Potential for Combined Offshore Wind and Wave Energy Harvesting in the Carolinas

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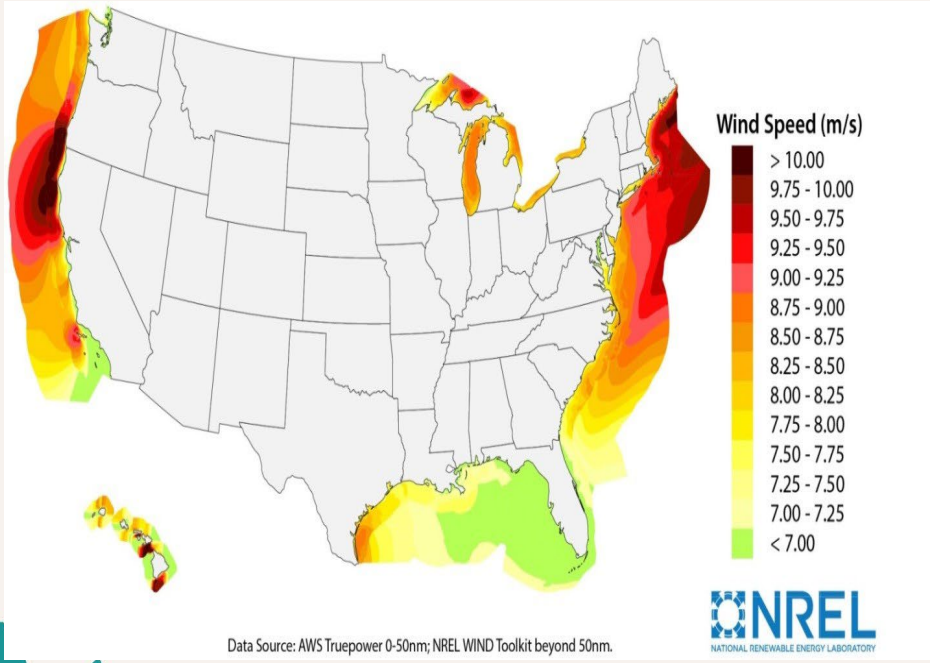
Offshore Wind Energy



- Technical resource potential of more than 2,000 GW of capacity, or 7,200 TWh of annual generation.
- Nearly double the nation's current electricity use.
- Even if only 1% of the technical potential is recovered, it can power 6.5 million homes.
- Developing just 86 GW, or about 4% of the technical resource potential by 2050 would support 160,000 jobs and reduce America's greenhouse gas emissions by 1.8%.

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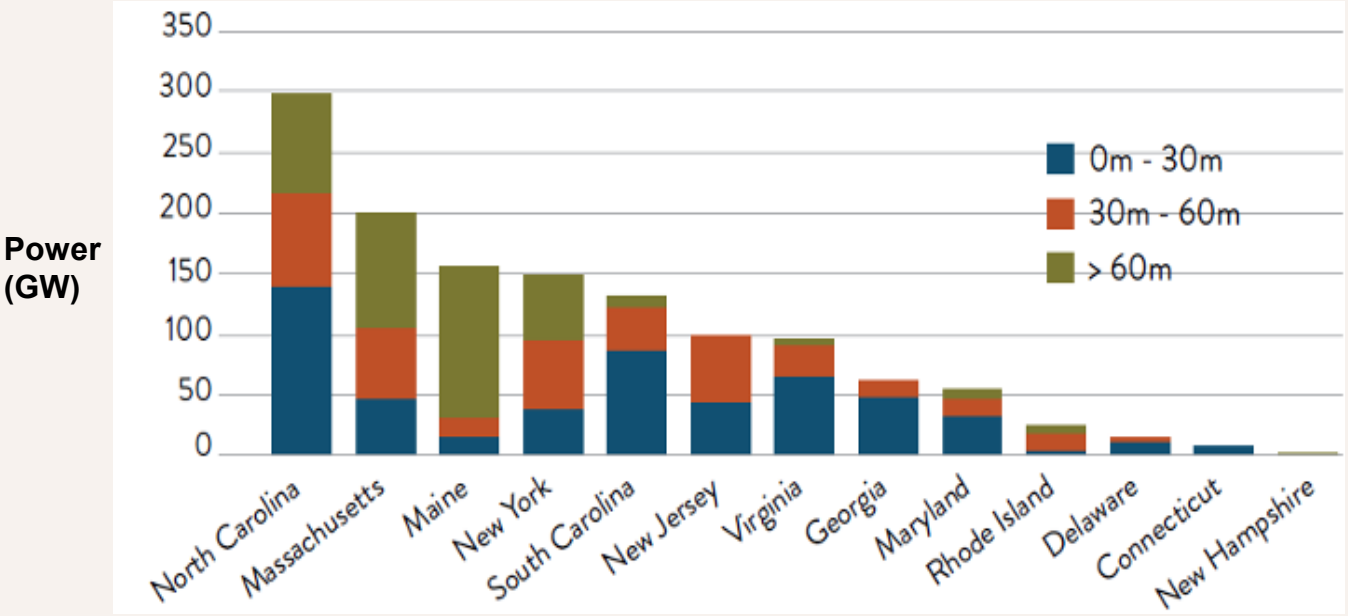
Offshore Wind Energy



