Offshore Habitat Assessment for US Wind Energy

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Preface

This report was generated as a Quarto book.

1 Introduction

Development of offshore wind energy will be essential for providing renewable energy to mitigate climate change impacts, yet needs to be sited responsibly to avoid sensitive habitats. Acoustic impacts from construction and operation may negatively impact some species (Mooney, Andersson, and Stanley 2022). Hard substrate provided by the platforms may actually benefit other species (Wilson and Elliott 2009). Wind energy areas are under active development by the Bureau of Ocean Energy Management (BOEM) throughout the United States. This study will assess habitats for sensitivity throughout strategic parts of the US.

A couple fundamental questions driving this analysis are:

1. *How different are existing lease areas from the rest of the region?* (***intra-region***)
   Areas not already slated for the offshore wind leasing impact species and habitats less, so could be candidates for alternative future planning. Areas with designated military use and outside BOEM's authority (e.g., National Marine Sanctuaries) need to be further excluded from consideration.

2. *How different are existing lease areas from each other within a given region?* (***inter-lease***)
   Within the leasing process the most oversight can be exercised within existing lease areas, especially ones in the earlier stages of Proposed Sale Notices and Call Areas. Identifying less impacted lease areas may lend greater stakeholder support for development.

2 Methods

2.1 Spatial Hierarchy: Regions > Zones > Blocks

Determination of regions for which to assess offshore habitat was based on BOEM activity and representativeness of habitats across the continental United States (Figure 2.1). The first (and presently only commercially in production) US wind farm at Block Island, NJ is in the North Atlantic where $4.4 billion was paid in offshore wind bids earlier this year (DOE news). The Atlantic seaboard slopes gradually making it appropriate for fixed platforms, whereas the Pacific coast drops off quickly into deeper depths making floating platforms more suitable. These technological differences therefore affect the bottom habitats differently. Whereas fixed platforms involve pile driving and addition of additional hard surfaces for habitats, the floating platforms leave only the benthic footprint of moorings and submarine cables.

2.1.1 Regions and Zones

2.1.2 Blocks

Table 2.1: Summary of Blocks per Zone, grouped by Region.

Zone	# of Blocks	Block Area (km²)
Atlantic		
Mid Atlantic	2,165	16,534
North Atlantic	342	859
South Atlantic	801	3,448
Gulf of Mexico		
Central Gulf of Mexico	33	762
Western Gulf of Mexico	96	2,215
Pacific		
Central California	16	23
Northern California	237	535
Southern California	673	2,590

Washington/Oregon	753	$4,684$

2.2 Datasets

Key	Name	Type	Taxa	# T
am	AquaMaps Global Probabilities	probability	All	9
rl	IUCN Global RedList Ranges	range	All	
du	Duke Atlantic Marine Mammal Densities	density	Marine mammals	
sw	SWFSC Pacific Cetacean Densities	density	Marine mammals	
gm	NOAA GoMex Cetacean & Sea Turtle Densities	density	Marine mammals, sea turtles	
nc	NCCOS Atlantic & Pacific Seabird Densities	density	Seabirds	
sm	SOEST Pacific Seamount Occurrences	occurrence		
ve	InterRidge Pacific Hydrothermal Vent Occurrences	occurrence		
vg	OregonState Global Productivity	productivity		

2.3 Analysis

A couple fundamental questions driving this analysis are: How different are existing lease areas from the rest of the region? (intra-region)

Areas not already slated for the offshore wind leasing impact species and habitats less, so could be candidates for alternative future planning. Areas with designated military use and outside BOEM's authority (e.g., National Marine Sanctuaries) need to be further excluded from consideration.

How different are existing lease areas from each other within a given region? (inter-lease)

Within the leasing process the most oversight can be exercised within existing lease areas, especially ones in the earlier stages of Proposed Sale Notices and Call Areas. Identifying less impacted lease areas may lend greater stakeholder support for development.

