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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

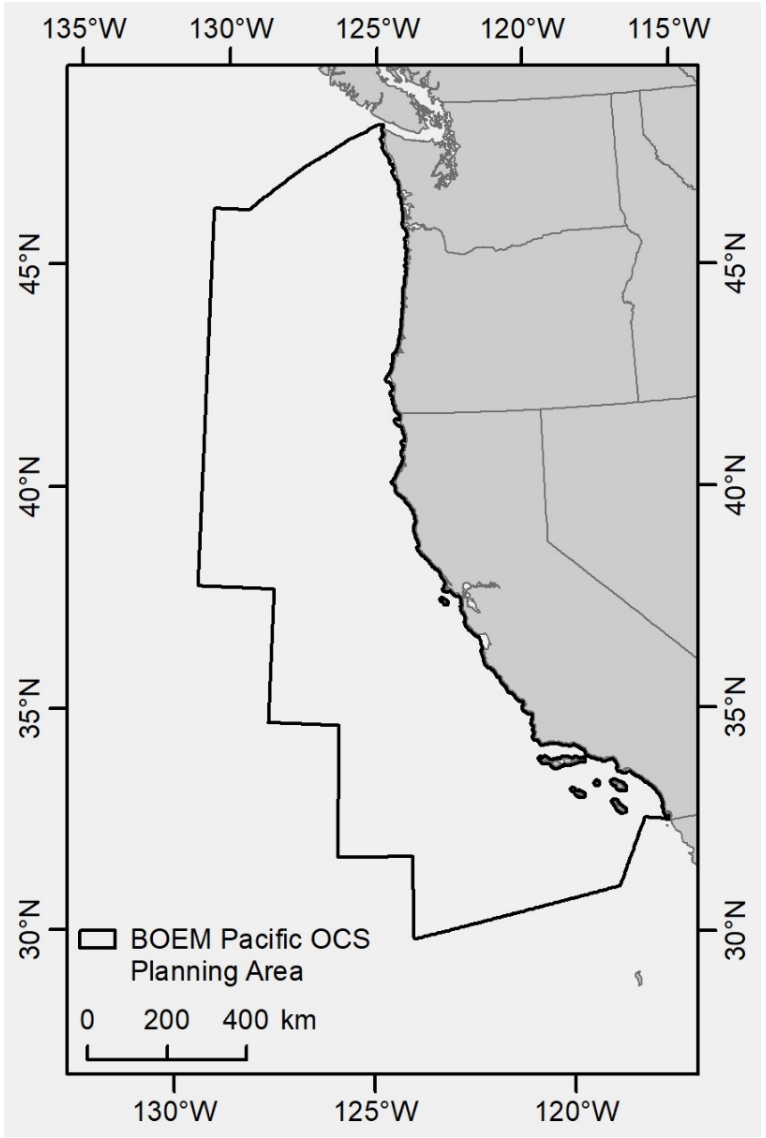
SCIENCE SERVING COASTAL COMMUNITIES

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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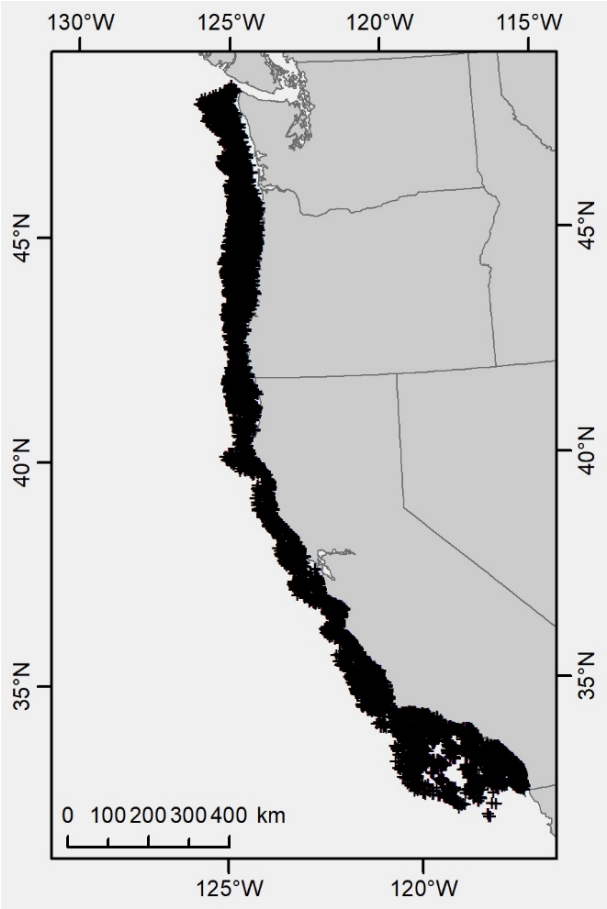
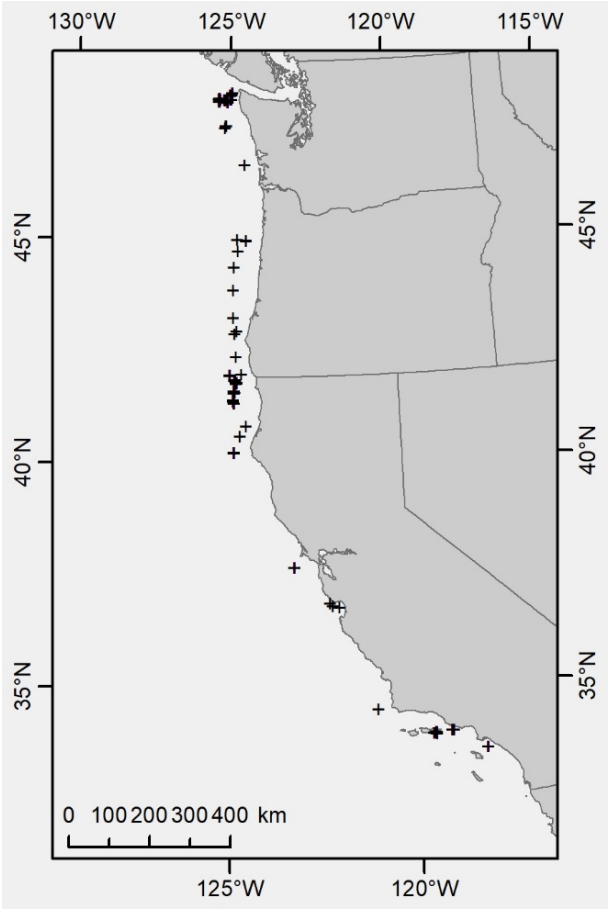
- NOAA DSCRTP National Database