NC has the highest gross OSW potential along the Atlantic seaboard (50% more than the next highest state, MA)

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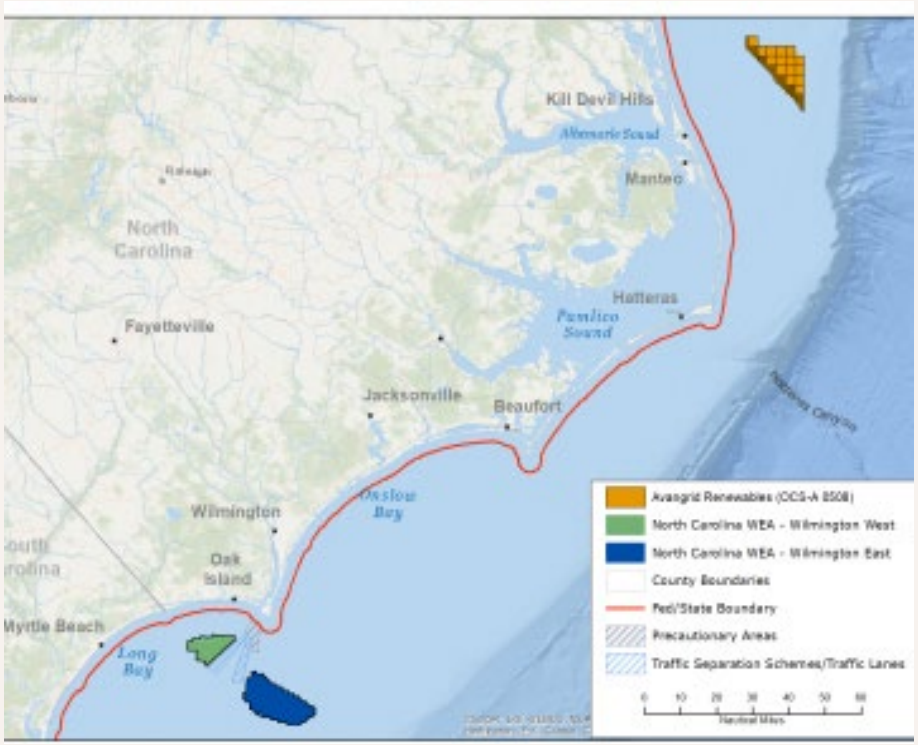
Federal and State Targets

US Government has set a goal of deploying 30 gigawatts (GW) of offshore wind by 2030, enough to power 10 million homes, and support 77,000 jobs.

Governor Cooper's Executive Order No. 218 established NC Taskforce for Offshore Wind Economic Resource Strategies (NC TOWERS) and set the state's OSW development targets: 2.8 GW by 2030 and 8.0 GW by 2040.



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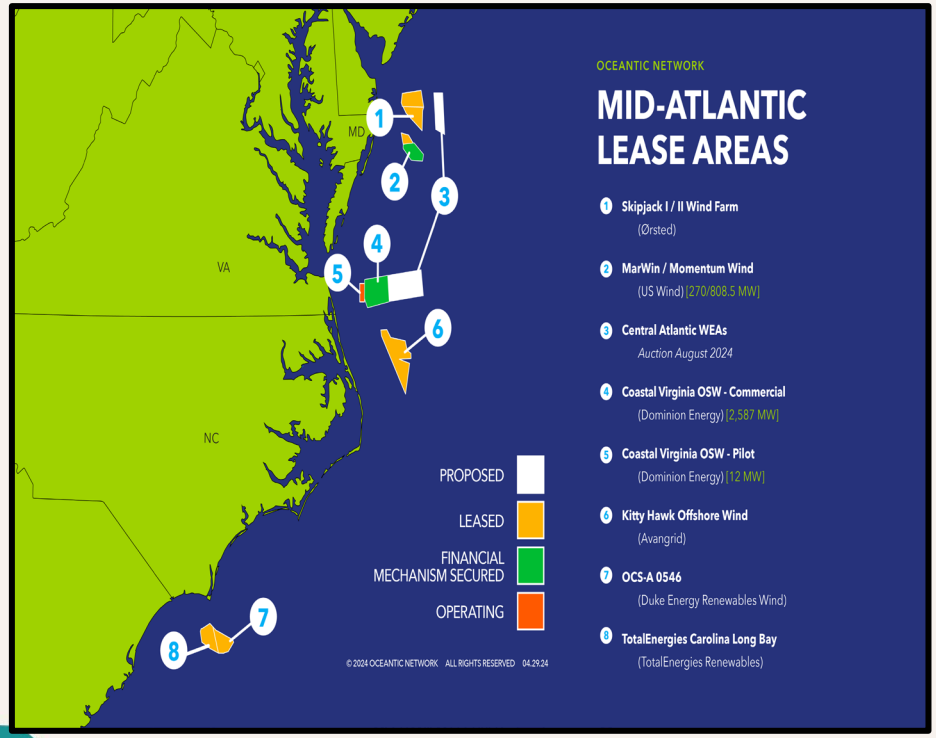

