



BOEM

Bureau of Ocean Energy Management

An Overview of Floating Offshore Wind and the Use of Spatial Data
on the West Coast

Frank Pendleton

Biologist / GIS Coordinator

West Coast Renewable Energy Science Exchange

November 13, 2019

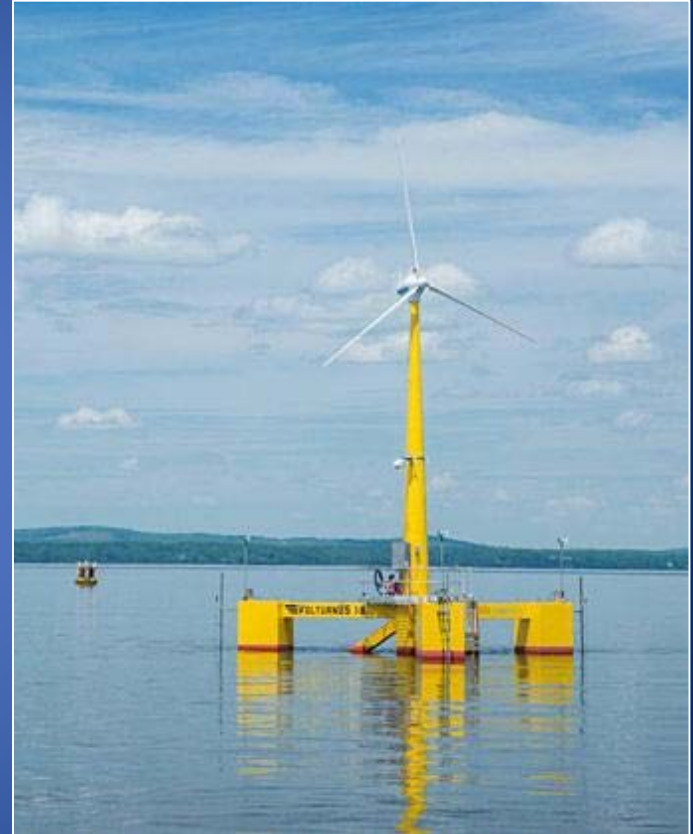
What We Will Cover

1 Why Offshore Wind (OSW)

2 State of Floating OSW Technology

3 California Case Study

4 Review a Few Datasets



VoltturnUS University of Maine

American Society of Mechanical Engineers

<https://www.asme.org/engineering-topics/articles/energy/developing-verifying-deepwater-offshore-wind>

California Climate Policy

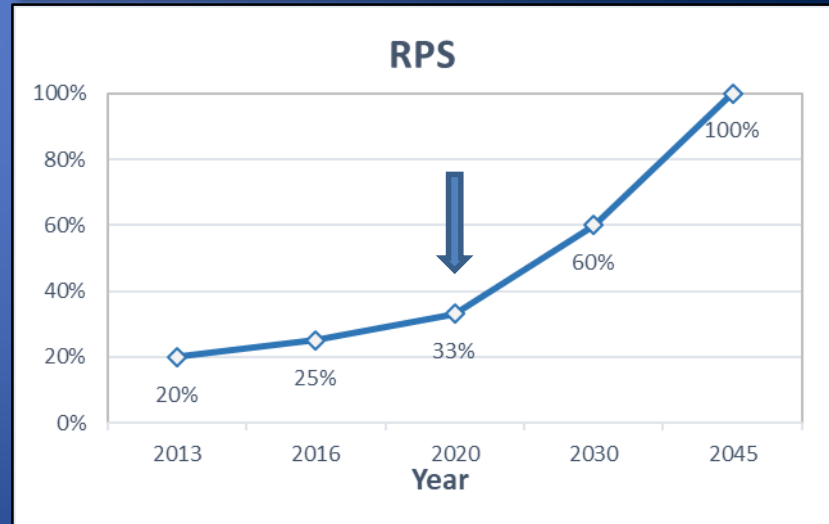
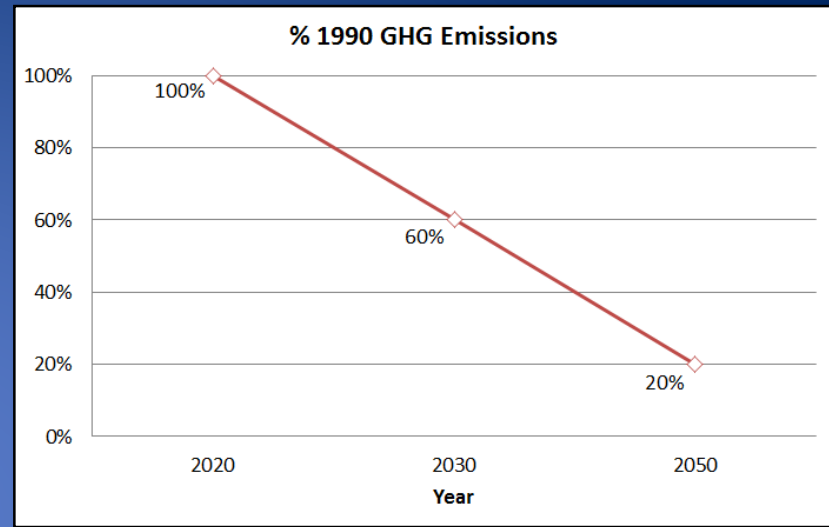
- Greenhouse Gas Legislation
- Renewable Portfolio Standards (RPS)
- 100% Carbon-Free Electricity by 2045



California Climate Policy

Greenhouse Gas Legislation

Renewable Portfolio Standard

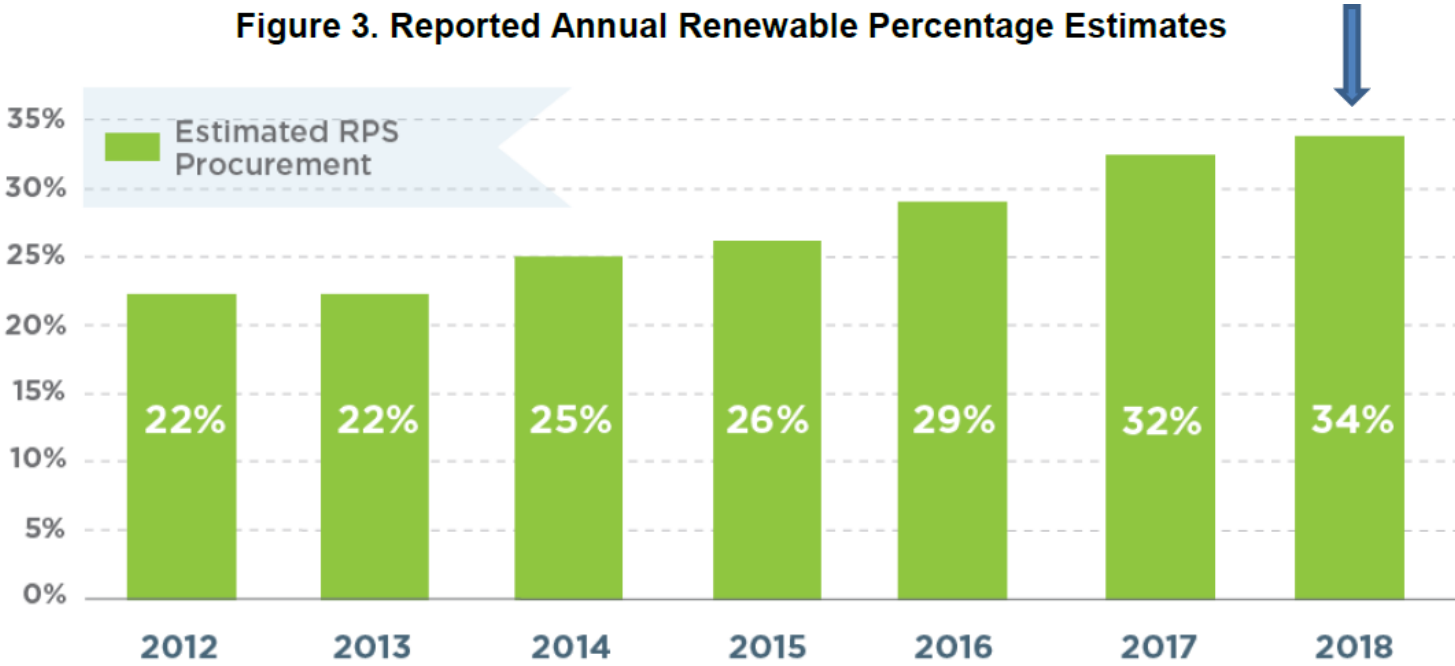


California Tracking



California Energy Commission – Tracking Progress

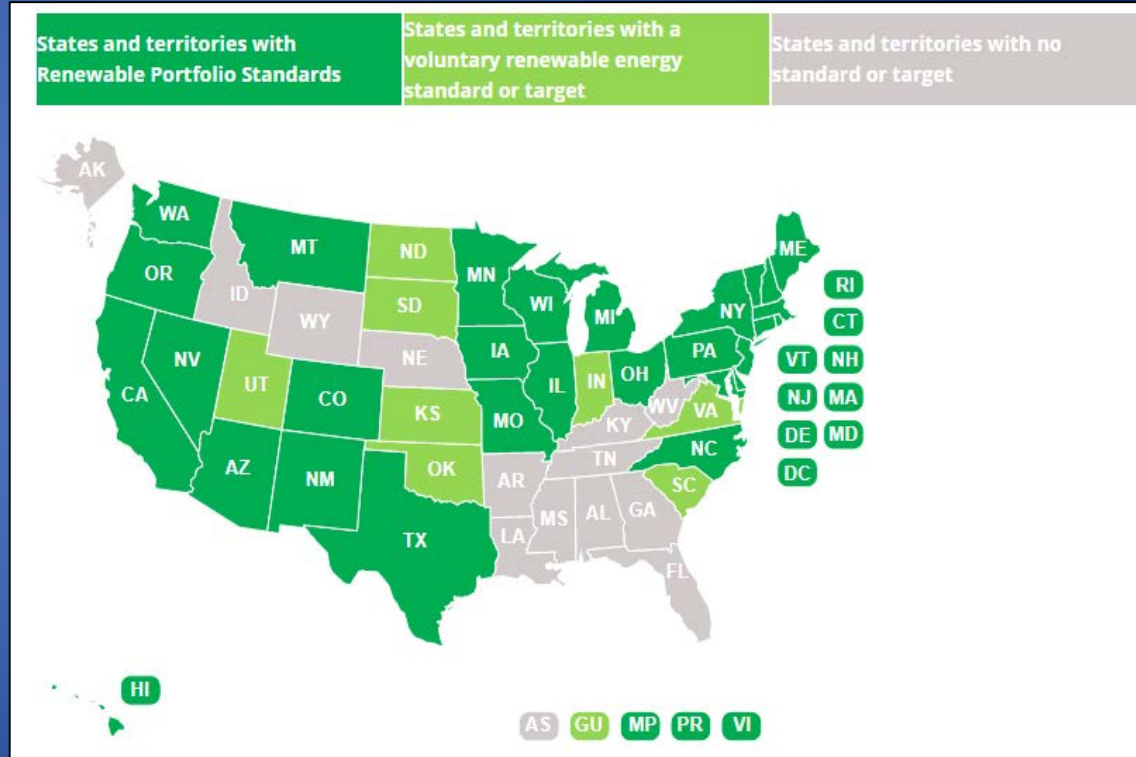
Figure 3. Reported Annual Renewable Percentage Estimates



Source: California Energy Commission, staff analysis November 2018

Renewable Portfolio Standards (RPS)

- 29 States have a RPS.
- 21 states have Carve Outs



*National Conference of State Legislators
<http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx>

Why Include Wind?

Solar has limits

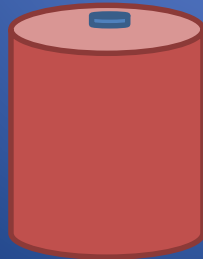
- Night



- Clouds



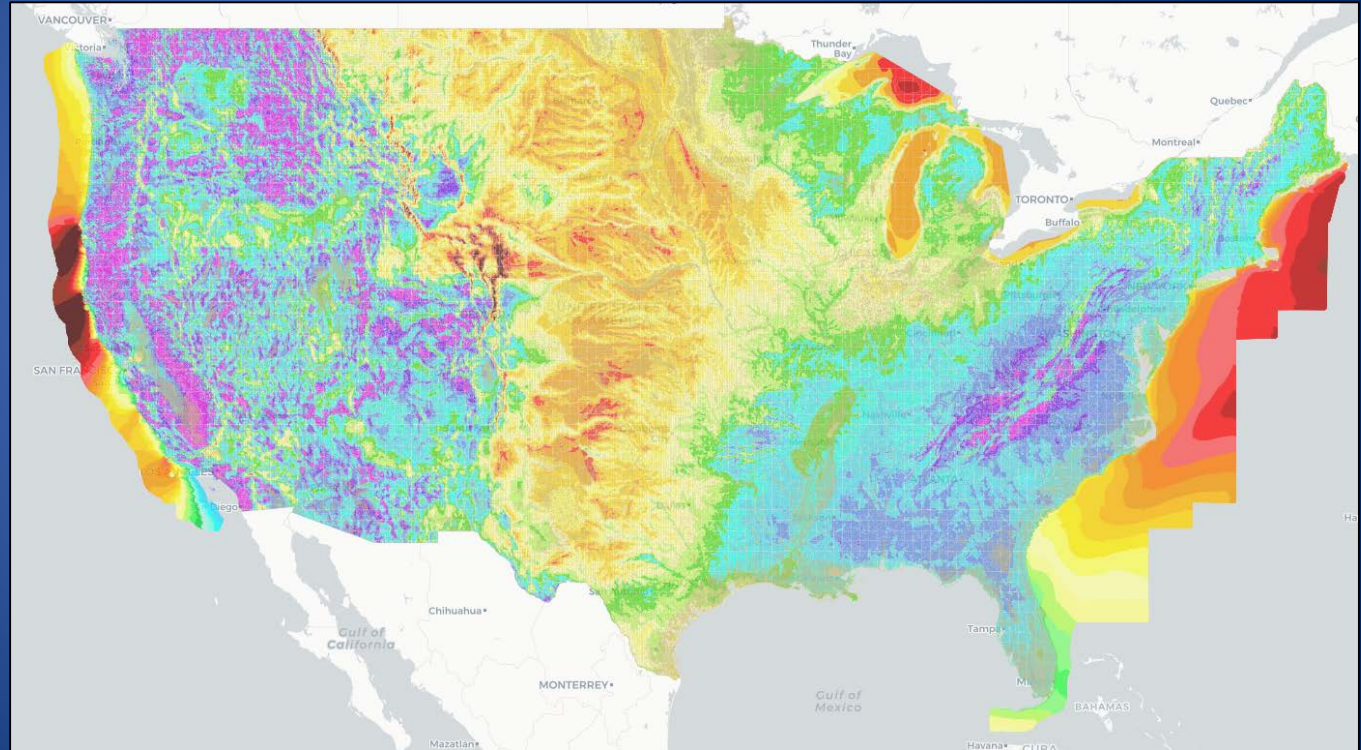
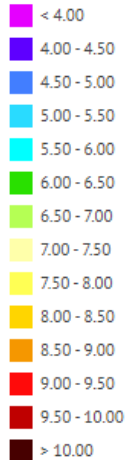
- Storage



Why Offshore Wind?

The Ocean is Windier!
More Consistent

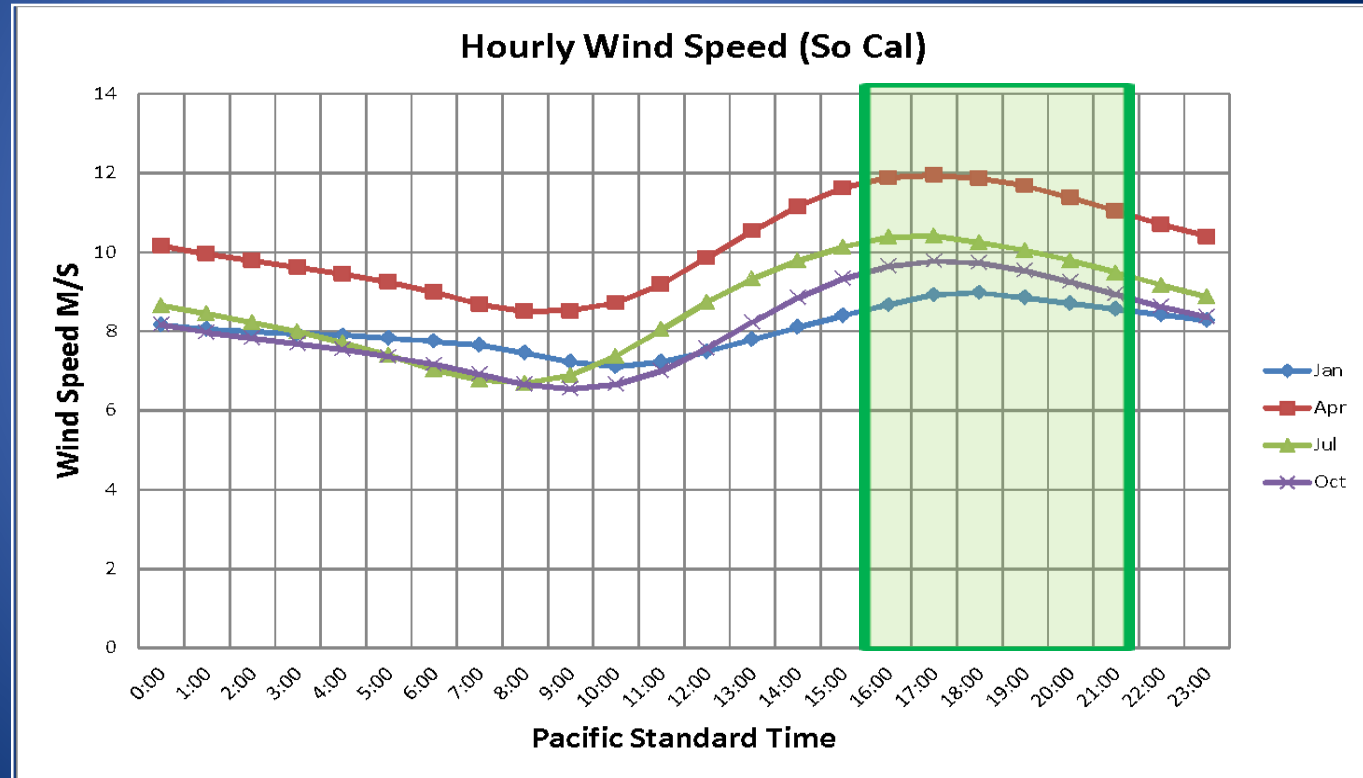
Wind Speed (m/s)



Why Offshore Wind?

