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# Characterizing Potential Distributions of Deep-Sea Corals and Sponges Offshore the US West Coast through Spatial Predictive Modeling

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1. CSS, Inc., USA
2. NOAA, NOS, National Centers for Coastal Ocean Science (NCCOS), USA
3. NOAA, NMFS, Southwest Fisheries Science Center, USA
4 University of California, Santa Cruz, USA
5. NOAA, NMFS, Northwest Fisheries Science Center, USA
6. Lynker Technologies under contract to NOAA, NMFS, Northwest Fisheries Science Center, USA
7. BOEM, Pacific OCS Region, USA
8. NOAA, NMFS, Deep Sea Coral Research and Technology Program, USA

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BOEM Bureau of Ocean Energy Management

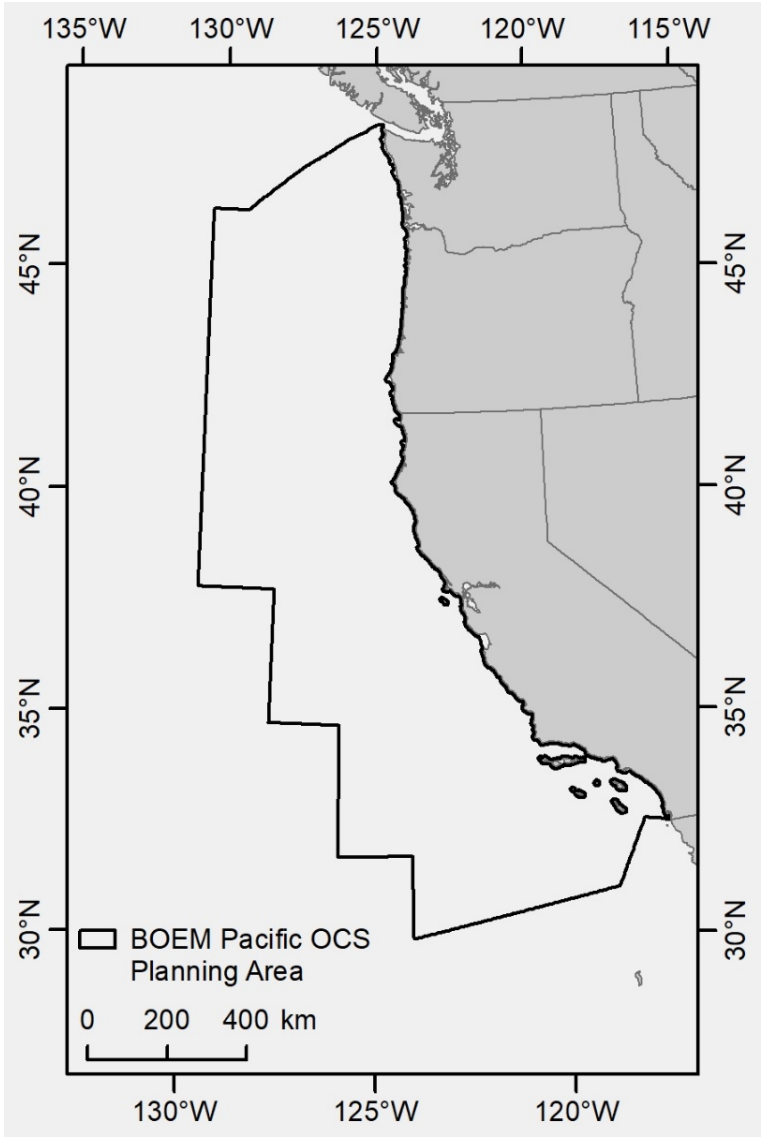
SCIENCE SERVING COASTAL COMMUNITIES

# Background

- Pacific OCS Region:
  BOEM oversees responsible development of energy and mineral resources for an extensive area offshore California, Oregon, Washington

Credit: Sarah Henkel, Oregon State University

Credit: NOAA SWFSC, Advanced Survey Technologies Group



# Objectives

- Compile observations of deep-sea corals and sponges (DSC&S)
- Identify potential environmental covariates
- Predict and map spatial patterns of habitat suitability
- Evaluate model performance
- Support management and exploration priorities

# Occurrence Data

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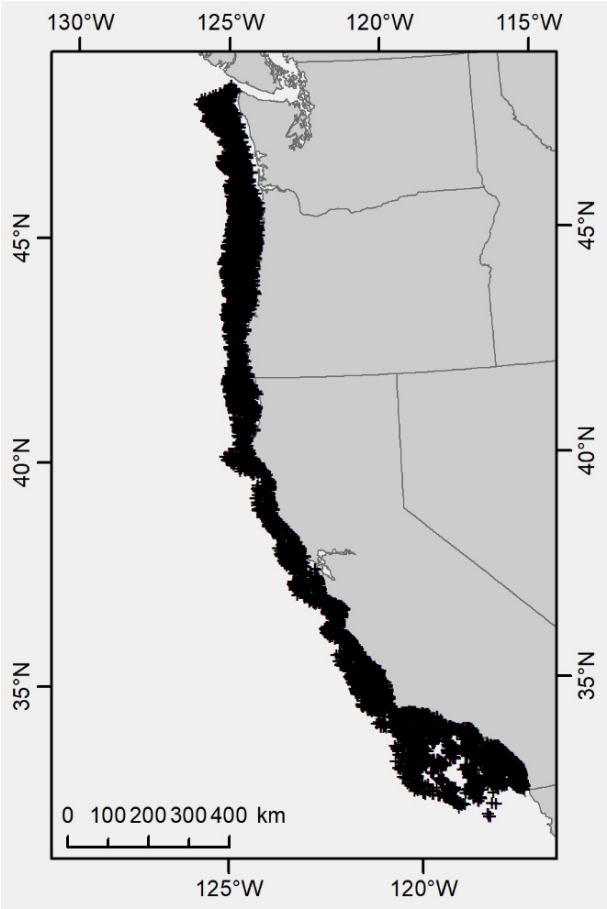
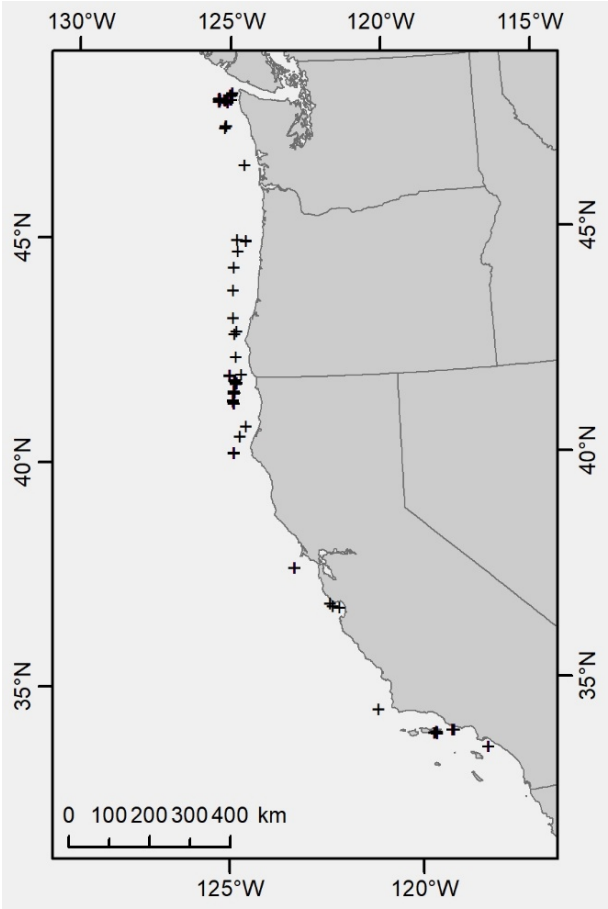
- NOAA DSCRTP National Database