DSC&S Presences



QA/QC
Subset by Taxonomy
Spatial Thinning

Swiftia pacifica Presences



Modeling Framework

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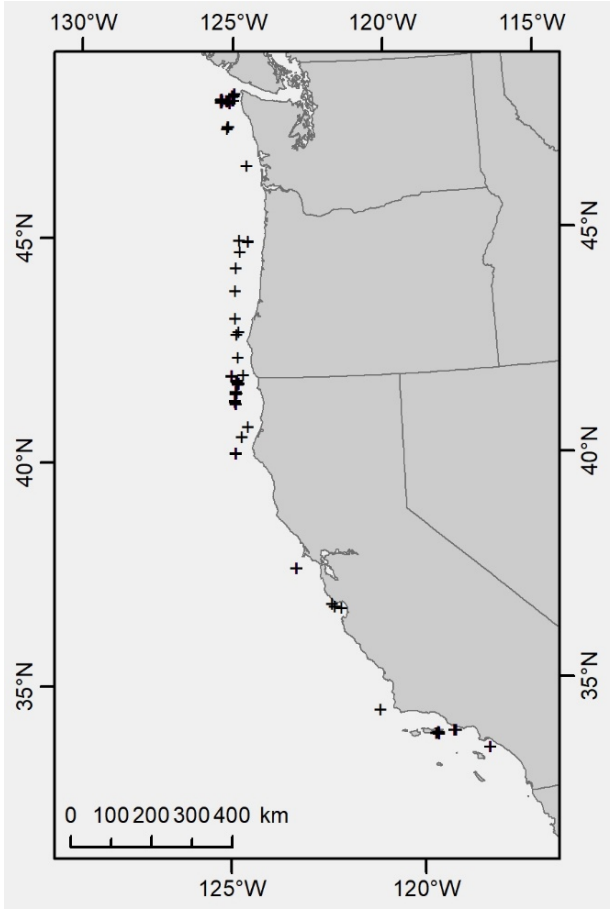
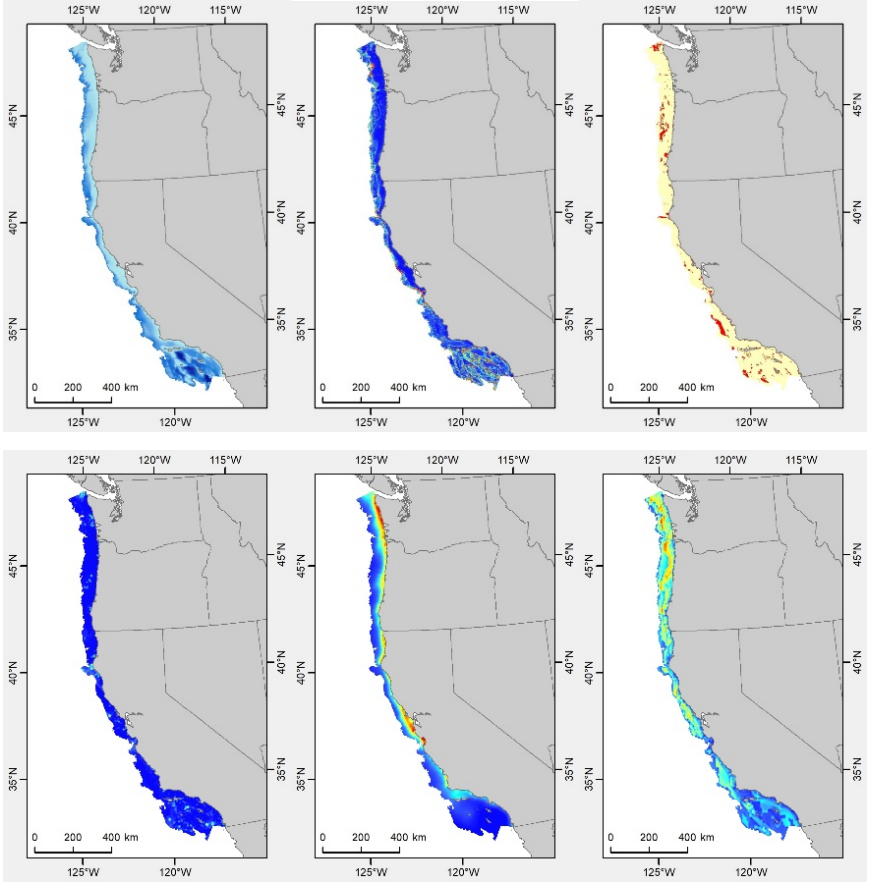
Step 1: Data preparation

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

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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

