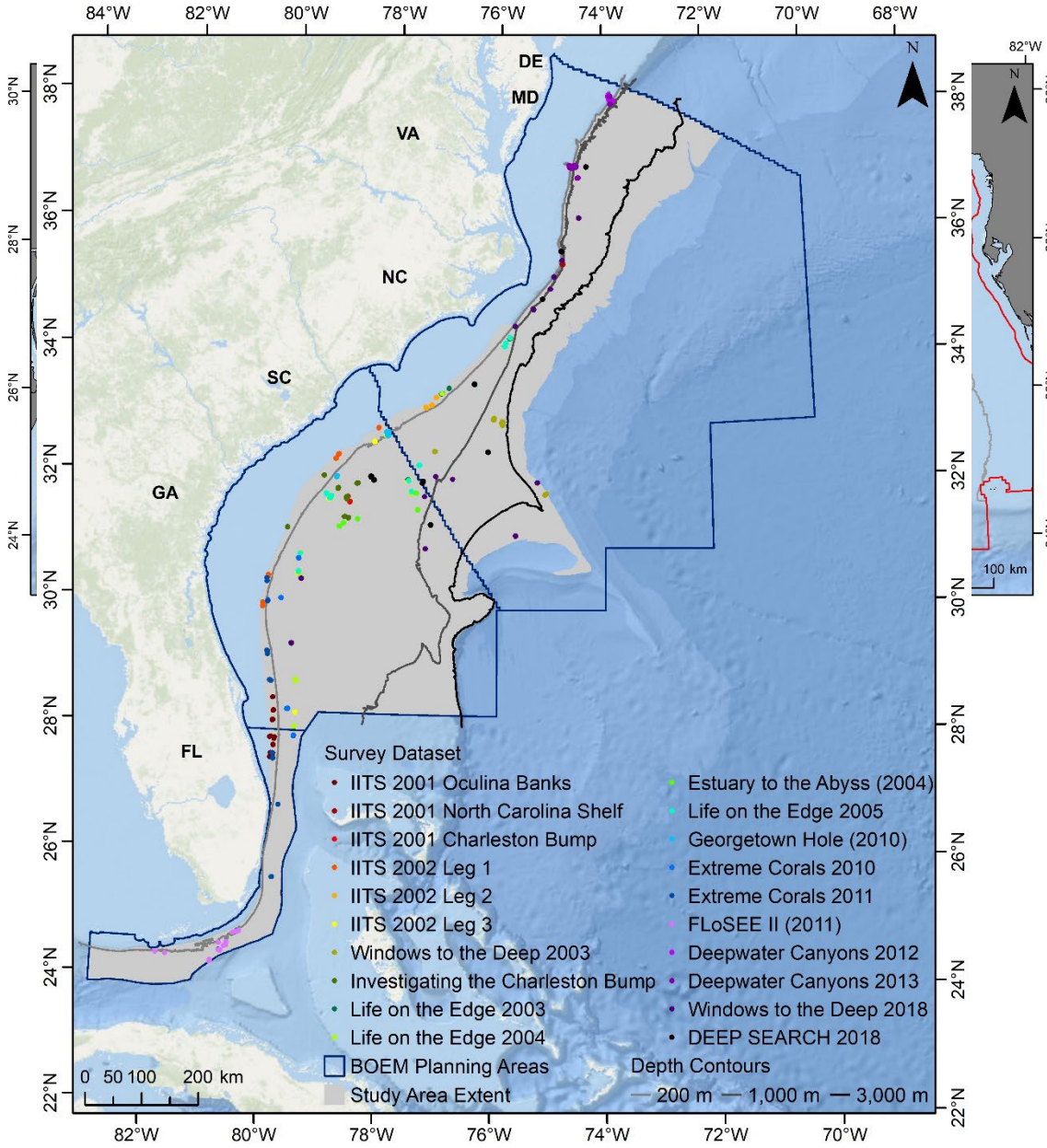
Background

- Activities related to development of offshore energy and mineral resources may physically disturb seafloor
- BOEM identified need for information on spatial distributions of sensitive benthic habitats in the Gulf of Mexico and offshore of southeastern US



Why Predictive Models?

- Although considerable research and exploration has been done, much of the region is still unmapped and unexplored
- Field surveys in the deep sea are logistically difficult and expensive
- Models can provide comprehensive maps to inform:
  - siting, environmental assessment for offshore activities
  - conservation, restoration
  - selection of targets for mapping and exploration



Predictive Models

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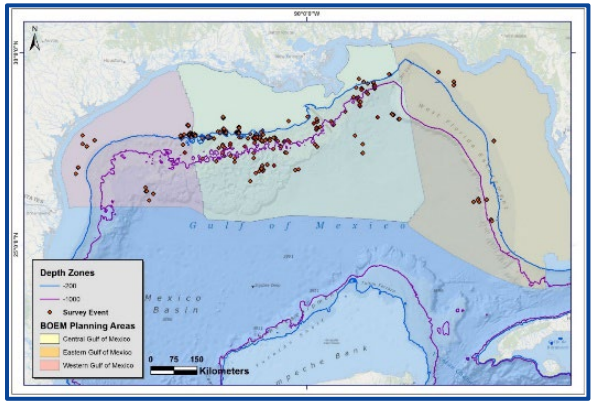
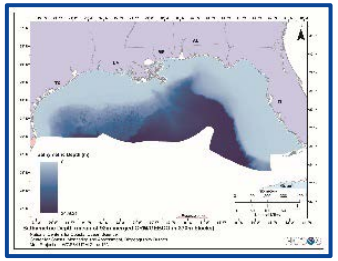
Observed occurrence

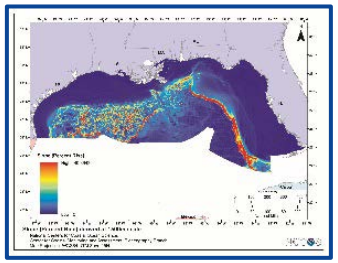


+

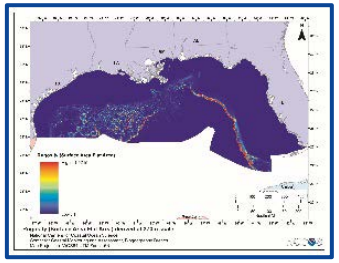
Environmental variables



Depth



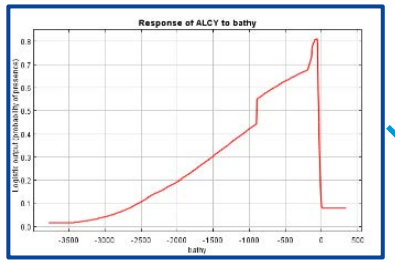
Slope



Rugosity

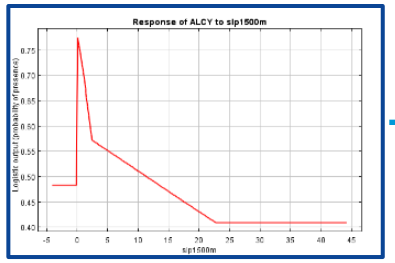
Functional relationships

Occurrence



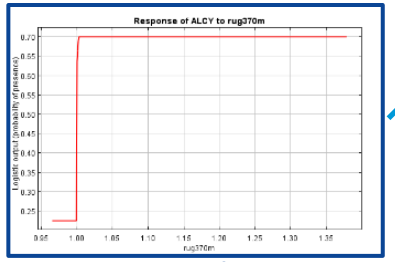
Depth

Occurrence



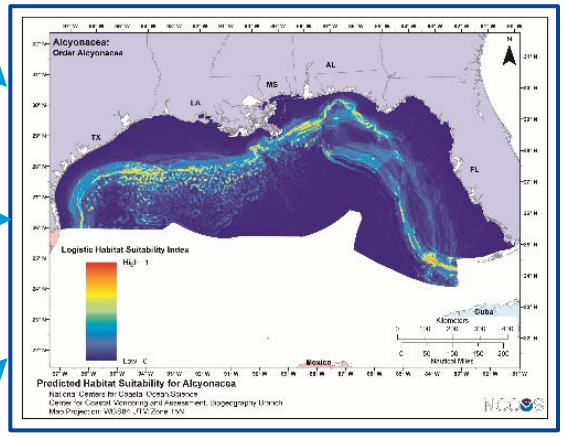
Slope

Occurrence



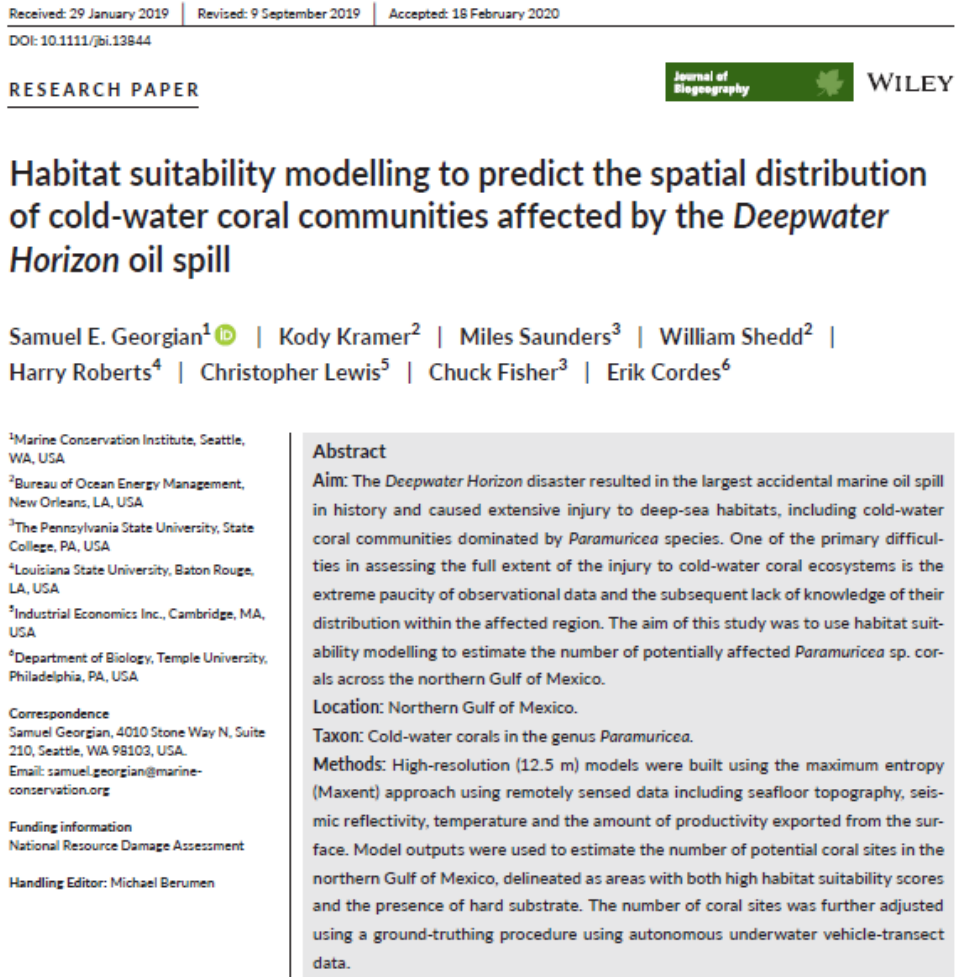
Rugosity

Predicted occurrence



Existing Predictive Models (GoMex)

- NCCOS regional scale models for 1 species and 2 genera of structure-forming stony corals, several other groups of DSCs
- Georgian et al. (2014) – model for *Lophelia pertusa* in northern Gulf of Mexico
- Silva and MacDonald (2017) – models for several taxa in northern Gulf of Mexico
- Georgian et al. (2020) – model for *Paramuricea* in northern Gulf of Mexico



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RESEARCH PAPER

Journal of Biogeography WILEY

Habitat suitability modelling to predict the spatial distribution of cold-water coral communities affected by the *Deepwater Horizon* oil spill

Samuel E. Georgian[1] | Kody Kramer[2] | Miles Saunders[3] | William Shedd[2] | Harry Roberts[4] | Christopher Lewis[5] | Chuck Fisher[3] | Erik Cordes[6]

[1]Marine Conservation Institute, Seattle, WA, USA
[2]Bureau of Ocean Energy Management, New Orleans, LA, USA
[3]The Pennsylvania State University, State College, PA, USA
[4]Louisiana State University, Baton Rouge, LA, USA
[5]Industrial Economics Inc., Cambridge, MA, USA
[6]Department of Biology, Temple University, Philadelphia, PA, USA

Correspondence
Samuel Georgian, 4010 Stone Way N, Suite 210, Seattle, WA 98103, USA.
Email: samuel.georgian@marine-conservation.org

Funding information
National Resource Damage Assessment

Handling Editor: Michael Berumen

Abstract

Aim: The *Deepwater Horizon* disaster resulted in the largest accidental marine oil spill in history and caused extensive injury to deep-sea habitats, including cold-water coral communities dominated by *Paramuricea* species. One of the primary difficulties in assessing the full extent of the injury to cold-water coral ecosystems is the extreme paucity of observational data and the subsequent lack of knowledge of their distribution within the affected region. The aim of this study was to use habitat suitability modelling to estimate the number of potentially affected *Paramuricea* sp. corals across the northern Gulf of Mexico.

Location: Northern Gulf of Mexico.

Taxon: Cold-water corals in the genus *Paramuricea*.

Methods: High-resolution (12.5 m) models were built using the maximum entropy (Maxent) approach using remotely sensed data including seafloor topography, seismic reflectivity, temperature and the amount of productivity exported from the surface. Model outputs were used to estimate the number of potential coral sites in the northern Gulf of Mexico, delineated as areas with both high habitat suitability scores and the presence of hard substrate. The number of coral sites was further adjusted using a ground-truthing procedure using autonomous underwater vehicle-transect data.

Existing Predictive Models (SE)

- Unpublished regional scale models for group of structure-forming stony corals by Davies
- NCCOS regional scale models for 3 species and 1 genus of structure-forming stony corals, several other groups of DSCs
- Mienis et al. (2014) – two regional scale models for *Lophelia pertusa*
- Gasbarro et al. (2022) – models for *Lophelia pertusa*, including climate-informed projections

Biogeosciences, 11, 2543–2560, 2014
www.biogeosciences.net/11/2543/2014/
doi:10.5194/bg-11-2543-2014

Biogeosciences Open Access

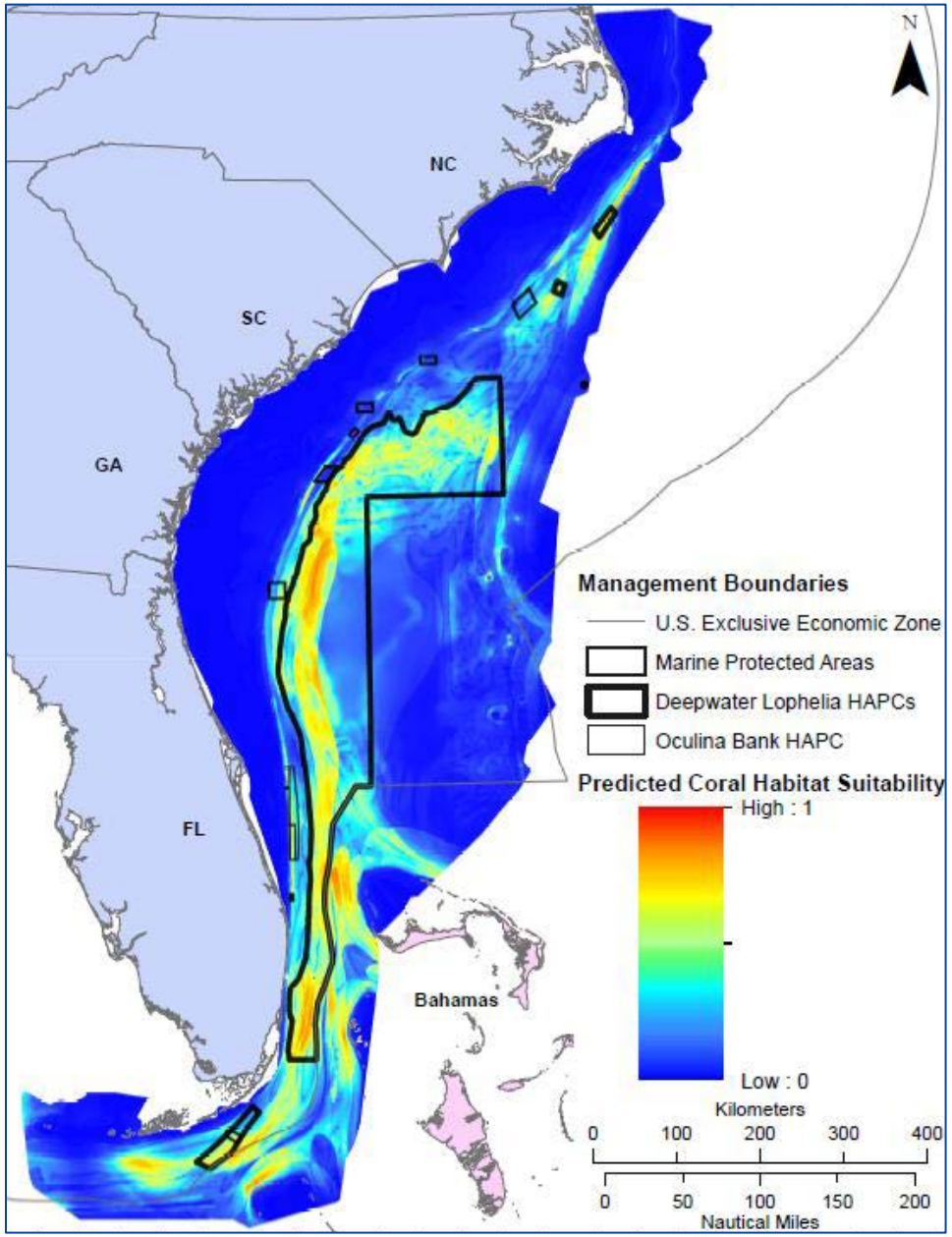
Cold-water coral growth under extreme environmental conditions, the Cape Lookout area, NW Atlantic

F. Mienis[1,2], G. C. A. Duineveld[3], A. J. Davies[4], M. M. S. Lavaleye[3], S. W. Ross[5], H. Seim[6], J. Bane[6], H. van Haren[7], M. J. N. Bergman[3], H. de Haas[1], S. Brooke[8], and T. C. E. van Weering[1]

[1]Royal Netherlands Institute for Sea Research, Department of Marine Geology, P.O. Box 59, 1790 AB Den Burg, the Netherlands
[2]MARUM, University of Bremen, Leobenerstrasse, 28253 Bremen, Germany
[3]Royal Netherlands Institute for Sea Research, Department of Marine Ecology, P.O. Box 59, 1790 AB Den Burg, the Netherlands
[4]School of Ocean Sciences, Bangor University, Isle of Anglesey, LL59 5AB, UK
[5]University of North Carolina-Wilmington, Center for Marine Science, 5600 Marvin Moss Lane, Wilmington, NC 28409, USA
[6]University of North Carolina-Chapel Hill, Department of Marine Sciences, 3202 Venable Hall, Chapel Hill, NC 27599-3300, USA
[7]Royal Netherlands Institute for Sea Research, Department of Physical Oceanography, P.O. Box 59, 1790 AB Den Burg, the Netherlands
[8]Florida State University Coastal and Marine Lab, 3618 Coastal Highway 98, St. Teresa, FL 32358, USA

Why *New* Predictive Models?

- Many of earlier models created for broad taxonomic groups that combined taxa with different habitat requirements
- Existing models were almost all presence-background models, fit using DSC presence data and randomly selected background locations rather than absence data



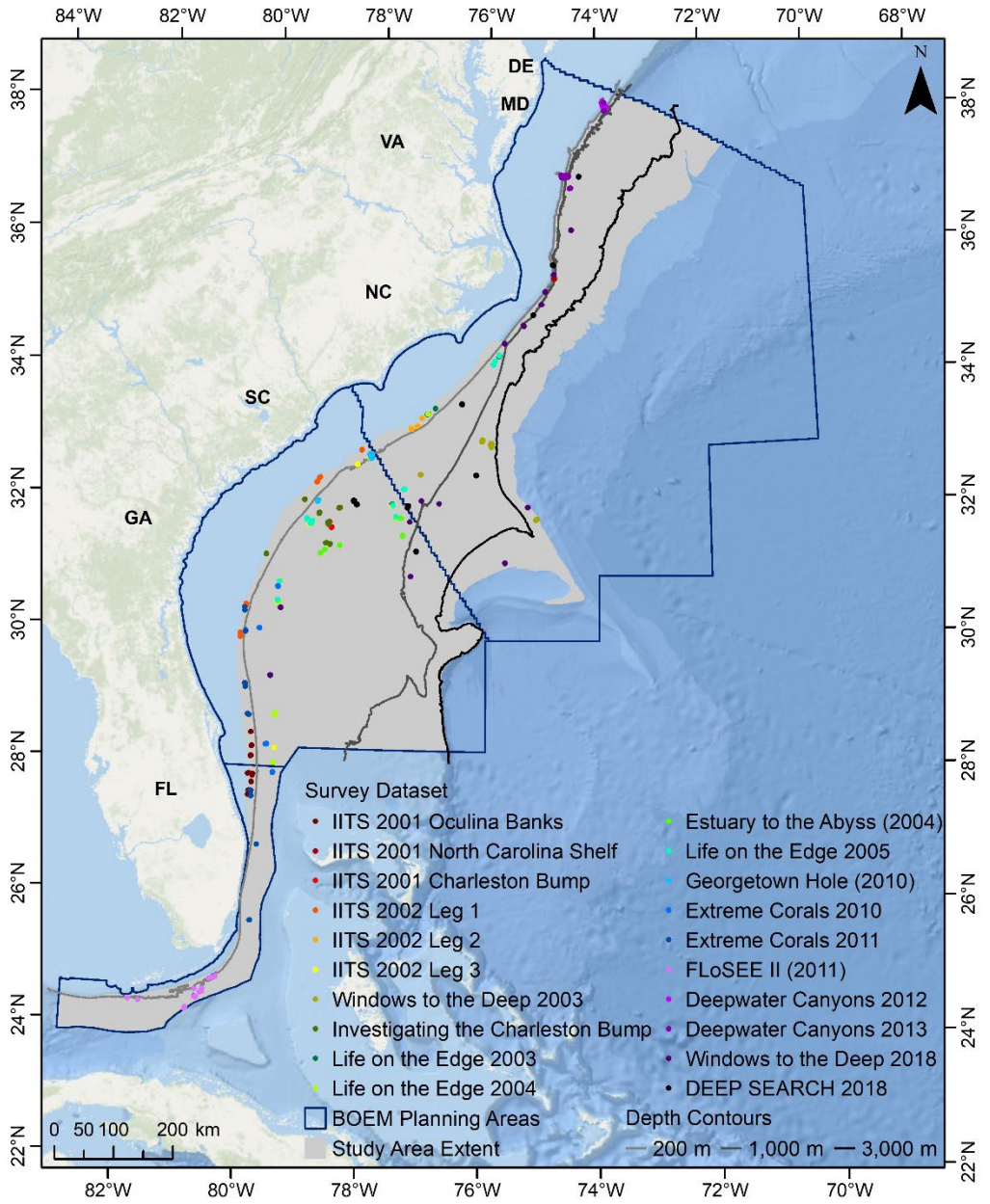
Objectives

- Data Synthesis: compile database of presence-absence records of DSC occurrence with associated measures of sampling effort and bottom type

- Predictive Modeling: develop predictive models that relate the occurrence of DSCs and hardbottom habitats to spatial environmental predictors in order to predict and map their potential spatial distributions across the study area

Methods (Data Synthesis)

- Inventory of available data from field surveys conducted by submersibles and ROVs used to compile a database of presence-absence records
- Each database record assigned a spatial position, estimate of survey area, DSCs observed, description of bottom type