## DSC&S Presences




QA/QC
Subset by Taxonomy
Spatial Thinning

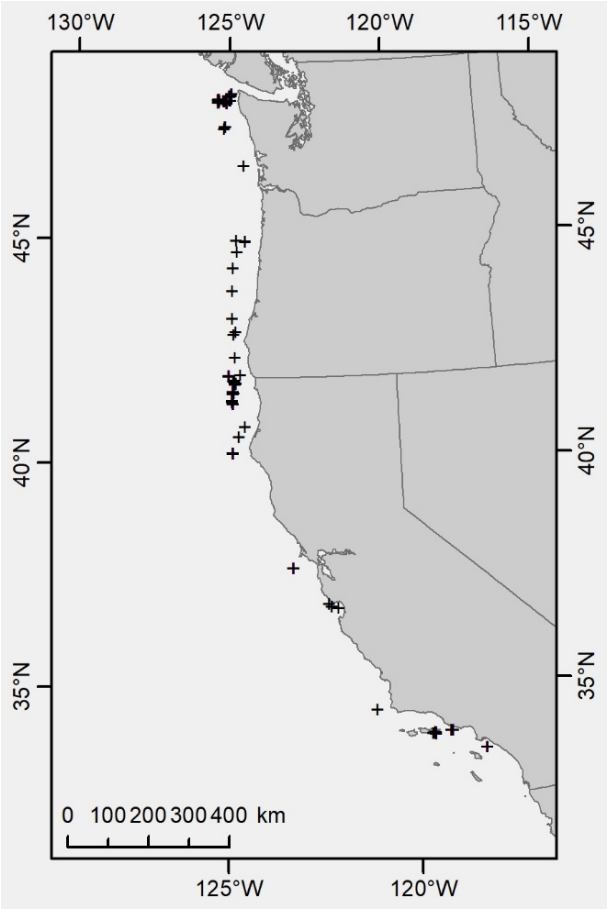
## *Swiftia pacifica* Presences



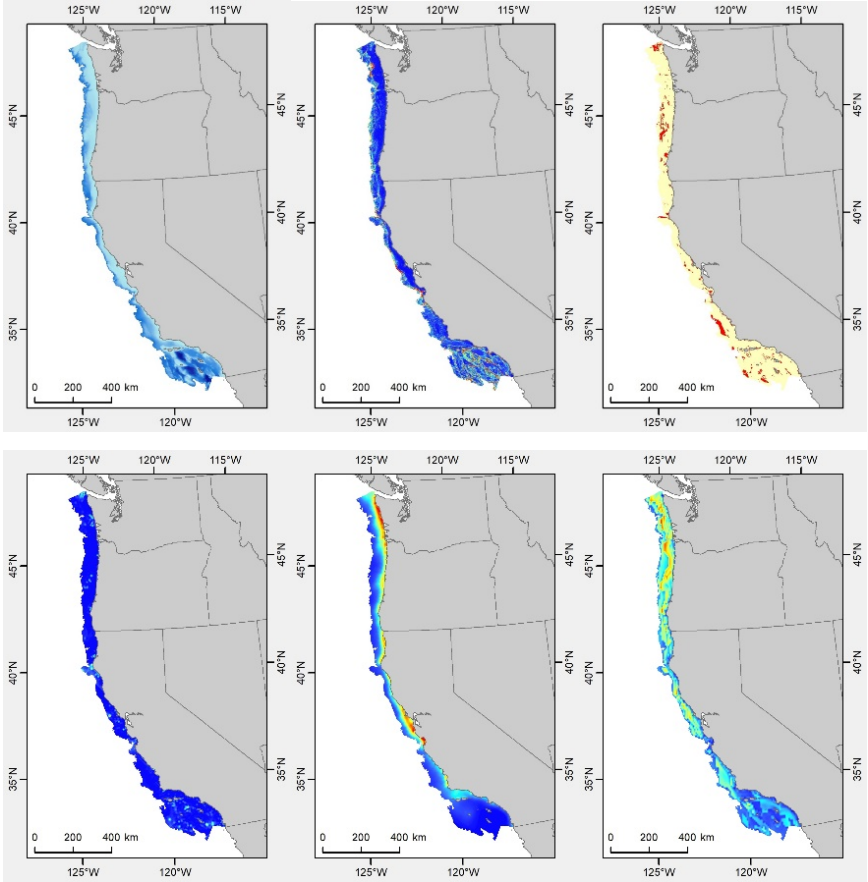
# Modeling Framework

## Step 1: Data preparation

### *Swiftia pacifica* Presences




### Spatial Environmental Predictors



# Modeling Framework

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## Step 2: Model fitting

- Models fit using ‘maxnet’ package in R
- Presence/background data

Ecography 40: 887–893, 2017
doi: 10.1111/ecog.03049
© 2017 The Authors. Ecography © 2017 Nordic Society Oikos
Subject Editor: Michael Borregaard. Editor-in-Chief: Miguel Araújo. Accepted 9 March 2017

**Opening the black box: an open-source release of Maxent**

**Steven J. Phillips, Robert P. Anderson, Miroslav Dudík, Robert E. Schapire and Mary E. Blair**

*S. J. Phillips (http://orcid.org/0000-0002-6991-608X) (mrmaxent@gmail.com) and M. E. Blair, Center for Biodiversity and Conservation, American Museum of Natural History, New York, NY, USA. – R. P. Anderson, Dept of Biology, City College of New York, City Univ. of New York, New York, NY, USA, and Program in Biology, Graduate Center, City Univ. of New York, New York, NY, USA, and Div. of Vertebrate Zoology (Mammalogy), American Museum of Natural History, New York, NY, USA. – M. Dudík and R. E. Schapire, Microsoft Research, New York, NY, USA.*

