Spatial Modeling for California's Offshore Wind Energy Planning

Data-driven support for sustainable renewable energy development

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Conservation Biology Institute

- Translating cutting-edge science into effective, real world solutions.
- Developing innovative tools to address complex issues and make better decisions.
- Providing customized products for conservation, restoration, and natural resource management.

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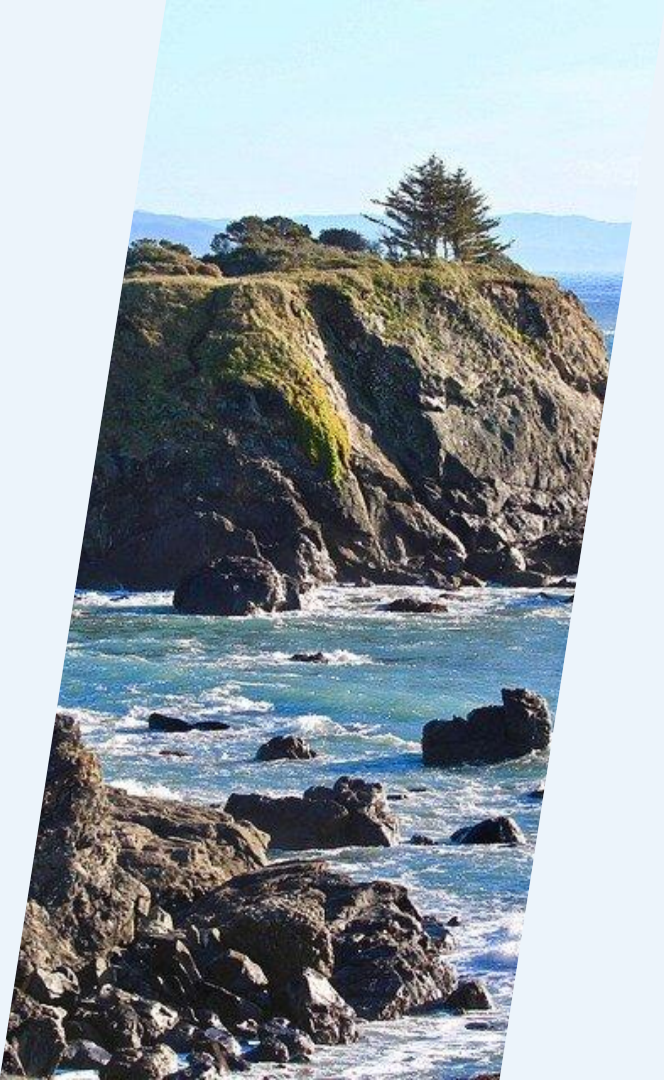
Thank You, data providers, subject matter experts, and agency staff!



Background

- Marine offshore wind energy is poised to play a vital role in helping California achieve its 100% renewable energy goals.
- The West Coast's deep ocean waters require floating offshore wind systems, an emerging technology quickly advancing toward commercial status.
- OSW has the potential to create new industry jobs, provide critical power at times when solar is unavailable, and reduce air pollution from fossil-fuel power generation.

However, implementation must be carefully balanced with:

1. Preserving existing ocean uses, such as fishing and recreation.
2. Engaging and responding to the needs of local communities.
3. Minimizing impacts to marine life dependent on the unique ecosystem off California's coast that supports numerous endangered and protected species.

Illustration by Josh Bauer, National Renewable Energy Lab

Background

1. **CA Offshore Wind Gateway**: Authoritative spatial data & mapping platform, supporting BOEM's Intergovernmental Renewable Energy Task Force's CA OSW planning effort; a source of information the CEC and BOEM used to identify areas for potential OSW development (WEAs).

2. **Data Basin** technology allows stakeholders to access, view, map, and contribute data. It supports public and private collaboration and integration with online tools.

3. **Spatial Modeling** integrates key data into a **framework to support State decision-makers** in offshore wind energy planning.

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Project Goals

1. **Synthesize key data using spatial modeling** to create an accessible framework to support various State activities, showing considerations of interest to OSW planning such as energy potential, deployment feasibility, ocean uses, fishing activity, and marine life occurrence, to raise awareness of the uses and resources in a given area.
2. **Make these analysis results accessible** by integrating them into transparent decision-support tools, e.g. EEMS Online and CA OSW Gateway.
3. **Allow decision makers & stakeholders to explore** results and data in online interactive maps and tools.

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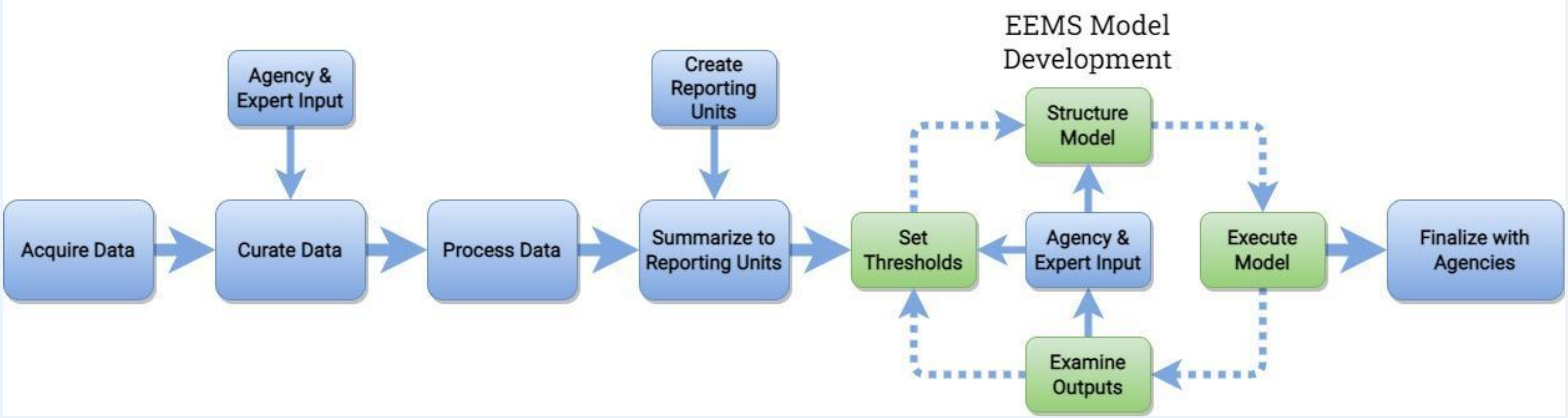
Input Data & Workflow Overview

Input Data: 239 input datasets were used in the models.

