

# Evaluating Competing Uses for Marine Renewable Energy

Ben Best<sup>1</sup>, Levi Kilcher<sup>2</sup>, Walter Musial<sup>2</sup>



Pacific Region Marine Renewables Environmental Regulatory Workshop  
Portland, OR  
September 12, 2017



<sup>1</sup> EcoQuants, Santa Barbara, CA

<sup>2</sup> National Renewable Energy Lab, Golden, CO



# Need for marine renewable energy

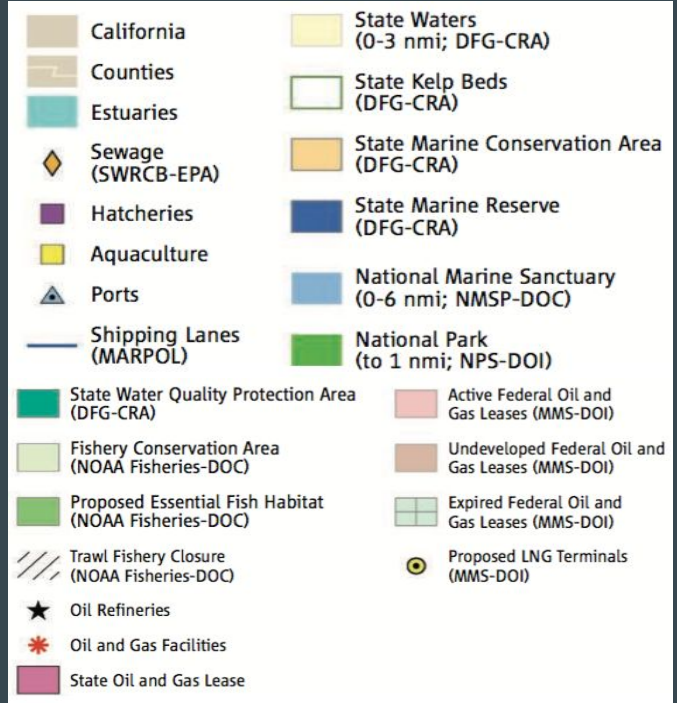
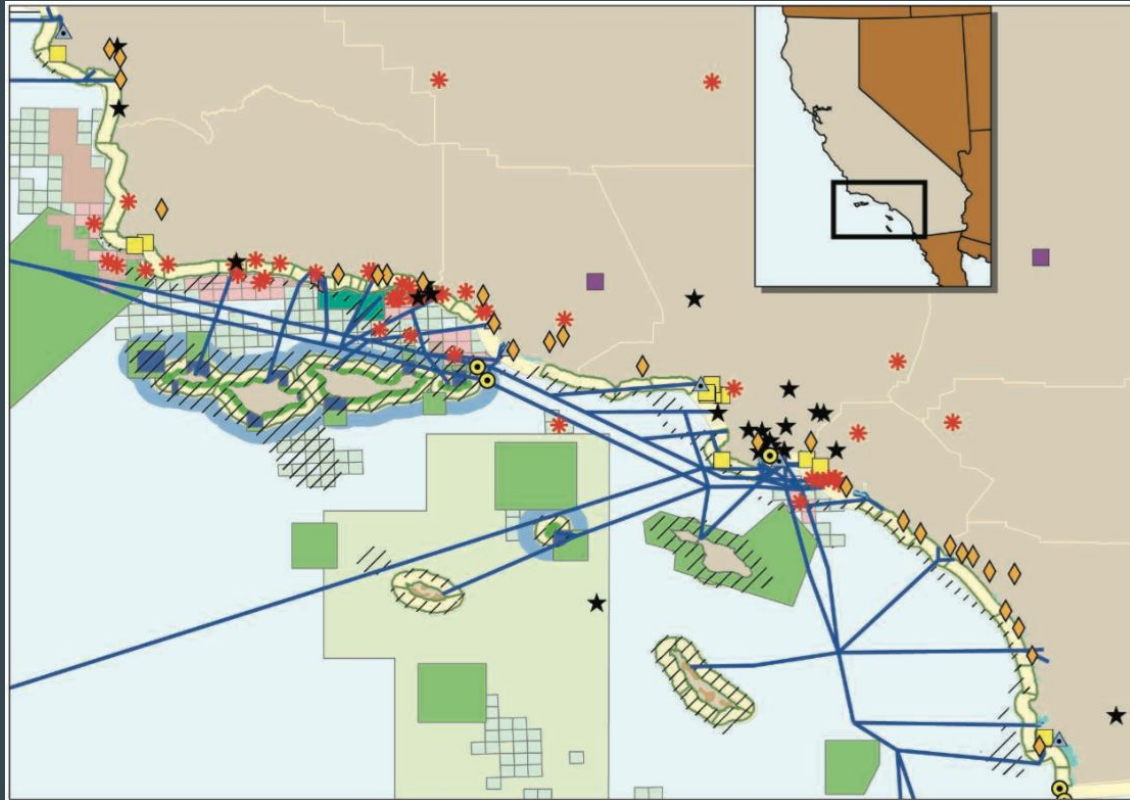
- Reduce:
  - Greenhouse gases
  - Foreign dependence on energy
- Marine energy advantages:
  - **Complementary** to other large scale renewable energy
  - **Predictable** throughout day and seasons
  - **Proximity** to dense coastal populations

# Outline

- Challenges
- Past Approaches
- Present Cable Analysis
- Future Competing Use Analysis

# Challenges

# Crowded ocean



Crowder et al (2006) Resolving Mismatches in U.S. Ocean Governance. *Science*

# Many data layers, how to synthesize?

The screenshot shows the MarineCadastre.gov website interface. At the top, there is a dark blue header with the site name and navigation links: Maps, Data, Uses, Tools, News, and About. Below the header is a search bar and a 'Help' button. The main content area is divided into two columns. The left column contains filters for 'Theme' and 'Region', with a 'Clear Filters' button and a 'Show More' link. The right column displays a list of datasets, each with a title, source, and a set of icons for map interaction. The datasets listed are: 12NM Territorial Sea (NOAA Office of Coast Survey), 2009 - 2014 National AIS at 1 Minute Intervals (MarineCadastre.gov), 2009 Vessel Traffic (AIS) (Bureau of Ocean Energy Management), and 2009-2010 Commercial Vessel Density (October - AIS) (NOAA Office of Coast Survey). Each dataset entry includes a '+ Add to Map' button.