# Modeling Framework

## Step 2: Model fitting (continued)

- Cross-validation using spatial blocking

Received: 19 January 2018 | Accepted: 5 October 2018

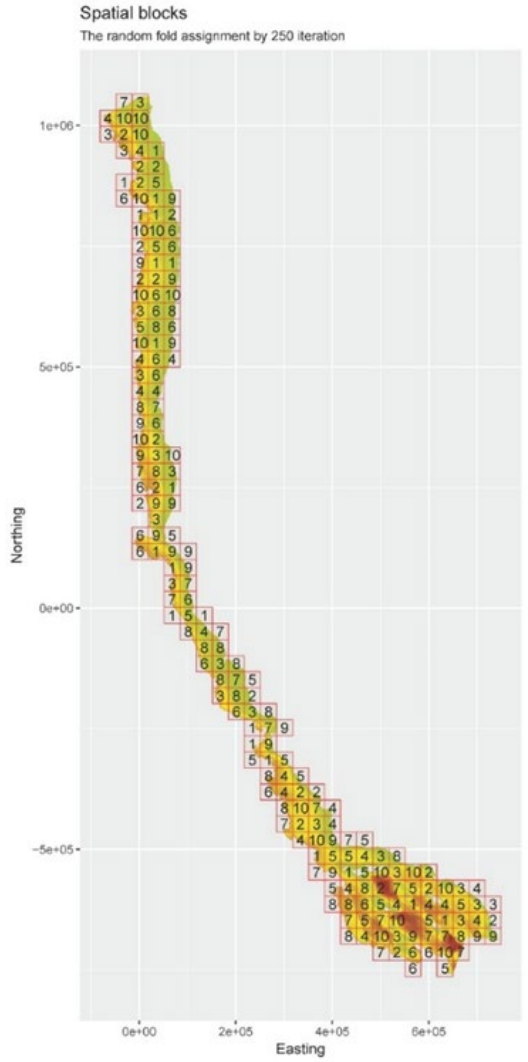
DOI: 10.1111/2041-210X.13107

APPLICATION

Methods in Ecology and Evolution | BRITISH ECOLOGICAL SOCIETY

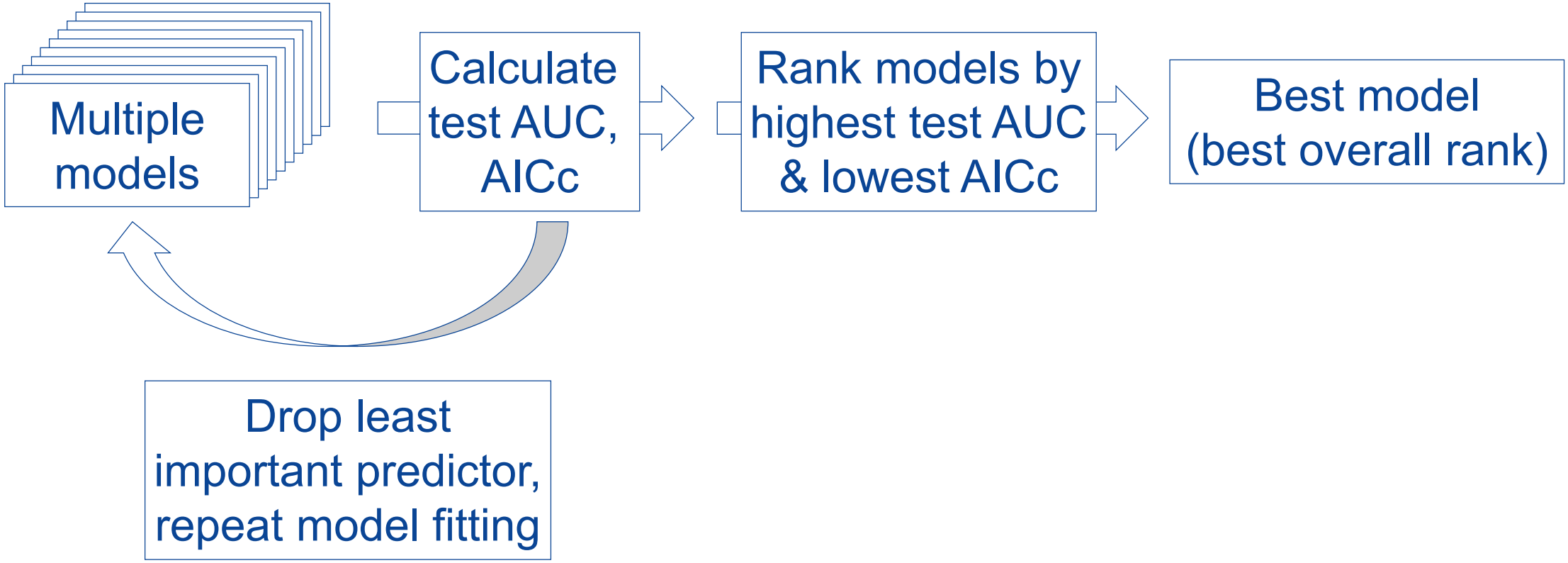
**BLOCKCV: An R package for generating spatially or environmentally separated folds for *k*-fold cross-validation of species distribution models**

Roozbeh Valavi | Jane Elith | José J. Lahoz-Monfort | Gurutzeta Guillera-Arroita



# Modeling Framework

## Step 3: Model selection



# Modeling Framework

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Step 4: Spatial prediction

- Create bootstrap samples
- Fit model for each bootstrap sample, using the predictors from the selected “best” model
- Make predictions at all model grid cells

