

EcoQuants Proposal for Offshore Environmental Sensitivity Indices

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1 Abstract

EcoQuants proposes to develop offshore Environmental Sensitivity Indices (ESIs) by producing fine resolution species distribution maps and a framework for matching species to sensitivities specific to oil, gas or wind energy human activities.

2 Framework for Environmental Sensitivity Indices

2.1 Atlas of Species and Habitats

Existing methods for ESI calculation (Niedoroda et al. 2014) only produced for very broad areas.

Downscale [AquaMaps.org](#) species distributions (Kaschner et al. 2023; Ready et al. 2010) from 0.5 decimal degrees to 15 arc seconds (~55 km to ~0.5 km at the equator), using the R package [aquamapsdata](#) and the General Bathymetric Chart of the Oceans [GEBCO](#).

Later we'll iterate over species and expand to global, which will require large raster handling techniques using Cloud-Optimized GeoTIFFS (COGs; see [cogeo.org](#)).

All code and files (except the large global GEBCO grid) are found in this repository:

- [github.com/marinebon/aquamaps-downscaled](#)
- [env_bluewhale](#) The blue whale (*Balaenoptera musculus*) and Southern California. (Figure 1)

See Figure 2.

Summarize by zone (Figure 3).

See Figure 4.

See Table 1.

Table 1: Summary of datasets.

# Species	Name	Year
9,639	AquaMaps Global Probabilities	2021
342	IUCN Global RedList Ranges	2022
79	NCCOS Atlantic & Pacific Seabird Densities	2021
48	Duke Atlantic Marine Mammal Densities	2022
13	SWFSC Pacific Cetacean Densities	2020
11	NOAA GoMex Cetacean & Sea Turtle Densities	2022
	InterRidge Pacific Hydrothermal Vent Occurrences	2020

Match and use the taxonomic unique identifier `aphia_id` used by the World Registry of Marine Species at [MarineSpecies.org](https://www.marinespecies.org).

2.2 Matrices of Sensitivity to Human Activities

Kelsey et al. (2018):

- We present a study of offshore wind energy infrastructure impacts on marine birds in the US Pacific Outer Continental Shelf.
- Using species-specific metrics, we calculated Population, Collision, and Displacement Vulnerability for 81 species.
- Species with highest Population Vulnerability included threatened species and year-round residents with small population sizes.
- Jaegers/skuas, pelicans, terns and gulls have high collision vulnerability.
- Loons, grebes, sea ducks, and alcids have high displacement vulnerability.

Michael et al. (2022) on seabird vulnerability to oil.

Also ships and whales. Rice's whale ecoquants.com/ricei/. (Best 2023)

Tradeoffs overview (Figure 5).

OHI value sets (Figure 6).

Human use atlases (D'lorio et al. 2015)

Mitigation strategies (Industrial Economics, Inc. 2012)

3 Interactive Applications

Propose to borrow from the suite of applications...

3.1 Ocean Health Index

The Ocean Health Index uses a framework of 10 broad goals with status, pressures, trend and status. The flower plot visualizes the score of each goal as its extent, and the weighted value to the overall score as the petal width. (Figure 7)