The Ocean is Windy at the Right Time

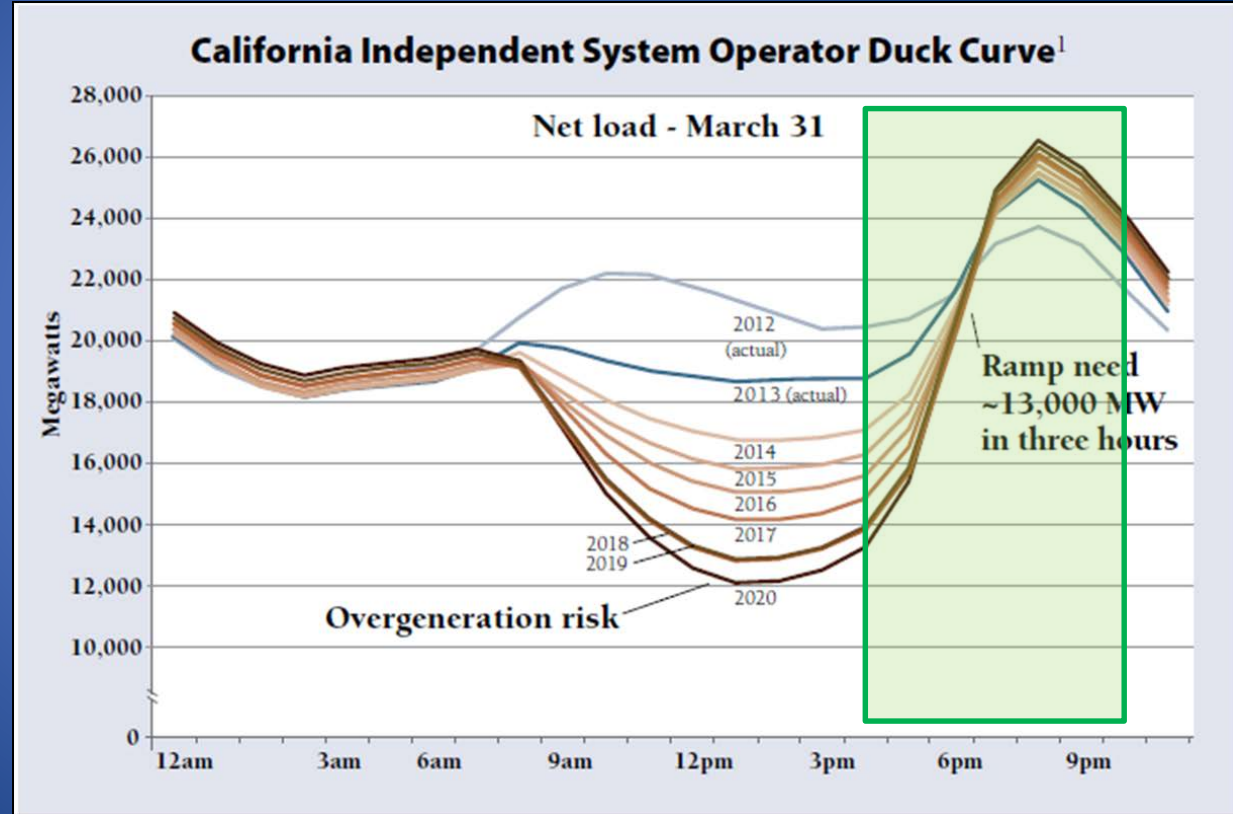
The Wind Picks Up as the Sun Goes Down



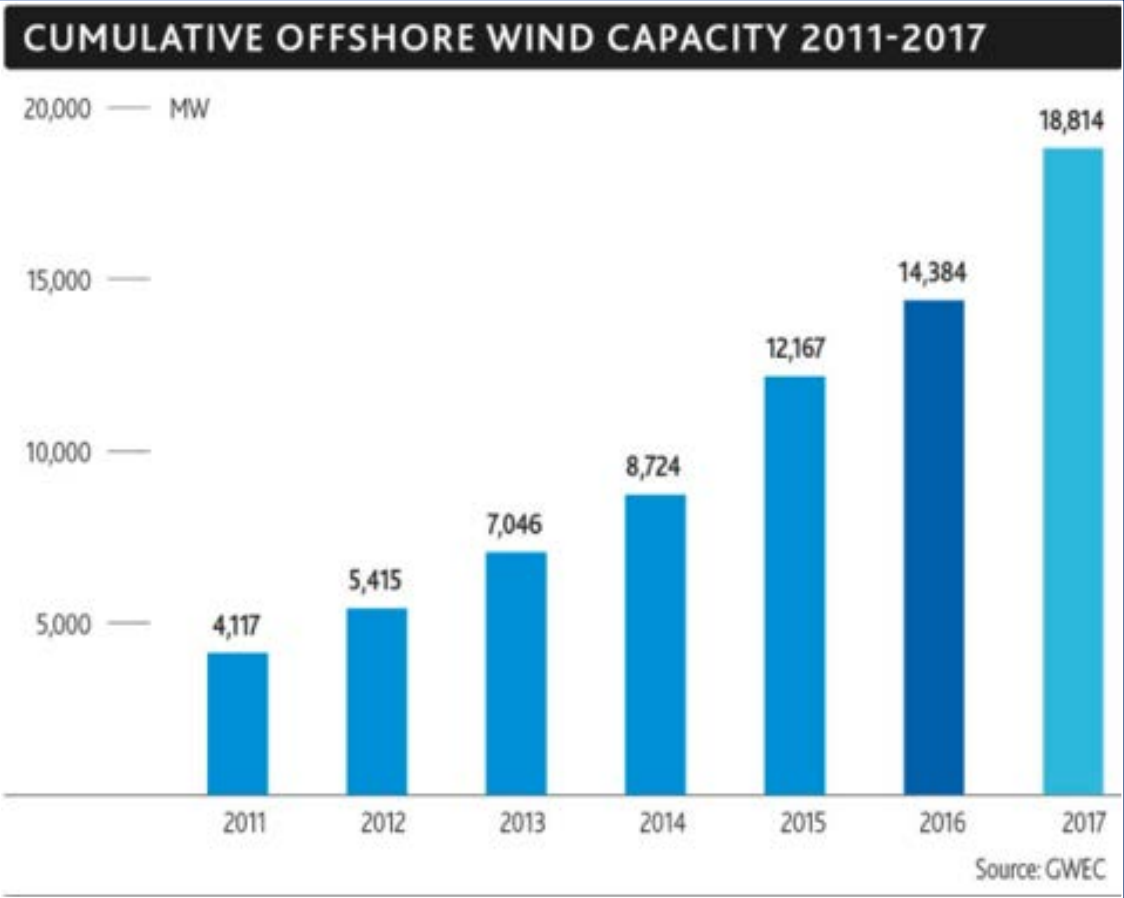
Windy at the Right Time

Duck Curve

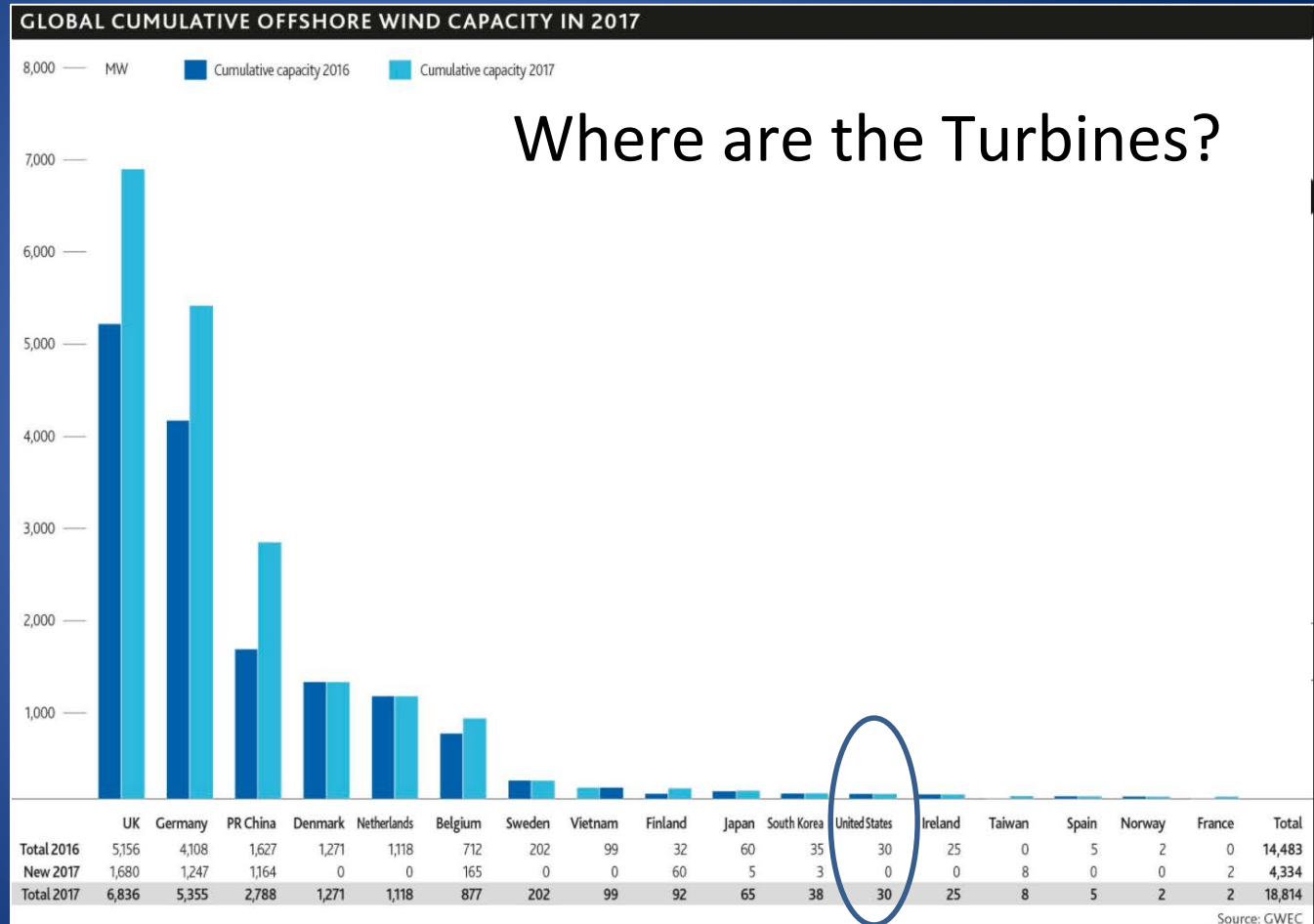
MW needed from
“non-solar” sources



How Many Megawatts World Wide?



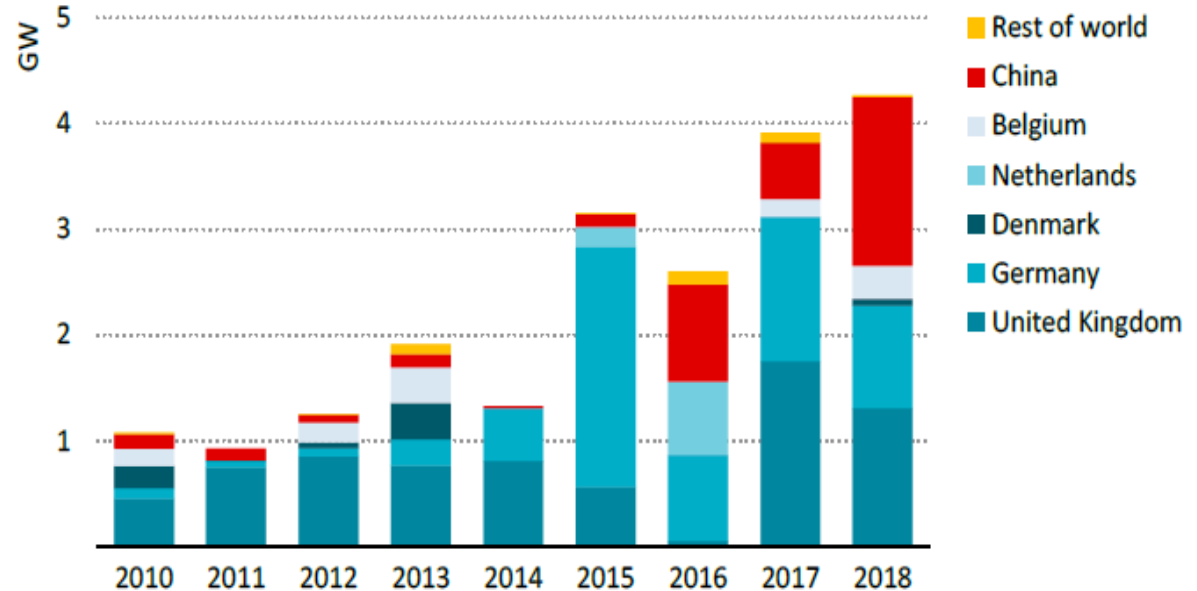
Megawatts by Country 2016-2017



Offshore Wind Outlook 2019

- Total OSW
 - 2010 = 3 GW
 - 2018 = 23 GW

Figure 1 ▶ Annual offshore wind capacity additions by region, 2010-2018



Deployment of offshore wind has increased by nearly 30% per year since 2010, second only to solar PV, as the technology and industry have matured

Offshore Wind Outlook 2019

- Good News
 - Price of OSW projected to decline 60% by 2040
- Challenges
 - Supply Chains
 - Support Vessels
 - Grid Infrastructure
 - Marine Planning

Offshore wind to become a \$1 trillion industry

25 October 2019



Europe is set to be the engine of growth for this flourishing renewable energy technology, followed closely by China and others
(Photograph: ABB)



COPENHAGEN - Offshore wind power will expand impressively over the next two decades, boosting efforts to decarbonise energy systems and reduce air pollution as it becomes a growing part of electricity supply, according to an International Energy Agency report published today.

Block Island Offshore Wind

- 1st Offshore Wind in US (2016)
- Rhode Island State Waters
- 5 Turbines
- 30 MW

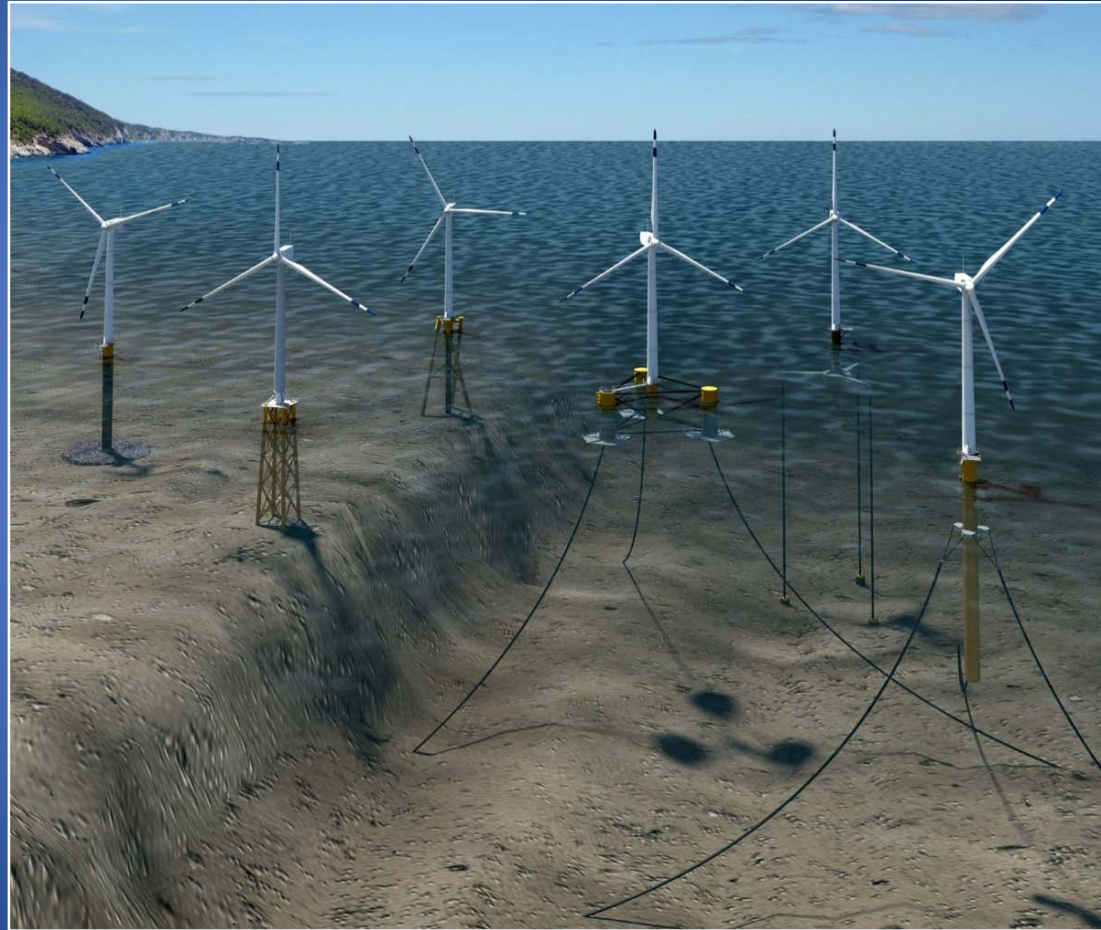
Deep Water Wind
<http://dwwind.com/project/block-island-wind-farm/>



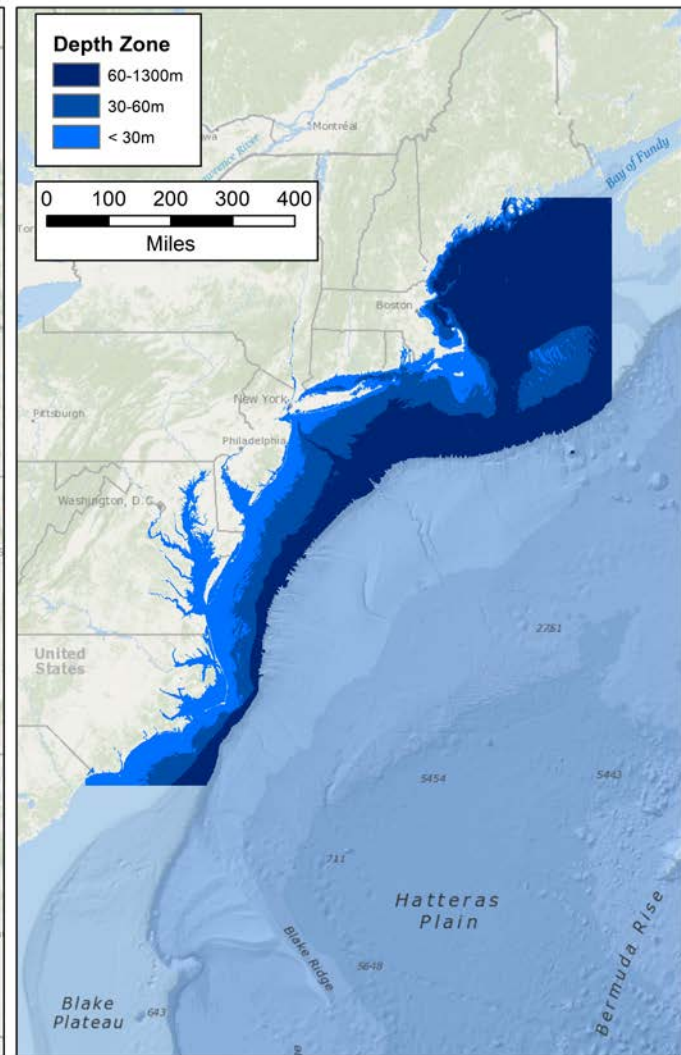
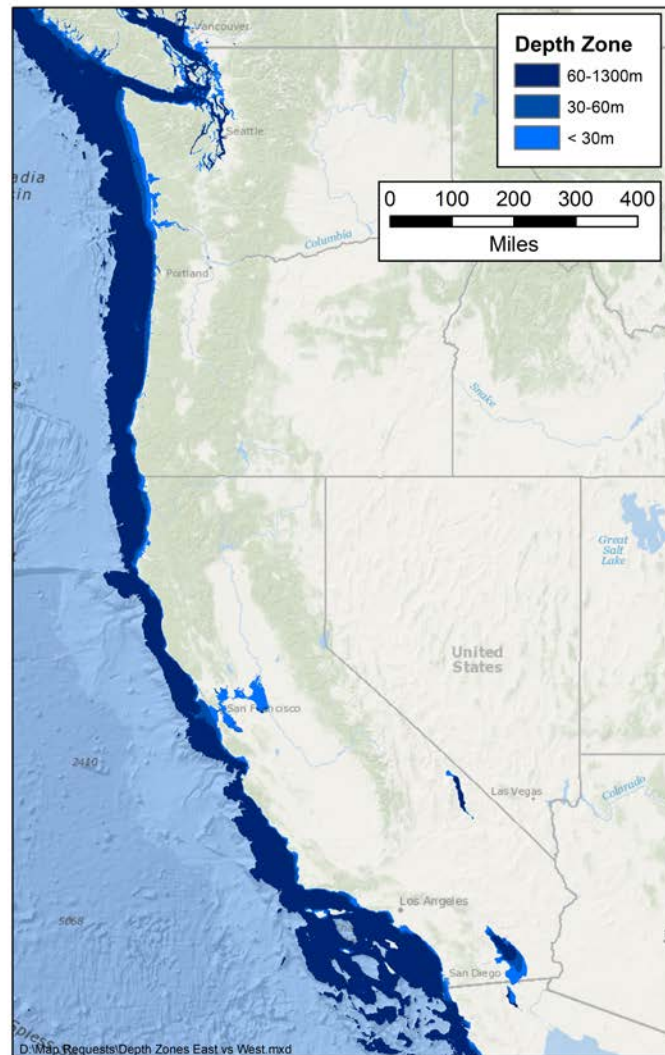
Block Island Offshore Wind