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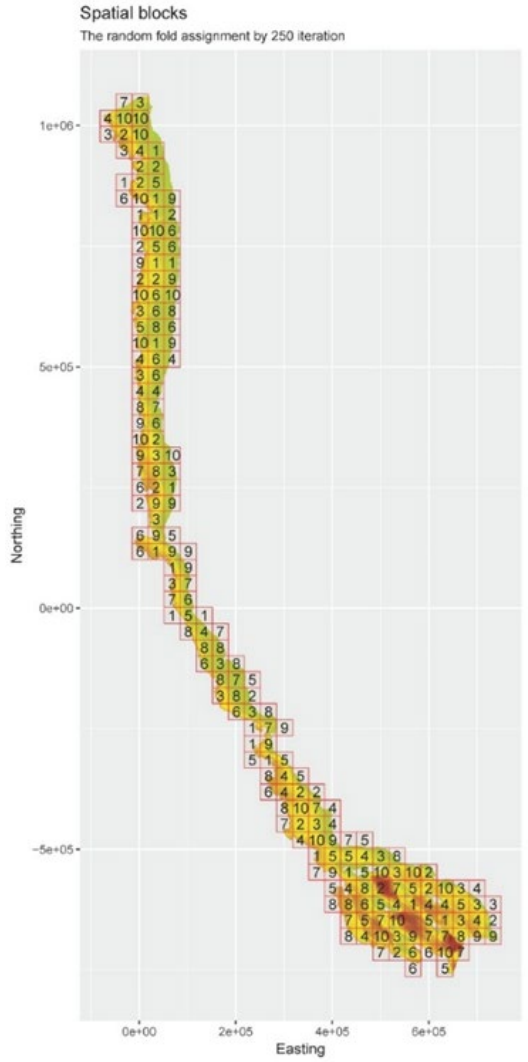
DOI: 10.1111/2041-210X.13107

APPLICATION

Methods in Ecology and Evolution | BRITISH ECOLOGICAL SOCIETY

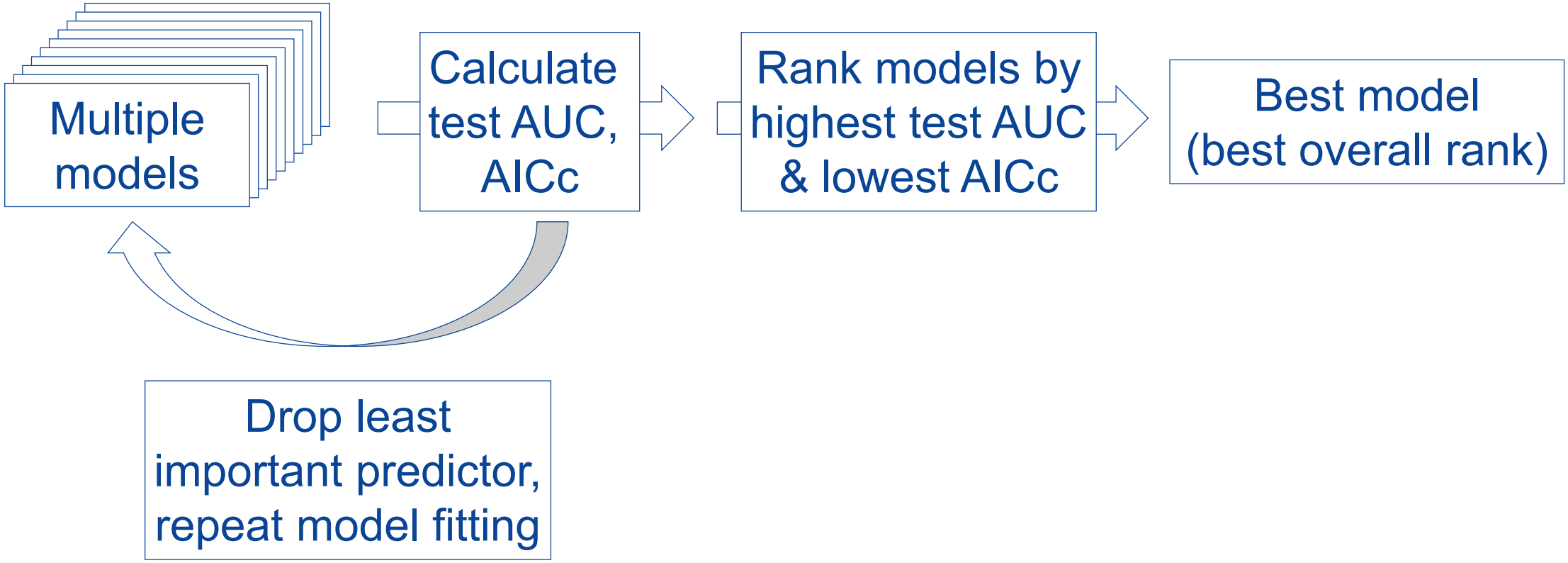
BLOCKCV: An R package for generating spatially or environmentally separated folds for *k*-fold cross-validation of species distribution models