**MarineCadastre.gov**   Maps   Data   Uses   Tools   News   About

Search     Help   My Map 0

Currently displaying  
**274 Datasets**

[Clear Filters](#)

**Theme**

- Benthic
- Birds
- Corals
- Economic
- Elevation
- Show More

**Region**

- Alaska
- Caribbean
- East Coast
- Great Lakes
- Gulf of Mexico
- Show More

**12NM Territorial Sea** ⓘ  
NOAA Office of Coast Survey

[+ Add to Map](#)

**2009 - 2014 National AIS at 1 Minute Intervals** ⓘ  
MarineCadastre.gov

[+ Add to Map](#)

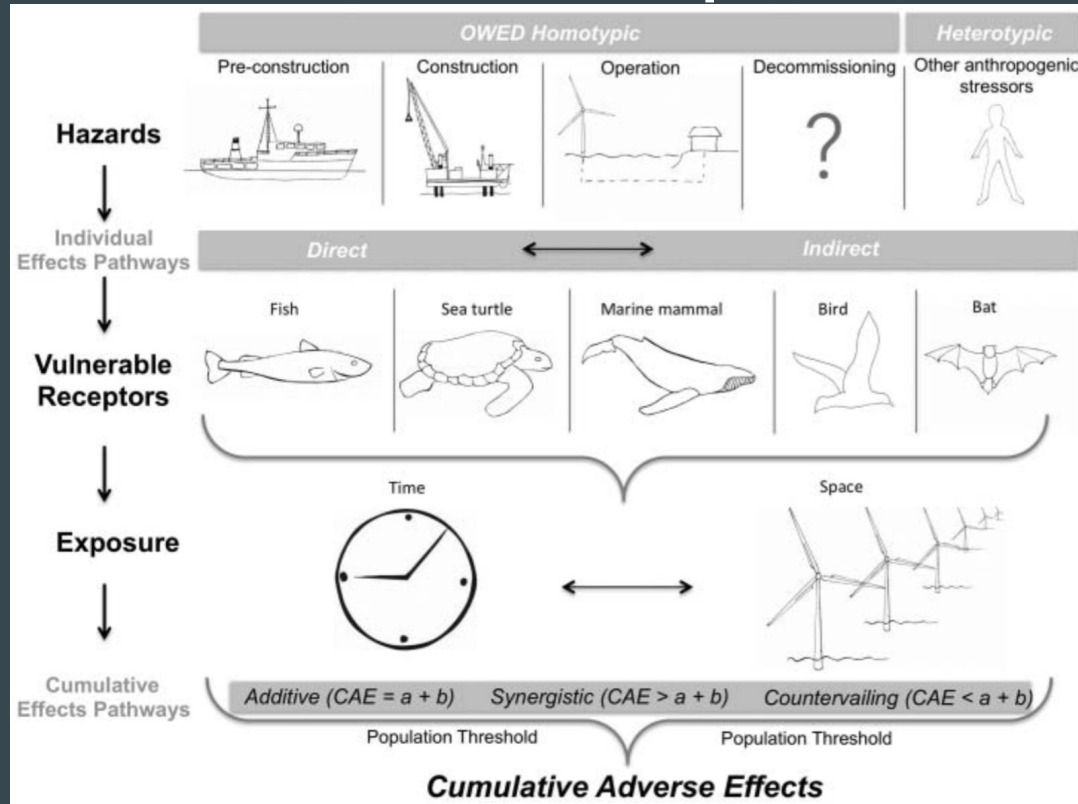
**2009 Vessel Traffic (AIS)** ⓘ  
Bureau of Ocean Energy Management

[+ Add to Map](#)

**2009-2010 Commercial Vessel Density (October - AIS)** ⓘ  
NOAA Office of Coast Survey

[+ Add to Map](#)

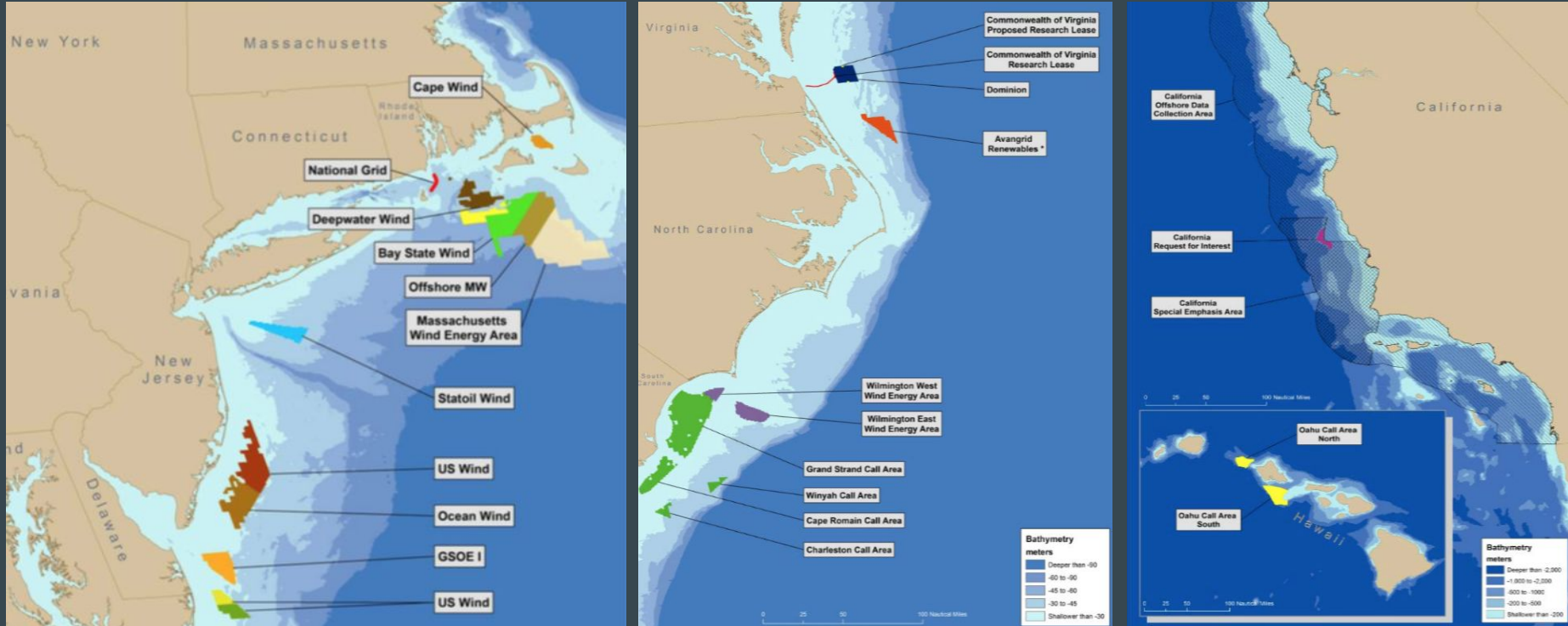
# Environmental interactions are complex