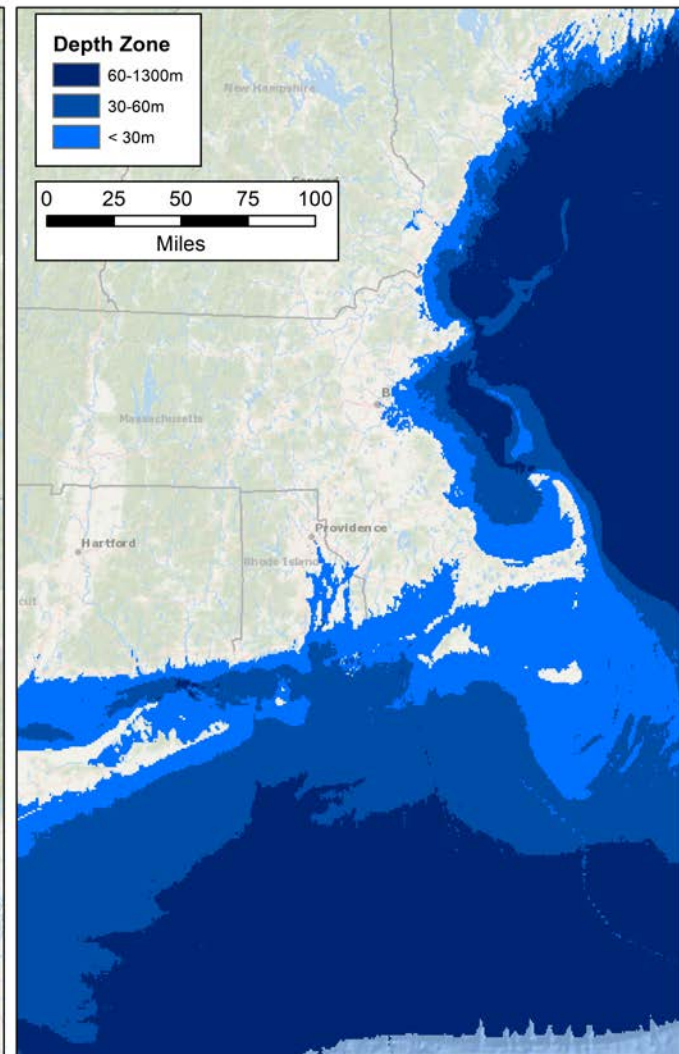
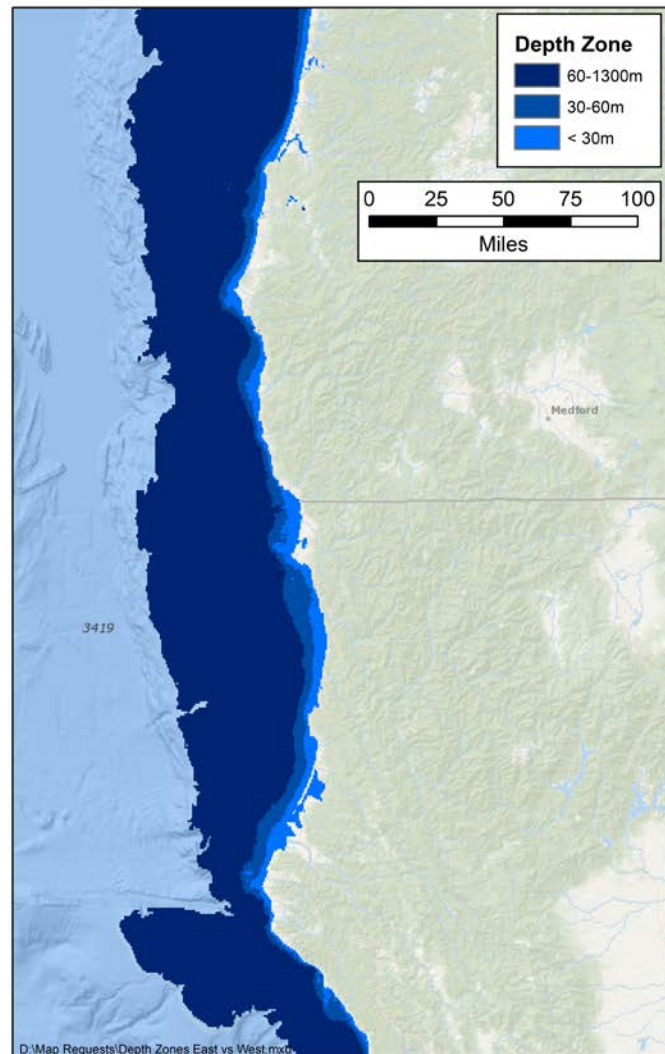
Offshore Wind Technologies



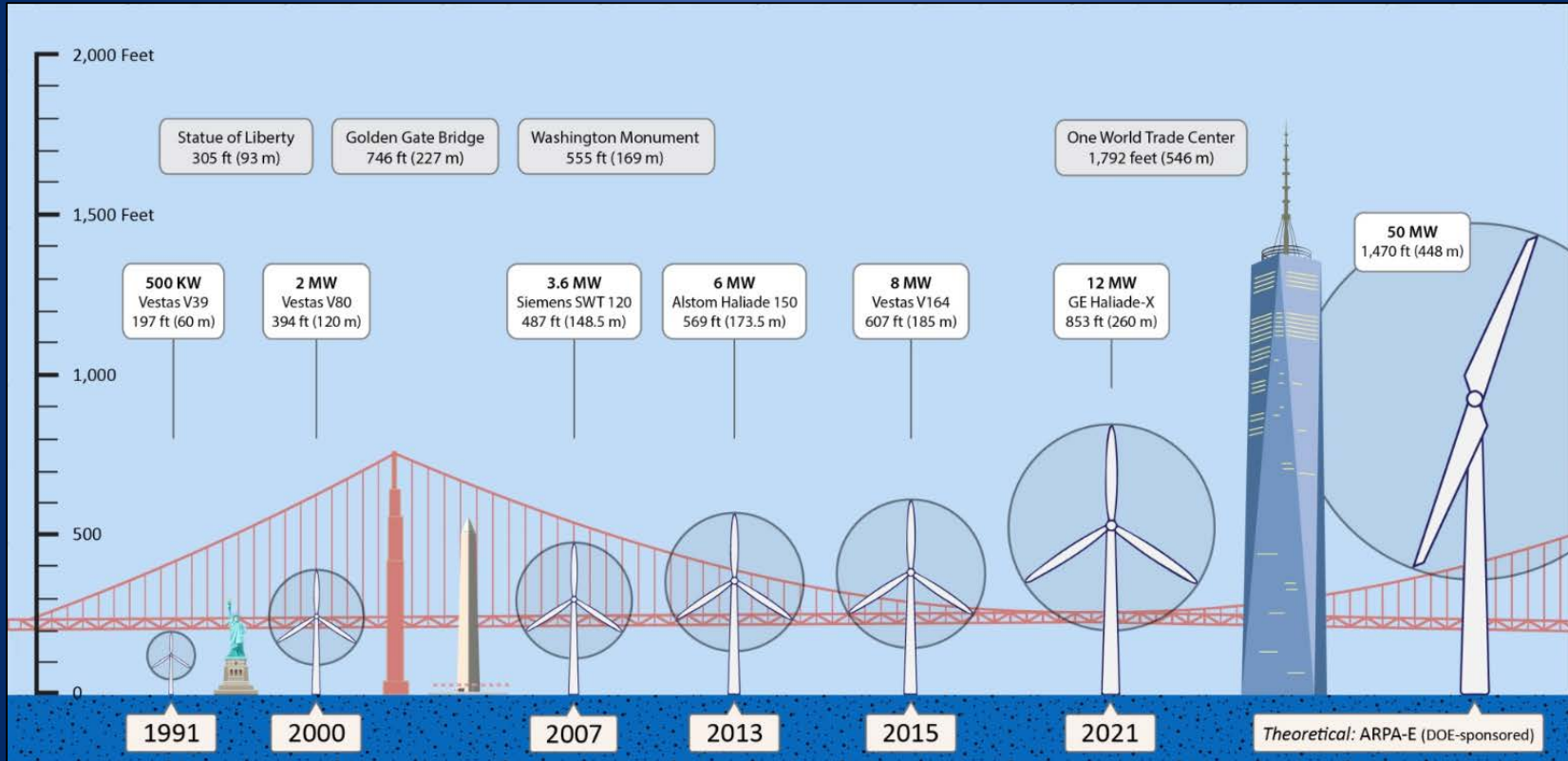
The West is Deep



The West is Deep



Technology: Growth of the Wind Turbine

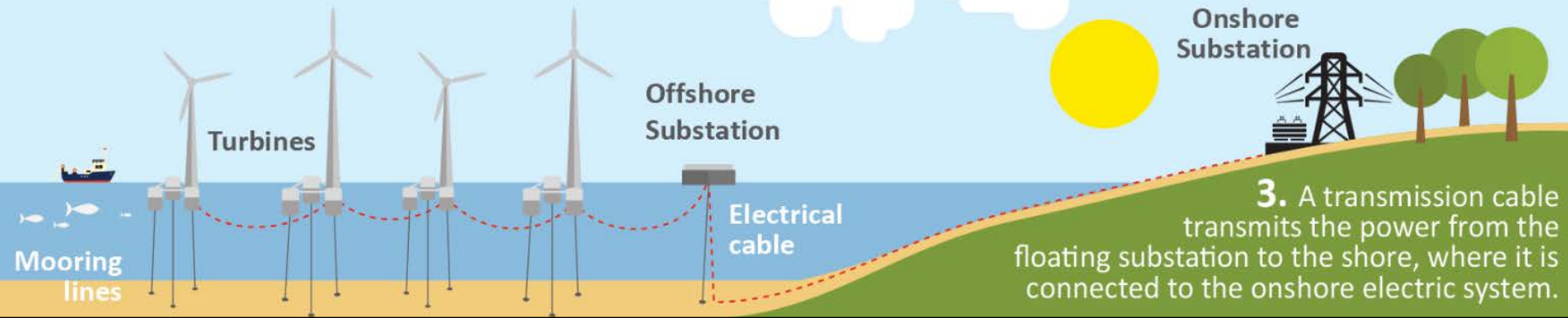


Floating Wind Farm

1. Floating wind turbines are configured in an array to optimize the capture of wind energy.

2. Energy captured by the turbines is conveyed through a transmission line to a floating substation.

3. A transmission cable transmits the power from the floating substation to the shore, where it is connected to the onshore electric system.



Prototypes



Statoil (Equinor)
2.3 MW Turbine
Norway
2009



Principle Power
2.0 MW Turbine
Portugal
2011 - 2016
17 m waves / 60 knot winds



University of Maine
20 kW Turbine
Maine USA
2013

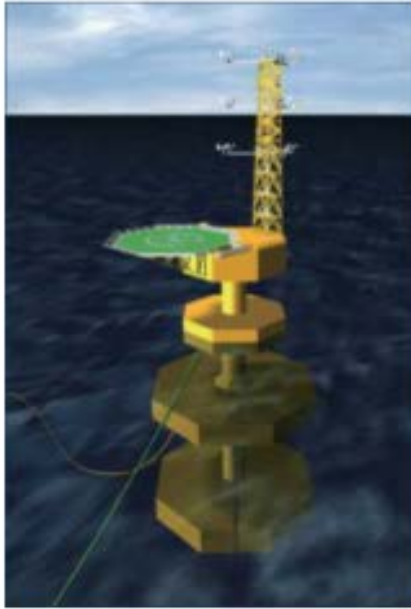


Fukushima Offshore

Phase I (2011~2013)

Phase II (2014~2015)

Floating Substation



Compact Semi-Sub
(2MW)



Advanced Spar
(7MW)



V-shape Semi-Sub
(7MW)



Fukushima Offshore



Floatgen (France)

- Dampening Pool
 - Deployed 2017
 - 2 MW
 - 33 m depth
 - Concrete



Anchor (© ECN)

Floatgen (Japan)

- Dampening Pool
 - Deployed 2018
 - 3 MW
 - 50 m depth
 - Steel



University of Maine

- Aqua Ventus Project
 - Two 6MW Turbines...or
 - One 10+MW Turbine
- Vibration Suppression
- Lighter = Cheaper



Hywind: OSW Goes Commercial

- 2017
- Scotland
- 5 Turbines
- 6 MW (30)
- 20,000 homes

Here is a turbine being towed through the North Sea by a tug boat.



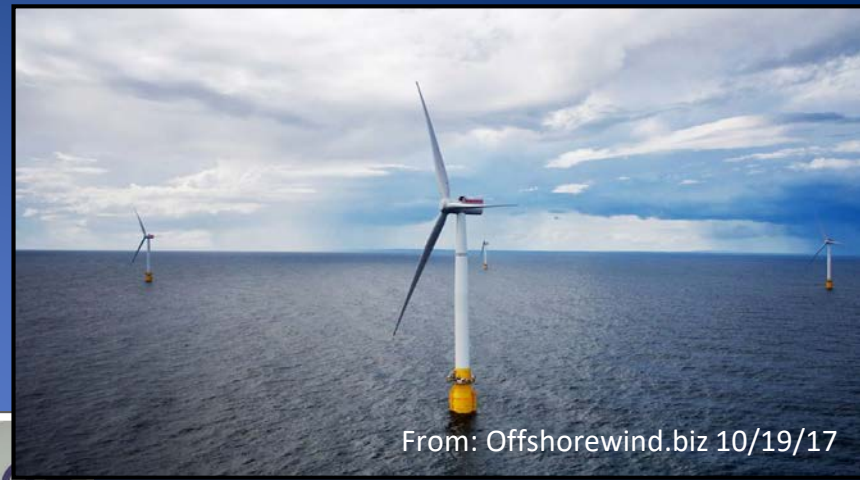
Preparations being made for the first turbine to be towed to Scotland. Espen Rennevik / Woldcam via Statoil

The floating technology allows the turbines to go in deeper waters.

Hywind: OSW Goes Commercial



Hywind: Batteries



From: Offshorewind.biz 10/19/17

http://www.offshorewind.biz/2017/10/18/industry-welcomes-hywind-opening/?utm_source=email&utm_medium=email&utm_campaign=daily-update-offshore-wind-2017-10-19&uid=64699



Statoil Orders Hywind Scotland Battery Set

From: Offshorewind.biz 11/29/17

WindFloat Atlantic

- 2019
- Portugal
- 3 Turbines
- 8.4 MW (25)
- 60,000 people



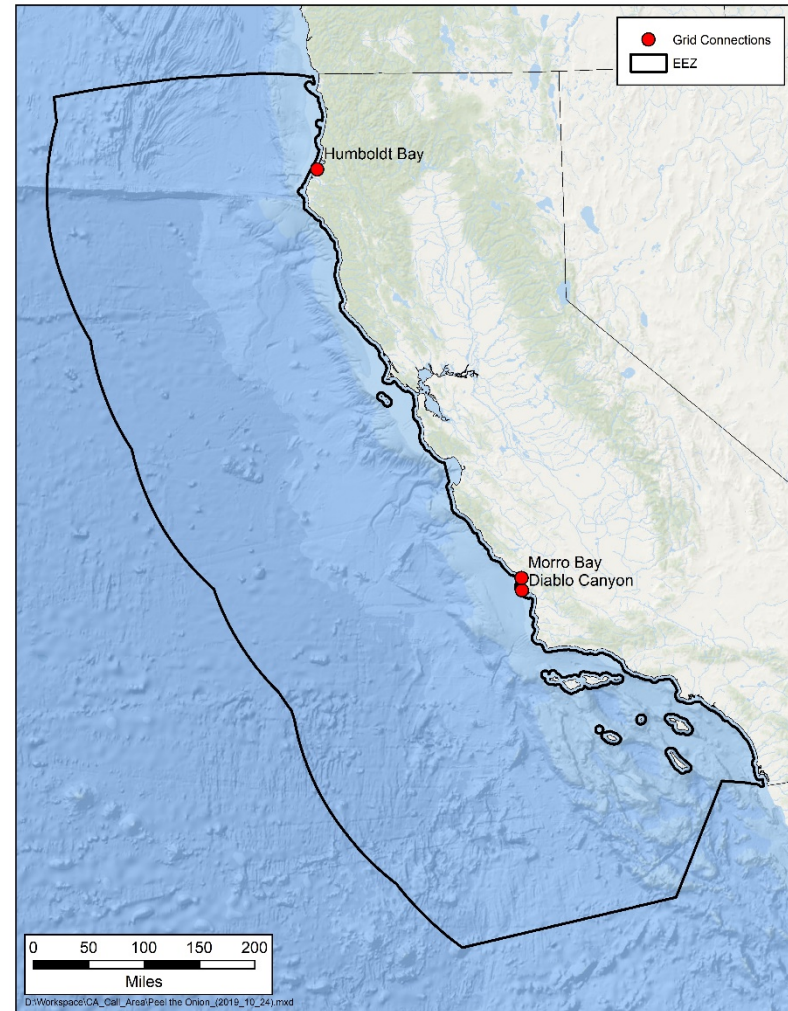
<https://www.youtube.com/watch?v=PiKa6steniw>

<http://www.mhivestasoffshore.com/first-turbine-of-windfloat-atlantic-moves-into-position/>

Where Can OSW Go

- BOEM Jurisdiction
 - Federal Waters
 - 3 nmi – 200 nmi
- $\approx 215,000$ sq miles

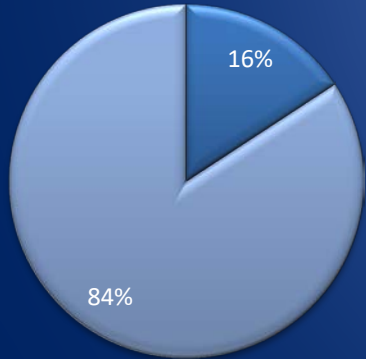
Percent of Federal Waters



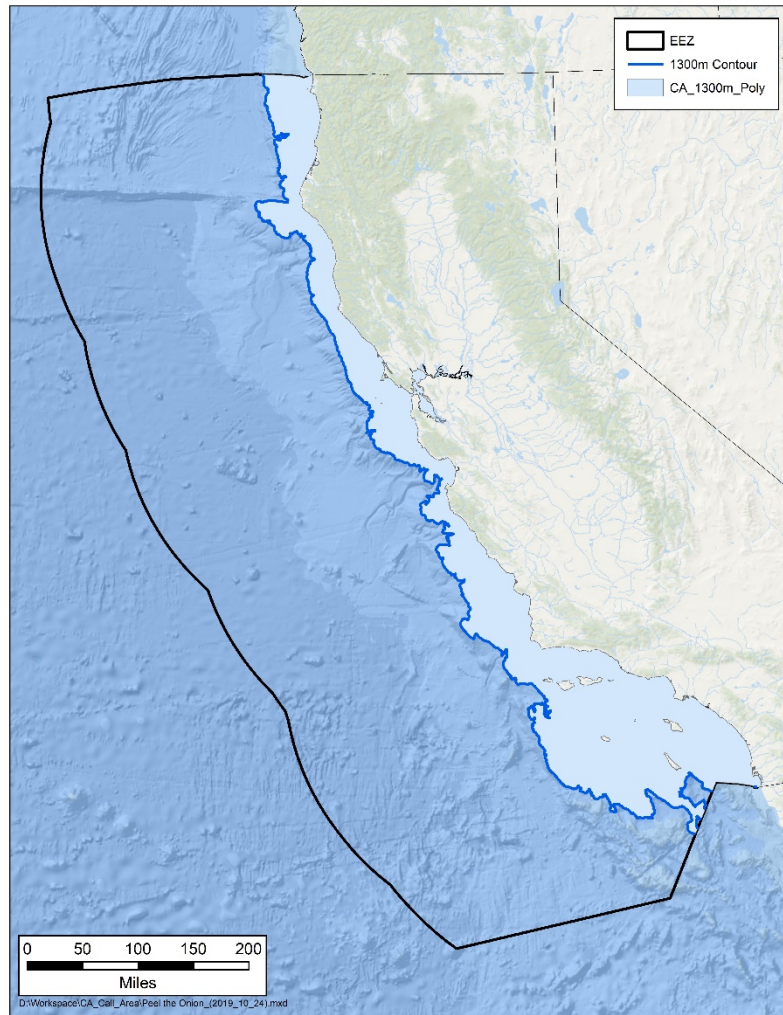
Where Can't OSW Go?