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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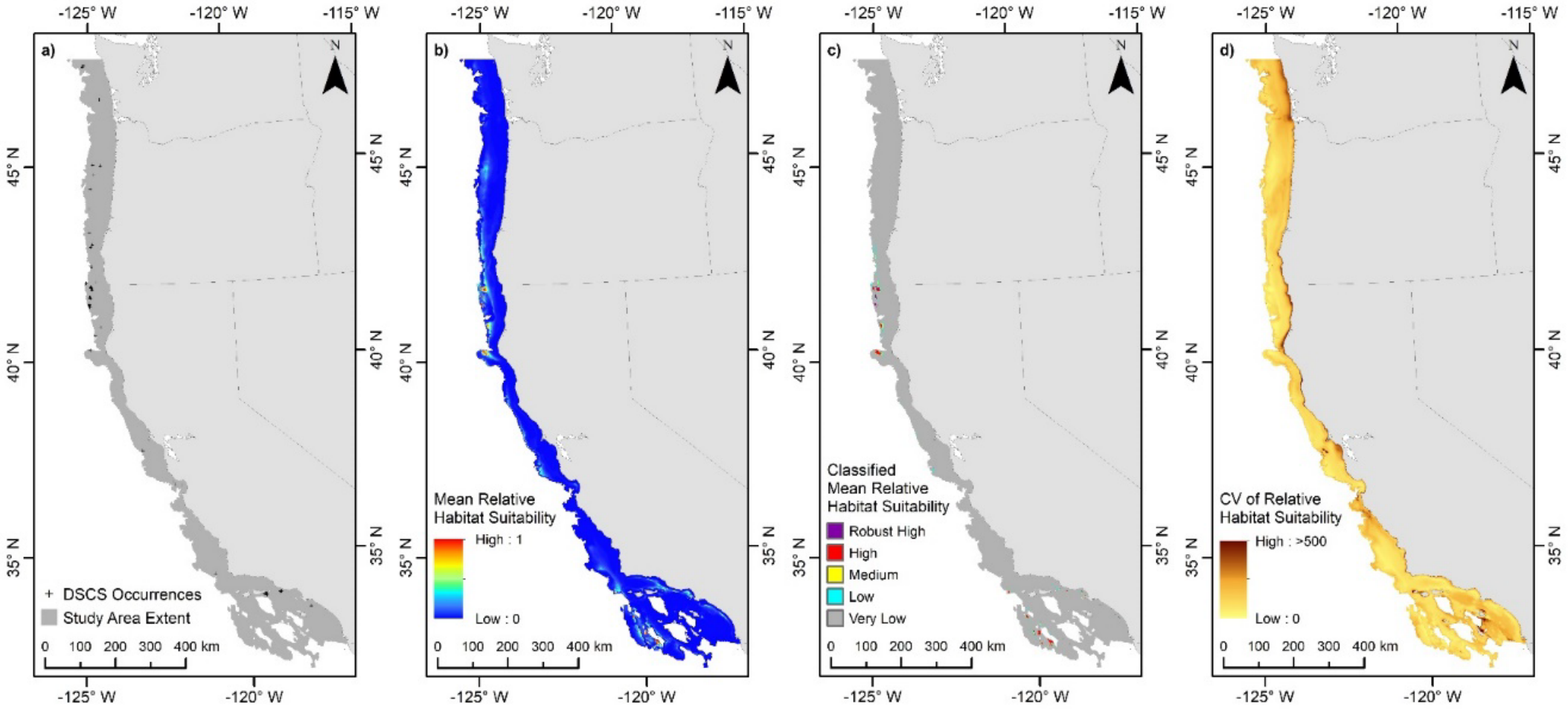
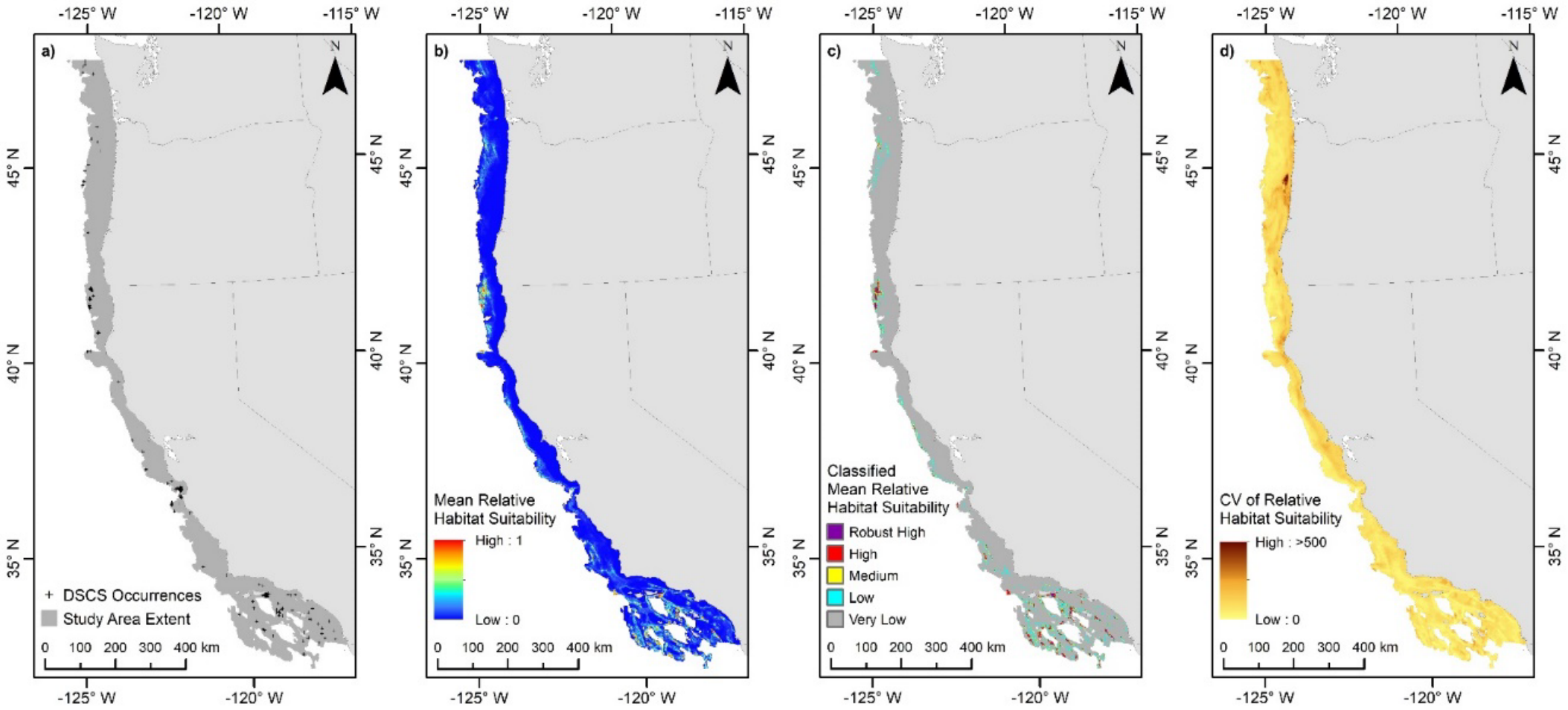
Swiftia pacifica