Benthic habitats will be the focus of input data, predominantly available through the Marine Cadastre (Table 1), especially based on seafloor properties (e.g., rock, grain size, rugosity), the presence of habitat forming species (e.g, coral, seagrasses, kelp) and other species. Species data will also be assessed from the AquaMaps distribution and OBIS observations.

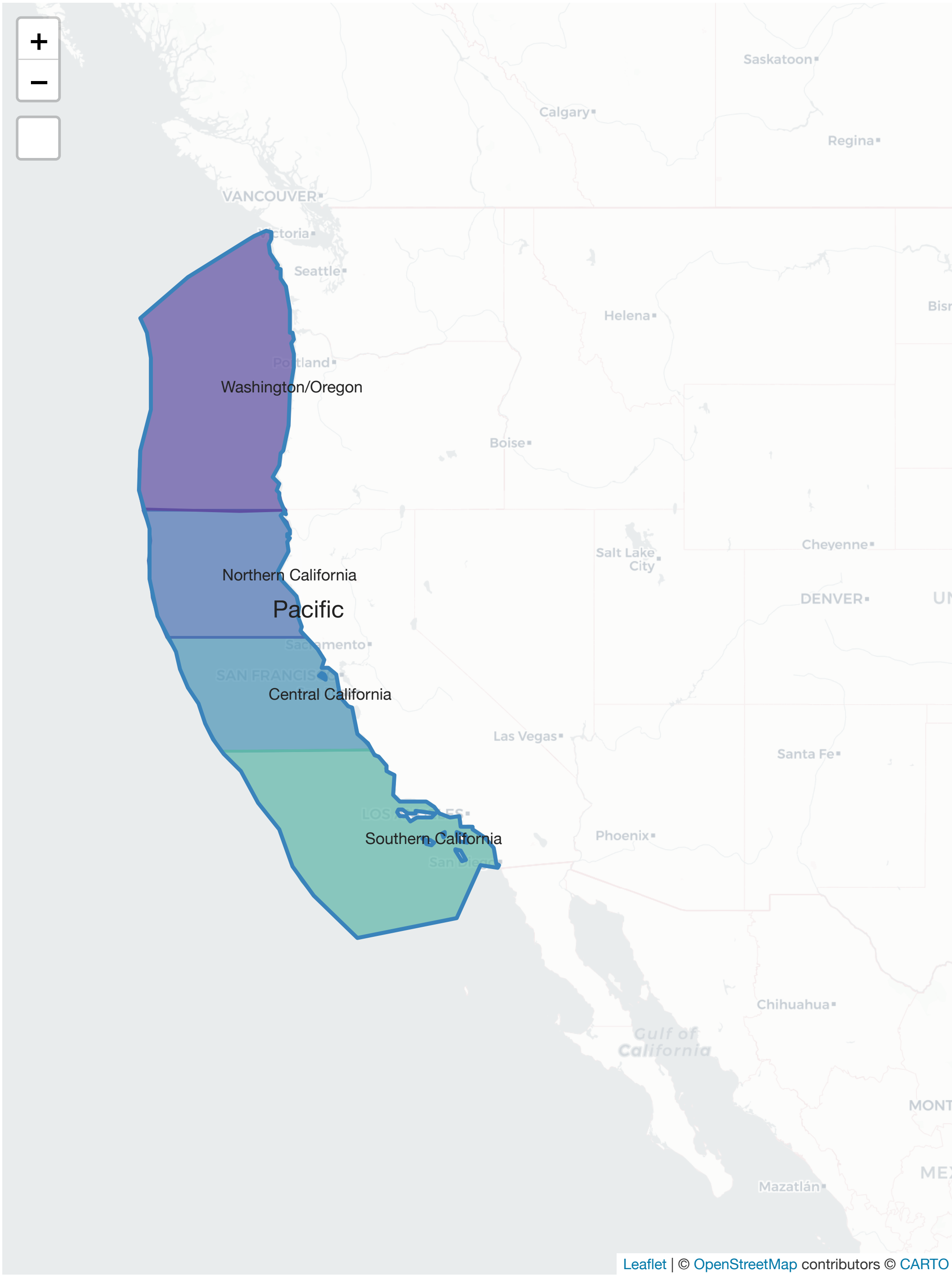


Figure 2.1: Regions (Atlantic, Gulf of Mexico, and Pacific) are subdivied into Zones corresponding to BOEM Planning Areas in federal waters clipped to the U.S. Exclusive Economic Zone (except Alaska and Hawaii). To prevent overcrowding of labels only abbreviations are shown for Central (CGM), Eastern (EGM) and Western (WGM) Gulf of Mexico.

2.3.1 Processing Steps

1. **Download dataset**
   As raster or vector

2. **Convert dataset layers to common raster format**
   In order to calculate quickly across a wide range of spatial data based on different formats (vector or raster), spatial units of analysis and projections, a common study area and grid was generated from the **GEBCO** elevation map and projected to Web Mercator for readily displaying in "slippy" maps online. The area-based distortion of Web Mercator was compensated for by calculating the true area per cell as a separate multiplicative layer for use in calculations.

3. **Average within dataset-species layers**
   Some datasets include seasonally (e.g., `[du]`) or regionally (e.g., `[nc]`) distinct density surfaces. These get averaged (for seasonal) and mosaicked (for regional) together to produce a single average per dataset and species.