- Depth
 - 1300 m
- 34,000 sq miles remaining

Percent of Federal Waters



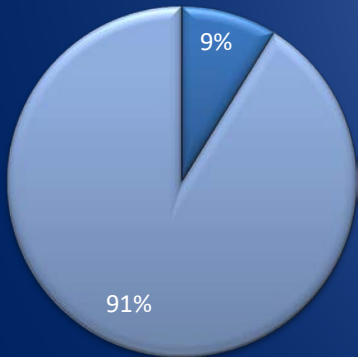
- Federal Waters
Depth > 1300 m
(34,000 sq mi)
- Rest of EEZ



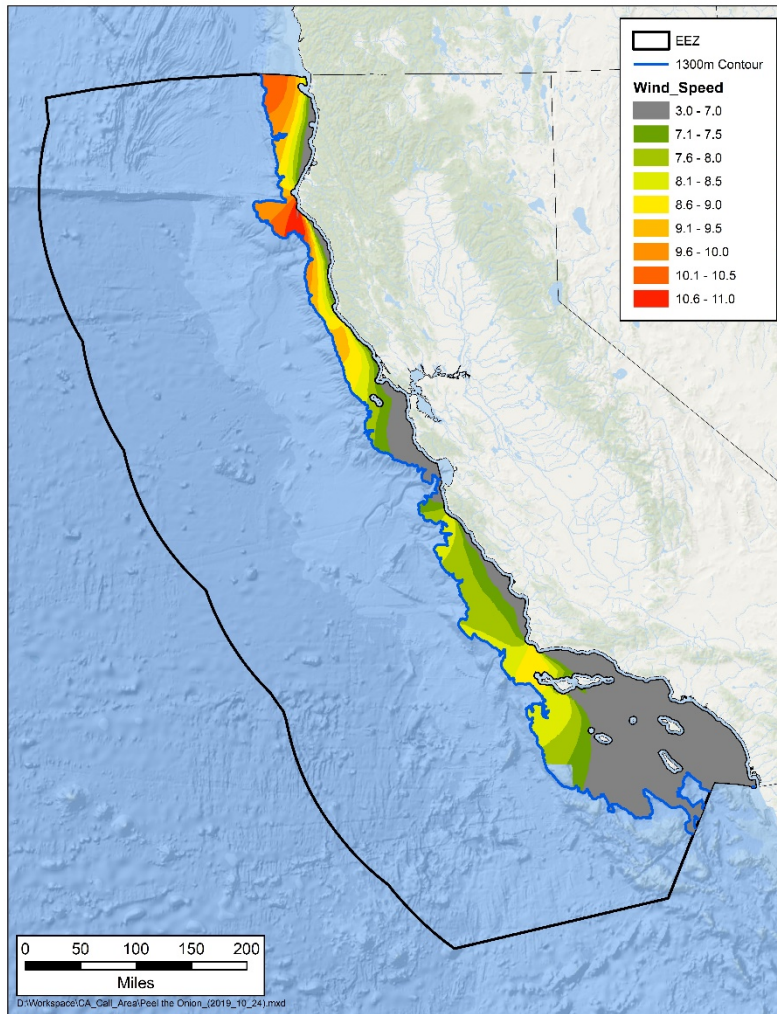
Where Can't OSW Go?

- Wind Speed
 - > 7 m/s
- 19,000 sq miles

Percent of Federal Waters



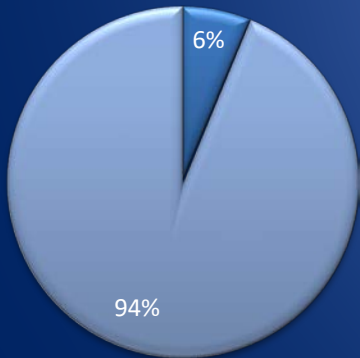
- Federal Waters
Depth > 1100 m
Winds > 7 m/s
(19,000 sq mi)
- Rest of EEZ



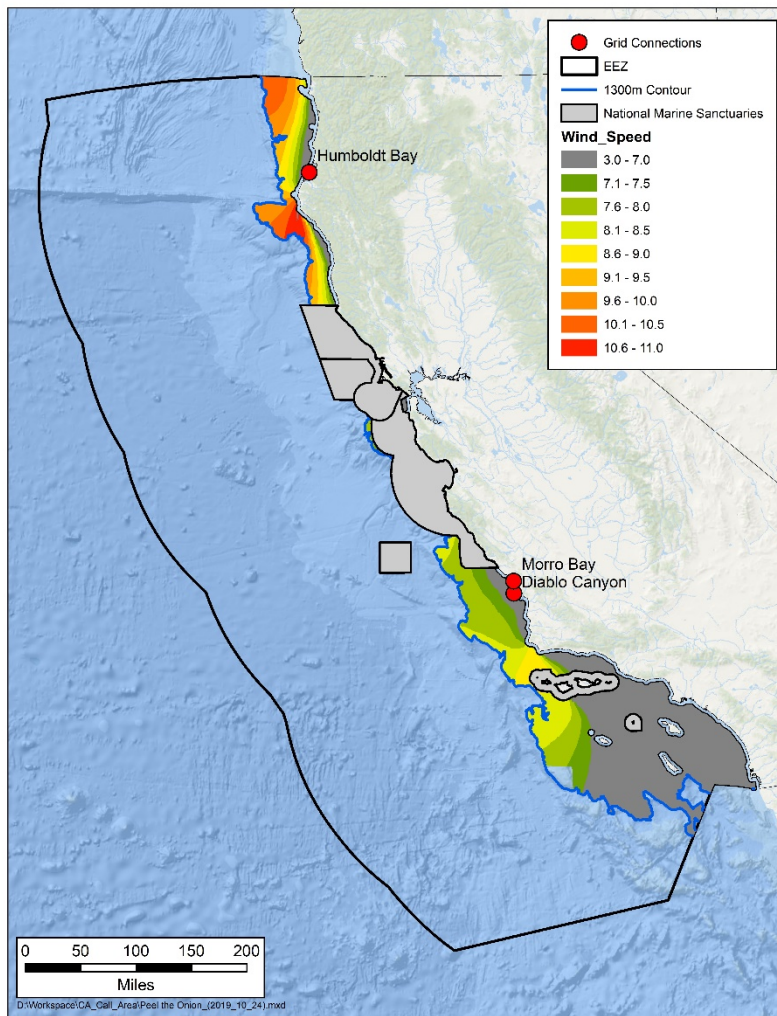
Where Can't OSW Go?

- National Marine Sanctuaries
 - Not BOEM Jurisdiction
- 14,000 sq miles remaining

Percent of Federal Waters

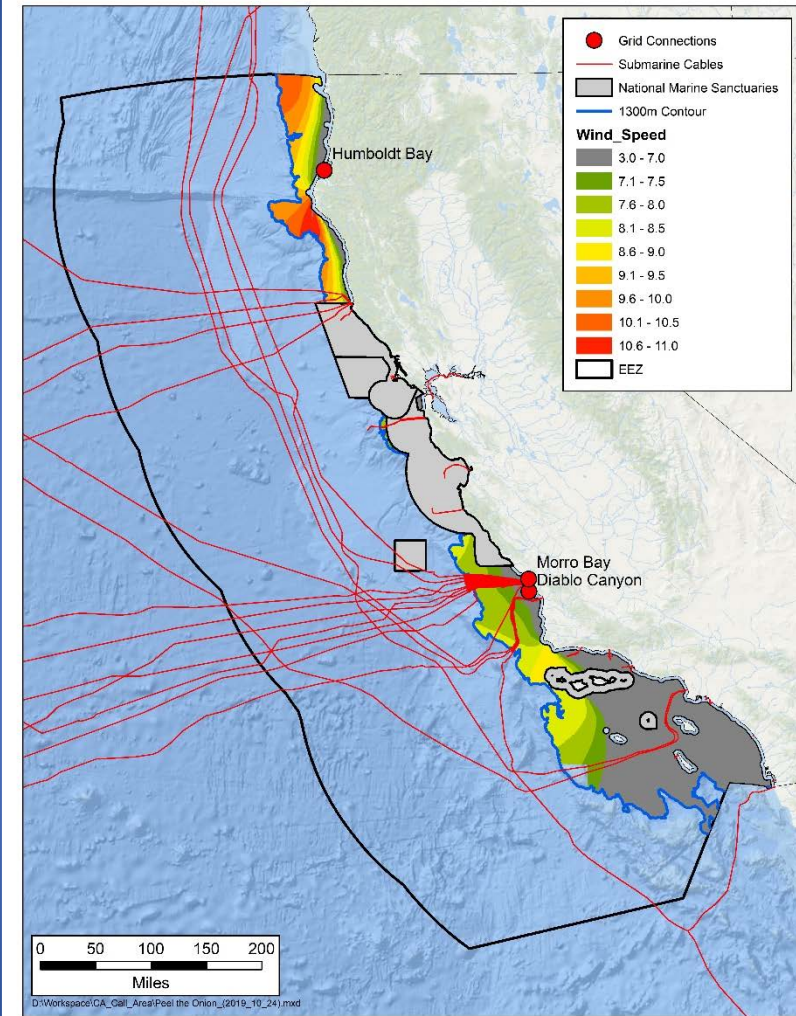


- Federal Waters
Depth > 1300 m
Winds > 7 m/s
No Sanctuaries
(14,000 sq mi)
- Rest of EEZ



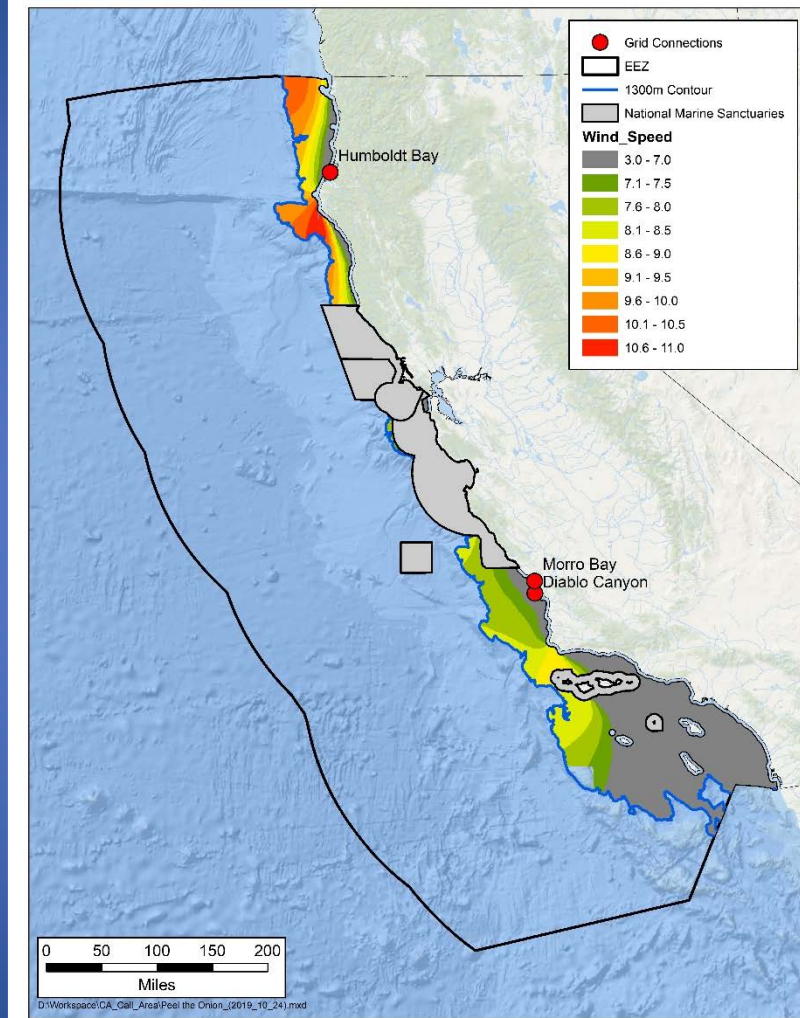
Where Can't OSW Go?

- Cables



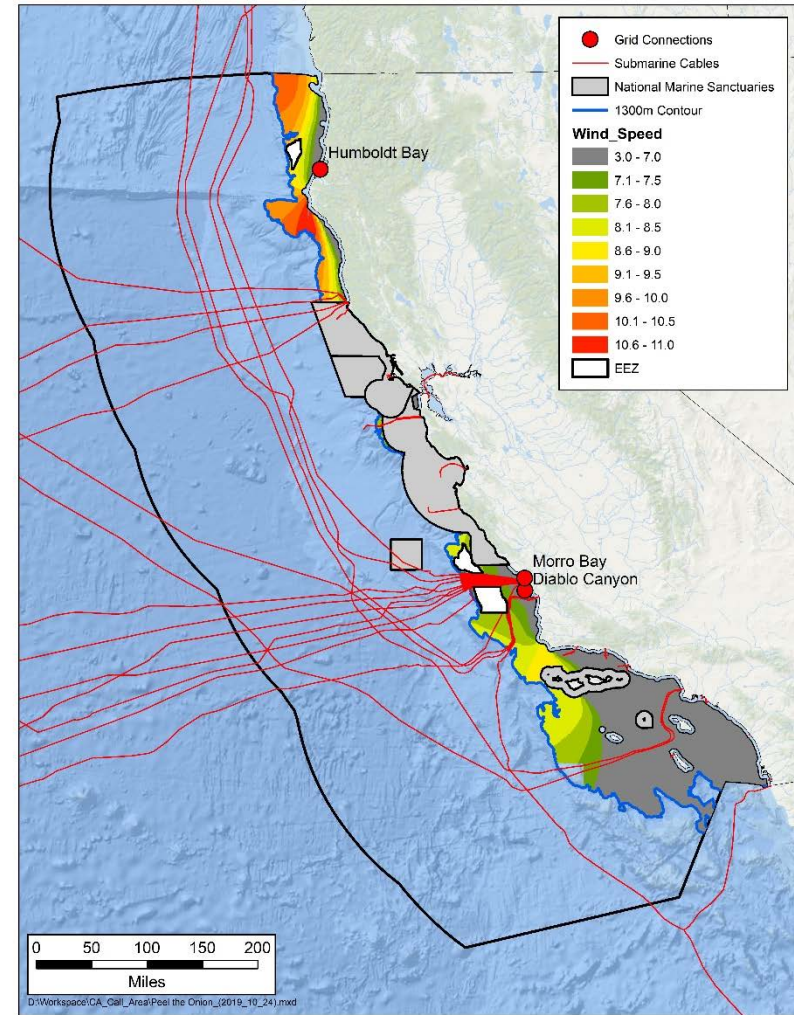
Where Can OSW Go?

- Near a Grid Connection
 - Morro Bay
 - Diablo Canyon
 - Eureka



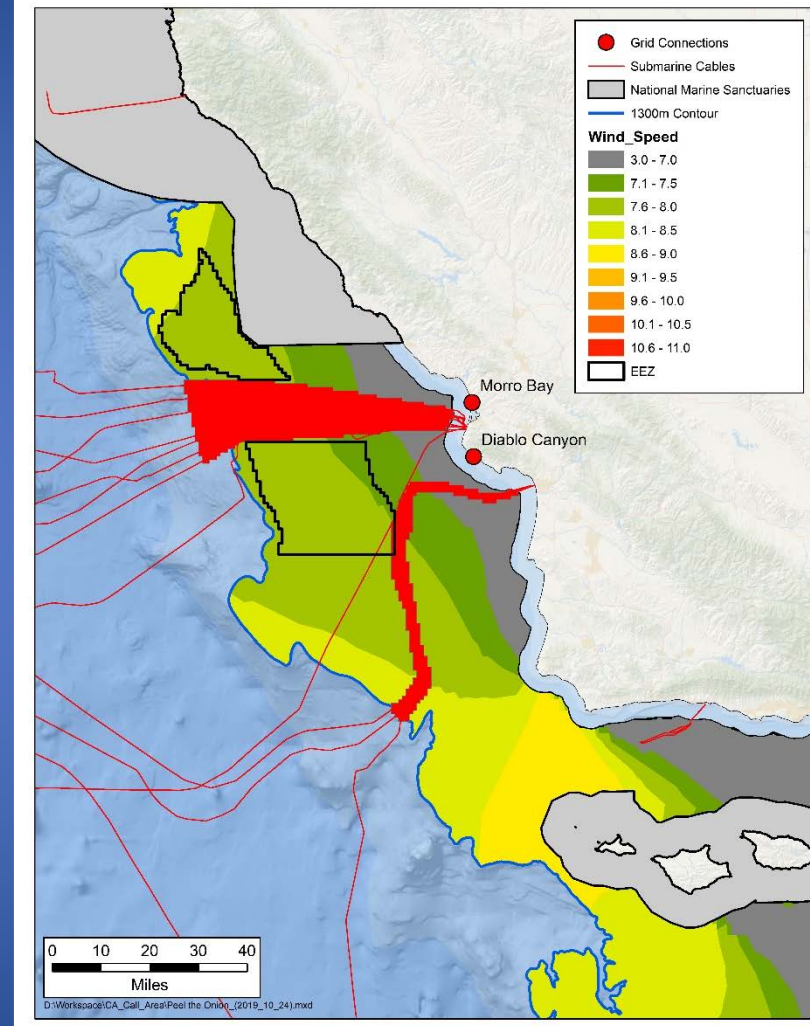
Where Can OSW Go?