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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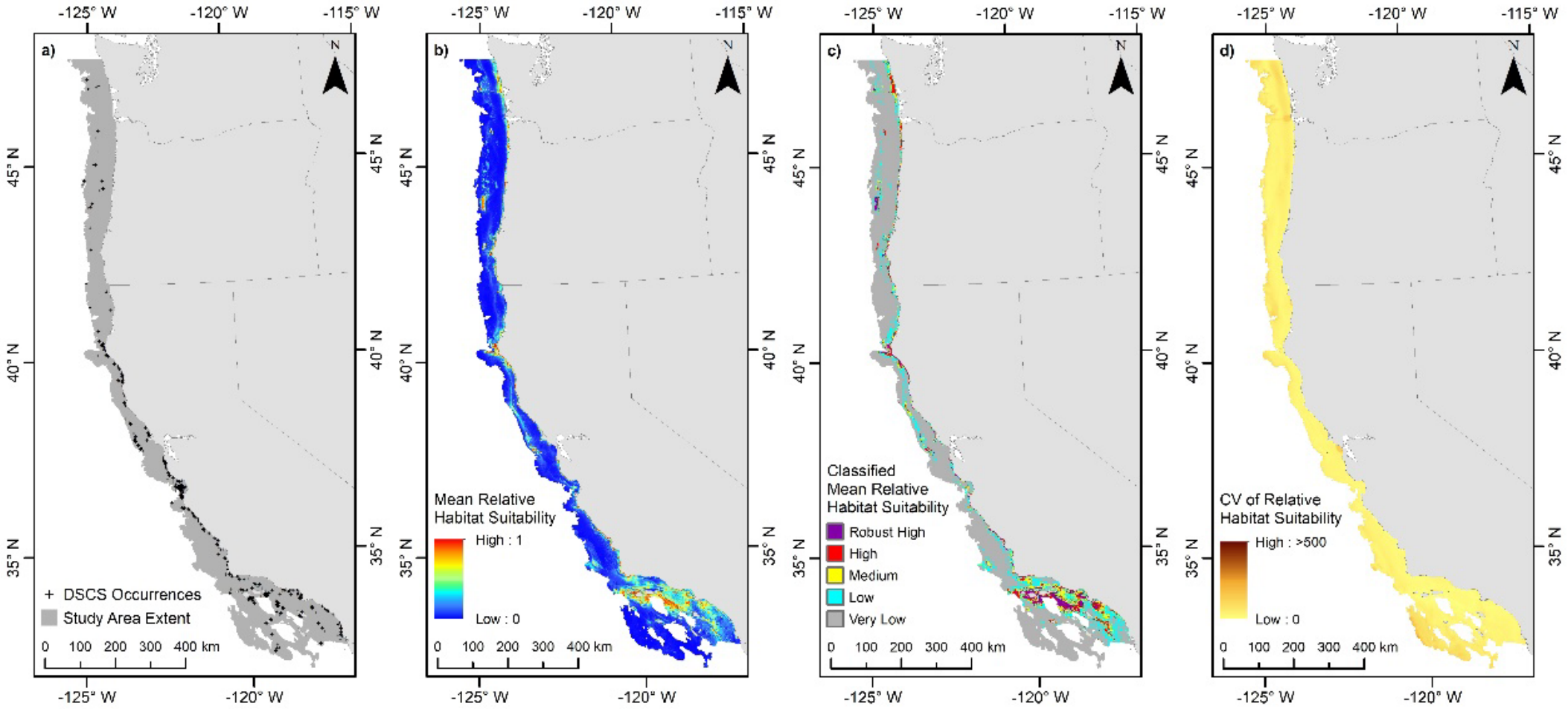
Demospongiae