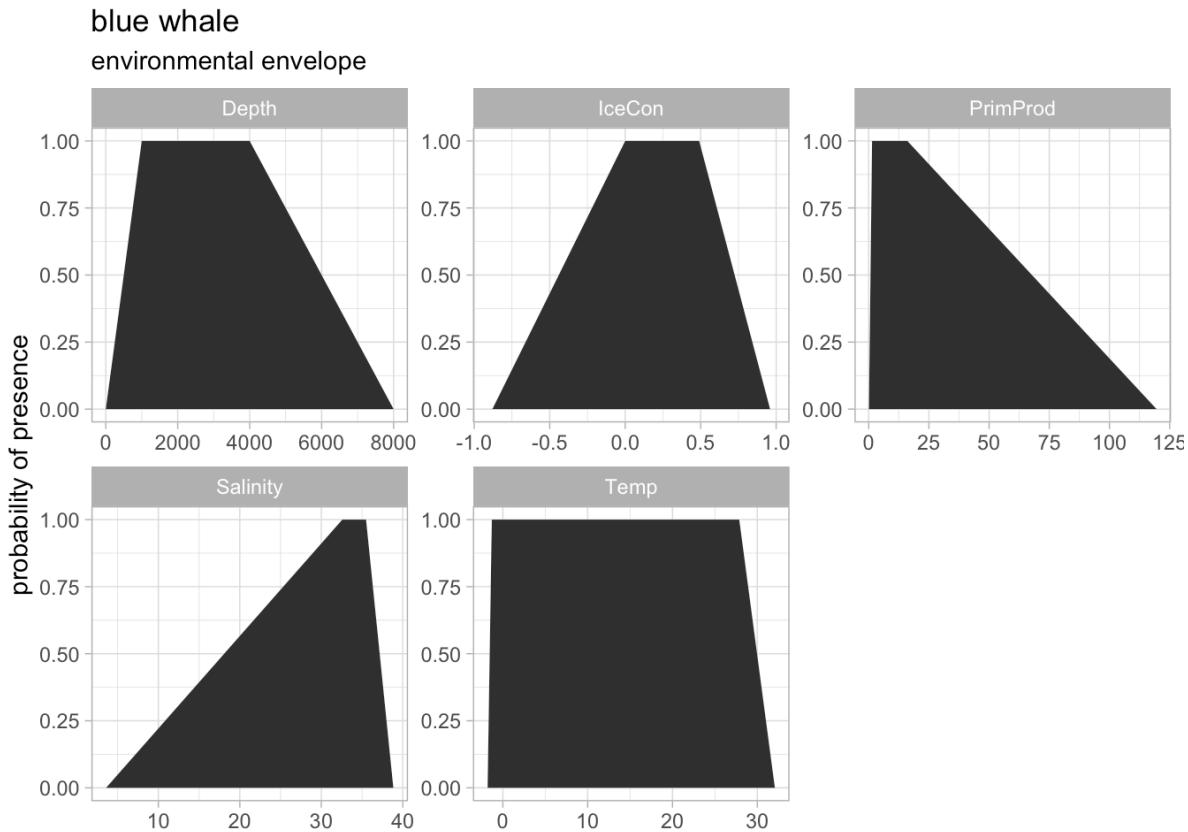


Figure 1: Plots of environmental suitability parameters from `aquamapsdata` for an example species of blue whale (*Balaenoptera musculus*).

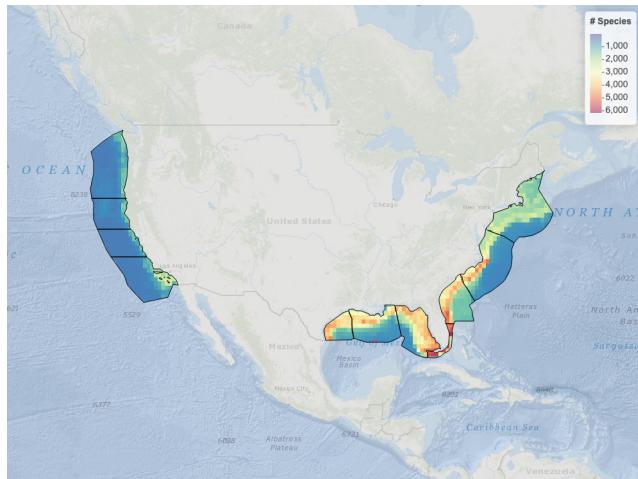


Figure 2: Screenshot of [interactive map of species richness by pixel](#) across federal waters for the contiguous United States.

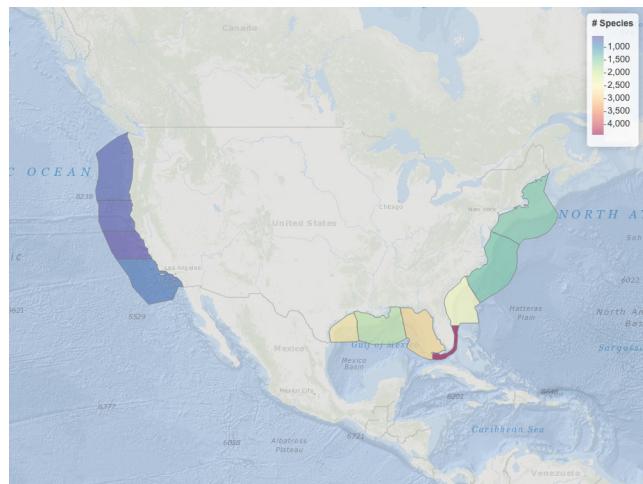


Figure 3: Screenshot of [interactive map of species richness by zone](#) across federal waters for the contiguous United States.