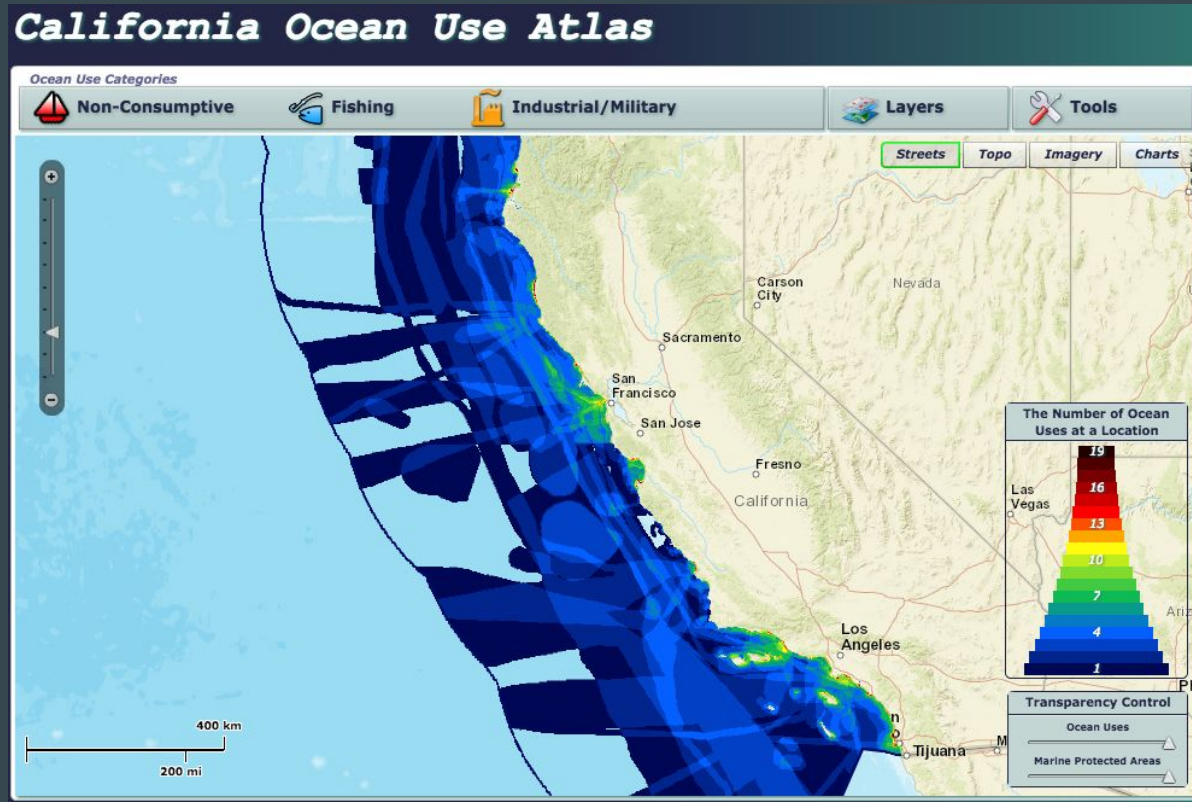
# Past Approaches



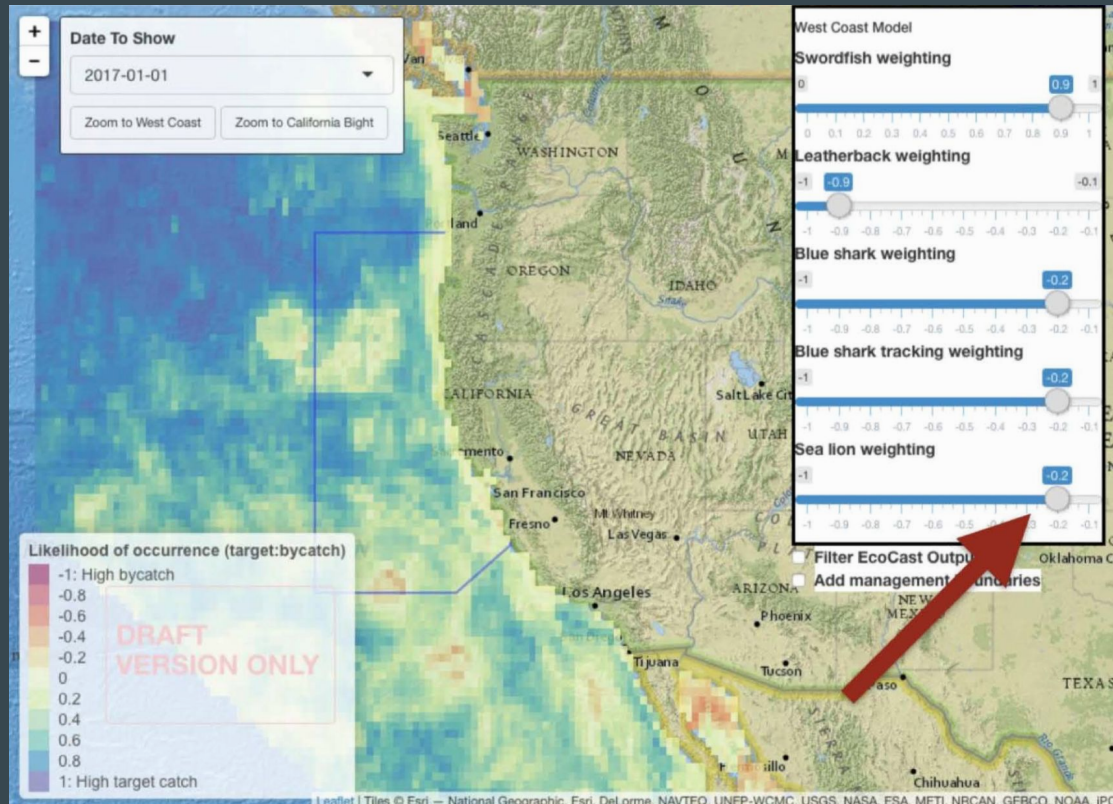
# Wind Energy Areas: stakeholder process (BOEM)



# Ocean uses: unweighted



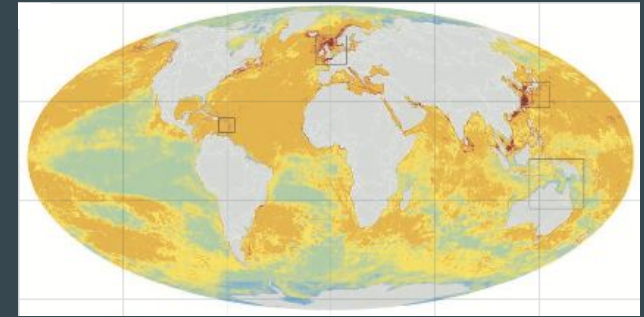
# User defined weights



# Expert derived weights

- Cumulative impact analysis  
habitat x human impact

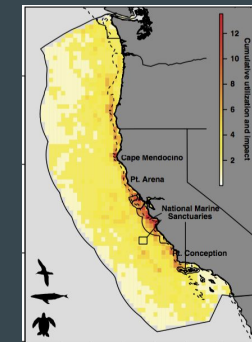
	pollution		climate change			...
habitat	chemical	nutrient	SST	acidification	UV	...
coral	1	2	3	1	1	
mangrove	1	1	0	0		