Coastal Virginia Offshore Wind (CVOW – North) Pilot turbines (12 MW)

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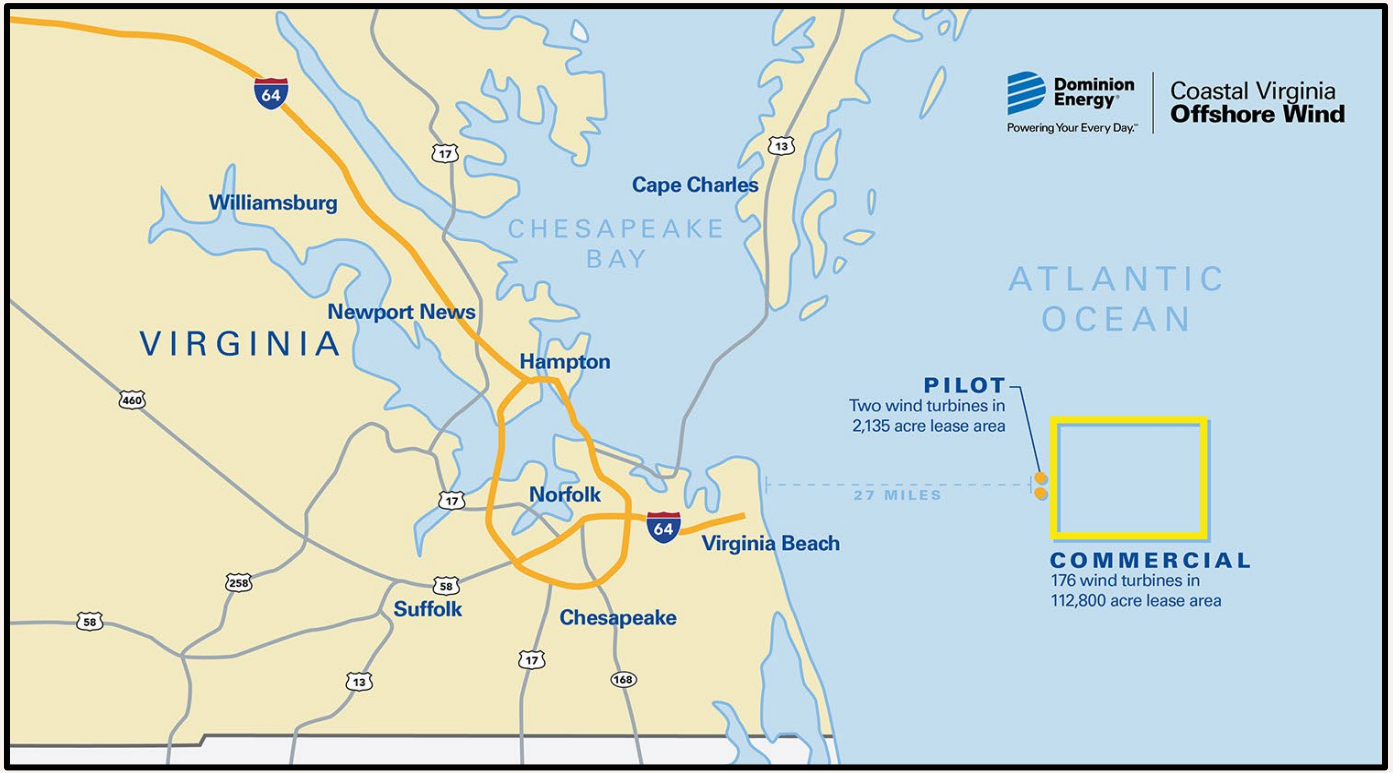