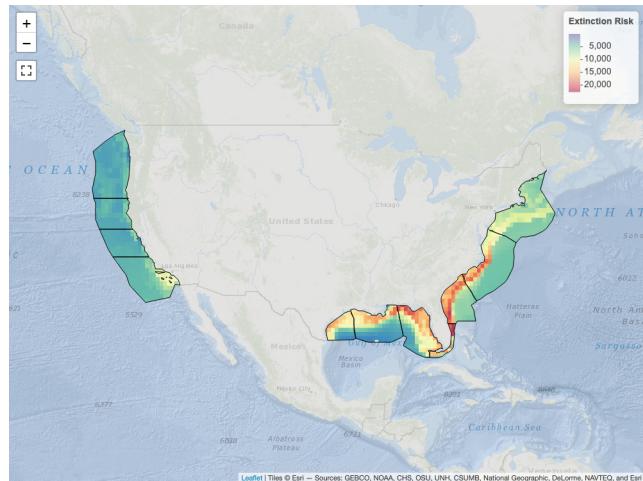


Figure 4: Screenshot of [interactive map of extinction risk](#) across federal waters for the contiguous United States.

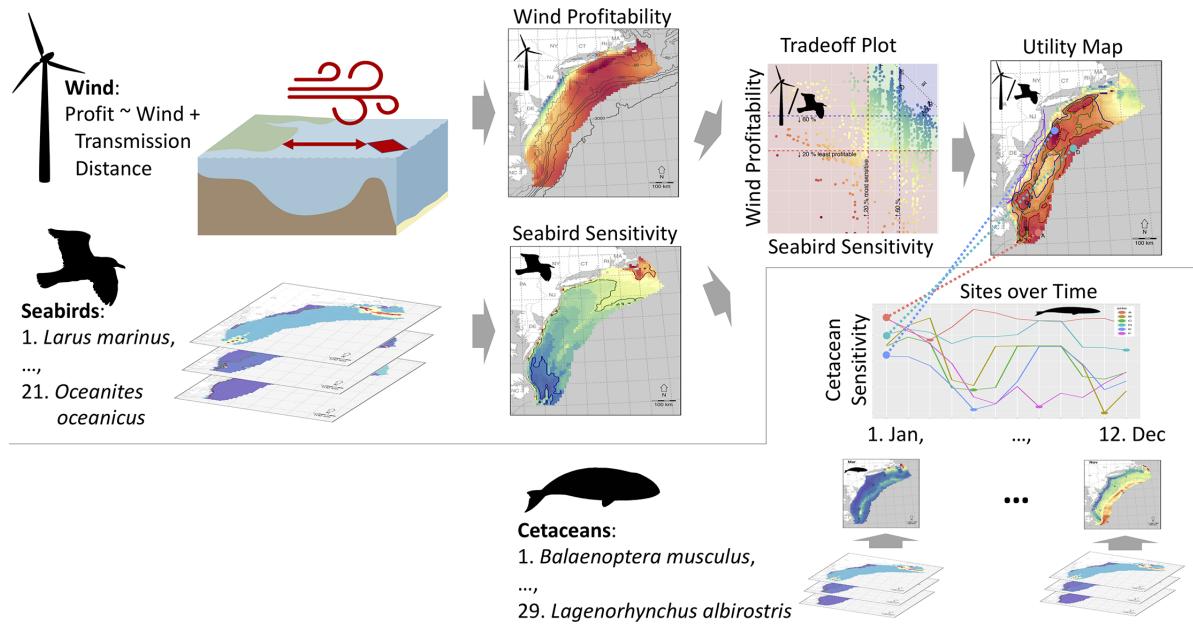


Figure 5: Overview of methods for bringing together wind profitability, seabird sensitivity over space, and cetacean sensitivity over space and time. Source: Best and Halpin (2019).

3.2 NREL Uses

Assign weights to human uses, species distributions and habitats. Sum them up to determine most sensitive areas. (Figure 8)

3.3 Tradeoffs

A tradeoff plot can visualizes two objectives at once. Selecting win-win areas in the plot, such as high wind and low seabird sensitivity, highlights those places on the map. (Figure 9)

Novel marine energy application (Barr et al. 2022).

3.4 MarineEnergy.app

Select tags (technology, stressor, and/or receptor), draw location and generate a report (Figure 10).

- Use OAuth2 to login via Google, Microsoft, Facebook, etc.
- Mitigation strategies
- Generate a report using API.