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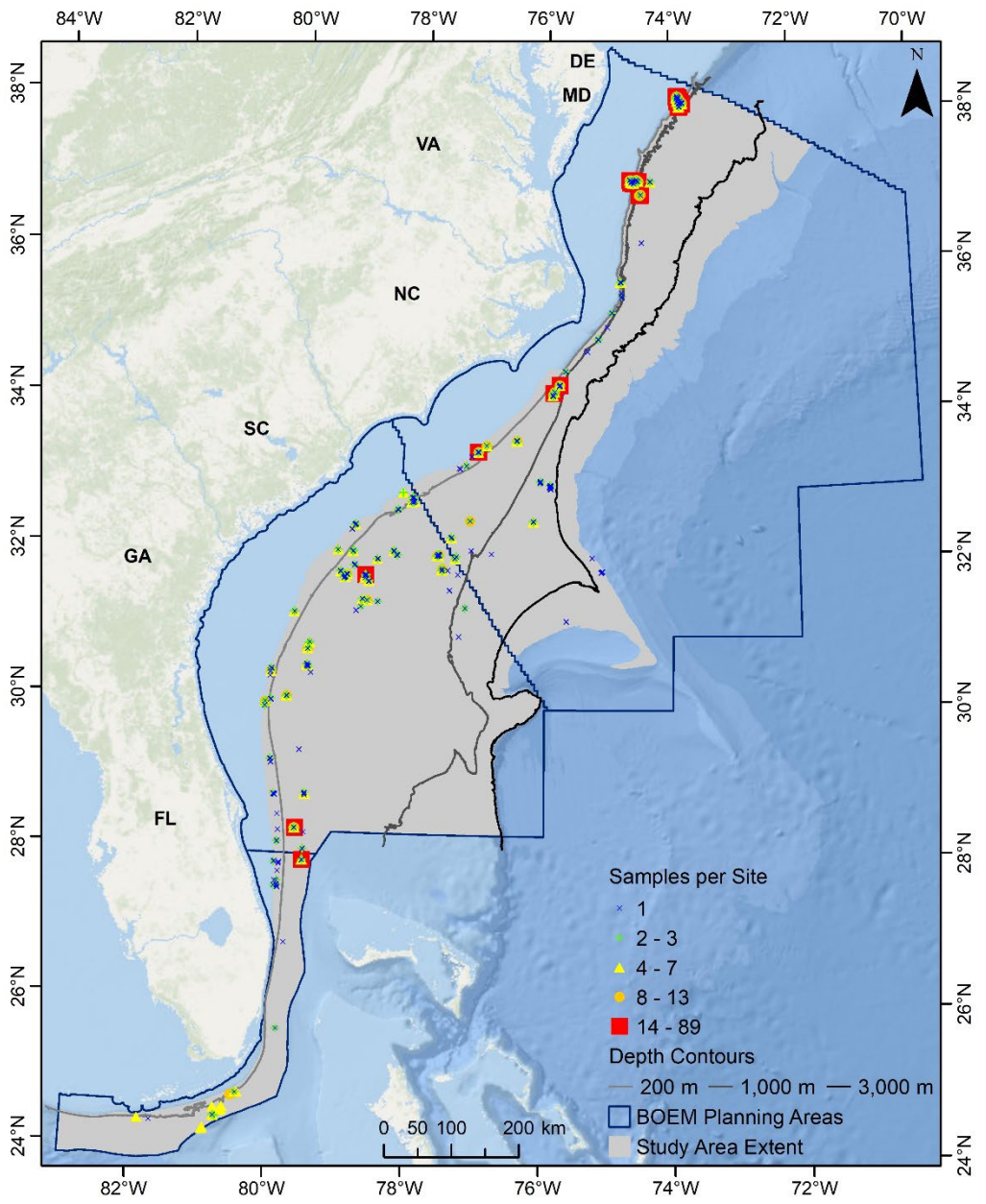
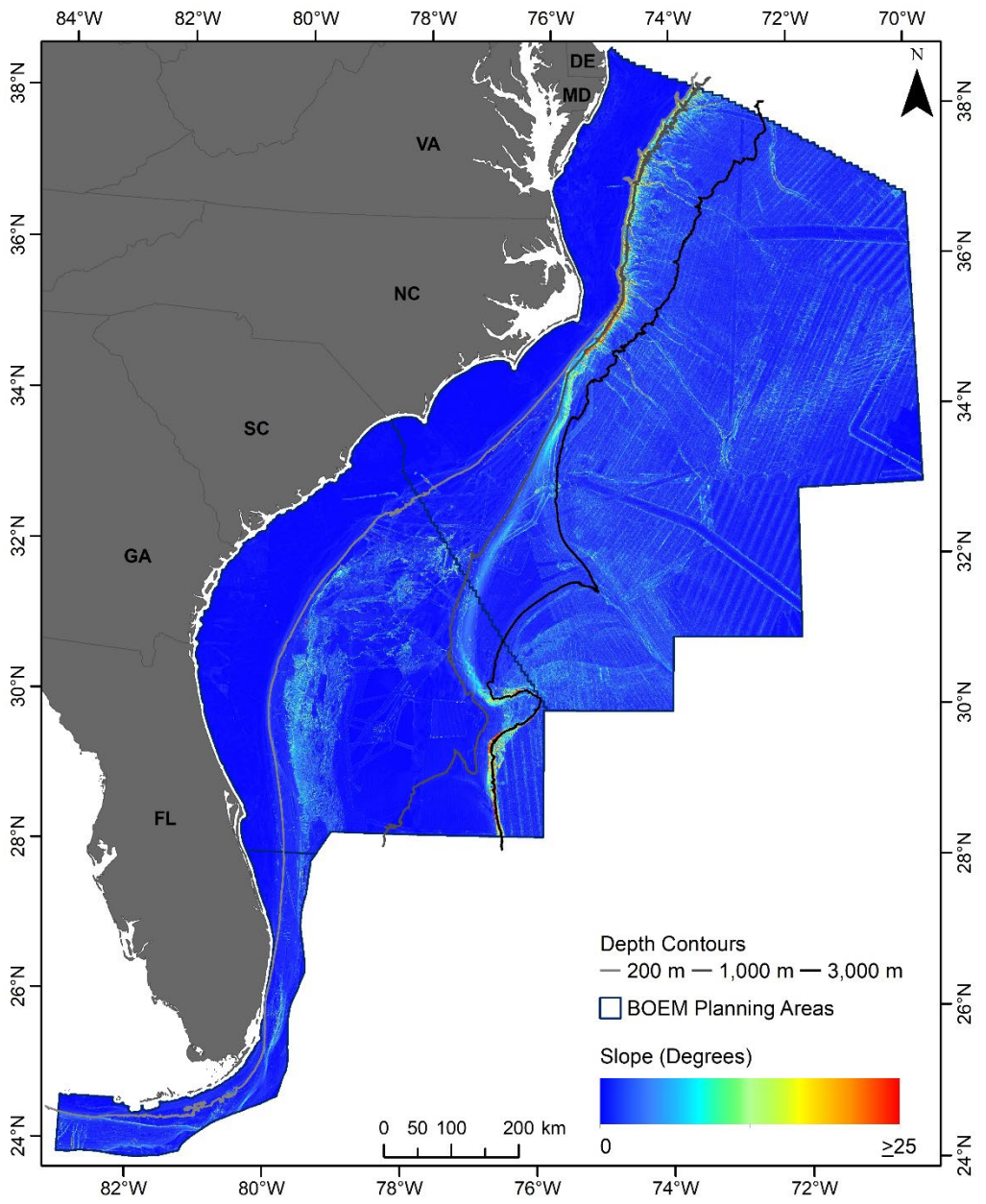


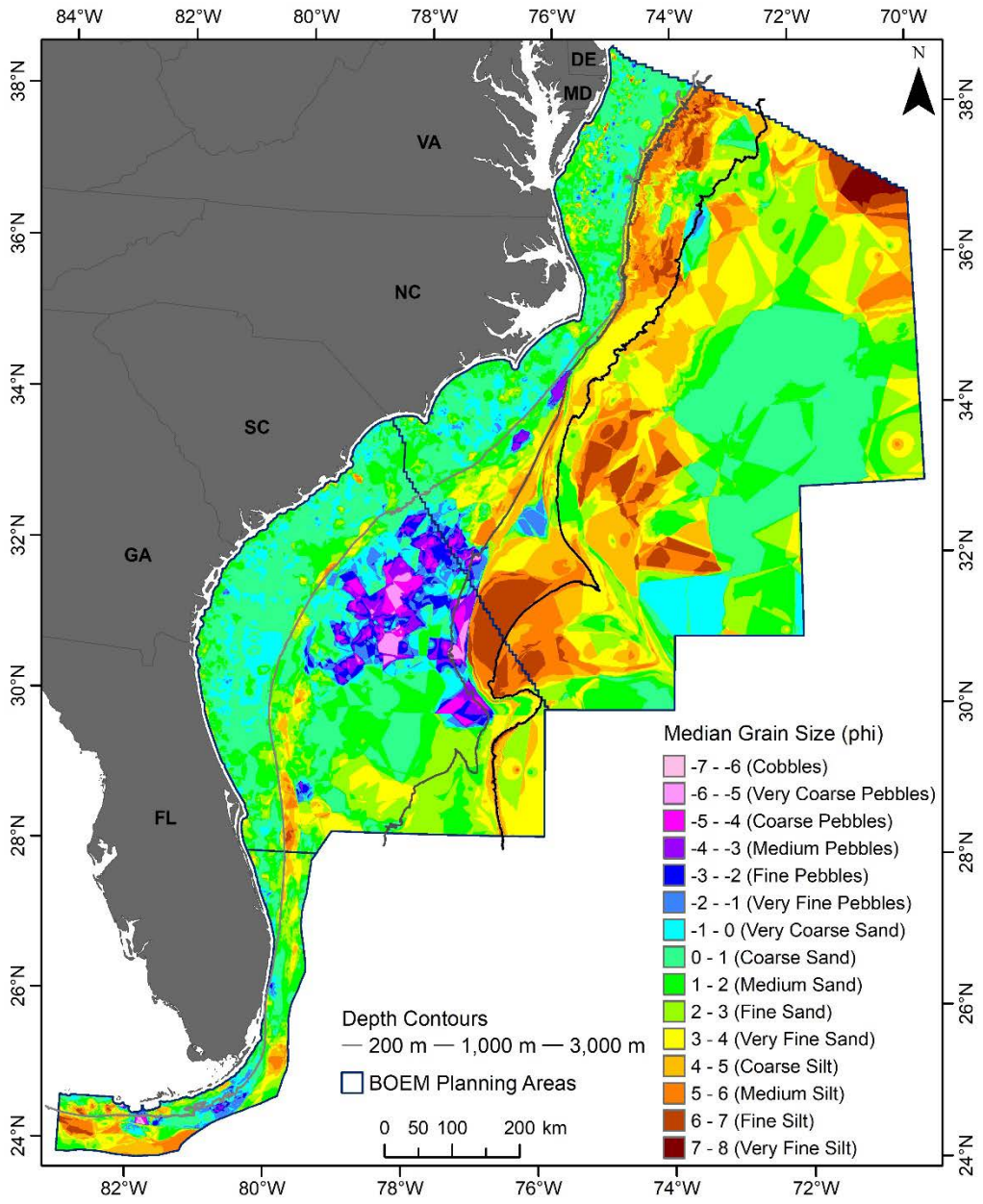
Methods (Predictive Models)

- Environmental predictors depicting:
  - depth and seafloor topography



Methods (Predictive Models)

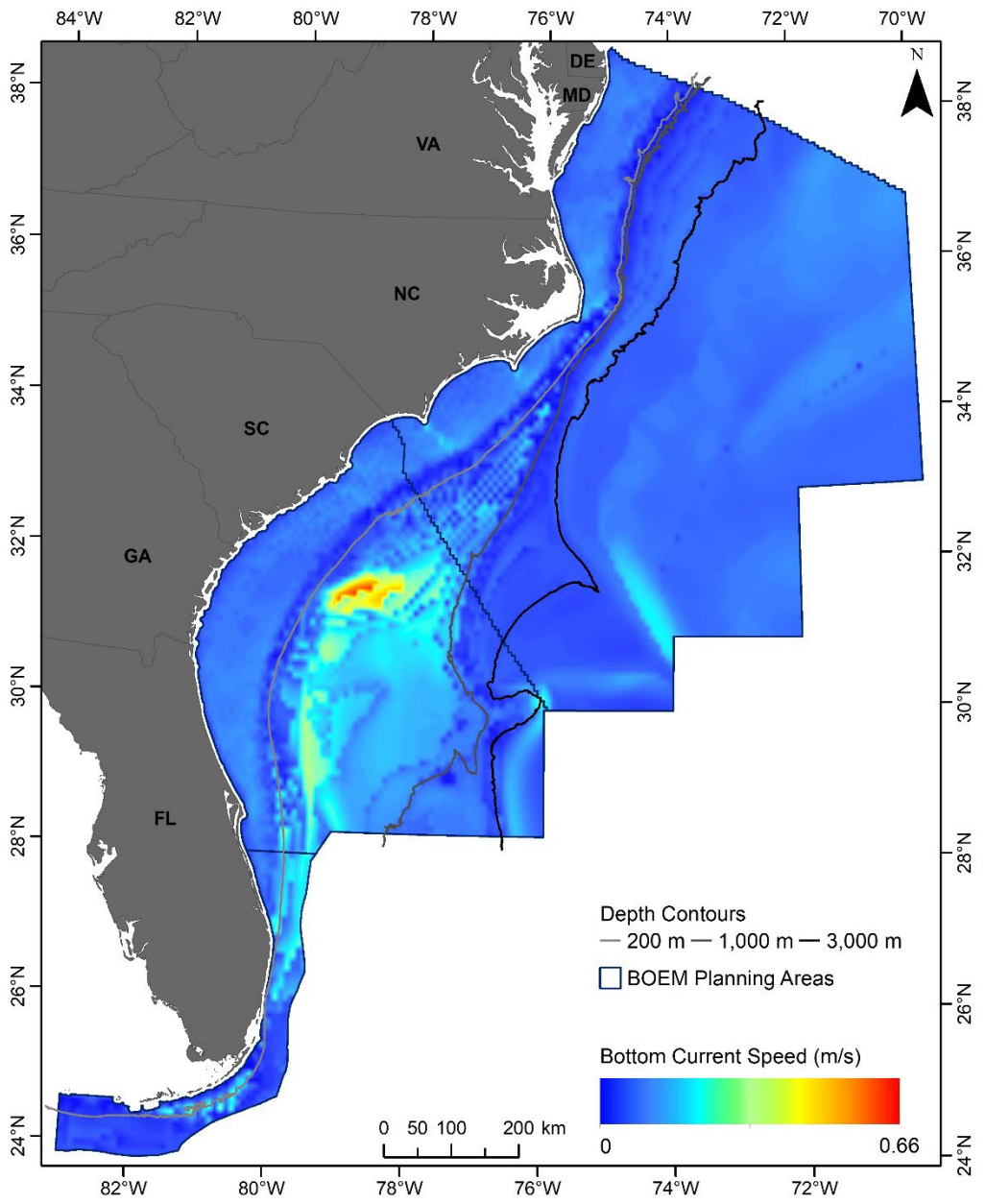
- Environmental predictors depicting:
  - depth and seafloor topography
  - substrate



Methods (Predictive Models)

- Environmental predictors depicting:
  - depth and seafloor topography
  - substrate
  - oceanography
  - geography

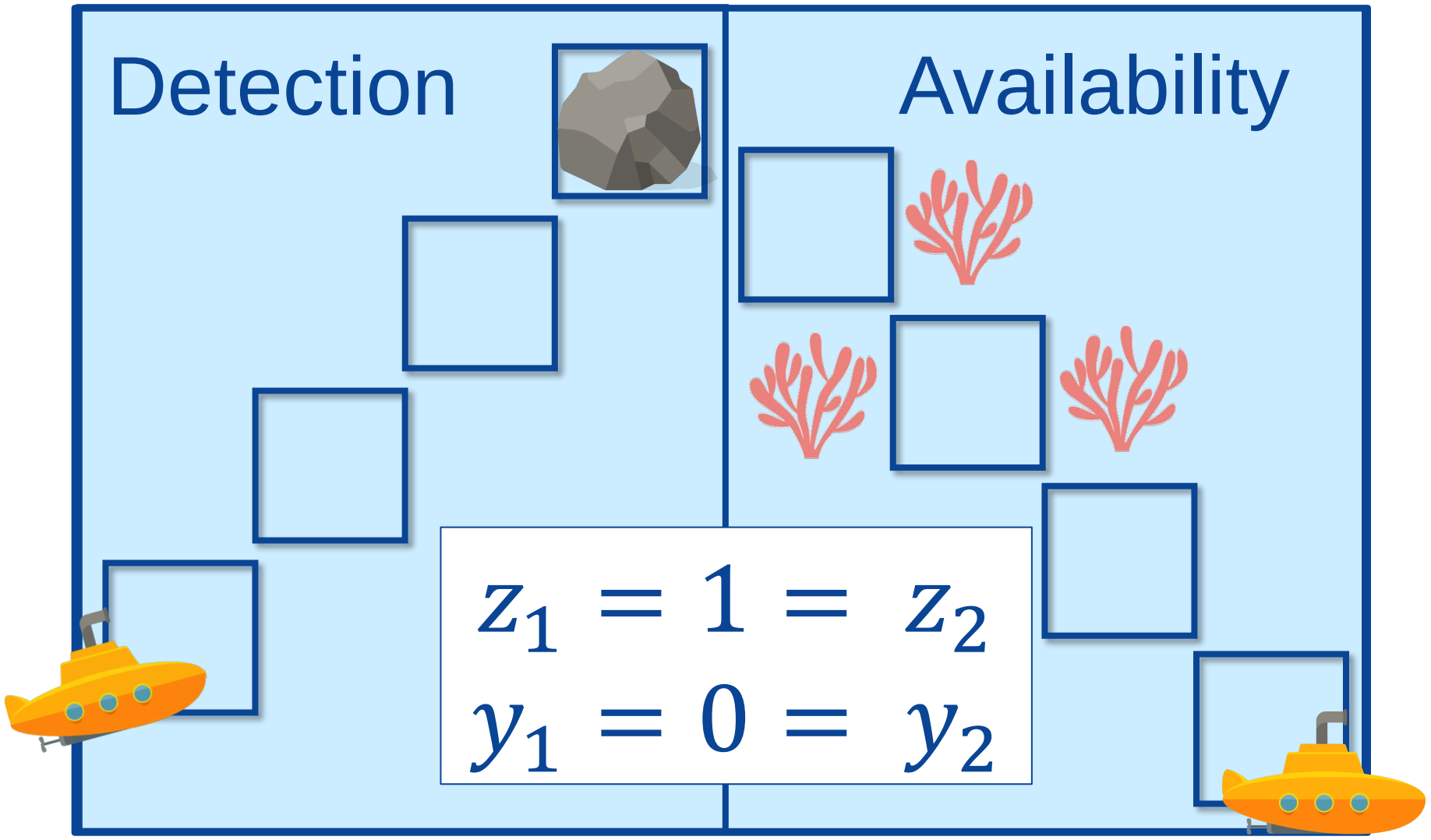
- Model grid at 100 x 100 m resol.



Methods (Predictive Models)

- Occupancy models – estimate both the probability of occurrence (occupancy probability) at a site (grid cell) and the probability of detecting an organism present at a site (detection probability)
- Space-for-time substitution using spatial replicates

Methods (Predictive Models)



Methods (Predictive Models)

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- Occupancy analysis assumptions:

1. Imperfect detection – sampled absences not treated as true absences
2. No false positives – DSC observations only to finest taxonomic level for which observation could be identified with confidence
3. Closure – sampling time frame short relative to system dynamics
4. Independence of occupancy and detection probabilities
5. Homogeneity of detection probability – assumption that detectability was consistent throughout study area unlikely to be met b/c of differences in survey data included; effort offset used to account for heterogeneity in detection probability; taxon- and site-level effects on detection probability also included

Methods (Predictive Models)

- Overall structure

$$y_{ijk} \sim Bernoulli\left(z_{ik} p_{ijk}\right)$$

presence-absence data

estimated occupancy state

detection probability

- State process (occupancy)

$$z_{ik} \sim Bernoulli\left(\Psi_{ik}\right)$$

occupancy probability

$$cloglog(\Psi_{ik}) = beta_{0k} + \sum_{v=1}^{n} f_{vk}(x_{vi}, beta_{vk})$$

genus-specific occupancy intercept

natural cubic polynomial spline

predictor-specific occupancy coefficients

$$beta_{0k} \sim Normal(u_{beta_0}, \tau_{beta_0})$$

$$beta_{vk} \sim Normal(u_{beta}, \tau_{beta})$$

i = site
j = occasion
k = genus
v = predictor
n = # predictors

Methods (Predictive Models)

- Observation process (detection)

$$cloglog(p_{ijk}) = alpha_0 + alpha_{1,i} + alpha_{2,k} + log(effort_{ij})$$

p_{ijk}	$alpha_0$	$alpha_{1,i}$	$alpha_{2,k}$	$log(effort_{ij})$
detection probability	detection intercept	site effect on detection	genus effect on detection	effort (area)

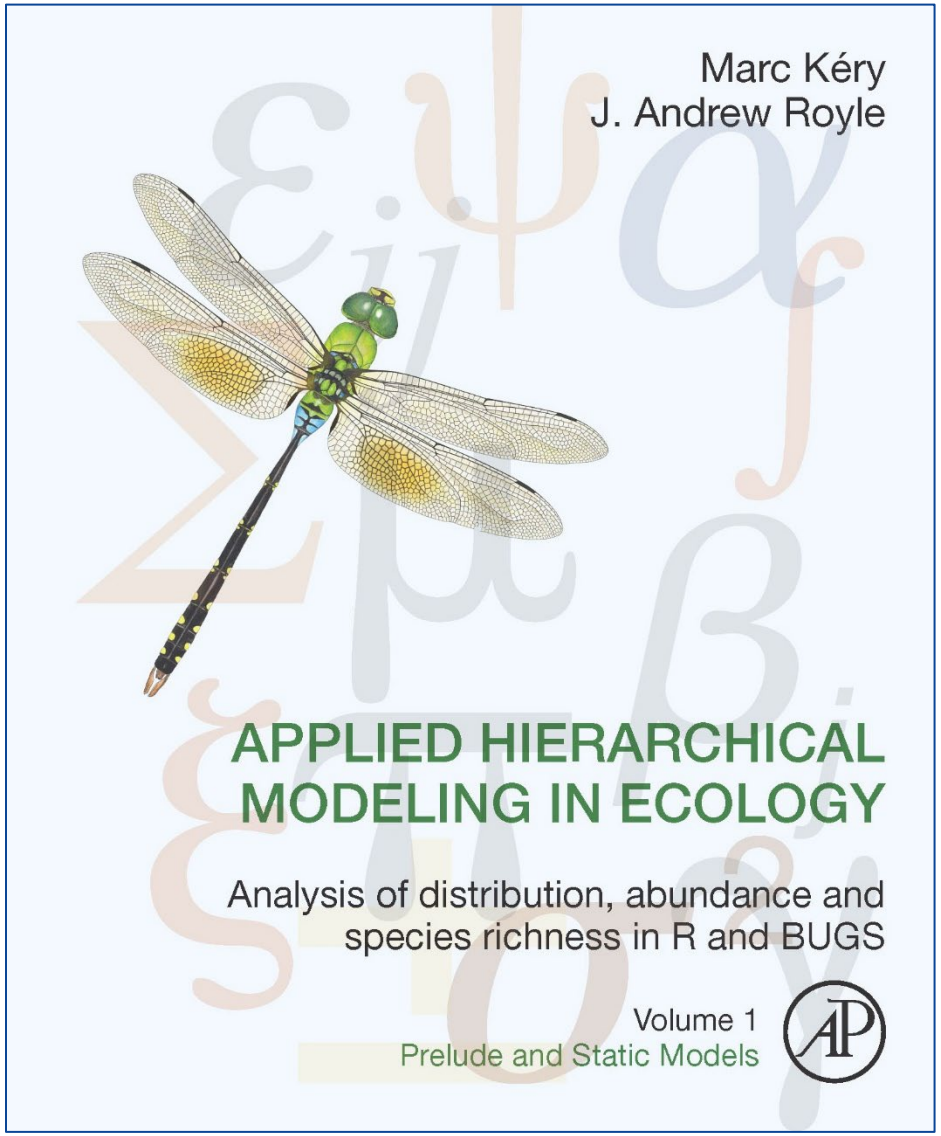
$$alpha_{1,i} \sim Normal(0, \tau_{clp1})$$

$$alpha_{2,k} \sim Normal(0, \tau_{clp2})$$

i = site
j = occasion
k = genus

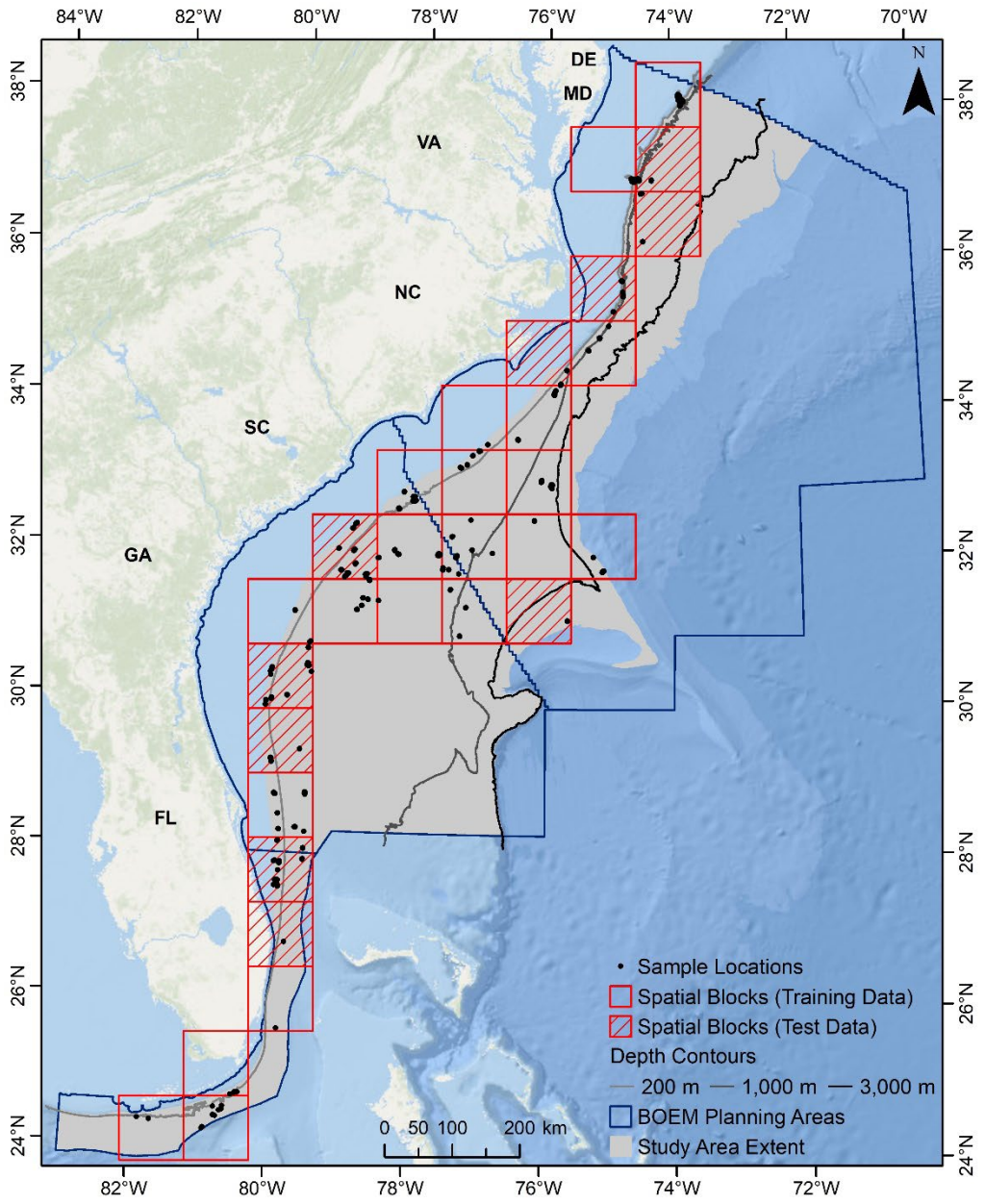
Methods (Predictive Models)