# Map Pages

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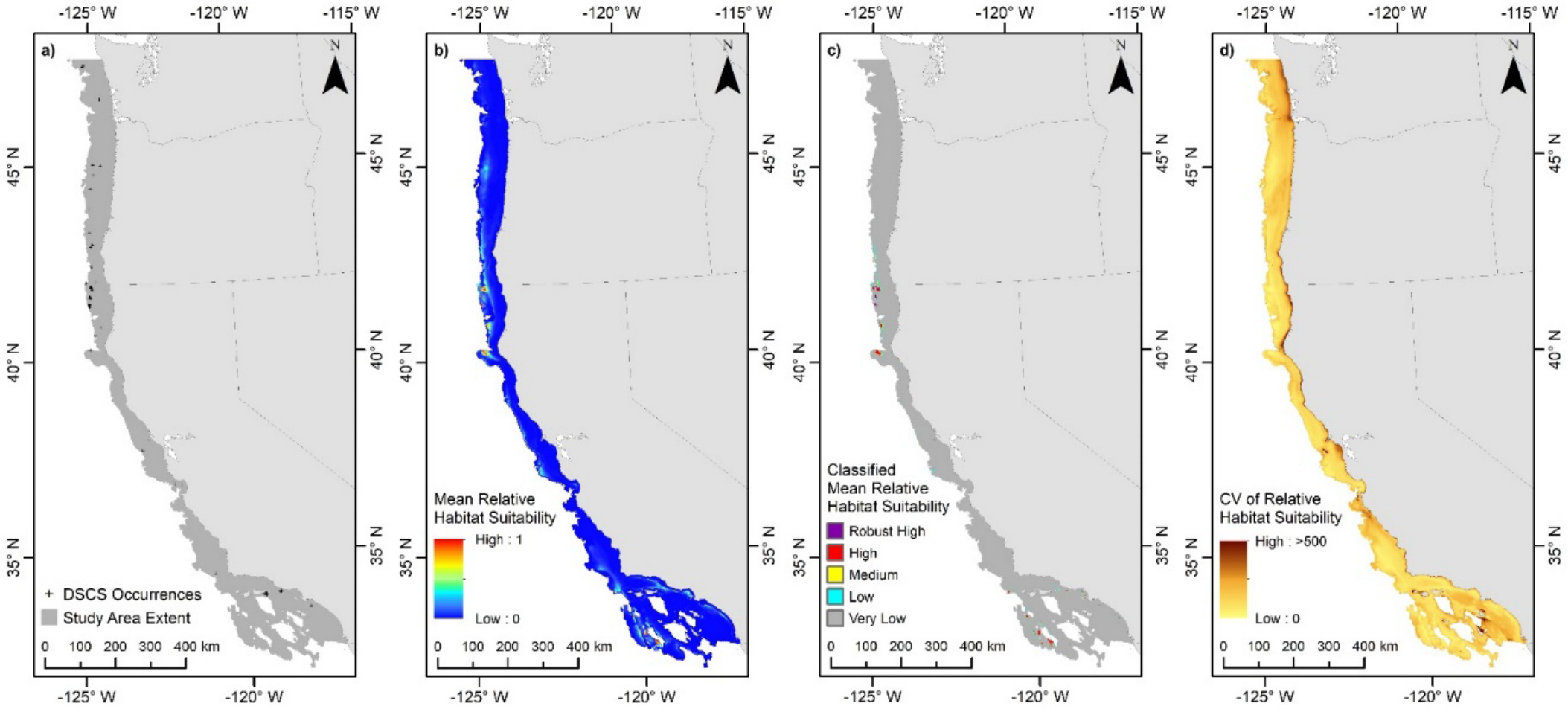
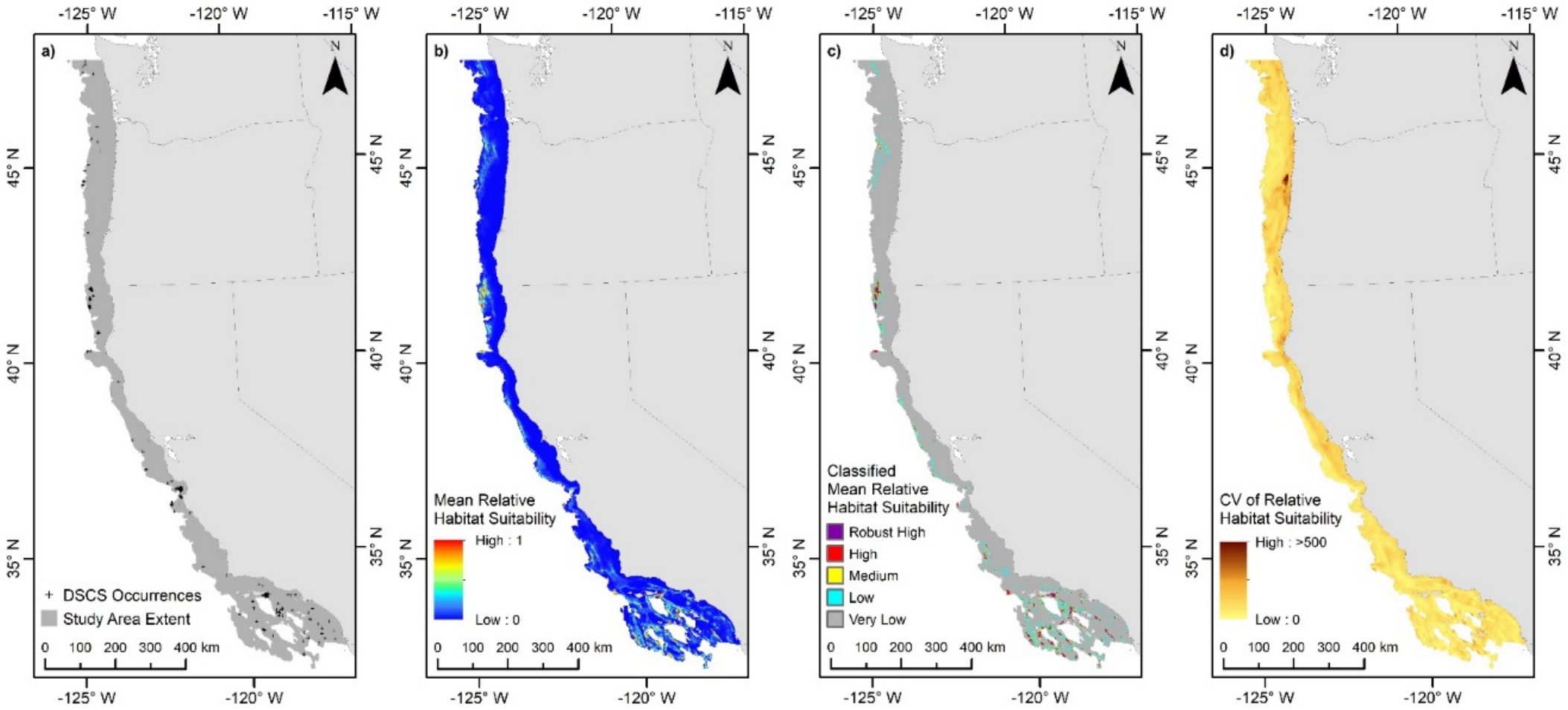
*Swiftia pacifica*




Cross-Val Mean AUC: 0.83; Model Fit: 85%; Model Stability: 16%

# Map Pages

*Paragorgia* spp.