Coastal Virginia Offshore Wind (CVOW) Project

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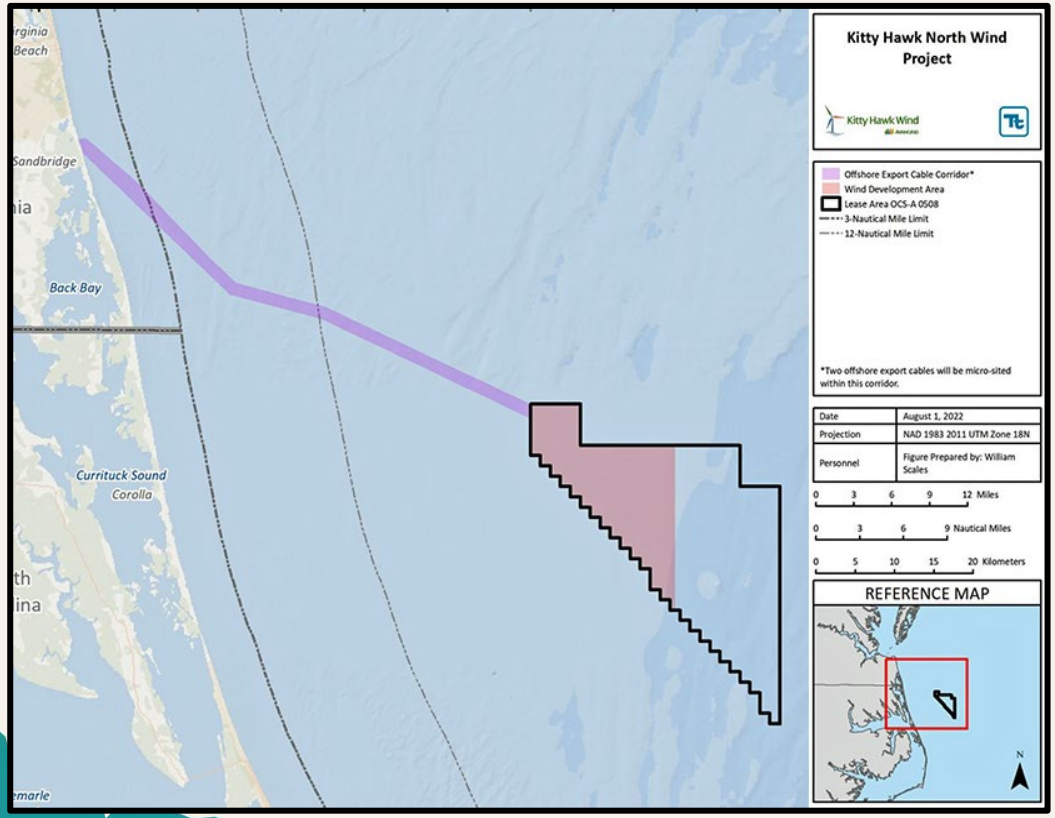

Dominion Energy to buy N.C. offshore wind lease for $160M

Fortune 500 utility will acquire Kitty Hawk North Wind lease from Avangrid

July 8, 2024

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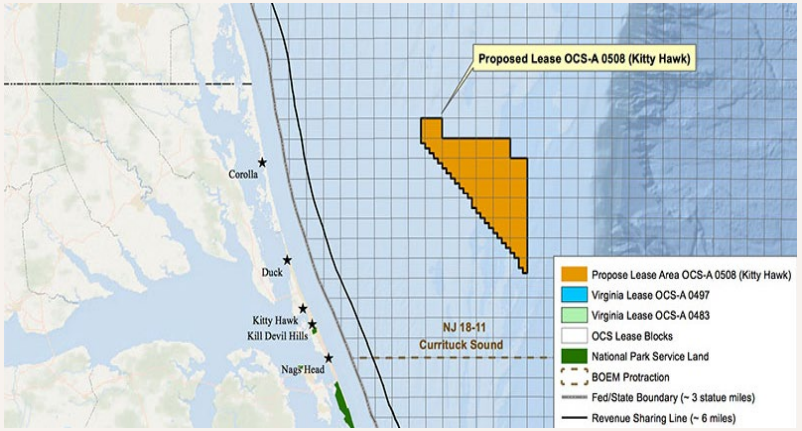
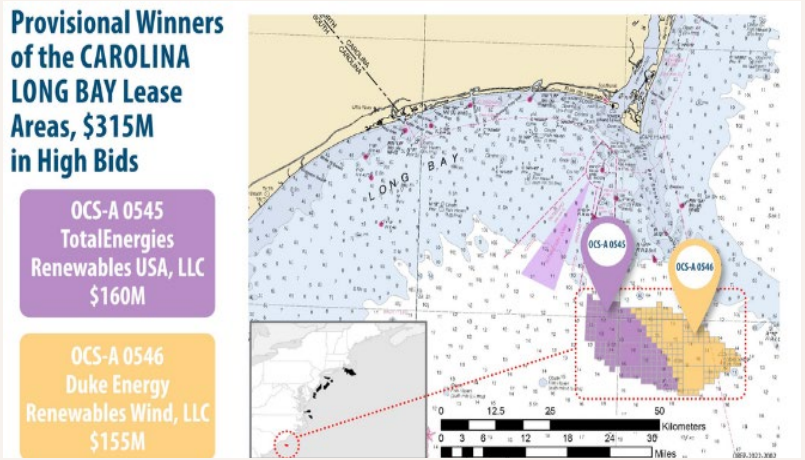
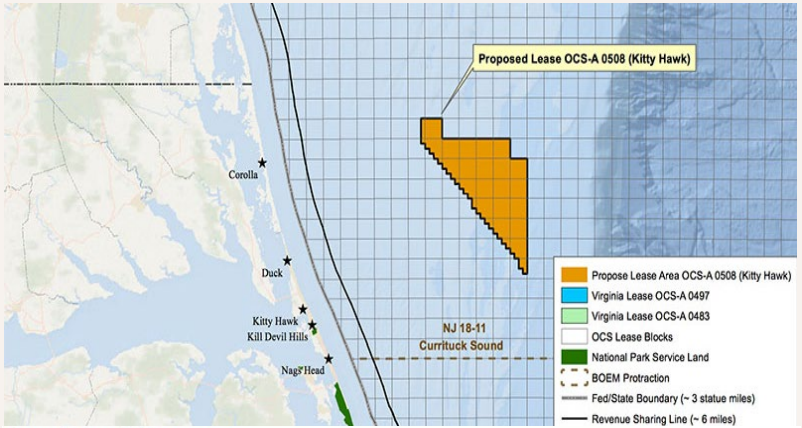
NC OSW Leases