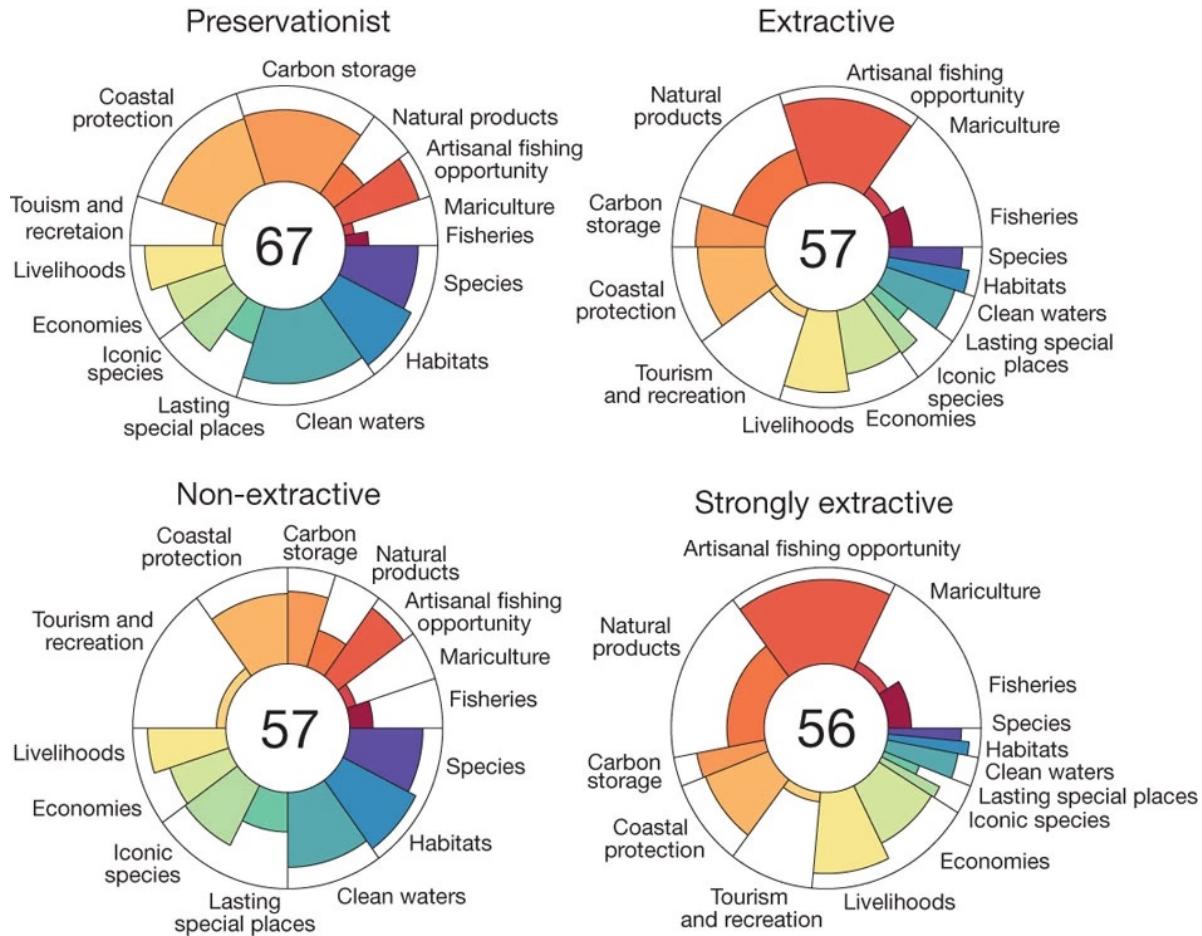


Figure 6: Value sets are illustrative rather than prescriptive; labels for the value sets are approximations and should not be interpreted literally. Source: Halpern et al. (2012)