Cross-Val Mean AUC: 0.87; Model Fit: 91%; Model Stability: 23%

# Map Pages

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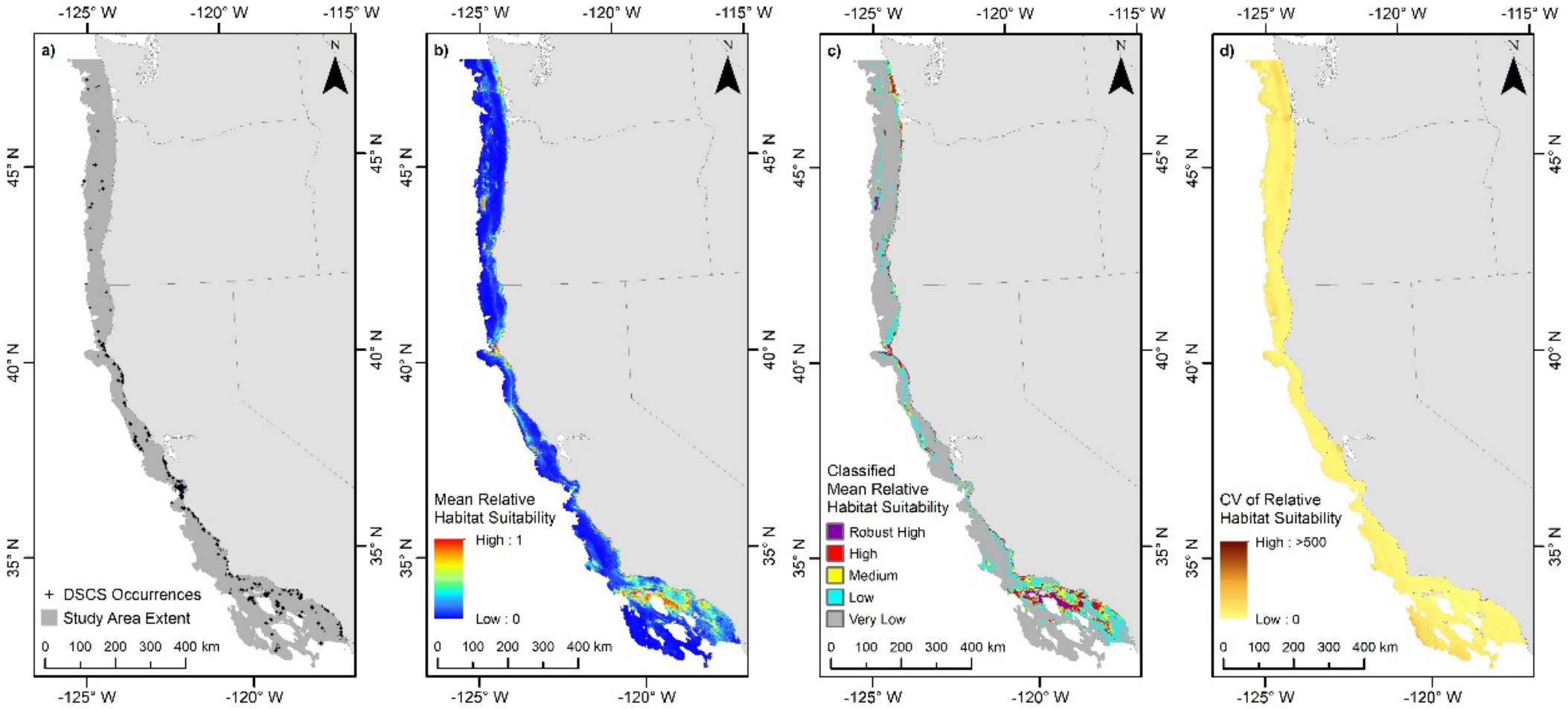
## Demospongiae




Cross-Val Mean AUC: 0.81; Model Fit: 90%; Model Stability: 43%

# Map Pages

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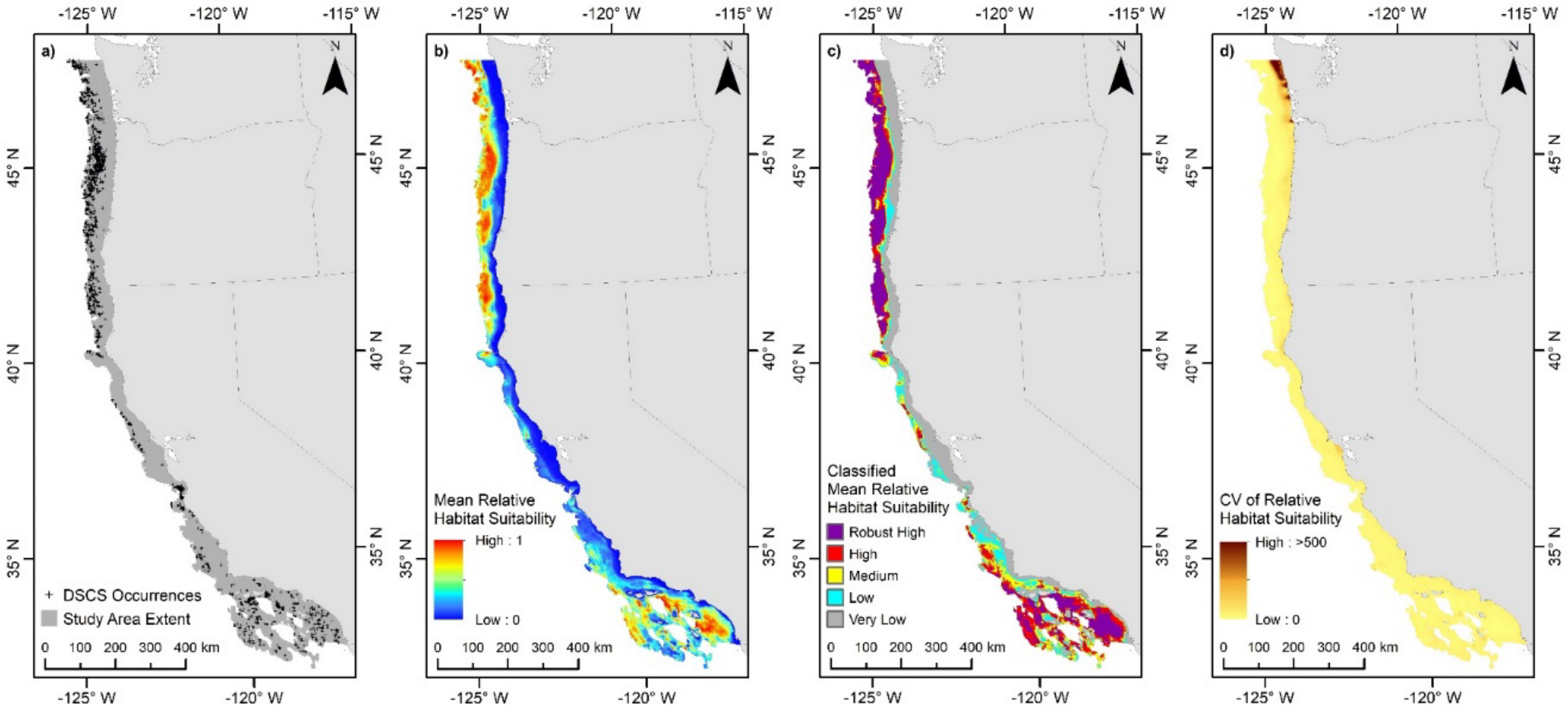
## Hexactinellida




Cross-Val Mean AUC: 0.82; Model Fit: 86%; Model Stability: 61%

# Caveats

- Presence-only data
- Spatial and taxonomic precision of DSC&S records
- Scale/resolution of environmental predictors
- Missing environmental predictors

# Objectives

- Compile observations of deep-sea corals and sponges (DSC&S)
- Identify potential environmental covariates
- Predict and map spatial patterns of habitat suitability
- Evaluate model performance
- Support management and exploration priorities

‘Opportunistic’ field validation using data from EXPRESS

# Model Validation

## Ideal – Independent Field Validation

Ocean & Coastal Management 120 (2016) 110–126

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

Field validation of habitat suitability model
ecosystems in the South Pacific Ocean: Imp
broad-scale models in fisheries managemer

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Sophie Mormede [a], Andrew J. Davies [c], David A. Bowde

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ICES Journal of Marine Science (2018), 75(1), 199–209. doi:10.1093/icesjms/fsx087

