Seabirds in 3D: a new framework for assessing collision vulnerability with floating offshore wind

Schatz Energy Research Center

H. T. HARVEY & ASSOCIATES
Ecological Consultants

Presented by: Sharon Kramer and Stephanie Schneider of H. T. Harvey & Associates
Eli Wallach and Arne Jacobson of the Schatz Energy Research Center

Agenda

1. Greeting and Introductions (5 min)
2. Overview of the Objectives and Approach (5 min)
3. 3D Seabird Model (20 min)
4. Power Generation Model (15 min)
5. Trade-offs Between Collision Vulnerability and Generation (15 min)
6. Data Gaps and Future Research Priorities (10 min)
7. Key Takeaways (5 min)
8. Panelists (10 min)
   - Garry George, Director of the Clean Energy Initiative for the National Audubon Society
   - David M. Pereksta, Avian Biologist at the Bureau of Ocean Energy Management
9. Questions and Answers (30 min)

Photo credit: Maia Cheli

Introductions – Project Team

Kaycee Chang David Stoms	Energy Research and Development Division	California Energy Commission
Arne Jacobson Eli Wallach Charles Chamberlin	Director Research Engineer Co-Director	Schatz Energy Research Center @ Cal Poly Humboldt
David Ainley Sharon Kramer Stephanie Schneider Scott Terrill	Senior Ecologist Principal Ecologist Vice President, Principal	H.T. Harvey & Associates
Glenn Ford	Principal Scientist	R. G. Ford Consulting Company
Jarrod Santora	Research Fish Biologist, Division Fisheries and Ecosystem Oceanography Team	NOAA's Southwest Fisheries Science Center

Acknowledgements

Project Sponsor

CALIFORNIA ENERGY COMMISSION

Special thanks go to:
Sophie Bernstein, Ryan Terrill, Sadie Trush, Jerome Qiriazi, Maia Cheli, Carisse Geronimo

Technical Advisory Committee Members (current and past)

Dan Barton	Dept. of Wildlife Chair and Associate Professor	Cal Poly Humboldt
Garry George	Director, Clean Energy Initiative	National Audubon Society
Mike Optis	Researcher	National Renewable Energy Laboratory
David Pereksta	Avian Biologist	Bureau of Ocean Energy Management
Chris Potter	Senior Environmental Specialist	CA Department of Fish and Wildlife
Kaus Raghukumar	Oceanographer	Integral Consulting Inc.
Mark Severy	Research Engineer	Pacific Northwest National Laboratory
Tyler Studds	Development – Offshore Wind	Ocean Winds
Yi-Hui Wang	Offshore Energy Postdoc	California Polytechnic State University
Brita Woeck	Lead Environmental & Permitting Specialist	Ørsted

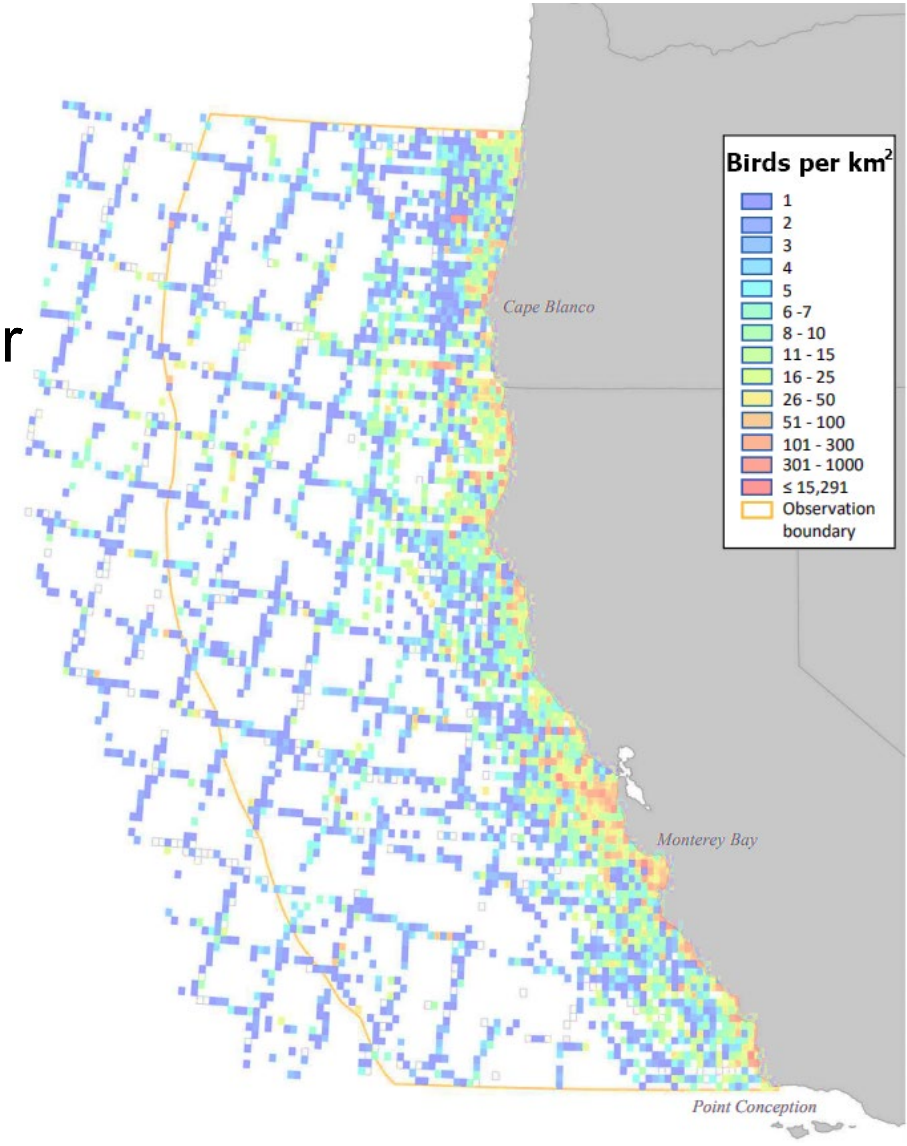
Key Messages

Seabirds and Offshore Wind

- Seabird community differs in nearshore versus offshore waters
- Only some seabird species fly high enough to enter the rotor swept zone of wind turbines
- Number of birds considered vulnerable to collision is much greater than the expected collision rates

Analysis of Tradeoffs

- Areas off Cape Mendocino and Crescent City are especially attractive for power generation (without considering seabird vulnerability)
- Once analysis for the full suite of birds is final, assessment of tradeoffs will be useful for large-scale planning



Overview of the 3D Seabird Project

Overview - The Issue

Offshore wind facilities pose risk to seabirds

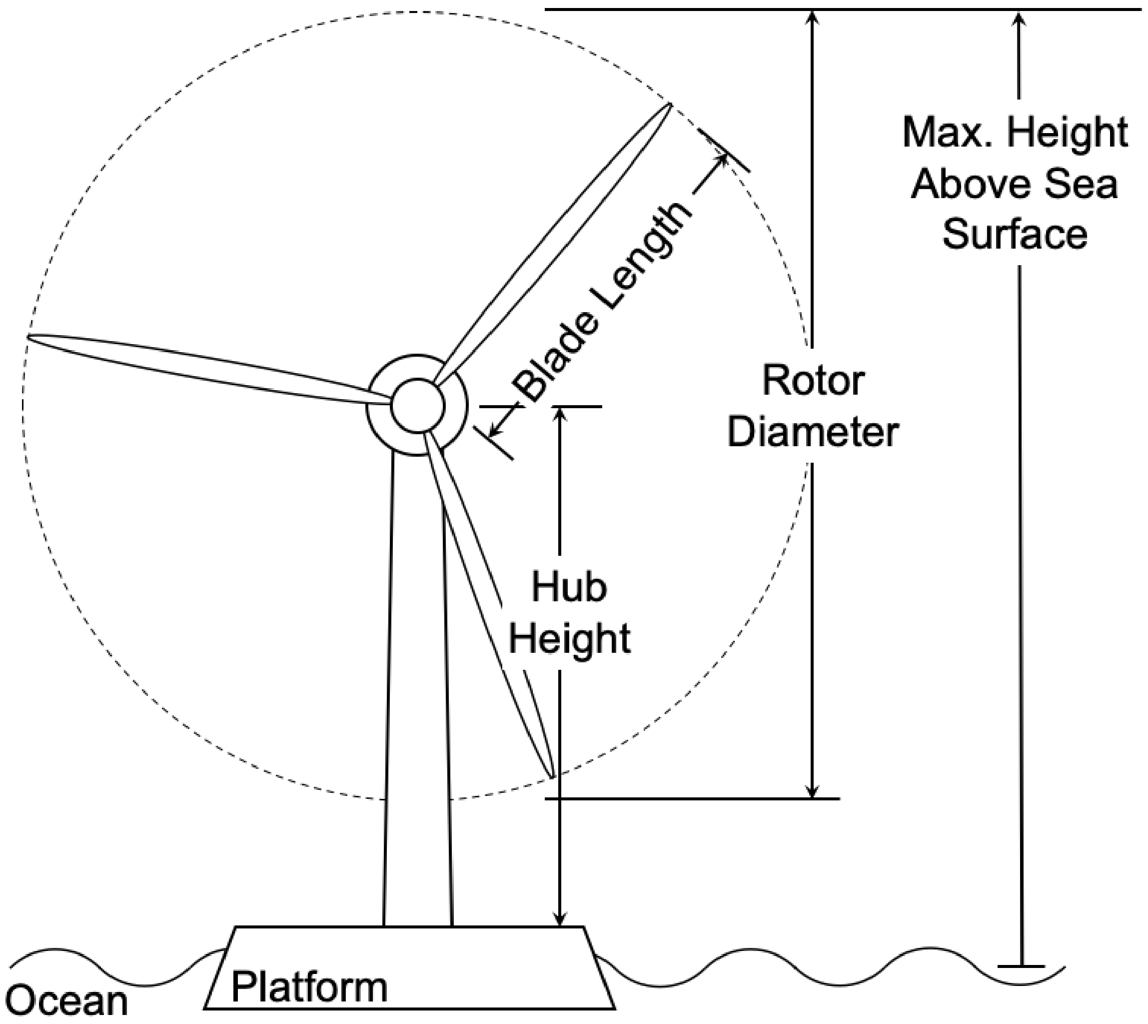
- Displacement versus collision

Existing 2D seabird models can identify hotspots of seabird activity

Estimating collision vulnerability requires better understanding of 3D use

- 2D models do not delineate presence of seabirds at different flight heights

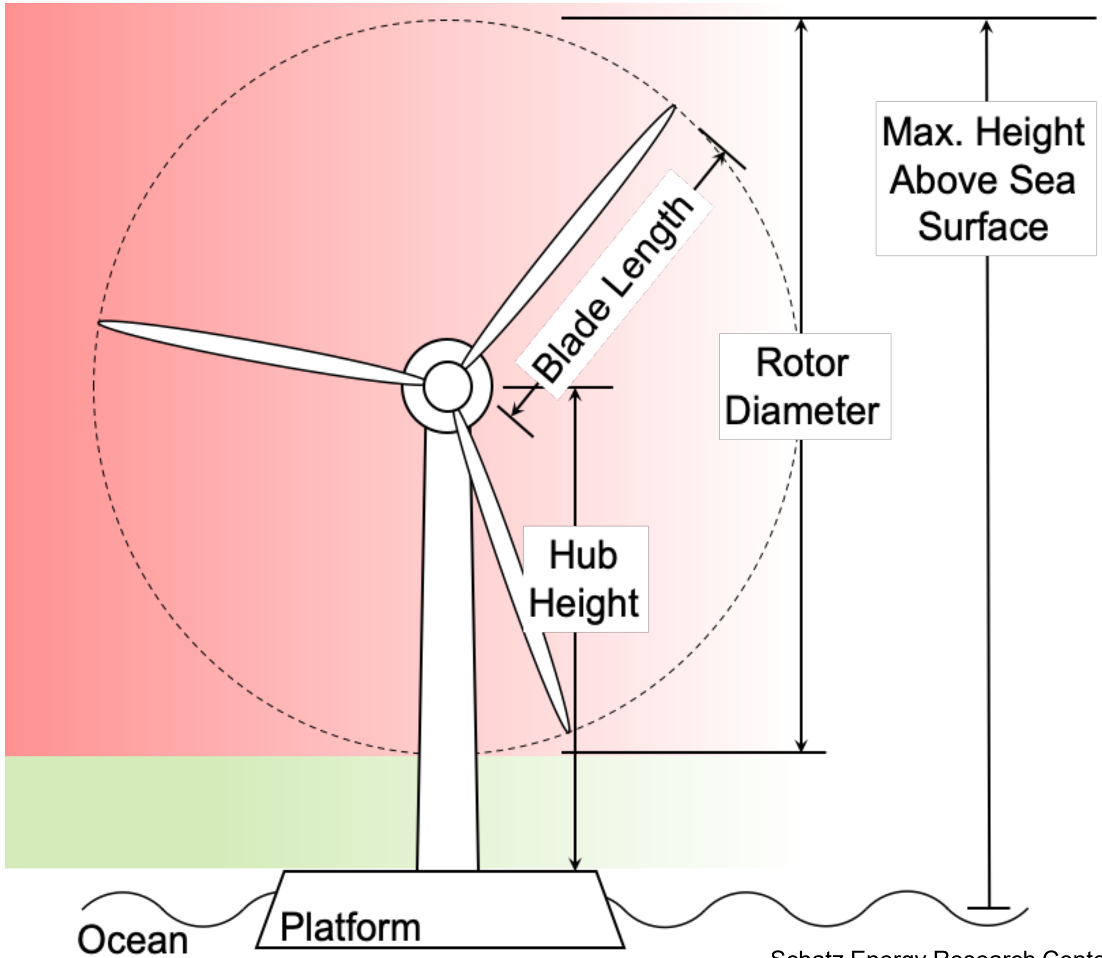
Flight height patterns vary by species and wind speed



Goals and Objectives

This project set out to:

- Develop a three-dimensional seabird distribution model for California
- Evaluate the relative vulnerability of seabirds in offshore wind development regions for different locations
- Compare tradeoffs between seabird vulnerability and power generation



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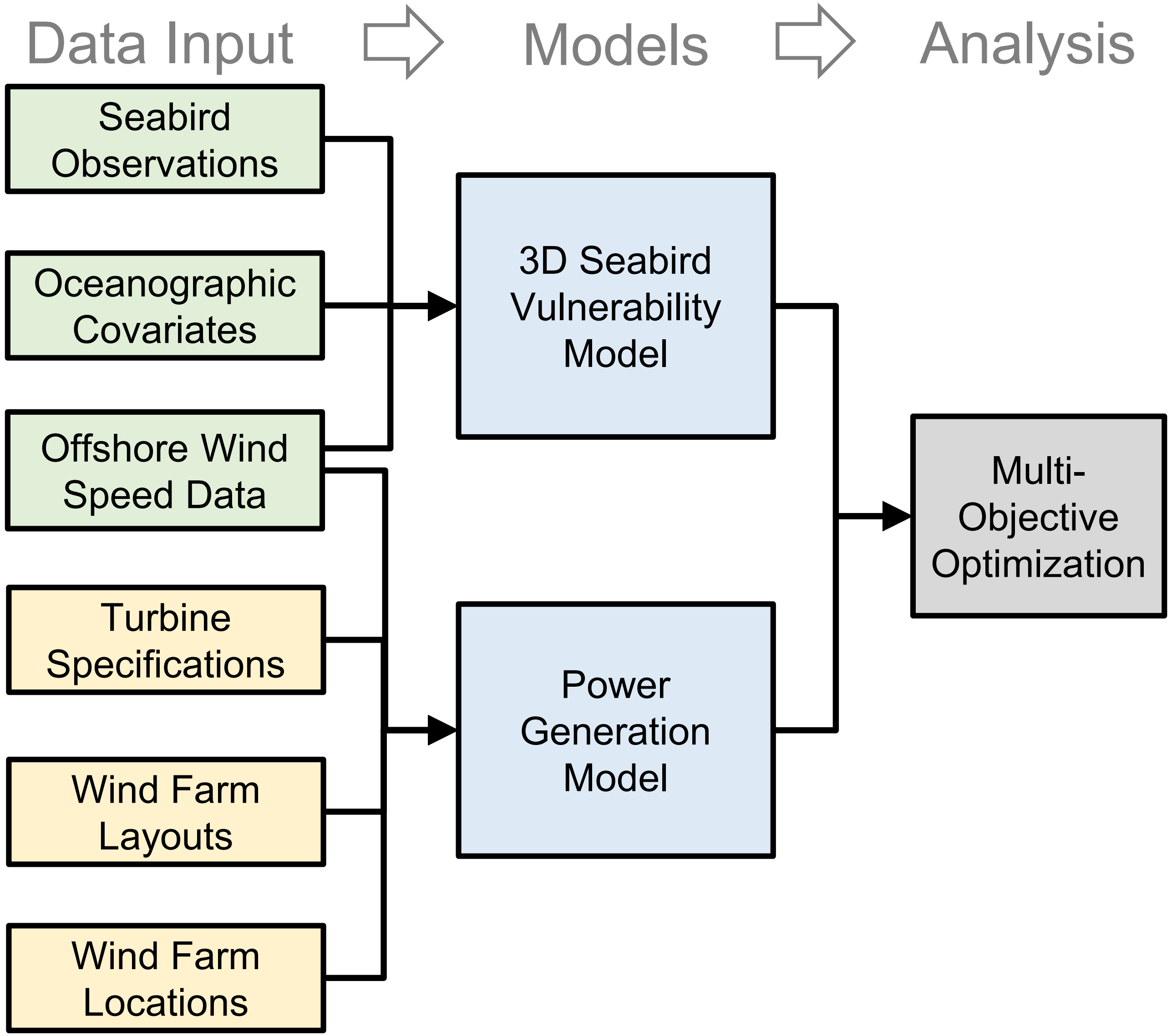
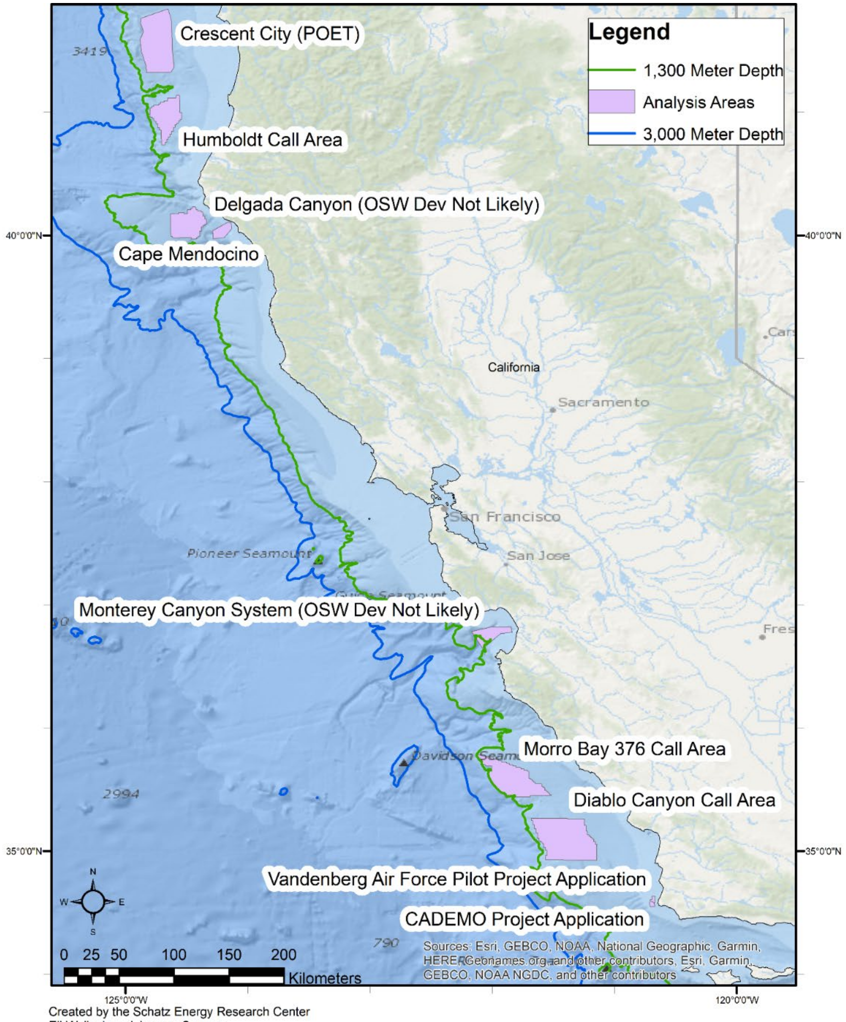
Project Overview





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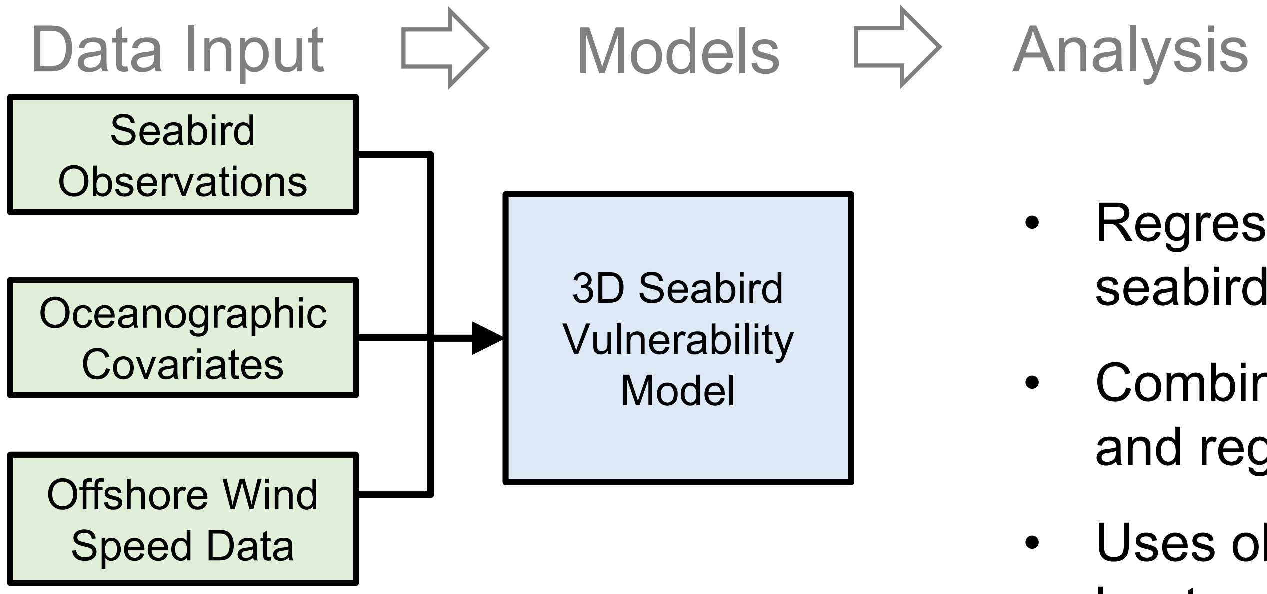
January, 2022

Bathymetry Data: https://pubs.usgs.gov/of/2015/1118/data_catalog.html
OSW Call Areas: https://www.boem.gov/california
IDEOL and CADEMO Project Areas: https://www.slc.ca.gov/renewable-energy/offshore-wind-applications/
Crescent City (POET) Location: from Bill Henry via POET

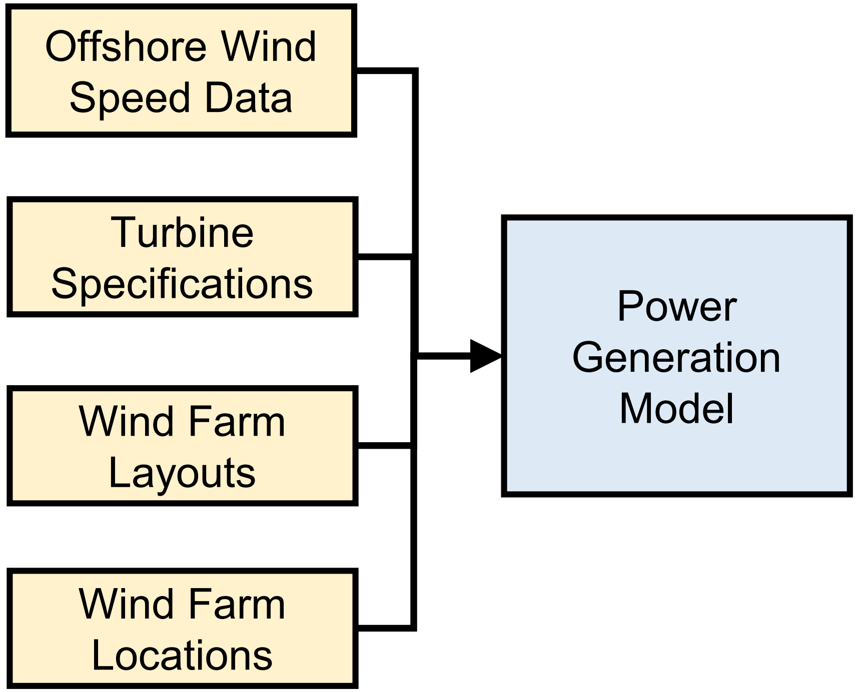
Project Overview – 3D Seabird Model



- Regression approach – Estimates density of seabirds above 10 m
- Combines regressions predicting flight height and regressions predicting abundance in 2D
- Uses observational data from aircraft and boats spanning the last 40 years
- Uses long term oceanographic conditions
- Uses modeled wind speed data (NREL CA-20 & Northwest Pacific; Windtoolkit databases)