- Bayesian hierarchical approach
- Multi-taxon model – allowed estimate of richness
- Gulf of Mexico: 28 genera of DSCs (6 stony corals, 7 black corals, 15 gorgonian corals)
- Southeast: 23 genera of DSCs (6 stony corals, 5 black corals, 12 gorgonian corals), Stylasteridae, hardbottom habitats



Methods (Predictive Models)

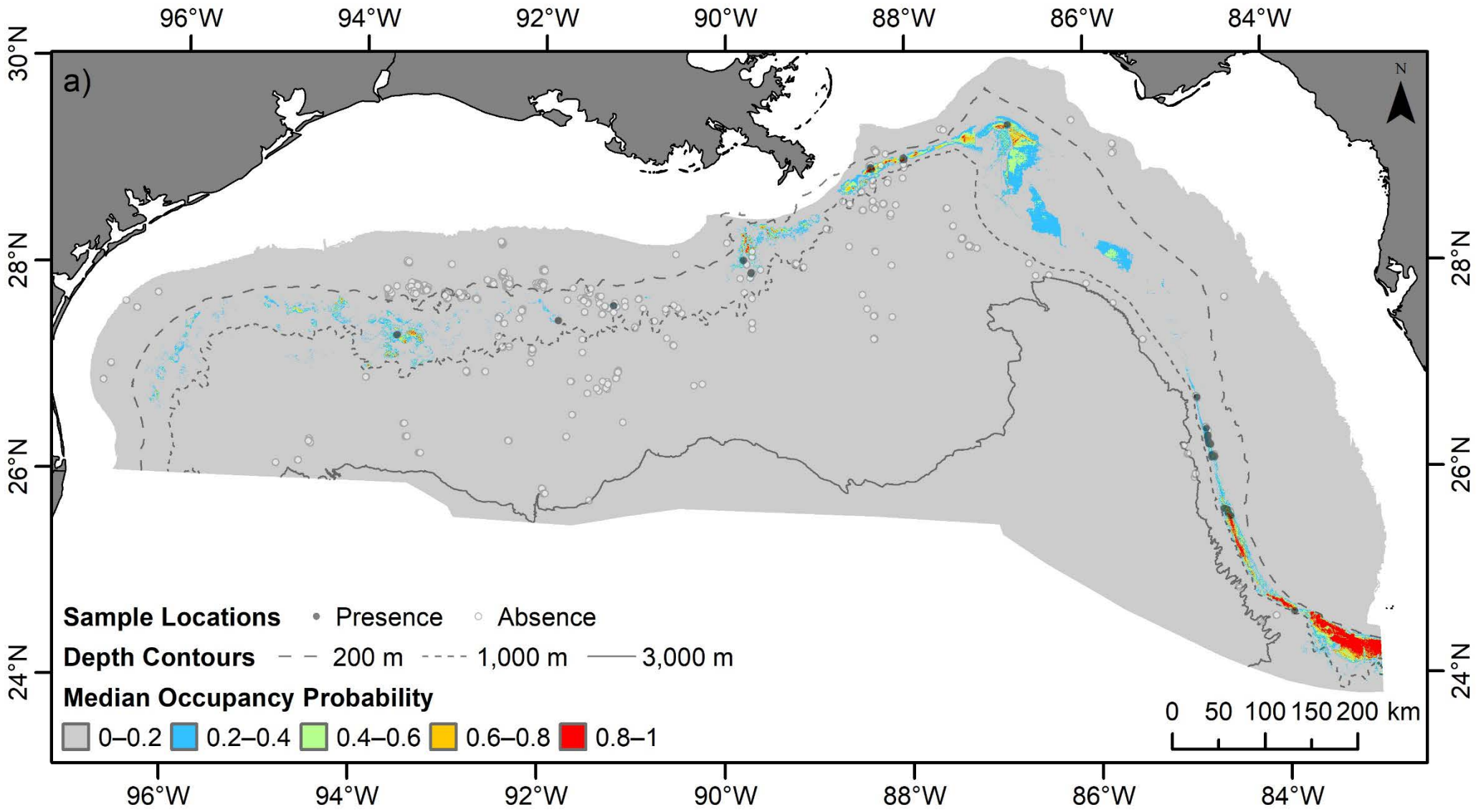
- Model fit assessed using AUC, point-biserial correlation coefficient
- Model predictive performance from validation – spatial blocks used to define training and test subsets of the sample data



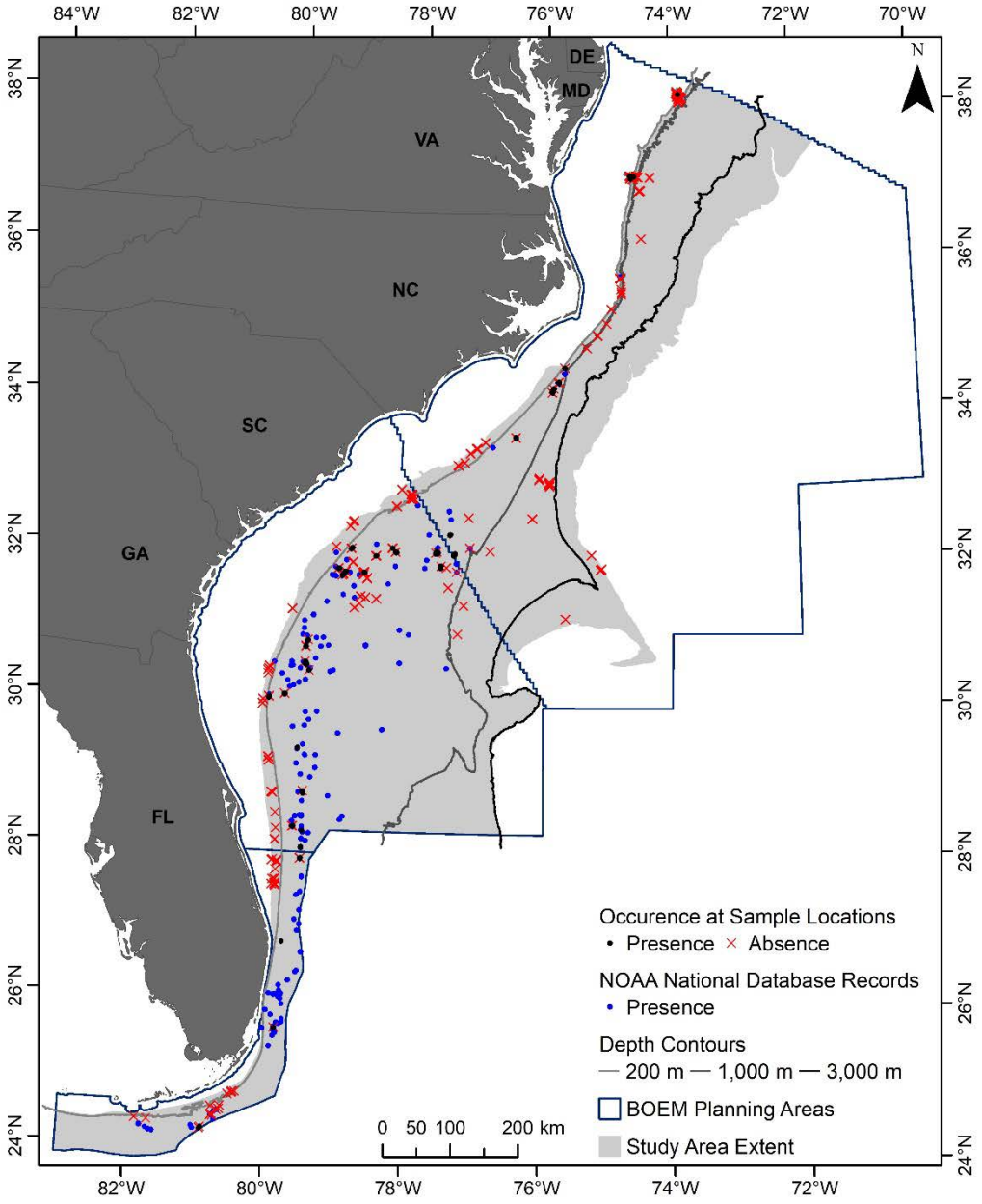
Results

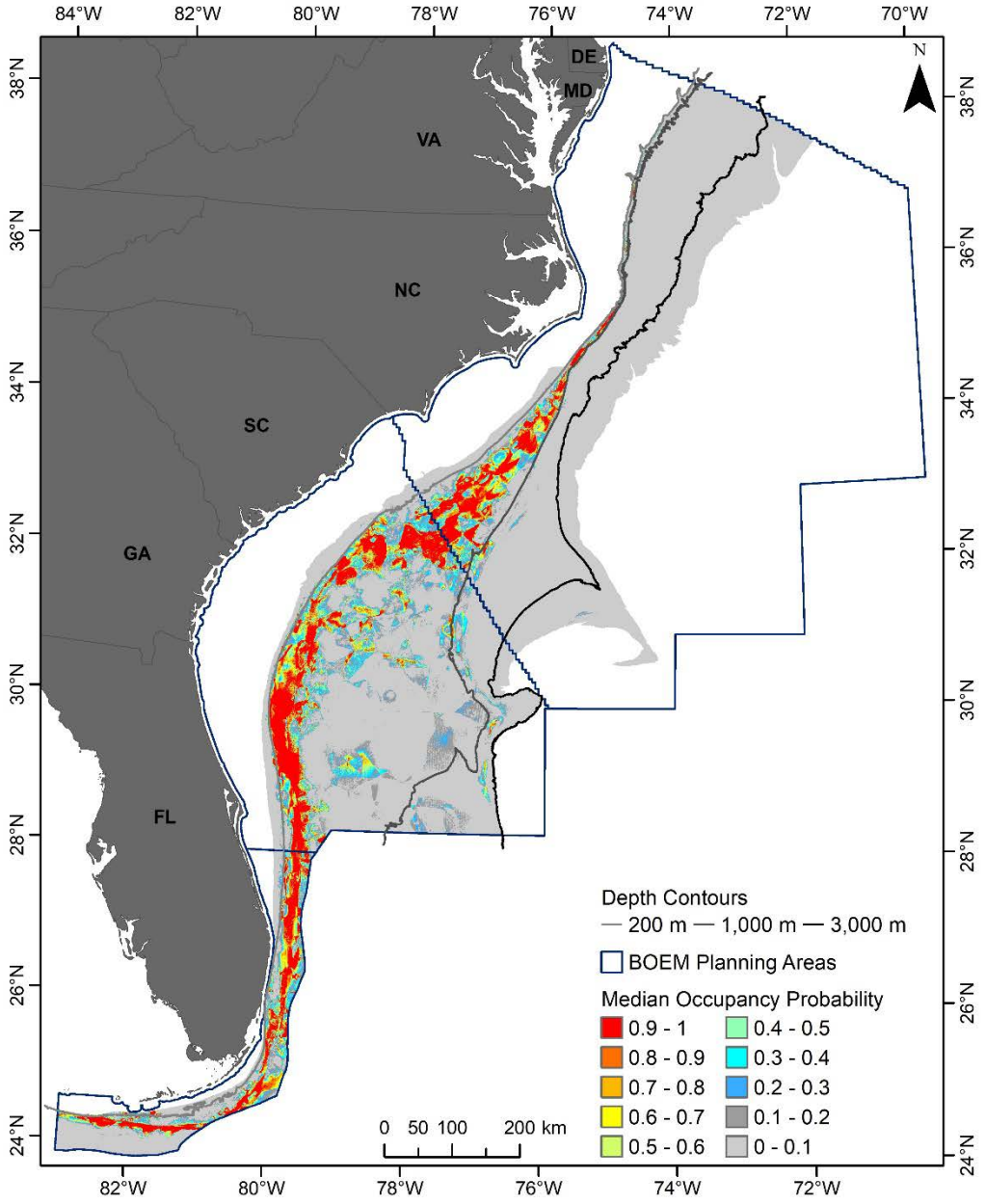
- Model predictive performance was a mixed bag
  - median correlation coefficients and AUC values suggested good model fit and predictive performance for some genera
  - spatial cross-validation suggested model predictions for unsampled sites less accurate than suggested by model fit to full dataset

Results - *Lophelia*

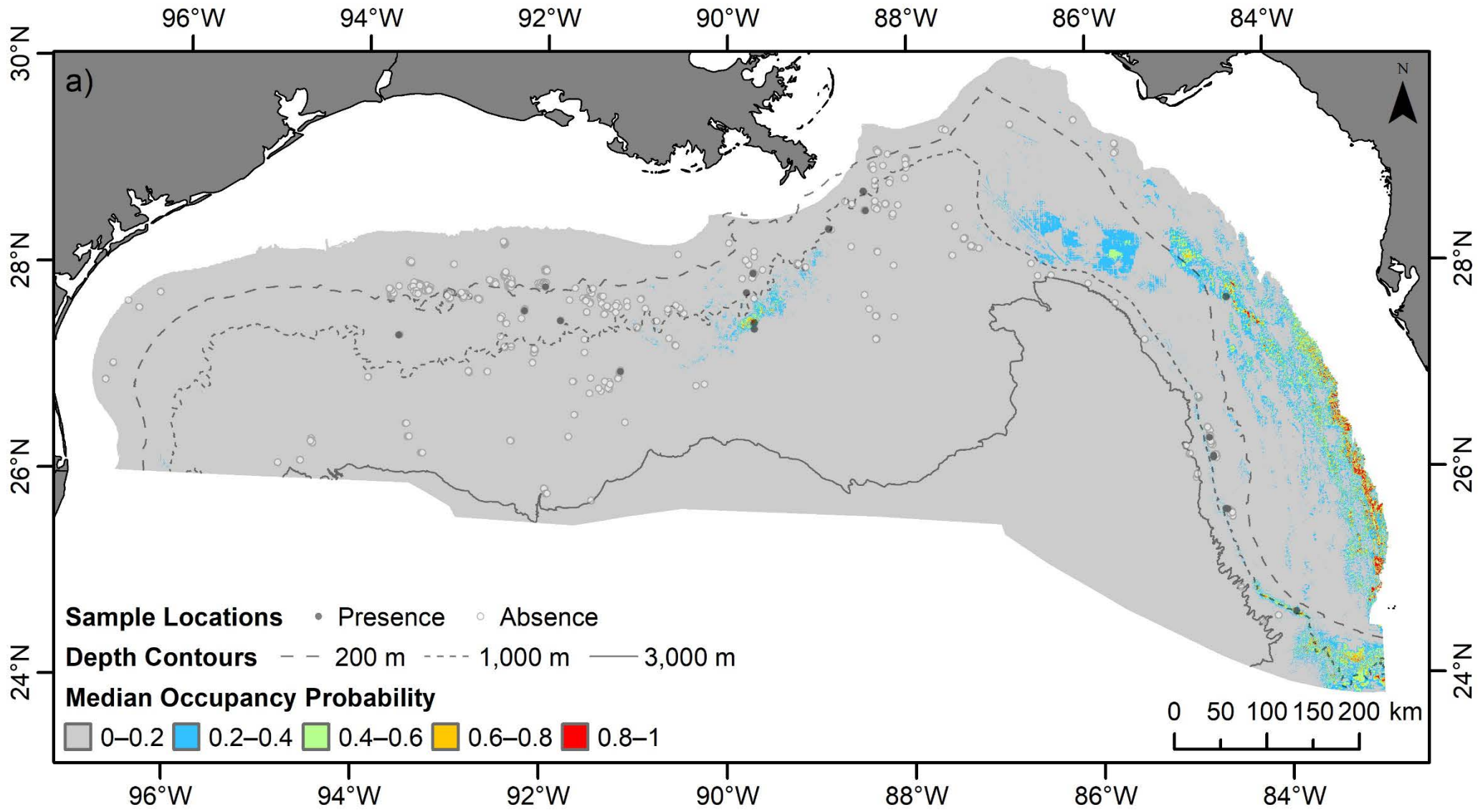


Results - *Lophelia*





Results - *Madrepora*



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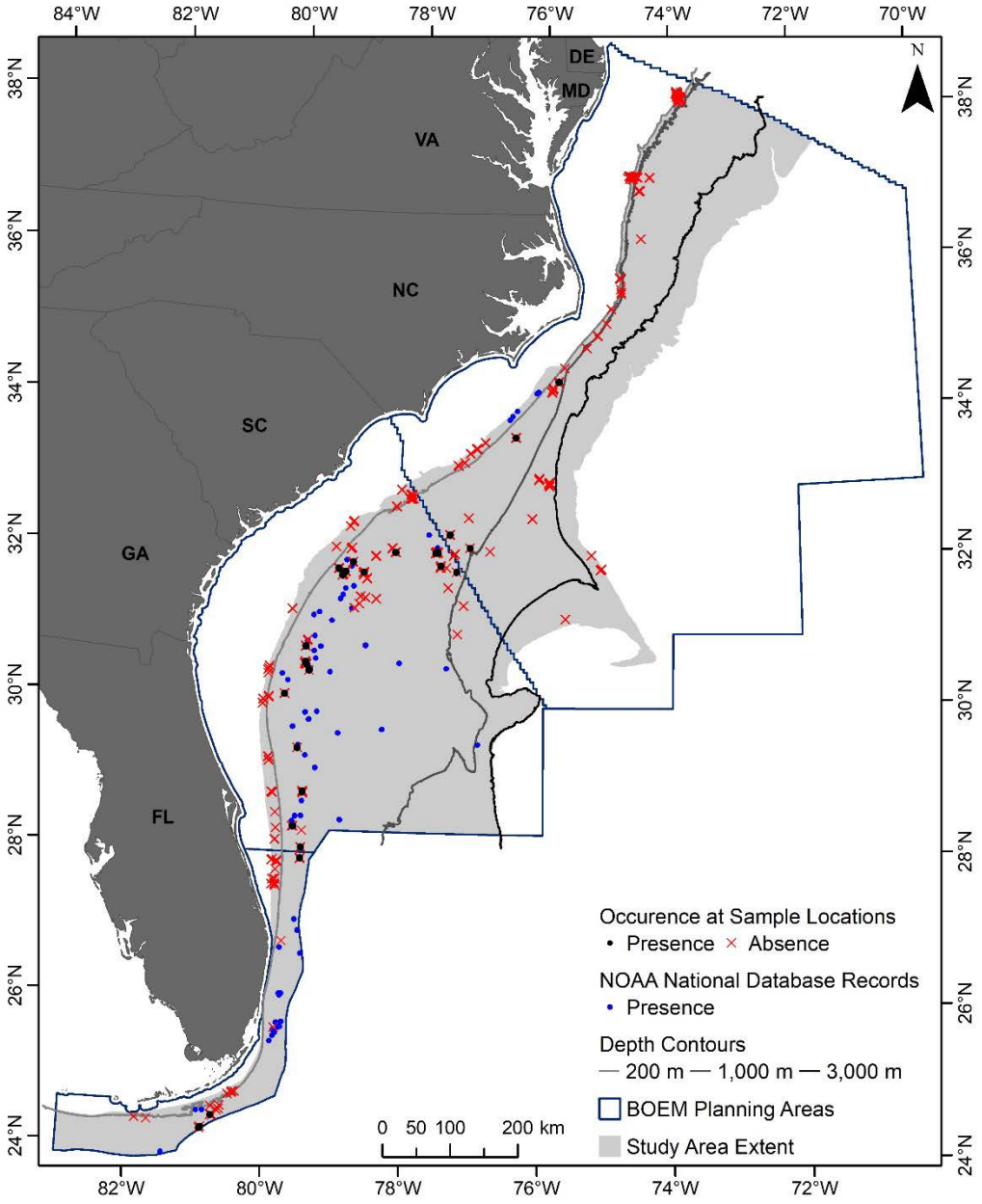
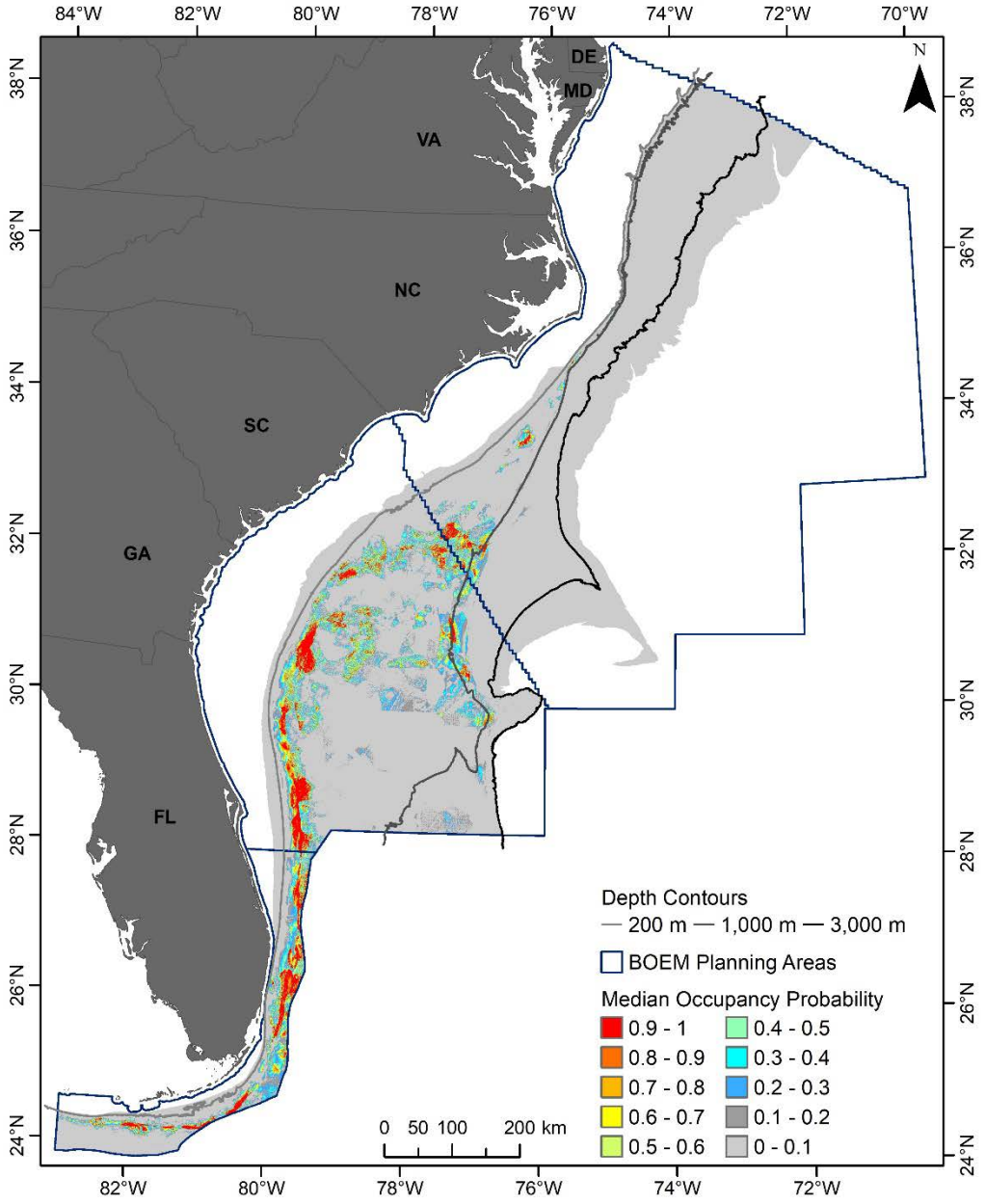
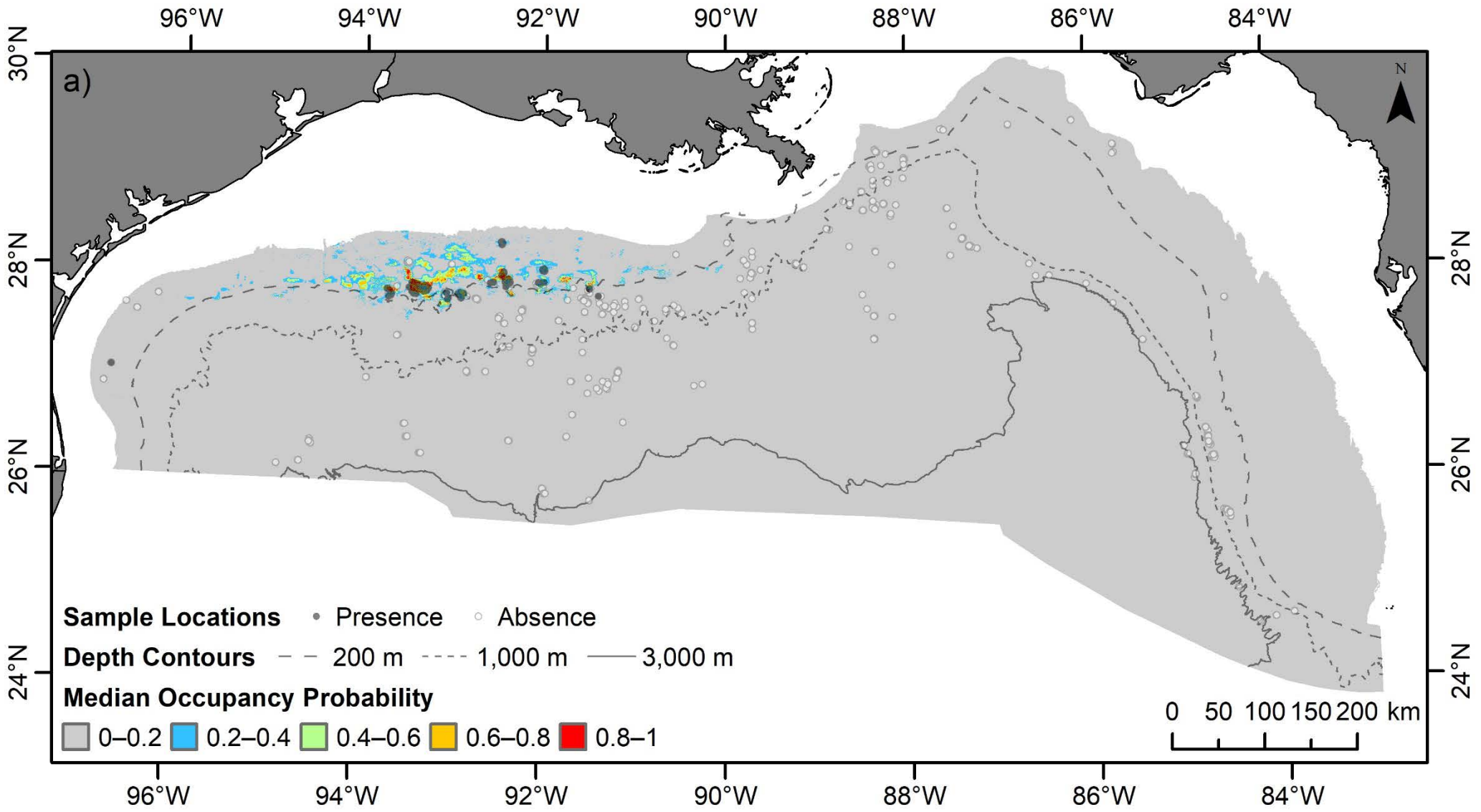
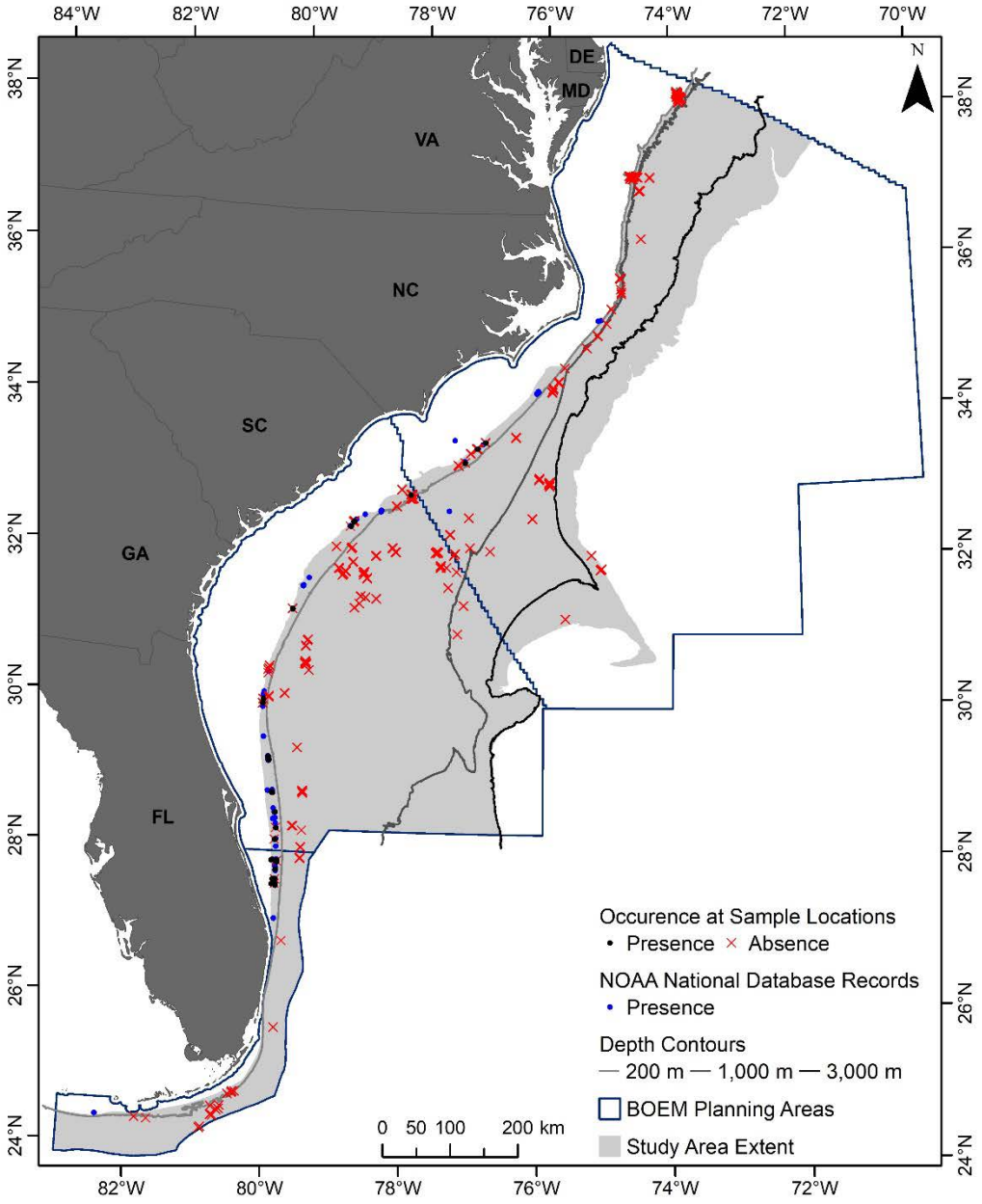