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

Map Pages

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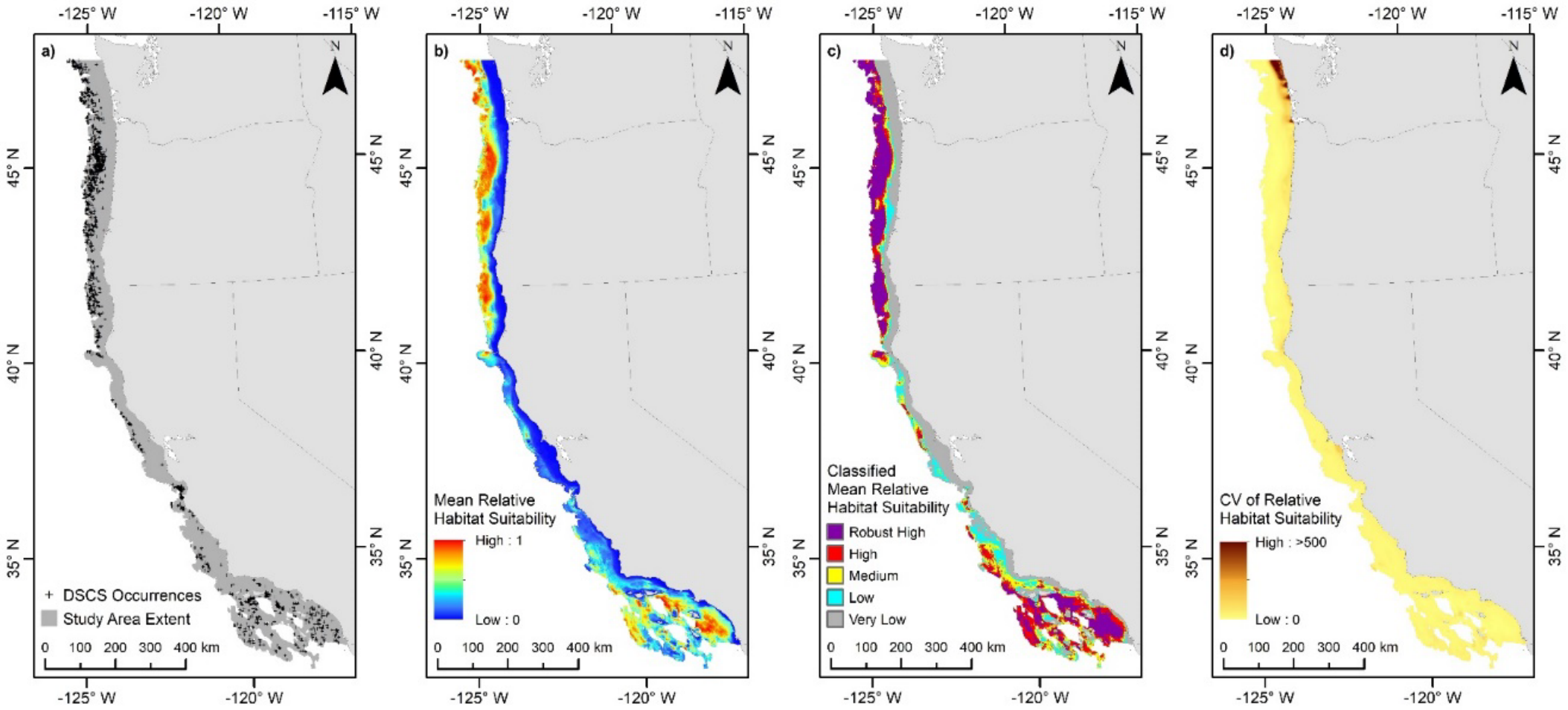
Hexactinellida



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

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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

[a] NIWA, Wellington, New Zealand
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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