Project Overview – Power Generation Model

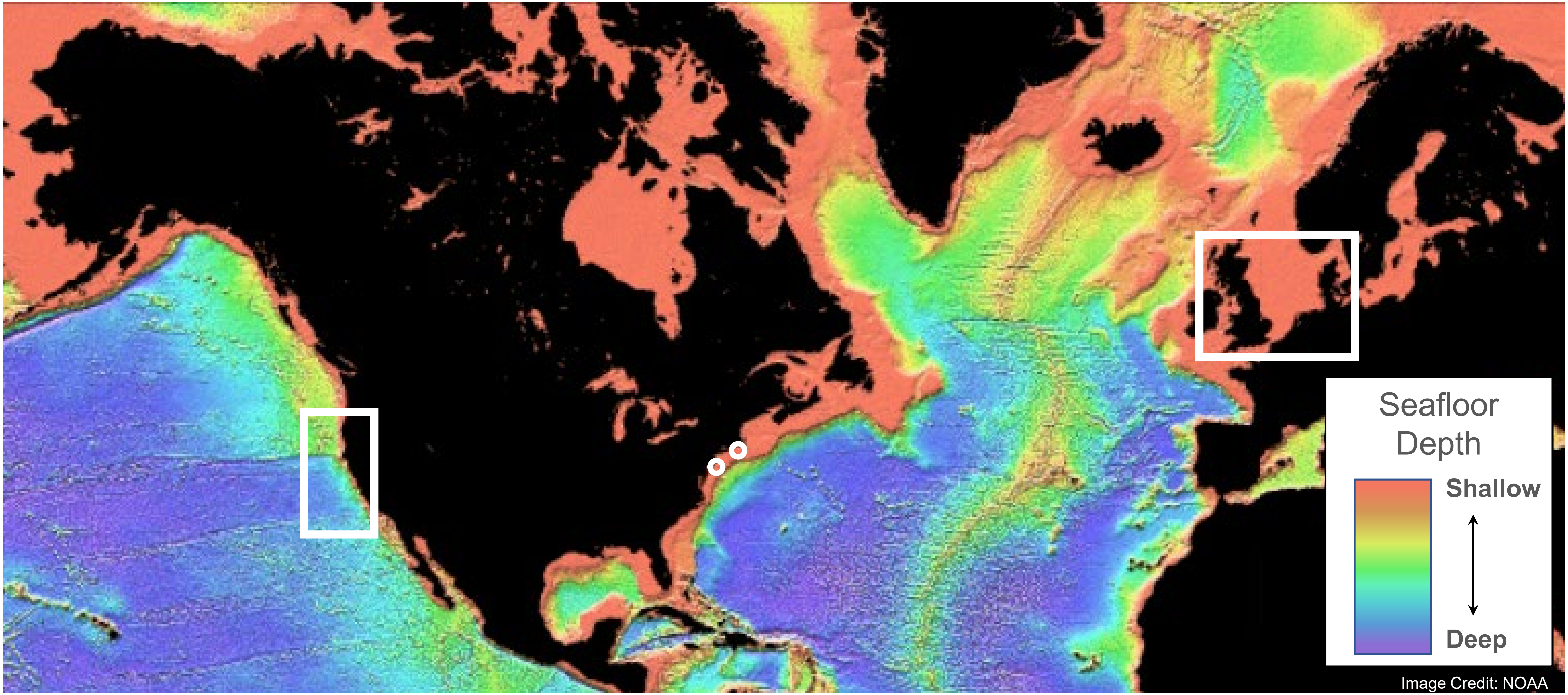
Data Input ⇨ Models



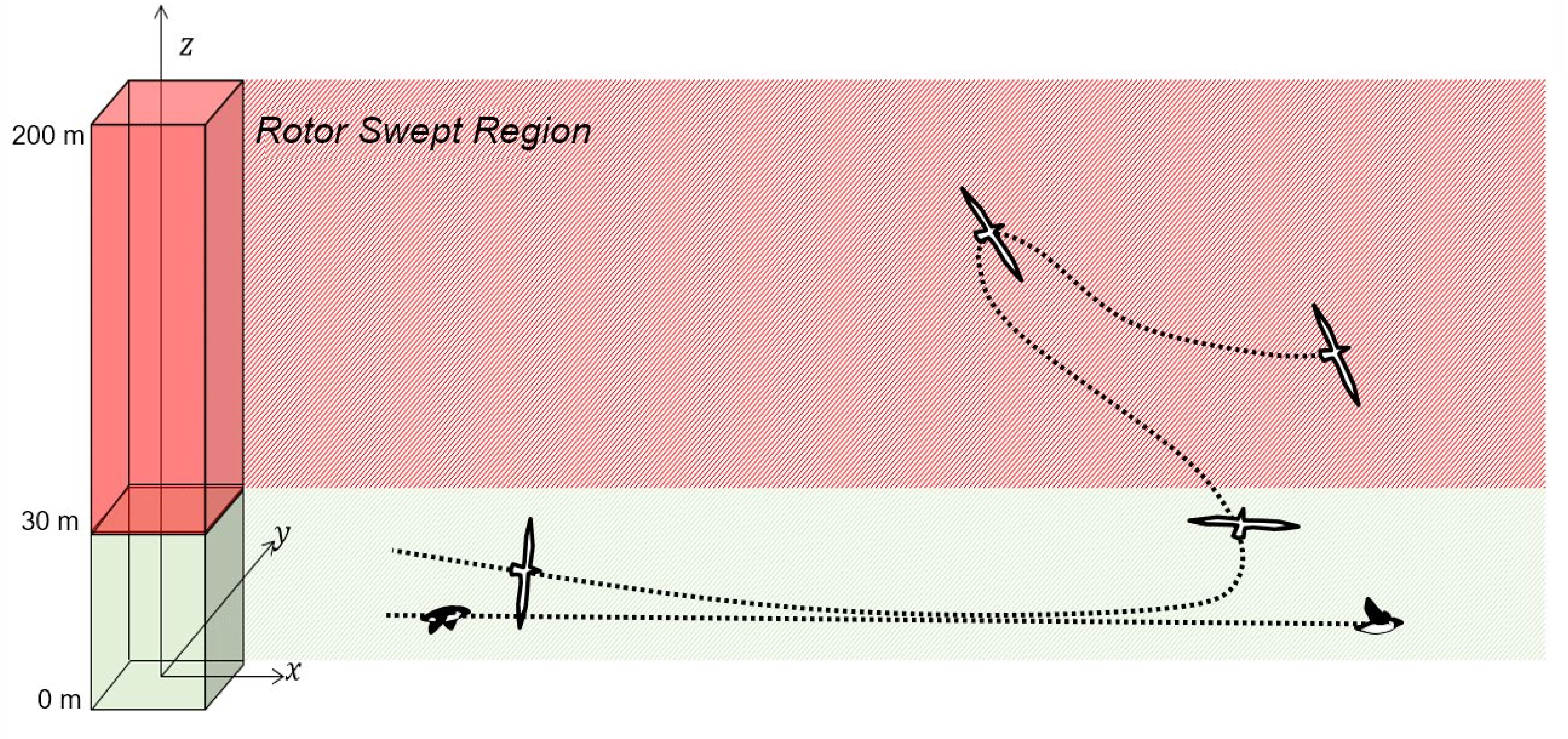
- Simulations modeling approach
- Simulates a variety of wind farm scenarios
- Uses modeled wind speed data (NREL CA-20 & Northwest Pacific; Windtoolkit databases)
- Based on NREL 12 & 15 MW reference turbines
- Uses an Eddy Viscosity model as implemented by SAM (System Advisor Model) to estimate wake losses

3D Seabird Model

Offshore Wind and Seabirds in the Pacific



Offshore Wind and Seabirds in the Pacific



Offshore Wind and Seabirds in the Pacific

Unlike areas developed for Offshore Wind in Europe and eastern USA, the California Current avifauna contains many dynamic soaring species (albatross, petrels, shearwaters)

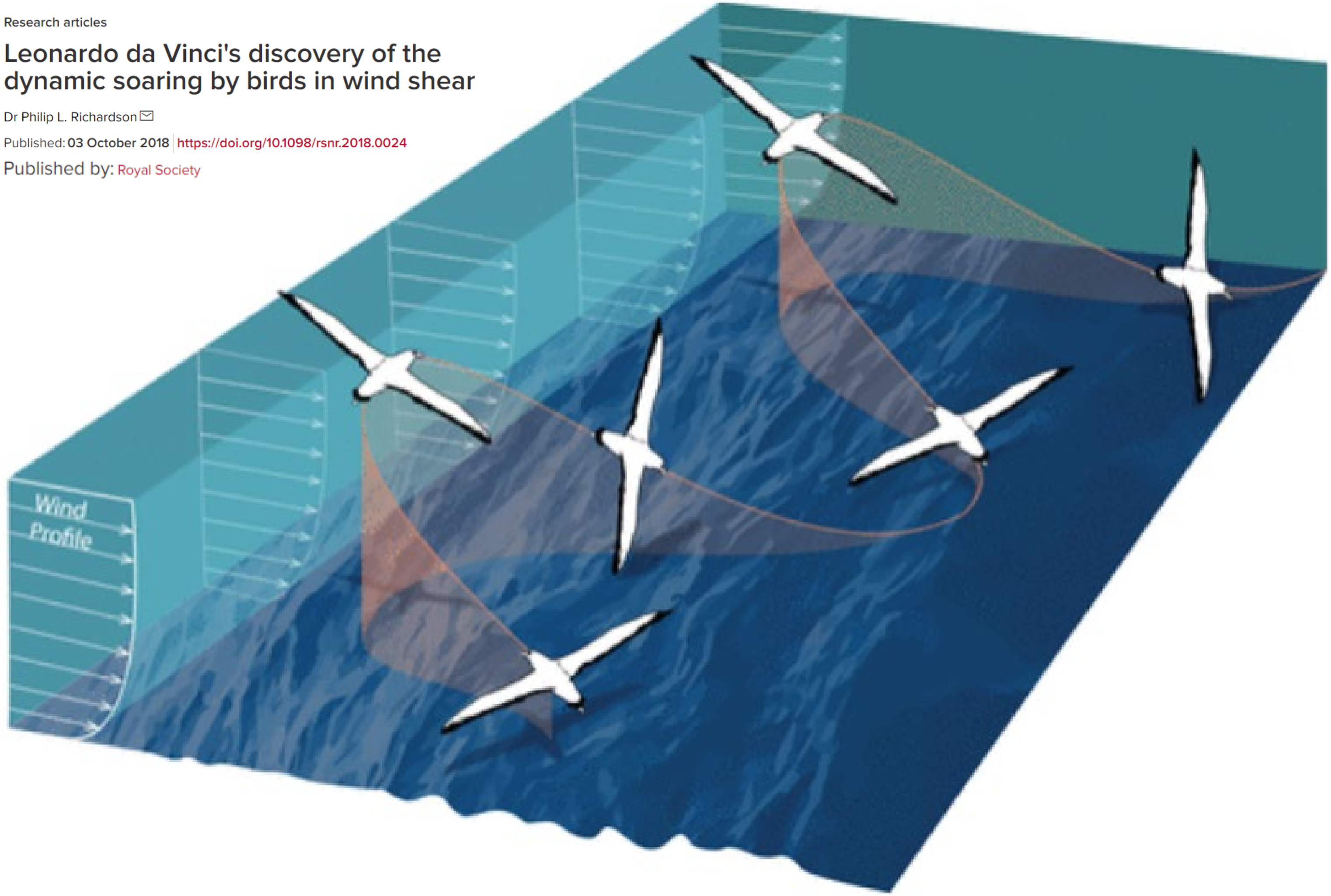
Research articles

Leonardo da Vinci's discovery of the dynamic soaring by birds in wind shear

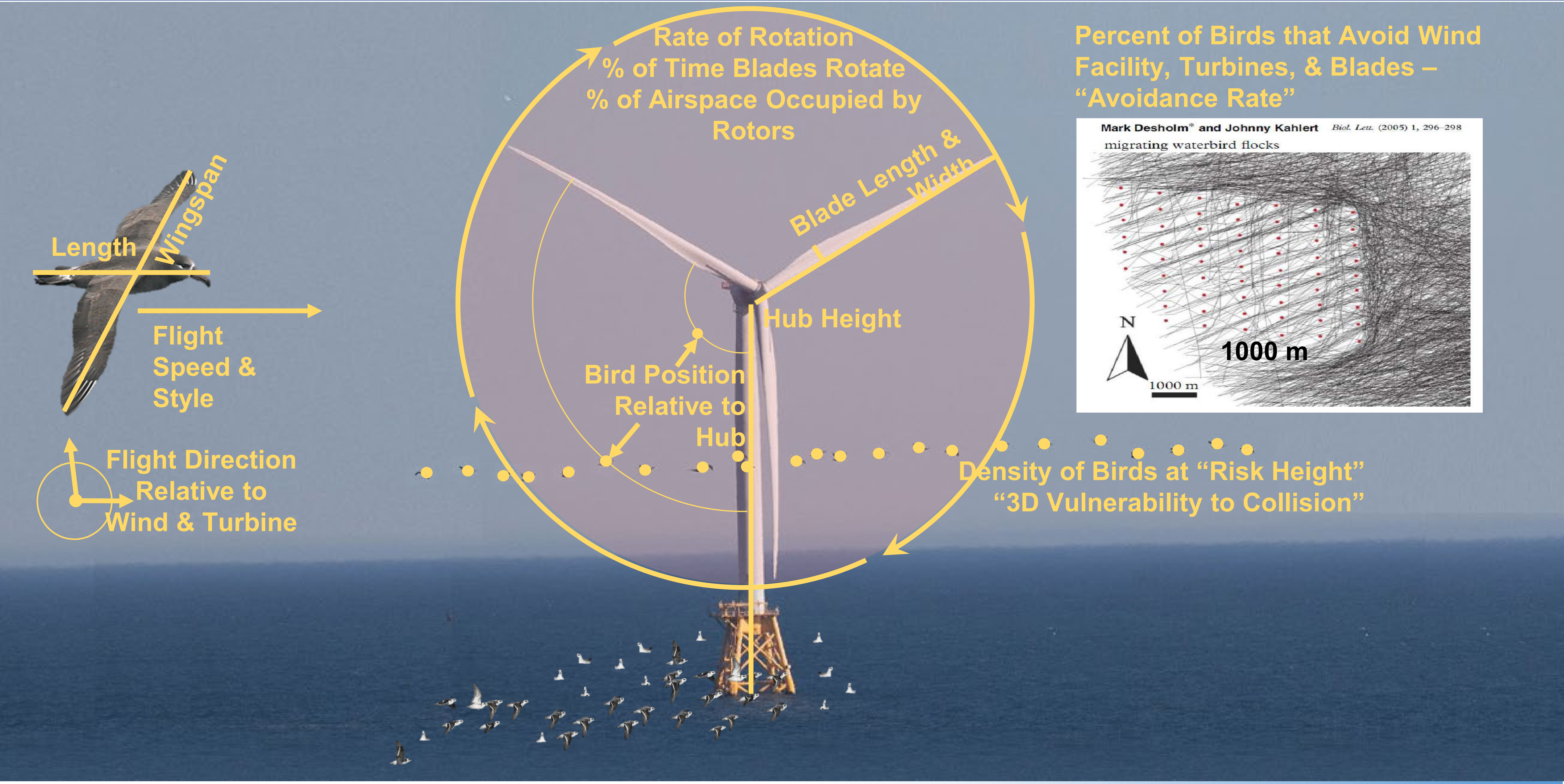
Dr Philip L. Richardson

Published: 03 October 2018 https://doi.org/10.1098/rsnr.2018.0024

Published by: Royal Society



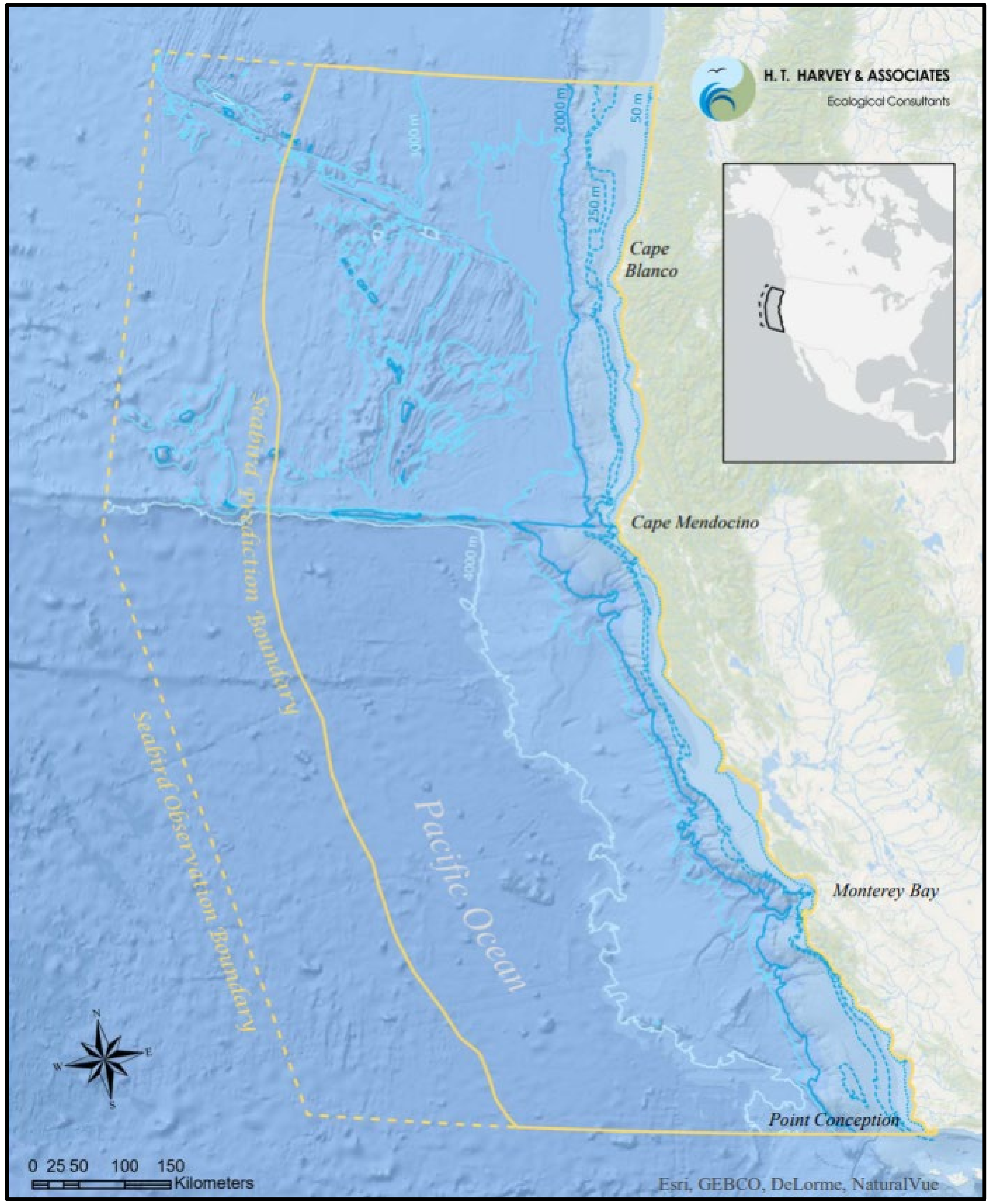
What is 3D Vulnerability?



3D Vulnerability Framework

Seabird Observations

Oceanographic Covariates



3D Vulnerability Framework

Seabird Observations

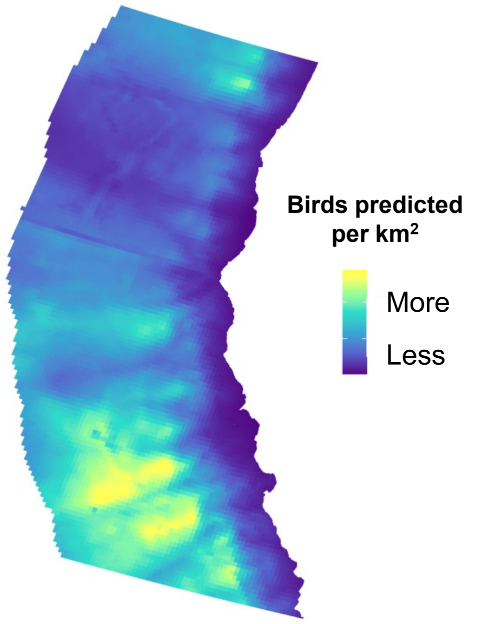
Oceanographic Covariates

2D species maps

Species *i*

Species 2

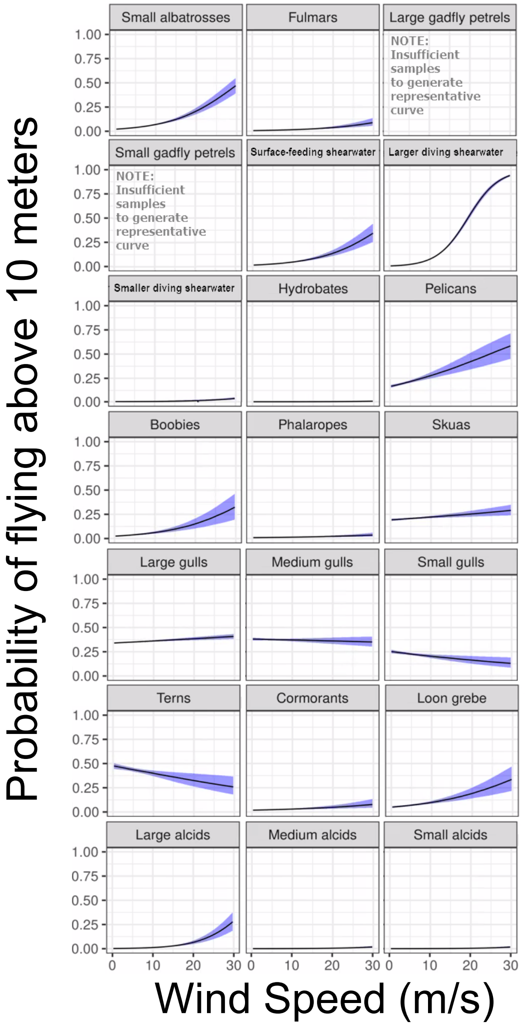
Species 1



Offshore Wind Speed Data

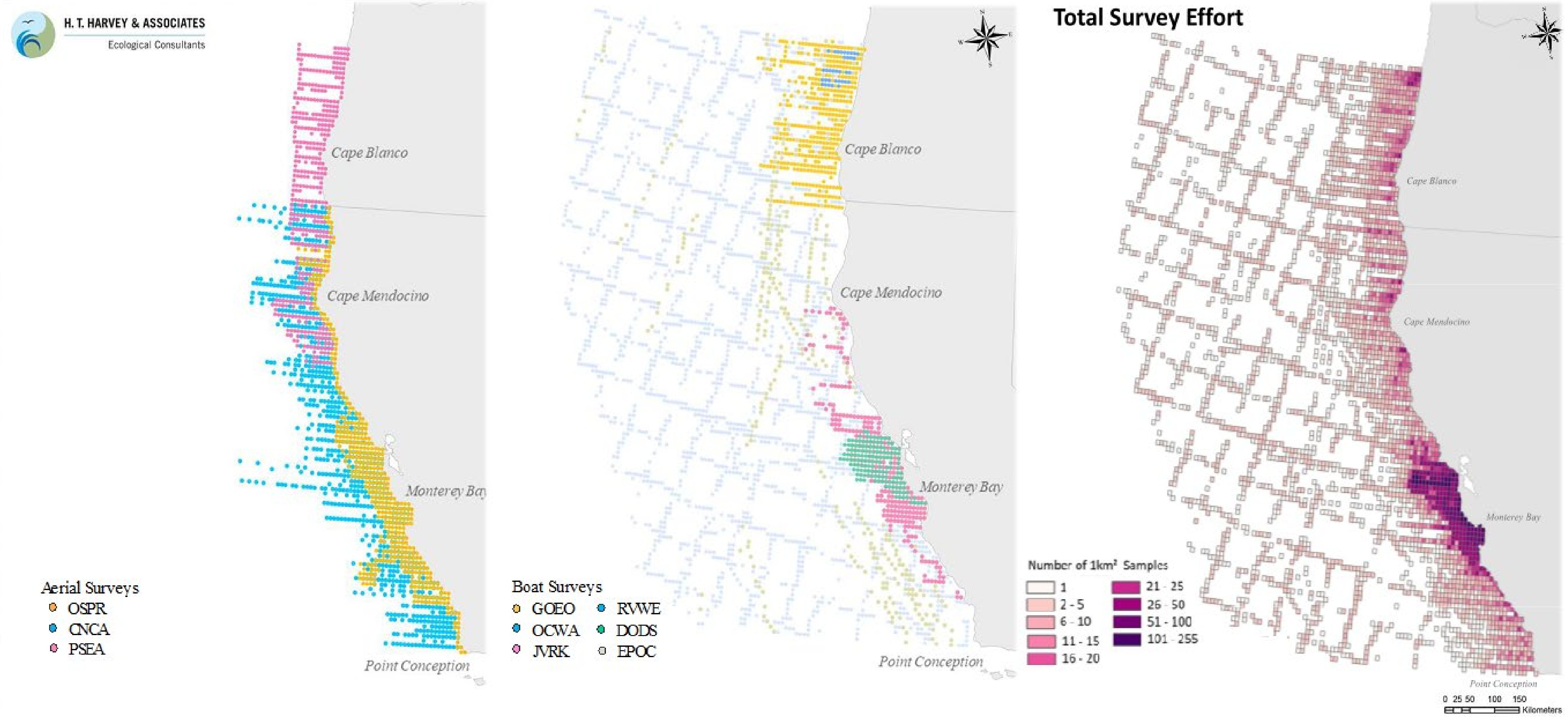
NREL WindToolKit (2000-2019)