Data Sources: California Offshore Wind Energy Gateway, Marine Cadastre, BOEM, NOAA, NREL, BSEE, ORNL, U.S. Coast Guard, CEC, CDFW, CDFG, and academic researchers.

Spatial models were generated using the EEMS fuzzy logic modeling system, iterating through the analysis process in close coordination with OPC, CEC, BOEM, and subject matter experts.

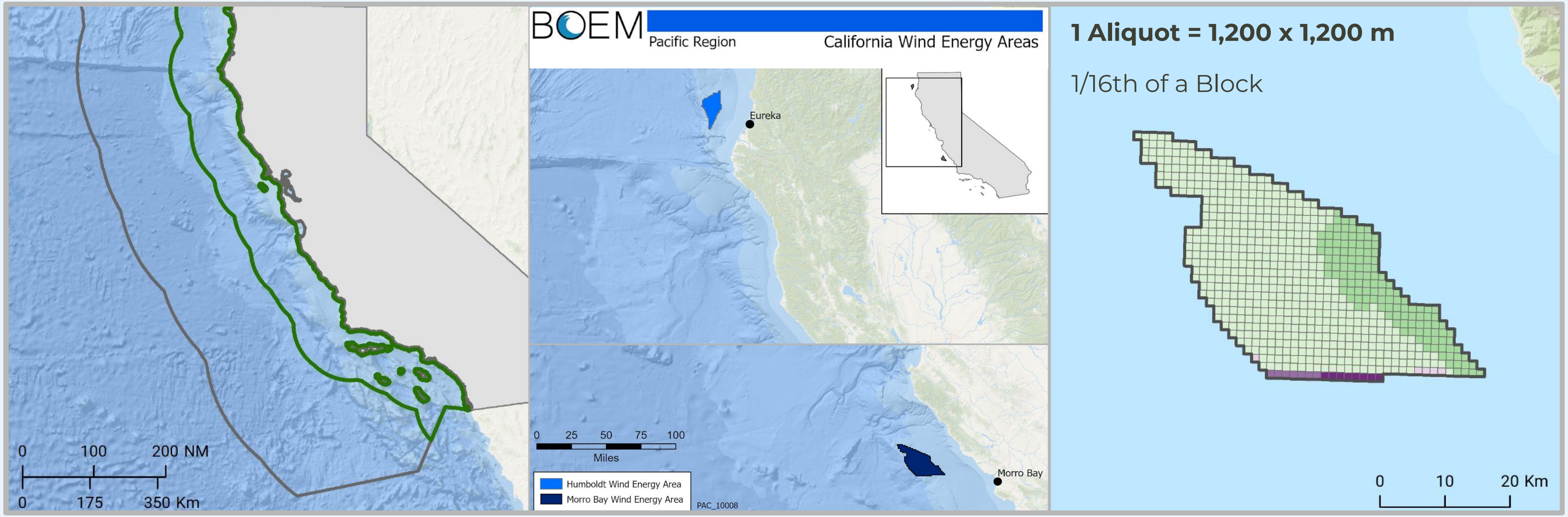
Main steps:



Analysis Study Area & Resolution

1. **Study Area**: Federal waters off the California coast - 3 NM to ~70 NM from shore, inside and outside of Wind Energy Areas.

2. **Analysis Resolution**: All data was summarized to BOEM Aliquots to provide maximum alignment with the leasing process, as well as an appropriate level of regional detail.



Analysis Approach & Outcomes

We generated EEMS models and online maps, showing a continuum of scores for key themes, summarizing available data to create a composite index.

Models Show Key Analysis Themes:

1. **High Energy Potential**
2. **High OSW Deployment Feasibility**
3. **High Existing Ocean Uses**
   Top Priority = Fishing
4. **High Key Species Considerations**
   Top Priority = Cetaceans, seabirds, turtles
   More broadly "Environmental Considerations"



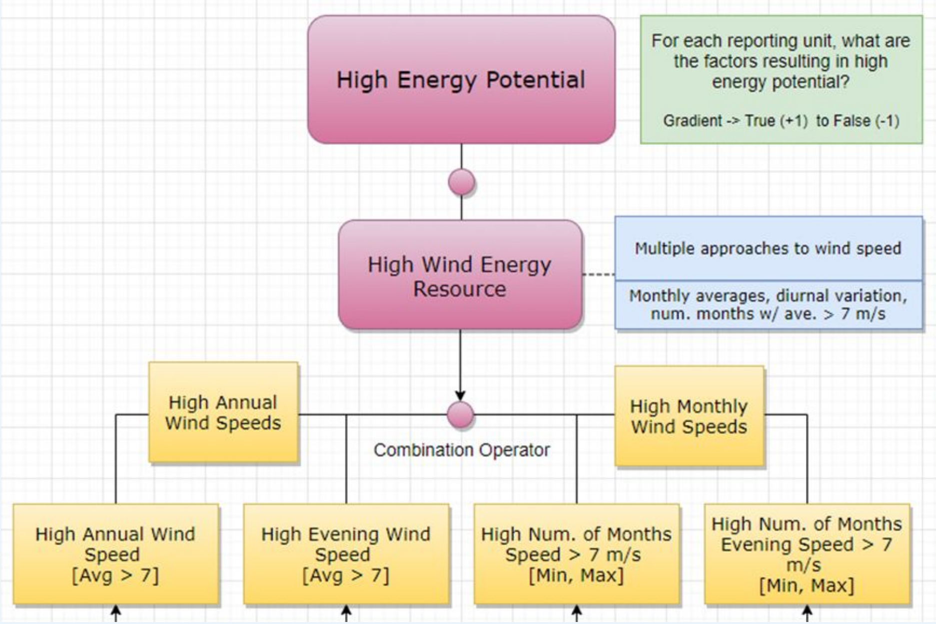

Tufted puffin image by Alan D. Wilson

Modeling Approach: EEMS

CBI's Environmental Evaluation Modeling System

EEMS is a spatial, fuzzy logic-based framework to:

- **Facilitate data-driven decision making** to answer complex questions
- **Integrate diverse types of data** to into transparent spatial models
- **Summarize, engage & explore results** with interactive online maps