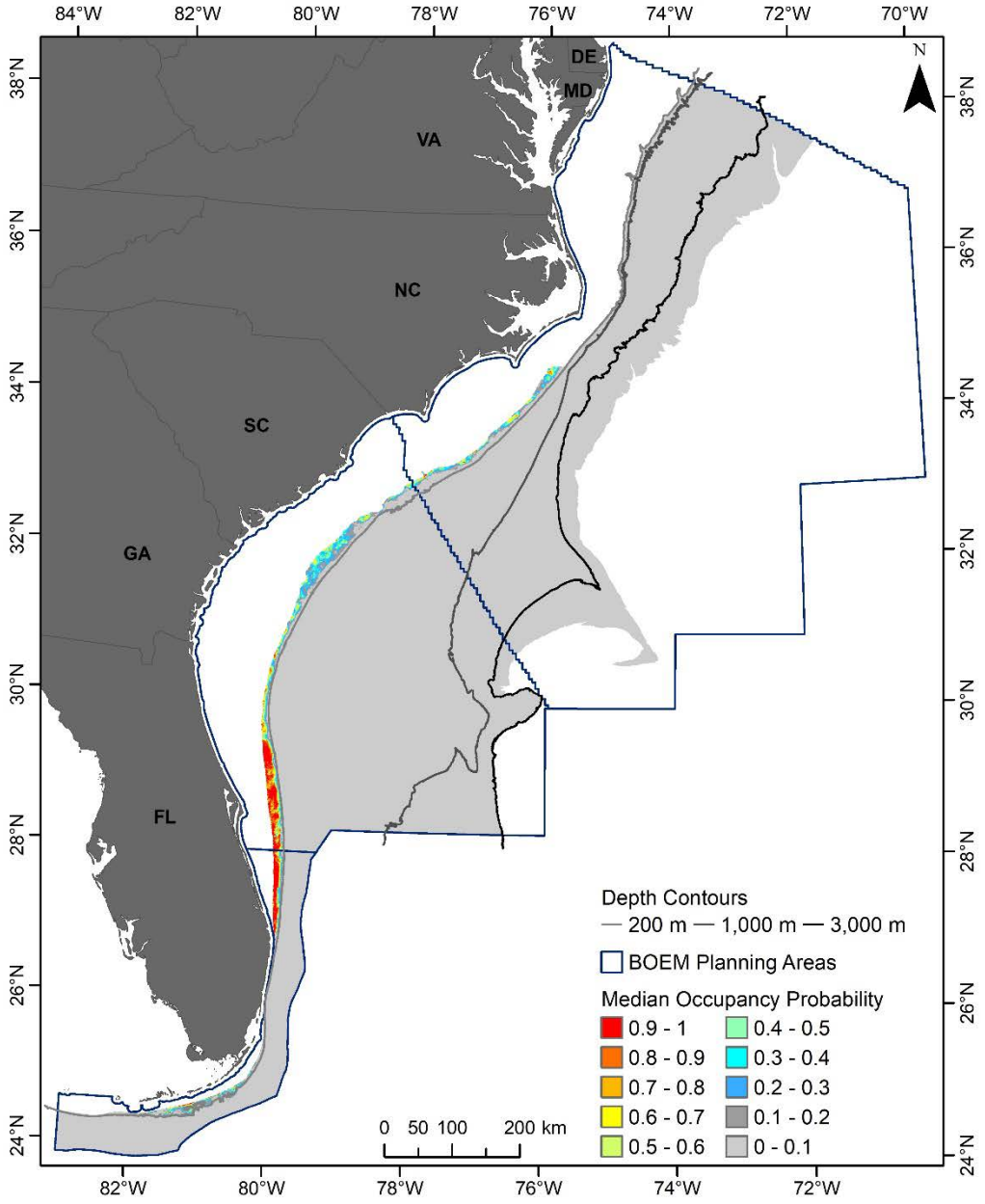


Results - *Oculina*

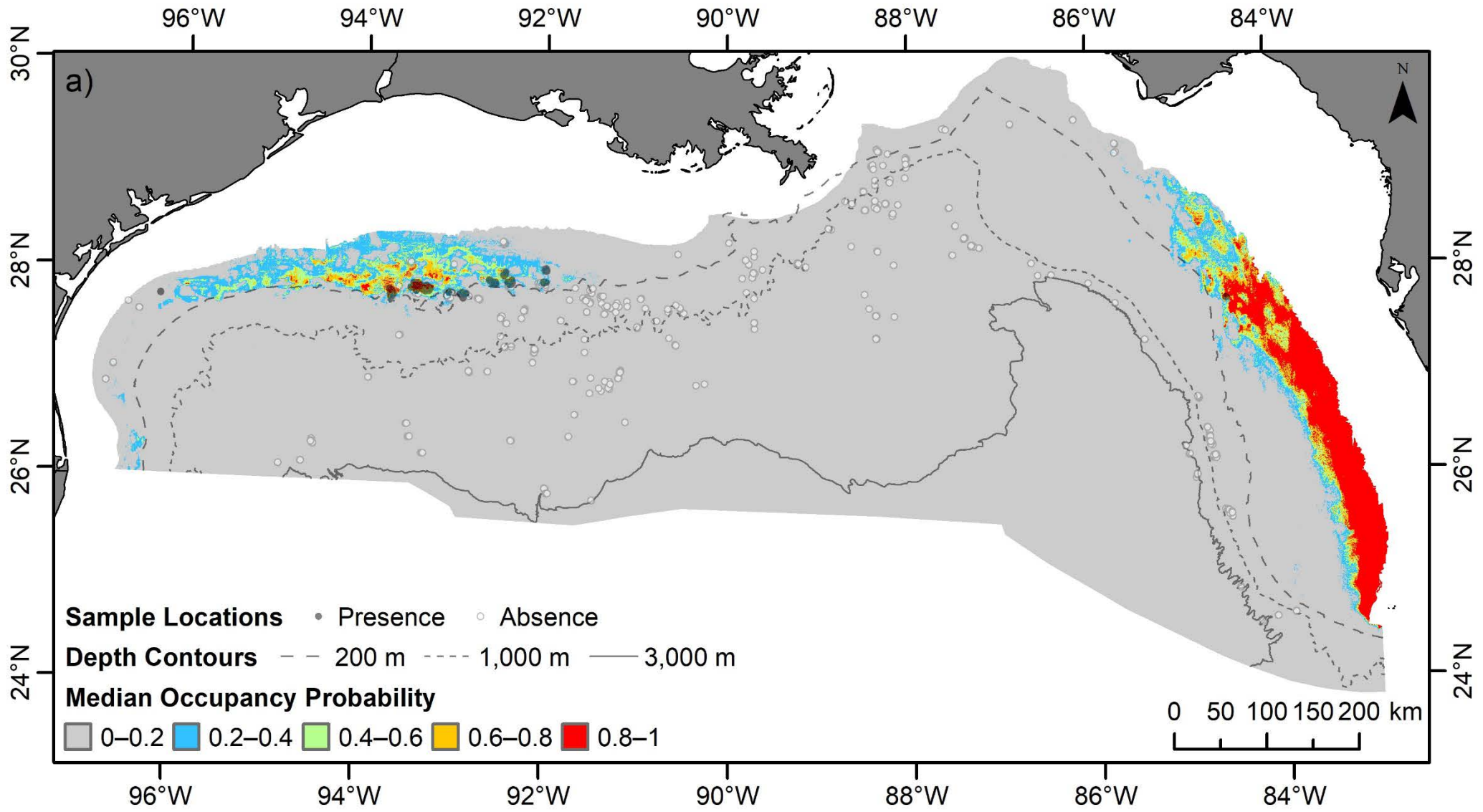


Results - *Oculina*

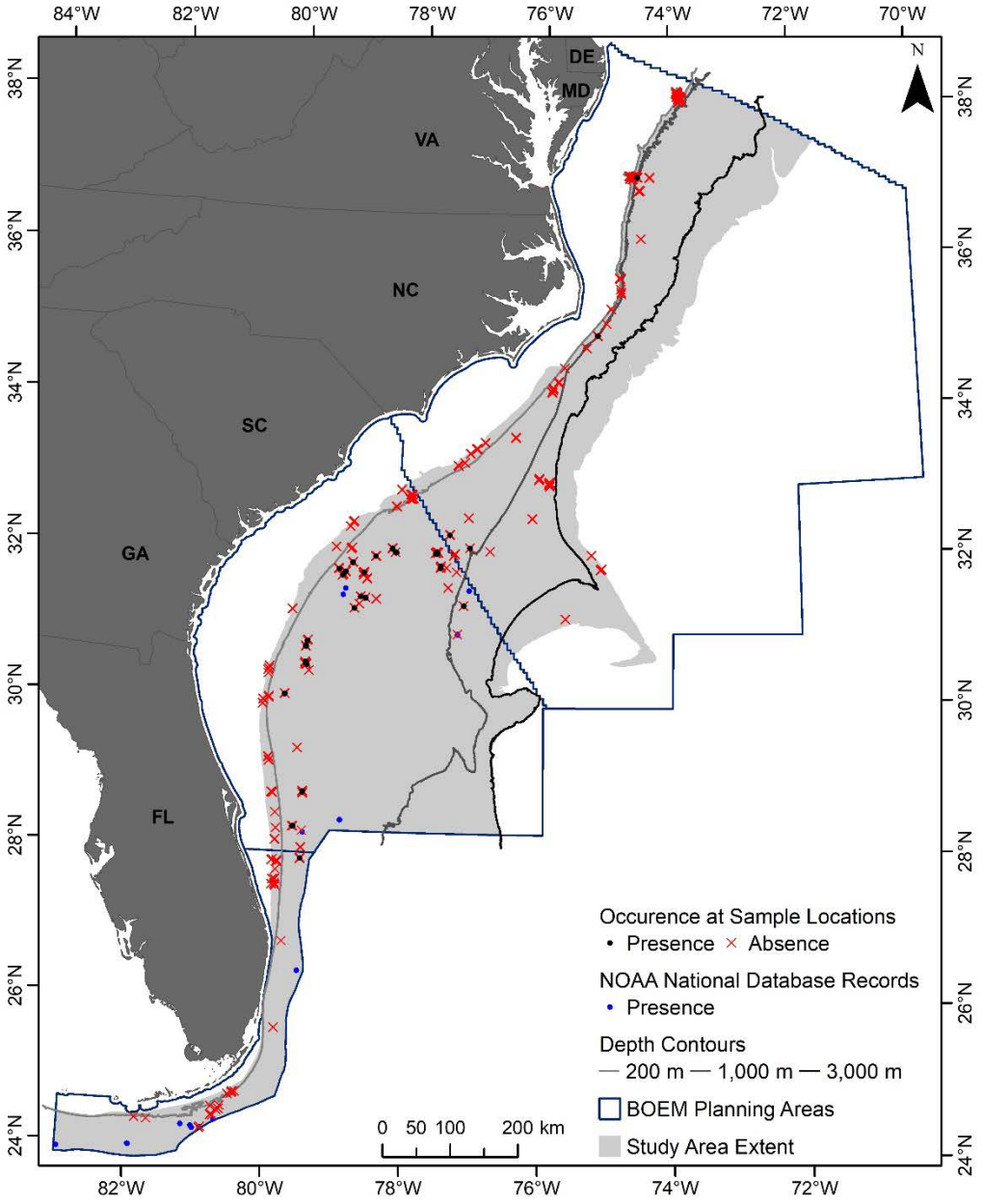


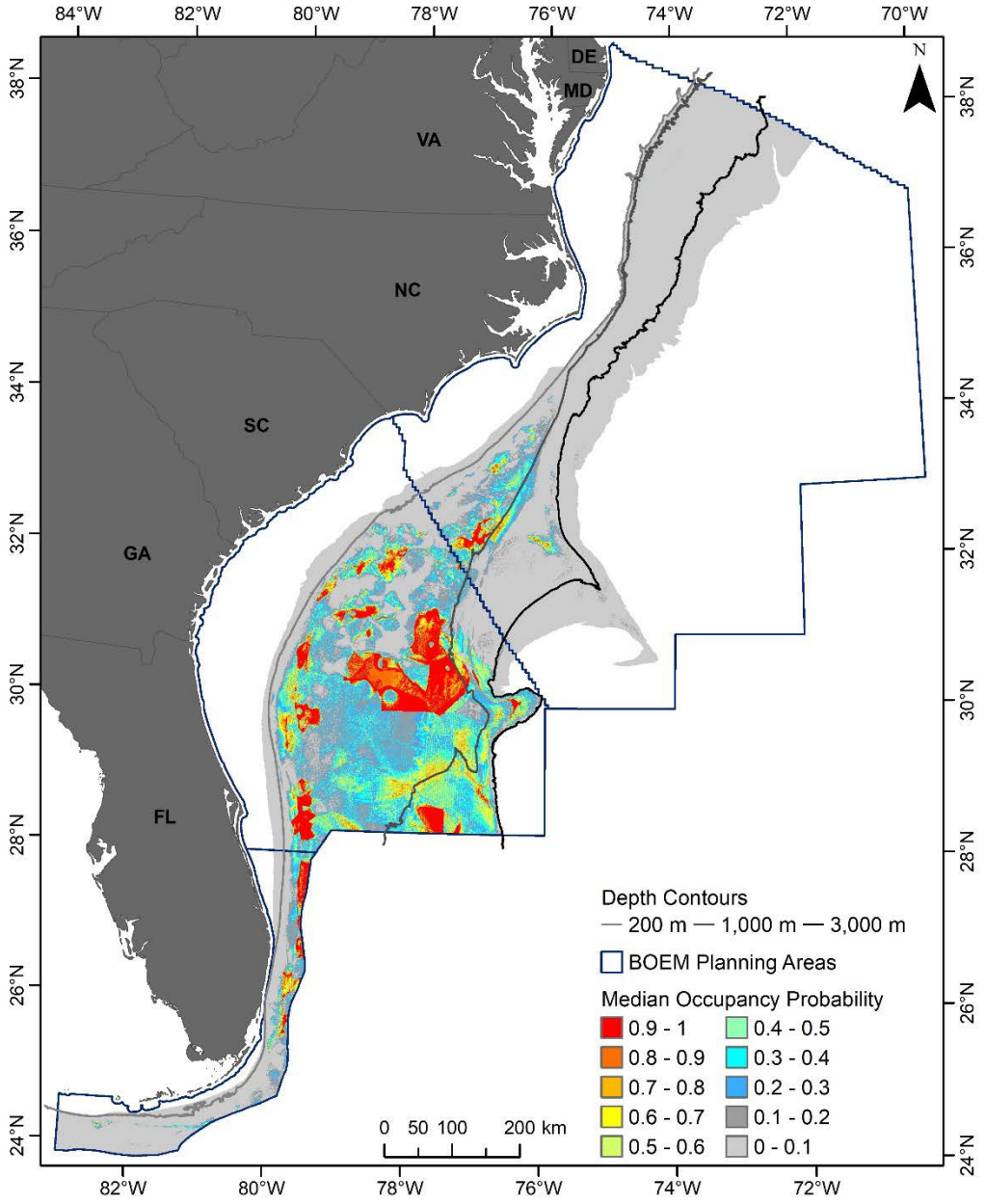


Results - *Madracis*

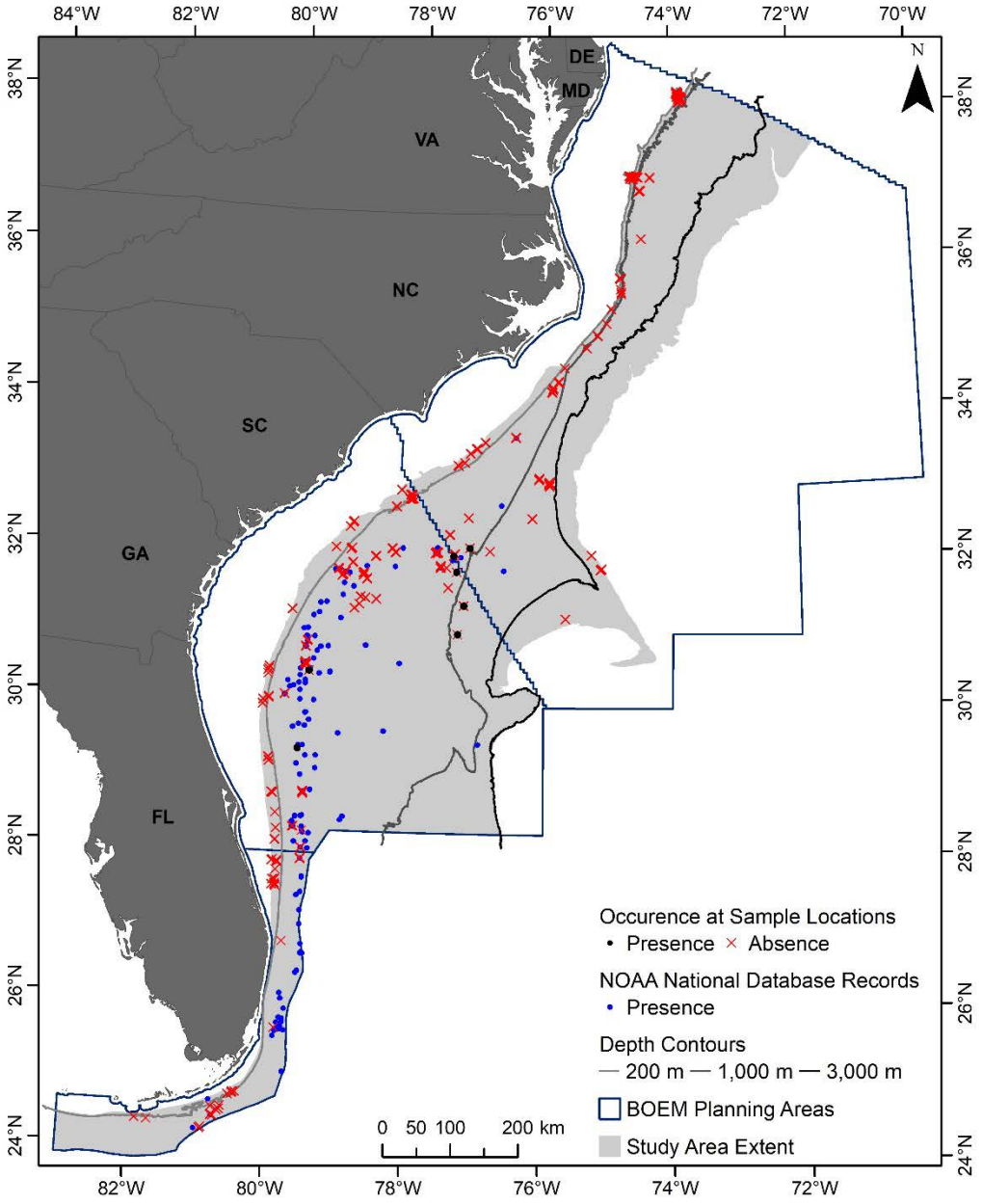


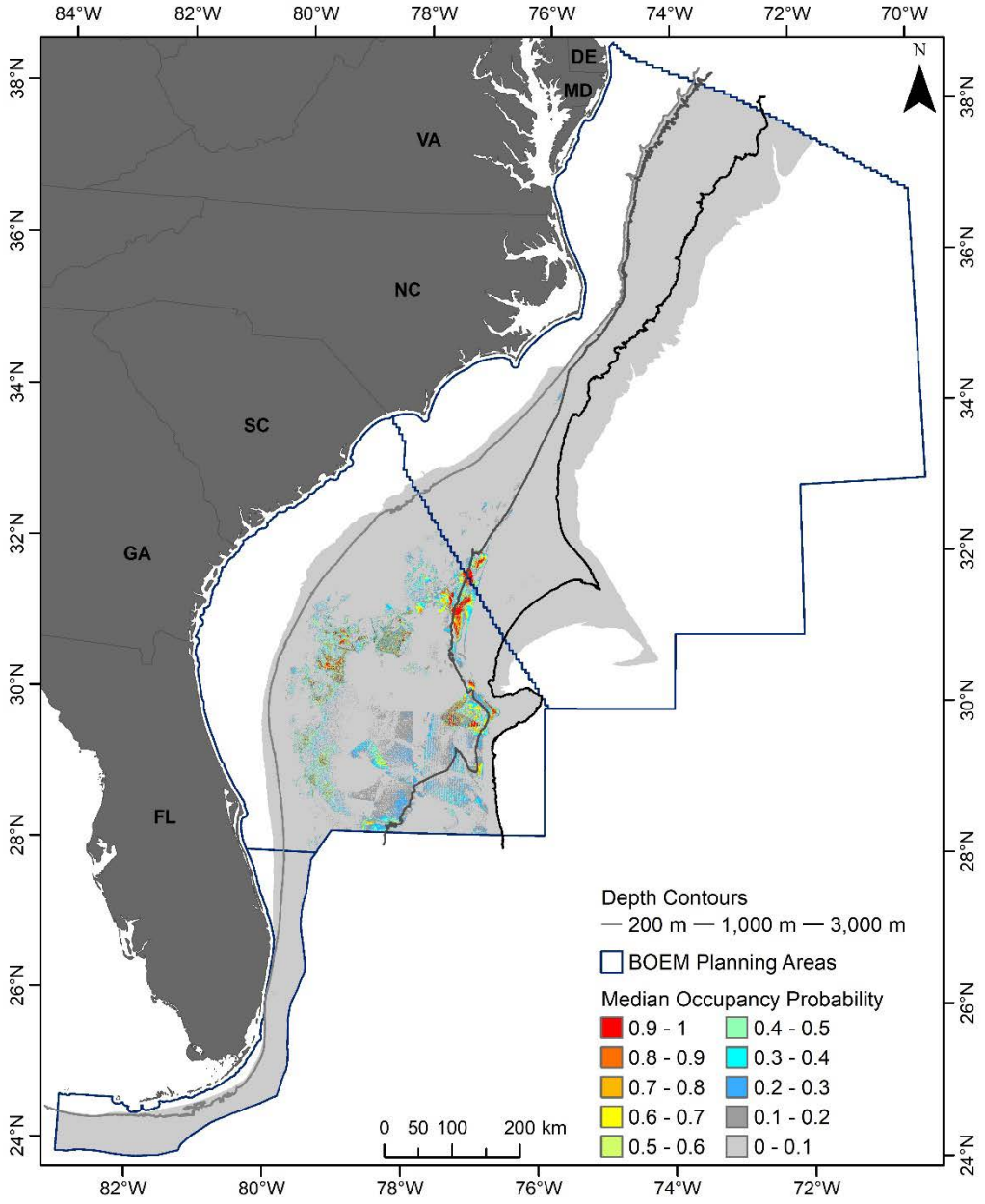
Results - *Solenosmilia*





Results - *Enallopsammia*