Many types of seabirds with varying flight height responses to wind speed



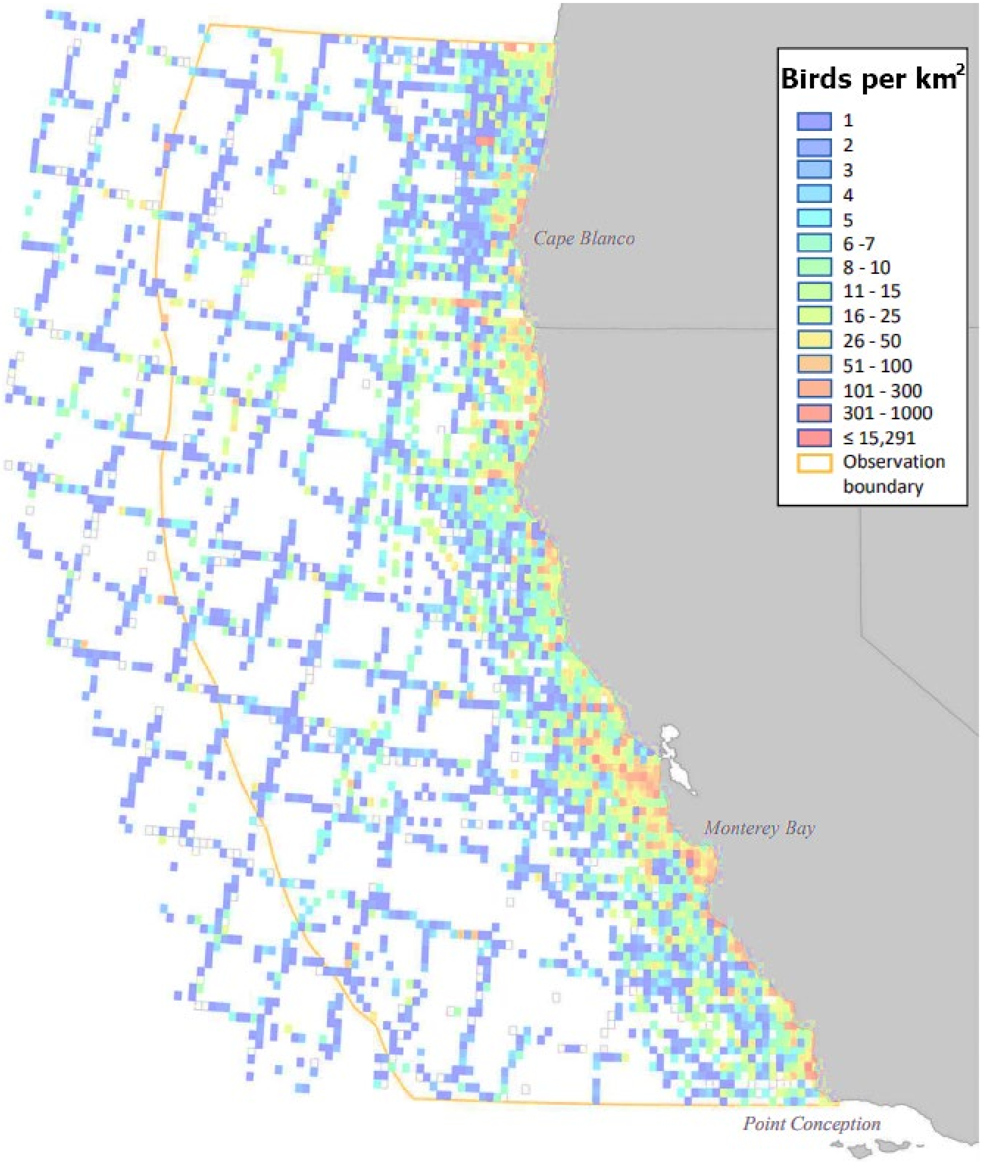
3D Seabird Vulnerability Model

Seabird Observations



Seabirds in 2D: Patterns Observed

All Birds in Vulnerability Model



Nearshore versus offshore patterns

- Abundance maximized in coastal areas

Nearshore

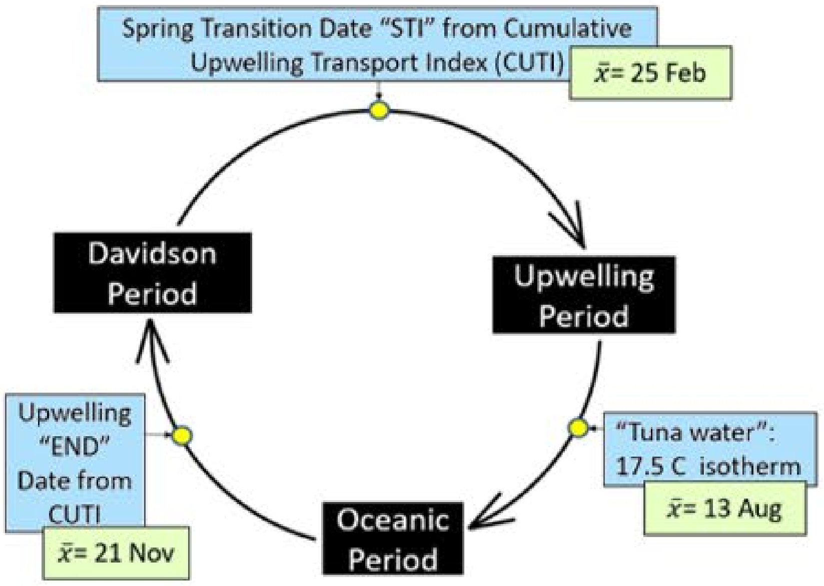
- Many species nest in California
- All nesting colonies except for the Farallon Islands are within 5 miles (8 km) of the coastline

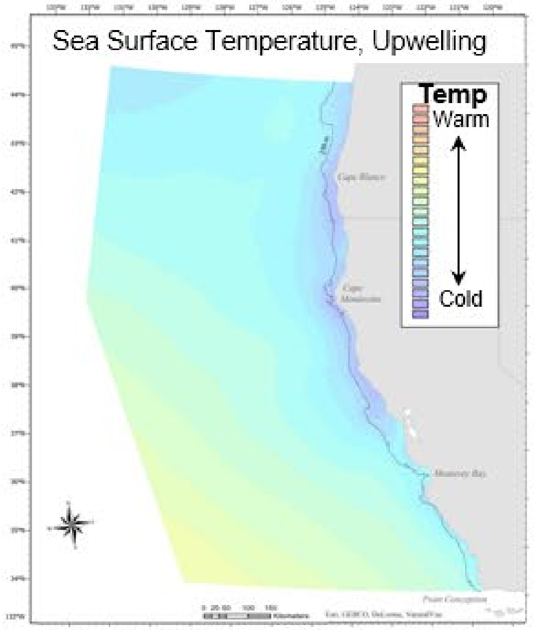
Offshore

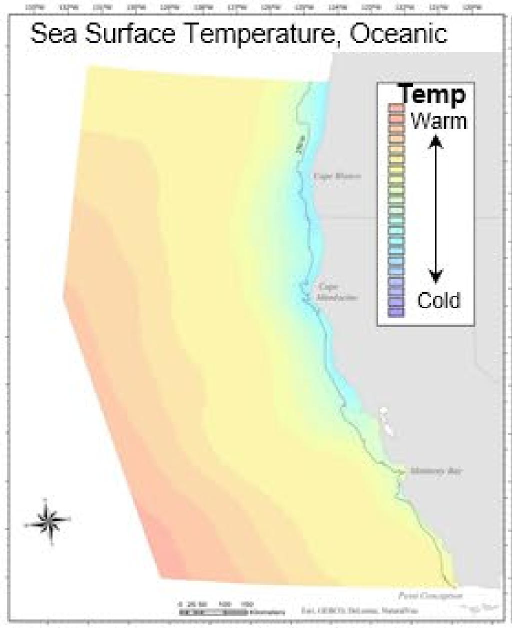
- Many species do not nest in California
- Long distance migrants in search of food outside of the nesting period

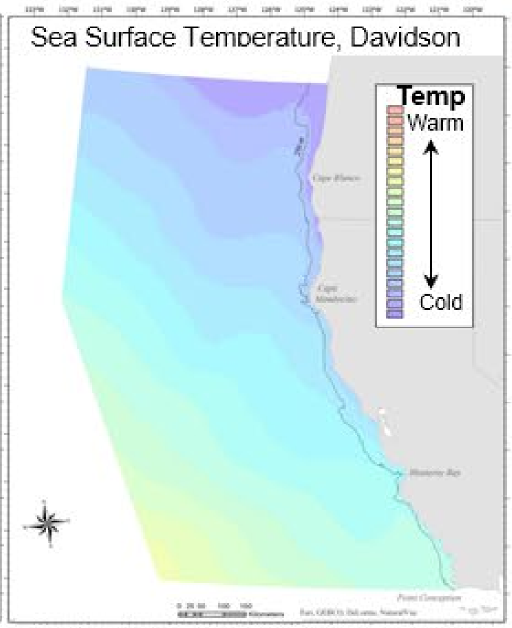
Changes through time – "seabird seasons"

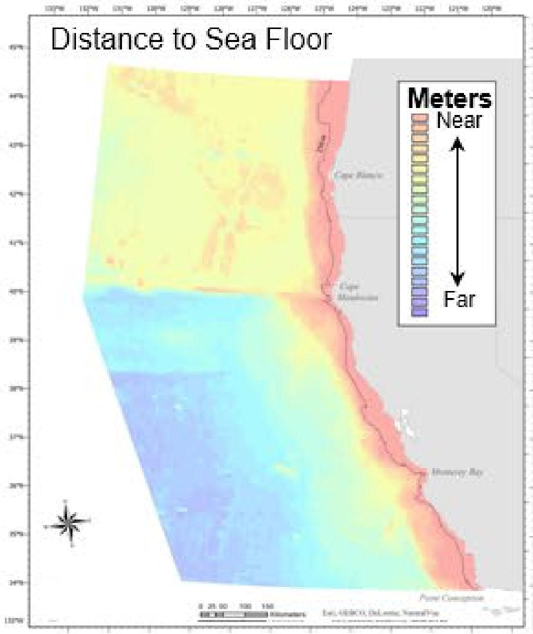
Oceanographic Covariates

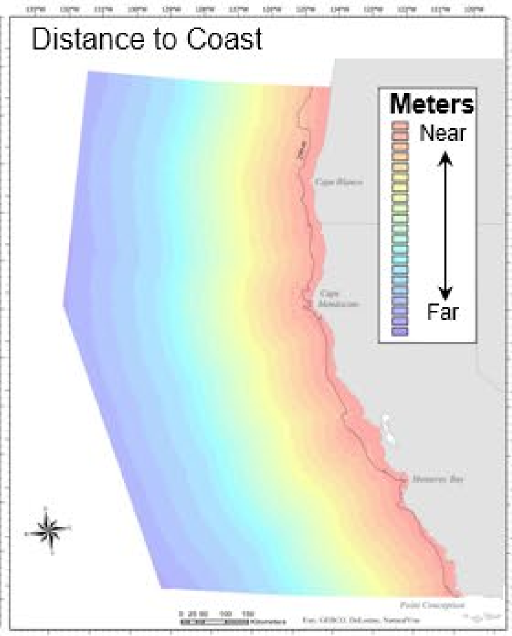


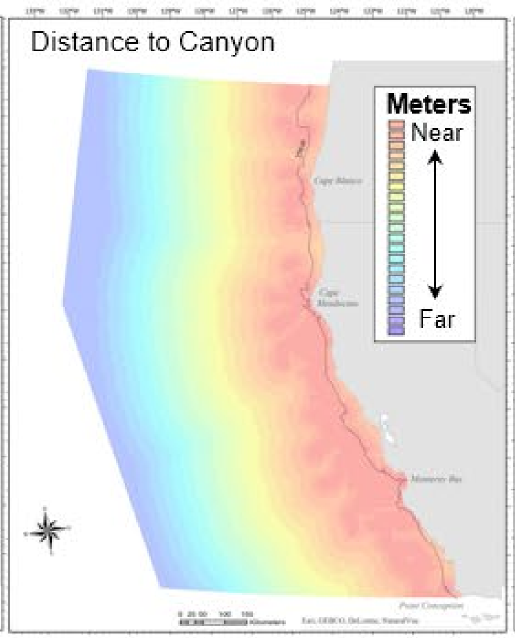


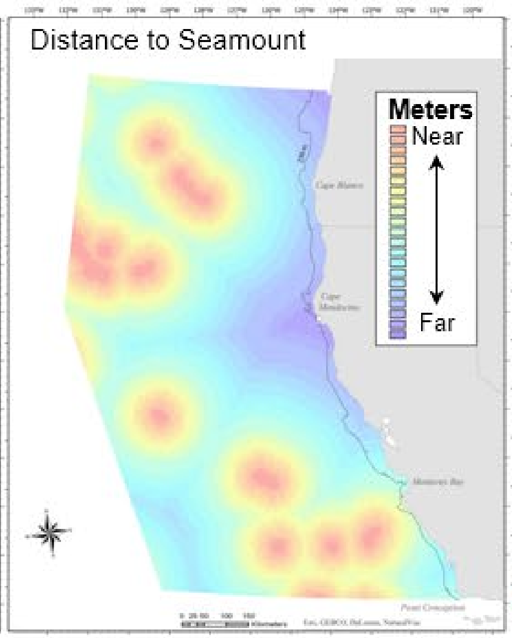


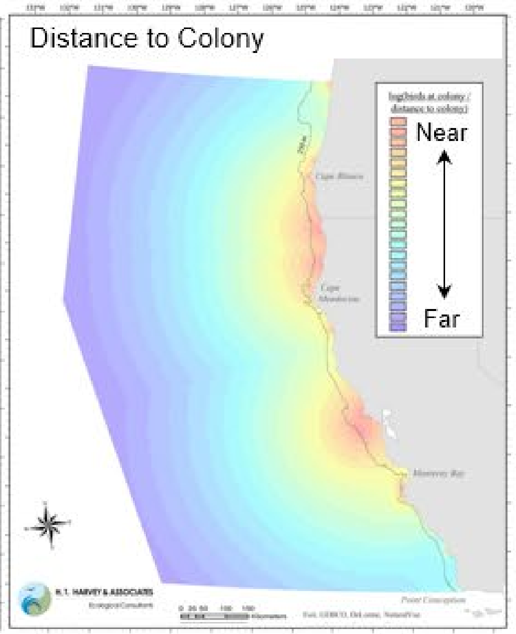








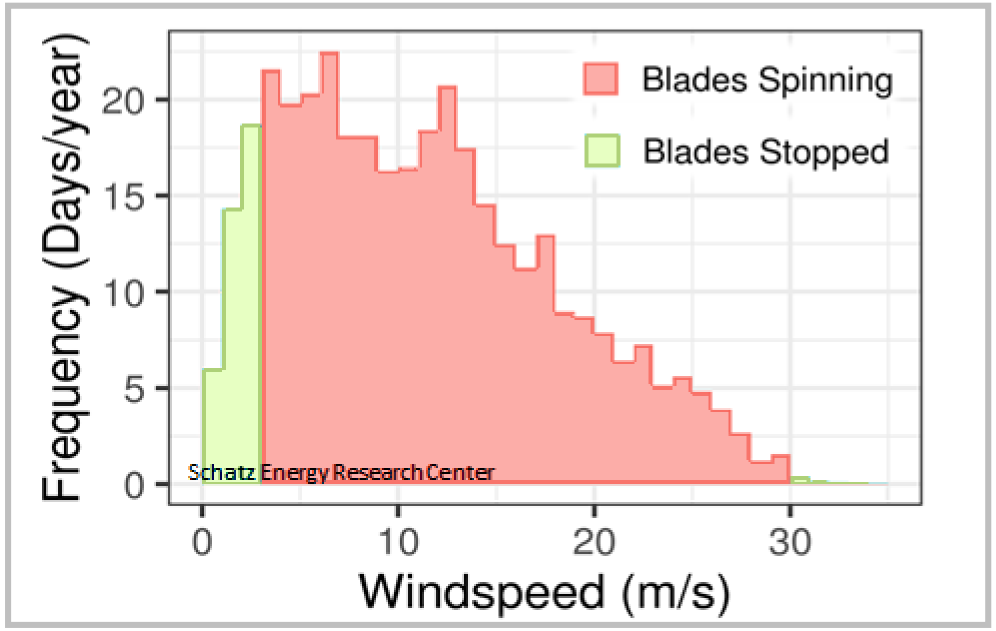




Seabirds in 3D: Flight Height

Extensive study on flight behavior

- Spanned much of the Pacific Basin
- 87 cruises from 1976-2006
- 131,354 sightings; 271 species
- Full spectrum of wind speeds
- Tailored to represent seabirds present in the California Current

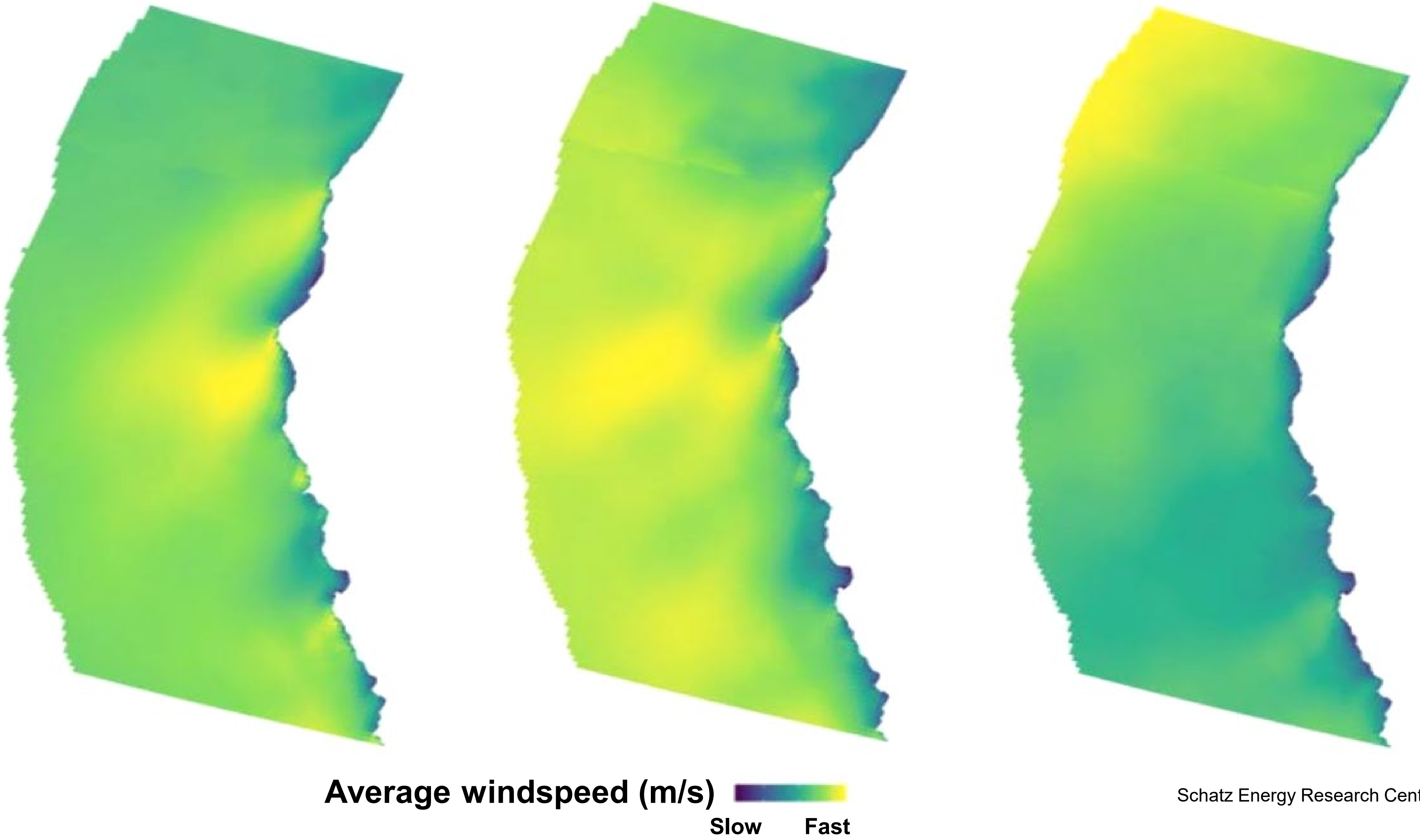


Seabird flight height data were binned

- **Categories:** On water, 0-3 m, 3-10 m, >10 m
- **Approach:** Logistic regression
- **Relevance to Rotor Swept Zone (RSZ):** 10 m is a conservative proxy for the lower extent of the RSZ
- **Outcome:** Probability of birds being above 10 meters across full spectrum of winds (0 to 30 m/s)