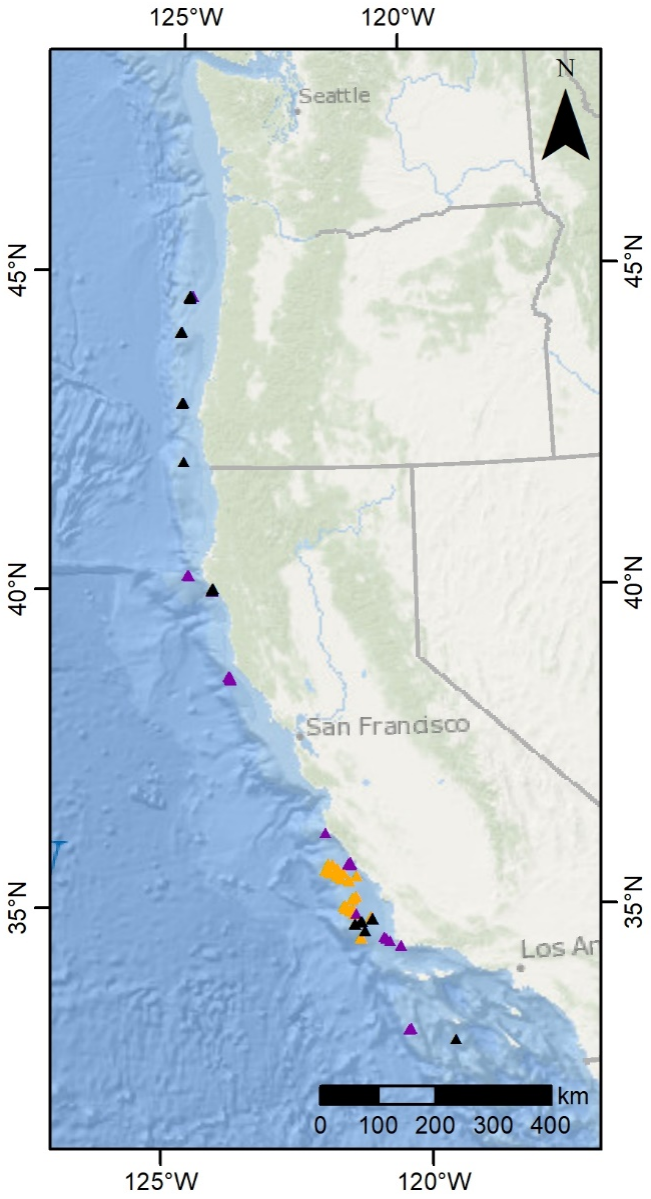
**Original Article**

## Validation of deep-sea coral and sponge distribution models in the Aleutian Islands, Alaska

Christopher N. Rooper,[1]* Rachel Wilborn,[1] Pamela Goddard,[1] Kresimir Williams,[1] Richard Towler,[1] and Gerald R. Hoff[1]

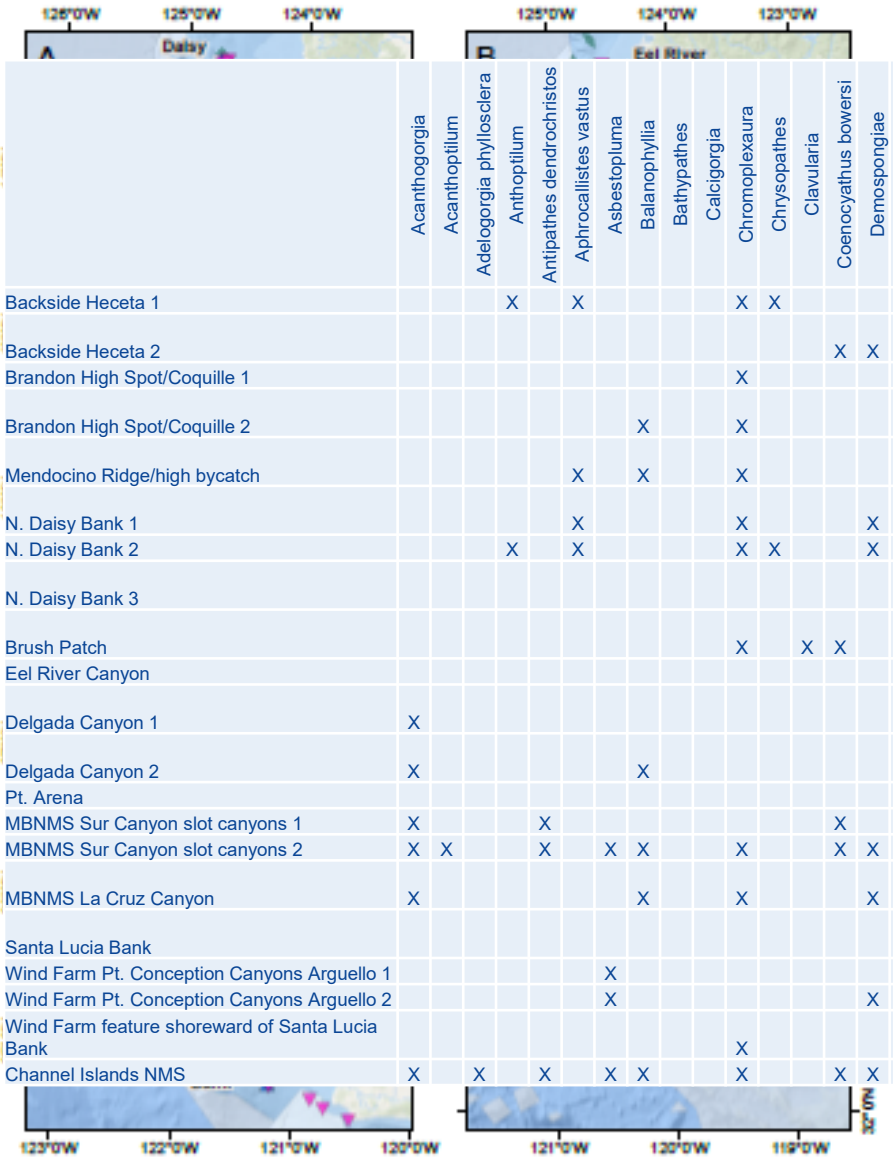
[1]Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115, USA

# Model Validation




- 2018 NOAA Ship Bell Shimada
  - ▲ AUV dives
  - ▲ ROV dives
- 2019 MBARI
  - ▲ ROV dives