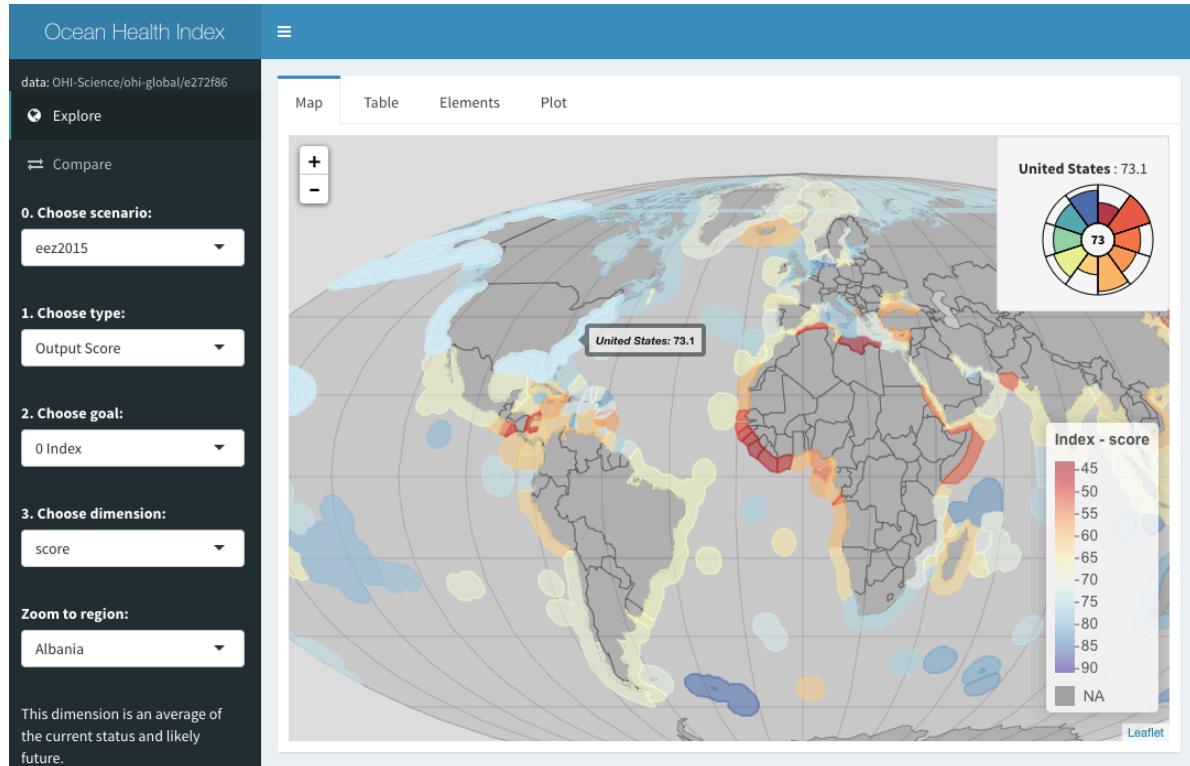


Figure 7: Screenshot of [Ocean Health Index application](#) ([source code](#)) showing scores on hover with flower plot from equally weighted goals (See Figure 6).