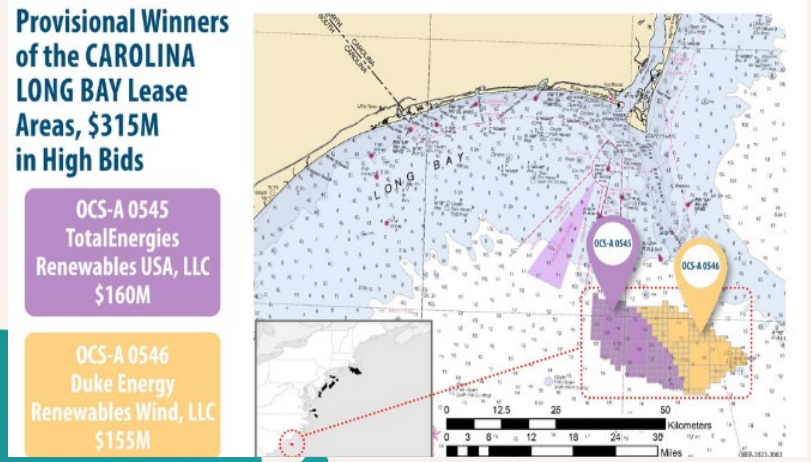
Lease Areas	Kitty Hawk	OCS-A 0545	OCS-A 0546
Owners	Dominion Energy/ Avangrid	TotalEnergies	Cinergy
Area [Acres]	122,405	54,937	55,154
Wind Power [GW]	3.5	0.889	1.3
Distance from Shore [NM]	27	22	22