- CA Call Areas



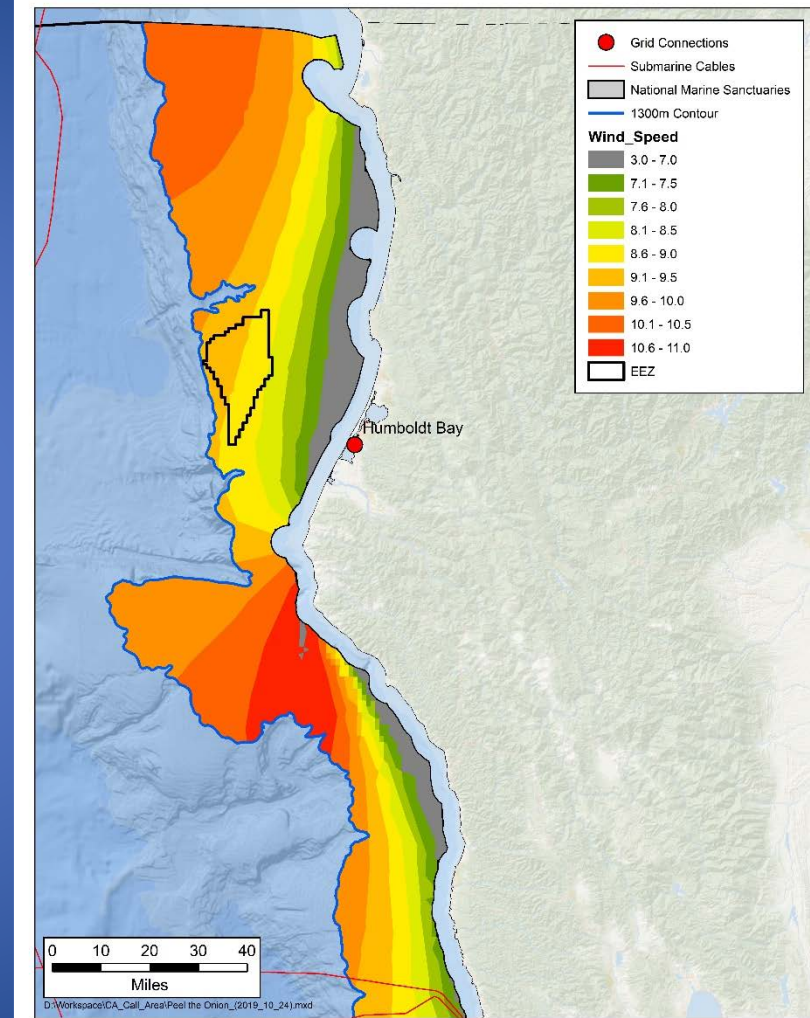
Where Can OSW Go?

- CA Call Areas



Where Can OSW Go?

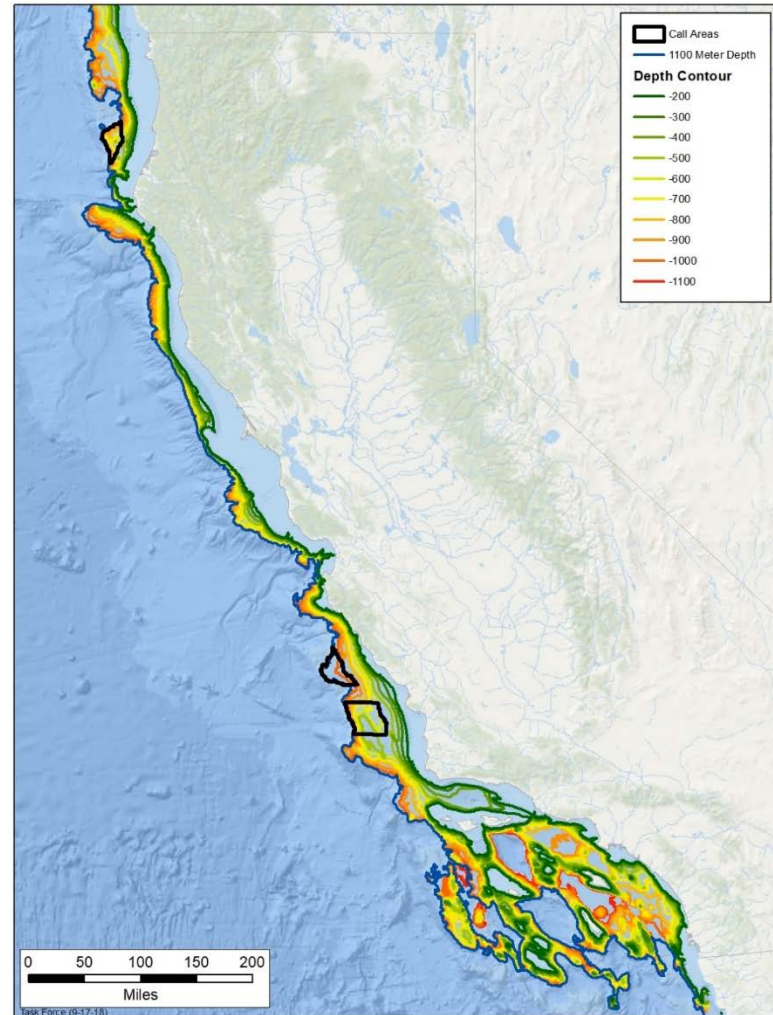
- CA Call Areas



Data!

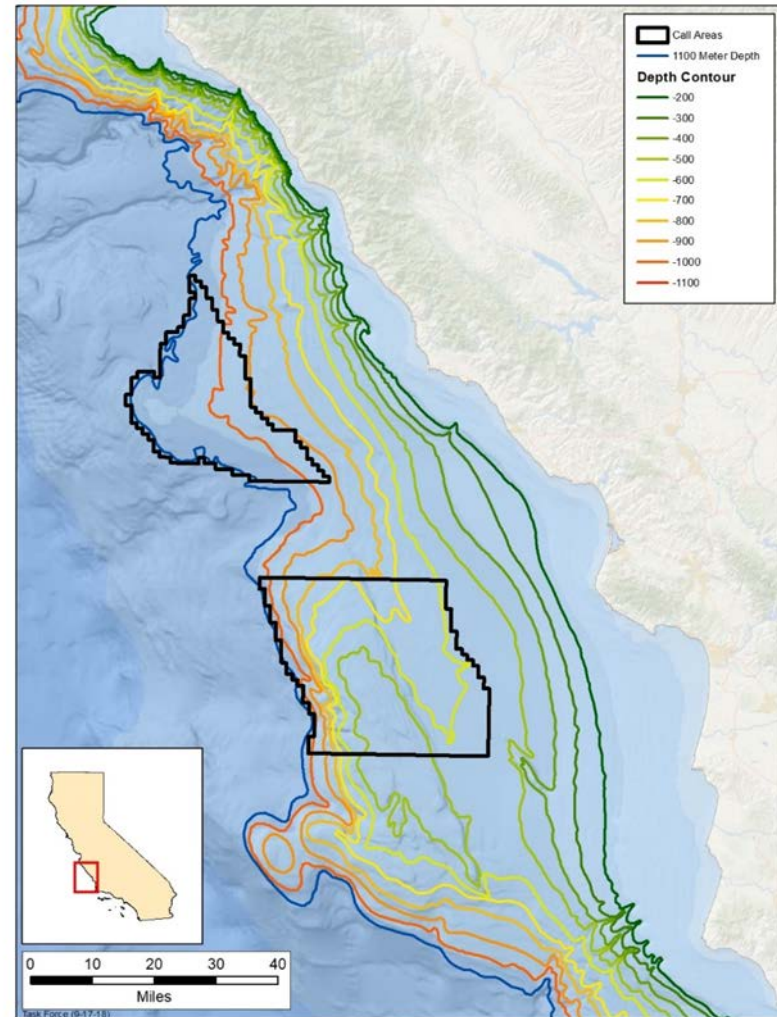
- Review a few Datasets
 - Bathymetry
 - Wind
 - Vessel Traffic
 - Birds
 - Marine Mammals

- CA OSW Energy Gateway
 - DataBasin



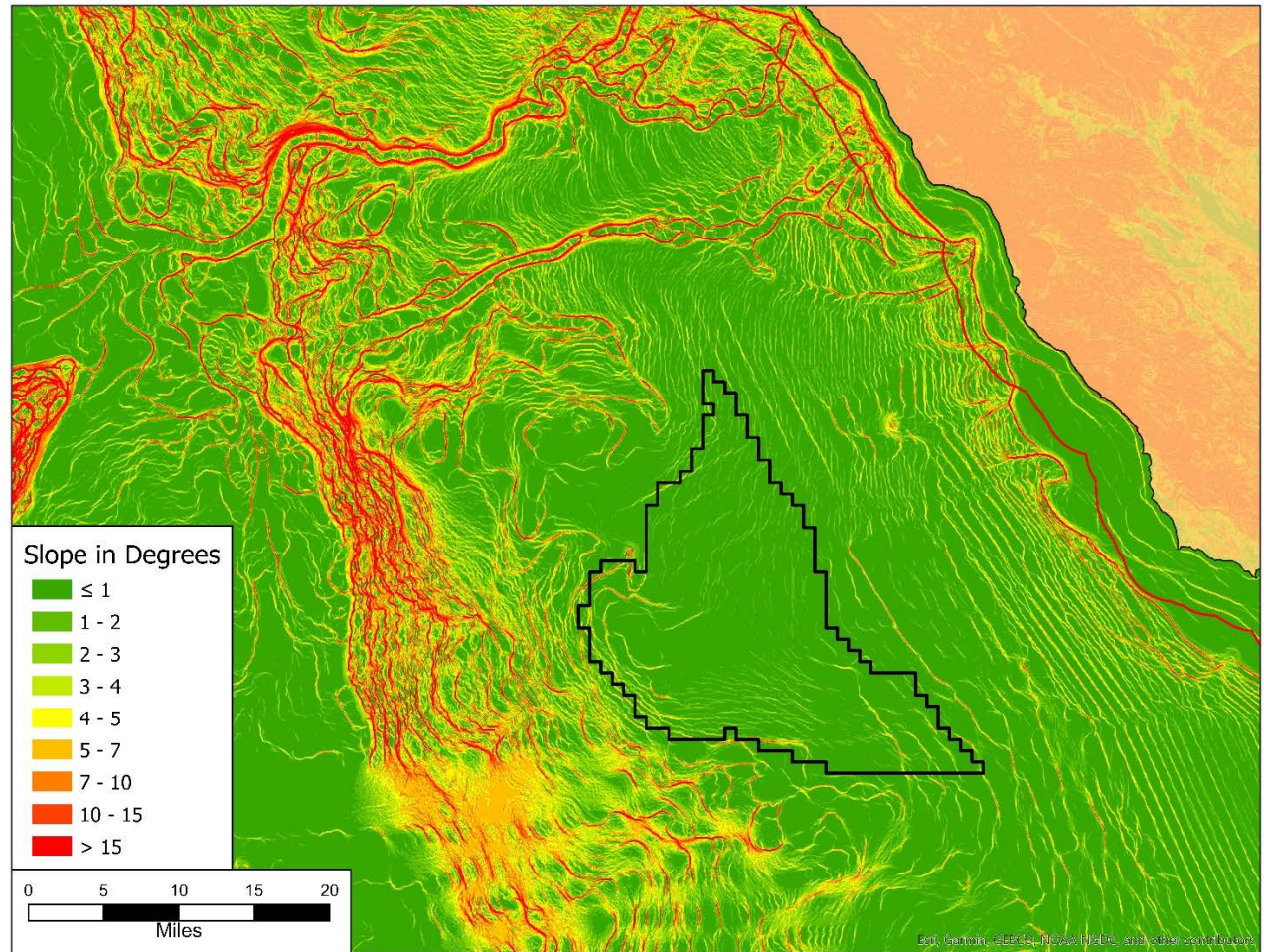
Bathymetry

- USGS Data
- 100 meter contours



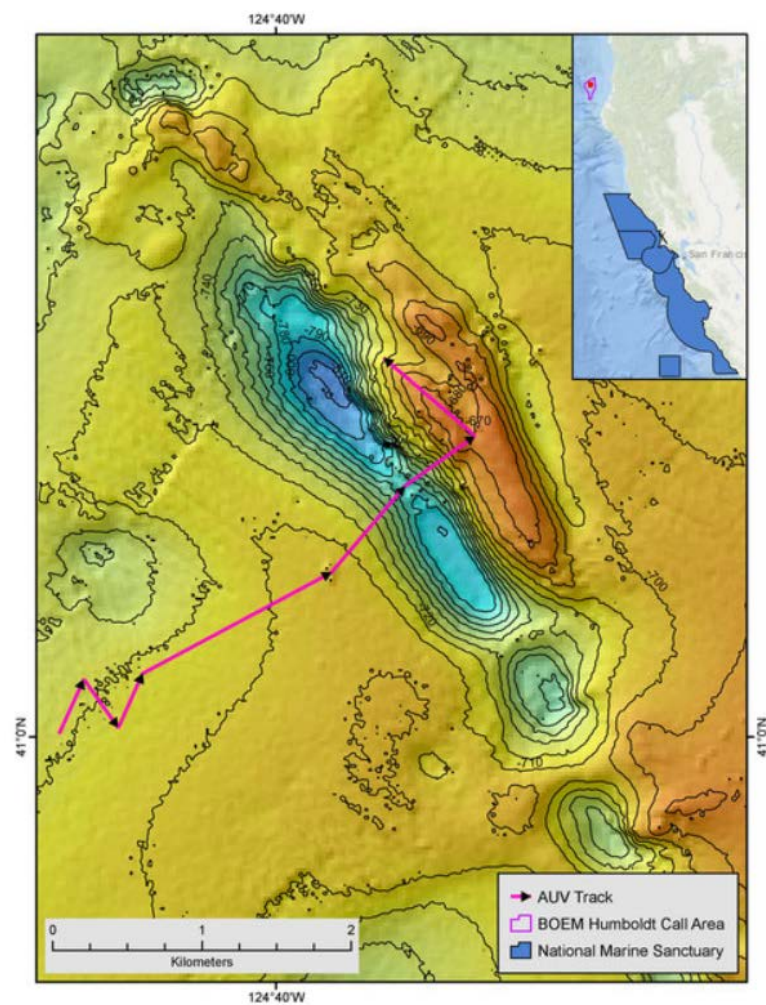
Slope

- NOAA DEMs
- ≈ 80 m pixels



EXPRESS

- Expanding Pacific Research and Exploration of Submerged Systems
- NOAA, MBARI, USGS, SeaGrant, GFOE, BOEM
- Seafloor Mapping
 - Bathymetry (depth)
 - Habitats / Ecosystems
 - Hazards
- Benthic Webinar



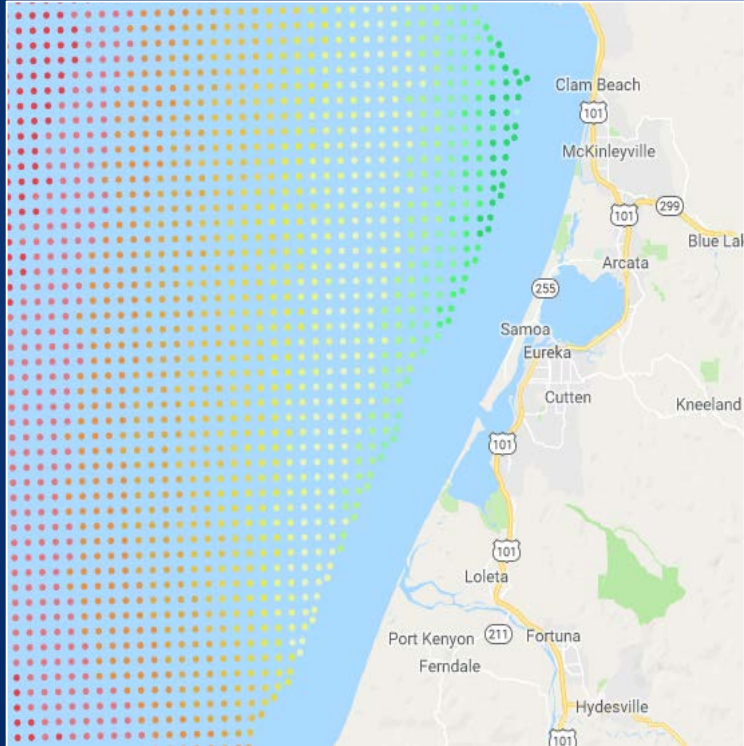
Wind Speed

- National Renewable Energy Lab (NREL)
- Many Data Sources
- Modeled to Provide consistent dataset for USA



Wind Speed Data

- NREL Wind Prospector



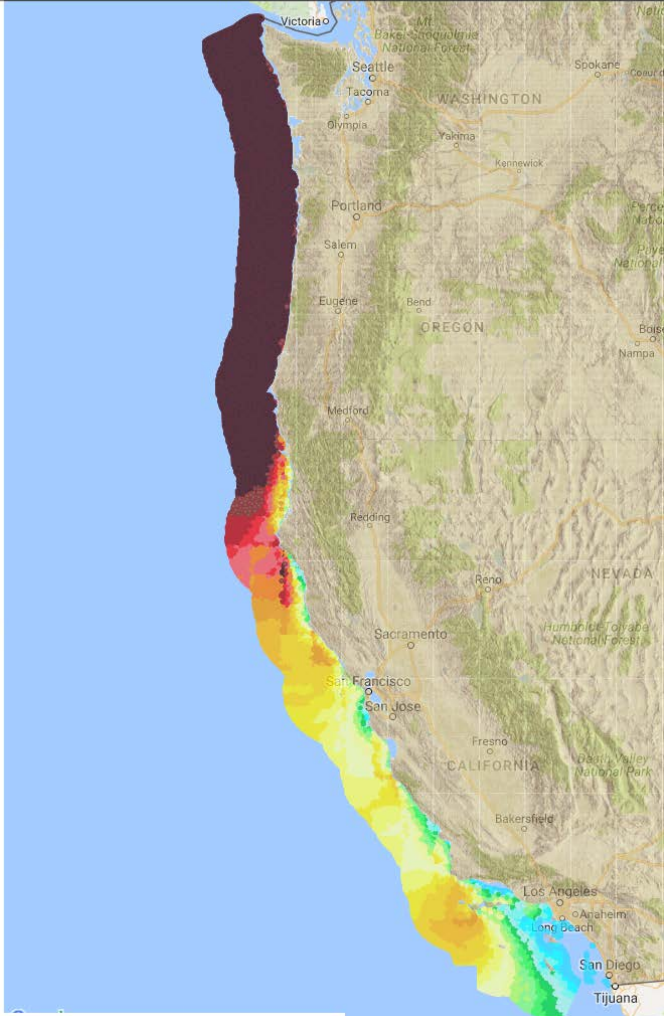
Select and Query Data Analysis & Downloads



Wind Prospector

Data Layers Legend Query

- ▾ County & State Borders
- ▾ Environmental Concern
- ▾ Infrastructure
- ▾ Land Ownership
- ▾ Regions & Study Areas
- ▾ Site Analysis
- ▾ **Topography**
 - Hillshade
 - Land Cover
 - Slope (< 20%)
- ▾ Hydrology
- ▾ **Wind Resource**
 - Land-Based Wind Speed 100m
 - Land-Based Wind Speed 80m
 - Offshore Wind Speed 90m
 - Wind Power Class (Exclusions Applied)
 - Wind Power Class (No Exclusions)
 - Wind Toolkit
 - Eastern Wind Dataset
 - Western Wind Dataset
 - NDBC Verification Points
- ▾ Potential Wind Capacity
- ▾ **Pacific Monthly Offshore Wind Speed**
 - Wind Speed - Annual
 - Wind Speed - January
 - Wind Speed - February
 - Wind Speed - March
 - Wind Speed - April
 - Wind Speed - May
 - Wind Speed - June
 - Wind Speed - July
 - Wind Speed - August
 - Wind Speed - September
 - Wind Speed - October
 - Wind Speed - November
 - Wind Speed - December
 - Alliquots
- ▾ Hawaii Monthly Offshore Wind Spe...
- ▾ USVI
- ▾ Philippines