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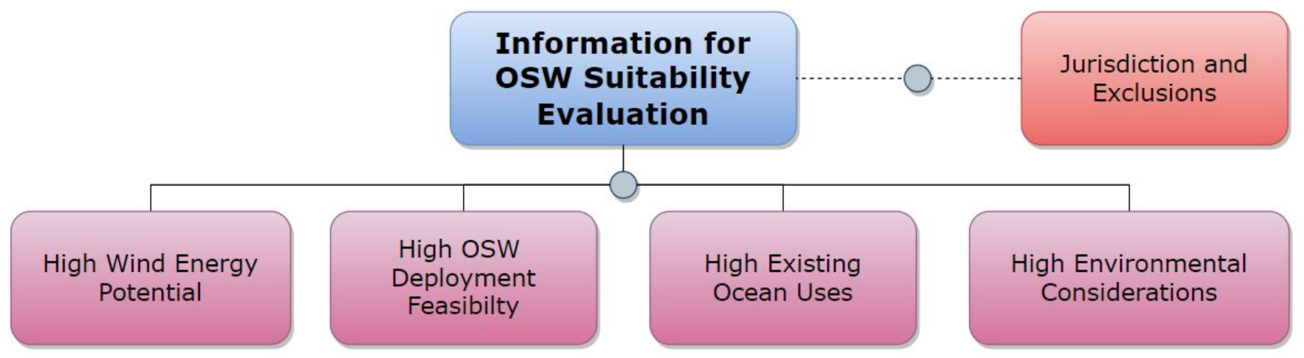
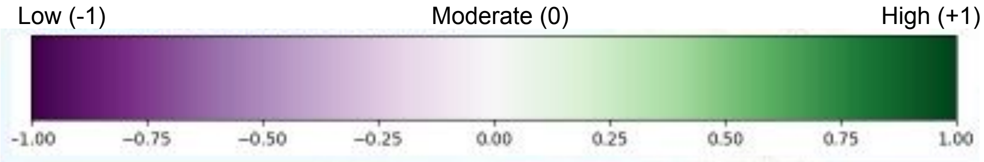
Modeling Approach

Our analysis synthesizes key data of interest to OSW planning and provides access to the spatial data that drives the models.

Models display an interactive composite index showing:





False (No) ← Scores on a gradient to capture detail. Where does a given location lie on this continuum? → **True (Yes)**

Model performance and optimization are achieved in several ways.

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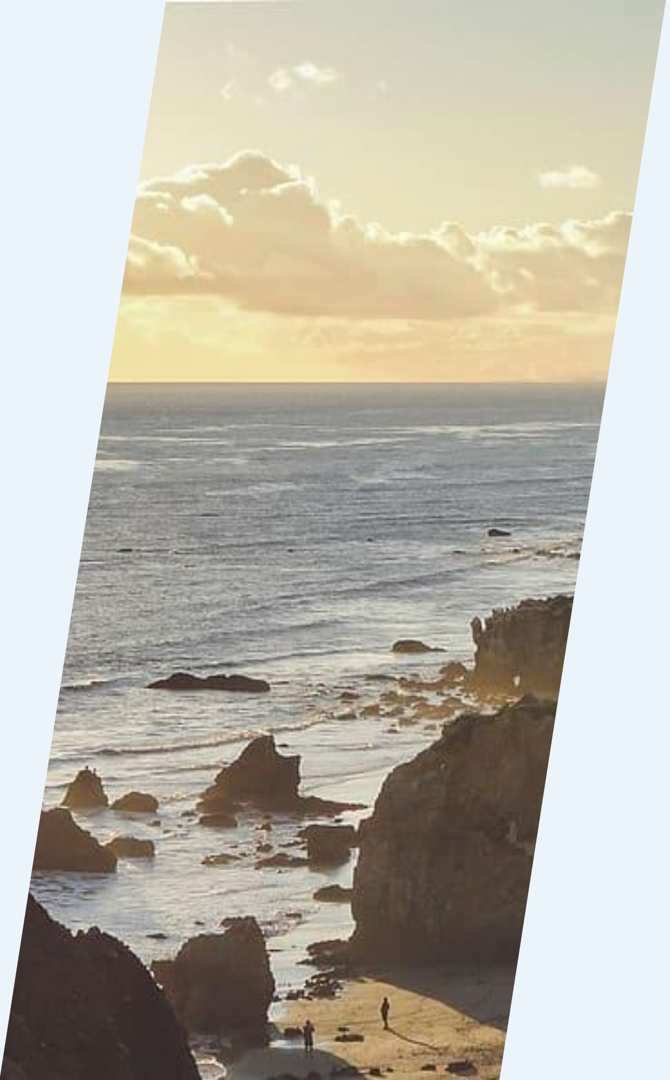

Modeling Approach: Thresholds

All input data values are scaled using **thresholds**, which determine **how each input's range is normalized along the continuum from -1 to +1**.

Thresholds can be set:

1. Using the full range of input data (minimum and maximum values)
2. Expert opinion/heuristics
3. Guided by the statistical distribution of the input dataset
4. Taken from previously published studies

During model development, we focused on setting thresholds so input datasets were represented in a balanced fashion across the study area.

We considered each factor individually, relying on expert input, literature, and statistically driven approaches when necessary, to ensure display of informative gradients across the study area for nuanced representation of model components & subtle patterns.

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Modeling Approach: Operators

In the EEMS model, **spatial data inputs and derived layers are integrated together using logic operators**.

Certain operators are best suited to different situations.

- The UNION (average) operator highlights places where considerations co-occur, e.g. activity in multiple fisheries.
- The OR (maximum) operator ensures features that do not overlap are represented in the output, e.g, endangered toothed whales.
- The AND (minimum) operator identifies where multiple criteria must be met, e.g. OSW deployment feasibility is highest at locations with low physical constraints that avoid existing infrastructure.