NC OSW Leases





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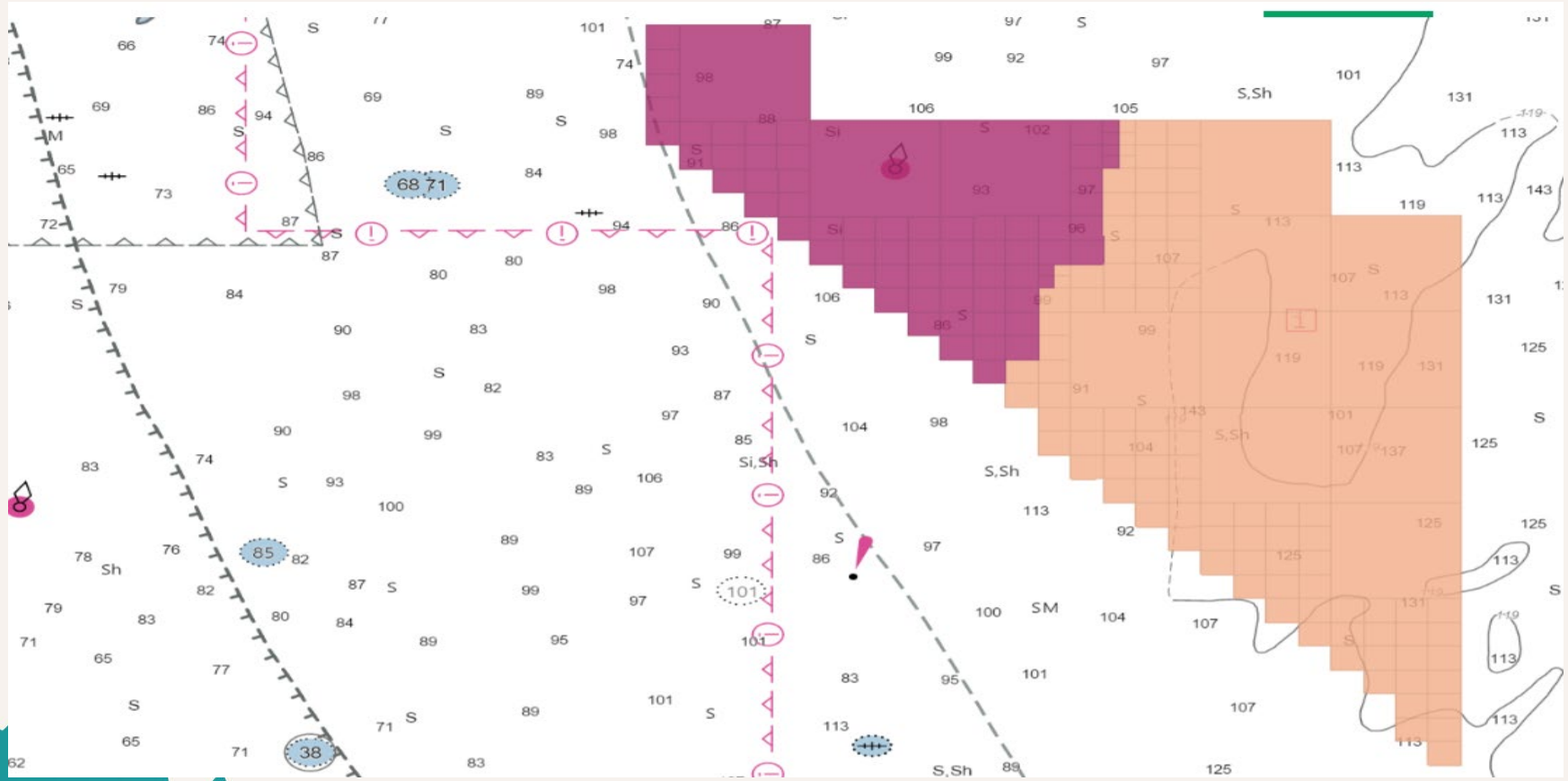
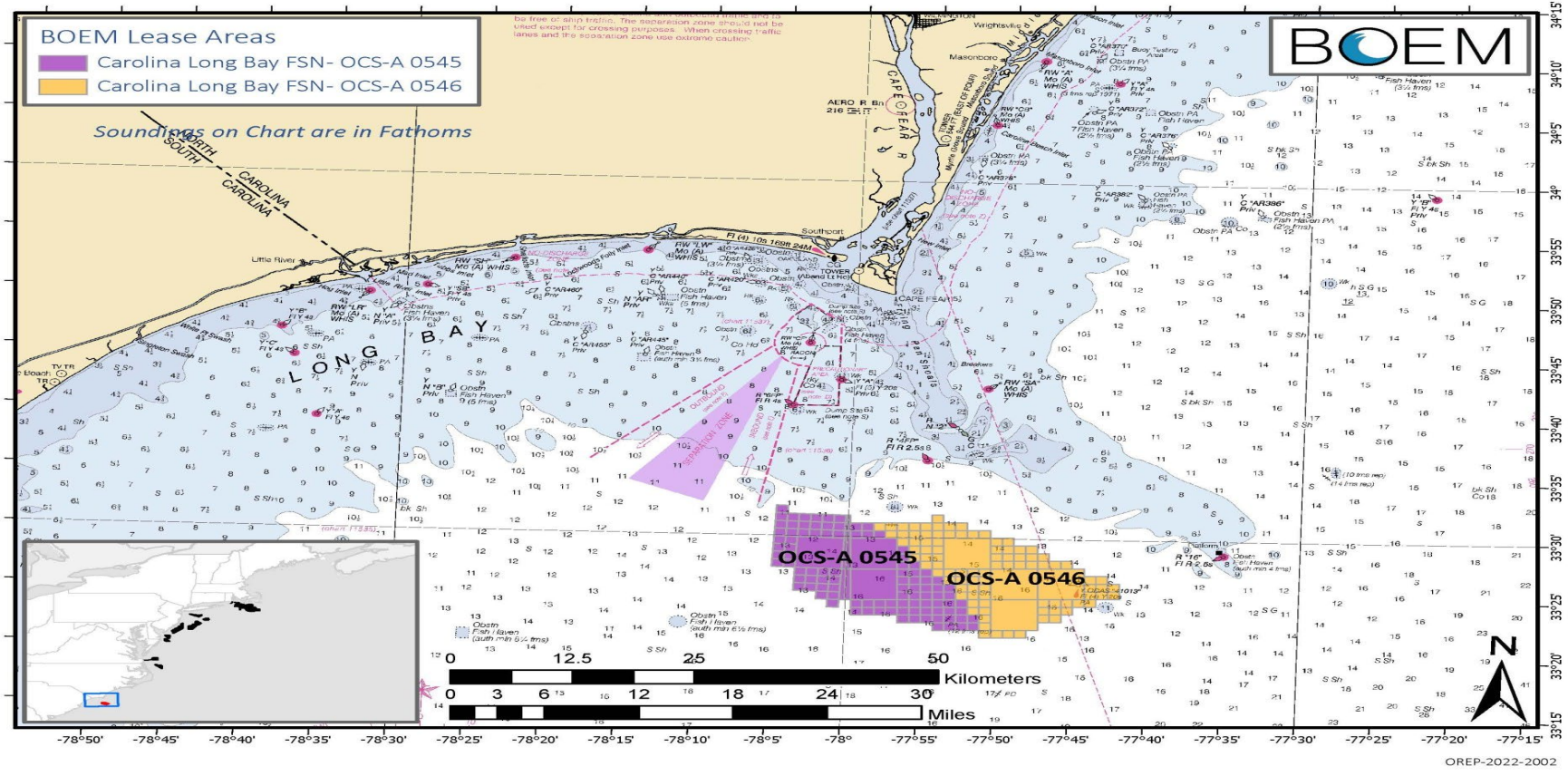