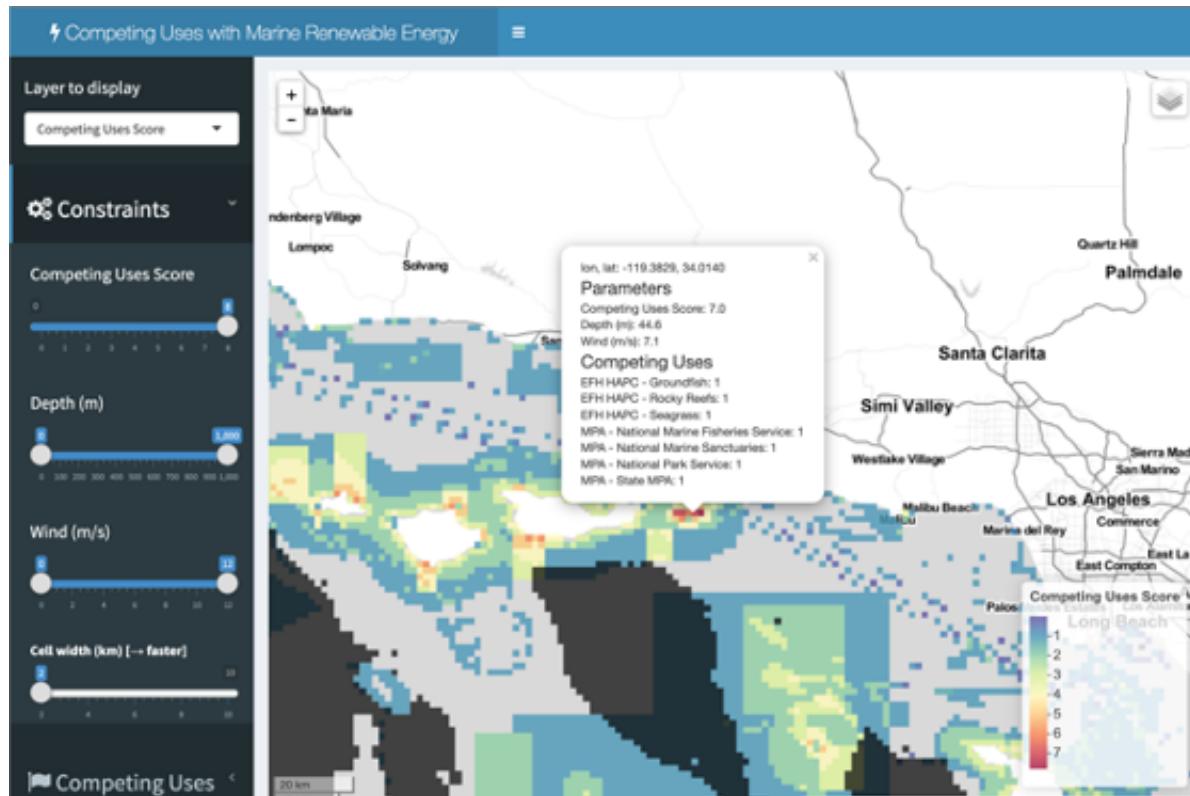


Figure 8: Screenshot of [NREL Uses application](#) (source code) showing sliders to apply constraints.

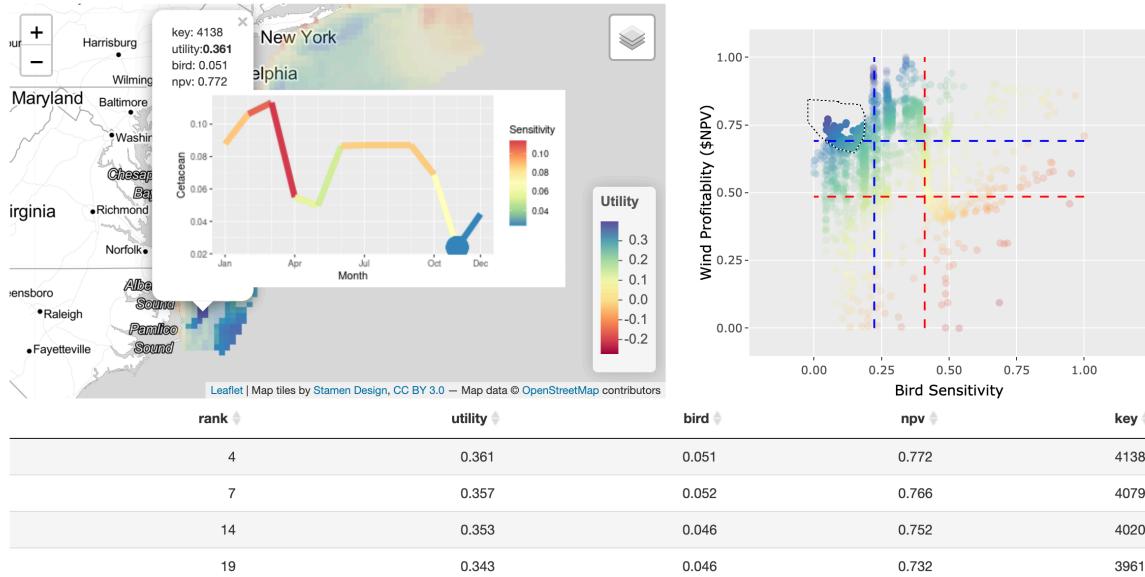


Figure 9: Screenshot of [Tradeoffs application](#) ([source code](#)) showing the ability to lasso pixels in tradeoff space to show up on the map and clicking on a given pixel to identify month of year to minimally impact marine mammals.

- Draw custom areas and generate outputs (Figure 11).

4 Infographics

Visualize the ecosystem with icons clickable to popup windows with data and details.

Infographics (Spector et al. 2021) (Figure 12) have been used on [SanctuaryWatch](#) and the NOAA Integrated Ecosystem Assesment (e.g., for the [California Ecosystem Status Report](#)).