4. **Rescale dataset-species layers 0 to 100% for all model types**
   While this analysis is detailed spatially, it is coarse in terms of abundance, since the best available spatial distribution information is combined across disparate dataset types, i.e. expert ***range*** maps (i.e., `[rl]`), ***probability*** of occurrence (i.e., `[am]`) and ***density*** surface models (e.g., `[du]`, `[sw]`, `[nc]`, `[gm]`). Model values were rescaled 0 to 100%, i.e. normalized to the existing probability of occurrence range of values (i.e., `[am]`). For instance, the original maximum ***density*** surface model value for common dolphins (*Delphinus delphis*) in the Atlantic from `[du]` is 286 individuals per km^2, whereas for the minke whale (Balaenoptera acutorostrata) in the Pacific from `[sw]` is 0.00491 individuals per km^2. Both of these maxima are converted to 100, since we are not comparing relative abundance between species but rather within species. Since expert ***range*** maps are binary in nature, i.e. in or out of range, a single value of 50% is applied within the range. Converting the stored values to single unsigned integers (`INT1U` for the range [0, 100]) enables a significant reduction of individual raster file sizes. Furthermore zeros were converted to `NA` (not available) for the sake of calculating the species range.

5. **Mosaic to single taxa across datasets, taxa**

6. **Apply weights**
   extinction risk, endemism, trophic level,….