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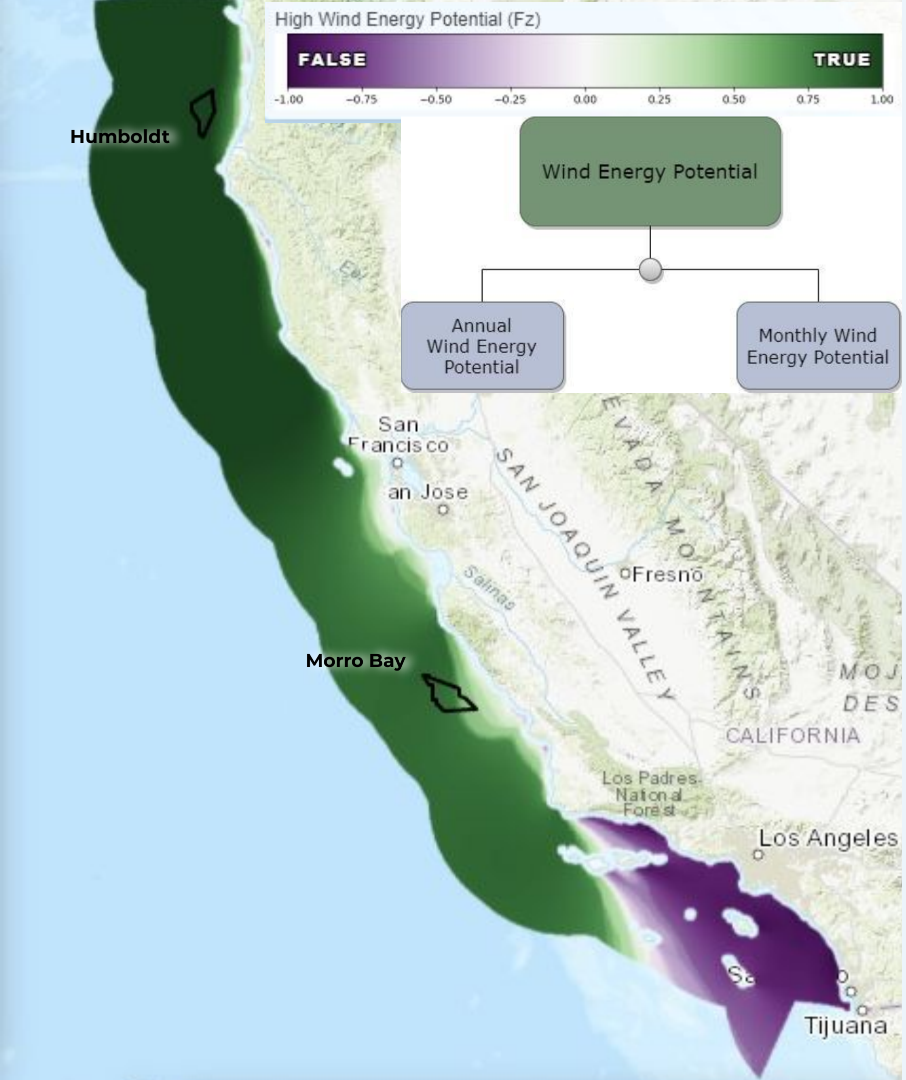

Wind Energy Potential

- **High Annual Wind Energy Potential**
  - High annual average wind speed
  - High annual average evening wind speed

- **High Monthly Wind Energy Potential**
  - High number of months with ave. wind > 7 m/s
  - High number of months with evening wind > 7 m/s

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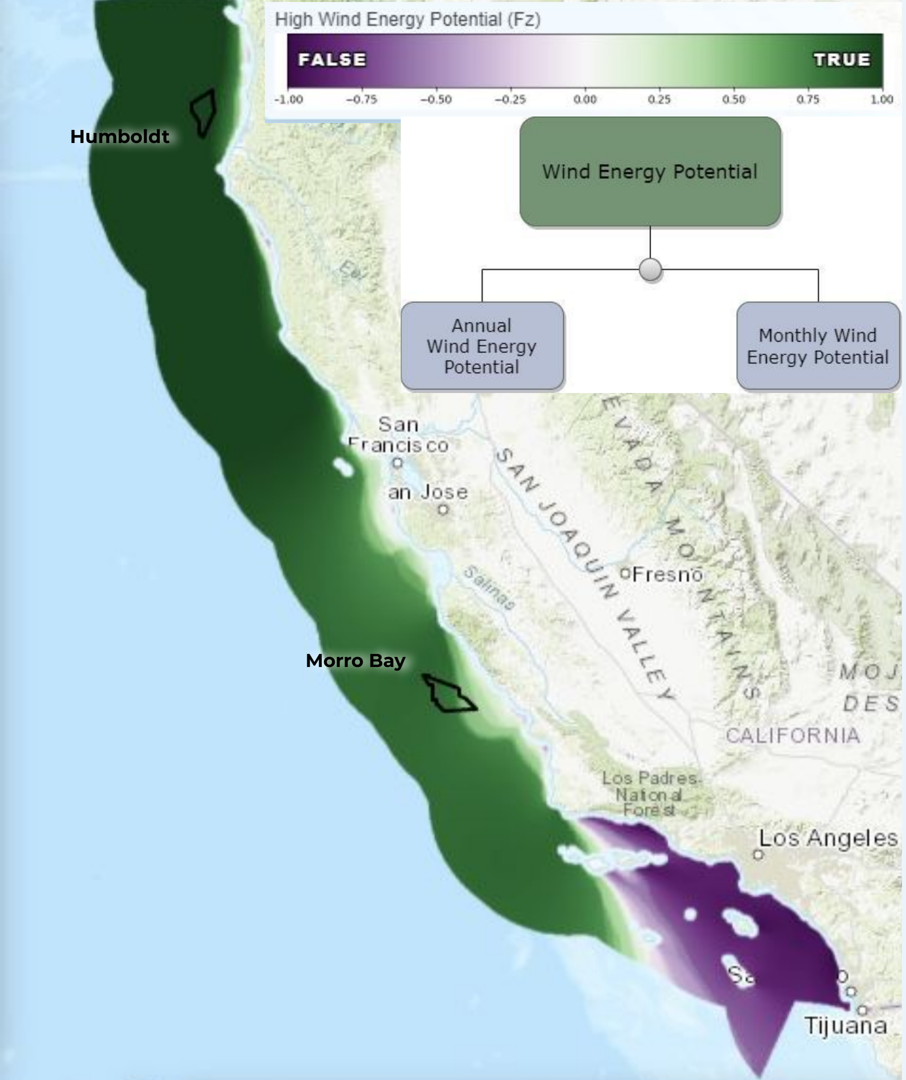
Wind Energy Potential



- High to very high wind energy potential exists across the majority of federal ocean waters off of the California Coast
- Waters off of the North Coast have very high wind energy potential.
- Waters off of the Central Coast have high wind energy potential.
- Waters off of Southern California have the lowest wind energy potential in the study site, with areas shown in purple generally considered to be less ideal for offshore wind energy development.
- In the future, this model could be refined with additional input from the CEC, BOEM, NREL, and OSW experts.