- Github real-time.
- SanctSound

5 Software Components

5.1 Folders & Repositories

- folders on a share drive

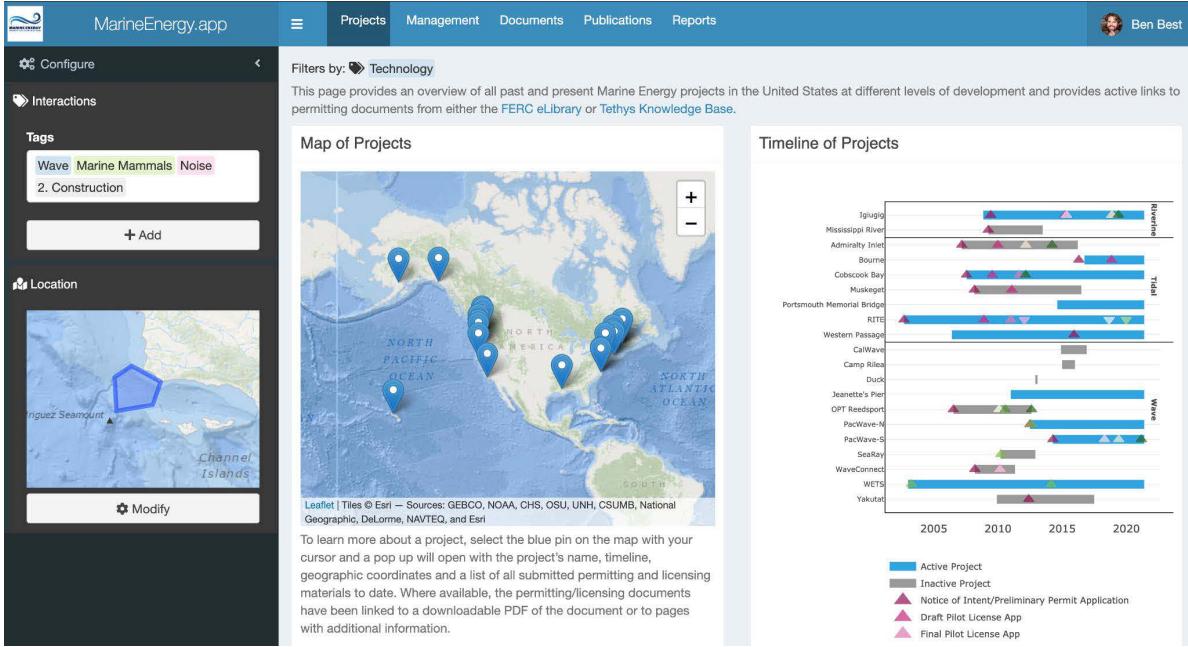


Figure 10: Screenshot of [Marine Energy application \(source code\)](#) Figure 2. The reporting application has an expandable sidebar for inputting a set of Tags as Interactions and a Location as a polygon. The top menu allows the user to navigate across content types. Here the Projects display a map and timeline of marine energy projects. Once the user submits the Add button on the Tags, the Projects map and timeline will reduce to just the Wave technology. Each of the content types filters on different tags, which are color coded. The Reports section enables users to save their reports (after logging in with a Google account) and share the online link with others. Source: Barr et al. (2022)