salt marsh	1	2	0	0	0	
seagrass	2	3	2	1		
...						



Halpern et al (2008) A Global Map of Human Impact on Marine Ecosystems. *Science*

- species x human impact

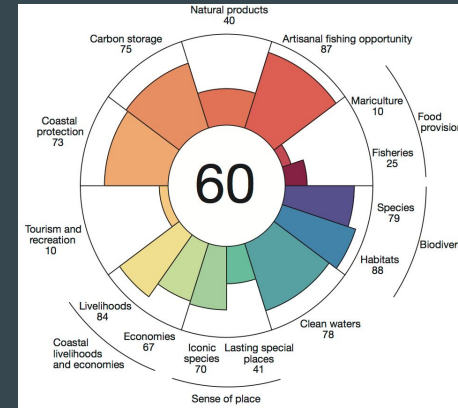
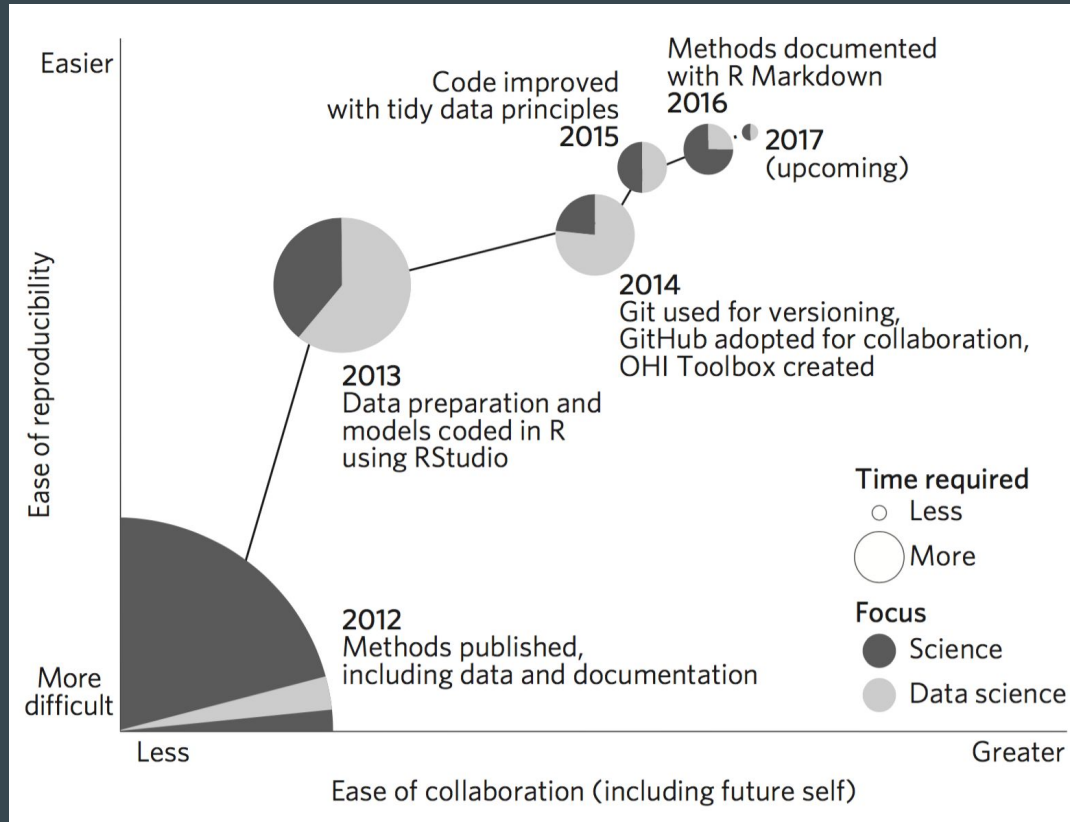
	pollution		climate change			...
species	chemical	nutrient	SST	acidification	UV	...
blue whales	13	11	12	12	14	
elephant seals	14	0	15	12	11	
black-footed albatross	15	14.5	15	12	11	
sooty shearwaters	13	6	10	11	12	
...						