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OSW Deployment Feasibility

- **High OSW Infrastructure Deployment Feasibility**
  - Distance to ports
  - Distance to transmission grid
- **Low Physical Constraints**
  - Depth
  - Slope
- **High Infrastructure Avoidance**
  - Cables
  - Pipelines
  - Wells
  - Navigation hazards

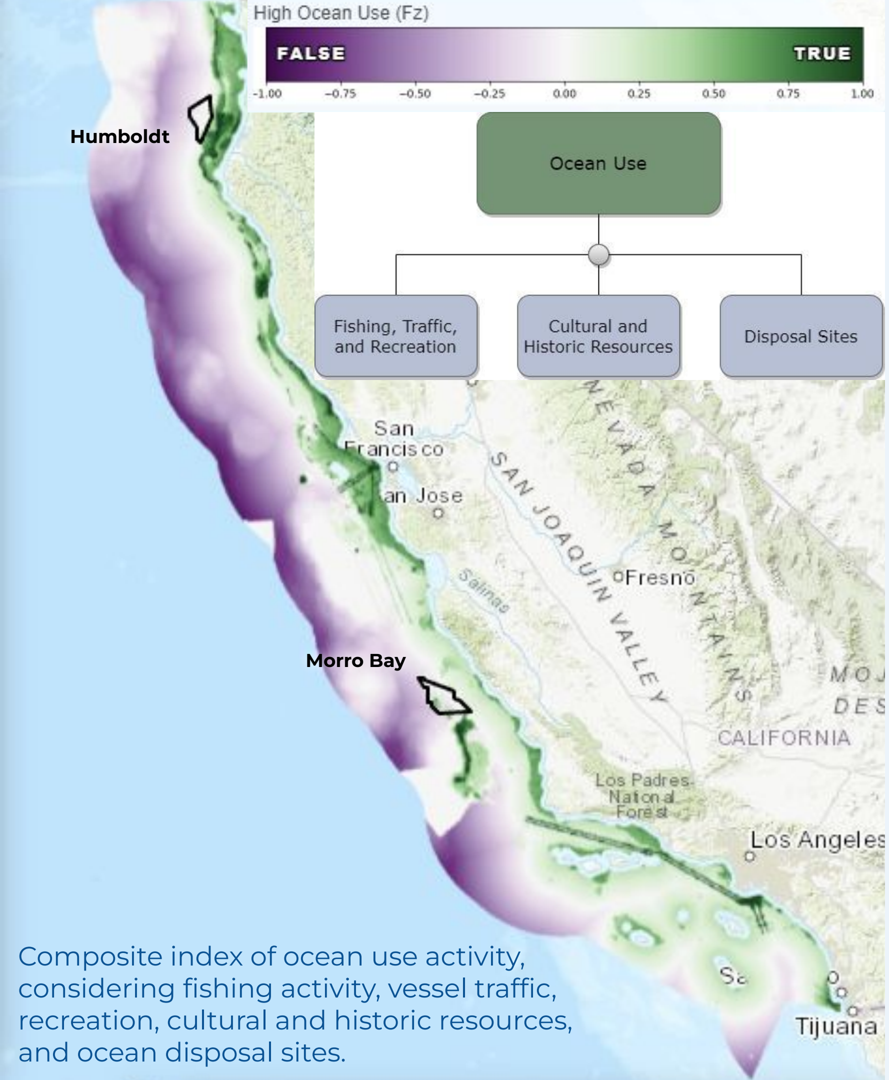
OSW Deployment Feasibility

- Deployment feasibility in federal waters generally increases with proximity to the shore. Areas near the coast provide better access to ports and power grid connections.

- Seafloor depth is a major consideration for OSW deployment on the West Coast. Our model depicts feasibility becoming lower as water becomes deeper than 1300 meters; however, a hard cutoff is not implemented in the model.

- Since concentrations of existing ocean use and marine biota occur nearer to shore, it could be beneficial to deploy OSW infrasture as far from the coast as is feasible, to minimize potential interactions.

- Floating OSW technology is evolving quickly, so it may be useful to consider deeper areas (with appropriate constraints as advised by OSW experts and industry), for long-term time horizons.



Composite index of ocean use activity, considering fishing activity, vessel traffic, recreation, cultural and historic resources, and ocean disposal sites.

Ocean Use

- **High Fishing Activity, Vessel Traffic, & Recreation**
  - Fishing: Mobile and Fixed Gear- Effort & density
    - Halibut, groundfish, sea cucumber trawl (CDFW)
    - Bottom, midwater trawl (NOAA, BOEM VMS)
    - Albacore trolling (CDFW)
    - Salmon trolling (BOEM VMS)
    - Hook-and-line & Pot (NOAA)
    - Dungeness crab (BOEM VMS)
  - Fishing: Historical groundfish, catch and value (Miller)
  - Vessel traffic
    - Vessel transit counts (AIS)
    - Vessel navigation areas (Shipping, boarding, anchorage)
  - Dive sites
- **High Cultural Use**
  - Distance from shore
  - Distance from shipwrecks
  - Submerged lands with potential cultural significance & archaeological sites
- **Near Disposal Sites**
  - Ocean disposal sites
  - Ordnance disposal areas