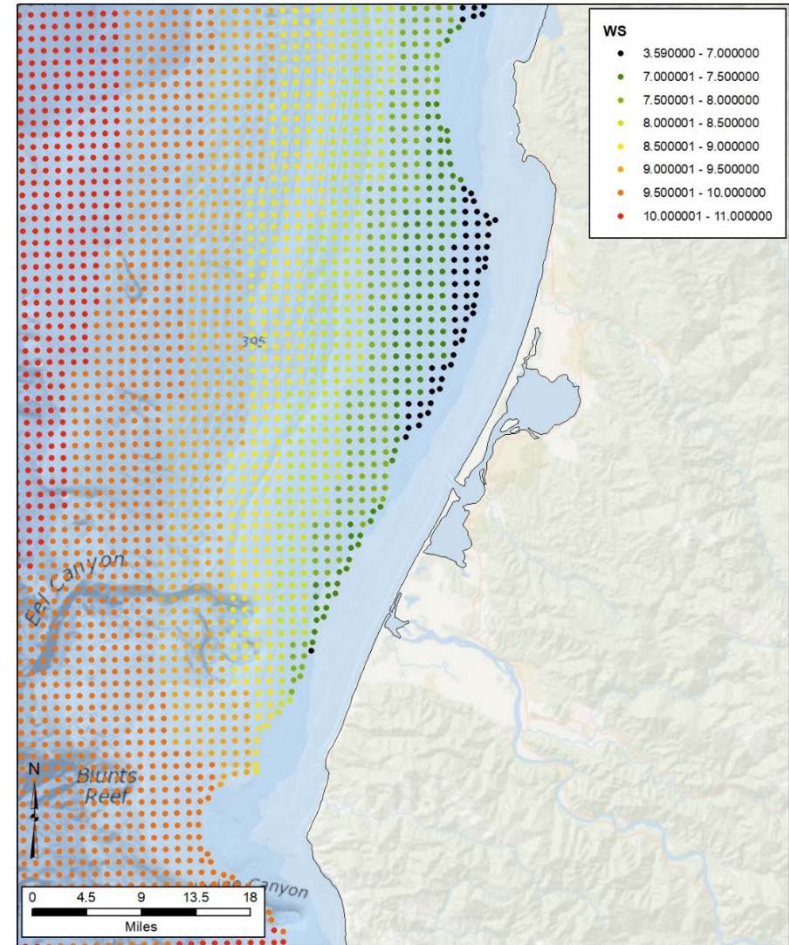
Wind Speed Data

- Hourly Wind Speed
- By Month (Jan)

jan_pacific

	Aliquot	JAN_WS	JAN_H00_WS	JAN_H01_WS	JAN_H02_WS
▶	NL09-05-6001A	9.17	8.97	9.15	9.15
	NL09-08-6001A	8.95	8.67	8.77	8.78
	NL10-05-6001A	9.17	8.97	9.15	9.15
	NL10-08-6001A	8.95	8.67	8.77	8.78
	NL10-11-6001A	8.47	8.32	8.35	8.49
	NI10-11-6001A	4.06	3.78	3.81	3.74
	NI09-03-6001A	7.3	7.55	7.32	7.18
	NI10-06-6001A	7.31	7.56	7.48	7.32
	NJ09-02-6001A	5.94	5.72	5.71	5.8
	NJ09-05-6001A	7.84	7.86	7.86	7.87

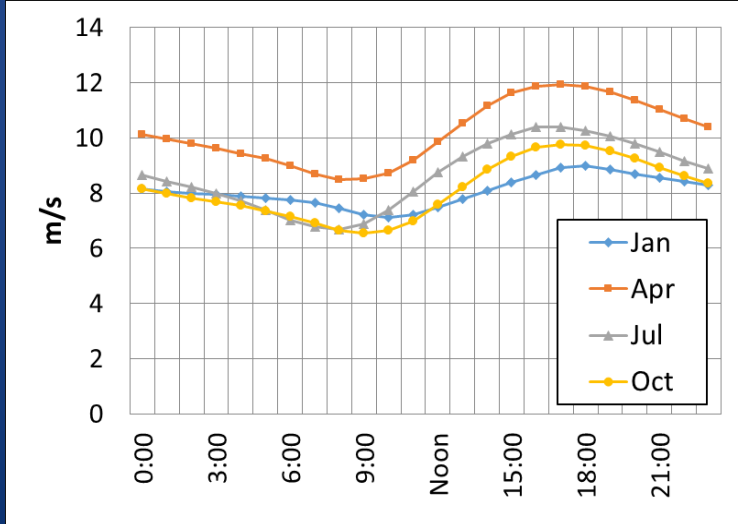
⏪ ⏩ 1 ⏪ ⏩ (0 out of 163052 Selected)



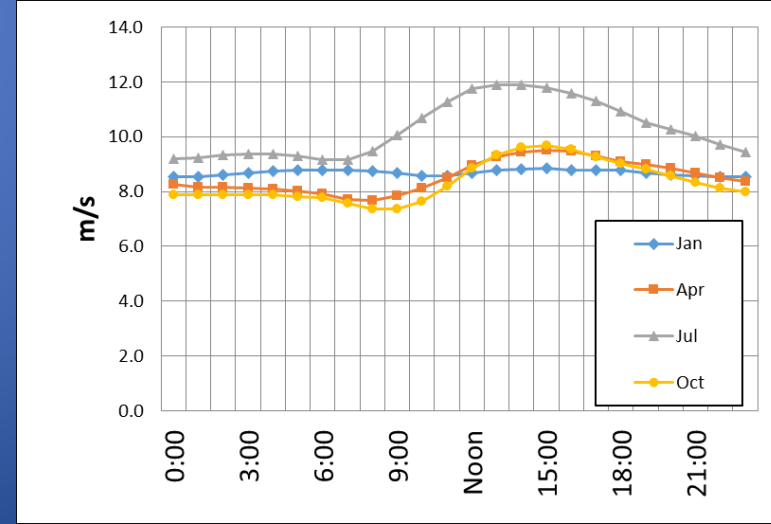
Hourly Wind Speed

“What’s the average wind speed at 2:00 in January?”

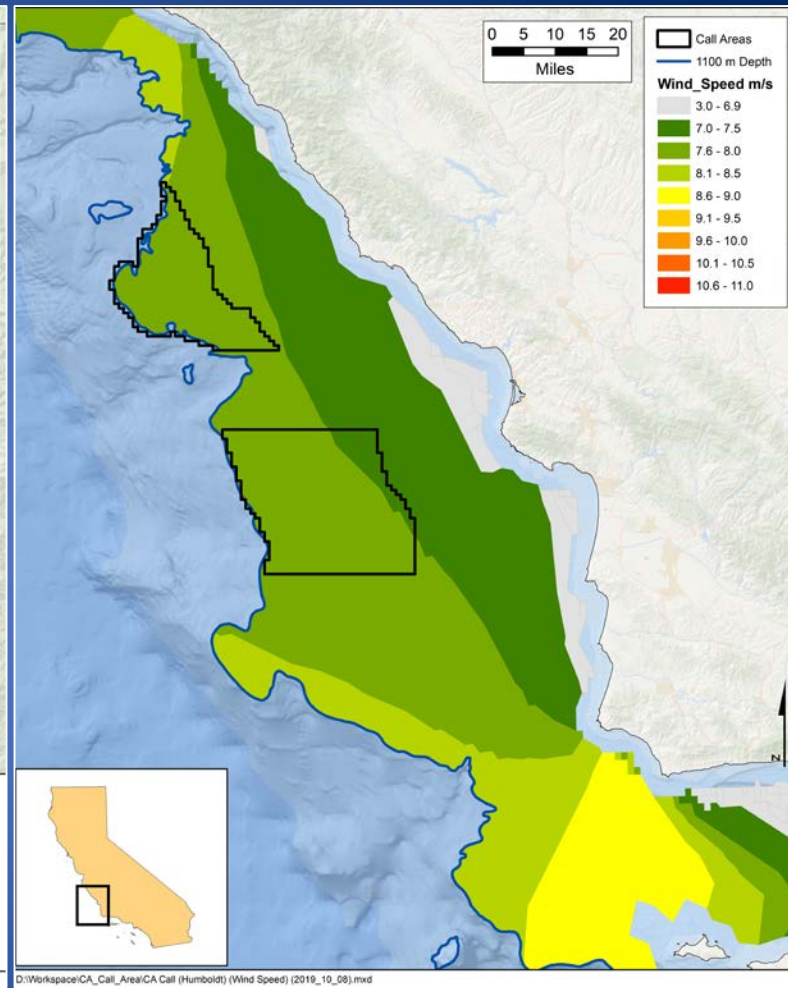
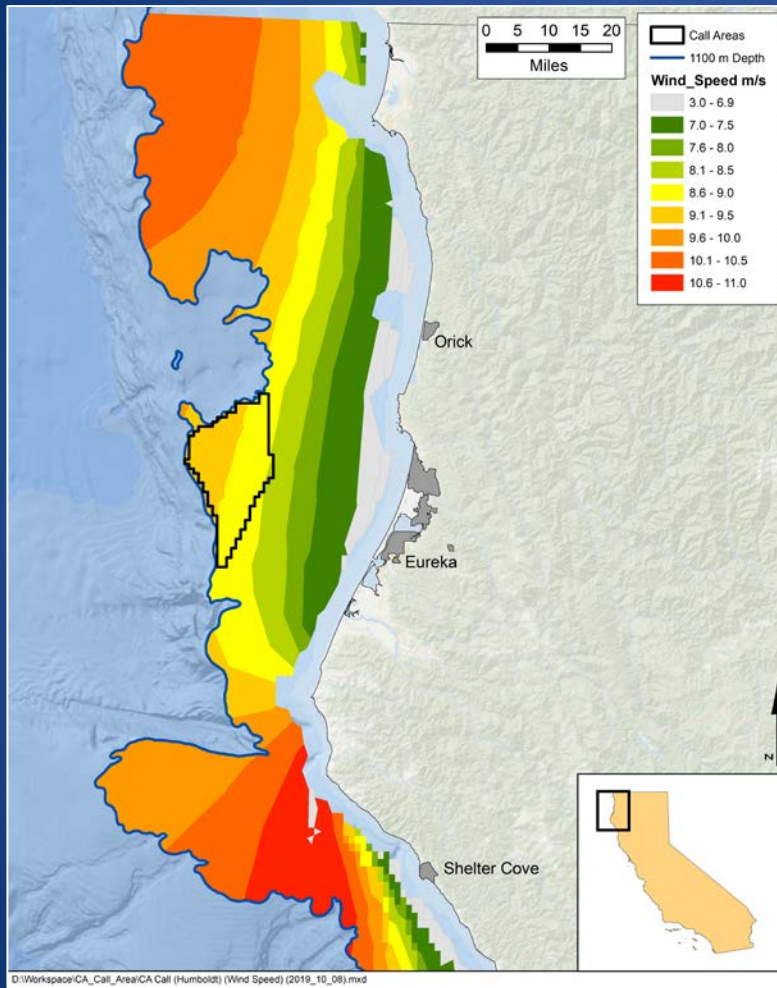
Central California



Humboldt

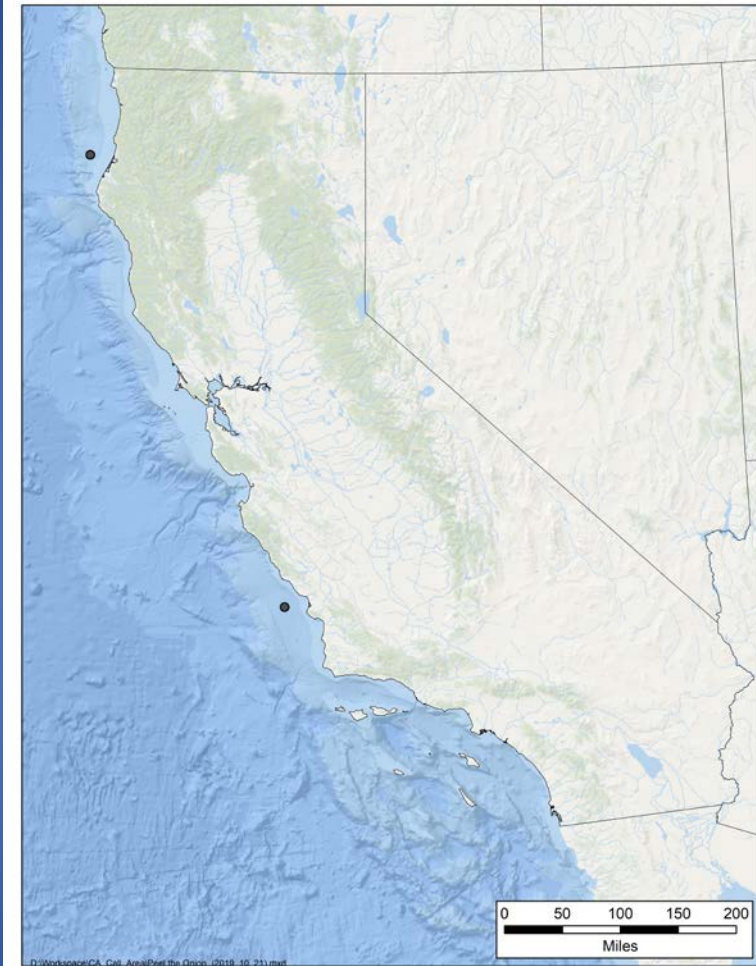


Annual Average Wind Speed



PNNL Lidar Buoys

- Spring 2020
- 1 Year
- Wind Profile



PNNL Lidar Buoys

Power & Data Communications

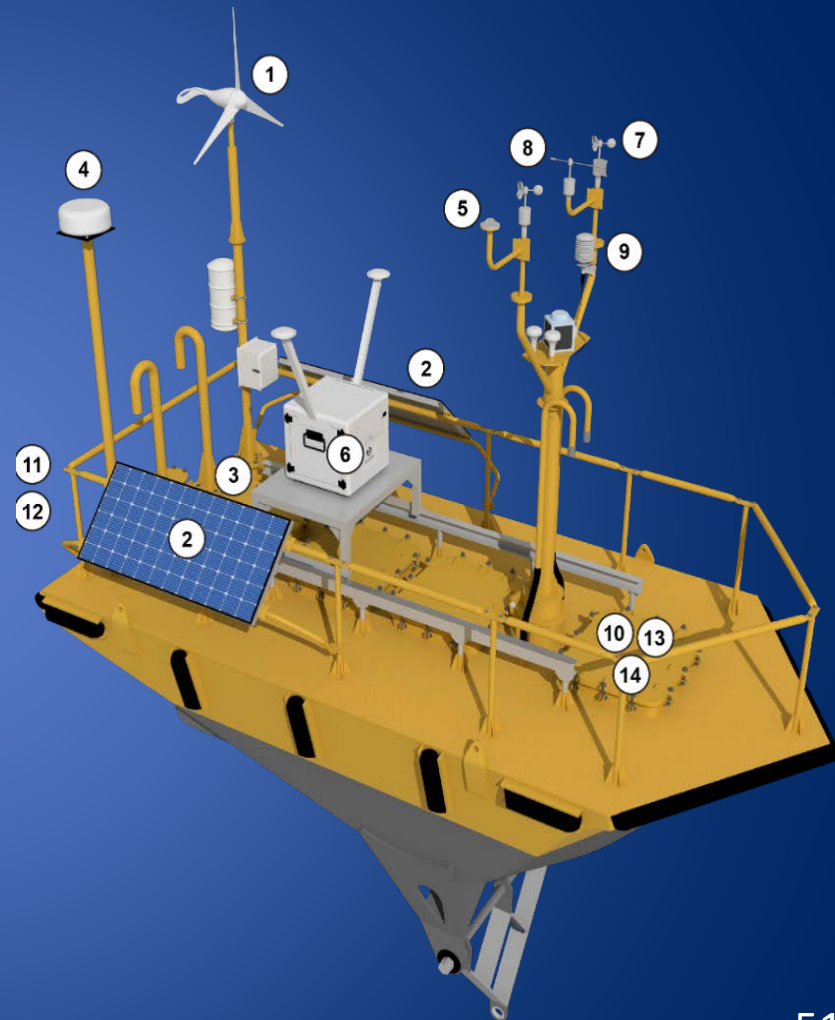
1. Turbine
2. Solar panels
3. Diesel generator (compartment)
4. Satellite antenna

Meteorological

5. Solar radiation
6. Wind profile
7. Wind speed
8. Wind direction
9. Air temperature & relative humidity
10. Barometric pressure (compartment)

Oceanographic

11. Water velocity profile (stern)
12. Water temperature & conductivity profile (stern)
13. Wave spectrum (compartment)
14. Sea surface temperature (compartment)



Other Factors

Vessel Traffic

* Marine Mammals

* Birds

* Fish & Fisheries

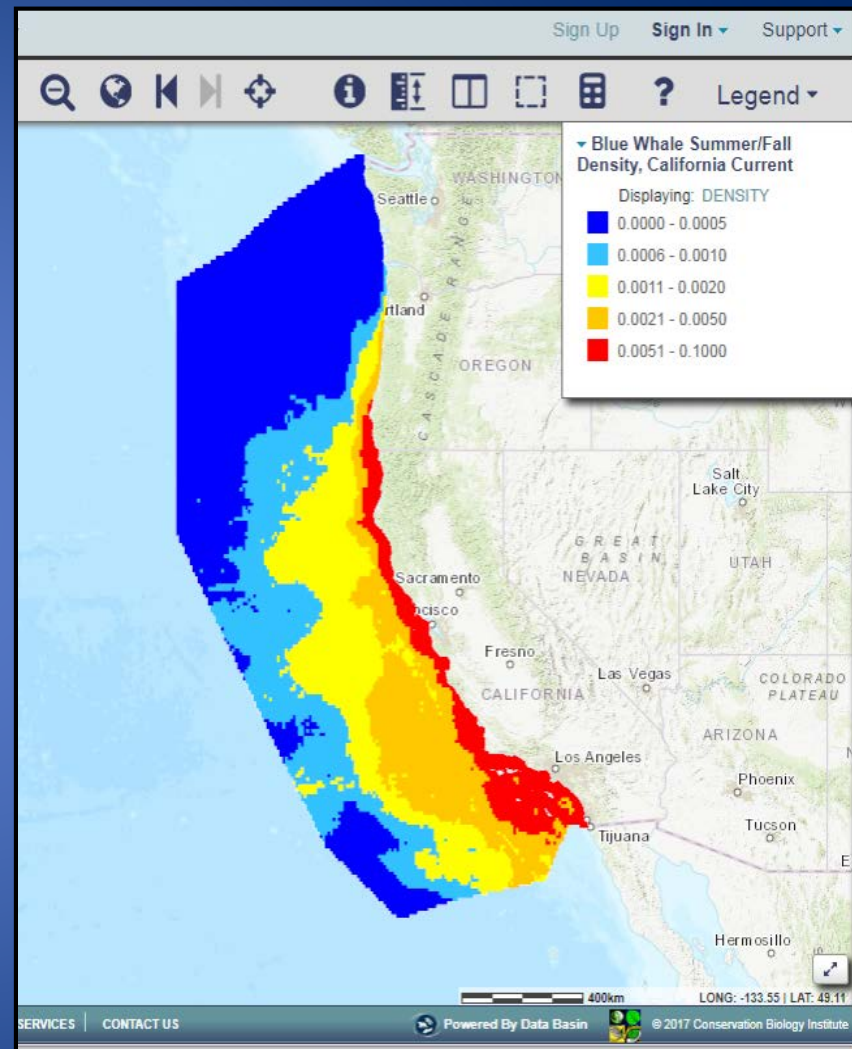
* Benthics

* Archaeology

Viewshed

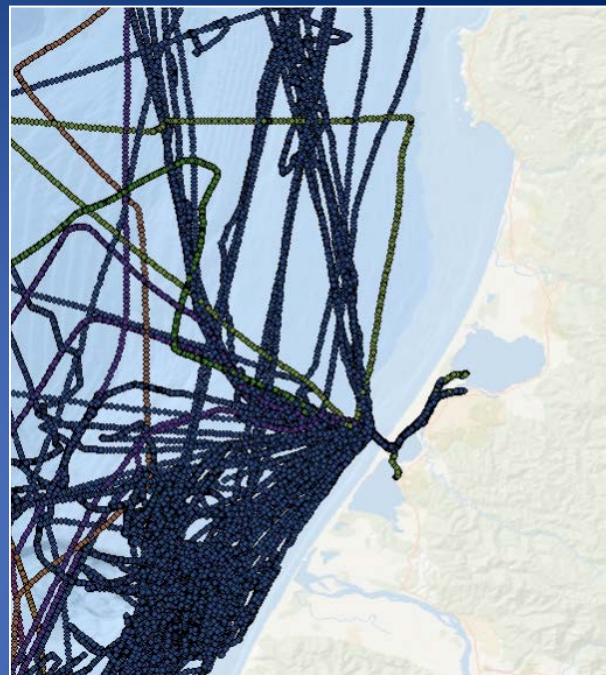
Department of Defense

Etc...