Results - *Stichopathes*

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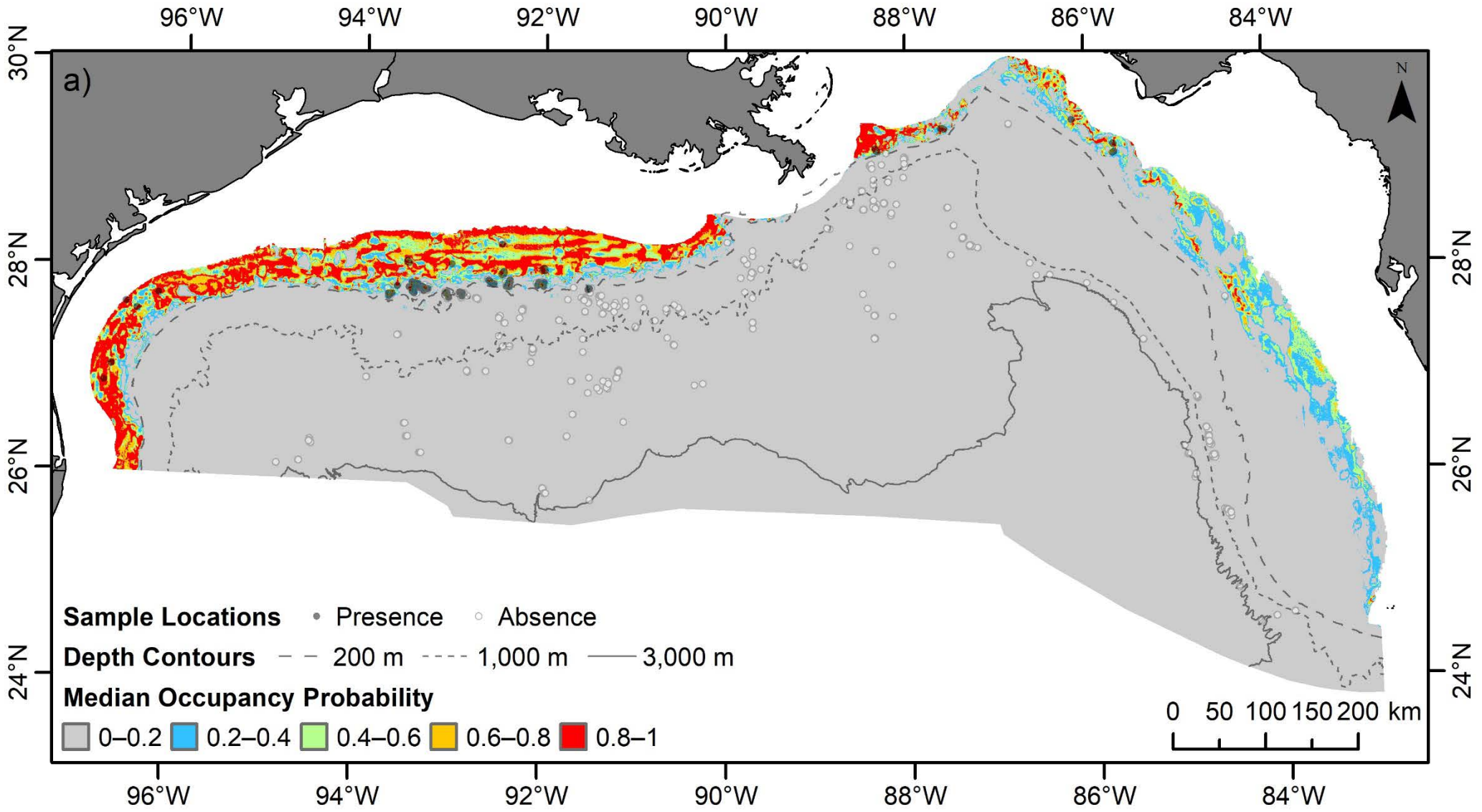

Results - *Stichopathes*

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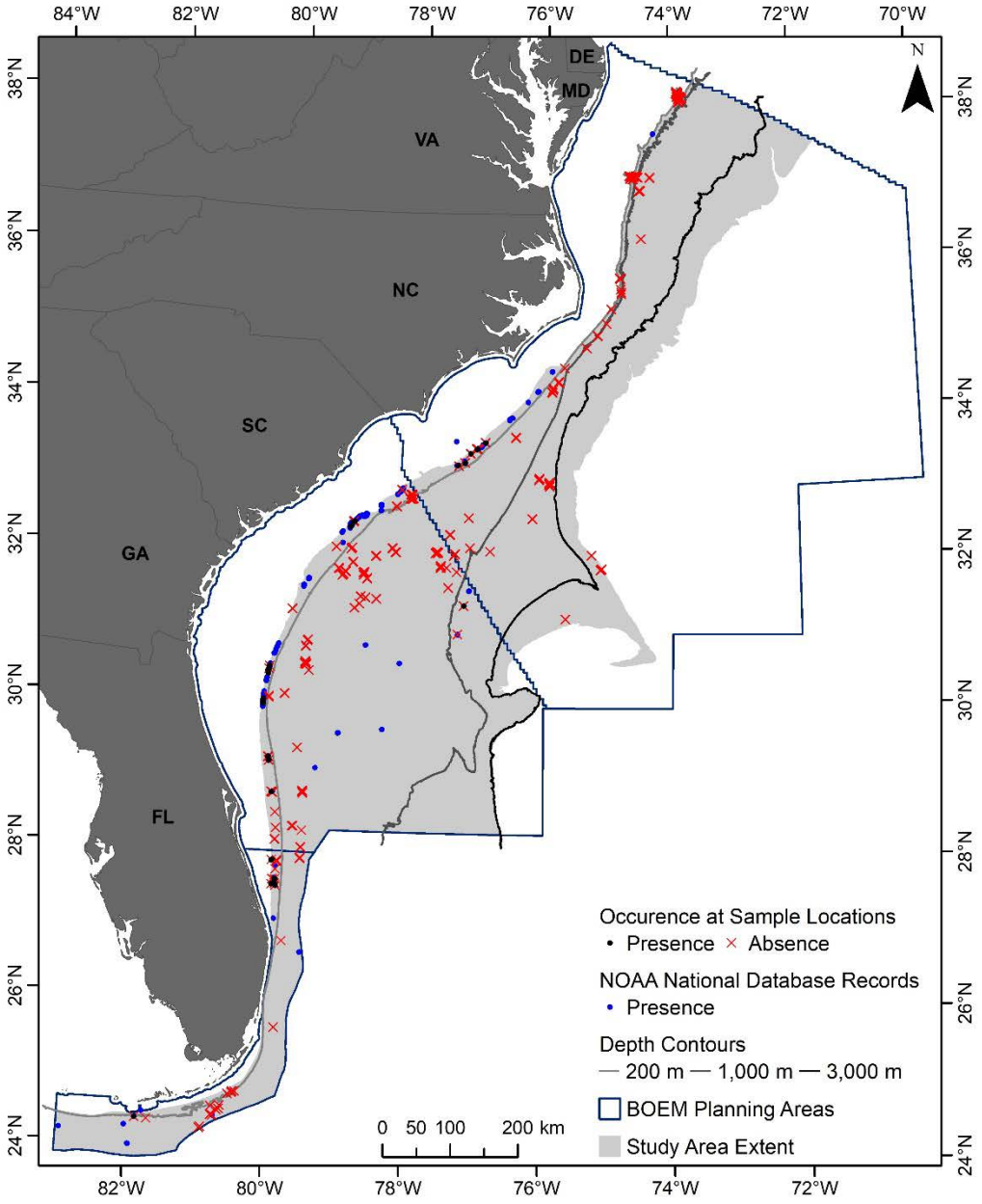
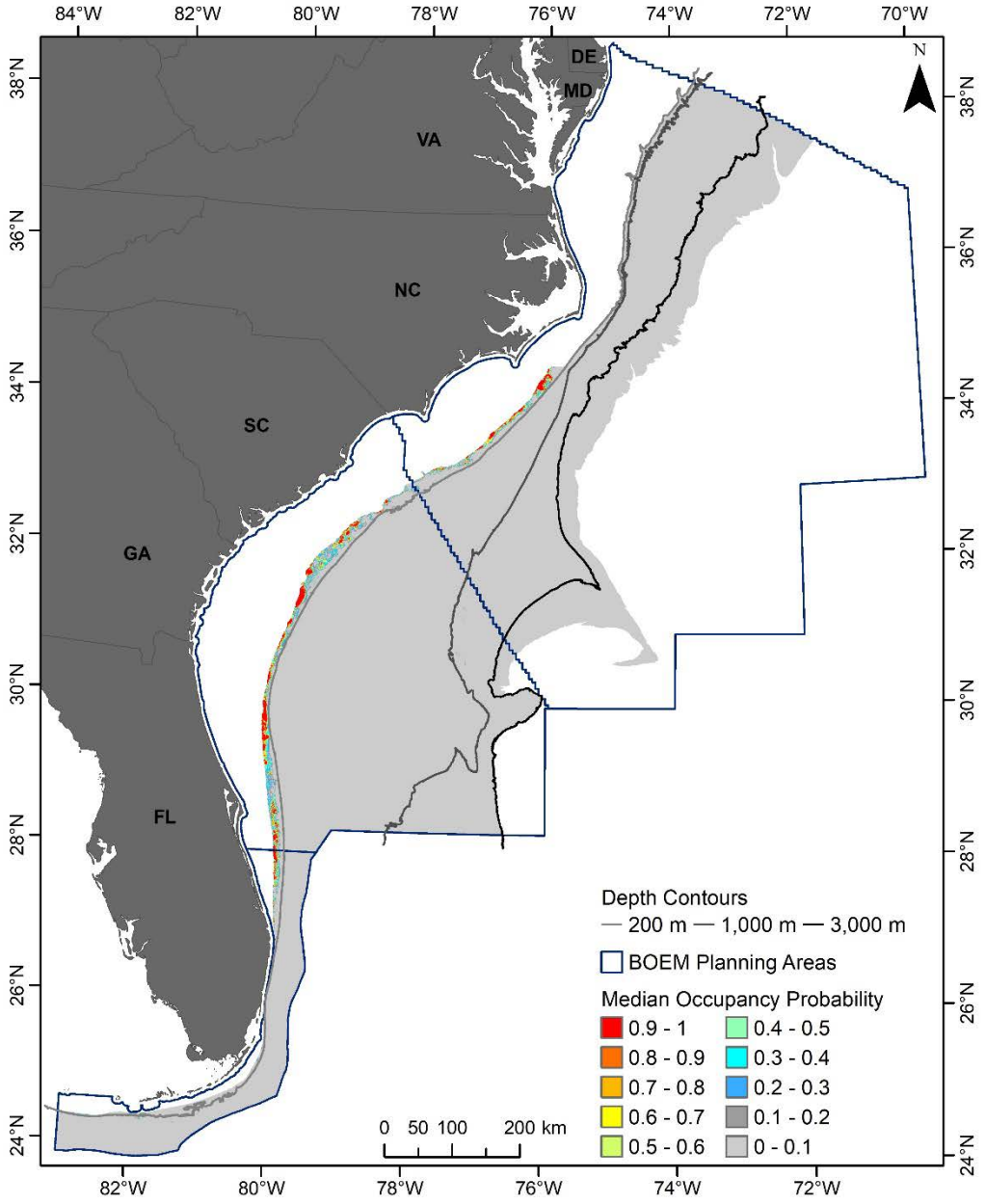
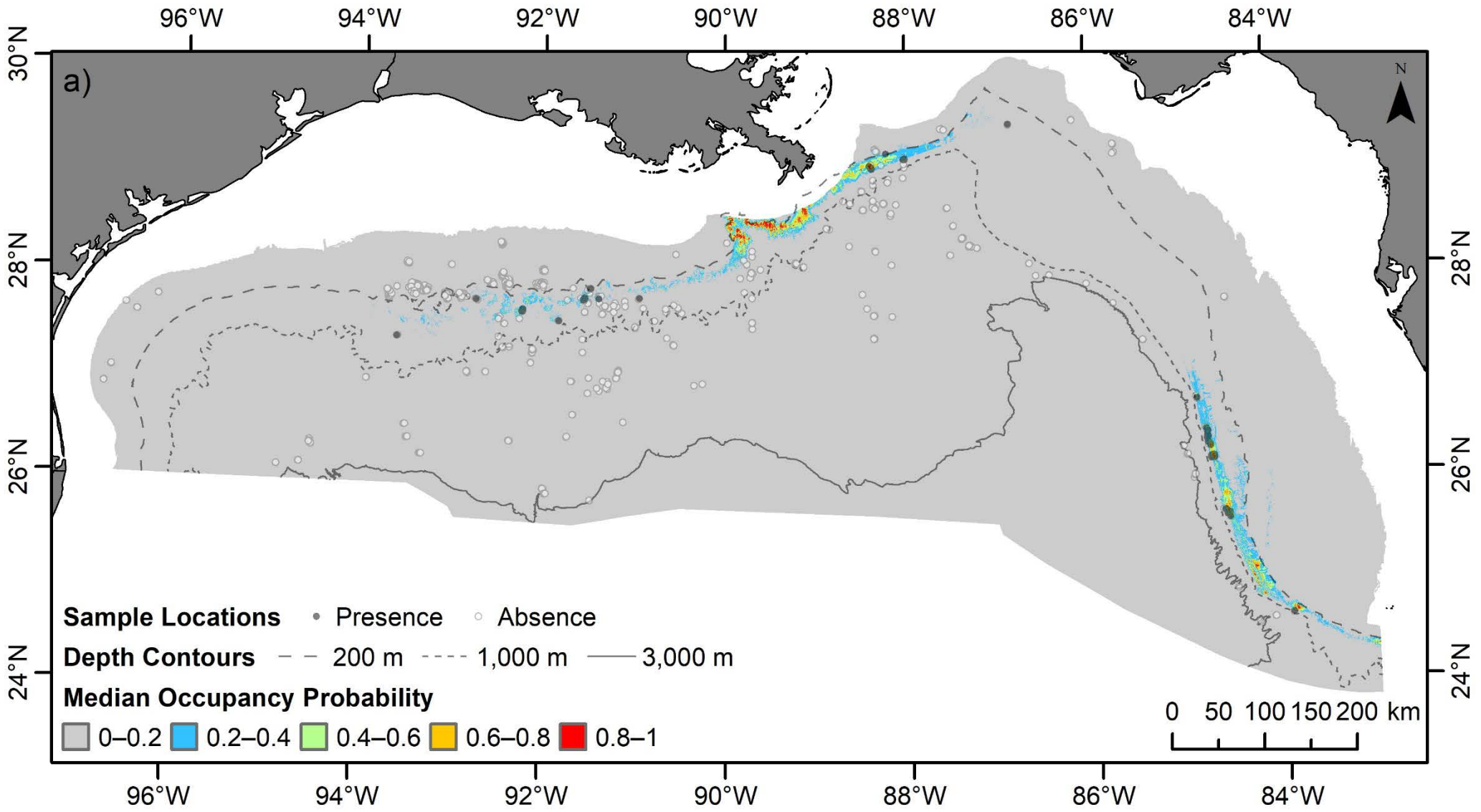
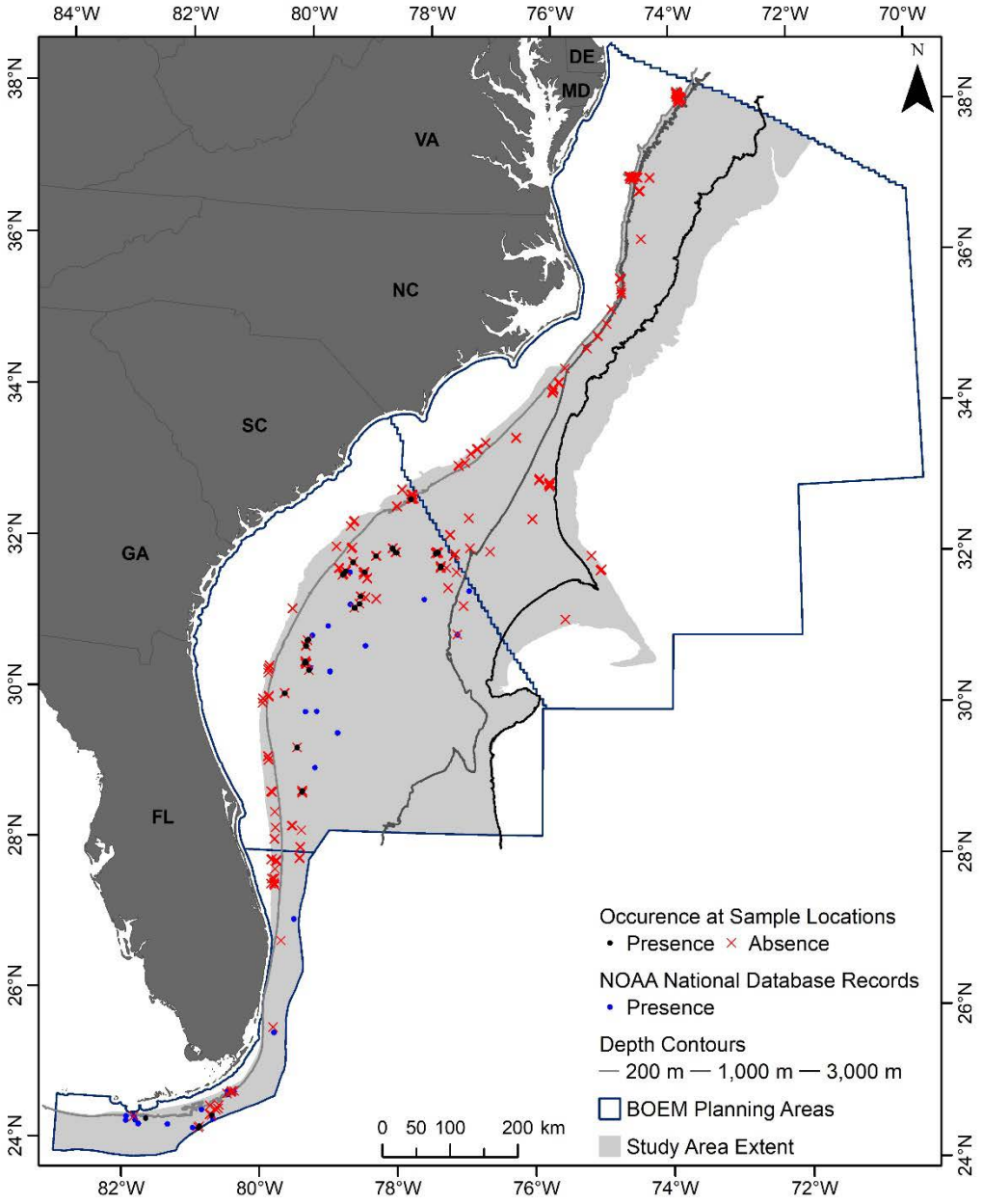