7. **Summarize with equation**

8. **Extract across spatial hierarchies**
   Study, Regions, Zones, Blocks

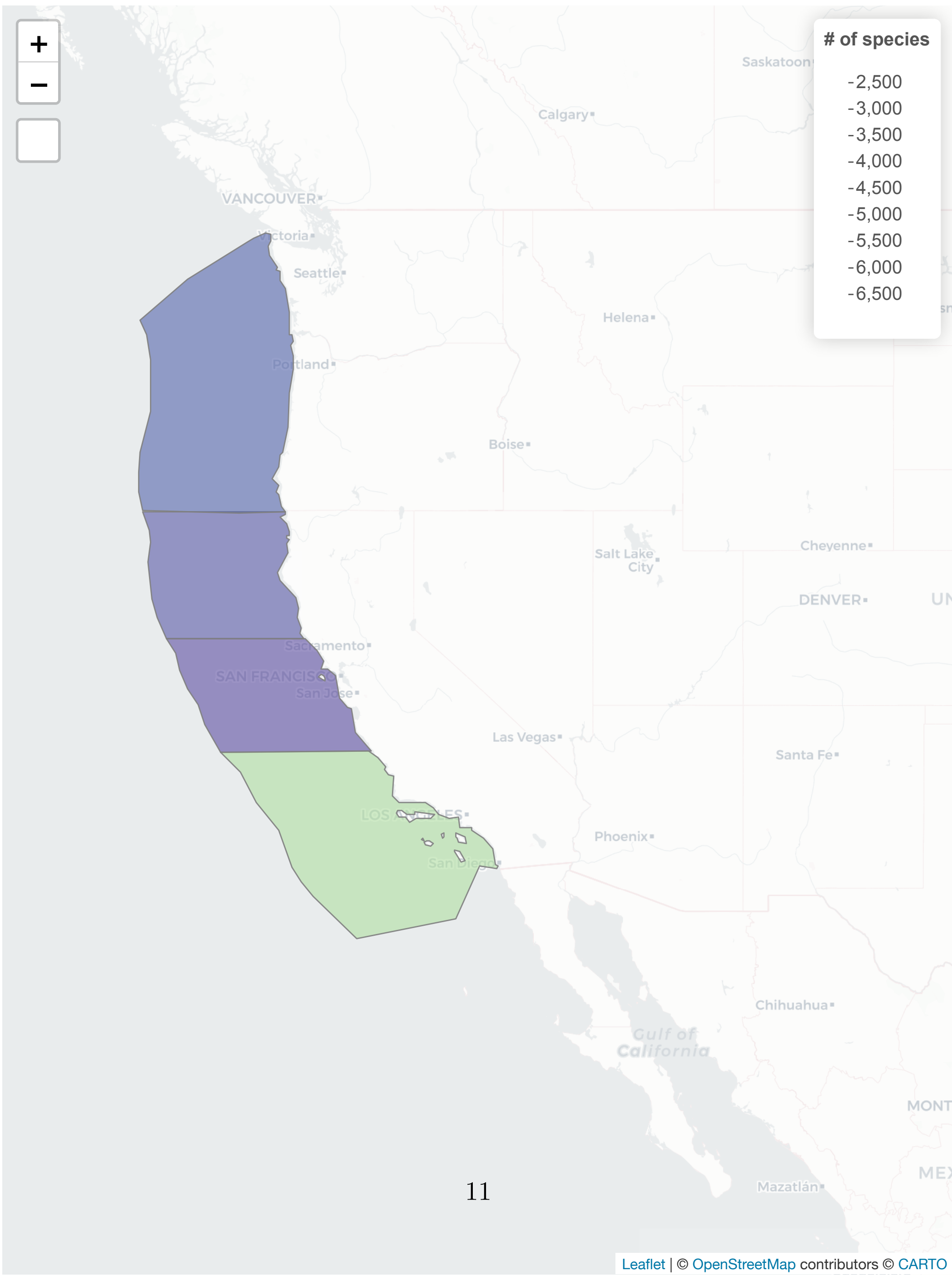
9. **Make scores relative to spatial hierarchy**

10.