Maxwell et al (2013) Cumulative human impacts on marine predators. *Nature Comm.*



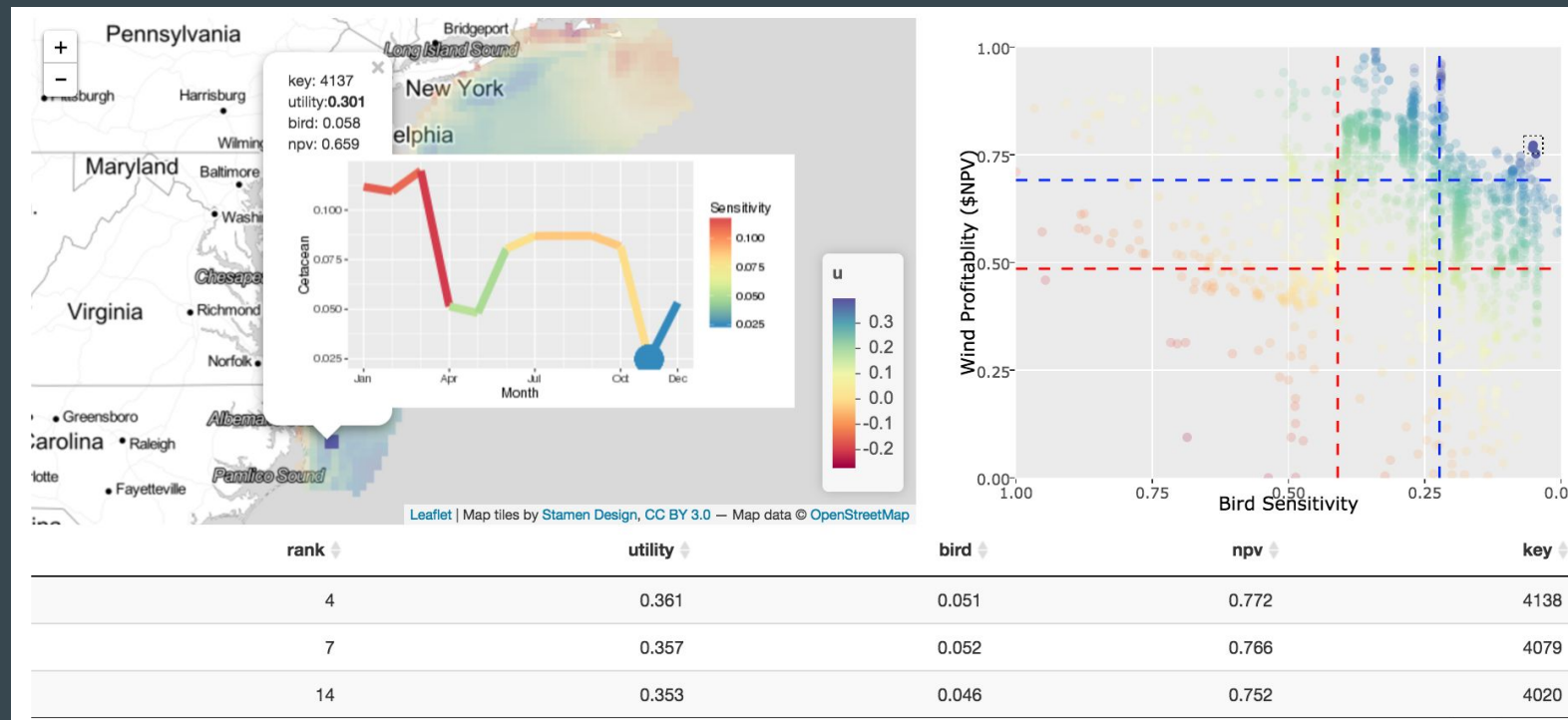
# Open data science tools - Ocean Health Index



[ohi-science.org](http://ohi-science.org)