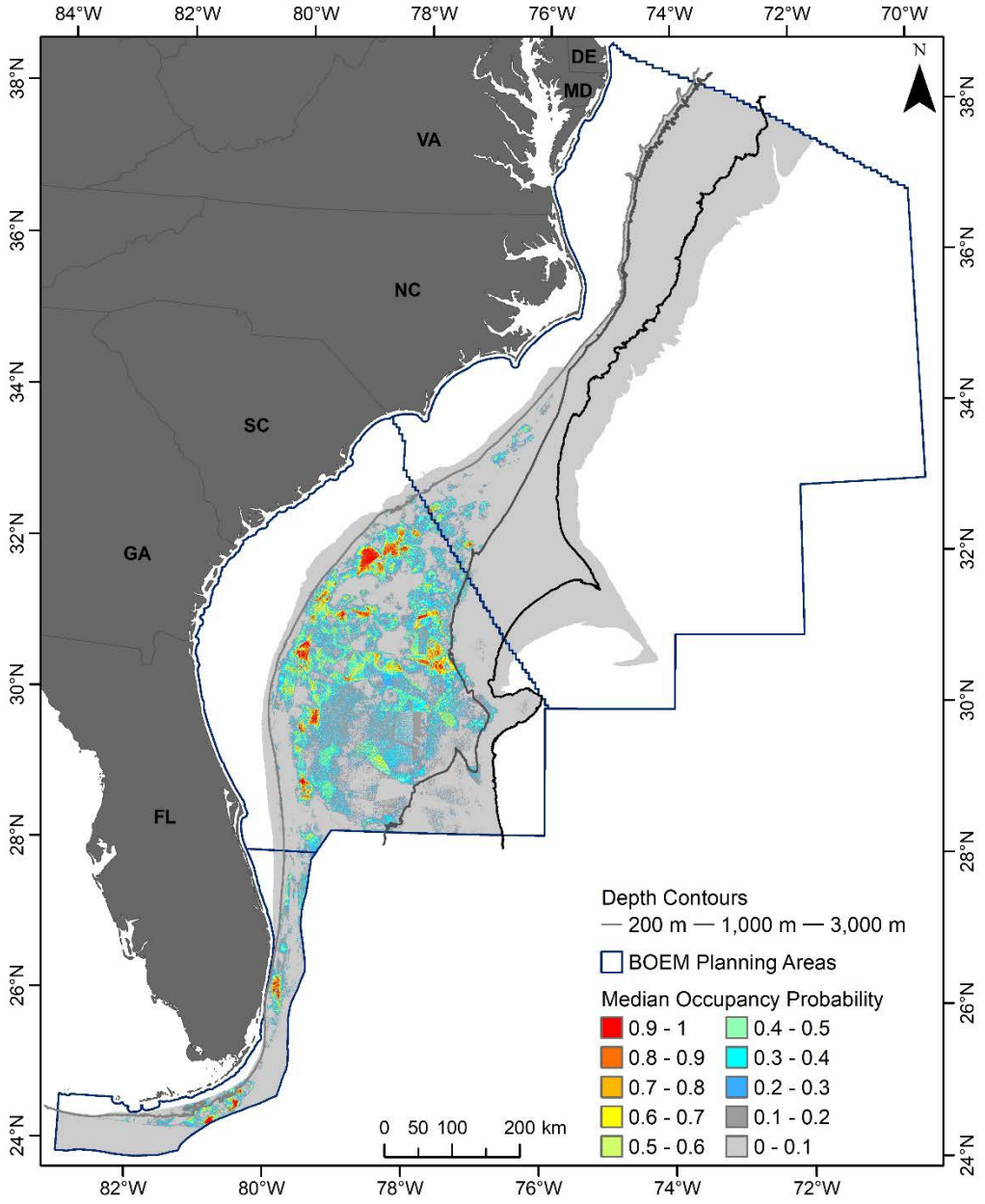


Results - *Leiopathes*

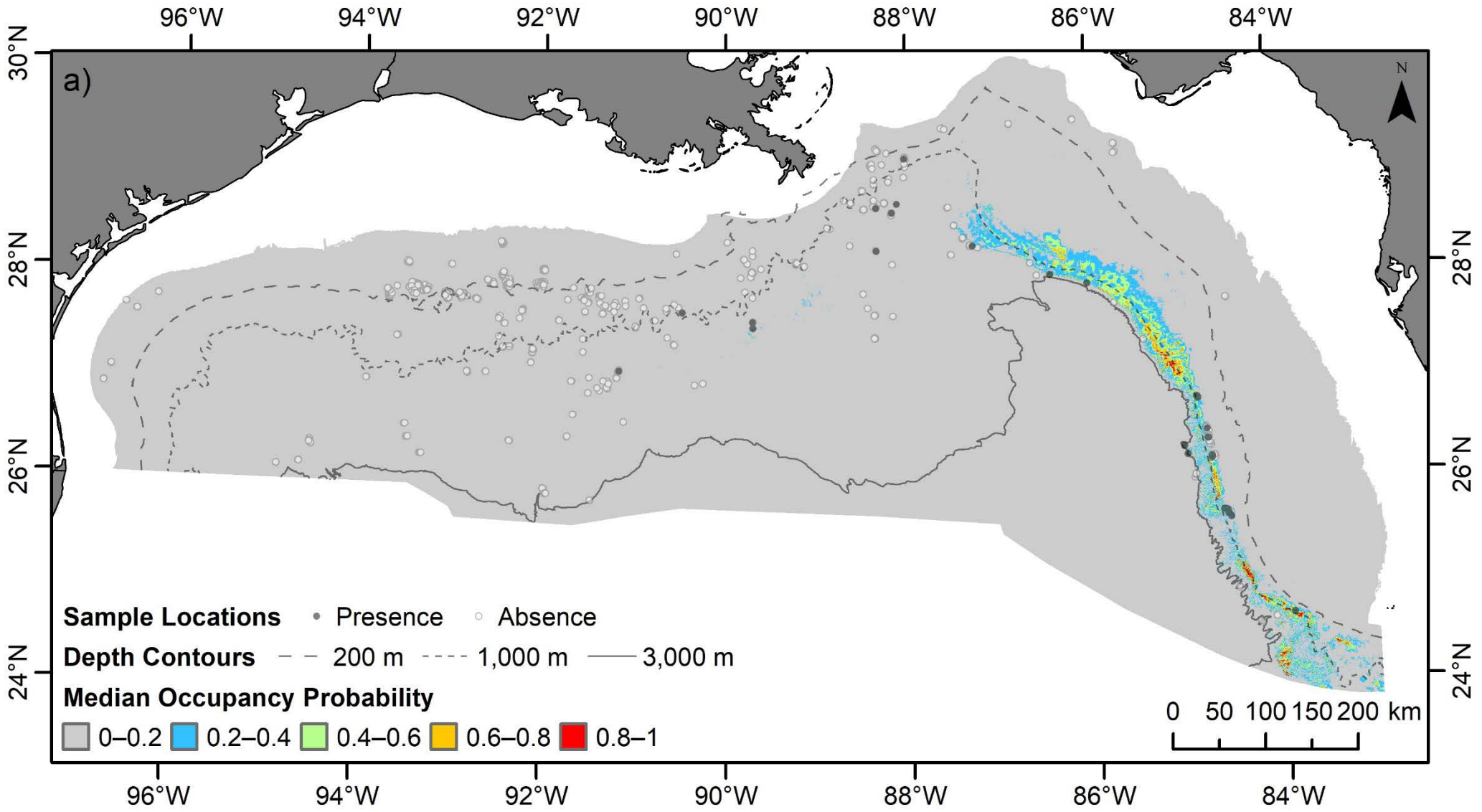


Results - *Leiopathes*

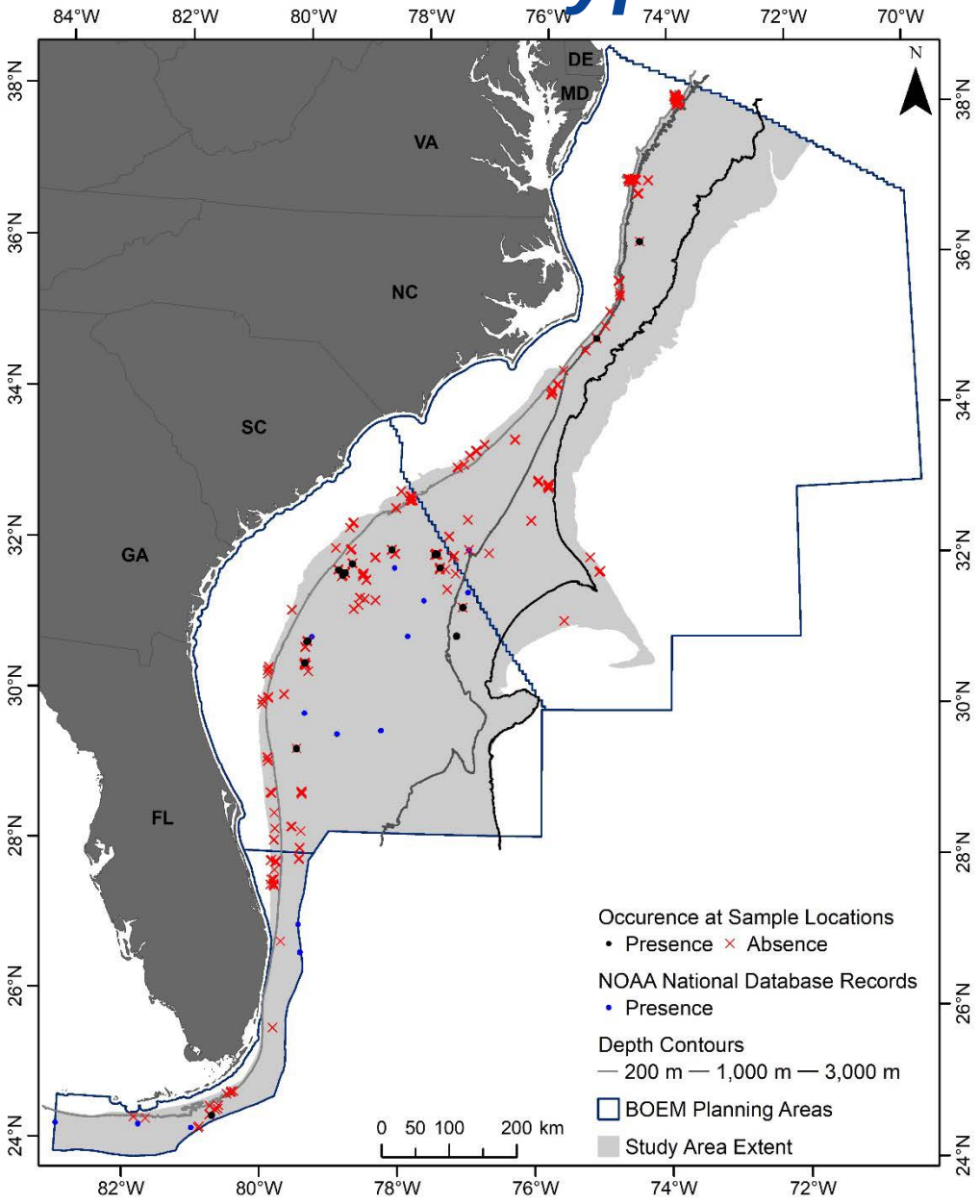


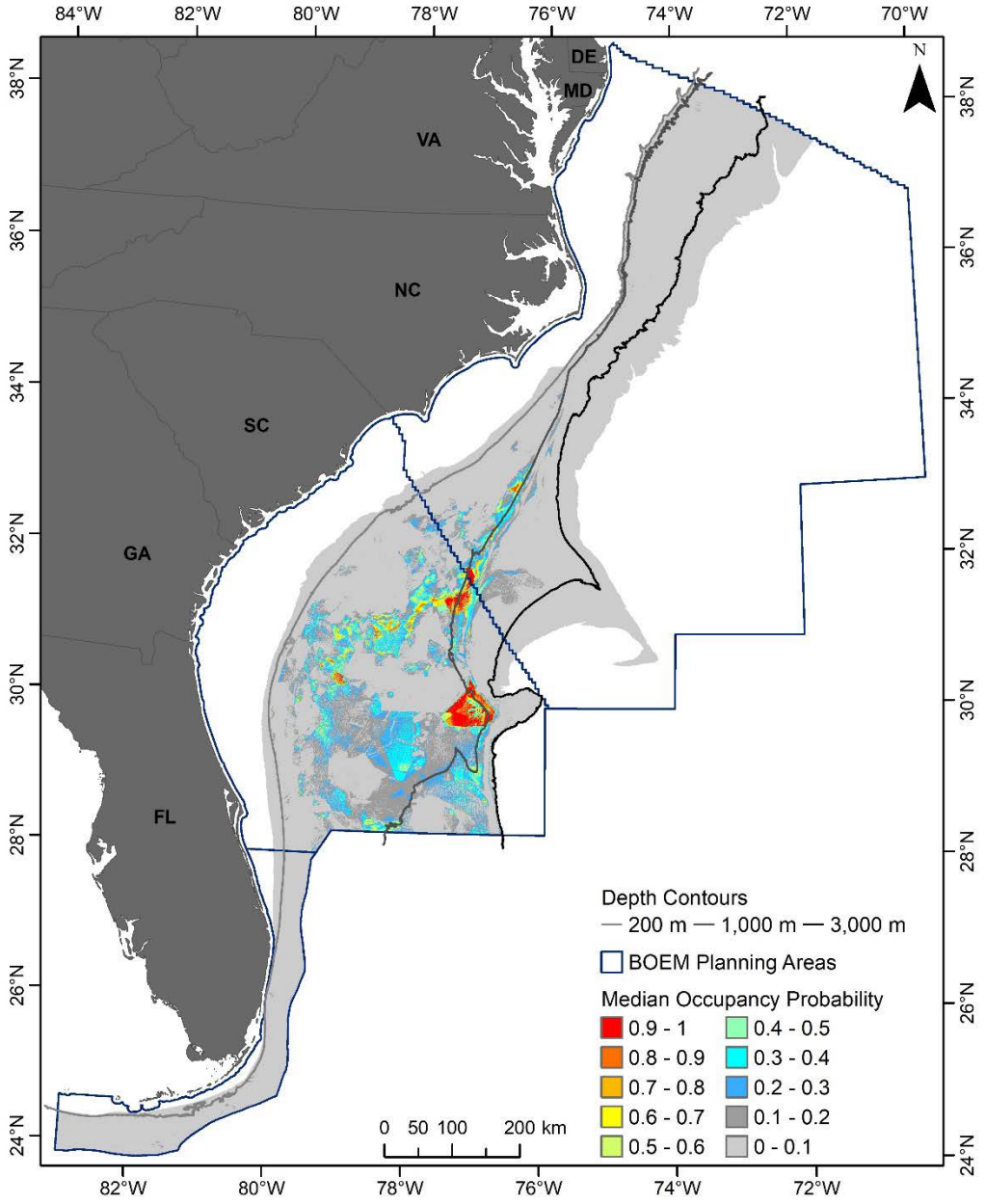


Results - *Bathypathes*

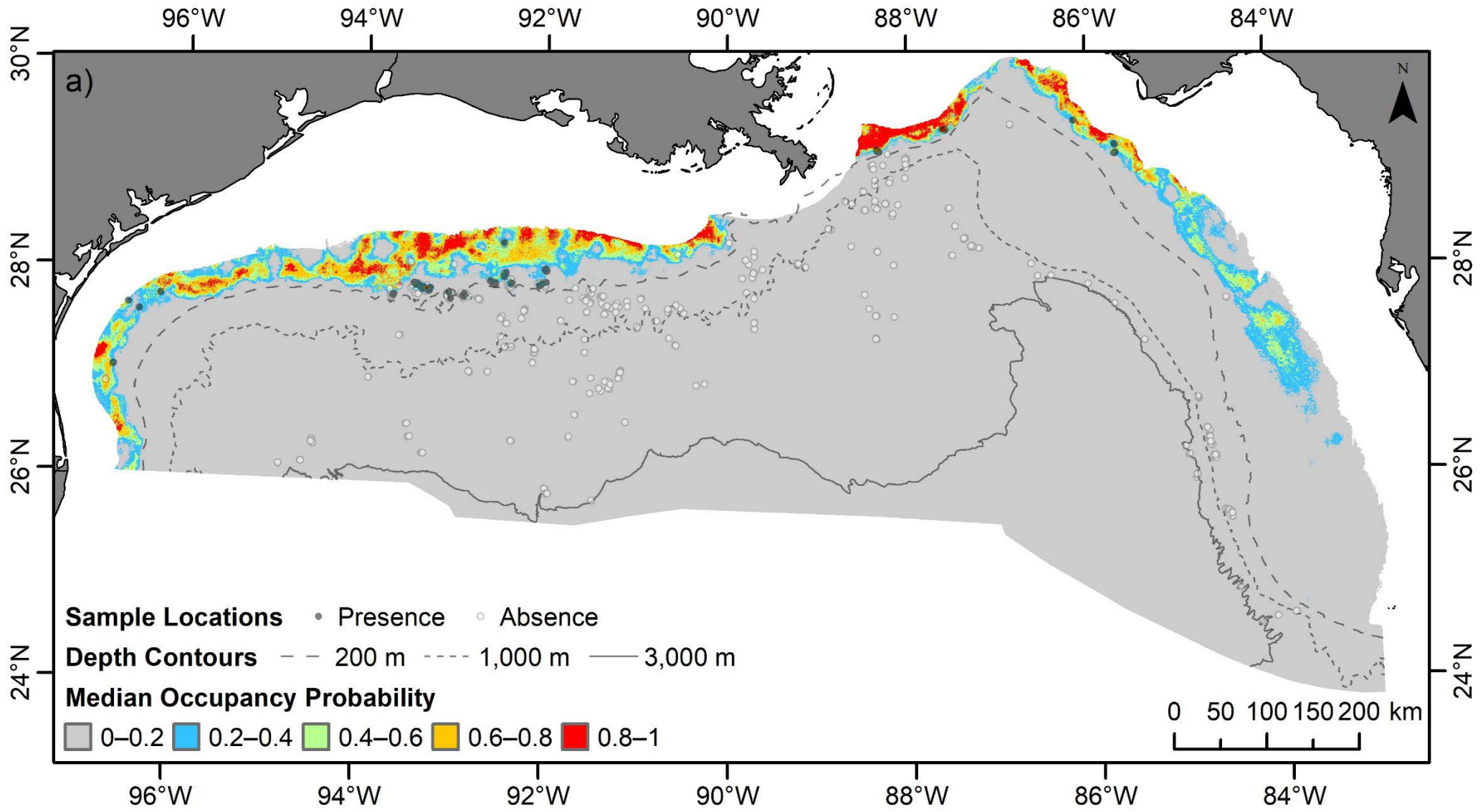


Results - *Bathypathes*

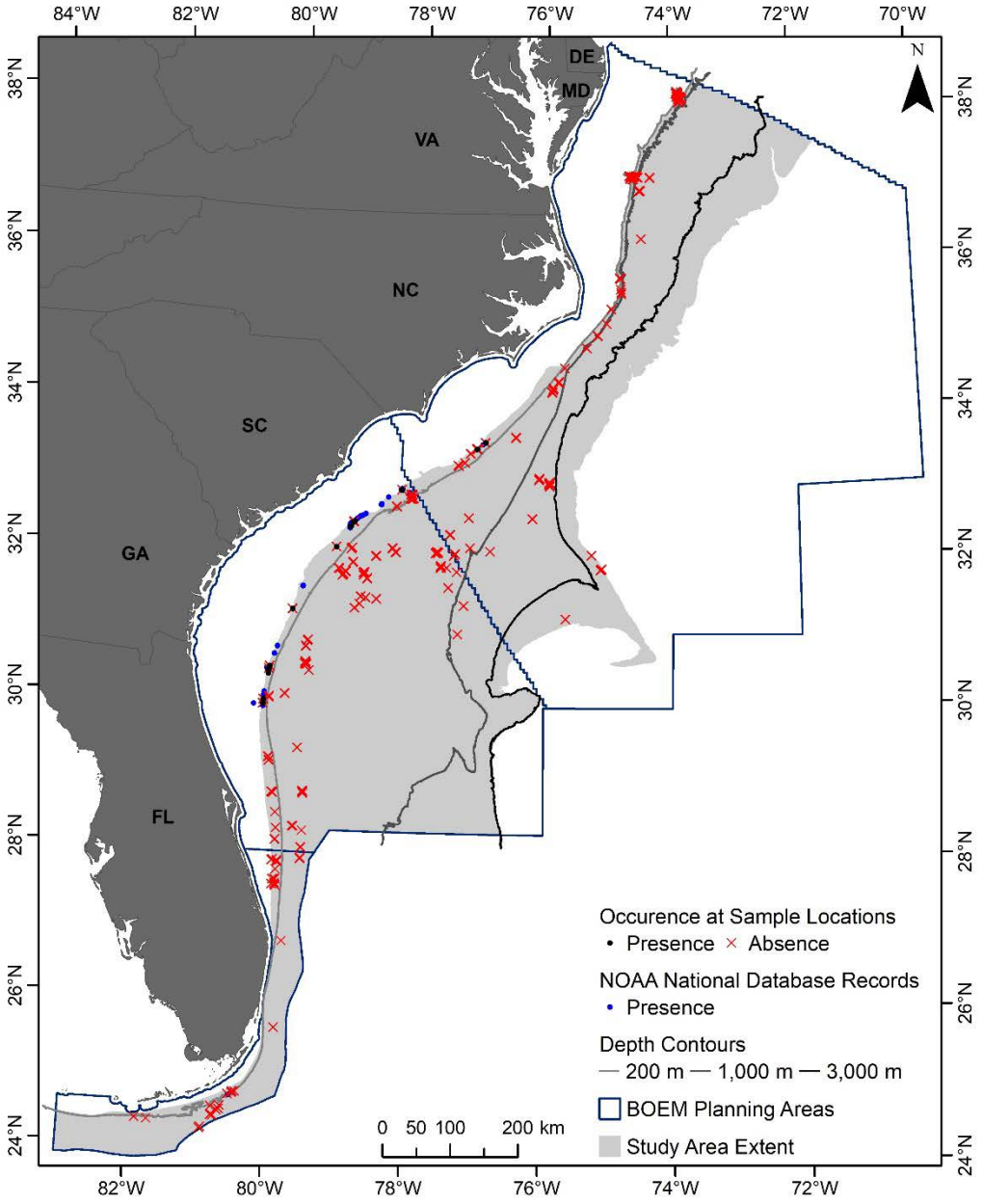


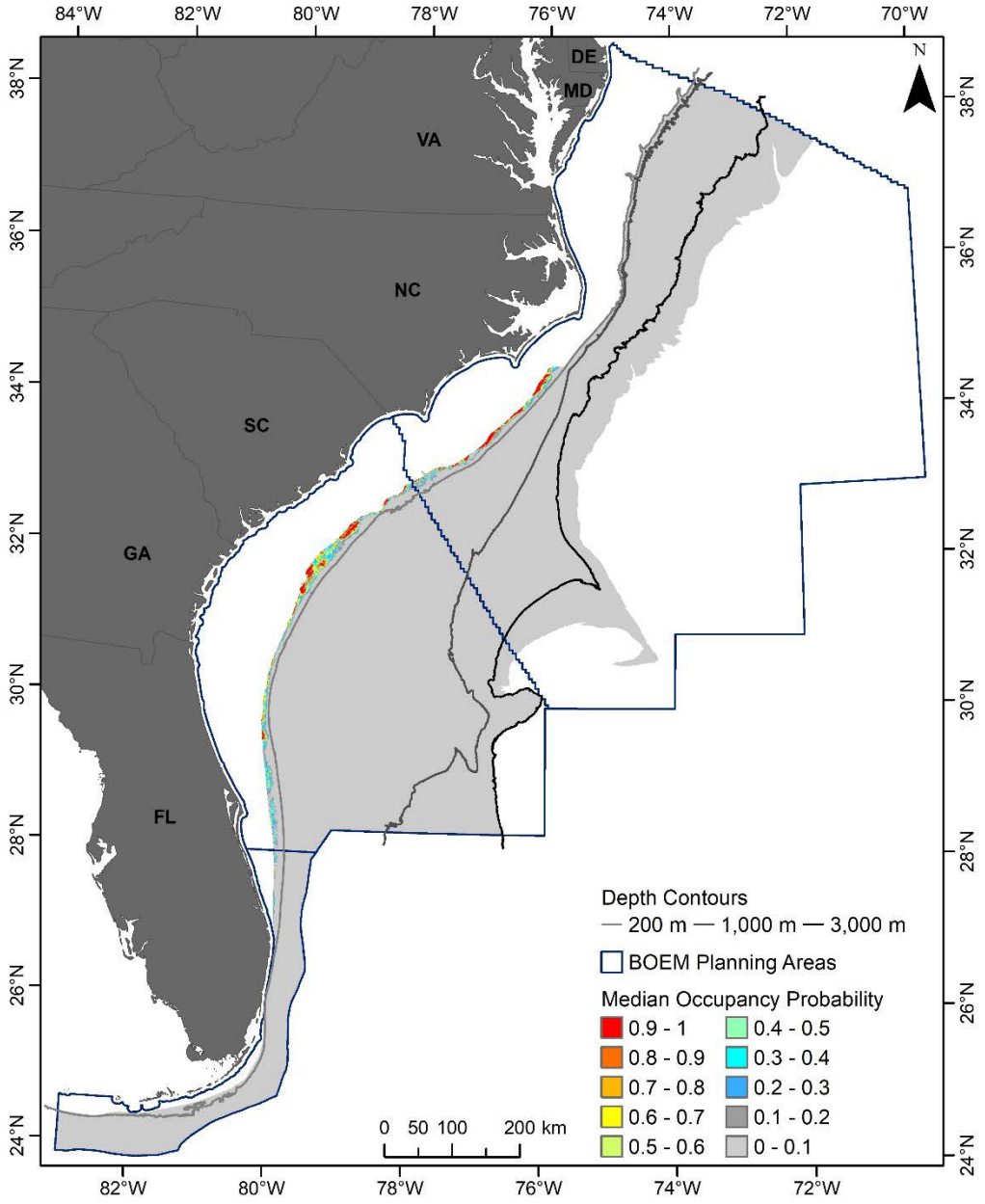


Results - *Muricea*

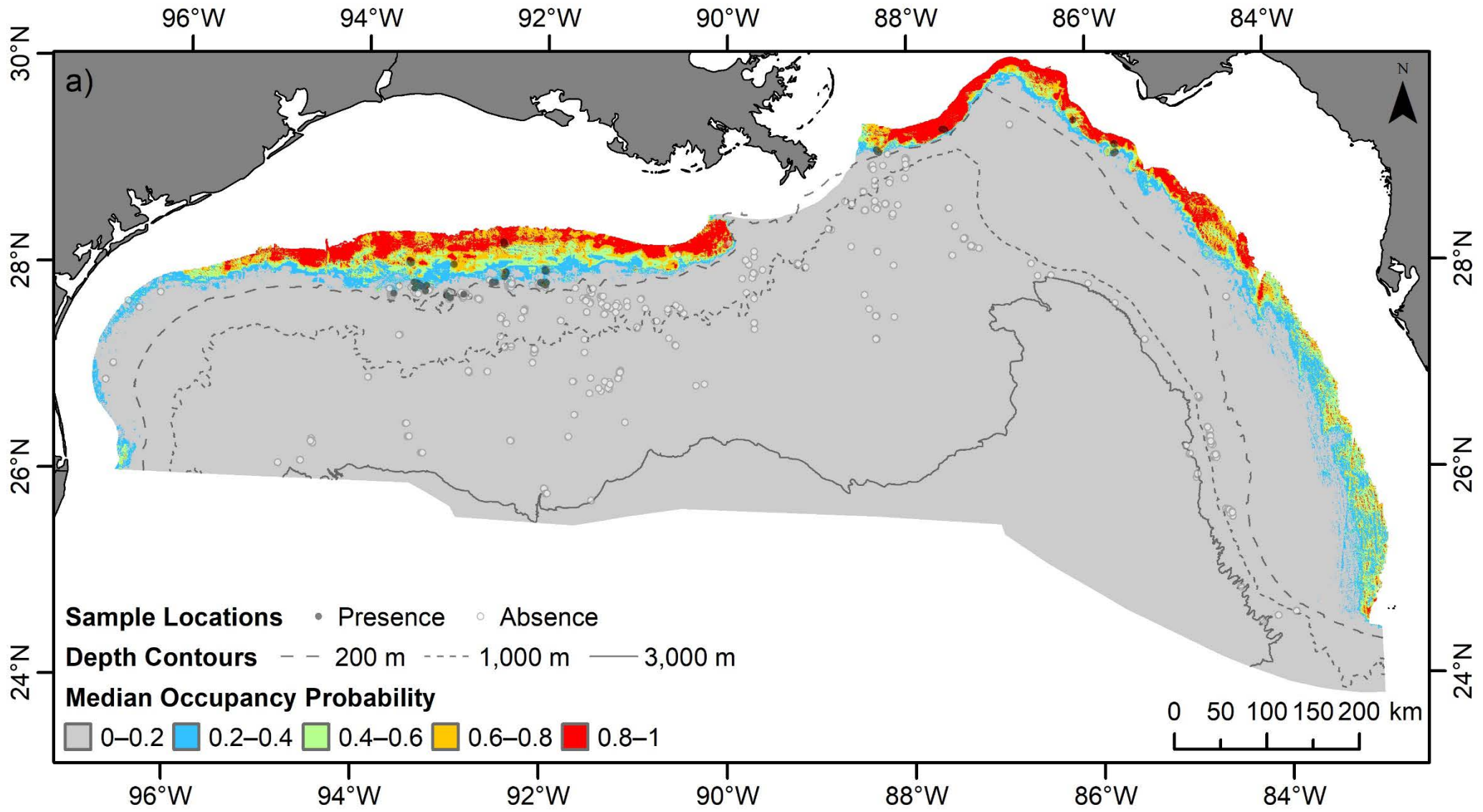


Results - *Muricea*

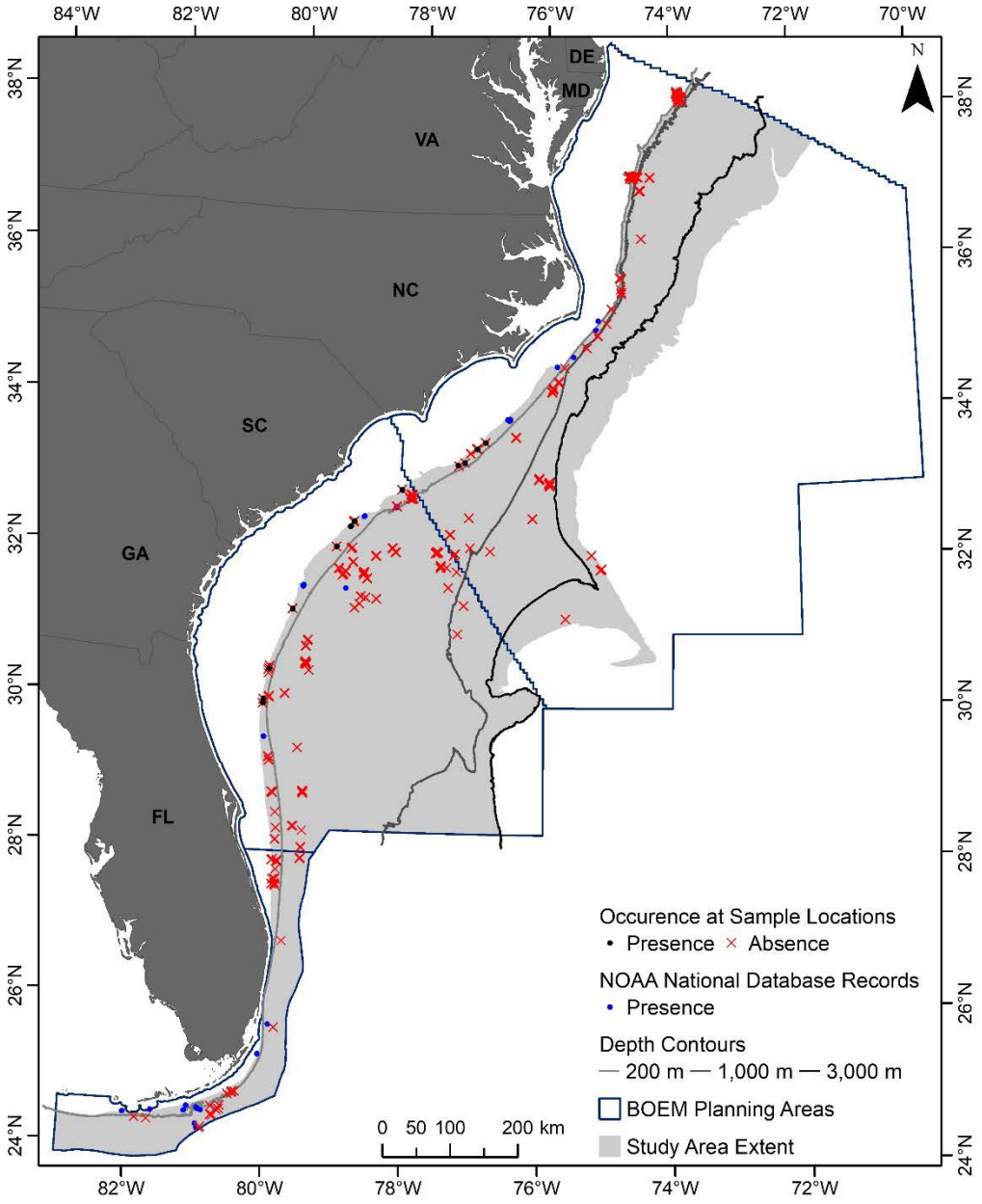


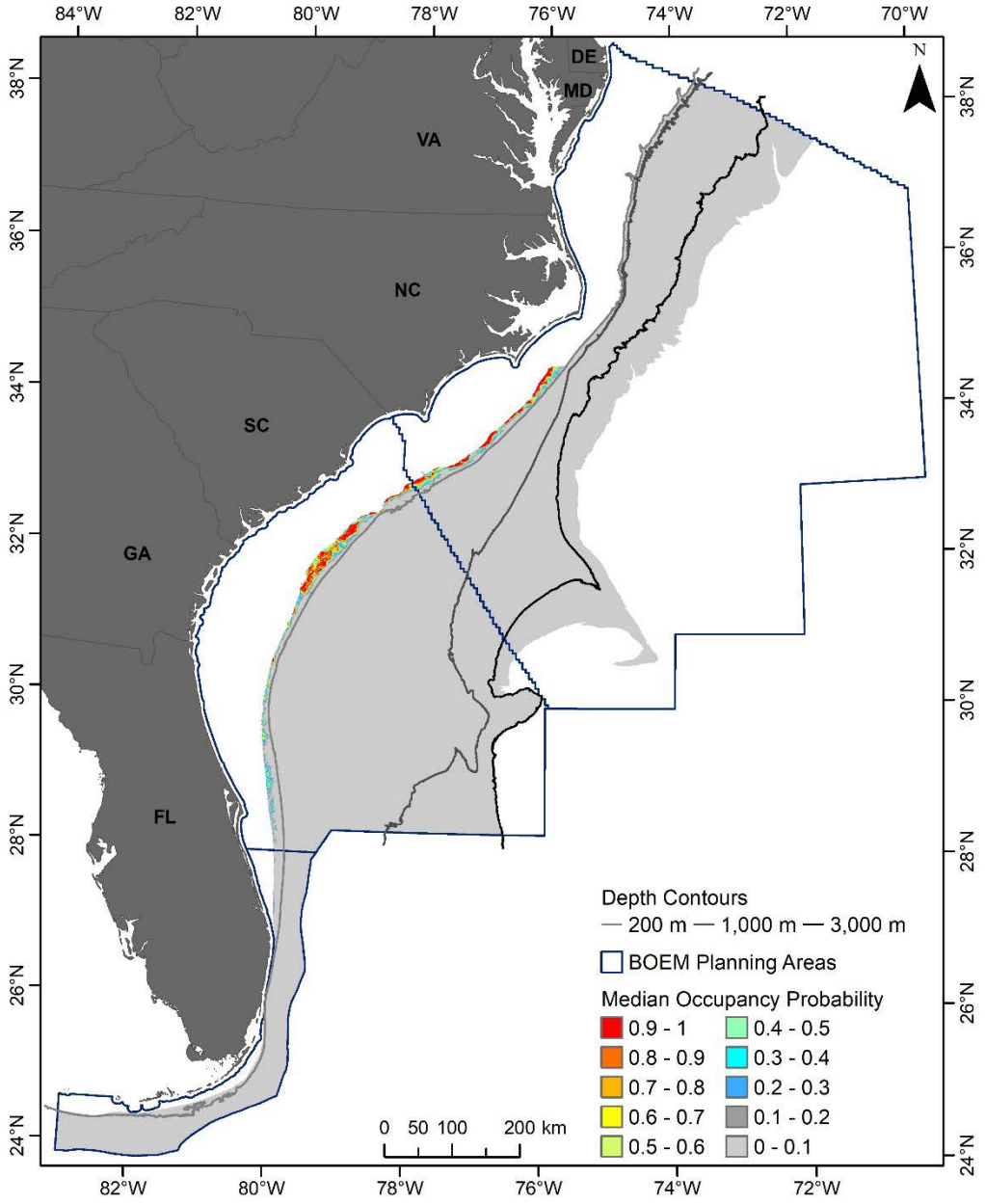


Results - *Thesea*

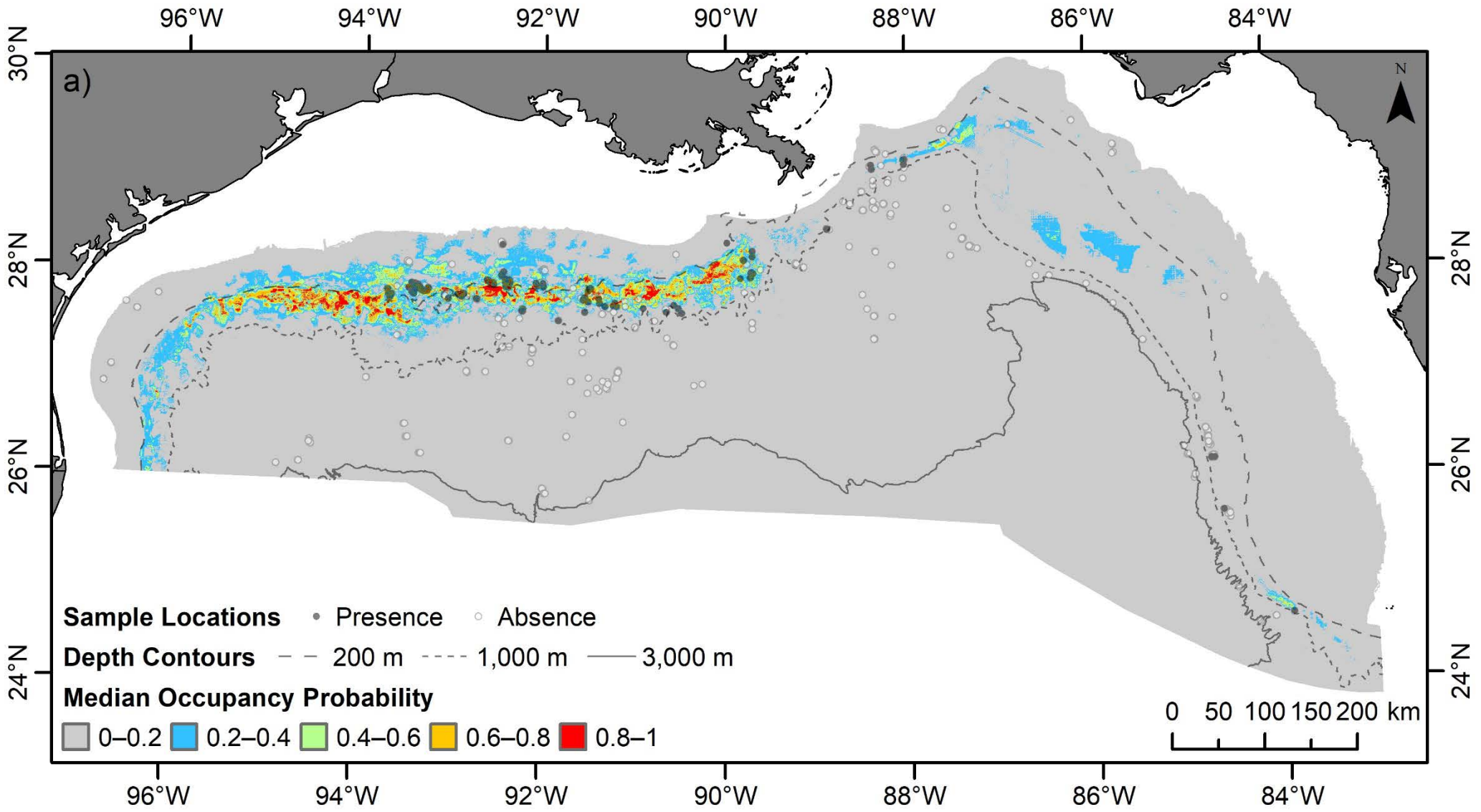


Results - *Thesea*

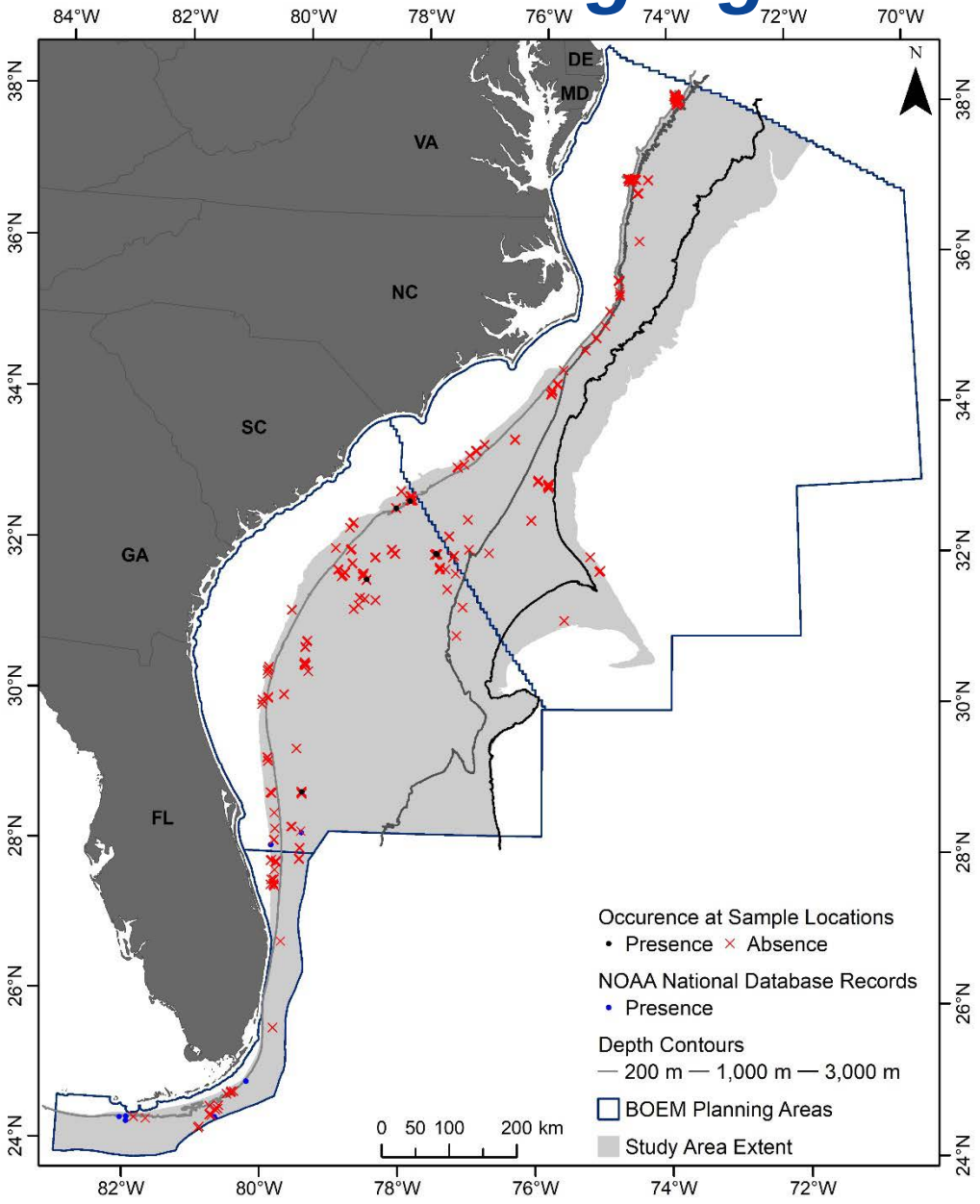


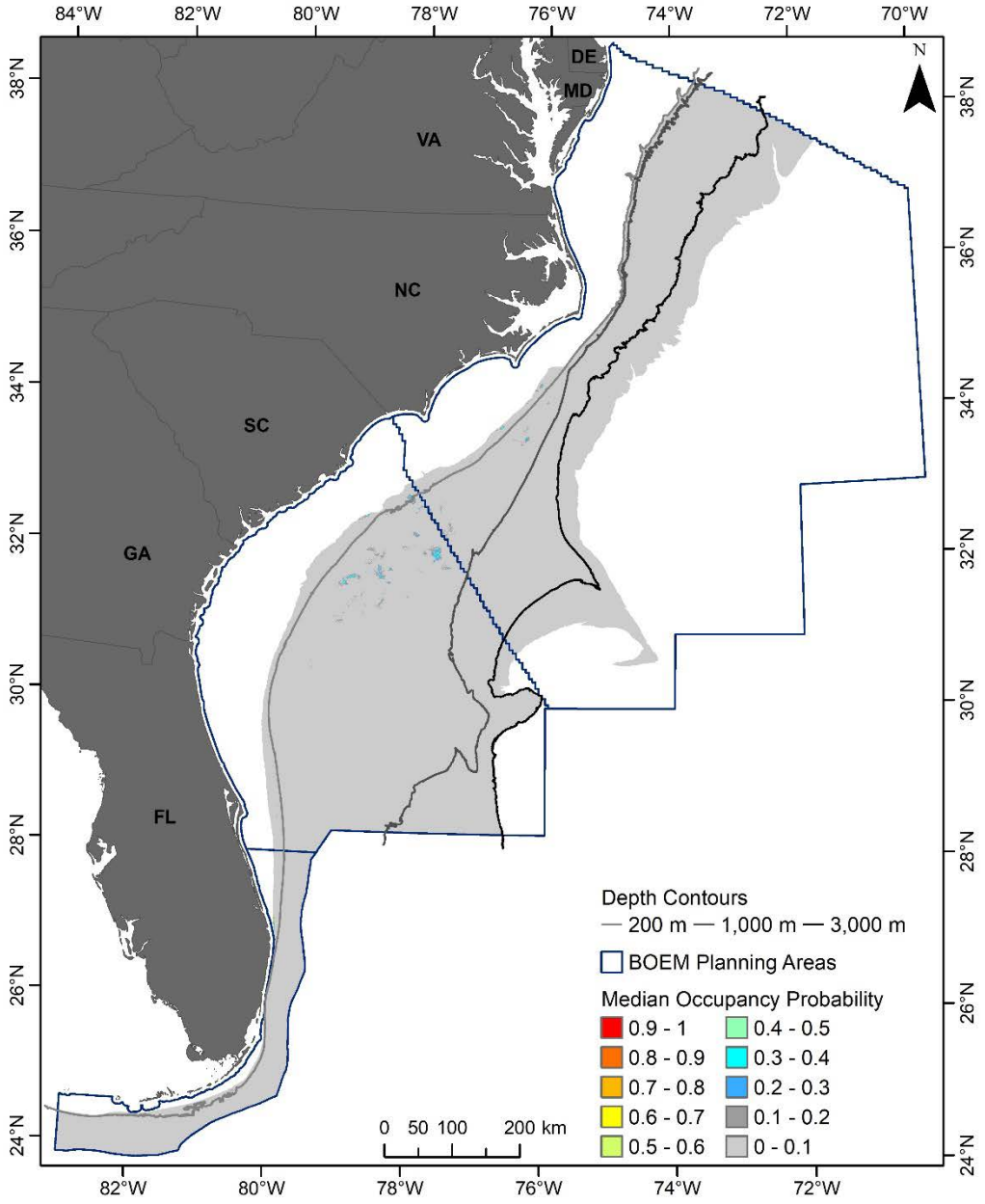


Results - *Callogorgia*

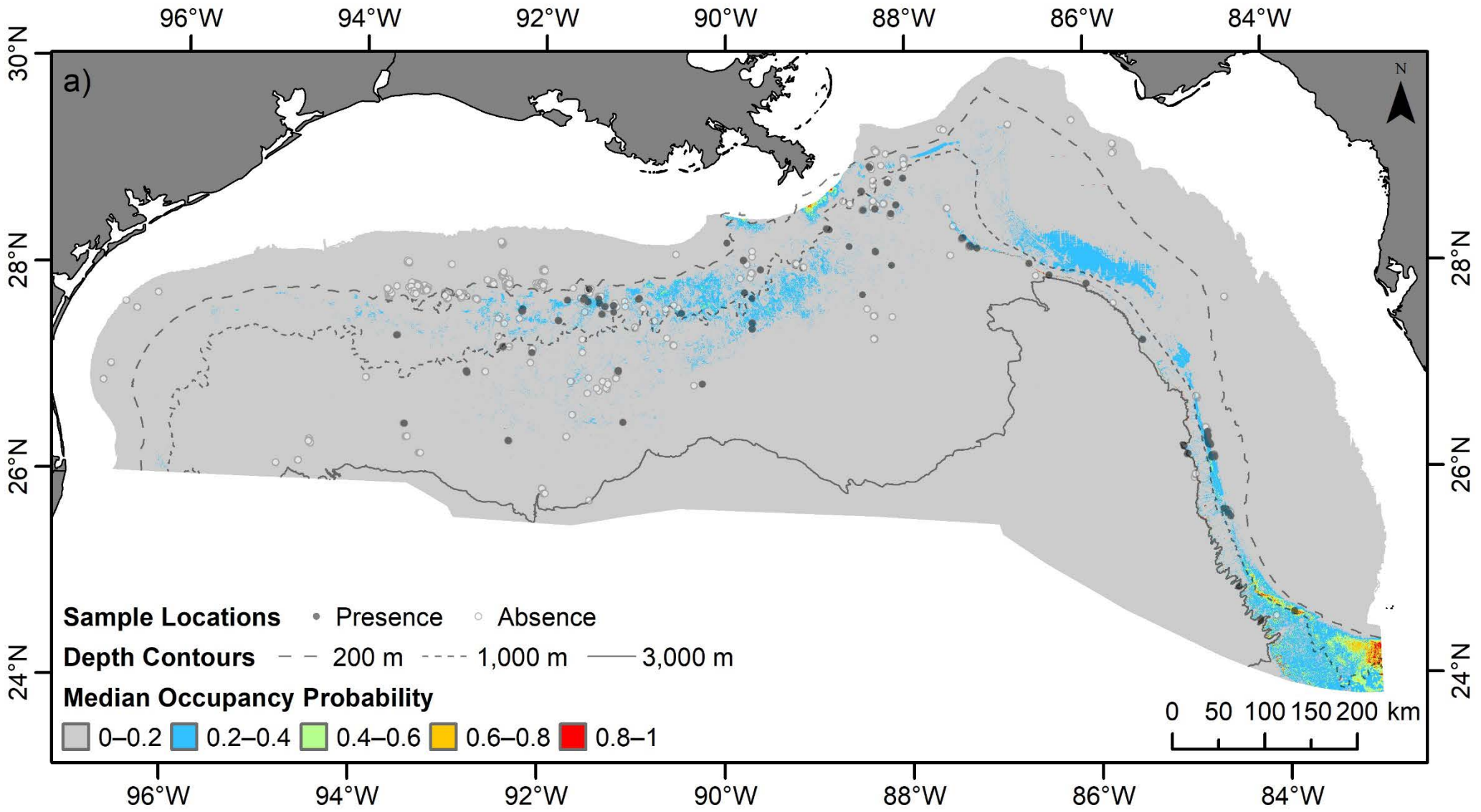


Results - *Callogorgia*

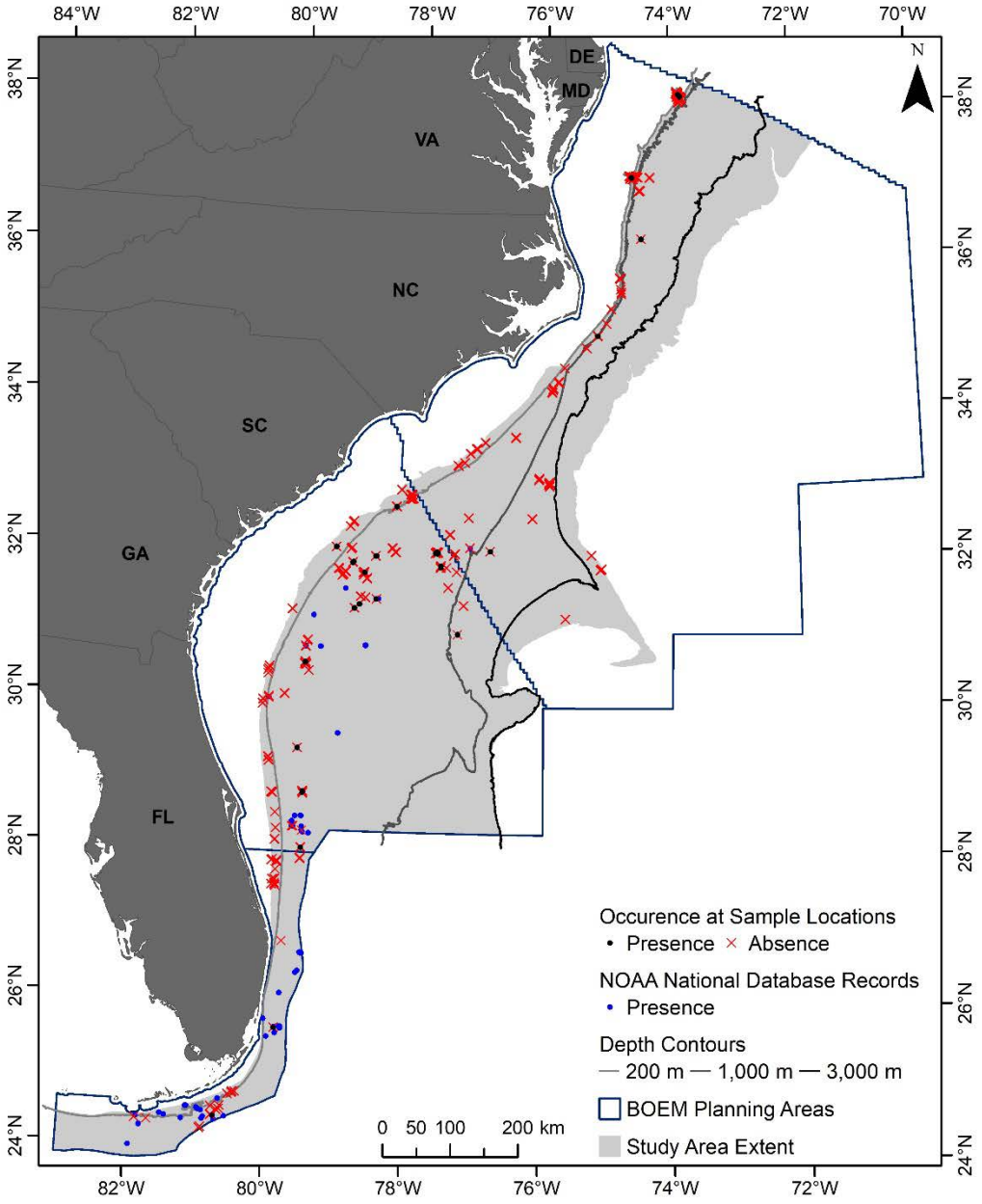


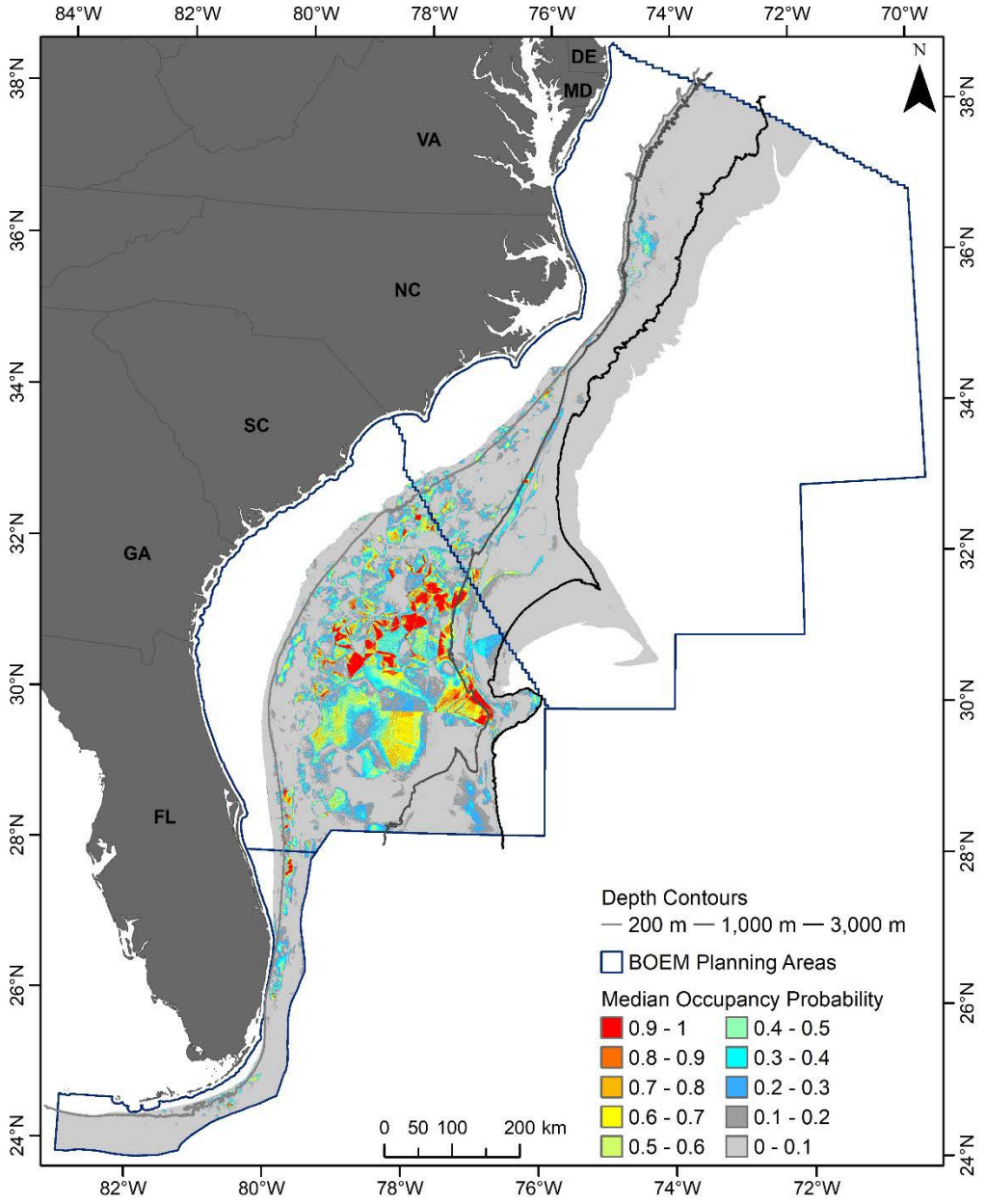


Results - *Paramuricea*



Results - *Paramuricea*





Results – *Genus Richness*

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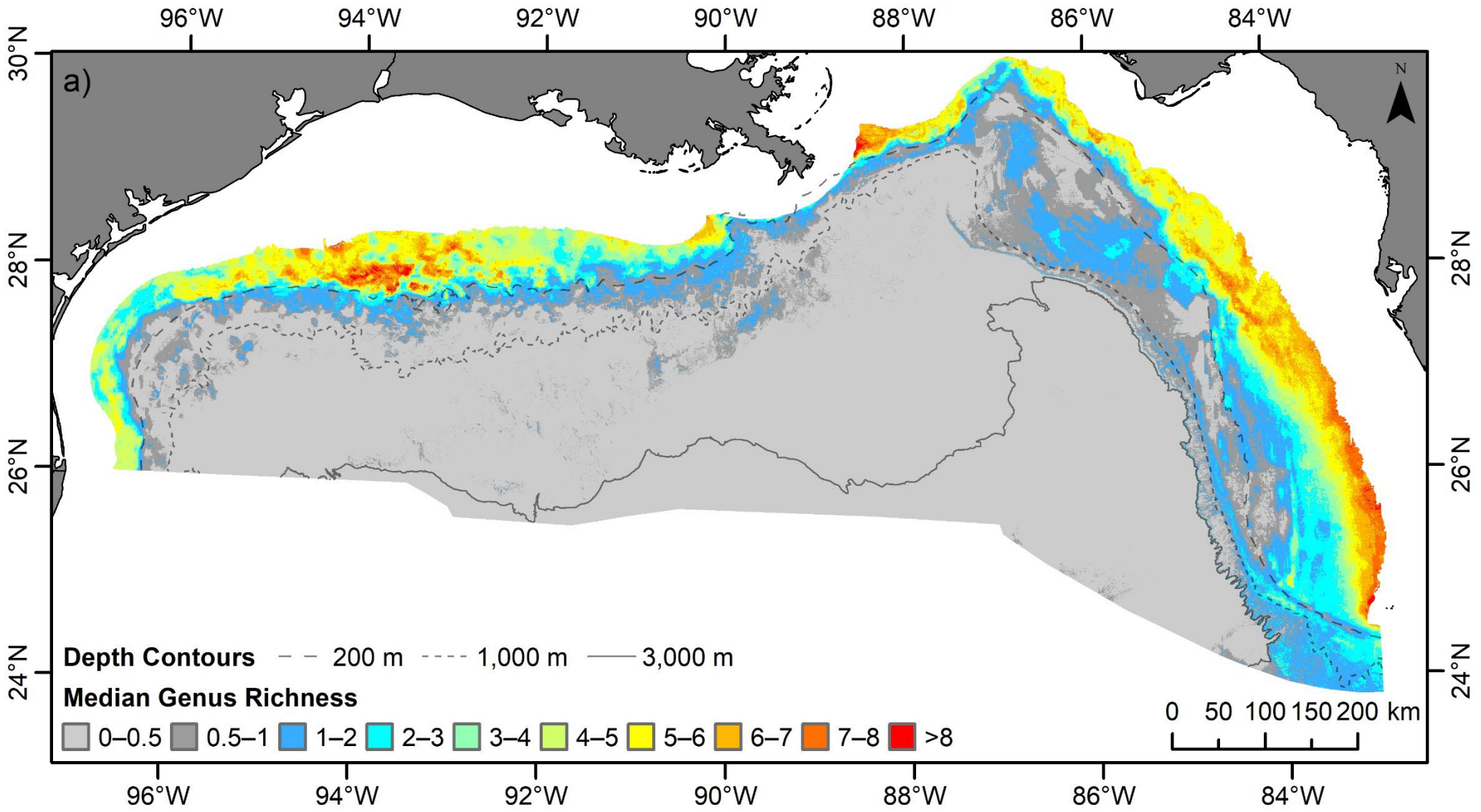
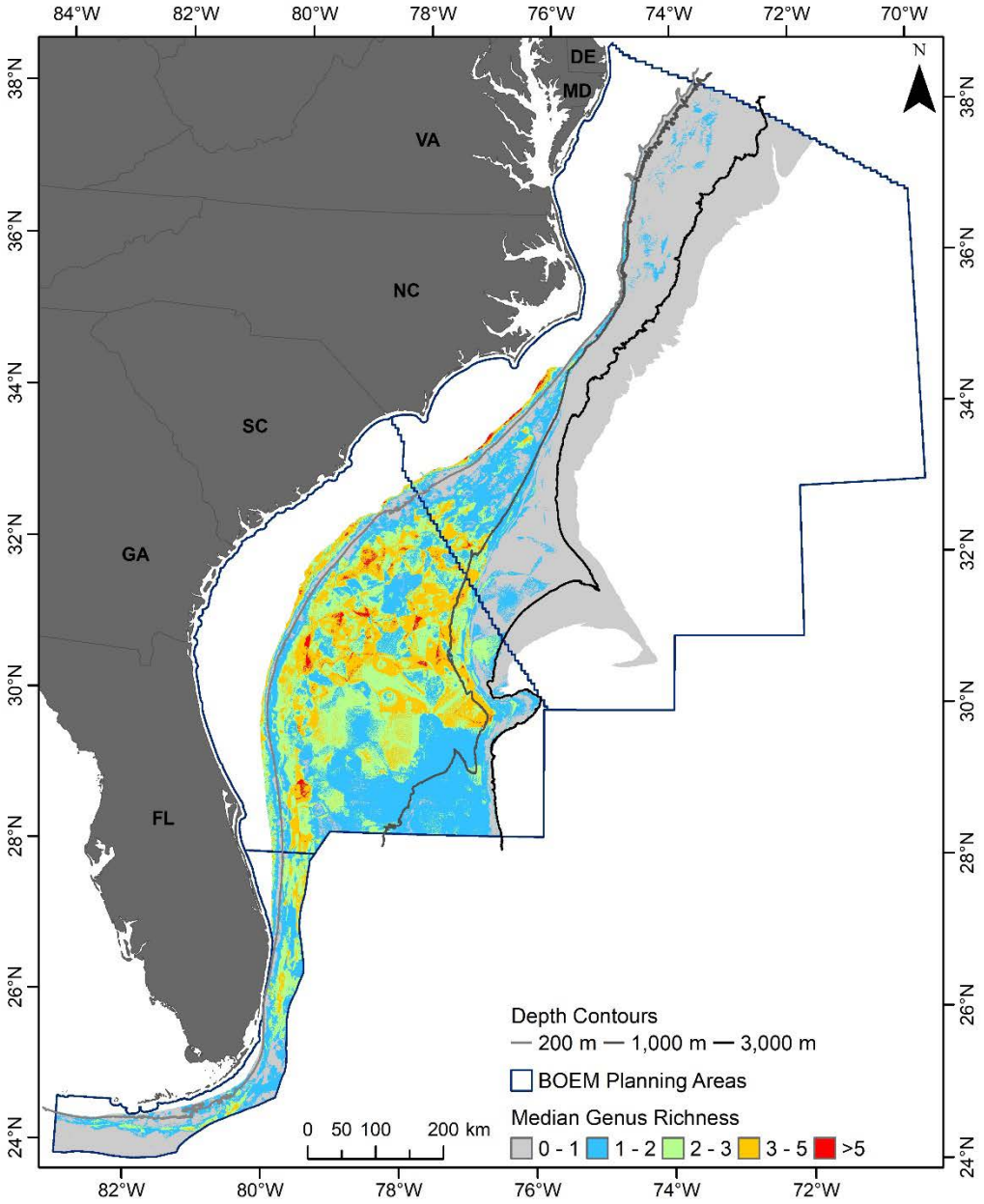
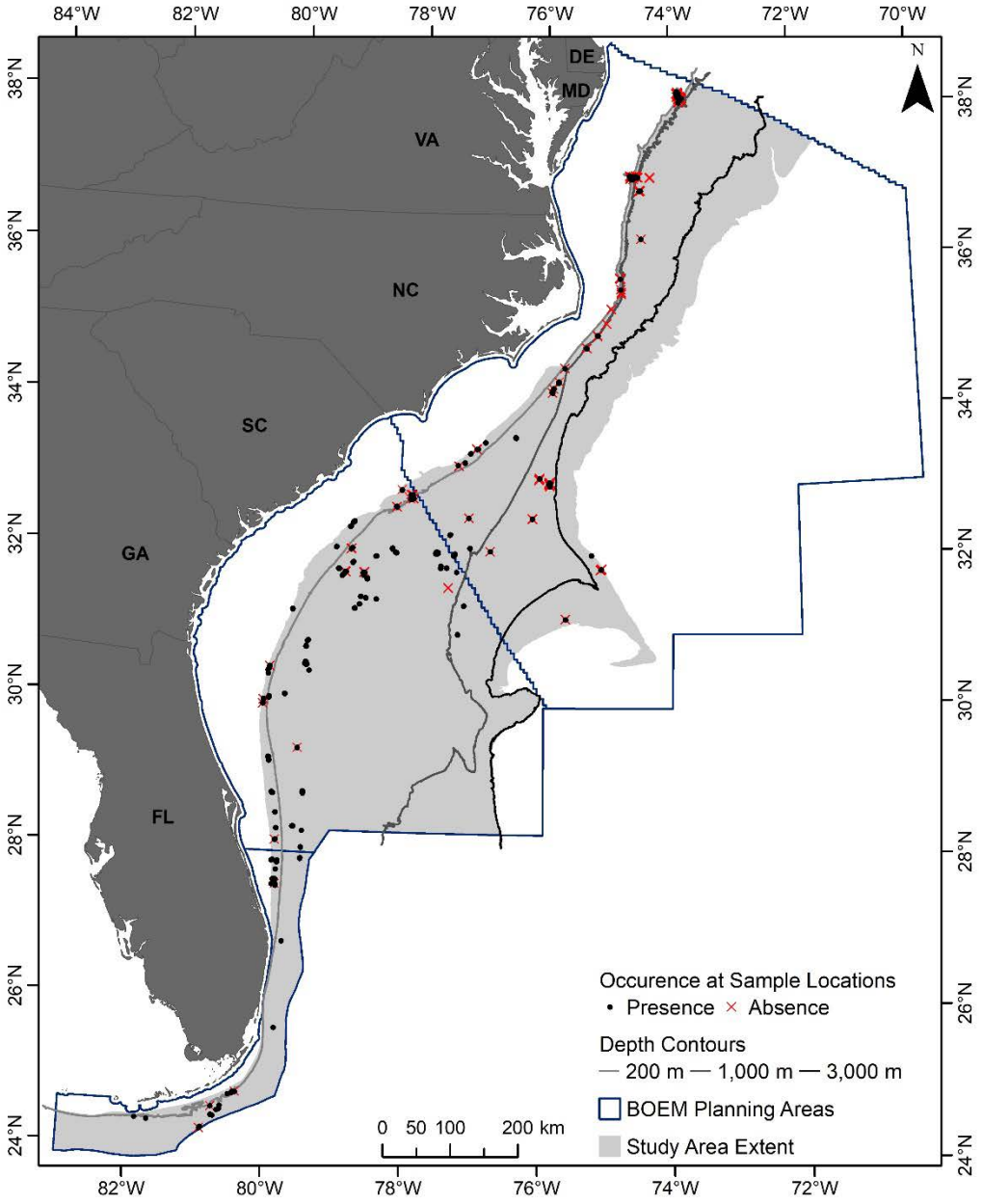
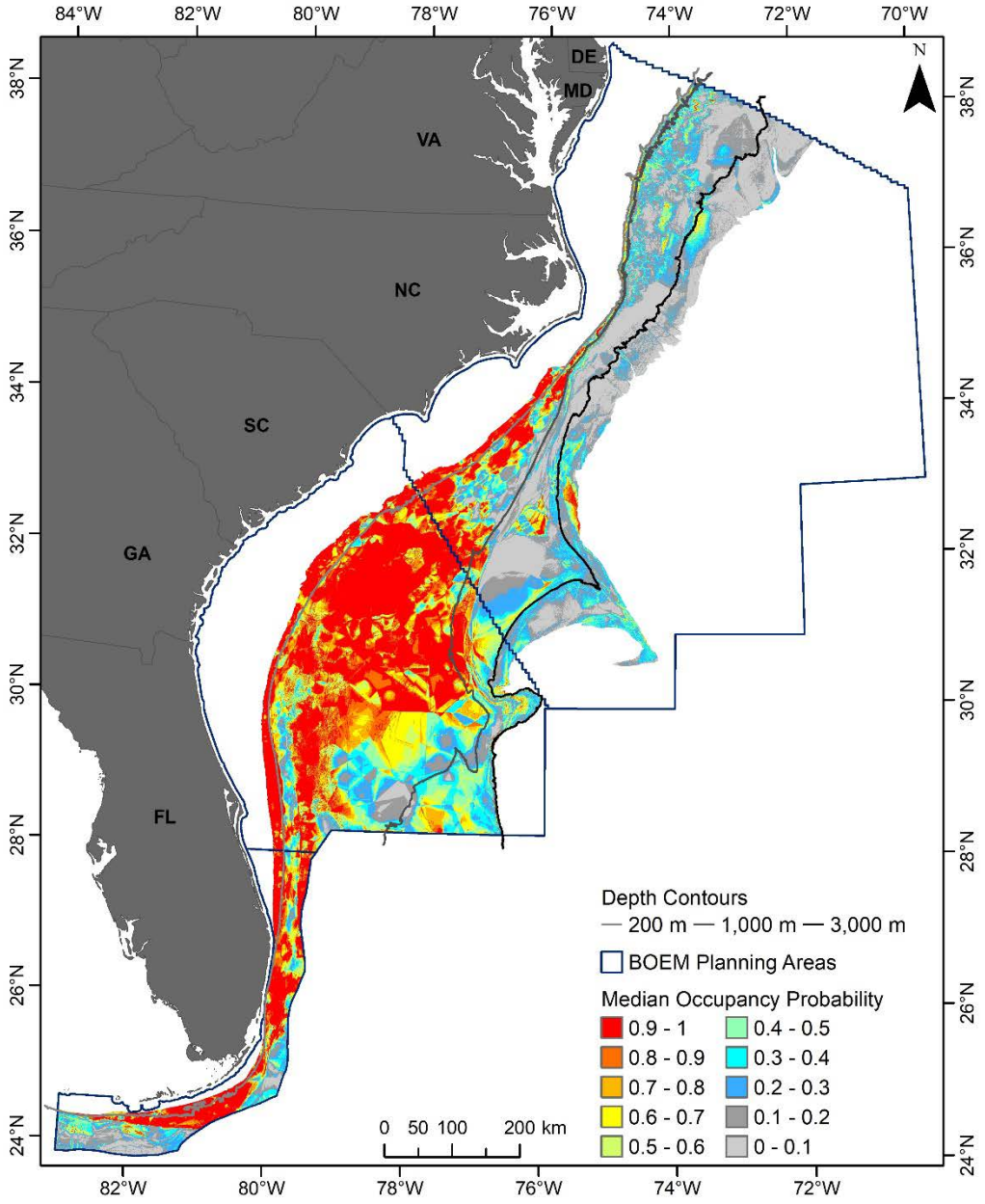


Results - Genus Richness



Results - Hardbottom





Conclusions

- Improvements over existing models for DSCs in region:
  incorporation of absence data with associated sampling effort