Seabirds in 3D: Windscape

Upwelling	Oceanic	Davidson



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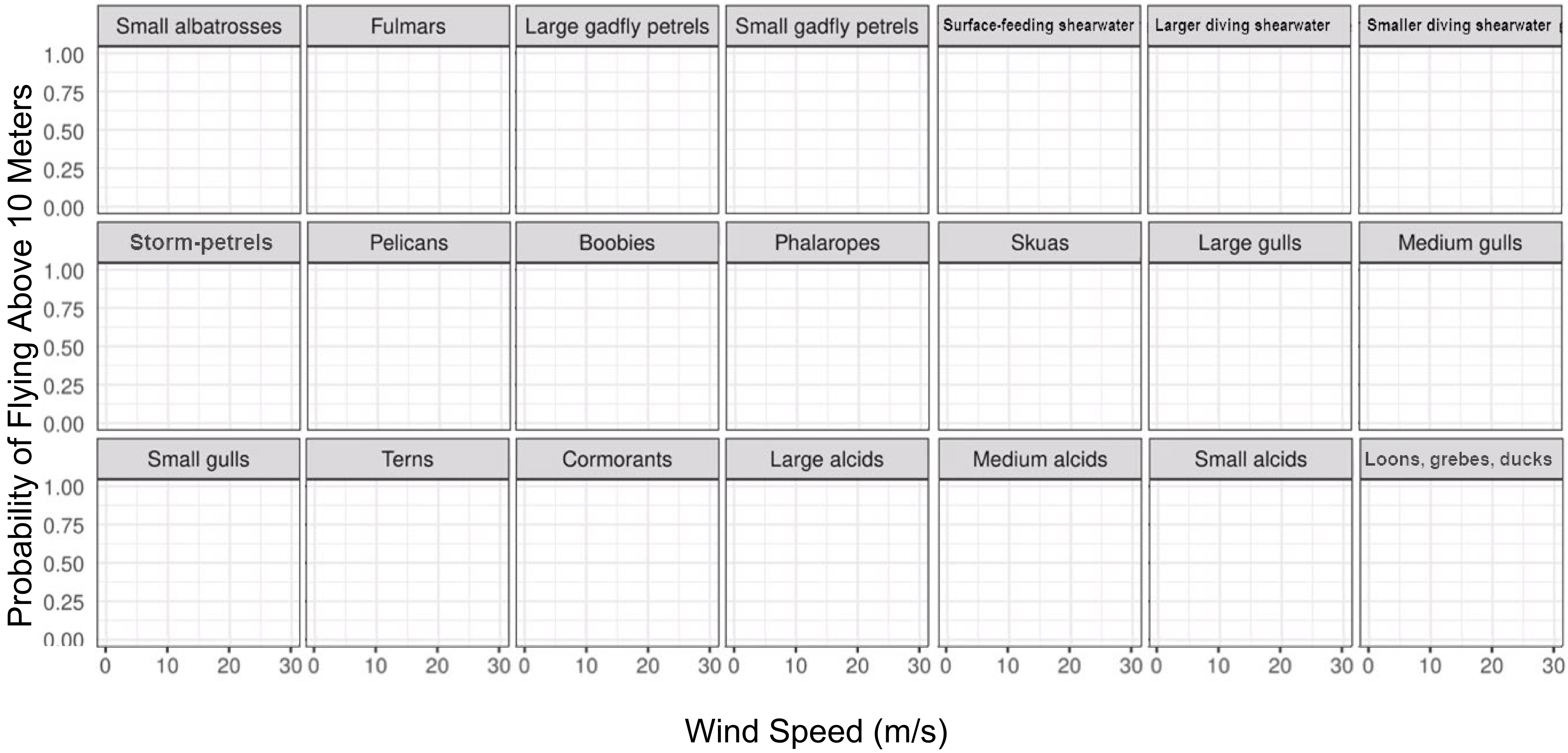
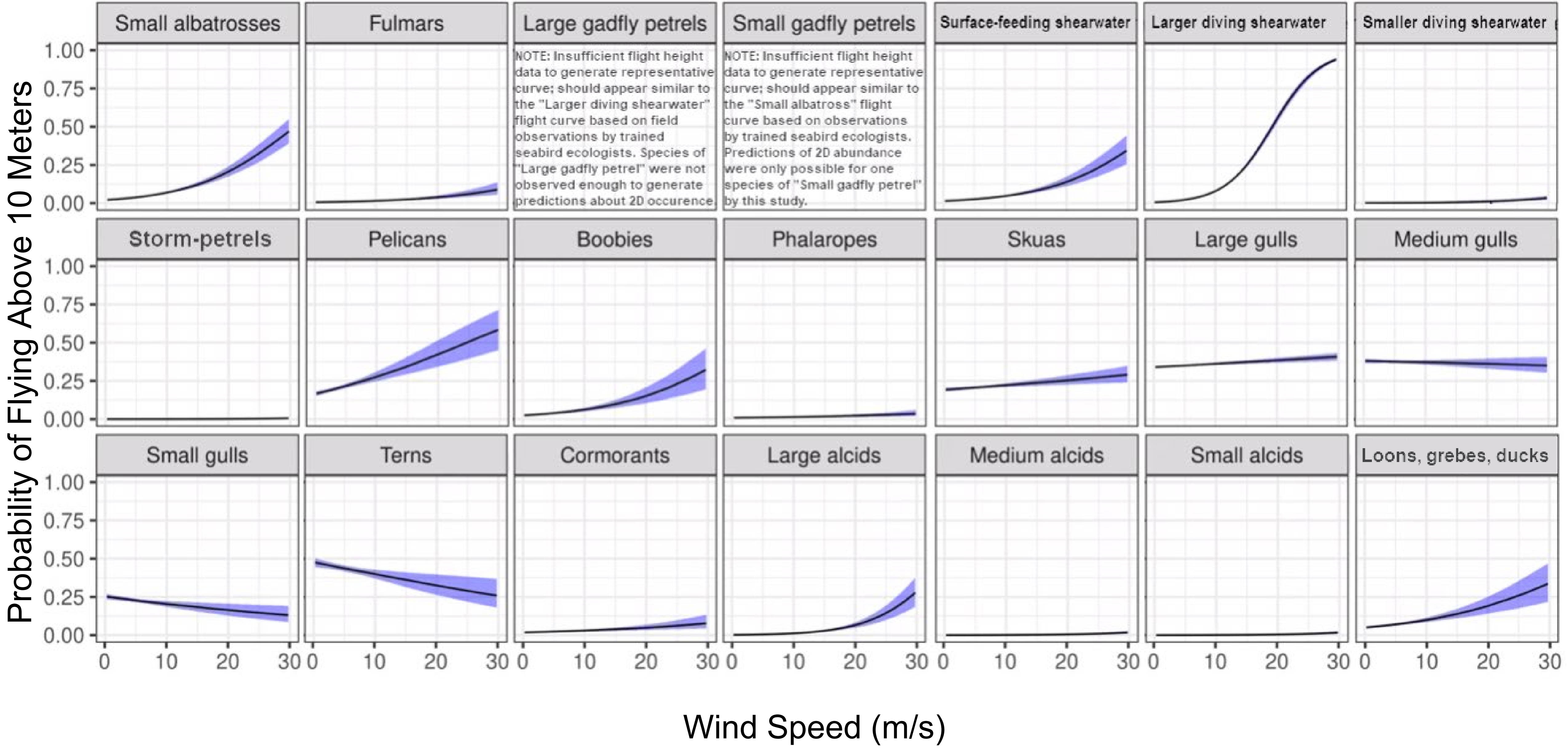
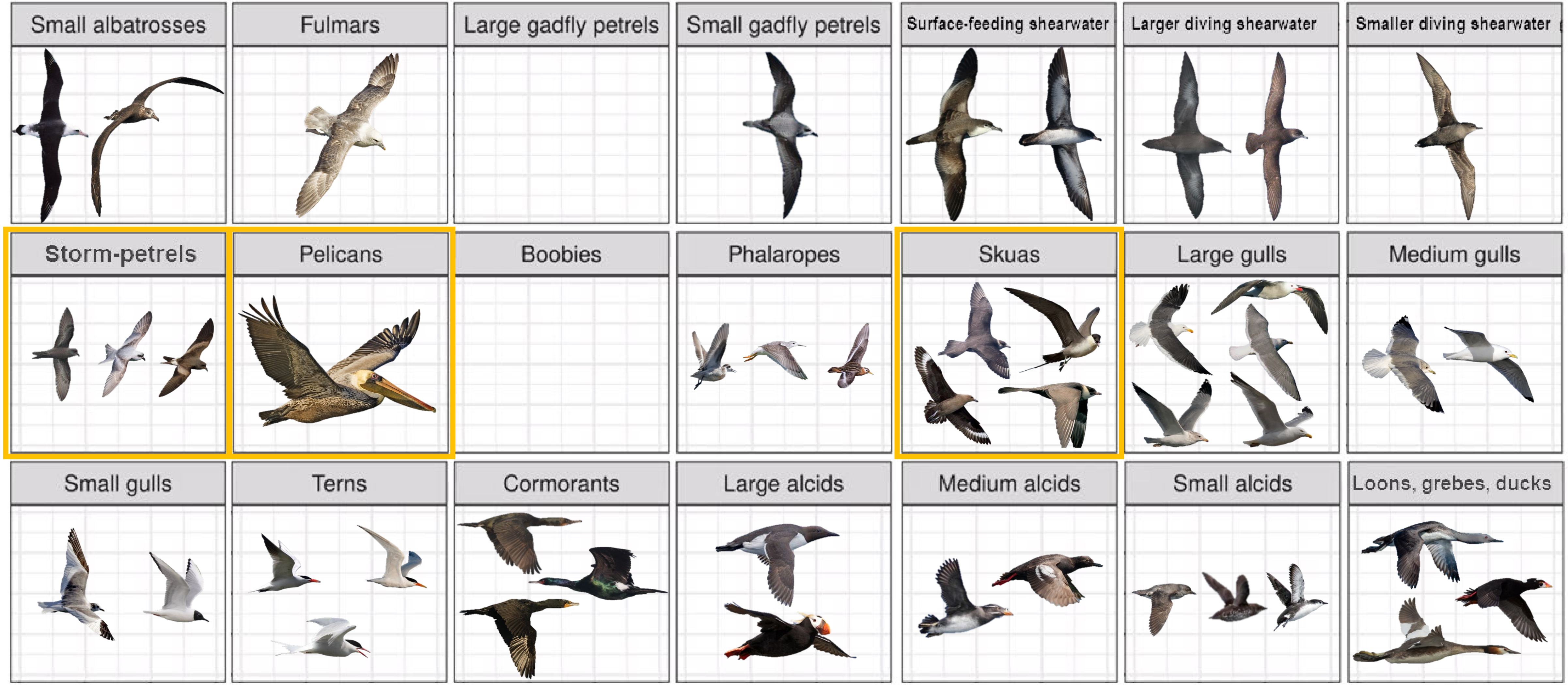
Seabirds in 3D: Wind Speed and Flight Height