# Model Validation (cont.)




| | Acanthogorgia | Acanthoptilum | Adelogorgia phyllosclera | Anthoptilum | Antipathes dendrochristos | Aphrocallistes vastus | Asbestopluma | Balanophyllia | Bathypathes | Calcigorgia | Chromoplexaura | Chrysopathes | Clavularia | Coenocyathus bowersi | Demospongiae | Desmophyllum | Distichoptilum | Eugorgia | Farrea occa | Funiculina | Halipteris | Heterochone calyx | Heteropolypus ritteri | Hexactinellida | Hyalonema | Isidella | Leptogorgia | Lophelia pertusa | Paracyathus | Paragorgia | Parastenella | Pennatula | Plumarella | Polymastia | Stylaster | Stylaster californicus | Stylatula | Swiftia kofoidi | Swiftia pacifica | Swiftia simplex | Umbellula | Virgularia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Backside Heceta 1 | | | | X | | X | | | | | X | X | | | | | | | | | | X | X | X | | | | | | X | X | | X | | | | | X | | | | |
| Backside Heceta 2 | | | | | | | | | | | | | | X | X | | | | | | | X | | | | | | X | | | | | | | X | | | | | | | low relief area, but not completely mapped with multibeam |
| Brandon High Spot/Coquille 1 | | | | | | | | | | | X | | | | | | | | X | | | X | | X | | | | | | | | | | X | | | | | | | |
| Brandon High Spot/Coquille 2 | | | | | | | | X | | | X | | | | | X | | | X | | | X | | X | | | | | | | | | X | | X | | | | | | | transect moves up and then along high slope (>30°) feature |
| Mendocino Ridge/high bycatch | | | | | | X | | X | | | X | | | | | | | | | | | X | X | X | | | | | | X | X | | X | | X | | | X | | | | transect moves up and along consecutive high slope (>45°) features |
| N. Daisy Bank 1 | | | | | | X | | | | | X | | | | X | | | | | | | | | X | | | | | | | | | X | | | | | | | | | transect moves up and then along high slope (>45°) feature |
| N. Daisy Bank 2 | | | | X | | X | | | | | X | X | | | X | | | | | | | X | X | X | | | | | | X | | | | X | | | | | | | | |
| N. Daisy Bank 3 | | | | | | | | | | | | | | | | | | | | | | | | X | | | | | | X | | | | | | | | | | | | transect moves up and then along low-moderate slope (>15°) feature |
| Brush Patch | | | | | | | | | | | X | | X | X | | | | | X | | | | X | X | | | | | | X | X | X | | | | | | X | | | | only small area shallower than 600m; transect moves along edge of high slope (15°-45°) feature |
| Eel River Canyon | | | | | | | | | | | | | | | | | | | | | X | | X | X | | | | | | | | | | | | | | X | | X | | | |
| Delgada Canyon 1 | X | | | | | | | | | | | | | | | X | | | | | | | X | X | | | | | | | X | | | | | | | X | | | | transect moves up and then along high slope (>45°) feature |
| Delgada Canyon 2 | X | | | | | | | X | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | transect moves up and along consecutive high slope (>45°) features |
| Pt. Arena | | | | | | | | | | | | | | | | | | | X | | | X | X | X | | | | | | | | | | | | | | | | | | | |
| MBNMS Sur Canyon slot canyons 1 | X | | | | X | | | | | | | | | X | | X | | | X | | | X | | X | | | | X | | | | X | X | X | | | | | | | | |
| MBNMS Sur Canyon slot canyons 2 | X | X | | | X | | X | X | | | X | | | X | X | X | | X | X | | X | X | | X | | | X | X | X | | X | X | X | | | | X | X | | | |
| MBNMS La Cruz Canyon | X | | | | | | | X | | | X | | | | X | X | | | X | | X | X | X | X | | | X | X | X | | | X | X | X | | X | | | | | | transect moves up and then along high slope (>45°) feature |
| Santa Lucia Bank | | | | | | | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | | | | | | | | transect moves up and then along high slope (>30°) feature |
| Wind Farm Pt. Conception Canyons Arguello 1 | | | | | | | X | | | | | | | | | | | | | | | | X | | | | | | | | X | | X | | | | | | | | |
| Wind Farm Pt. Conception Canyons Arguello 2 | | | | | | | X | | | | | | | | X | | | | | | X | | | | | | | | | | X | | X | | | | X | | | | |
| Wind Farm feature shoreward of Santa Lucia Bank | | | | | | | | | | | X | | | | | | | | | | X | X | X | | | | | | | | | | | | | | | | | | | | |
| Channel Islands NMS | X | | X | | X | | X | X | | | X | | | X | X | X | | X | X | | | X | | X | | | X | X | | | | X | X | | | | | X | | | | X | |

# Model Validation (cont.)

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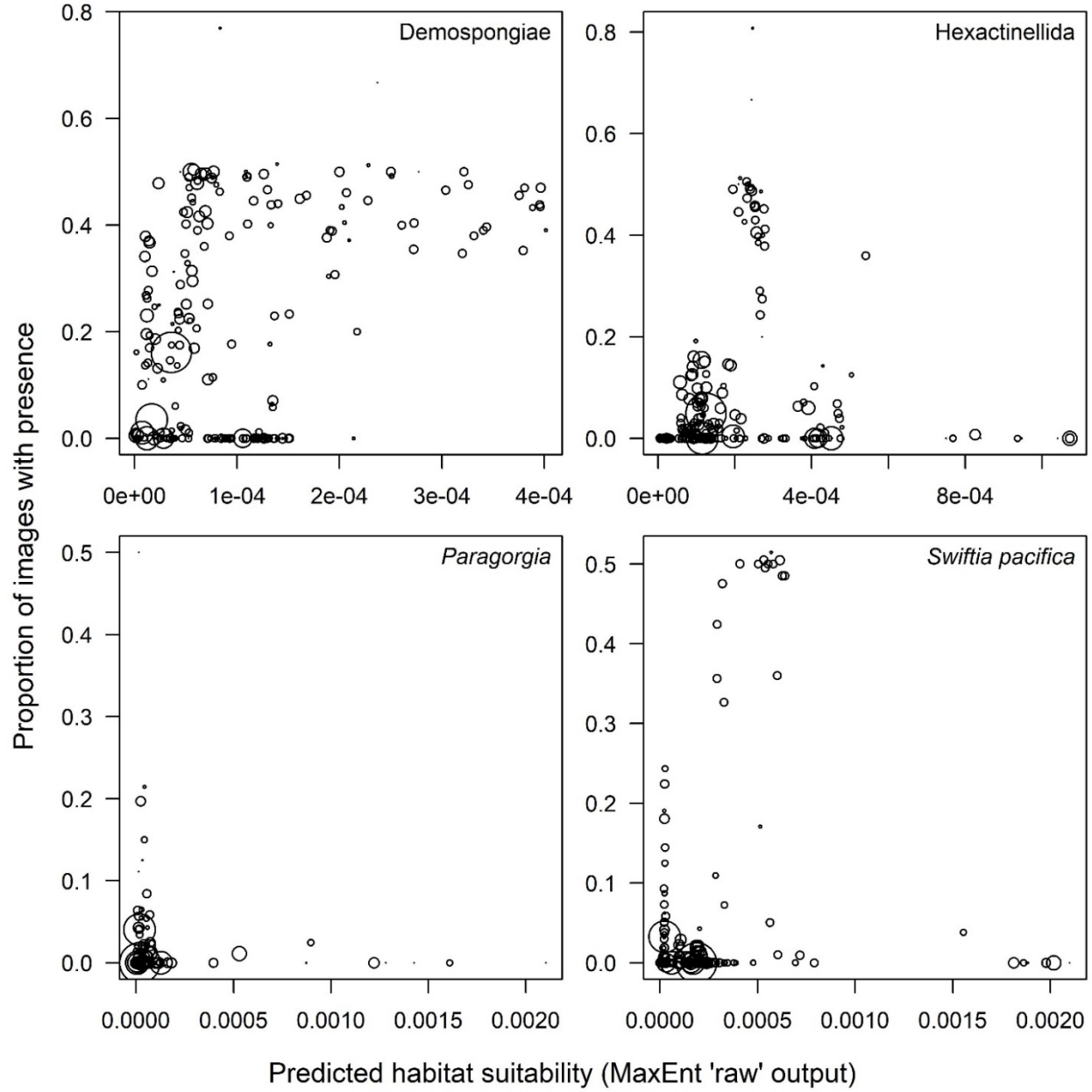
Approaches