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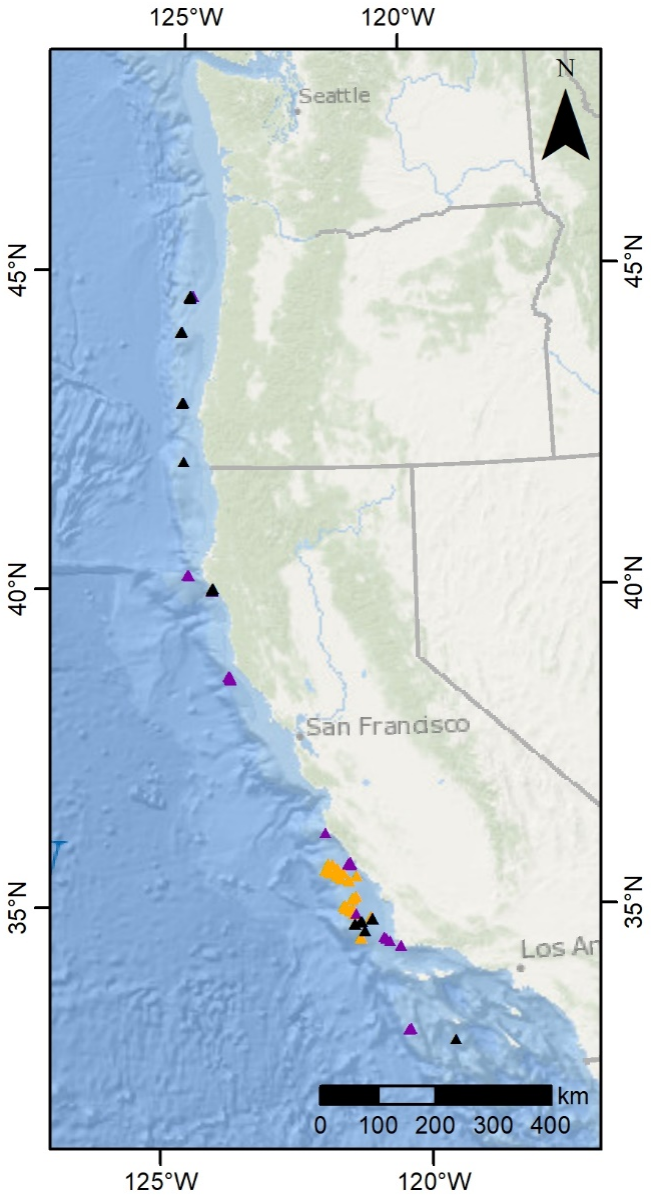
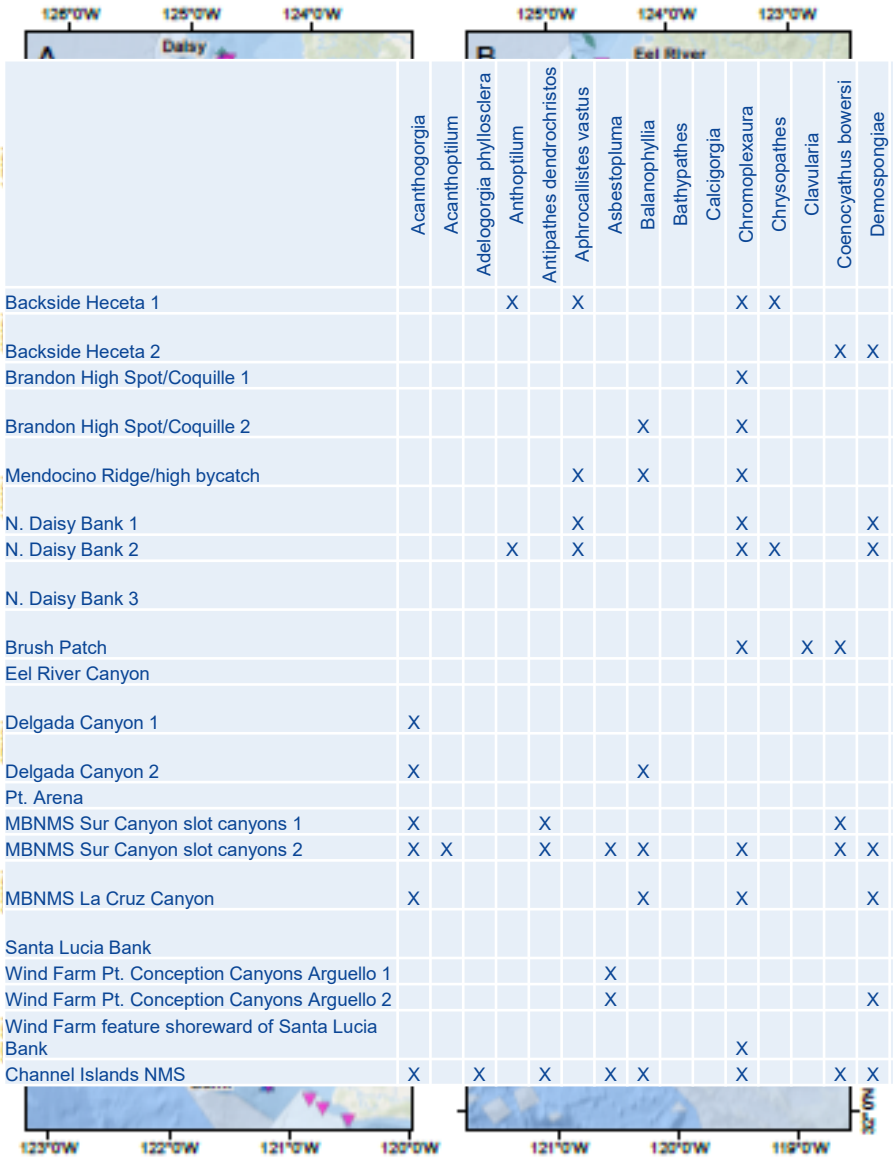
Model Validation



- 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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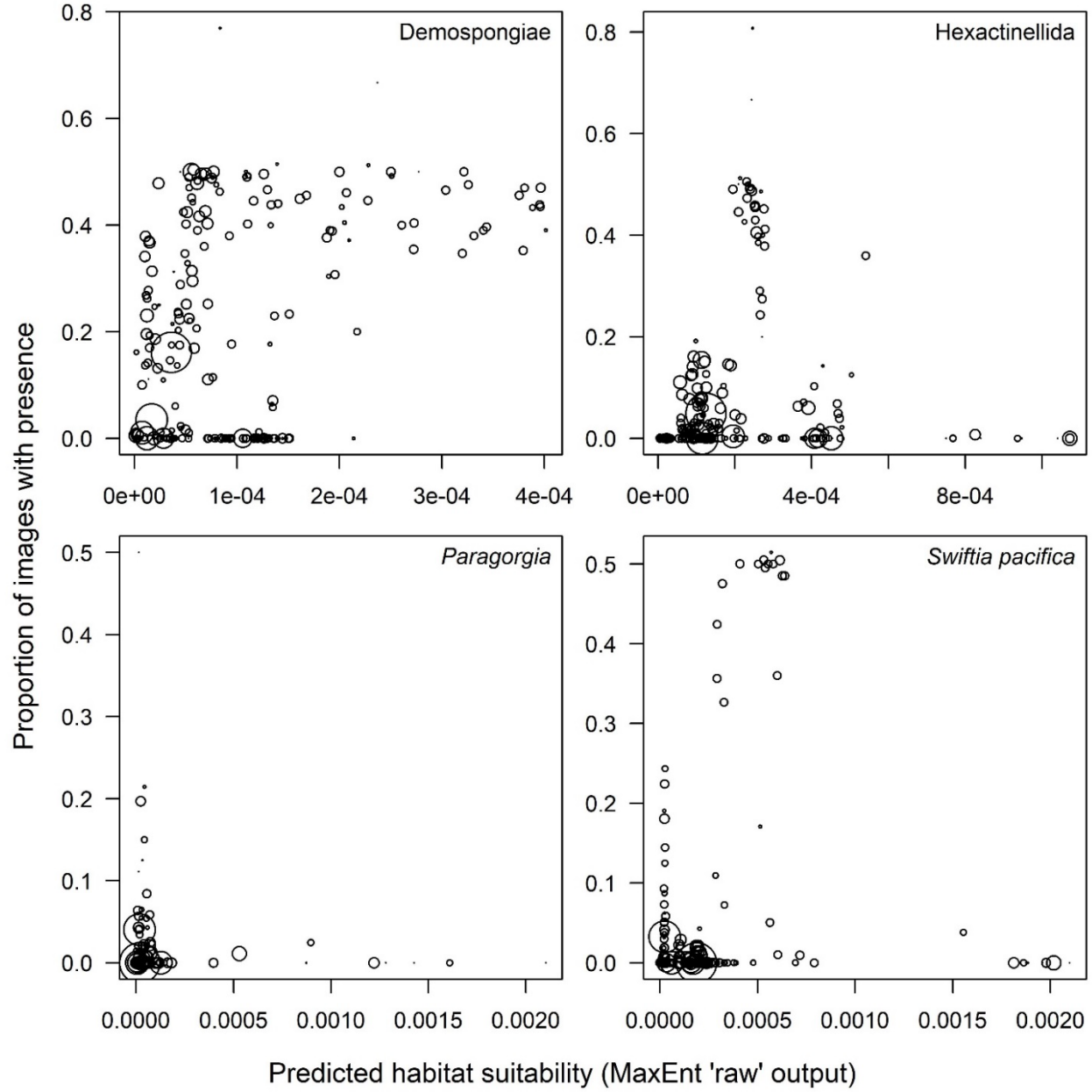
Approaches