Seabirds in 3D: Wind Speed and Flight Height

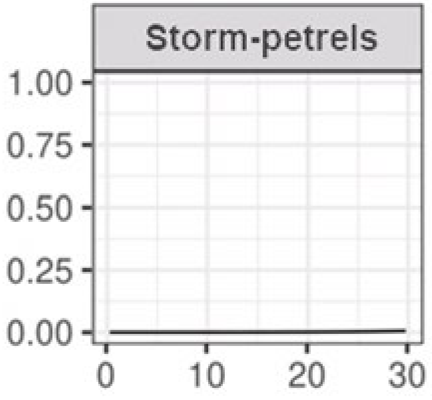


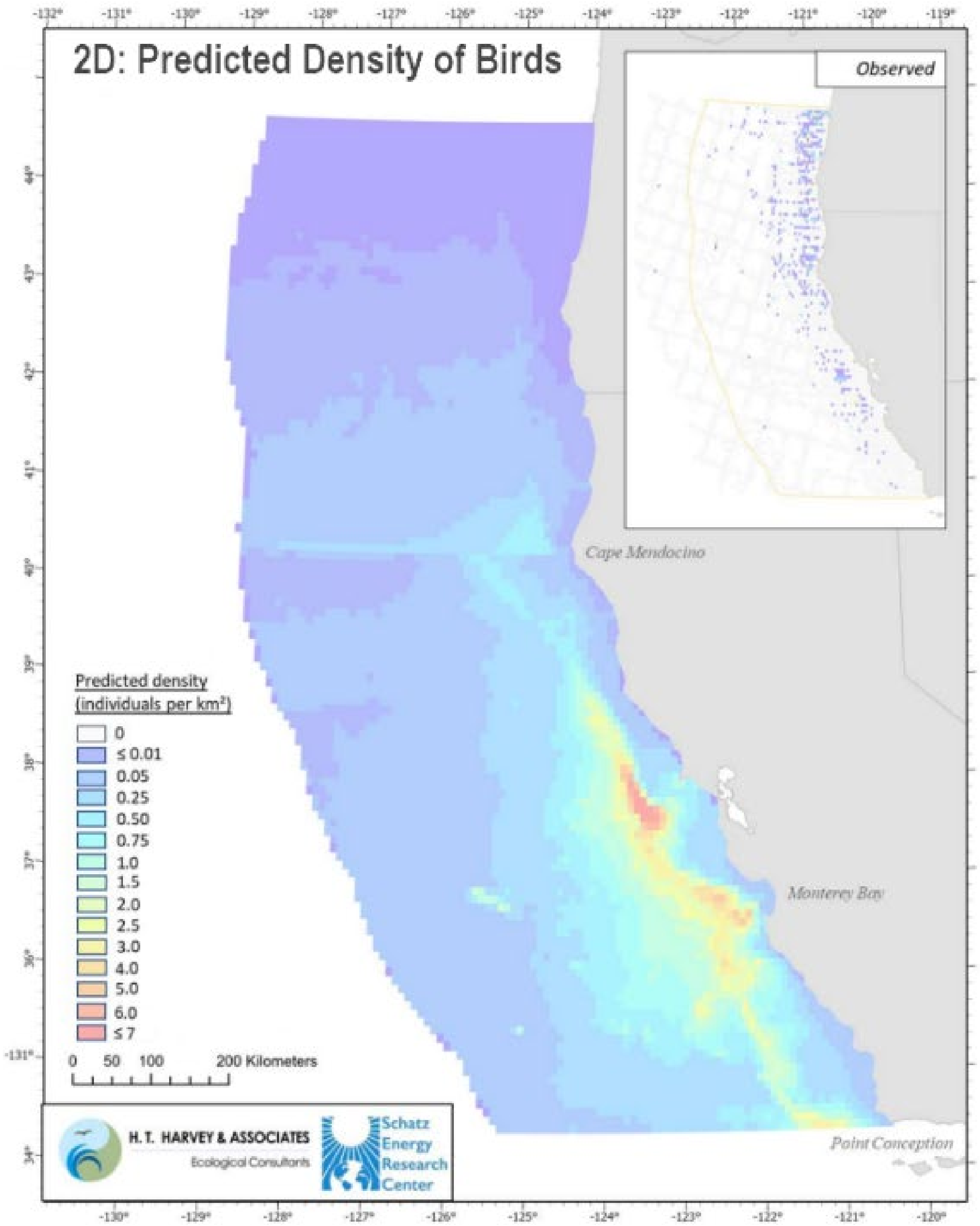
Seabirds in 3D: Species Included

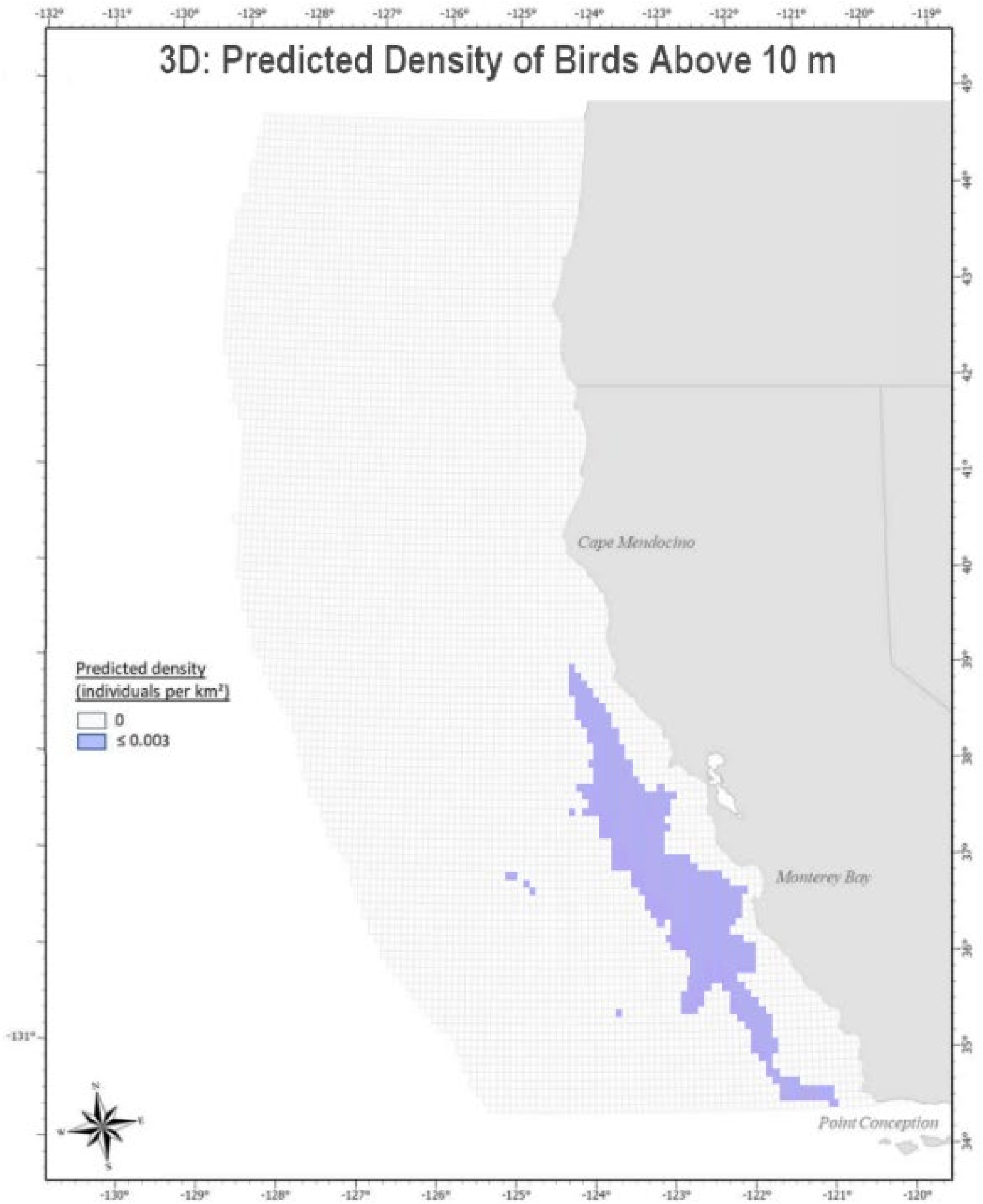


NOTE: Bird images are not to scale

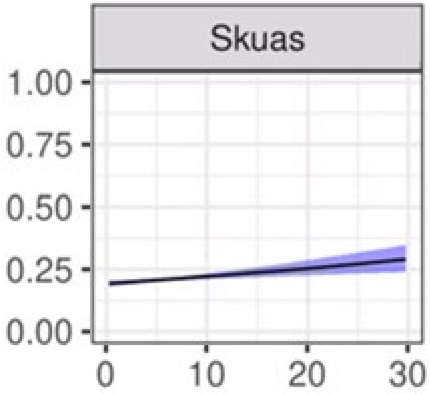
Seabirds in 3D: Ashy Storm-petrel

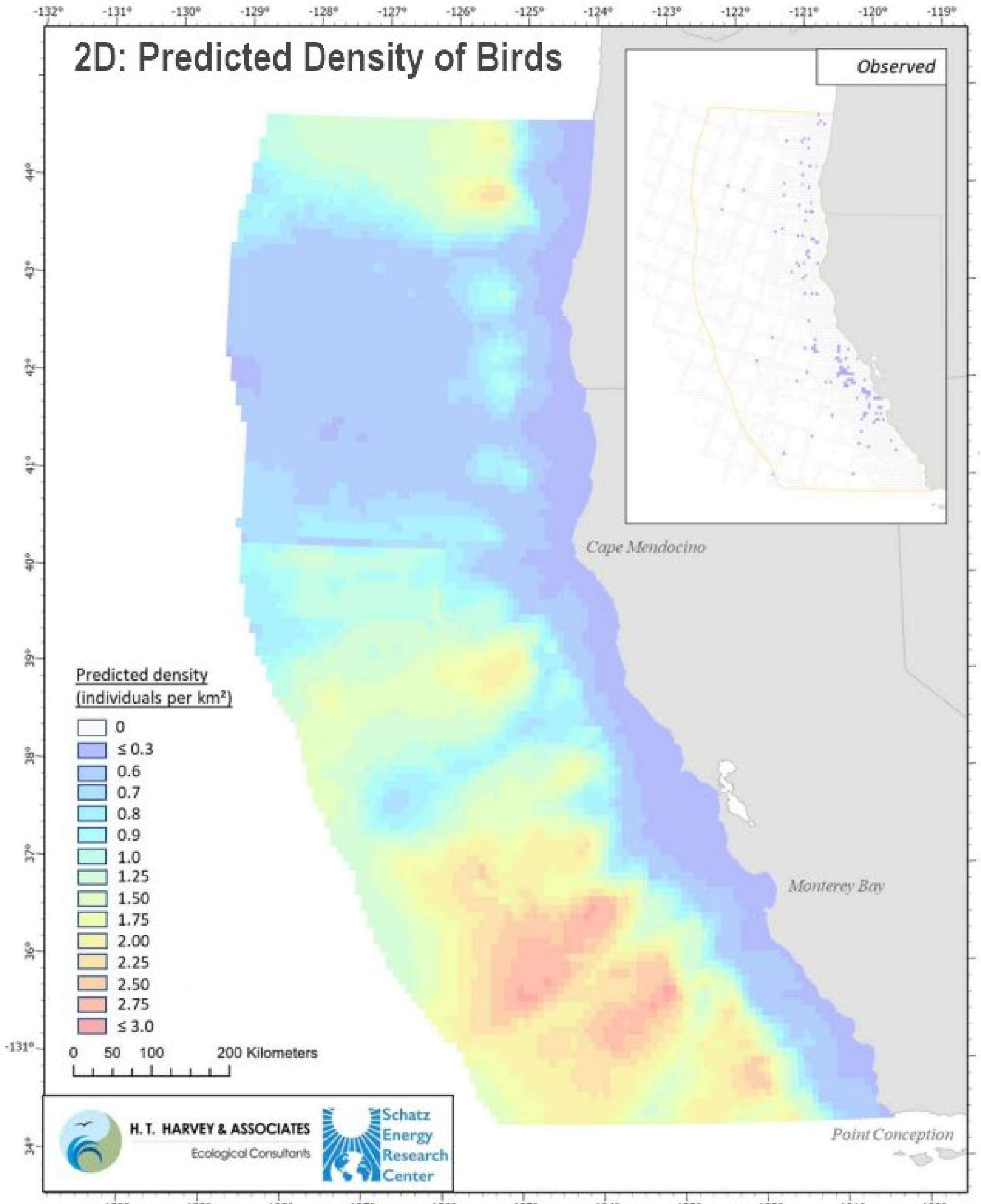


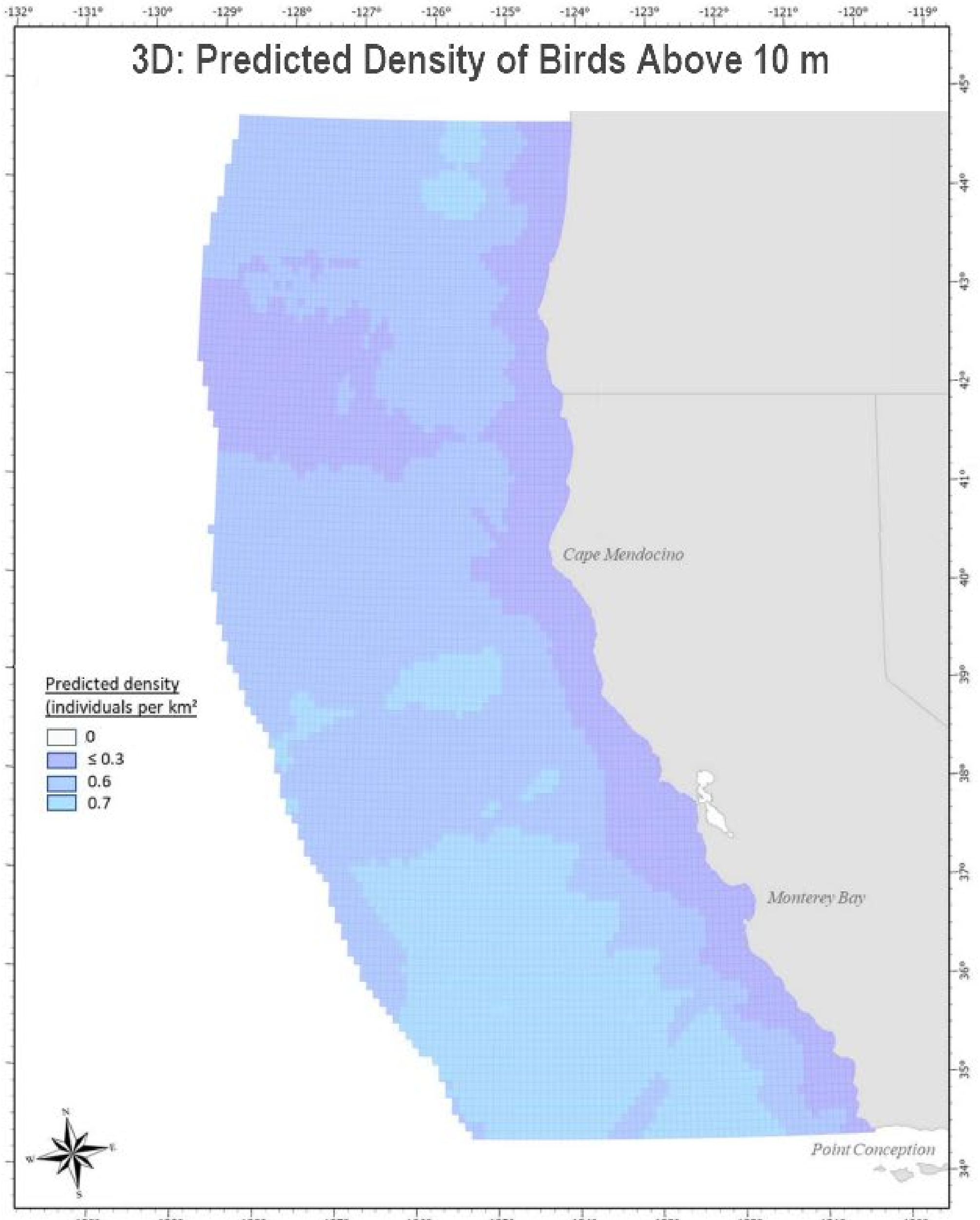




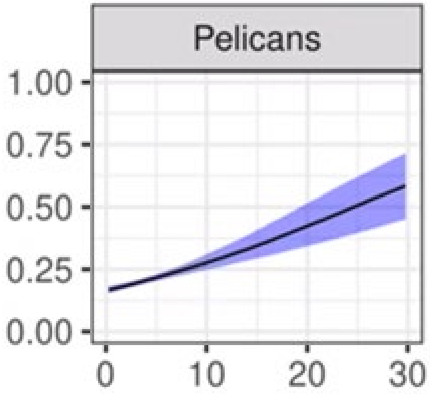
Seabirds in 3D: South Polar Skua

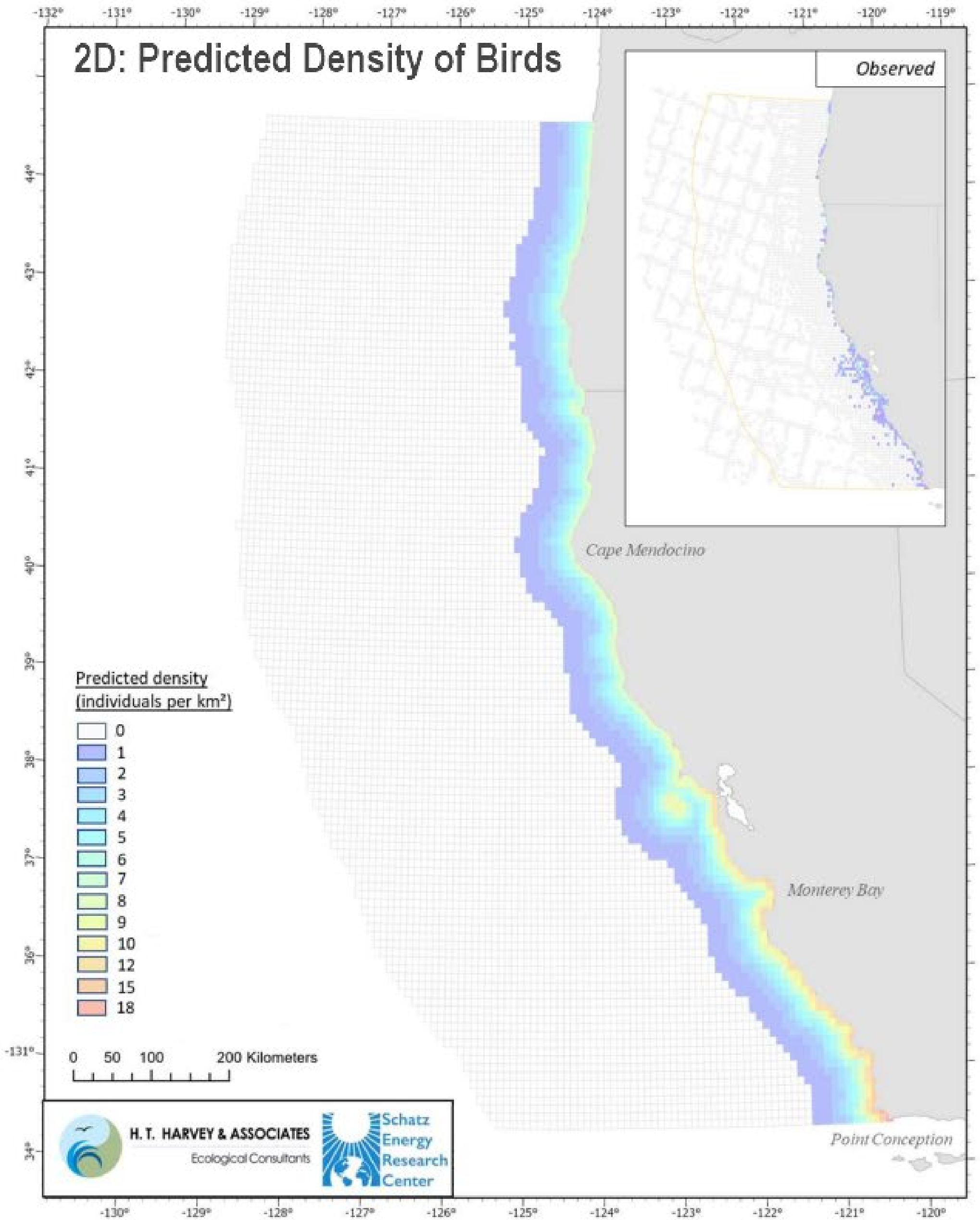


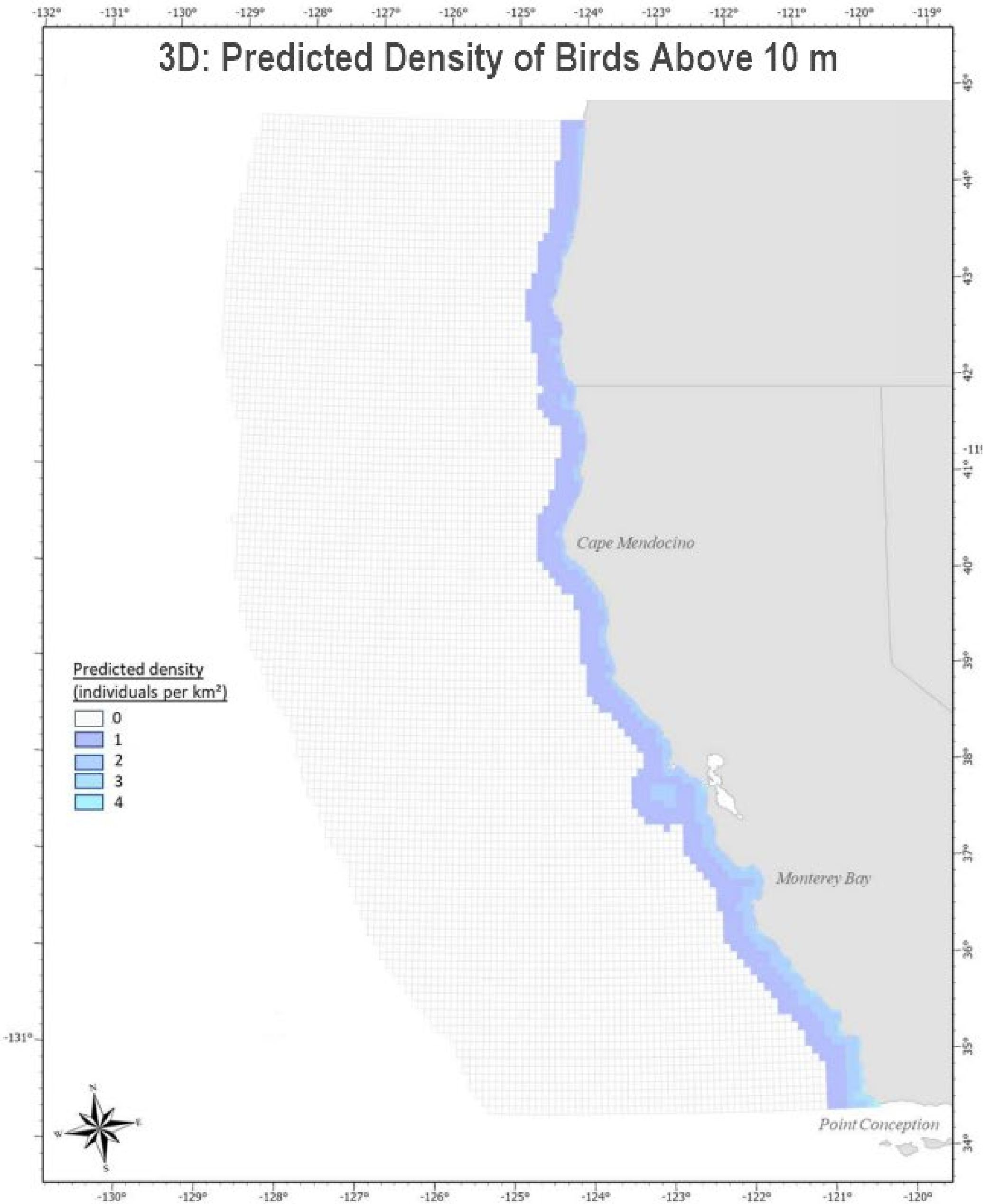




Seabirds in 3D: Brown Pelican

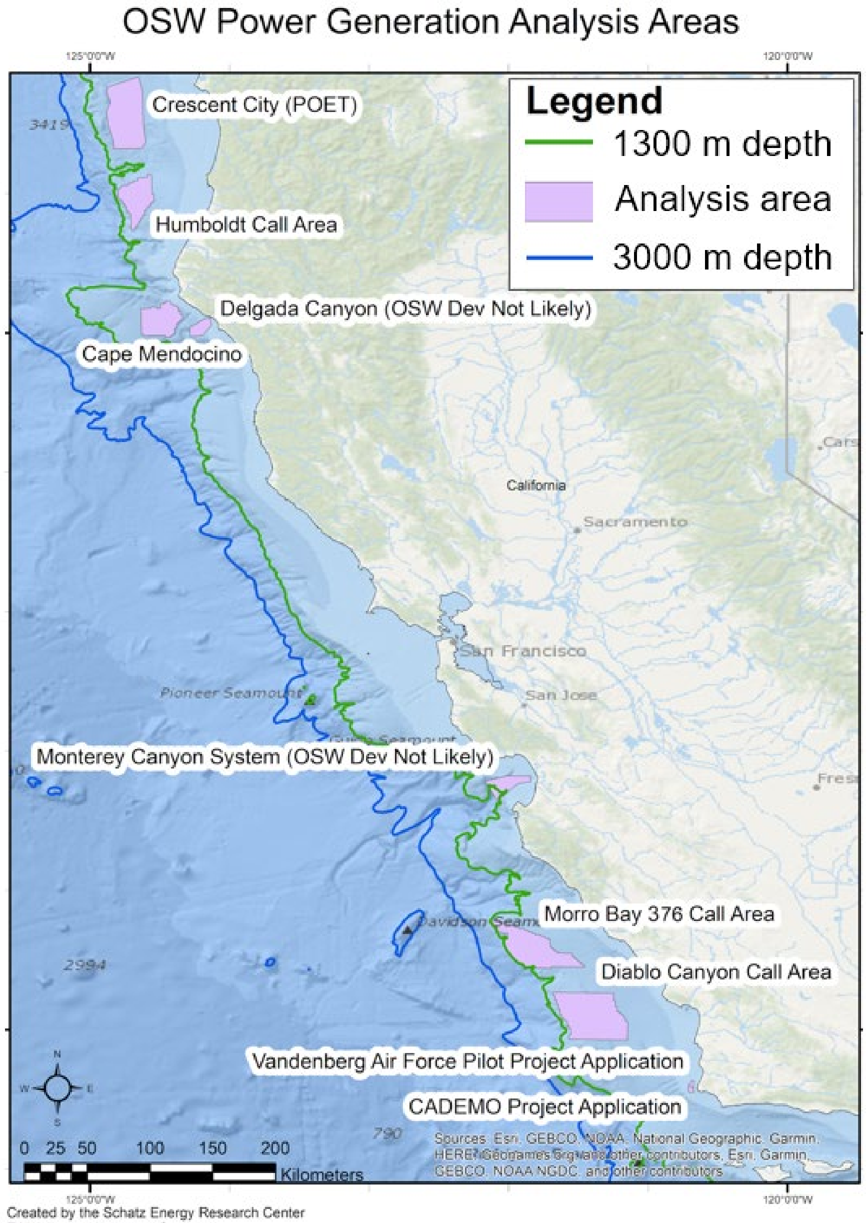






Power Generation Model

Power Generation Scenarios



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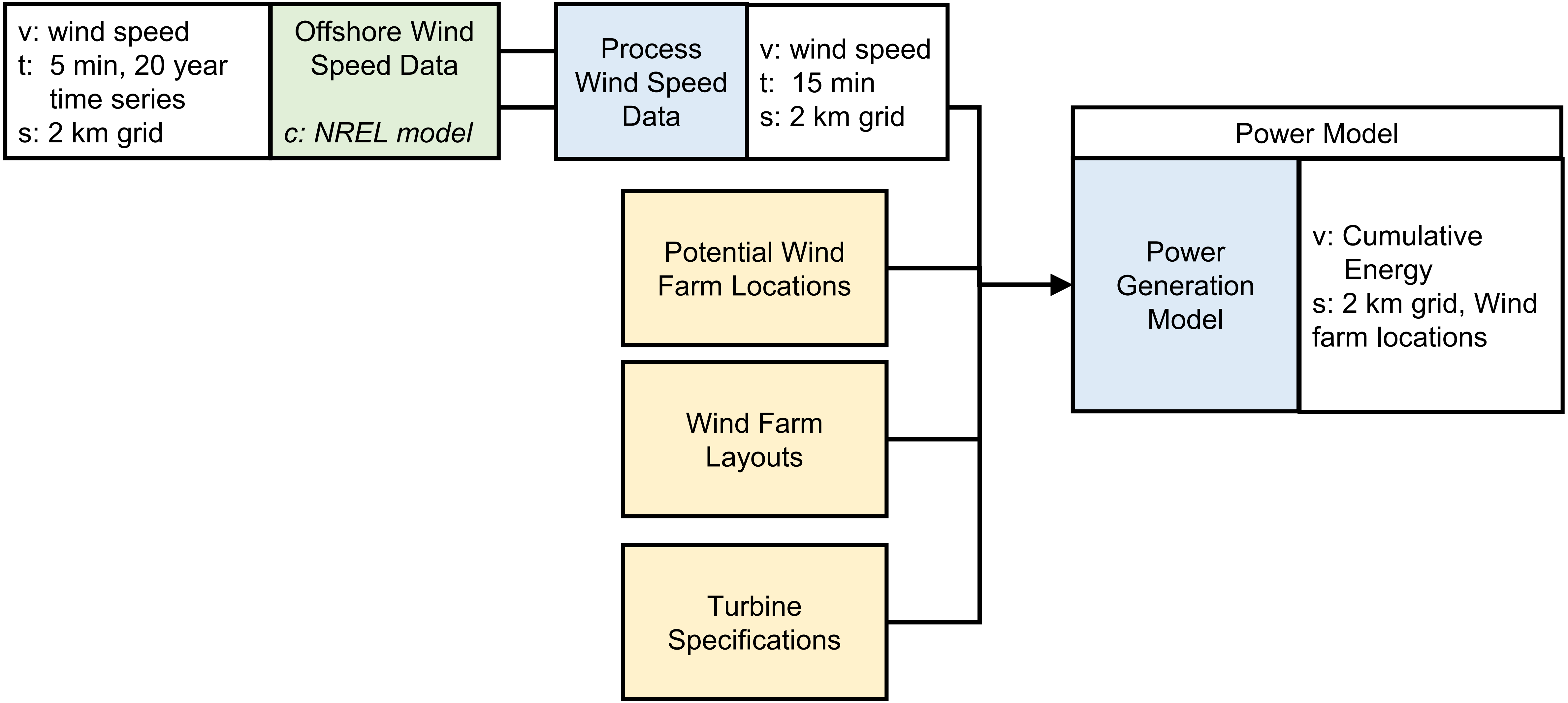
Eli Wallach and Jerome Carman
June, 2021

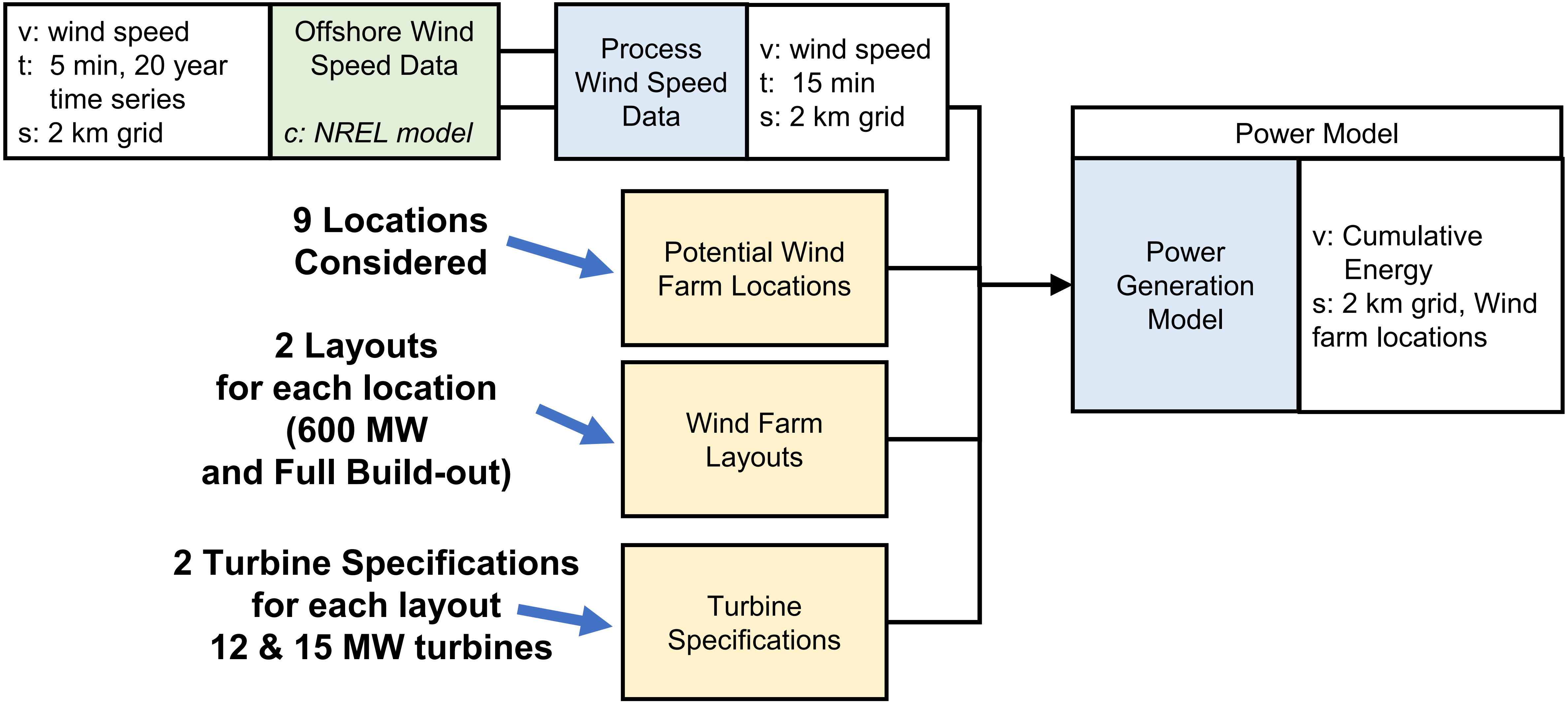
Locations

- BOEM Wind Energy Areas (WEAs): Humboldt, Morro Bay, & Diablo Canyon (former call area)
- Notional Areas for Potential Wind Development: Crescent City (POET) & Cape Mendocino
- Proposed Wind Demonstration Project Areas in California State Waters: Vandenberg Air Force Pilot Project & CADEMO Project
- Seabird Hot Spots: Delgada Canyon & Monterey Canyon System (OSW development unlikely)
- Full Coast Analysis considering a single turbine

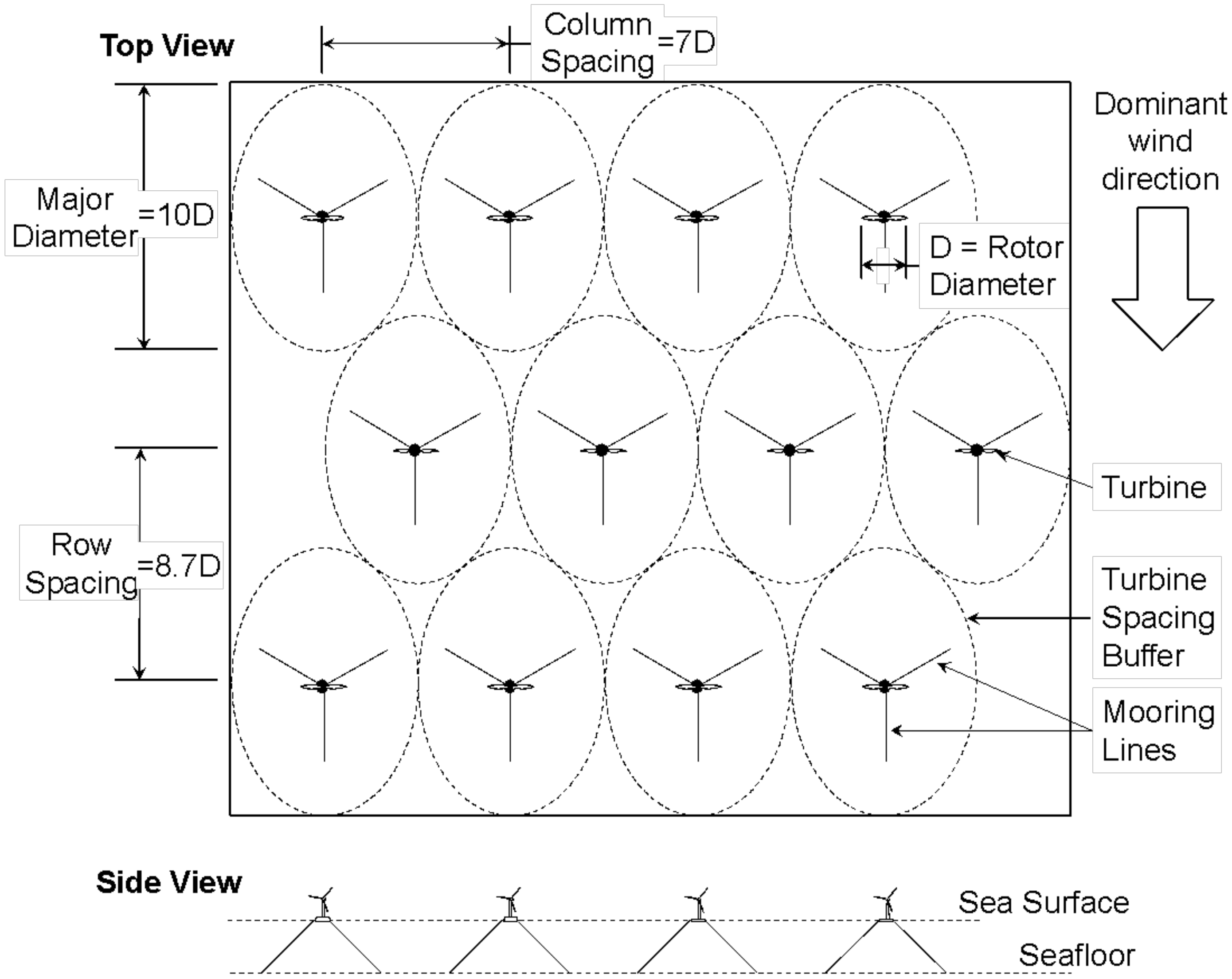
Power Generation Scenarios



Power Generation Scenarios



Power Generation Scenarios

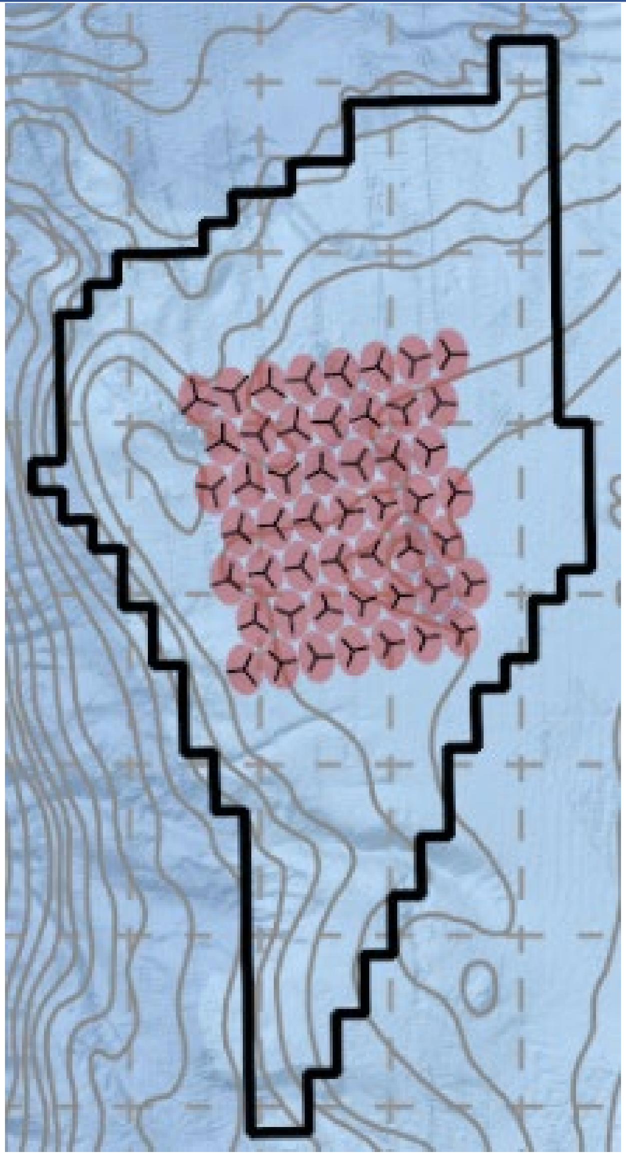


Layout Criteria

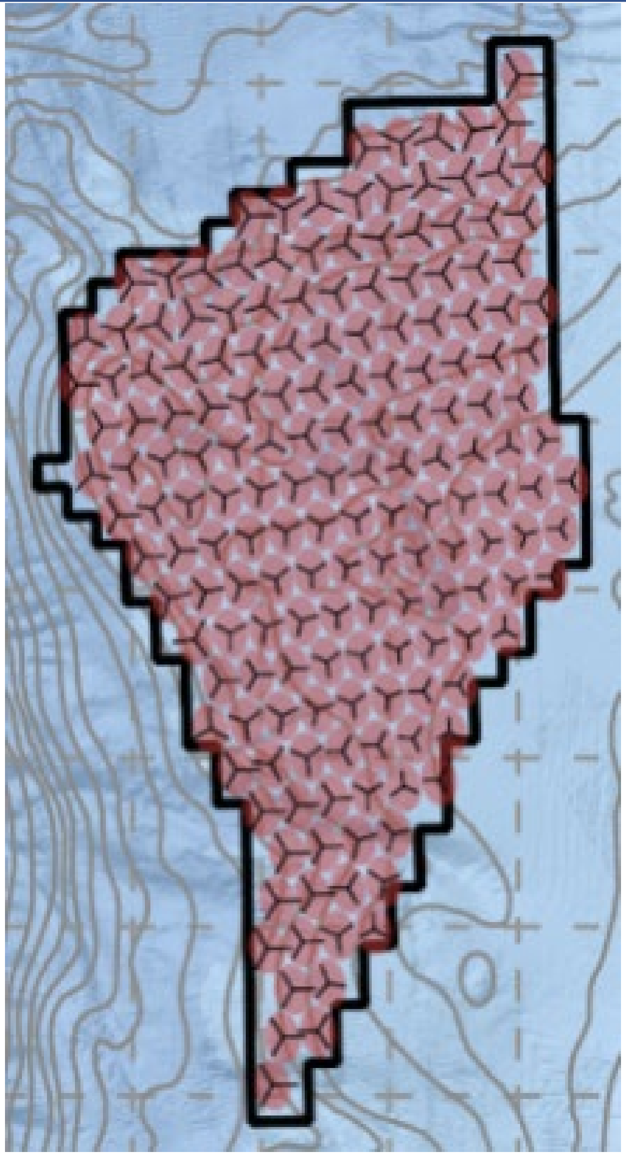
- 7D X 10D Elliptical Spacing Requirement
- Mooring lines not to overlap
- Turbines and mooring anchors fall within WEA
- Layout criteria and how close developers envision placing these turbines has been changir
- These assumptions are likely conservative