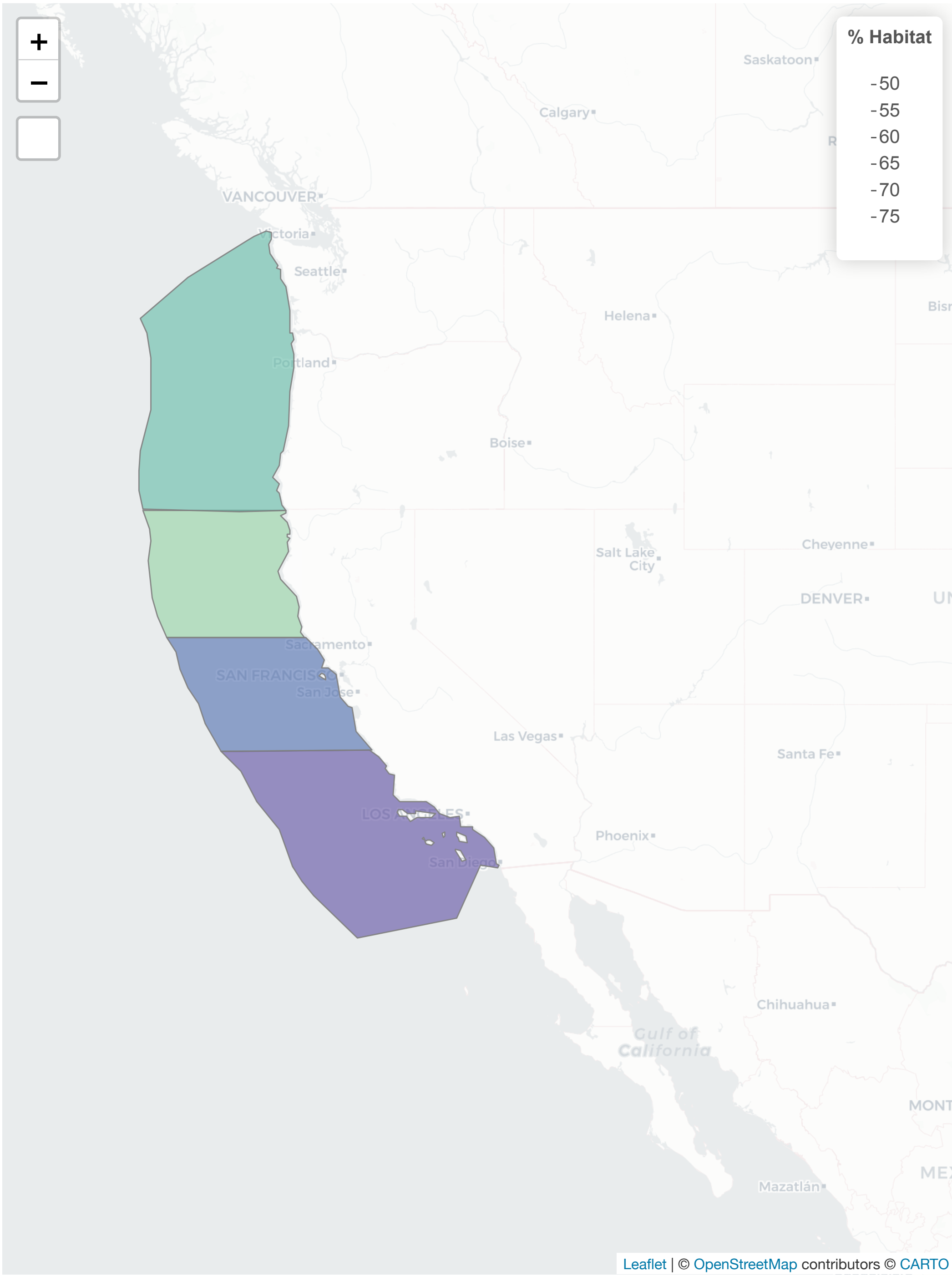
3 Results

3.1 Zones across U.S. (lower 48) Federal Waters

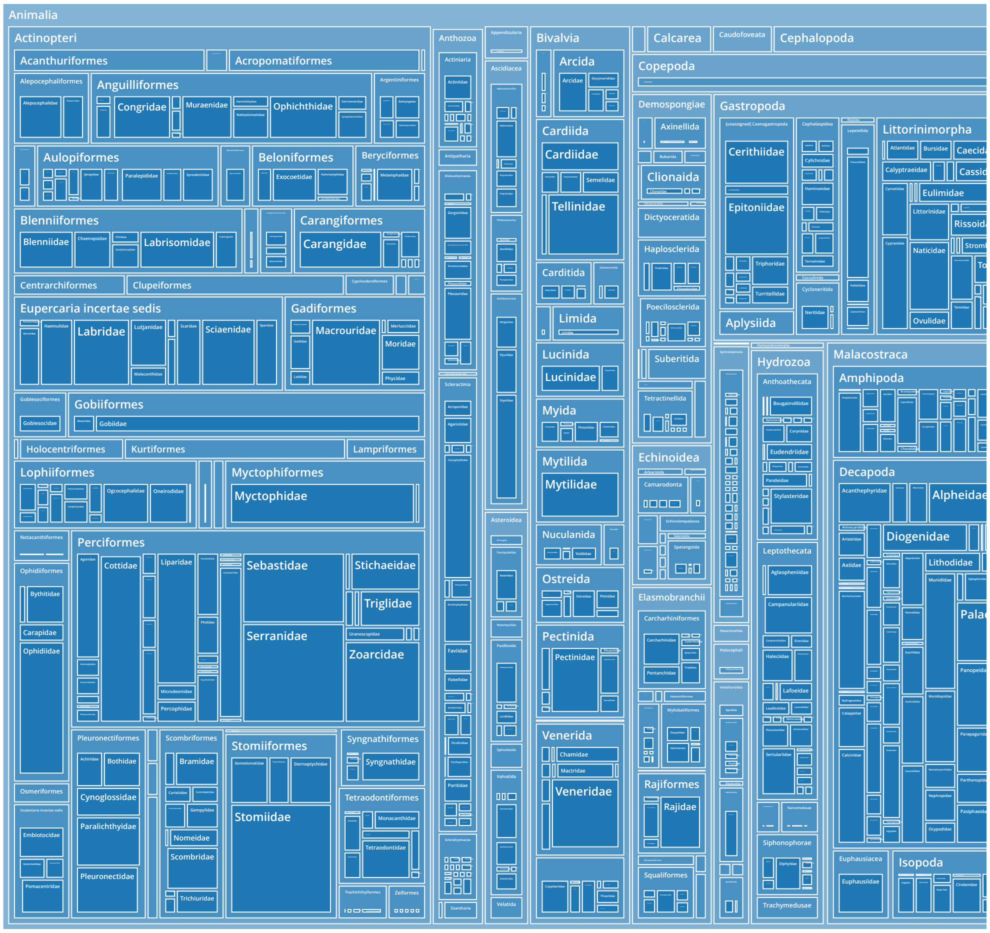
3.1.0.1 Species Presence



3.1.0.2 Species Abundance

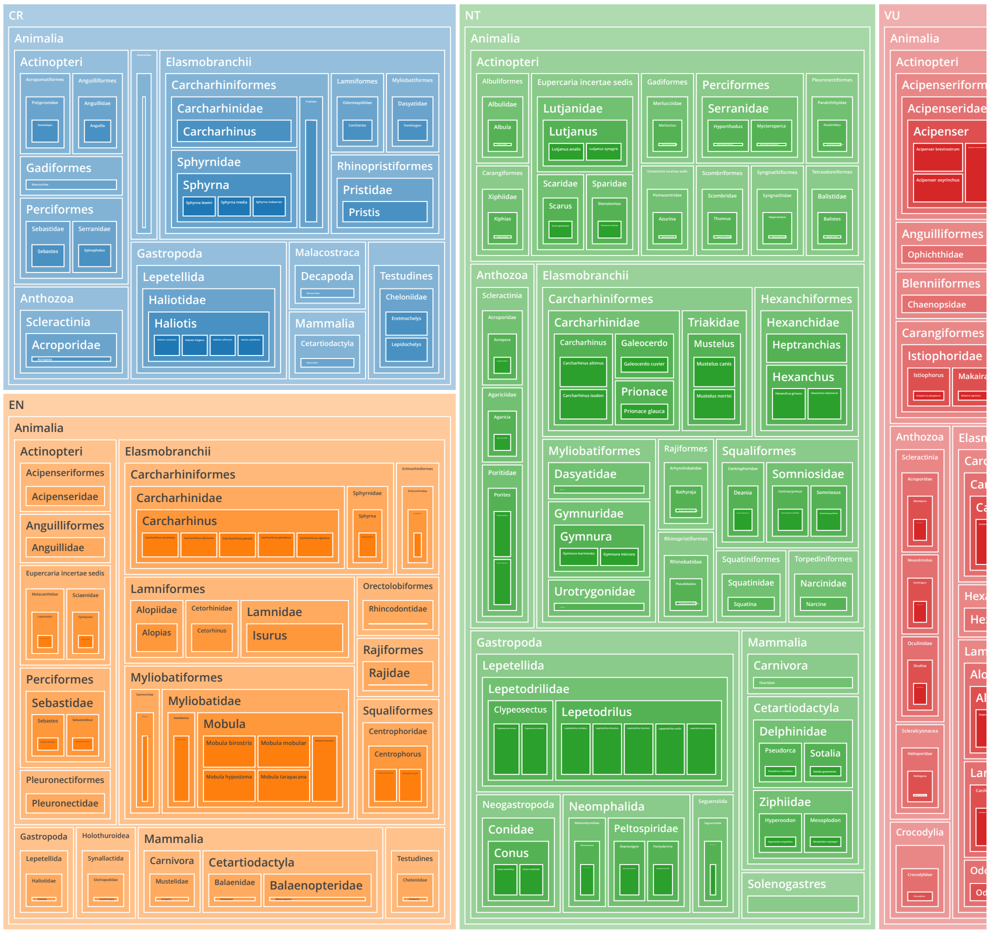


3.2 Species Composition for Study Area



3.3 Extinction Risk

3.3.1 Species for Extinction Risk



Show 10 entries Search:

	rl_category	rl_score	description
1	NT	1	Near Threatened
2	VU	2	VUlnerable
3	EN	3	ENdangered
4	CR	4	CRitically endangered

Showing 1 to 4 of 4 entries Previous 1 Next

Show 10 entries Search:

	rl_score	rl_category	kingdom	class	order	family	genus	scientificname	aphia_id