- 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.)

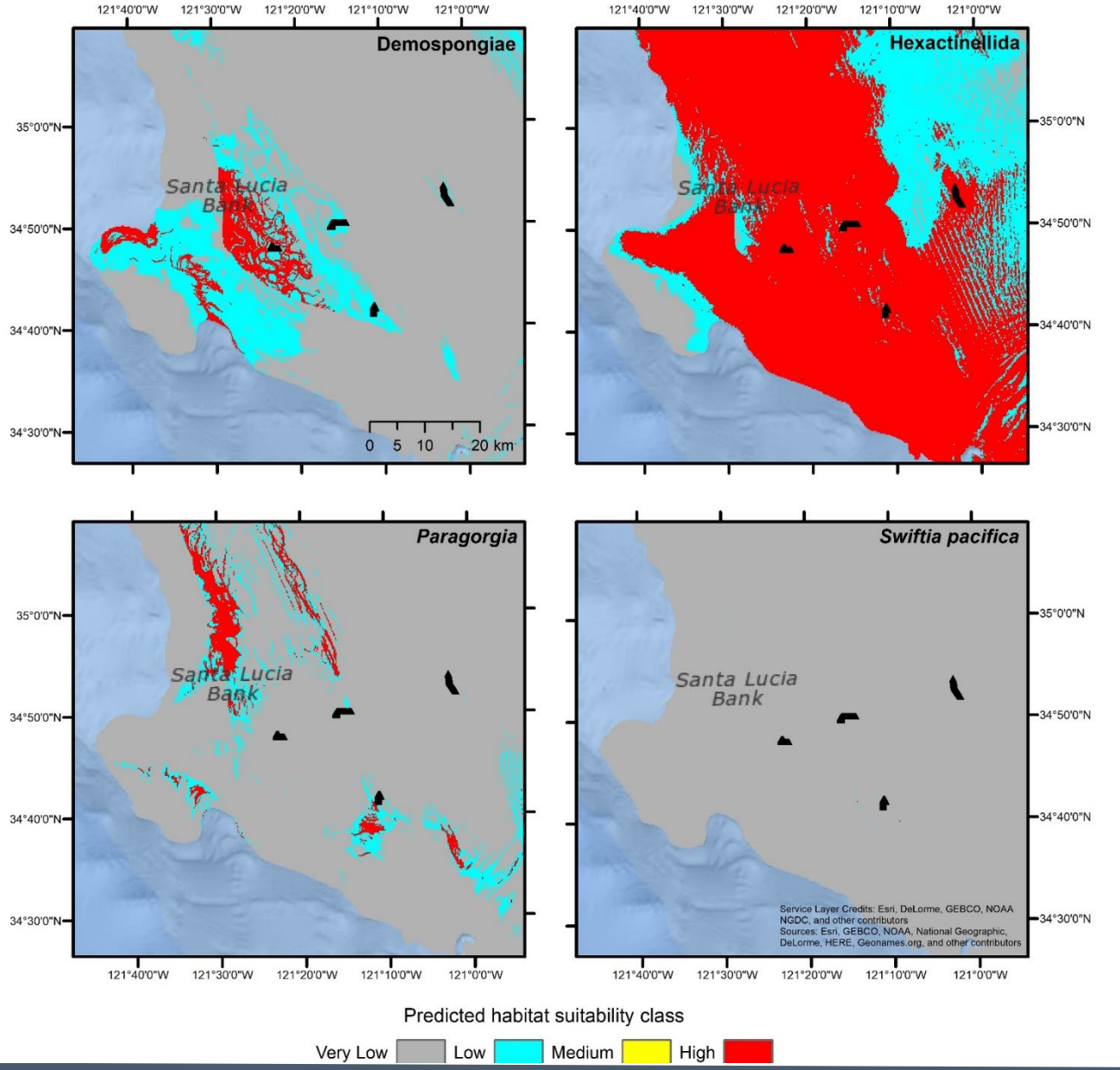


Model Validation (cont.)

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

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- Sam Georgian (Marine Conservation Institute)
- Chris Rooper (DFO Canada)
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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)
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- Jeff Leirness (NOAA NCCOS)
- Heather Coleman (NOAA DSCRTP)
- Robert McGuinn (NOAA NCEI)

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Questions?

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