Turbine Placements Complete

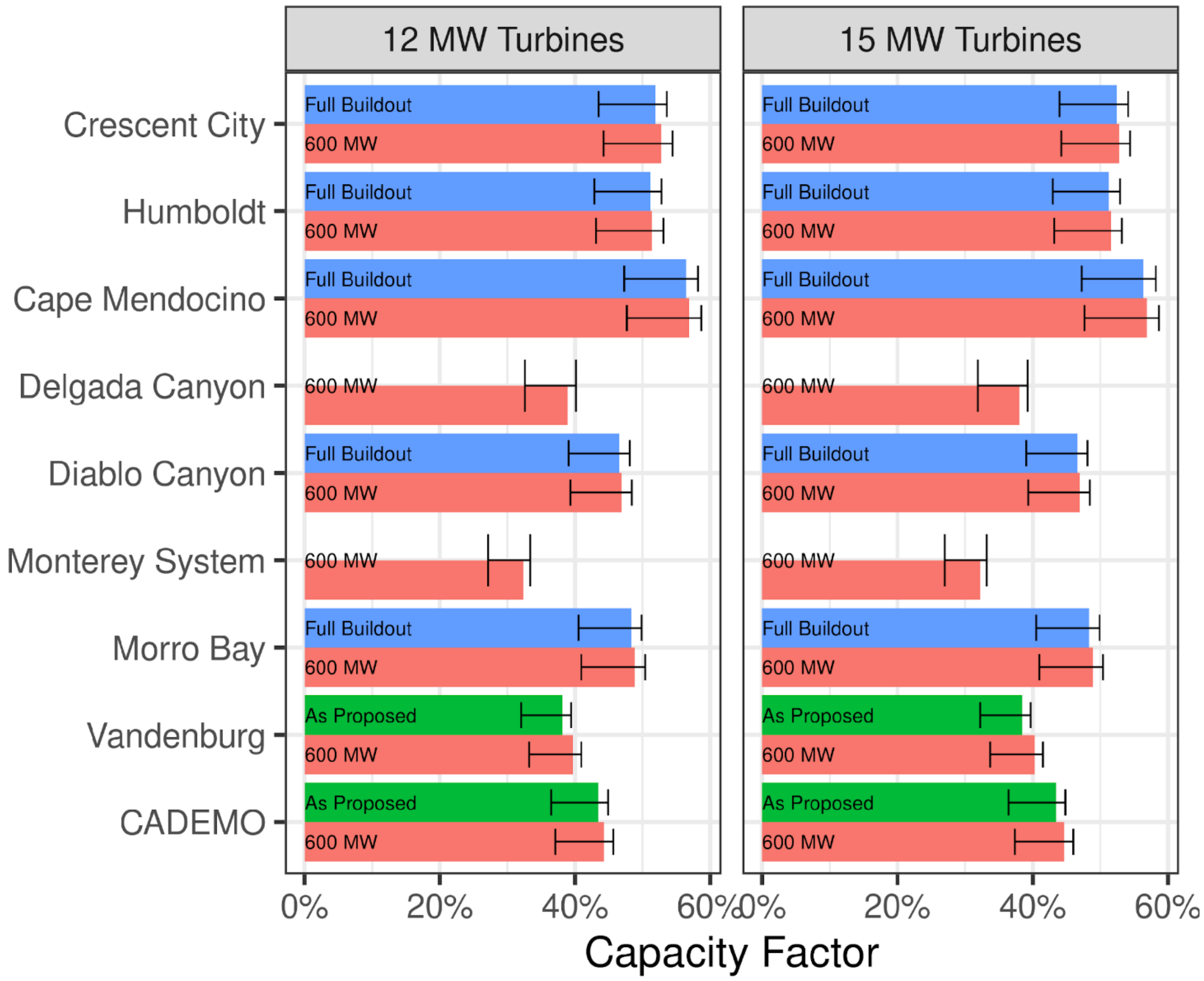
Turbine Size: 12 MW
Sizing: 600MW

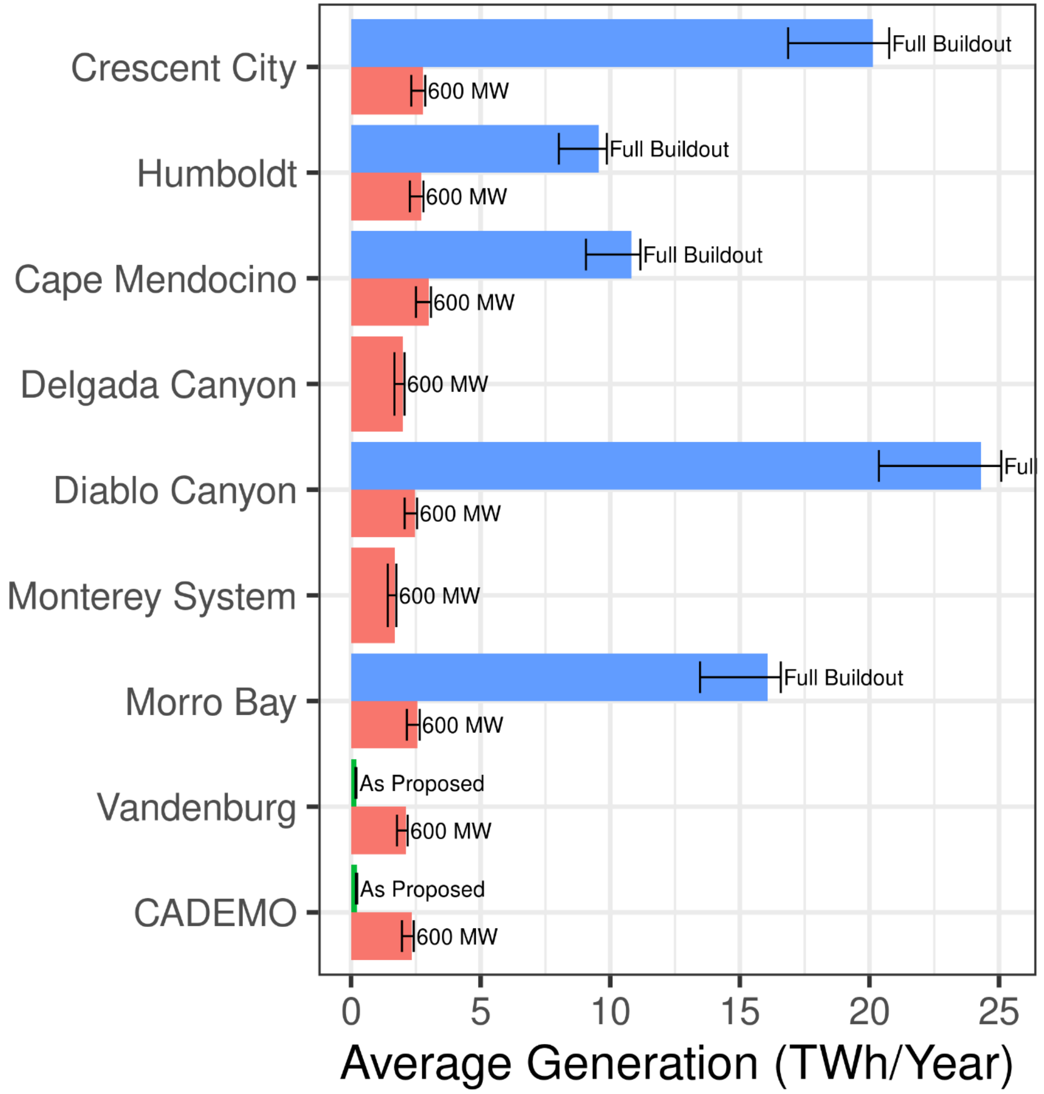


Turbine Size: 12 MW
Sizing: Full-buildout
Windfarm Size: 2,112 MW

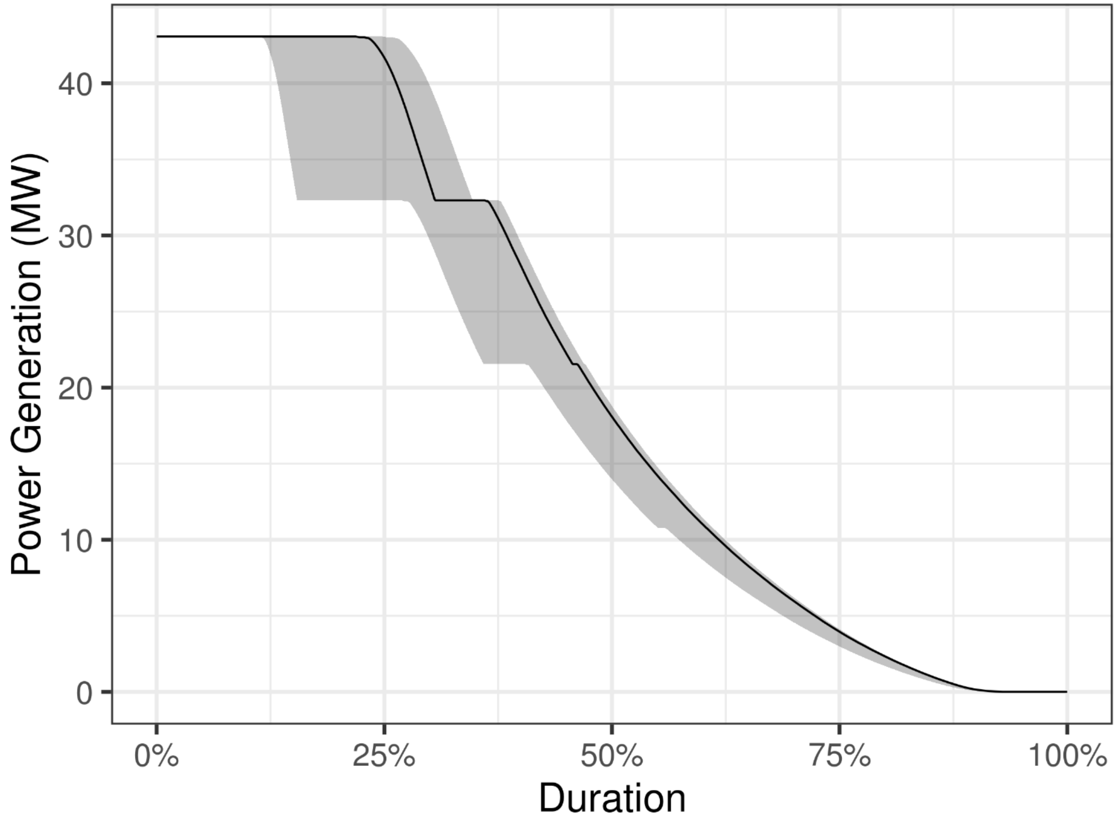


Wind Farm-Power Generation Results

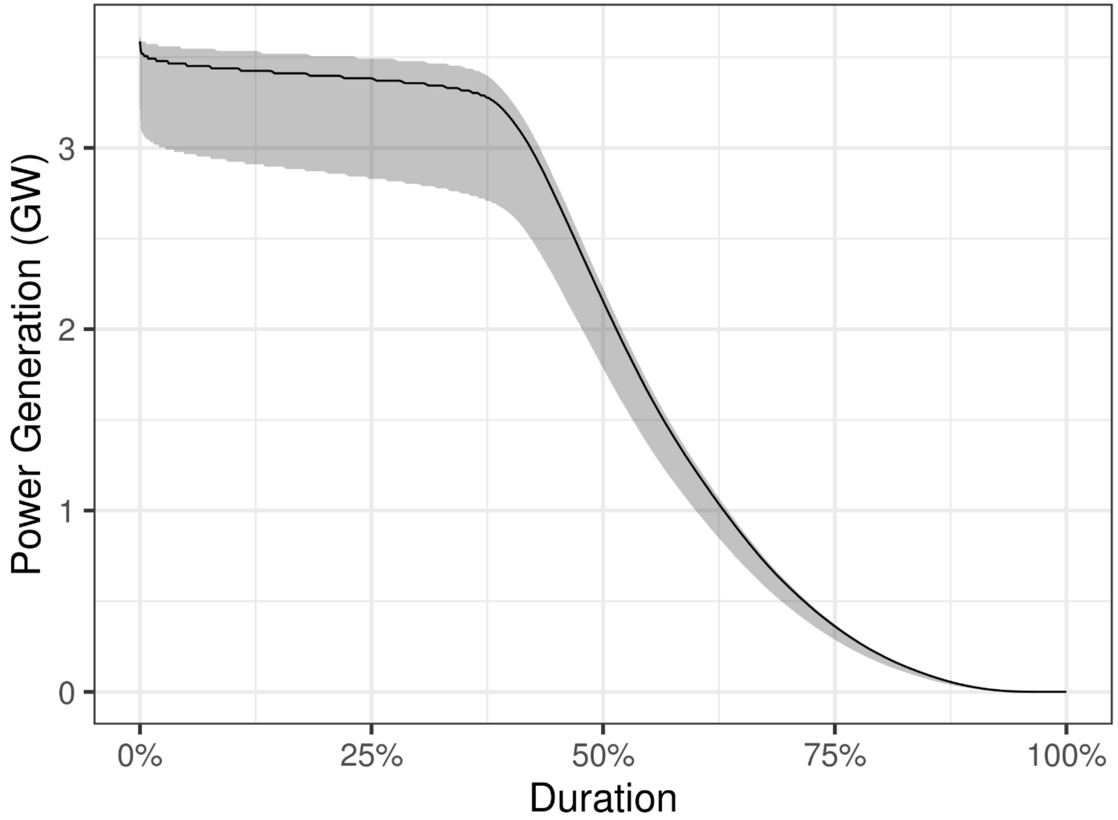




Generation Duration Curves



Location: CADEMO
Turbine Size: 12 MW
Farm Sizing: As proposed (4 Turbines; 48 MW)

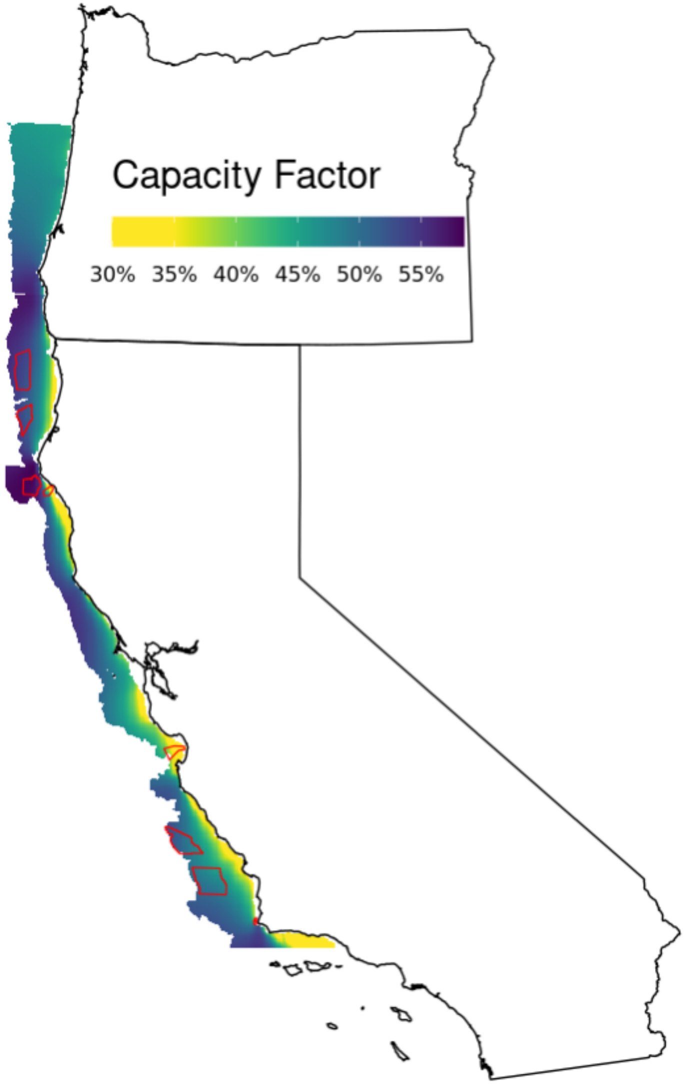


Location: Morro Bay
Turbine Size: 15MW
Farm Sizing: full Build-out (267 Turbines; 4 GW)

Full Coast Analysis

Results for a single 12 MW turbine in each of the 2x2km grid cells

- Estimated wind generation values for sites as deep as 1300 m
- Capacity factors are slightly higher than for actual windfarms as wake losses are not considered
- The generation potential is generally better further offshore
- Best wind resource is available offshore of Cape Mendocino and Southern Oregon



Tradeoffs Between Power Generation and Seabird Vulnerability

Pareto Analysis - Introduction

Why Pareto Analysis

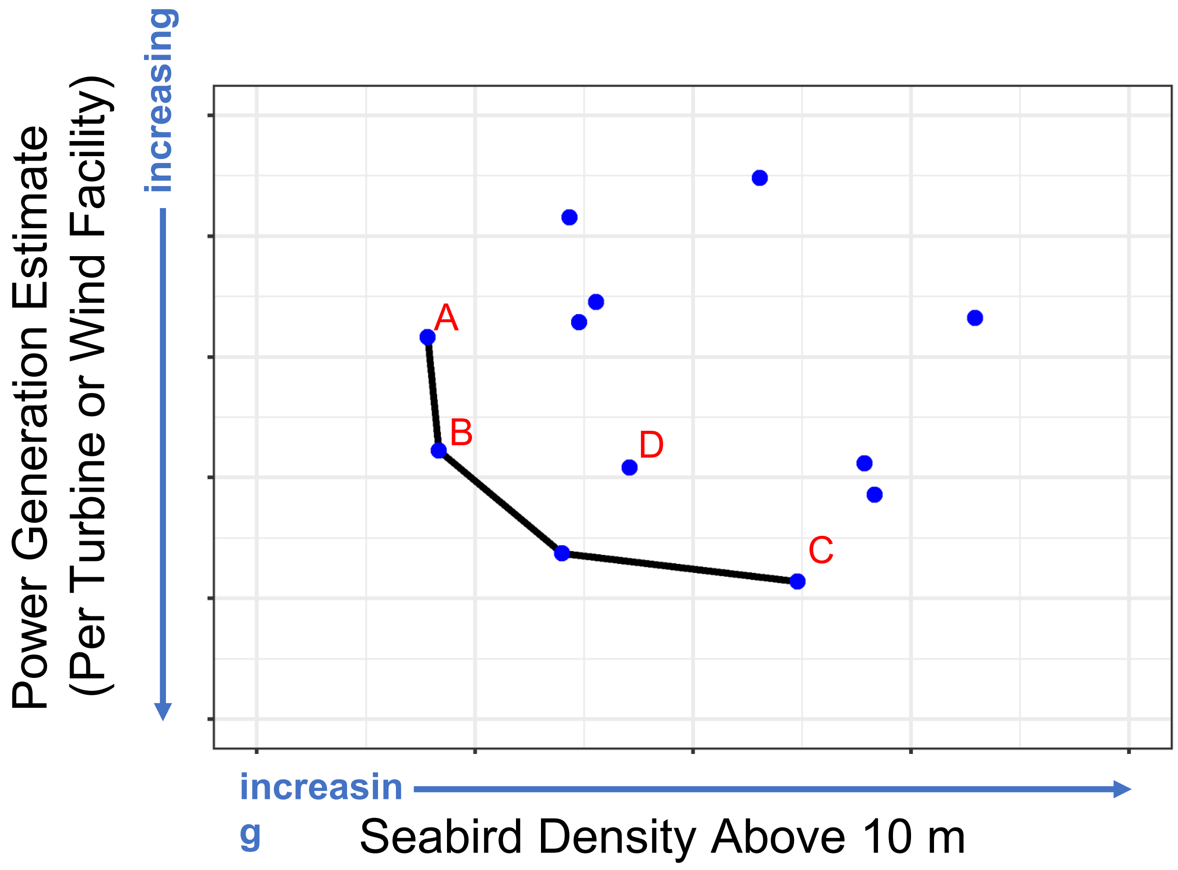
- Commonly used for multi-objective decision making
- Enables comparison of marginal benefit between alternatives
- Does not require assigning weights to each objective

Pareto Analysis Framing

- Typical to maximize or minimize both objectives
- The metrics used are (i) inverse annual energy generation and (ii) seabird density above 10 m

Conceptual Example of Pareto Analysis

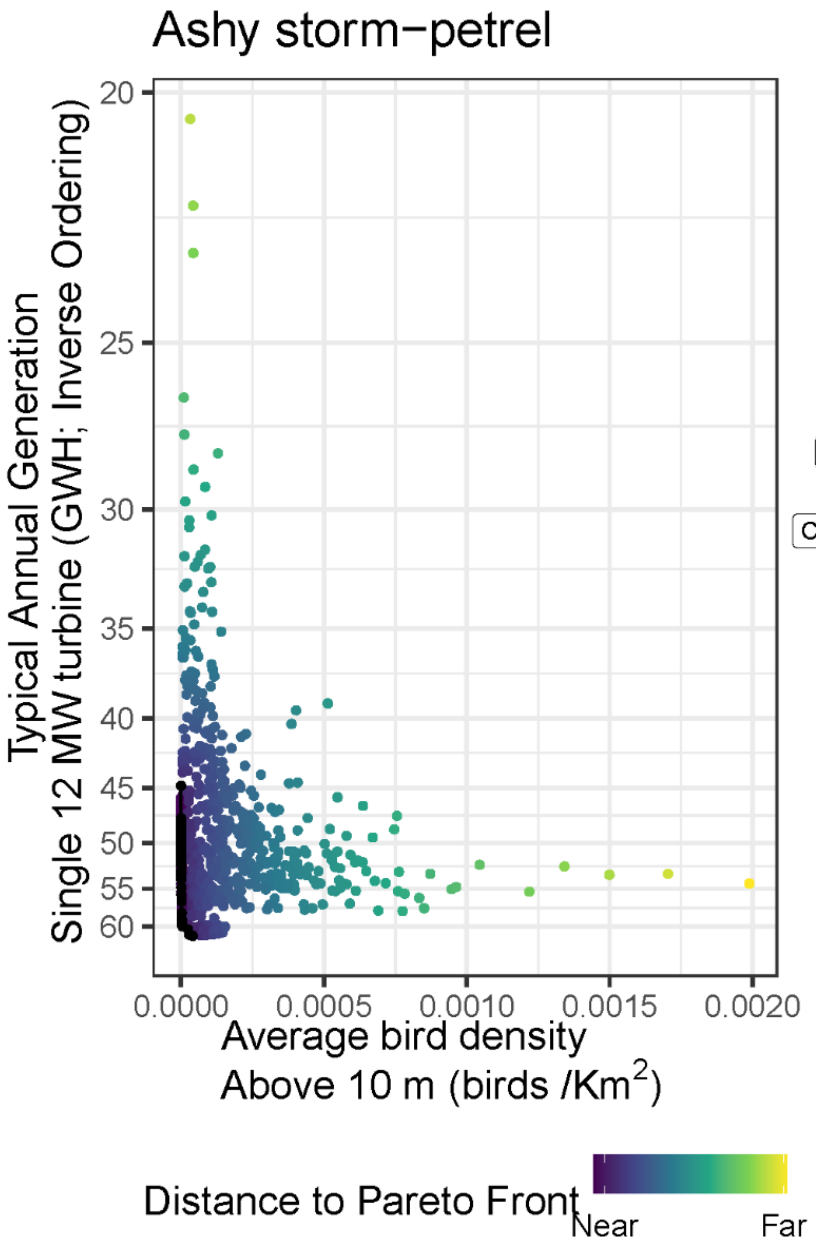
- Pareto Efficient alternatives shown with a black line – the Pareto front
- Alternatives to the left have lowest seabird vulnerability
- Alternatives to the bottom have the highest wind energy generation

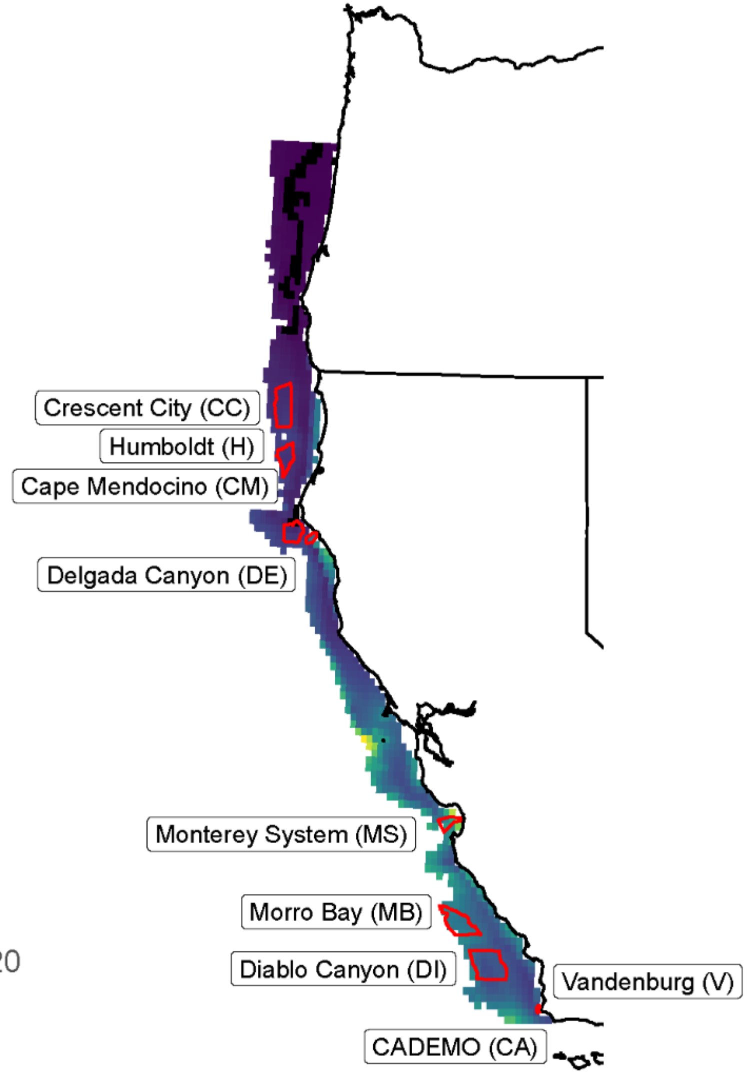


Pareto Curve Results
Low Flier

- Each point represents a grid cell with a single 12 MW turbine
- Dark (purple) areas on the map indicate alternatives near to the Pareto front
- Lighter (yellow) areas indicate alternatives far from the Pareto front