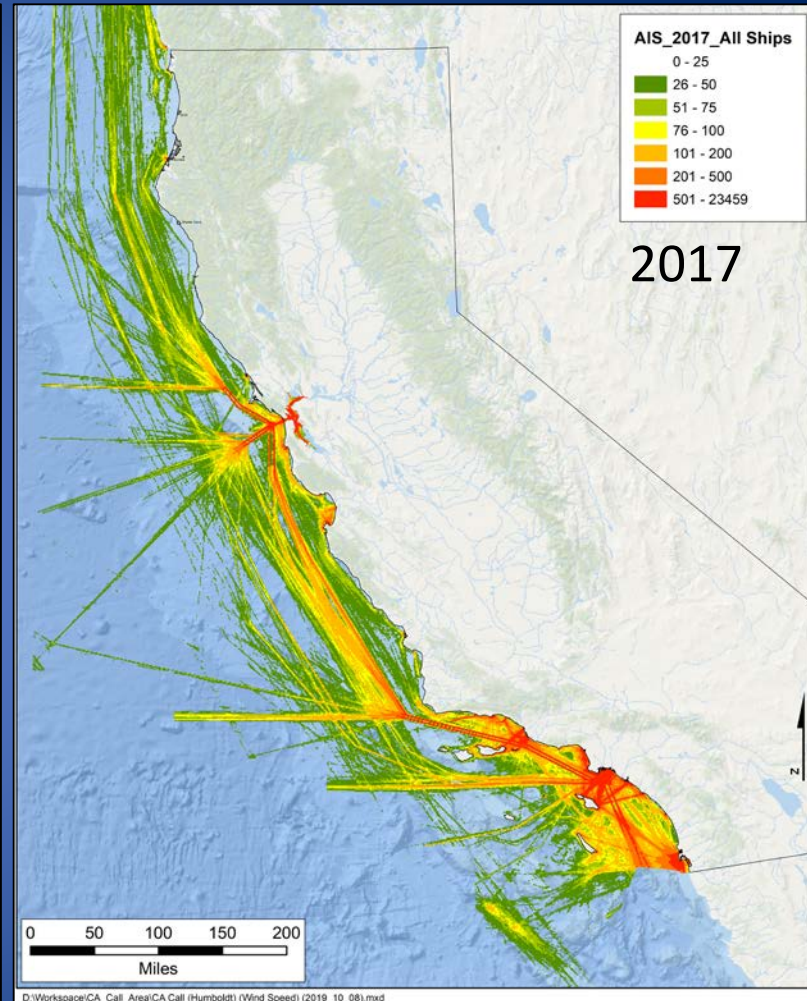
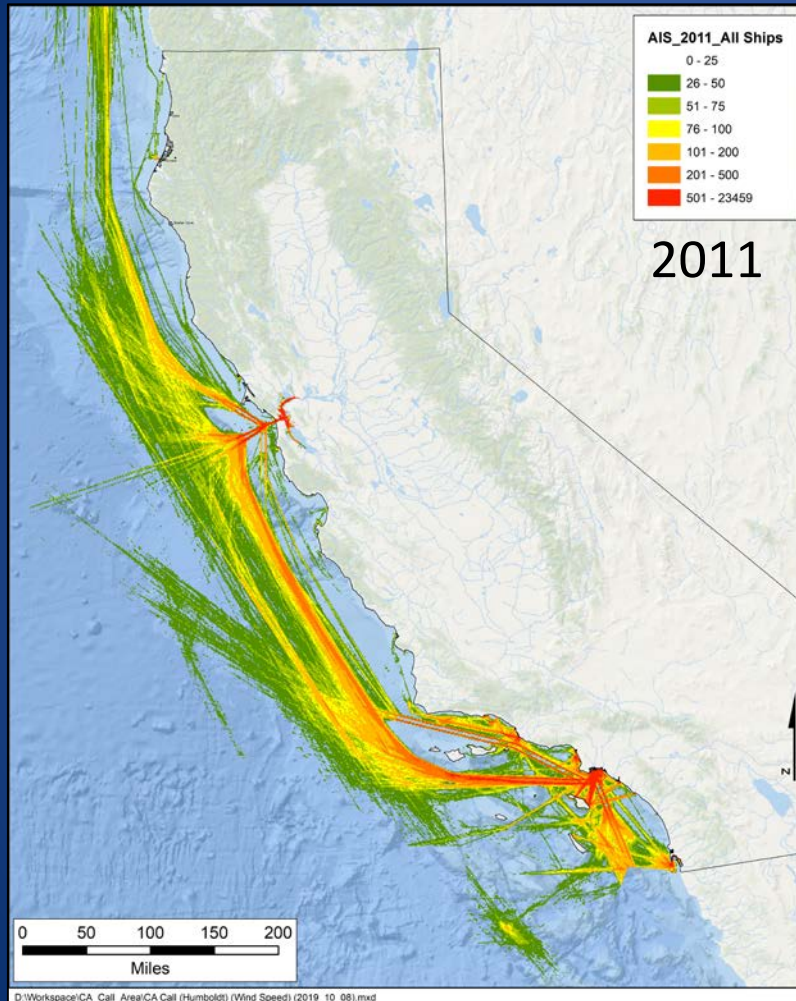
Vessel Traffic

- Automatic Identification System (AIS)
 - Air Traffic Control for Ships
- 25,000,000 points / month
 - MairneCadastre.gov/ais
- Vessel ID, Date, Type, Size, Status...

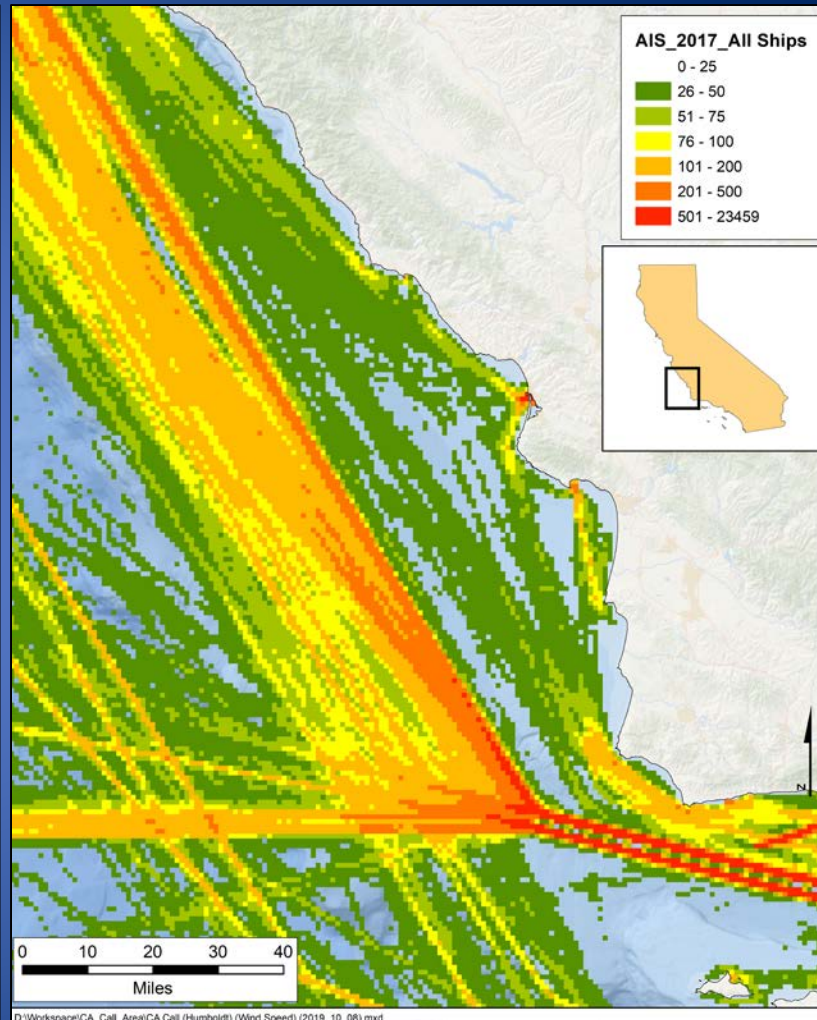
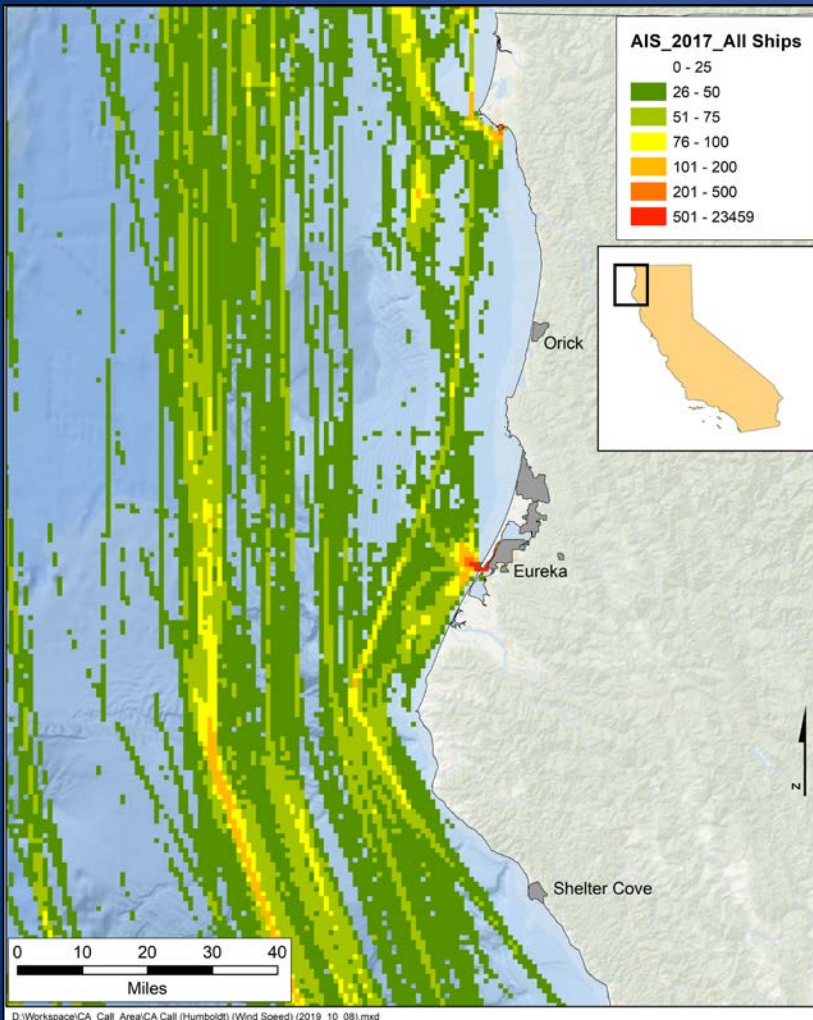


BaseDateTime	VesselType	Length	Width	DimensionComponents	Status
1/31/2014 11:59:57 PM	Fishing	100	0	50,50,0,0	Under way using
1/31/2014 11:59:57 PM	Cargo ships	50	9	36,14,6,3	Under way using
2/1/2014	Pleasure craft	88	14	32,56,5,9	Moored
2/1/2014	Tanker(s)	182	32	151,31,16,16	Under way using
2/1/2014 12:00:02 AM	Passenger ship	271	40	26,245,20,20	Moored
2/1/2014 12:00:02 AM	Engaged in dred	0	0	0,0,0,0	Under way using
2/1/2014 12:00:03 AM	Fishing	17	7	8,9,3,4	Under way using
2/1/2014 12:00:03 AM	Towing and len	38	12	11,27,6,6	Under way using
2/1/2014 12:00:03 AM	Towing	0	0	0,0,0,0	Under way using

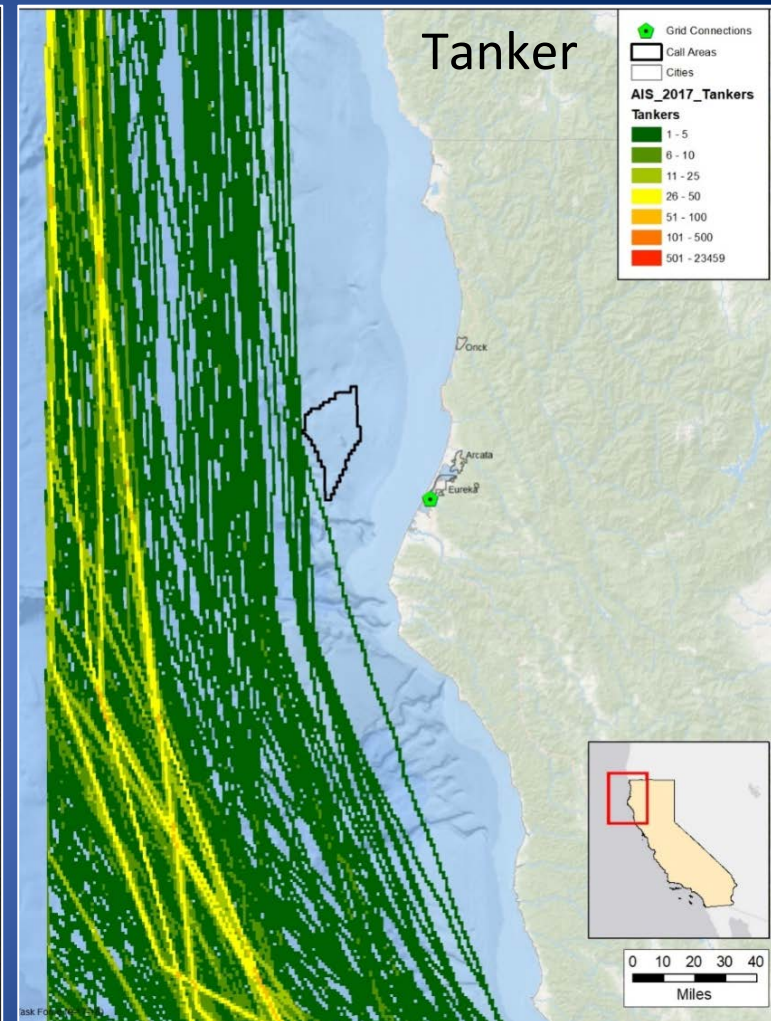
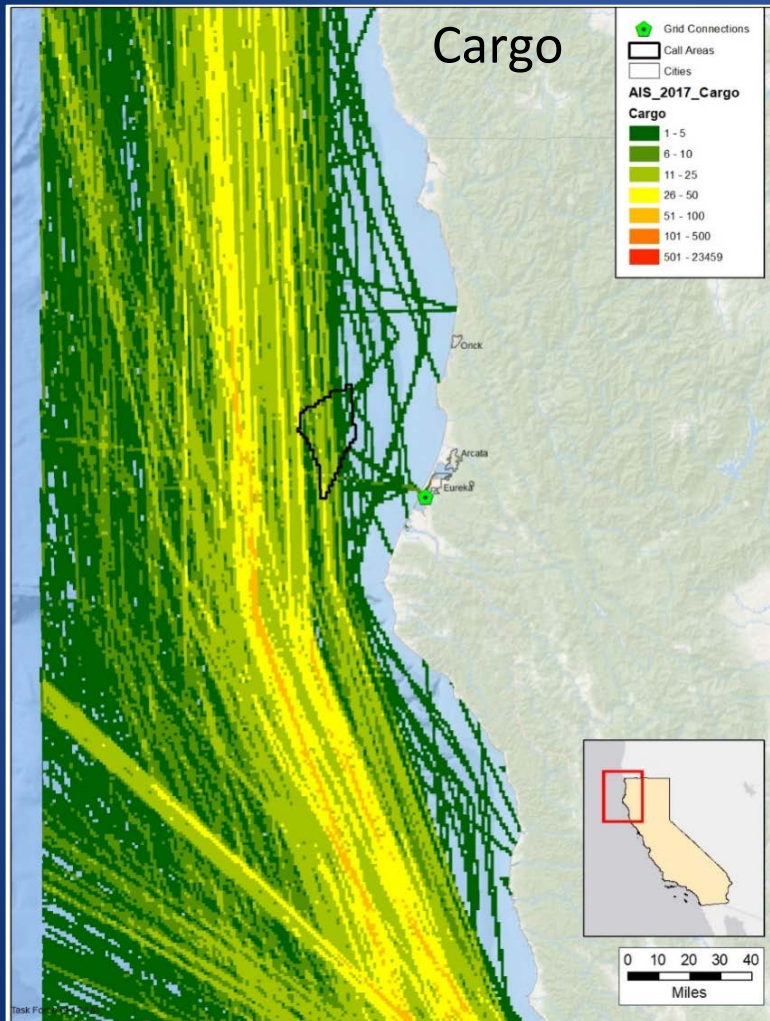
All Ships



All Ships 2017



Ship Type



Bird Data

- Survey Type
 - Observers (Ships)
 - *Observers (Aerial)*
 - Aerial Photos
- Models
 - Habitat Maps

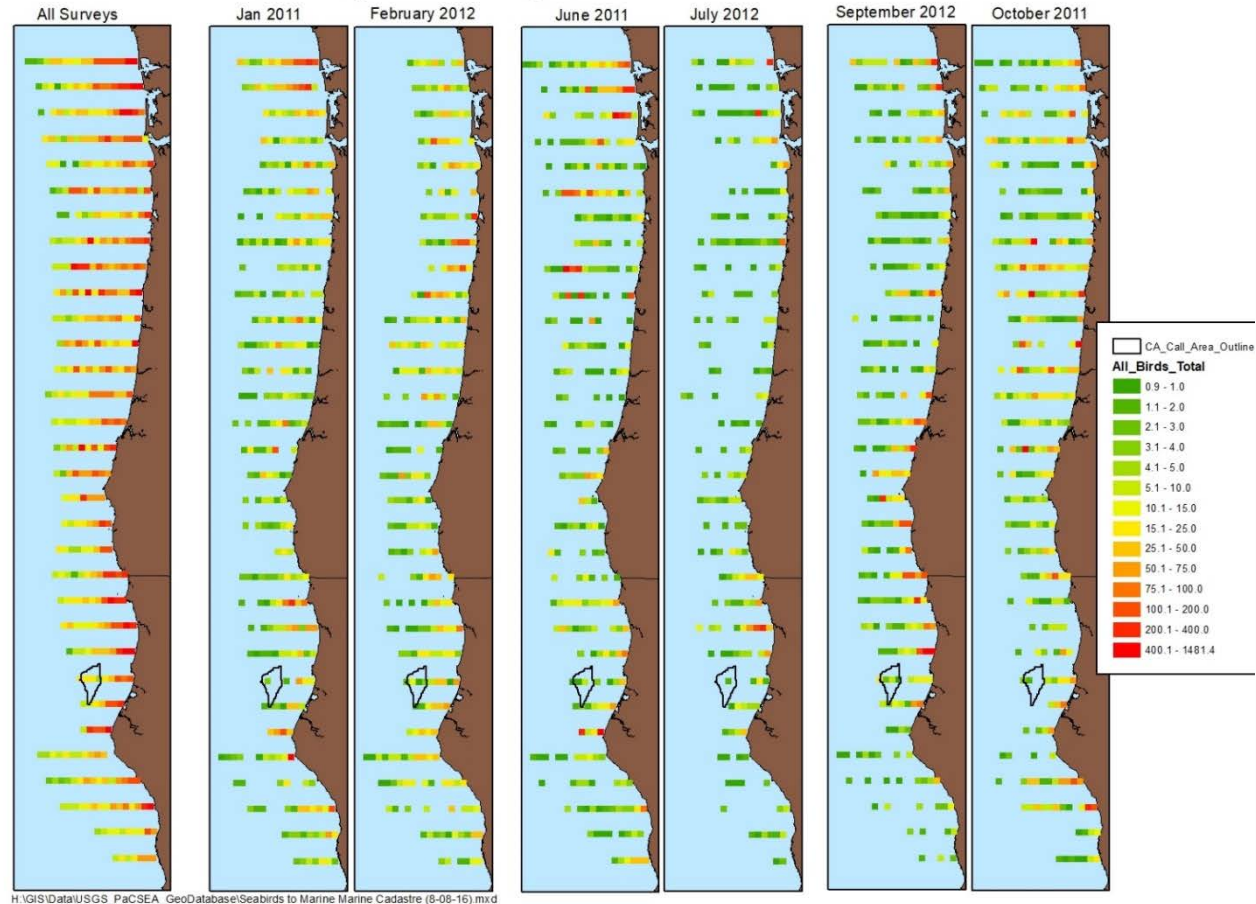


© David Pereksta

Bird Data

- PaCSEA
 - USGS, BOEM
 - Aerial Surveys
 - 2011 and 2012
 - 6 Surveys

PaCSEA Bird Survey Summary Data



Seabird Resources

- Vulnerability Index
 - USGS / BOEM
 - Conservation Status, Behavior, Flight Height...