# Spatial decision support system

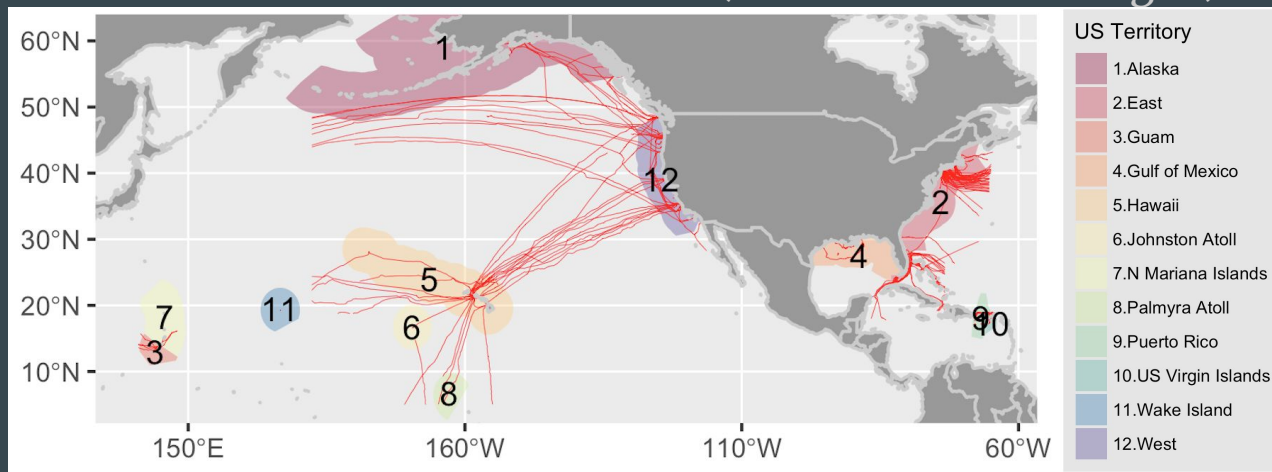


[ecoquants.com/app/siting](https://ecoquants.com/app/siting)

# Present Cable Analysis

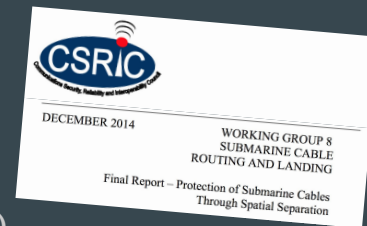
# Submarine cable safety product

- Derive from Submarine Cables (on MarineCadastre.gov)



- Apply industry advised horizontal buffers based on depth
  - Minimum:  $\max(500\text{m}, 2 \times \text{depth})$
  - Recommended:  $\max(500\text{m}, 3 \times \text{depth})$
- Extract overlap with energy resources: tidal, wave, wind (tidal: Haas et al 2011; wave: P. T. Jacobson et al 2011; wind: Schwartz et al 2010)

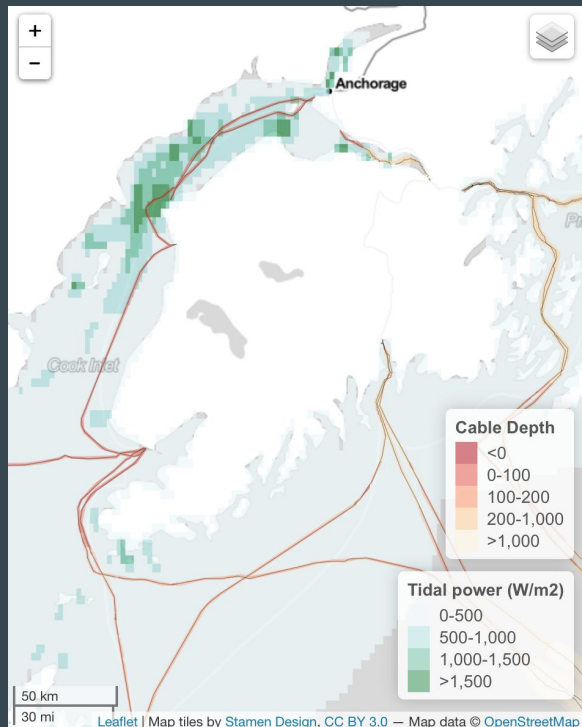
Territory	Tide	Wave	Wind
Alaska	✓	✓	
East	✓	✓	✓
Gulf of Mexico	✓	✓	✓
Hawaii		✓	✓
Puerto Rico	✓	✓	
US Virgin Isl.	✓	✓	
West	✓	✓	✓