1	4	CR	Animalia	Actinopteri	Acropomatiformes	Polyprionidae	Stereolepis	Stereolepis gigas	282
2	4	CR	Animalia	Actinopteri	Anguilliformes	Anguillidae	Anguilla	Anguilla anguilla	126
3	4	CR	Animalia	Actinopteri	Gadiformes	Macrouridae	Coryphaenoides	Coryphaenoides rupestris	158
4	4	CR	Animalia	Actinopteri	Perciformes	Sebastidae	Sebastes	Sebastes paucispinis	274
5	4	CR	Animalia	Actinopteri	Perciformes	Serranidae	Epinephelus	Epinephelus striatus	159
6	4	CR	Animalia	Anthozoa	Scleractinia	Acroporidae	Acropora	Acropora cervicornis	206
7	4	CR	Animalia	Anthozoa	Scleractinia	Acroporidae	Acropora	Acropora palmata	288
8	4	CR	Animalia	Asteroidea	Forcipulatida	Asteriidae	Pycnopodia	Pycnopodia helianthoides	240
9	4	CR	Animalia	Elasmobranchii	Carcharhiniformes	Carcharhinidae	Carcharhinus	Carcharhinus longimanus	105
10	4	CR	Animalia	Elasmobranchii	Carcharhiniformes	Carcharhinidae	Carcharhinus	Carcharhinus porosus	217

Showing 1 to 10 of 207 entries Previous 1 2 3 4 5 … 21 Next

3.4 Productivity

3.5 Block relative to Zones

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4 Summary

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References

Mooney, T Aran, Mathias H Andersson, and Jenni Stanley. 2022. "ACOUSTIC IMPACTS OF OFFSHORE WIND ENERGY ON FISHERY RESOURCES." *Oceanography*, 15.