- Bird Webinar Jan 8th 2020

Prepared in cooperation with Bureau of Ocean Energy Management
(OCS Study, BOEM 2016-043)

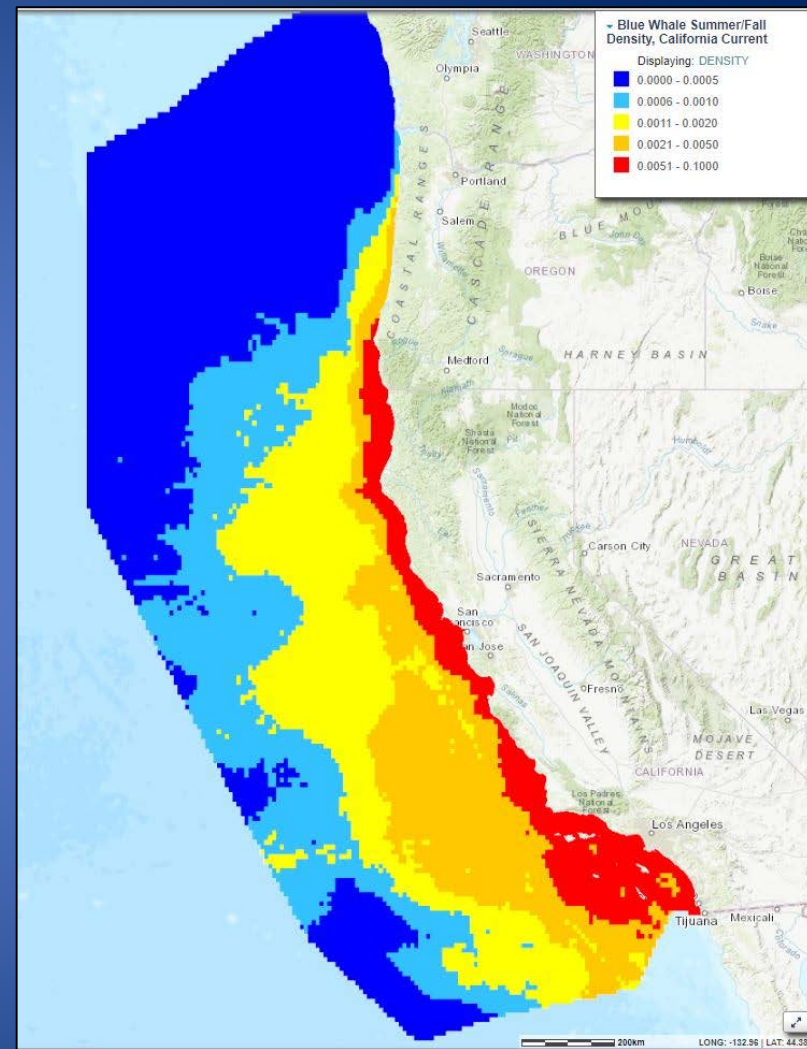
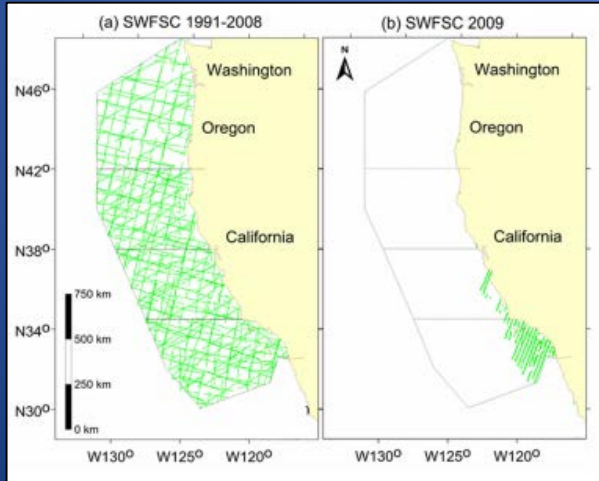
Collision and Displacement Vulnerability among Marine Birds of the California Current System Associated with Offshore Wind Energy Infrastructure



Open-File Report 2016-1154

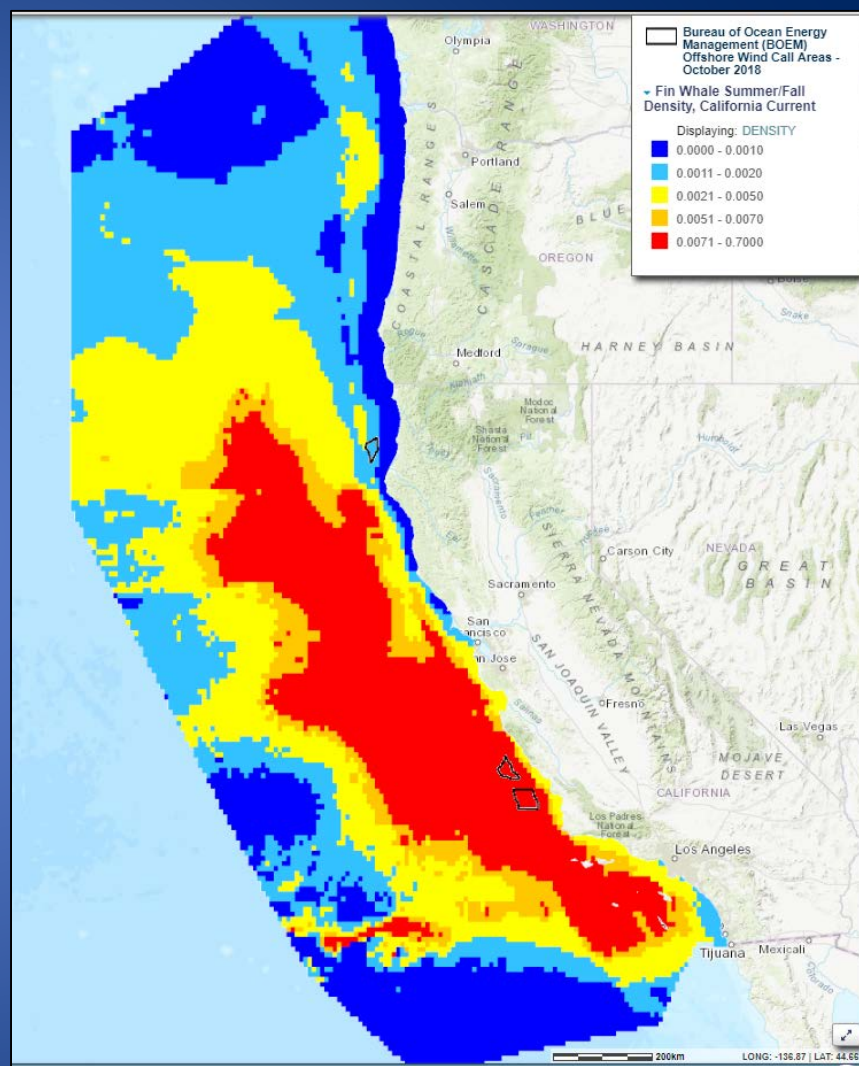
Marine Mammals

- Whales and Dolphins
 - NOAA
 - Surveys July – Dec
 - 1991, 1993, 1996, 2001, 2005, 2008



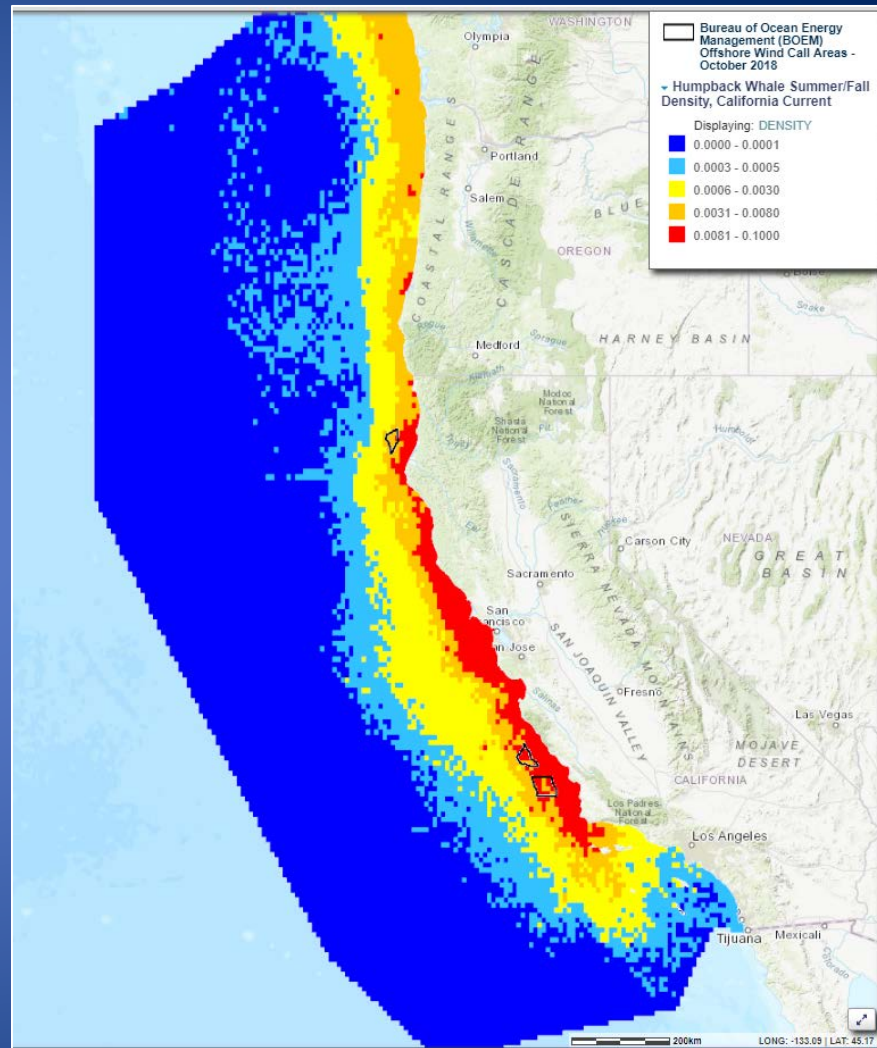
Marine Mammals

- Fin Whale
(Summer / Fall)



Marine Mammals

- Humpback Whale (Summer / Fall)



DataBasin

California Offshore Wind Energy Gateway

Databasin.org

The screenshot shows the DataBasin website interface. At the top, there is a navigation bar with tabs for 'Get Started', 'Explore', 'Create', 'Community', and 'My Workspace'. A search bar is located in the top right corner. Below the navigation bar, there is a main content area with a large image of a tiger's face. To the left of the tiger image are four blue buttons: 'What is Data Basin?', 'What can I do?', 'Who is using Data Basin?', and 'How do I start exploring?'. Below these buttons is a grey bar with the text 'Get started quickly with Data Basin' and a yellow 'Take a Tour' button. The main content area is divided into three columns. The left column is titled 'Explore Data Basin Guides & Case Studies...' and features a thumbnail image of a grassland with a lake. Below the image is the title 'Building a Network of Grassland Landscapes in the Midwest: Change Strategies for the Future of Grassland Birds' and a short paragraph of text. The middle column is titled 'Explore Data Basin Mapping Tools' and lists several bullet points: 'View and analyze geospatial conservation data', 'Collaborate with colleagues using sharing and commenting tools', 'Generate custom analyses and summary reports of your data', and 'And much more...'. Below this list is a section titled 'How to Create a Map' with a thumbnail image of a map. The right column is titled 'Gateways' and features a thumbnail image of a desert landscape. Below the image is a paragraph of text explaining what Gateways are and a 'See All Gateways' button. A red arrow points to the 'Gateways' section. At the bottom of the page, there is a section titled 'Upcoming Events' with the text 'No items at this time' and a 'see more' link.

DATA BASIN

Search by keyword or location

Get Started Explore Create Community My Workspace

What is Data Basin?

What can I do?


Who is using Data Basin?

How do I start exploring?

Data Basin is a science-based mapping and analysis platform that supports learning, research, and sustainable environmental stewardship.

Get started quickly with Data Basin [Take a Tour](#)

Explore Data Basin Guides & Case Studies...



Building a Network of Grassland Landscapes in the Midwest: Change Strategies for the Future of Grassland Birds

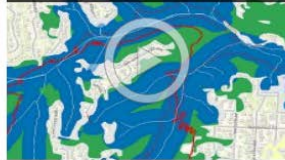
The Midwest Grasslands Network recognizes that successful grassland conservation needs to take effect at larger scales and in permanent ways in order to halt the long-term declines of grassland bird populations. In 2015 the Network convened a seminar to develop strategies for scaling up... [read more](#)

Explore Data Basin Mapping Tools

With the Data Basin full-screen mapping tools, you can:

- View and analyze geospatial conservation data
- Collaborate with colleagues using sharing and commenting tools
- Generate custom analyses and summary reports of your data
- And much more...

How to Create a Map



Gateways

Gateways are unique spaces for finding curated spatial data. They build upon the existing Data Basin framework and are customized to meet the needs of a target audience. Customizations can include custom mapping and analysis tools.

[See All Gateways](#)

Upcoming Events

No items at this time [see more](#)

DataBasin

CA Offshore Wind Energy Gateway

Databasin.org

DATA BASIN

Search by keyword or location

Get Started Explore Create Community My Workspace

Gateways

Data Basin sites curated to meet a specific need

Gateways are sites powered by Data Basin and curated by members of various interest groups. They showcase spatial information for a particular geography, topic, project or organization. Gateways include a subset of the data available on Data Basin.

<p>AdaptWest - A Climate Adaptation Conservation Planning Database for Western North America</p>	<p>Alaska and Northwest Canada Regional Conservation Planning Atlas</p>	<p>Appalachian LCC Conservation Planning Atlas</p>
<p>Bat Acoustic Monitoring Portal</p>	<p>The Boreal Avian Modelling Project</p>	<p>California Offshore Wind Energy Gateway</p>
<p>California Water Planning Information Exchange</p>	<p>The Caribbean Landscape Conservation Cooperative</p>	<p>Conservation Biology Institute Climate Center</p>

DataBasin

California Offshore Wind Energy Gateway

Databasin.org

The screenshot shows the homepage of the California Offshore Wind Energy Gateway. At the top, there is a logo for the gateway, which includes a stylized lightbulb with a wind turbine inside, and the text "California Offshore Wind Energy Gateway" and "In support of the Intergovernmental Renewable Energy Task Force". To the right of the logo is a search bar with the text "Search by keyword or location" and a magnifying glass icon. Below the search bar is the text "powered by DATA BASIN".

The main navigation bar consists of five tabs: "Get Started", "Explore", "Create", "Community", and "My Workspace".

The "Get Started" section contains three links: "What is the California Offshore Wind Energy Gateway?", "What can I do?", and "How do I start exploring?".

The "Explore" section features a large text block: "The Offshore Renewable Wind Energy Gateway assembles geospatial information on ocean wind resources, ecological and natural resources, ocean commercial and recreational uses and community values. This information will help identify areas off of California that are potentially suitable for wind energy generation." Below this text is a "read more" link. To the right of the text is a large image of ocean waves. A red arrow points from the "read more" link to the "California Marine & Coastal Ecology and Natural Resources" tile.

Below the "Explore" section are four tiles representing different categories: "California Marine & Coastal Energy", "California Marine & Coastal Management", "California Marine & Coastal Ecology and Natural Resources", and "California Marine Fishing and Traditional Uses".

The "Featured Items" section displays six map thumbnails with titles: "California Commercial Fishing Recent History", "West Coast USA Federal and State Marine Protected Areas", "California Offshore Wind Resources", "Central California Offshore Use Zones", "Central California Offshore Geology and Wind Technology Depth Zones", and "Central California Offshore Biological Resources".

The "California Off-Shore Wind Resources" section features a large map of the California coast showing wind resource potential. Below the map is the text: "This map is comprised of spatial datasets provided by BOEM to highlight wind resources along the coast of California along with some other designations."

At the bottom of the page, there are two buttons: "Download the Fact Sheet & Get Involved" and "Follow Progress".

California Offshore Wind Energy Gateway
In support of the Intergovernmental Renewable Energy Task Force

Search in this gallery

powered by DATA BASIN

Get Started **Explore** **Create** **Community** **My Workspace**

CA OFFSHORE WIND ENERGY | GALLERIES | CALIFORNIA MARINE & COASTAL ECOLOGY AND NATURAL RESOURCES

California Marine & Coastal Ecology and Natural Resources

Created by Conservation Biology Institute Mar 16, 2017 (Last modified Mar 27, 2017)



About
This gallery contains datasets and maps pertaining to the biological and ecological resources of the coastal and marine environments off in California.

Tags
california, wind

Gallery Contents

This gallery is visible to everyone

Gallery contains

- 27 Folders
- 216 Datasets
- 13 Maps

Gallery Contents

Sort by: Display:

-  **Dataset**
Pelagic Important Bird Areas
-  **Dataset**
Passage Assessment Database (PAD)
-  **Dataset**
NFHAP Coastal Assessment - Coastal Habitat Condition Index Scores
-  **Dataset**
Areas of Special Biological Significance
-  **Dataset**
ACP Environmental Sensitive Sites
-  **Dataset**
California Estuaries

Birds (8 folder(s) and 66 item(s))

Fishes (29 items)

Marine Mammals (7 folder(s) and 76 item(s))

Physical Setting (20 items)

Sea Turtles (5 folder(s) and 9 item(s))

Special Habitats & Invertebrates (20 items)



Maps bring data into your soul...
“trog luddite”

frank.pendleton@boem.gov