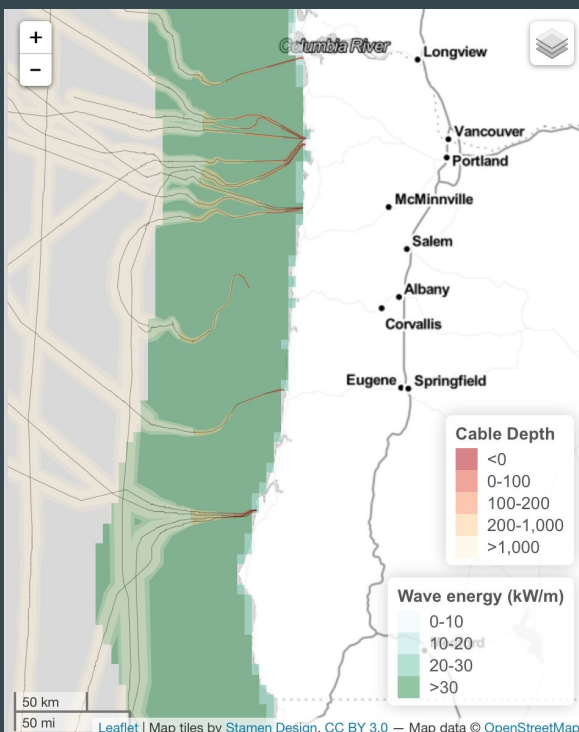


# Depth-varying cable buffer

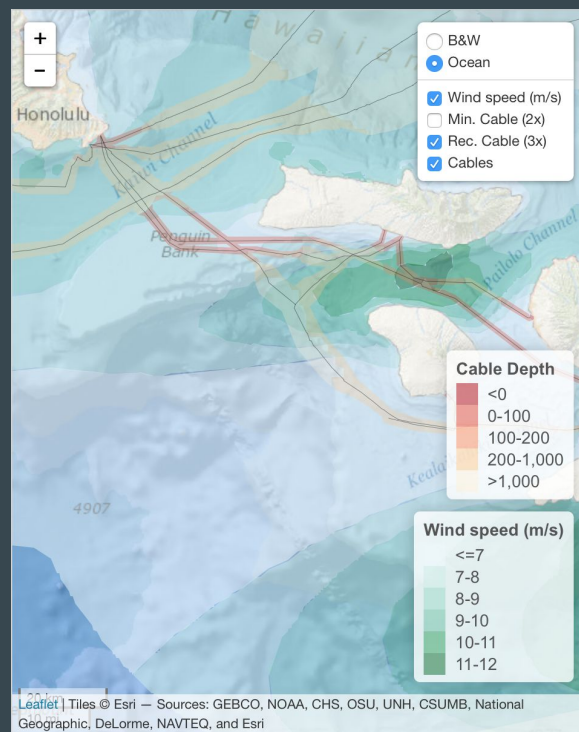
## Tide in Alaska



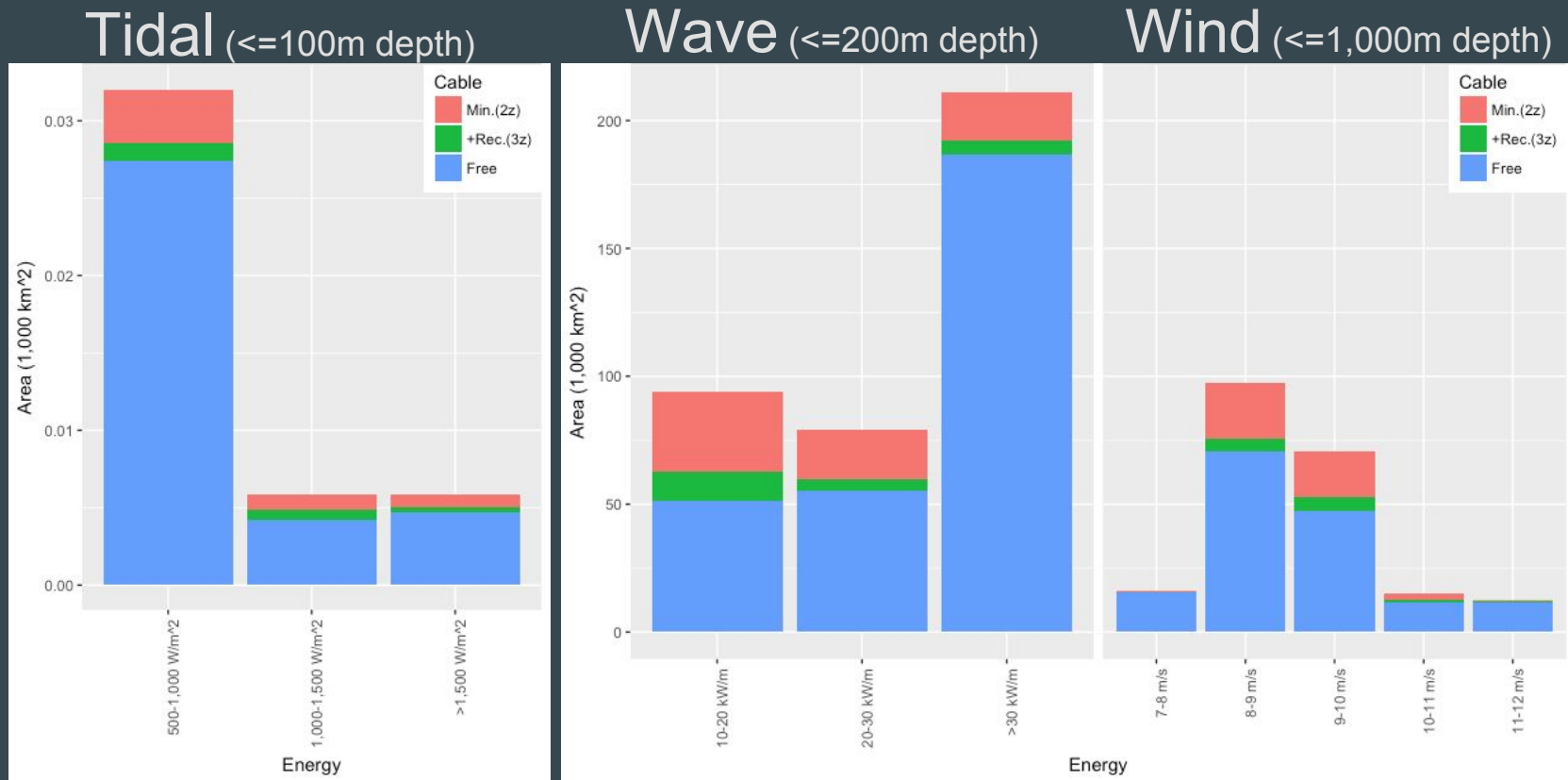
## Wave in West



## Wind in Hawaii



# Overlap of cable buffers with energy resources



# Future Competing Uses Analysis

# Future NREL Competing Use Work

- Timeline: Oct 2017 - Oct 2018
- Goal
  - Provide common reference to competing uses and potential conflict when evaluating marine renewable energy
  - Update Black & Veatch (2010) report with open, current data
  - Utilize best available data with best available science to provide decision support (advisory vs. exclusive)
  - Create tool to ingest data layers and evaluate competing ocean uses
- Data sources
  - MarineCadastre.gov ([scrape-marinecadastre](#))
  - Others: [CA Offshore Wind Energy](#), [West Coast Ocean Data Portal](#), [Northeast Ocean Data Portal](#), [Mid-Atlantic Ocean Data Portal](#), [Governors' South Atlantic Alliance Portal](#), [Gulf of Mexico Data Atlas](#)

# Ocean use categories

## Nonliving Resources

- Energy Resources (n=8)  
Oil Resources, Natural Gas Resources, Tides, Wind, Ocean Currents, Geothermal Resources, Ocean Thermal Resources, Solar Radiation
- Material Resources (n=2)  
Sand Resources, Mineral Resources
- Physical/Chemical Features (n=5)  
Physical Habitats and Geomorphology, Bathymetry and Elevation, Substrate, Water Column Features, Water-Quality Parameters

## Living Resources

- Habitat
- Ecological Functions and Services (n=2)  
Biological Production, Biodiversity
- Biological Occurrence (n=7)  
Fishes, Invertebrates, Flora, Mammals, Birds, Reptiles, Invasive Species