Carolina Long Bay - Final Notice of Sale Areas - March 25, 2022



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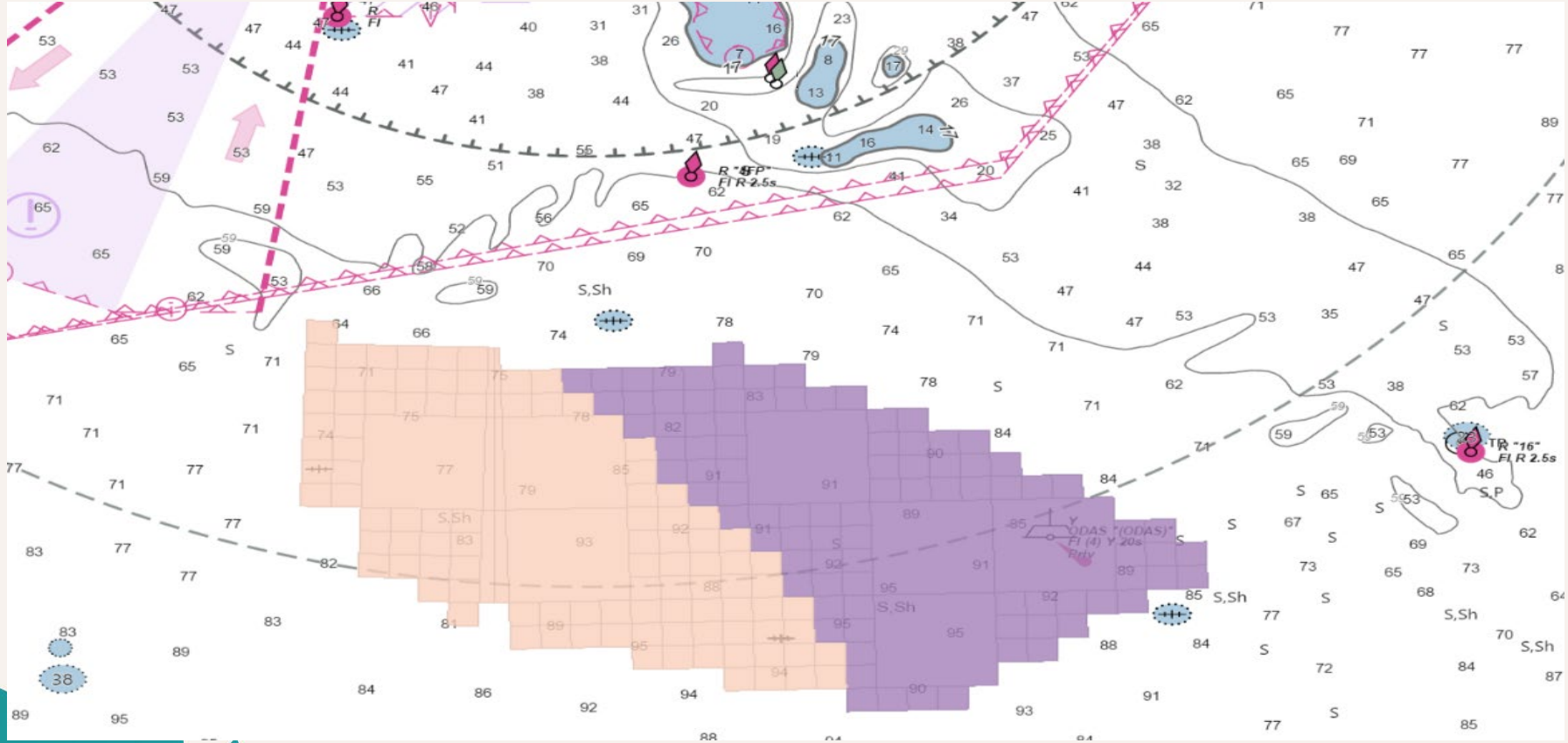

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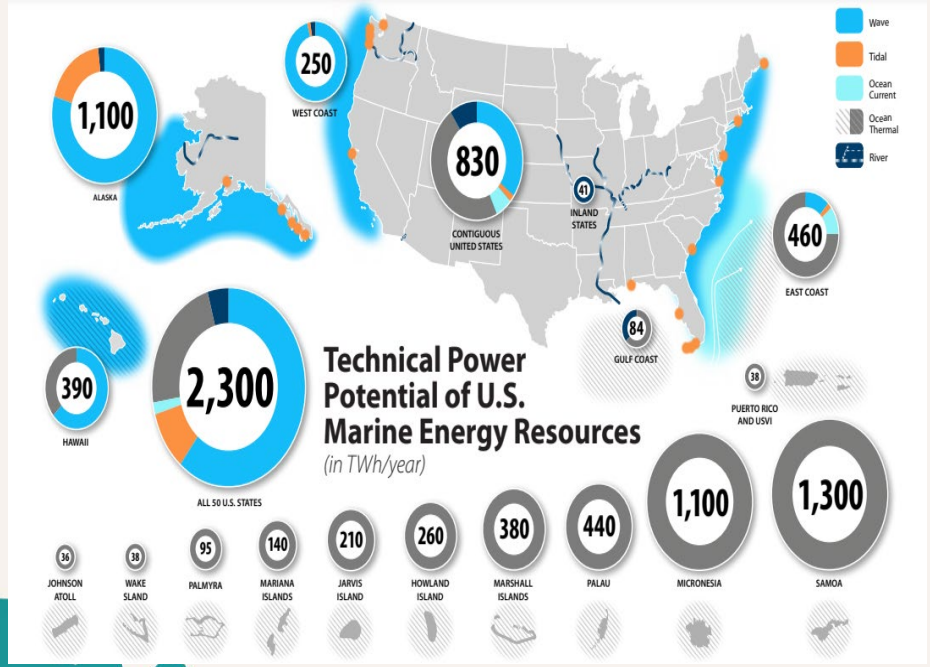
Marine Energy Potential