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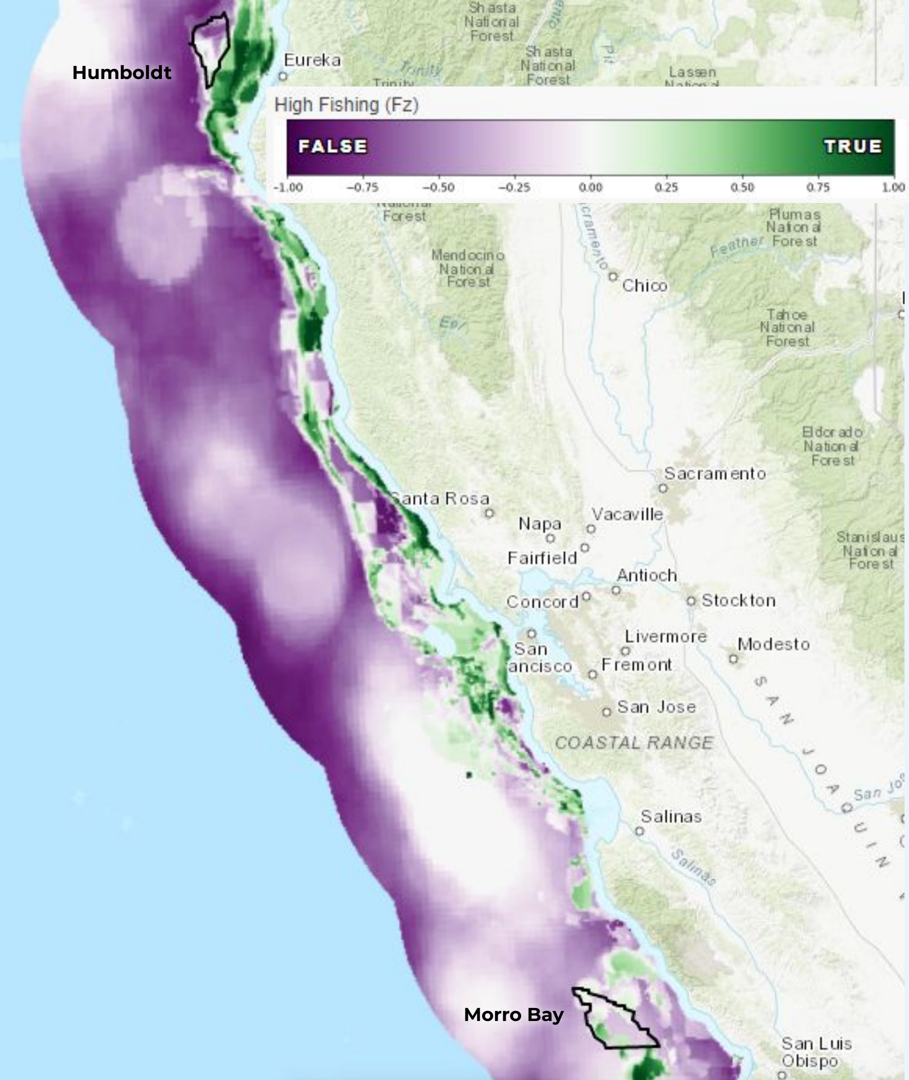
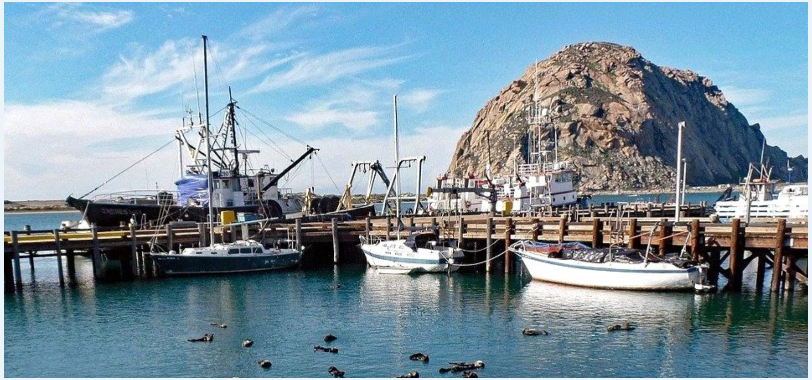
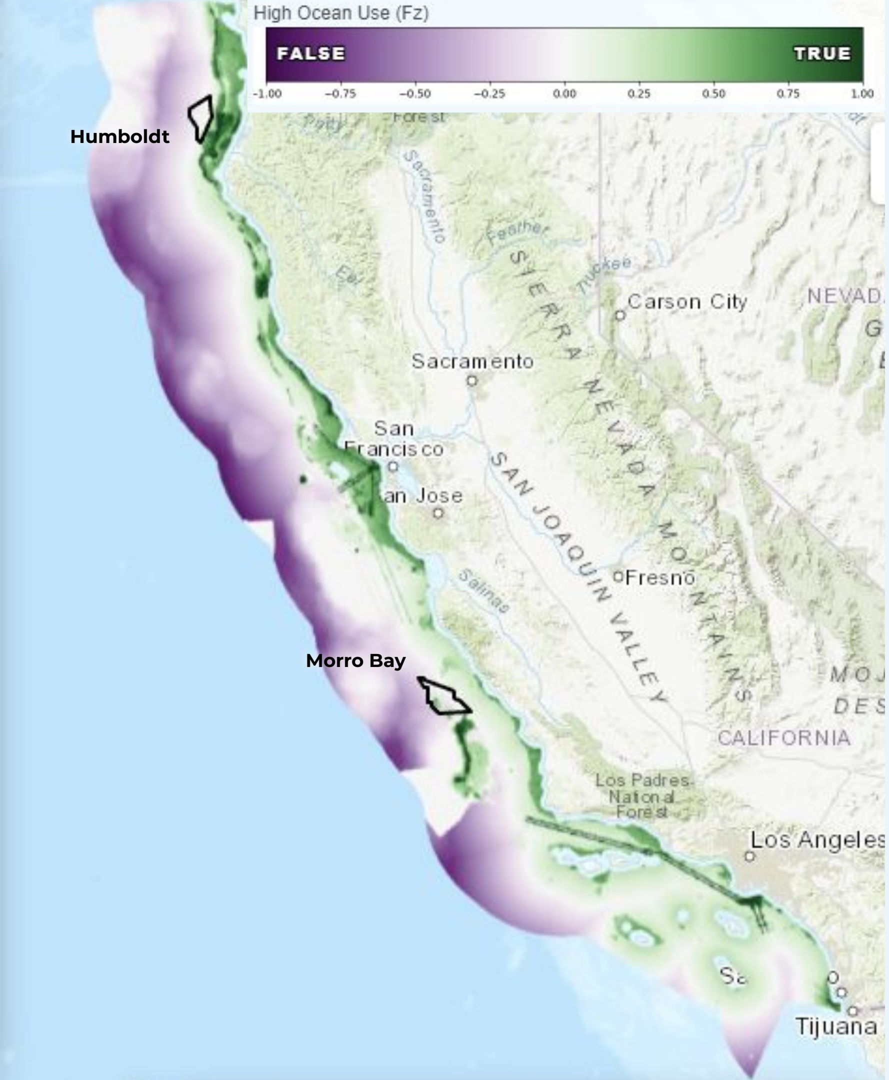


Ocean Use & Fishing Activity

- Federal waters off California have a wealth of existing ocean uses, with the highest activity levels generally occurring within ~20 miles of shore. However, use of deeper waters does occur, esp. commercial fishing.
- The model's fishing activity component shows the Wind Energy Areas avoid places with the highest fishing activity in federal waters off California.
- However, some fishing activity takes place in each WEA, esp. bottom trawl in the Humboldt WEA and trolling and pot trap fishing in the Morro Bay WEA.