Wilson, Jennifer C., and Michael Elliott. 2009. "The Habitat-Creation Potential of Offshore Wind Farms." *Wind Energy* 12 (2): 203–12. https://doi.org/10.1002/we.324.

A Technical

A.1 Relational Database Structure

A.1.1 Typography

- *: wildcard indicating any value, such as *.csv for any file name ending in .csv
- {*}: surrounding curly braces ({}) indicates variable substitution, e.g. ds_{mdl_key} would evaluate to the value ds_am for mdl_key = "am", as in the dataset (ds) for AquaMaps (am)
- [*]: surrounding brackets ([]) indicates an optional value, such as [ply_grp] is an optional column in the ds_gm table
- <*>: surrounds the columns used to identify columns that uniquely identify (and index) each row
- ...: additional columns, unique to the table

The format below is of the following format where the top line of a bulleted list item describes the table and the columns in that table are directly below, nested in hierarchical order:

- {table name} ({description})
  <{column 1}, {column 2}>, {column 3}, ...

A.1.2 Database Naming Conventions

- Use all **lower-case** column names with underscores (i.e. from using janitor::clean_names()) to prevent need to quote SQL statements.
- For short unique **identifiers** use suffix *_id for integer and *_key for short text.

A.1.3 Models Based on Polygons

Models based on polygons have an attribute table that may contain multiple values of interest. The normalized form of the database should not require repeating the geometry for each polygon to reproduce the original dataset that may be shared across values for an individual model as well as across multiple models. If models in the dataset use more than one collection of polygons, then the polygon group `ply_grp` field is optionally used to differentiate which set of polygons to use.

All features are projected to the geographic (`EPSG:4326`) coordinate reference system for `leaflet` R package visualization of polygons with "slippy" basemaps (e.g. "Esri.OceanBasemap" at Leaflet Providers).

- `datasets`
  <`ds_key`>, ...
- `cells_ds_ply` (cells to dataset polygons)
  <`ds_key`, `ply_id`, `cell_id`>
- `ds_{ds_key}` (dataset model attributes)
  <`ds_key`, `mdl_id`>, `aphia_id`, `fld_ply_val`, `val_type`, ...
- `ds_{ds_key}_plys` (dataset polygon attributes, including values)
  <`ds_key`, `ply_id`>, `val = {fc_flds}`, ...

A.1.4 Models Based on Rasters

All rasters are projected to web Mercator (`EPSG:3857`) coordinate reference system for `leaflet` R package visualization of rasters with "slippy" basemaps (e.g. "Esri.OceanBasemap" at Leaflet Providers). Since the variable is usually continuous, new values may be interpolated to the web Mercator raster with `method = "bilinear"` option (versus `method = "nearest"`). Because of this, the value is directly stored in the `_cells_rast` table for all raster models (versus a lookup of OffHab cell_ids to the original raster's pixel).

- `datasets` <`ds_key`>, …
- `ds_cells_rast` (cells to dataset pixel values)
  <`ds_key`, `mdl_id`, `cell_id`>, `val`
- `mdls_{ds_key}` (dataset model attributes)
  <`ds_key`, `mdl_id`>, `aphia_id`, `val_type`, ...

A.1.5 Future Development

1. Add columns to handle relationships between models, such as uncertainty (e.g. `sd`/`cv`/ `ci95pct` / `ci5pct`; not using yet) associated with which density:
   - `{mdl_key}_mdls.`: `mdl_related` | `mdl_relationship`
2. Add value transformation column (`val_transform`) to `{mdl_key}_mdls` to standardize values from original to `val_type` (not using yet since all relative so far):

- `oa_mdls.val_transform`: val^3
- `du_mdls.val_transform` $val/100$