- Assess correlation between observations and model predictions
- Calculate accuracy measure using confusion matrix
- Fit GLMs to see if model predictions explain variation in observations

# Model Validation (cont.)

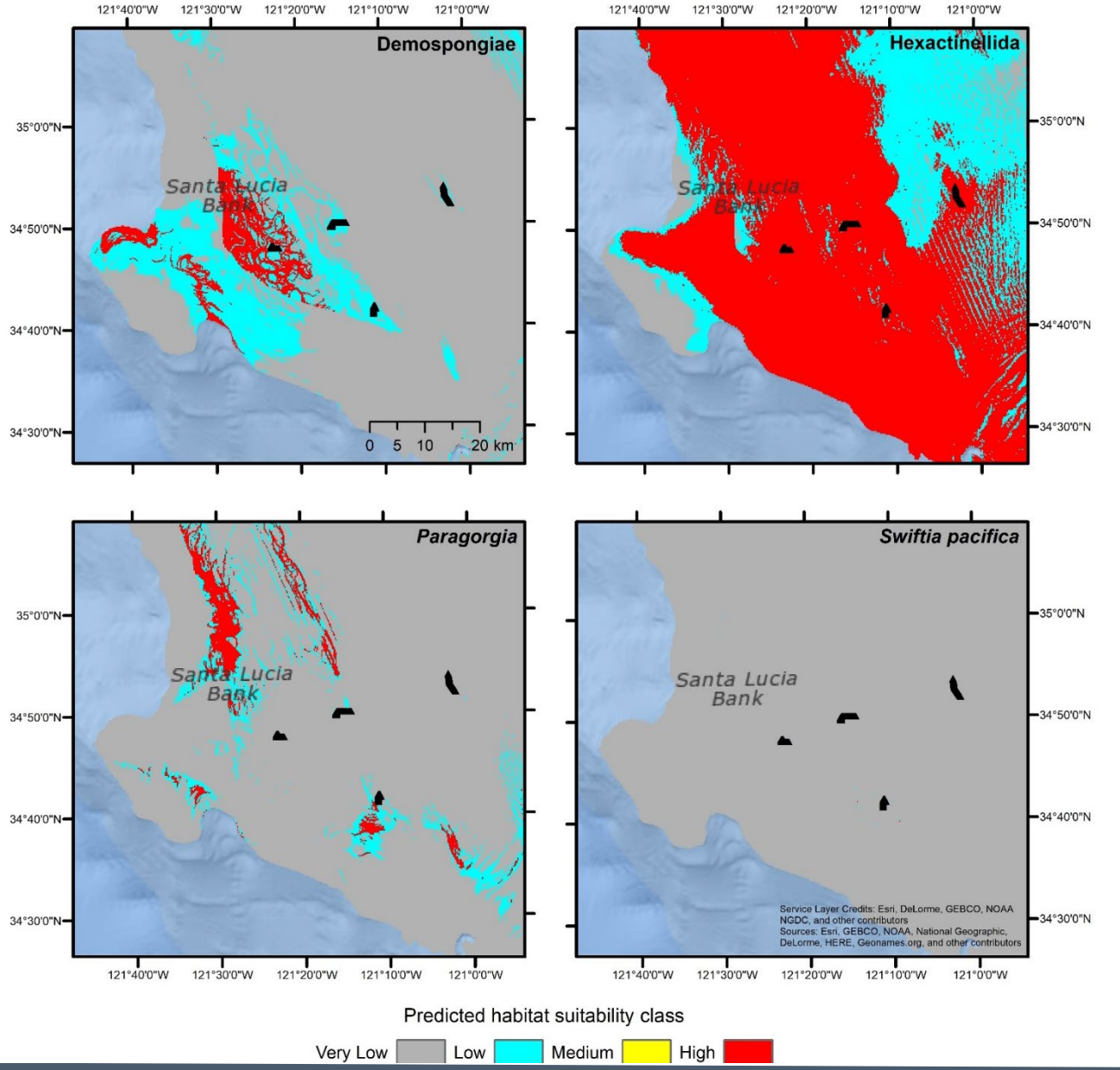


# Model Validation (cont.)

Table 1. Sample size (number of study grid cells with ≥1 image) by predicted habitat suitability class for each taxon. There were a total of 220 cells with images.

| Taxon | Predicted habitat suitability class | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Very low | | | | Low | Medium | High | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Demospongiae | 0 | 0 | 12 | 20 | 38 | 81 | 44 | 25 | 0 | 0 |
| Hexactinellida | 0 | 0 | 8 | 9 | 20 | 6 | 56 | 79 | 33 | 9 |
| *Paragorgia* | 89 | 15 | 69 | 14 | 23 | 1 | 2 | 5 | 2 | 0 |
| *Swiftia pacifica* | 24 | 49 | 52 | 69 | 17 | 0 | 9 | 0 | 0 | 0 |

# Model Validation (cont.)



# Model Validation (cont.)

Table 2. Results of statistical analyses of the relationship between taxa occurrence and predicted habitat suitability (MaxEnt 'raw' predictions): 1) Spearman rank correlation coefficient (*r*) between proportion of images where taxa were present and predicted habitat suitability; and 2) quasi-Poisson generalized linear model (GLM) of number of images where taxa was present as function of predicted habitat suitability. For the GLM, the percentage of deviance explained by the model and the *p*-value of the positive effect of predicted habitat suitability are presented.

| Taxon | *R* | GLM | |
|---|---|---|---|
| | | % deviance explained | *p* |
| Demospongiae | 0.24 | 9 | <1e-7 |
| Hexactinellida | 0.27 | 1 | 0.135 |
| *Paragorgia* | 0.44 | 0 | 0.894 |
| *Swiftia pacifica* | 0.14 | 5 | <0.01 |

# Model Validation (cont.)

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Conclusions

- Challenging to collect samples across range of model predictions when using ‘opportunistic’ samples
- When incorporating different sources of data (e.g., AUV + ROV), need to consider sampling effort
- Important to link modeling efforts with exploration

# Next steps

- Continue opportunistic collection of data for model validation
- Additional models using absence, abundance data
- Explore additional environmental predictor variables

# Acknowledgments


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- Linda Kuhnz (MBARI)
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- David Huff (NOAA NMFS NWFSC)
- Chris Caldow (Channel Islands National Marine Sanctuary)
- Ryan Freedman (Channel Islands National Marine Sanctuary)
- Elizabeth Duncan (Channel Islands National Marine Sanctuary)
- Andrew Moore (UC Santa Cruz)
- Steven Bograd (NOAA NMFS SWFSC)
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- Susan Zaleski (BOEM)
- Brian Zelenke (BOEM)
- Peter Etnoyer (NOAA NCCOS)
- Jeff Leirness (NOAA NCCOS)
- Heather Coleman (NOAA DSCRTP)
- Robert McGuinn (NOAA NCEI)

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# Questions?

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