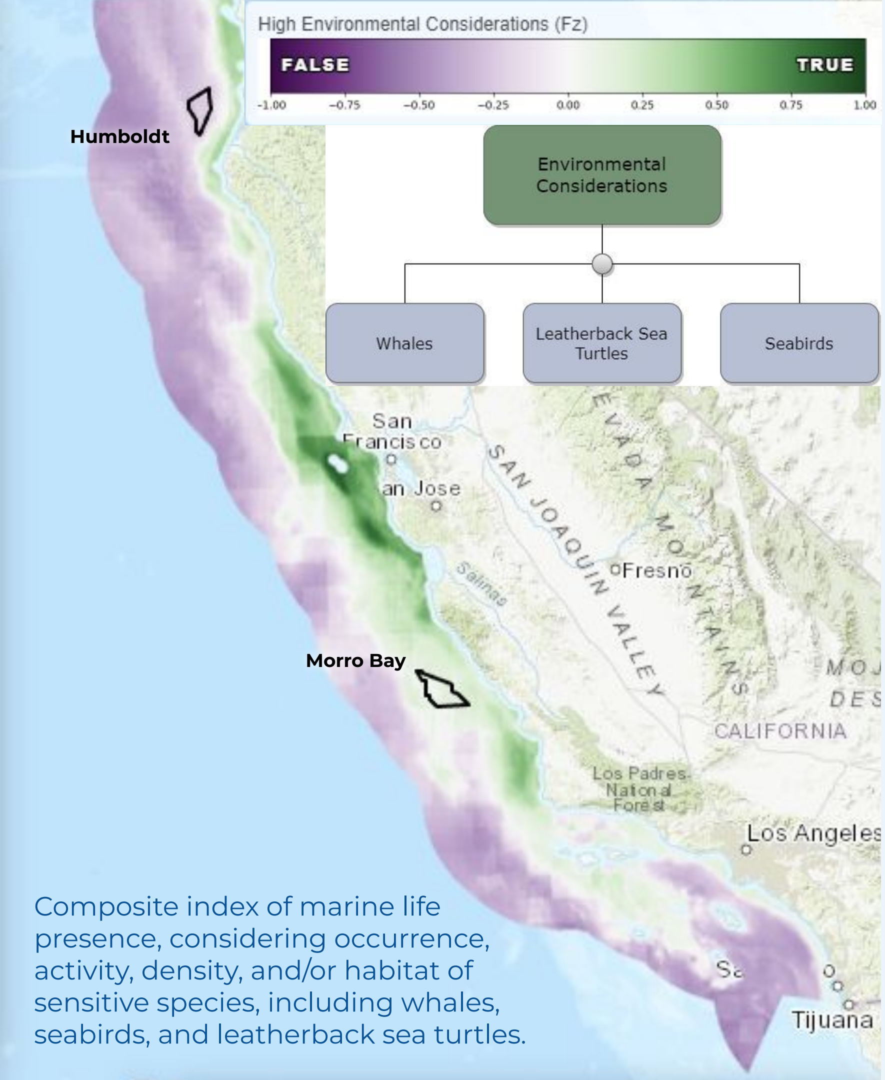


Ocean Use

- In the future, this model could be refined as new data become available, esp. to include better representation of fisheries targeting highly migratory species, a known data gap in the model, as well as to represent forecast shifts in activity patterns based on changes in climate.

- The recreation and cultural value components could also be enhanced, (esp. with local and Indigenous community feedback).

- Continuation of ongoing engagement with stakeholders is recommended to gain additional understanding around commercial fishing and other important ocean uses, to ensure valuable perspectives not represented by spatial data are taken into account during the OSW planning process.



Composite index of marine life presence, considering occurrence, activity, density, and/or habitat of sensitive species, including whales, seabirds, and leatherback sea turtles.

Environmental Considerations

- **High Whale Habitat, Occurrence & Density**
  - Baleen whales
    - Humpback whale*
    - Blue whale*
    - Fin whale*
    - Gray whale
    - Minke whale
  - Toothed whales
    - Southern resident killer whale*
    - Sperm whale*
    - Dall's porpoise
    - Beaked whales
    - Dolphins
- **High Seabird Occurrence & Density**
  - Pelagic Important Bird Areas
  - Seabird predicted densities; 7 with high threat status*
  - Seabird activity (telemetry data)
- **High Sea Turtle Habitat & Occurrence**
  - Leatherback sea turtle* critical habitat & activity

*** ESA Endangered/MMPA Depleted/High Threat Status**

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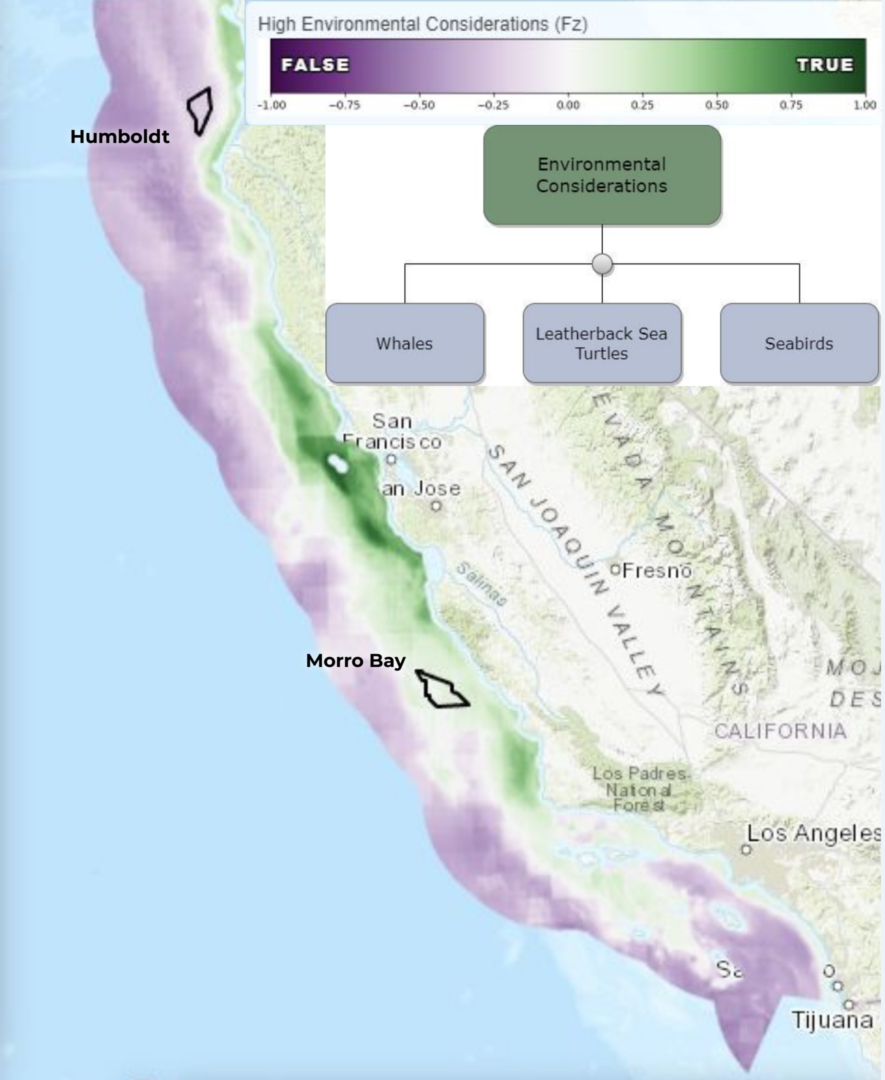


Environmental Considerations

- Federal waters off California support a rich ecosystem with diverse marine life, including protected whales, seabirds, and turtles.
- The very highest concentrations of marine life presence, (as represented by a composite index of species occurrence, activity, density, and/or habitat, with an emphasis on threatened/protected species) occur in waters off the Bay Area (Mendocino to Point Sur) and south from San Luis Obispo to Lompoc.
- The composite index shows that moderate to high concentrations of species generally occur in waters less than ~20 miles from the North Coast. Moderate to high species concentrations extend to ~40 miles off the greater Bay Area, Central Coast, and further south.
- Both Wind Energy Areas avoid the highest environmental considerations, as represented by the occurrence of protected species. However, based on the data incorporated into the model, some protected species have the potential to occur in each WEA.