- Low propensity to fly above 10 m leads to near-zero estimates of bird density
- Greatest density above 10 m is equivalent to 1 bird per 500 km²

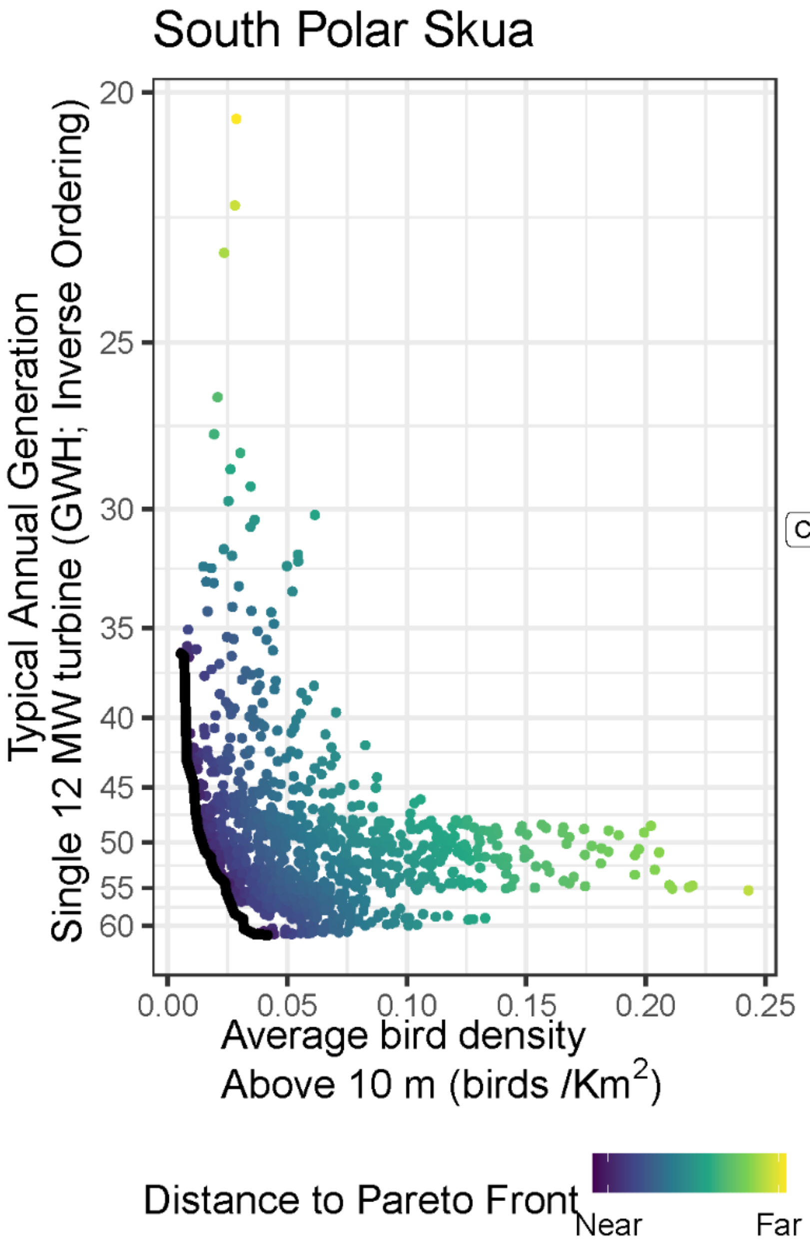


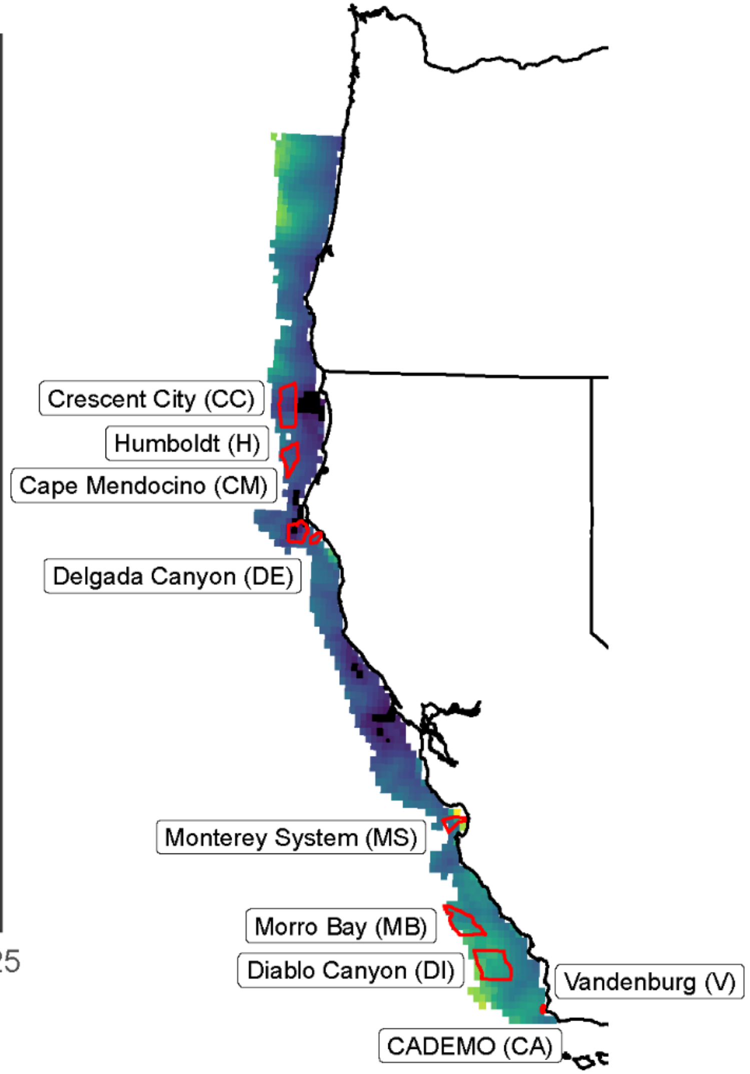


Pareto Curve Results
High Flier

- This species is relatively uncommon leading to low bird densities above 10 m
- Greatest density above 10 m is equivalent to 1 bird in 4 km^2

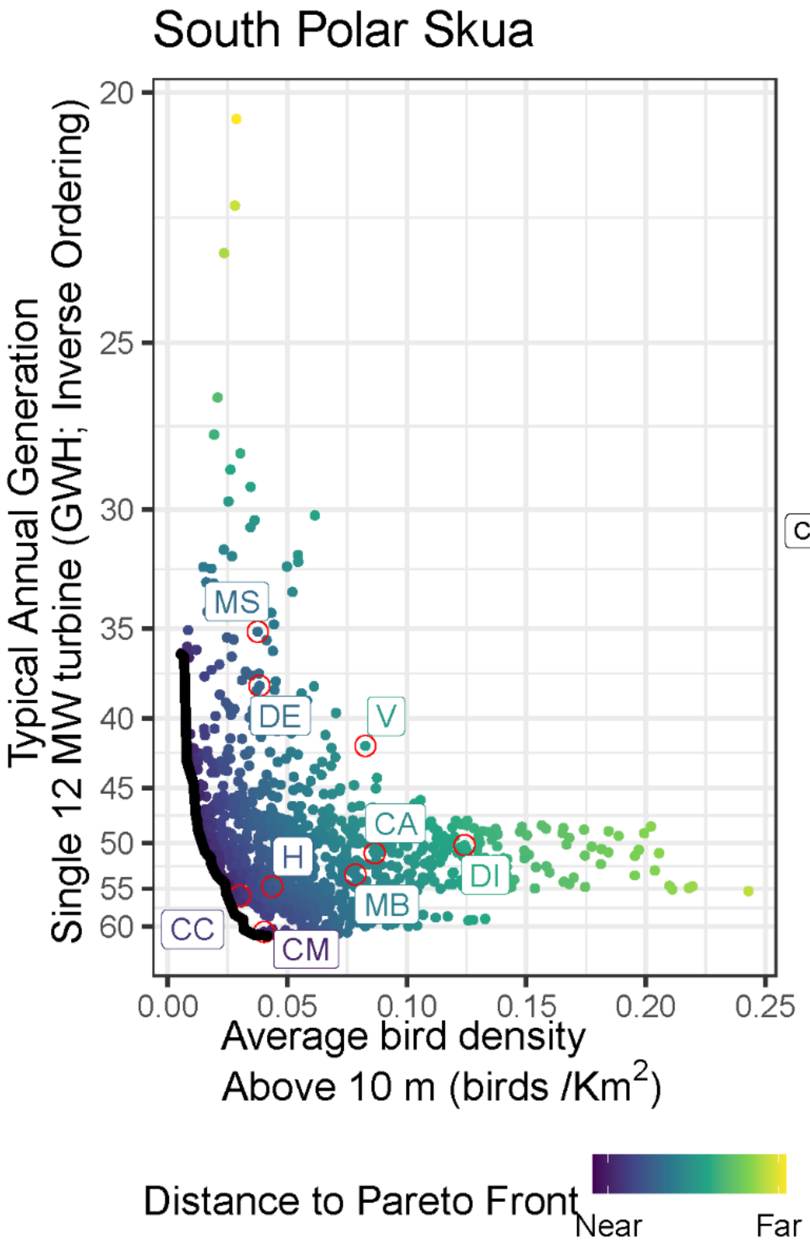
- Each point represents a grid cell with a single 12 MW turbine
- Areas which fall on the Pareto front are shown in black
- Alternative can be near to the Pareto front due to high generation or low bird densities

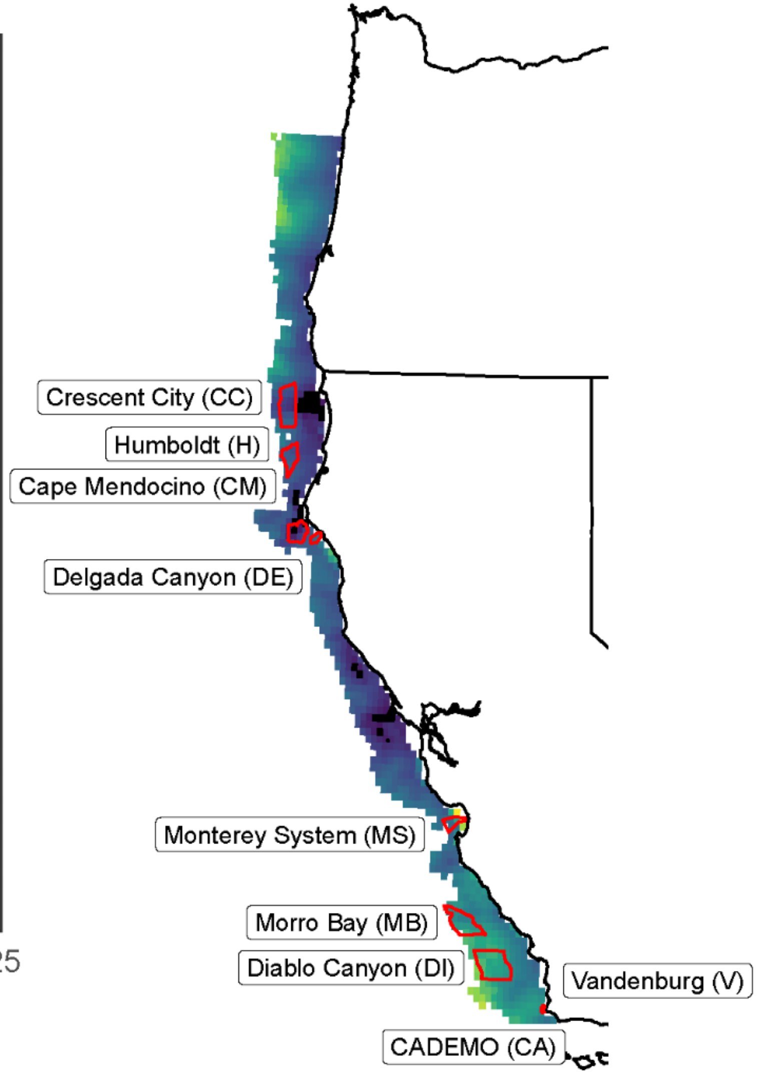




Pareto Curve Results High Flier

- Highlighting center of each wind area and seabird hotspot



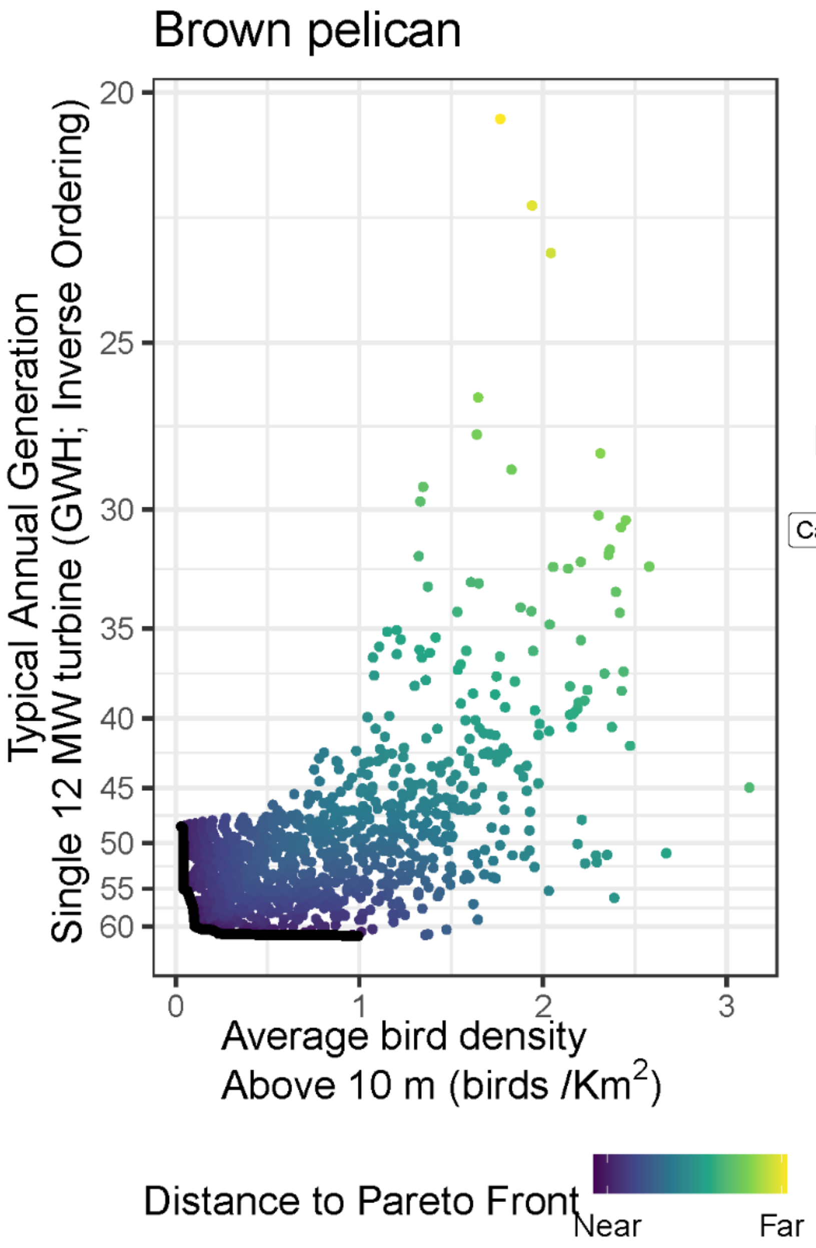


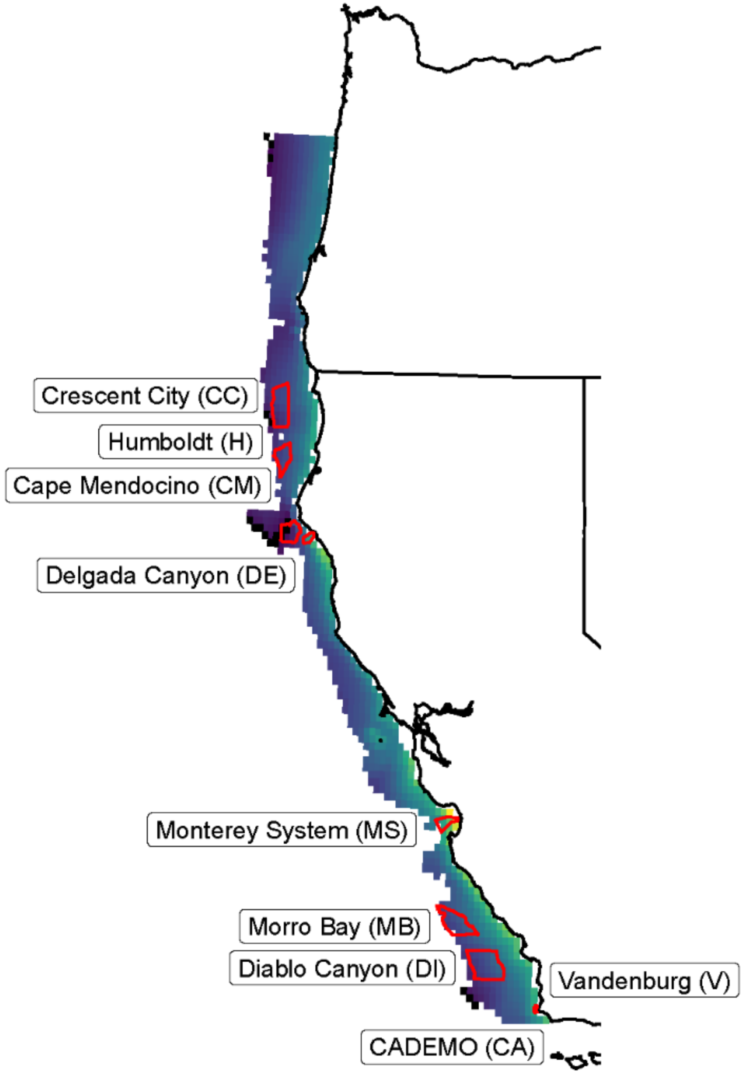
- Each point represents a grid cell with a single 12 MW turbine
- Areas which fall on the Pareto front are shown in black
- Alternative can be near to the Pareto front due to high generation or low bird densities

Pareto Curve Results Nearshore Species

- Density maximized nearshore, which is inversely related to wind generation due to stronger winds offshore
- Greatest density above 10 m is equivalent to 3 birds per km^2

- Each point represents a grid cell with a single 12 MW turbine
- Areas which fall on the Pareto front are shown in black
- Alternative can be near to the Pareto front due to high generation or low bird densities

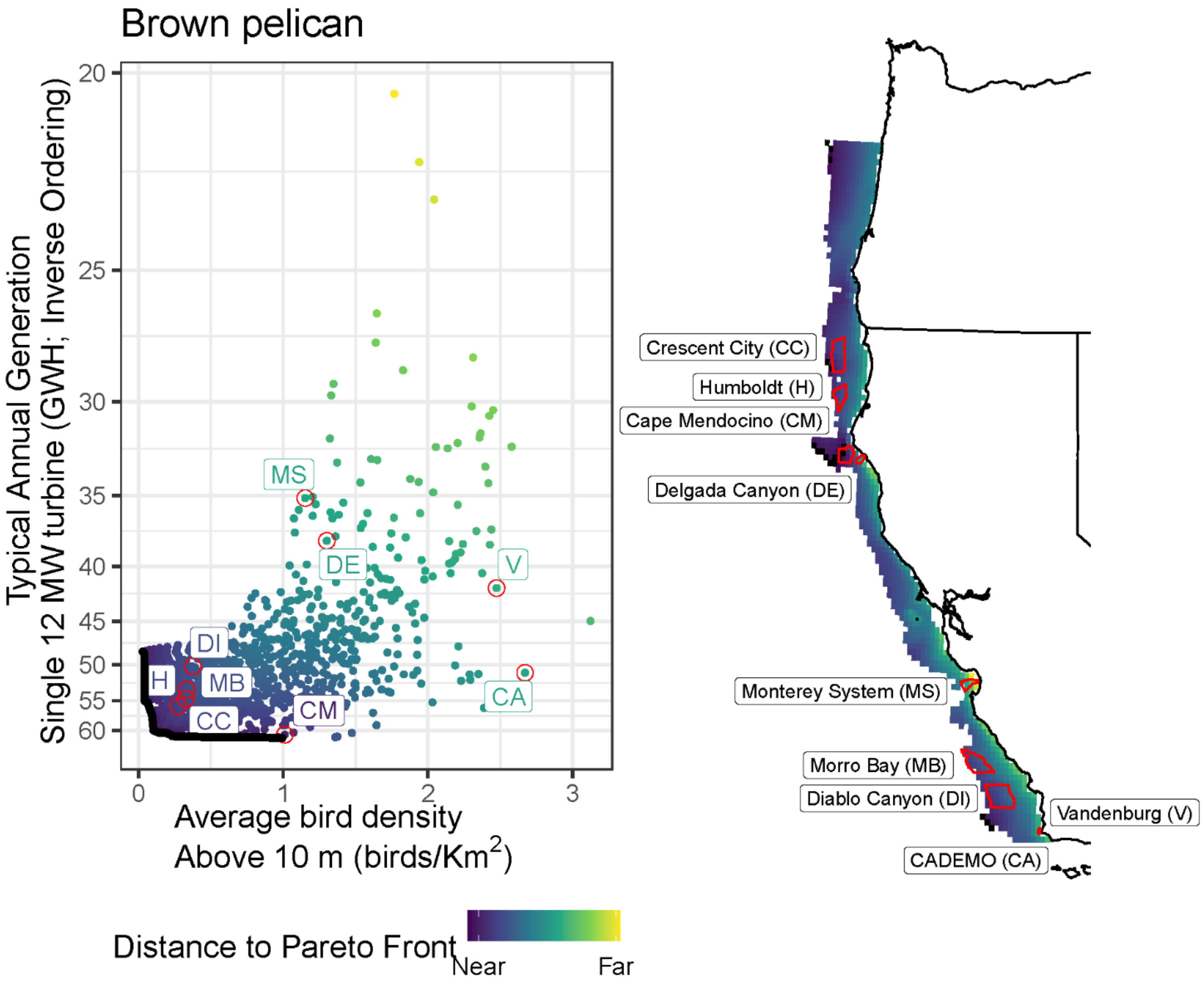




Pareto Curve Results Nearshore Species

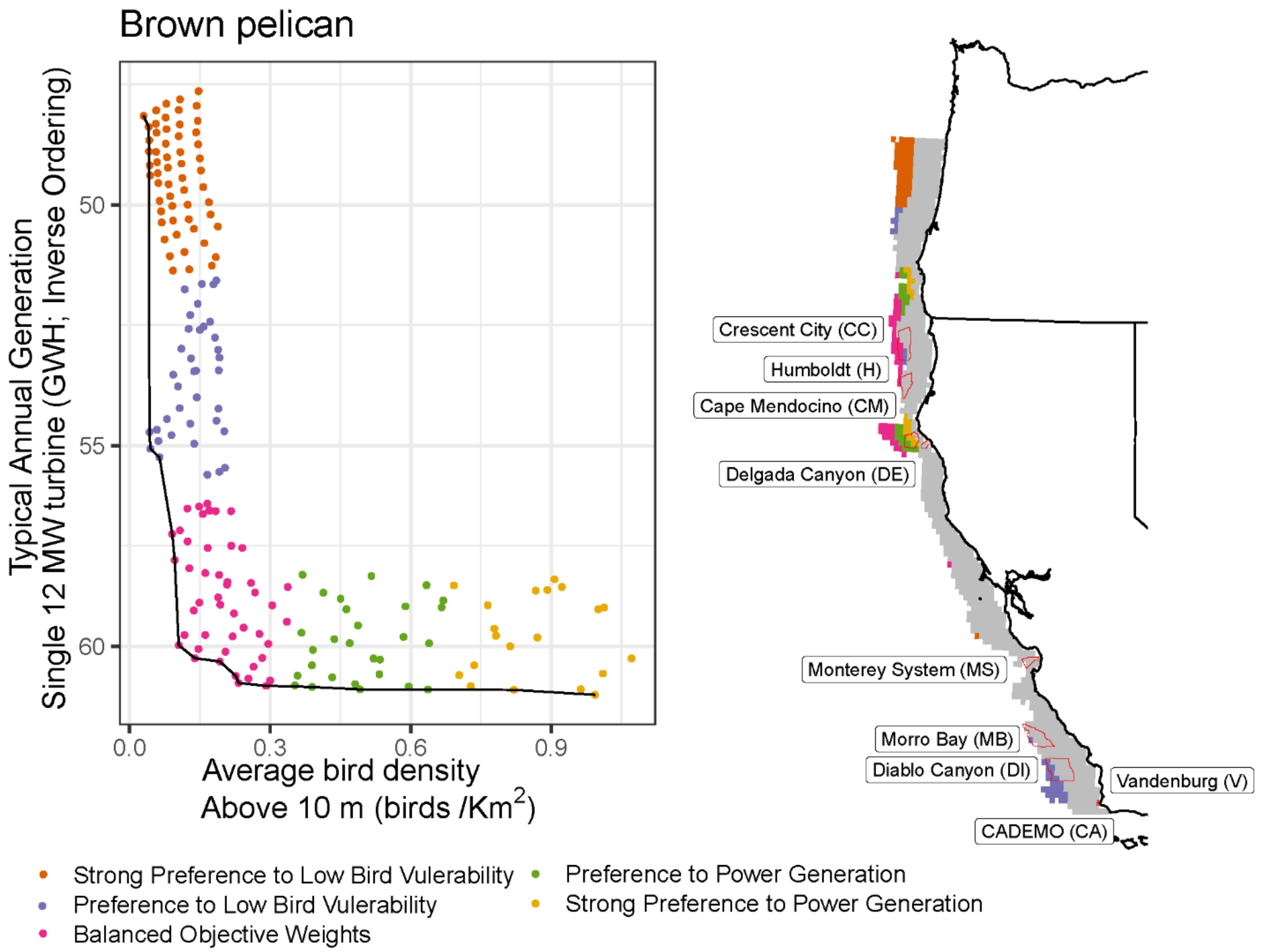
- Highlighting center of each wind area and seabird hotspot