  models attempted to distinguish true from false absences
  incorporation of bathymetry data from multibeam mapping
  incorporation of ocean current predictors
  genus level models instead of broad taxonomic groups
  joint modeling of multiple genera

Conclusions

- Limitations:
  - challenges of ‘opportunistic’ compilation of sample data
    - sample dataset unbalanced, not standardized
  - variability in # of observations, replicate samples at each site
  - missing environmental predictor variables
  - spatial scale and resolution

- Recommendation:
  - promote systematic sampling design intended to inform models of
    - abundance/density

Data Products

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- Data products include:
  MS Access database of presence-absence records
  maps and GIS data of model predictions

- Data products can be used to support environmental risk assessments, environmental impact statements, etc. related to review of proposed offshore activities

- Data products can also inform future research and exploration

- More information available at NCCOS project websites

- Upcoming methods paper (Goyert et al.)

Acknowledgments

- NCCOS Deep Coral Ecology Lab, led by Peter Etnoyer

- Many, many survey data providers

- Multibeam bathymetry provided by Jason Chaytor (USGS), Scott Harris (College of Charleston)

- Surficial sediment data layers provided by Chris Jenkins (University of Colorado)

- Feedback on modeling methods from SAFMC Scientific and Statistical Committee

- Feedback on maps of model predictions from:
  Martha Nizinski (NOAA), Sandra Brooke (FSU), Erik Cordes (Temple)

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Questions?

For more information, see:

https://coastalscience.noaa.gov/project/characterizing-spatial-distributions-of-deep-sea-corals-and-chemosynthetic-communities-in-the-u-s-gulf-of-mexico/

https://coastalscience.noaa.gov/project/characterizing-spatial-distributions-of-deep-sea-corals-and-hardbottom-habitats-in-the-u-s-southeast-atlantic/

or contact: Matthew Poti, matthew.poti@noaa.gov

Staff updates

- 3 remaining indicator review calls

3 remaining indicator review calls

- So far, we've held external review calls for:
  - Grasslands & savannas
  - Gulf coral & hardbottom
- 3 calls remaining:
  - Forest birds
    - Thursday, March 21st @ 2 pm ET/1 pm CT: Register via Zoom
  - Landscape condition
    - Tuesday, March 26th @ 10 am ET/9 am CT: Register via Zoom
    - Wednesday, March 27th @ 2 pm ET/1 pm CT: Register via Zoom

How to get involved in SECAS

- Sign up for the SECAS newsletter

  secassoutheast.org

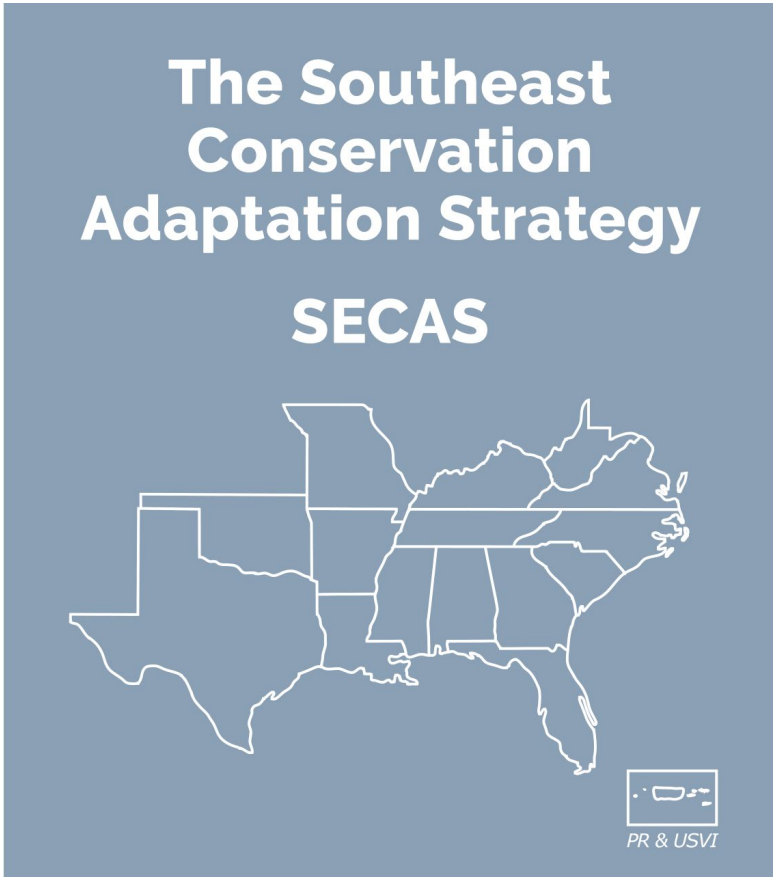
- Connect with SECAS staff or partners

  secassoutheast.org/staff

  secassoutheast.org/partners

- Explore the Southeast Conservation Blueprint

  secassoutheast.org/blueprint




Questions?