Environmental Considerations

- Endangered humpback, fin, and blue whales show moderately-high presence in the Morro Bay WEA, and blue whales show moderately-high presence in the Humboldt WEA.

- The endangered leatherback sea turtle shows a moderate level of activity in the Morro Bay WEA, which overlaps the species critical habitat.

- Seabirds with high threat status that may occur in the Wind Energy Areas during at least one season, (based on normalized predicted densities), include marbled murrelet, tufted puffin, ashy storm-petrel, and pink-footed shearwater. Of these, pink-footed shearwater is the only species to show high concentrations in a Wind Energy Area (Morro Bay).

- Many other species were included in this model, and these should be examined on an individual basis using the interactive online interface. Of particular interest is the rich seabird data, depicting relative density of species and species groups across multiple seasons. It should be noted that the documentation for model input datasets and application caveats should be carefully read and understood when using these models.

- **Models identify where potential interactions might occur, not impacts!**

Pink-footed shearwater image by Eleanor Briccetti

Environmental Considerations

- These models could be expanded to include other species, (such as seals, sea otters, sea lions, bats, and krill), and to add ecological characteristics, (such as productivity and upwelling), that play an important role in the California Current System.

- Data on forecast shifts in species' ranges based on changes in climate, could be added as it becomes available.

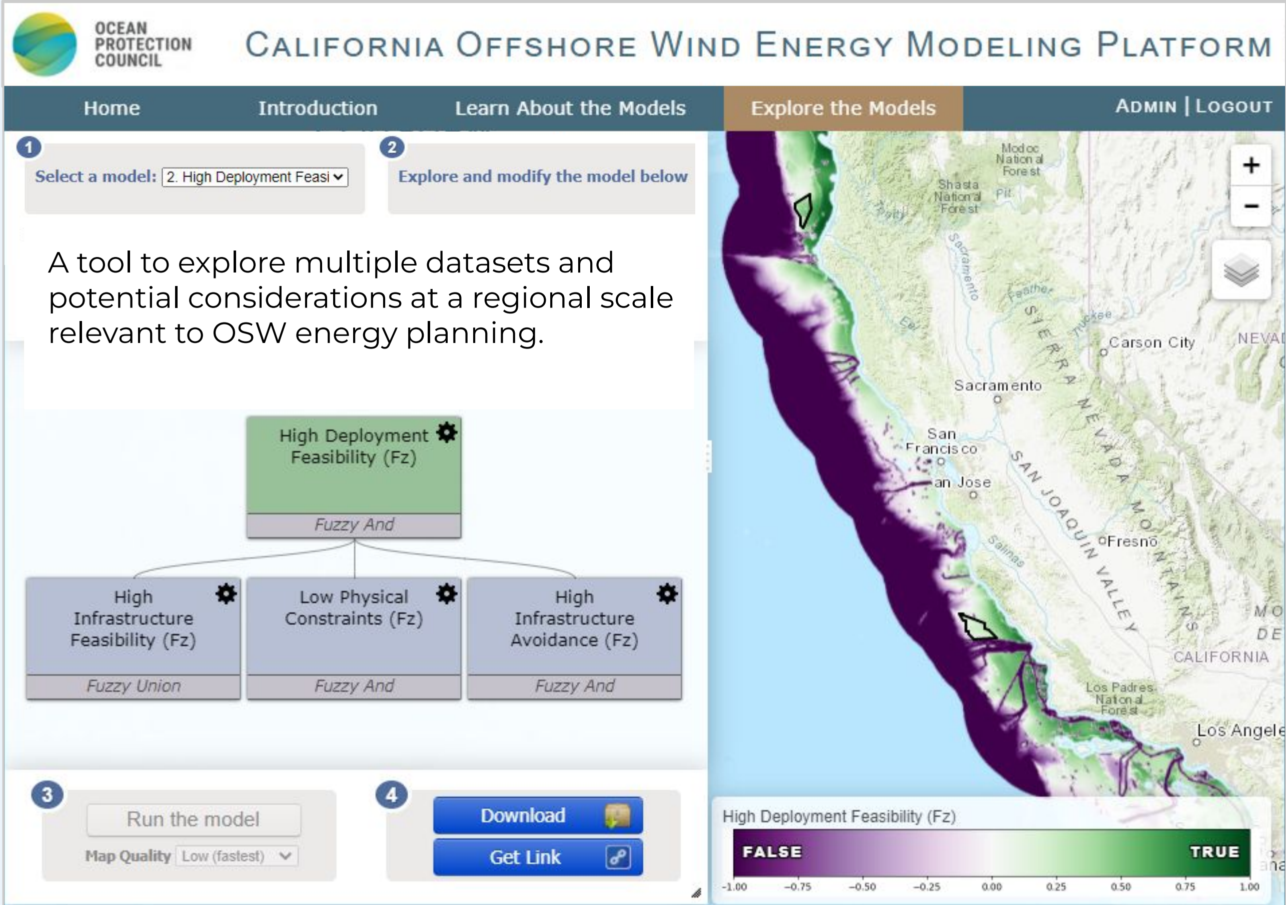
- Individual species sensitivity and vulnerability to OSW deployment are not factored into the current analysis.

- Of note, a recent review of potential environmental effects of floating OSW highlighted that many factors (physical, acoustic, electromagnetic, and infrastructure) appear to have low potential for major impact or may be mitigable. Monitoring data from pilot facilities could be invaluable in helping understand actual environmental effects in-situ.

- Continuation of ongoing engagement with experts is recommended to ensure valuable information not represented by spatial data is taken into account during the OSW planning process.

Exploring Results: EEMS Online

A tool to explore multiple datasets and potential considerations at a regional scale relevant to OSW energy planning.



Path Forward

1. In the future, CBI's models could be extended geographically, (e.g. to include California's state waters or to Oregon for regional planning efforts), and/or enhanced with additional data and expert input, based on agency and stakeholder priorities.
2. This work could be leveraged to further support strategic planning by combining the thematic models in a least-conflict analysis to highlight areas most suited for exploration of OSW development, under different scenarios.
3. There is a need for continued investment, to keep the analysis current and relevant as the offshore wind energy planning process progresses.