- Each point represents a grid cell with a single 12 MW turbine
- Areas which fall on the Pareto front are shown in black
- Alternative can be near to the Pareto front due to high generation or low bird densities



Pareto Curve Results Nearshore Species

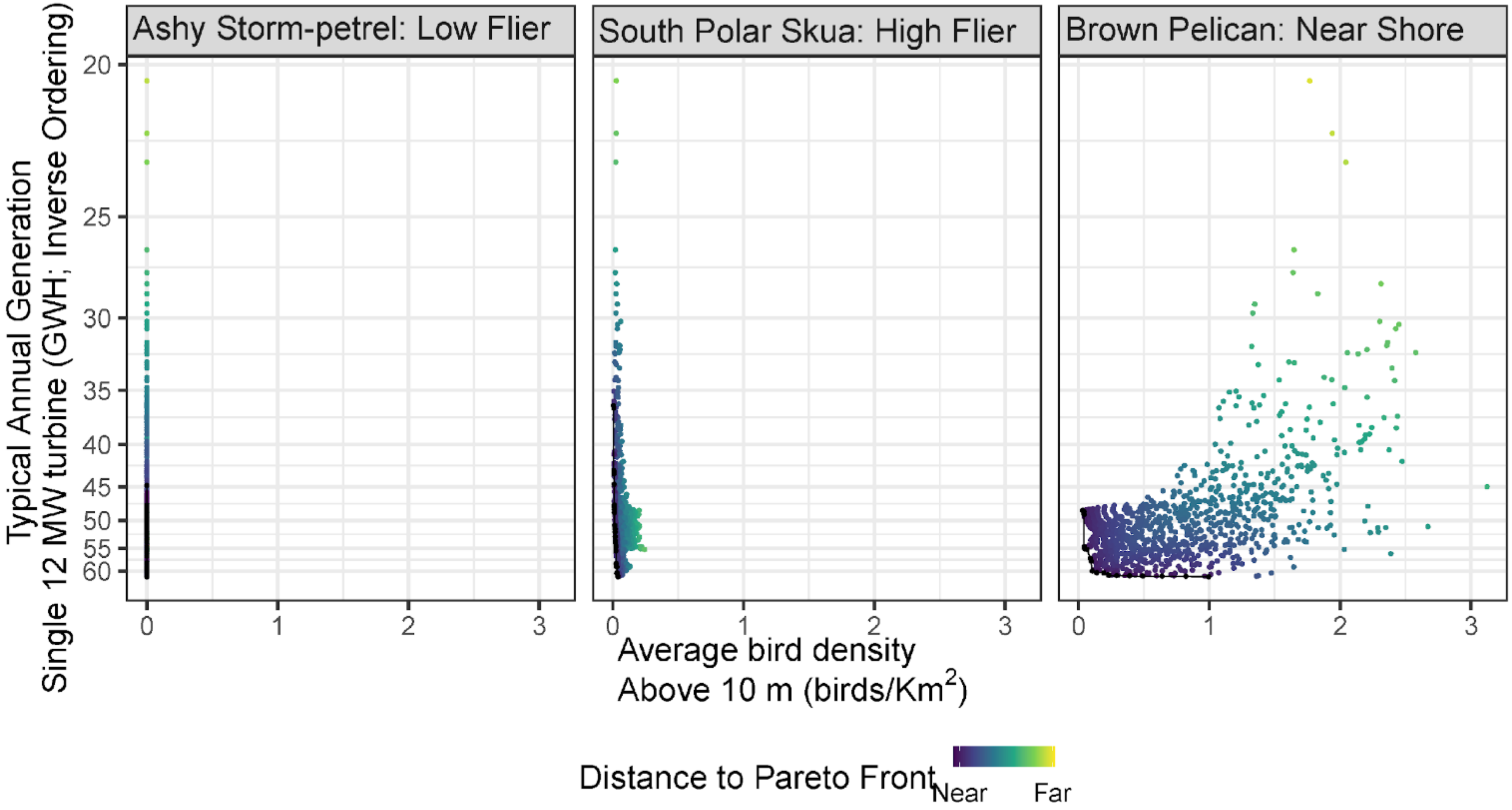
- Zoom in on the 25% of alternatives nearest Pareto front
- Grouped and colored to show which metric is favored



Pareto Analysis – Zoom Out

The same graphics but at a fixed scale to show relative bird densities

Brown Pelicans above 10 m denser than both Ashy Storm Petrel and South Polar Skua



Pareto Analysis – Next Steps

- Complete analysis for all 45 seabird species
- Carry out Pareto analysis of seabirds in aggregate (sum)
- Carry out Pareto analysis of special status seabirds

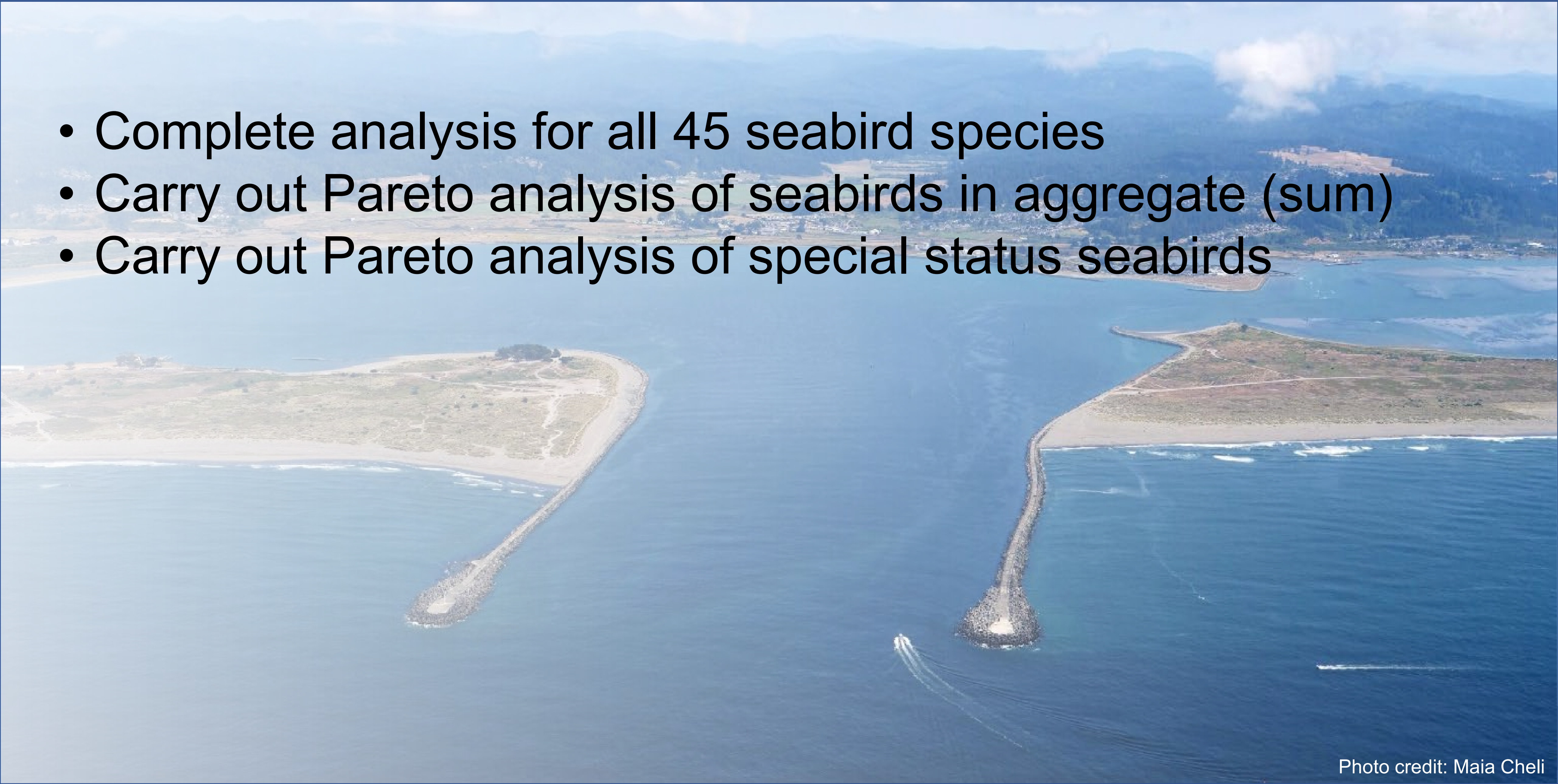


Photo credit: Maia Cheli

Data Gaps and Future Research Priorities

Data Gaps

Modeling challenges

- The Monterey Submarine Canyon in Monterey Bay proved challenging
  - Interesting mix of nearshore and offshore characteristics
- Ongoing and future changes to marine environment or species abundance are not explicitly included
- Migratory movements are not necessarily represented by at-sea survey transect data

Historical at-sea seabird observations limited by capacity of human observers

- Restricted to periods of relatively suitable weather
- Restricted to times with adequate light (i.e., daytime)
- Limited duration (i.e., snapshots in time)
- Challenging to detect and estimate flight height as bird height above sea level increases

This study does not estimate collision rates for future wind facilities

- Potential exposure and vulnerability intended to inform tradeoffs in large-scale siting decisions

Future Research Priorities

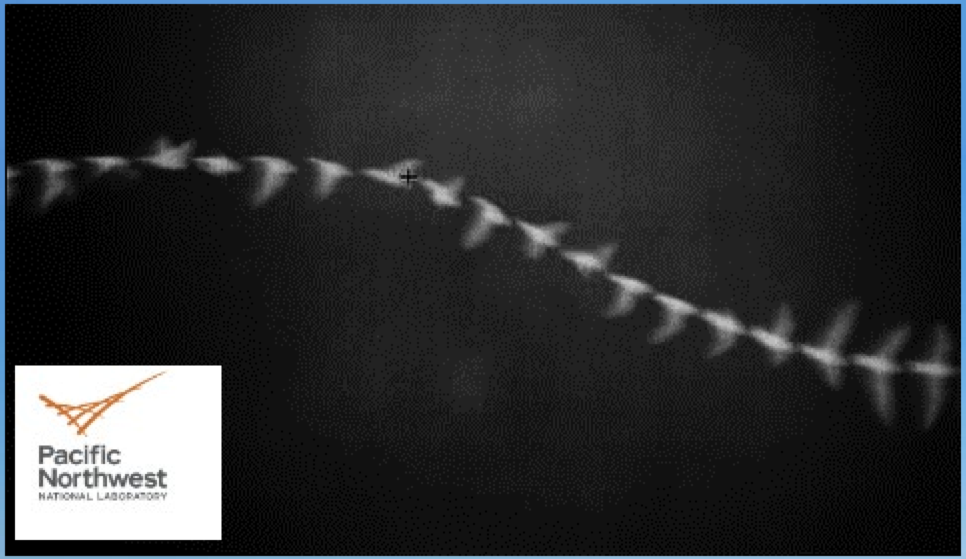


FIGURE 3. Orientation of the TT3D and its field of view (FOV) alongside a generic 230-m diameter offshore wind turbine

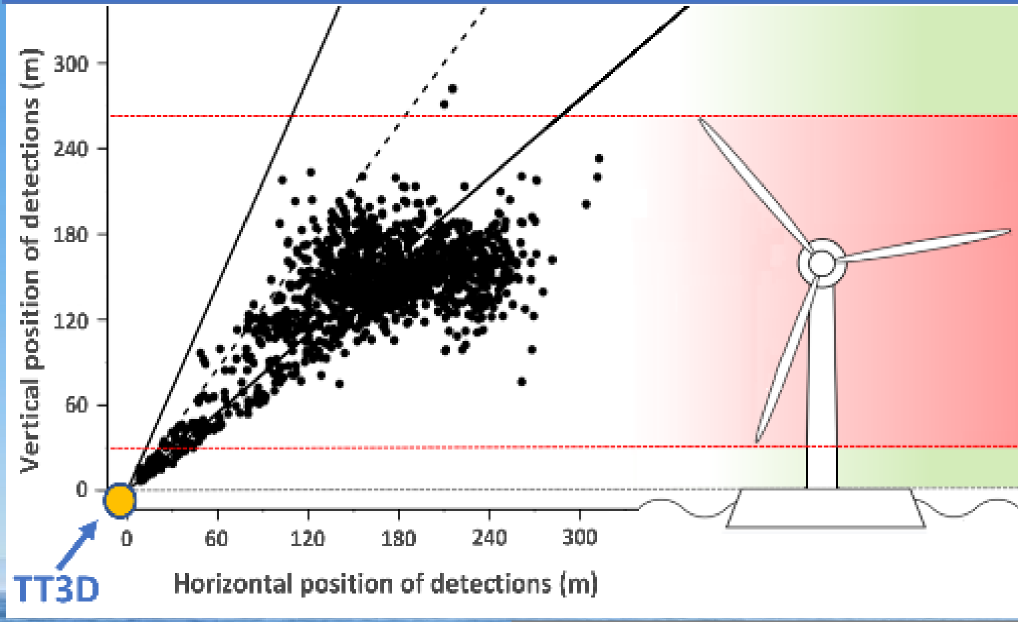
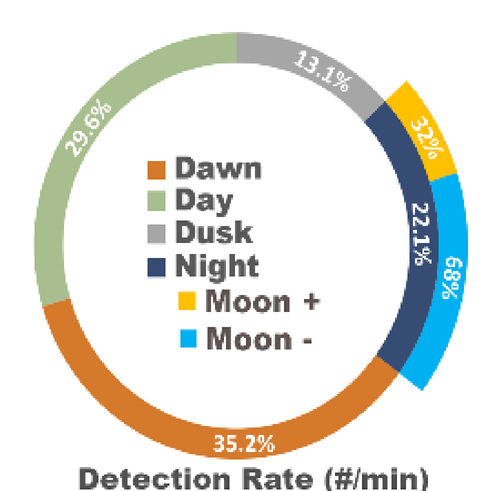


FIGURE 6. Detection rates for various ambient light conditions



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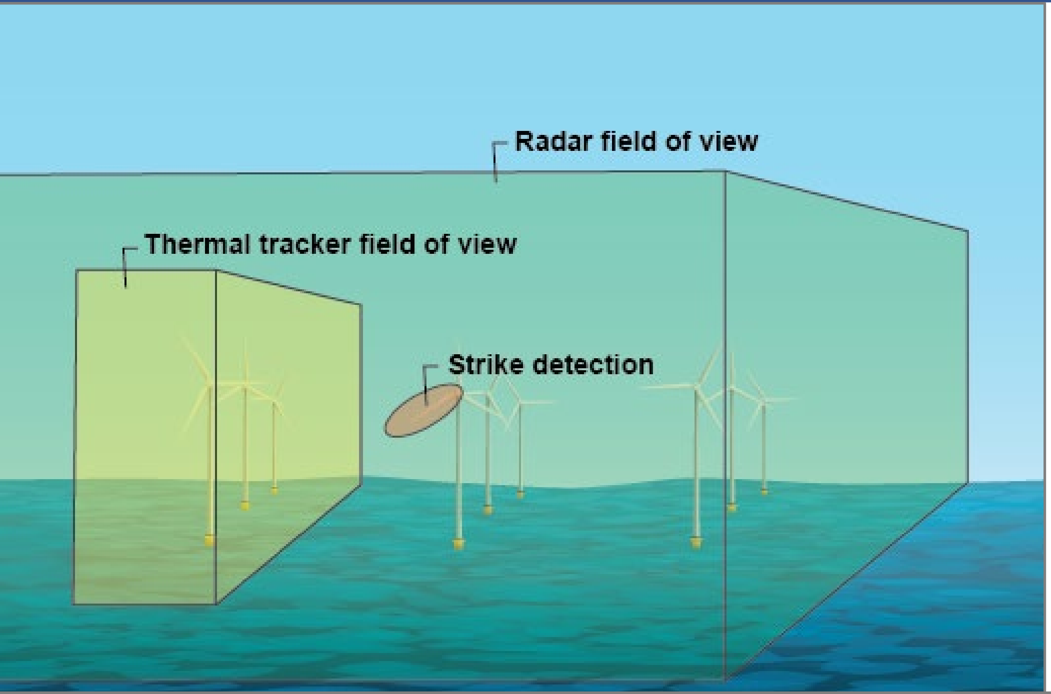
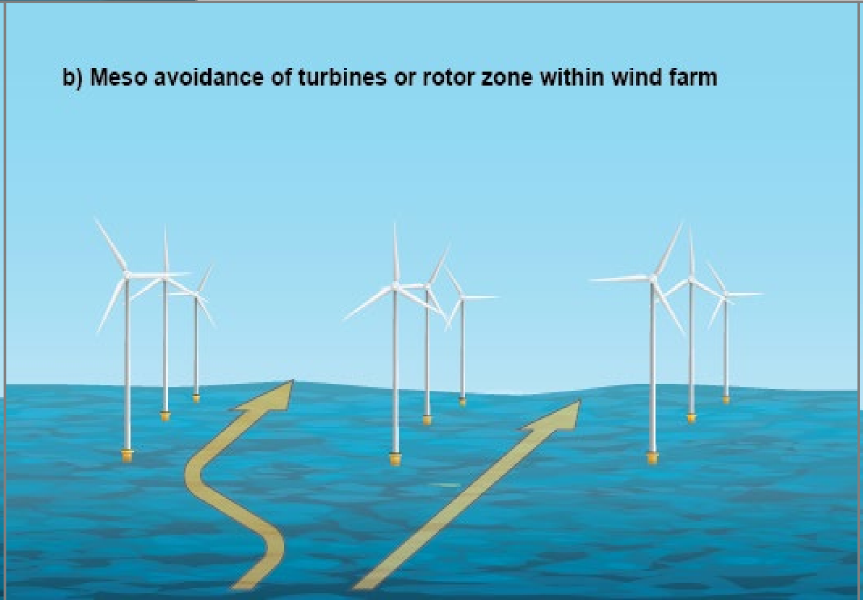
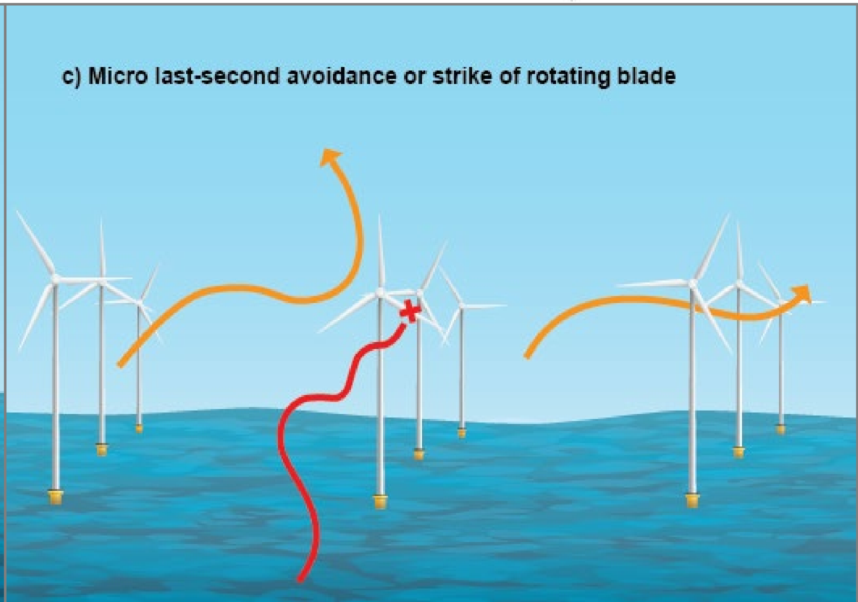
Future Research Priorities



Integrated, Real-Time, Multi-Scale System for Monitoring Seabird Interactions with Floating Offshore Wind Technologies

- Develop and test technology capable of gathering data needed to generate collision risk models





Key Takeaways for Today’s Meeting

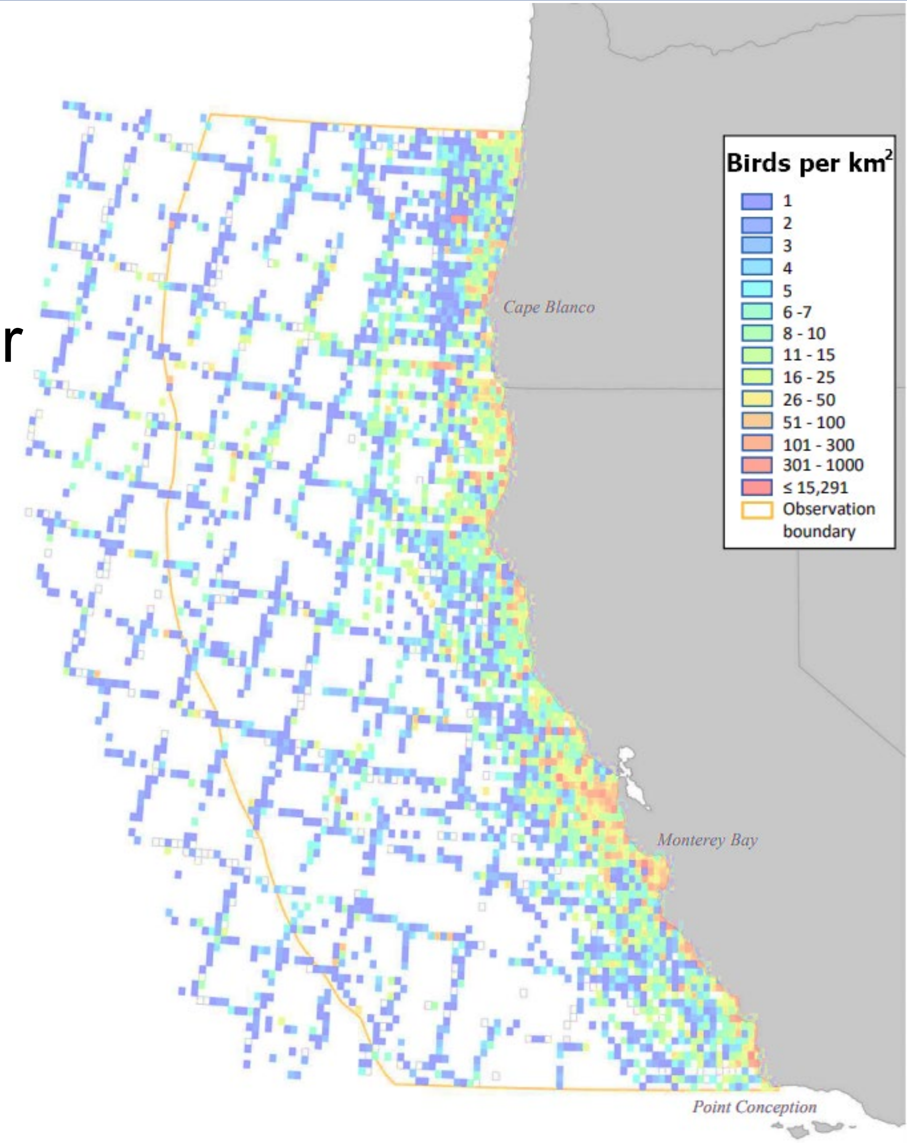
Key Takeaways

Seabirds and Offshore Wind

- Seabird community differs in nearshore versus offshore waters
- Only some seabird species fly high enough to enter the rotor swept zone of wind turbines
- Number of birds considered vulnerable to collision is much greater than the expected collision rates

Analysis of Tradeoffs

- Areas off Cape Mendocino and Crescent City are especially attractive for power generation (without considering seabird vulnerability)
- Once analysis for the full suite of birds is final, assessment of tradeoffs will be useful for large-scale planning



Panelists Discussion

Garry George, Director of the Clean Energy Initiative for the National Audubon Society

David M. Pereksta, Avian Biologist at the Bureau of Ocean Energy Management

Question and Answer

If you're interested in receiving updates on our newly released reports and upcoming events, please email us at windstudies@schatzcenter.org