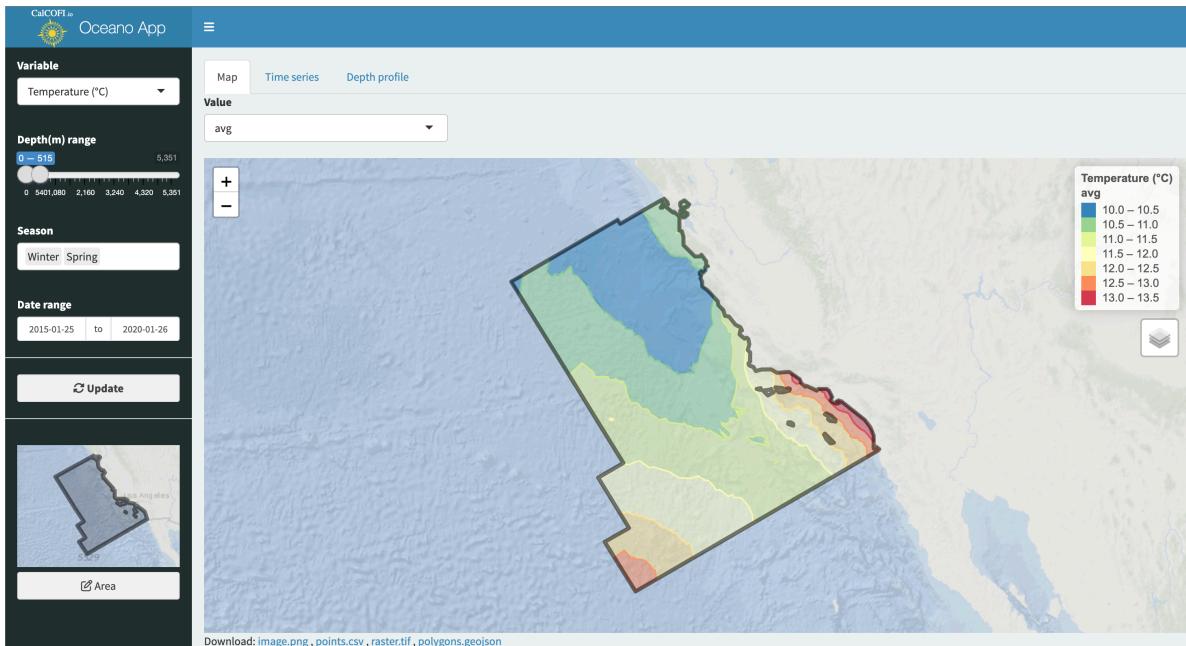
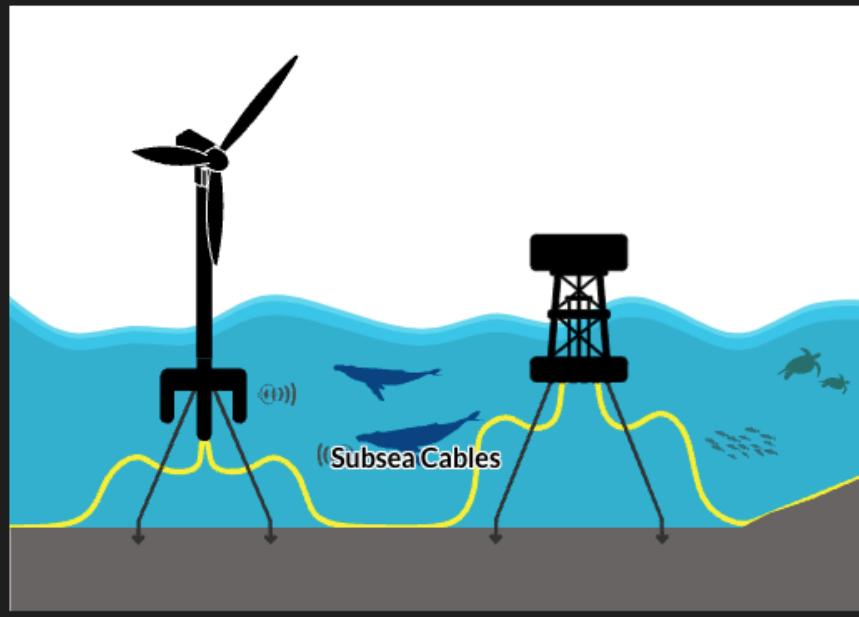


Figure 11: Screenshot of [CalCOFI oceanographic application](#) ([source code](#)) showing ability to generate contours on the fly as well as select existing or custom areas of interest over which to summarize in space, time or depth.

Whale Interactions

How do baleen whales interact with the cables?



Full Screen

- Cetacean Sounds
- Moorings
- Offshore Platforms
- Offshore Substation
- Subsea Cables
- Turbine Sounds
- Whales
- Wind Turbines

Figure 12: Screenshot of [interactive infographic](#) informing on whale interactions with offshore wind energy, built using the [infographiq](#) JavaScript library. Clicking on elements in the scene or contents on the right opens a window with multimedia content describing in detail.

- data
- documents
- bibliography
 - Zotero
- Github repositories
 - 1 GB limit
 - Github Pages for sharing like this proposal

5.2 Server Software

- Docker
- Database
 - Postgres + PostGIS

5.3 Application Programming Interfaces

- Custom
 - R Plumber
- PostgREST
- Examples
 - api.marineenergy.app
 - api.calcofi.io

5.4 R Library

- R library [offhabr](#)
- R library [calcofi4r](#) with vignette.
- Overall catalog of open-source products with links to source code repositories and live product at [CalCOFI.io](#).
- Categories
 - Read

- Analyze
- Visualize

6 Reproducible Results

This proposal was produced using the principles of reproducible research (Lowndes et al. 2017) with the R programming language (R Core Team 2023).

All source code for this proposal can be found at github.com/ecoquants/boem-esi.

Statistical analysis will be performed using the libraries and methods of the `tidyverse` (Wickham et al. 2019) and spatial features `sf` (Pebesma 2018) output to a `Quarto` document (Allaire 2022). All source code is available in the Github repository github.com/ecoquants/ricei. The interactive version of this report is available at ecoquants.com/ricei.

7 Project Management

- Github Project
- Personell: Ben
- Project Manager

7.1 Draft Milestones

- spin up server environment
 - docker: rstu
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