## Governance

- Marine Protected Areas (MPAs)
- De Facto MPAs
- Commercial Leases
- Jurisdictional Boundaries
- Tribally Governed Areas
- Regulatory Use Restrictions

## Ocean Uses

- Recreational Nonextractive / Cultural Use (n=10)  
Scuba/Snorkeling, Swimming, Surface Board Sports, Paddling, Sailing, Motorized Boating, Wildlife Viewing at Sea, Tide Pooling, Shore Use, Cultural Use
- Harvesting Living Resources (n=9)  
Pelagic Fishing, Fishing with Benthic Mobile Gear, Fishing with Benthic Fixed Gear, Kayak Fishing, Dive Fishing, Fishing from Shore, Gathering from Shore, Offshore Seaweed Harvest, Hunting
- Energy Production (n=6)  
Wind Energy Production, Wave Energy Production, Ocean Current Energy Production, Tidal Current Energy Production, Ocean Thermal Energy Conversion, Offshore Oil and Gas Production
- Transportation (n=3)  
Shipping, Cruise Ships, Military Vessels
- Other Commercial/Industrial Uses (n=7)  
Mining and Mineral Extraction, Offshore Aquaculture, Coastal Aquaculture, Seawater Intake, Sewage Discharge, Ocean Dumping, Underwater Transmission Cables

## Infrastructure

- Ports
- Cables, Pipelines, and Power Grids
- Buoys and Navigational Aids
- Structures

# Ocean Use Weighting

- energy x ocean use

	recreational non-extractive		harvesting		transportation		biological		...
energy	scuba	surfing	pelagic fishing	benthic fishing	shipping	military	mammals	birds	...
tidal	1	2	1	1	1	1	1	1.5	
wind	1	1	2	2	0		1.5	2.5	
wave	1	3	1	1	0	0	1.5	1	

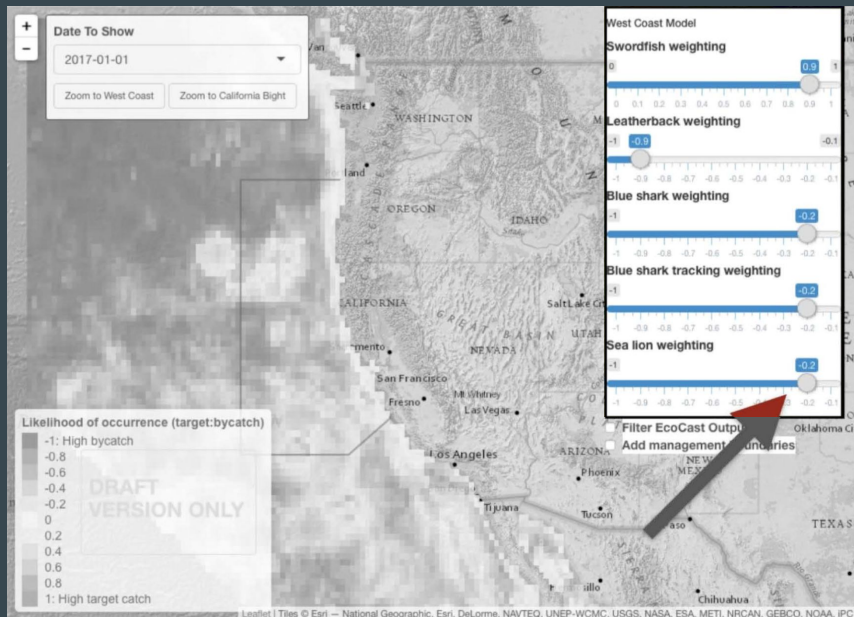
- energy x ocean use - species

	mammals		birds	
energy	blue whales	elephant seals	black-footed albatross	leatherback sea turtles
tidal	1	1	1	2
wind	2	1	2	3
wave	3	0	0	2

average

# Tool for competing ocean uses

## Graphical User Interface (GUI)

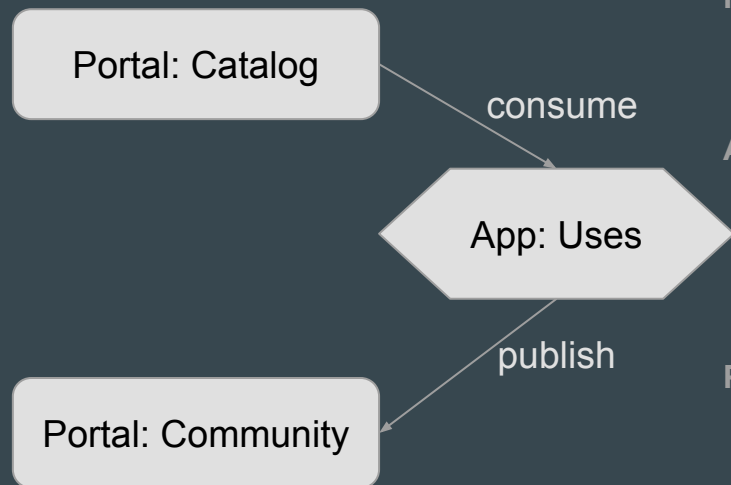


- Functions
  - Fetch data layers from data catalogs
  - Integrate rescale layers, apply weights, aggregate
  - Visualize maps, plots, tables; static/interactive
- Weights
  - Default even weighting
  - Upload table
  - Modify with sliders
- Output
  - Report
  - Bookmark URL

# Future Work

- Detailed Parameters & Models
  - Qualitative Index → Quantitative Units
  - General Implementation → Specific Configurations

- Application Sandwich



## Portal: Catalog

- Curate catalog of data layers
- Make available online via web services

## App: Competing Uses

- Integrate layers for siting, permit prep
- Enter weights and other parameters
- Run models
- Output results as static reports, interactive app

## Portal: Community

- Spatially comment
- Internally vet proposals
- Externally engage stakeholders





Thank you

comments / questions most welcome

[ben@ecoquants.com](mailto:ben@ecoquants.com)