Objectives

- Wave energy resource assessment in OSW lease areas
- Potential for combined wind and wave energy harvesting
- Examine seasonal variations in wind and wave resources.

Provision for a marine energy testing block in OSW lease area

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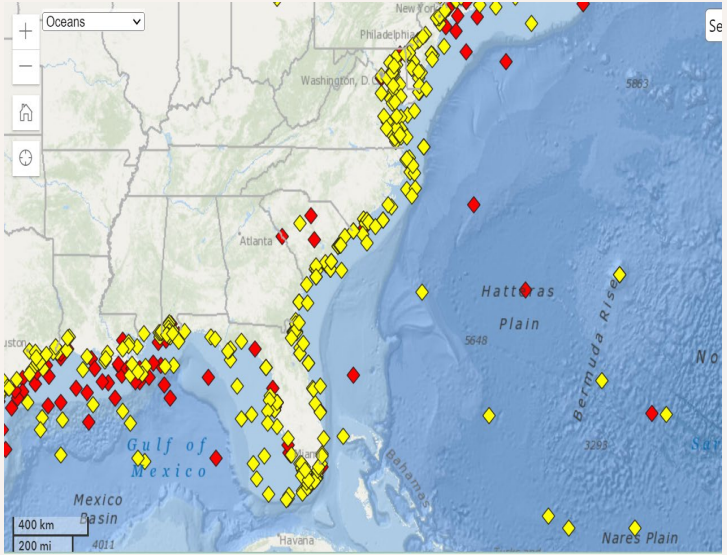
Data Sources



- Innovative Data Energy Applications (IDEA) group in Strategic Energy Analysis Center (SEAC)
- WIND (Wind Integration National Dataset) Toolkit
  - Meteorological data based on mesoscale model
  - Wind power production data
  - Power and wind speed forecast data
- NREL's National Solar Radiation Database (Met data including wind speeds)
- NREL's Marine Energy Atlas (Hindcast data: 1979 – 2010, 3-hourly data)
- NOAA's National Data Buoy Center (NDBC) Buoys (2010 to present, hourly data)

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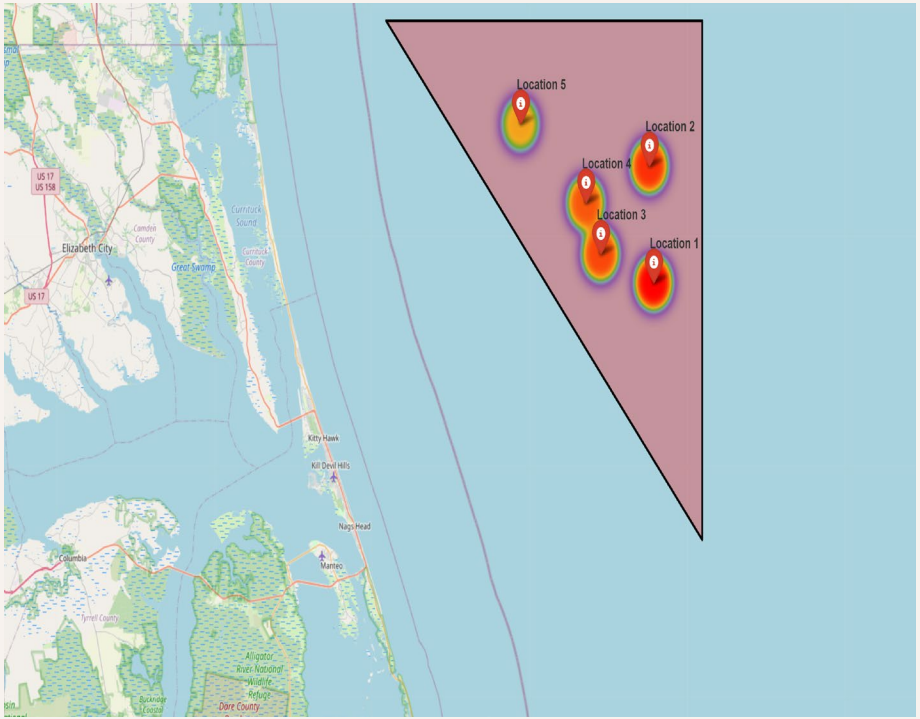
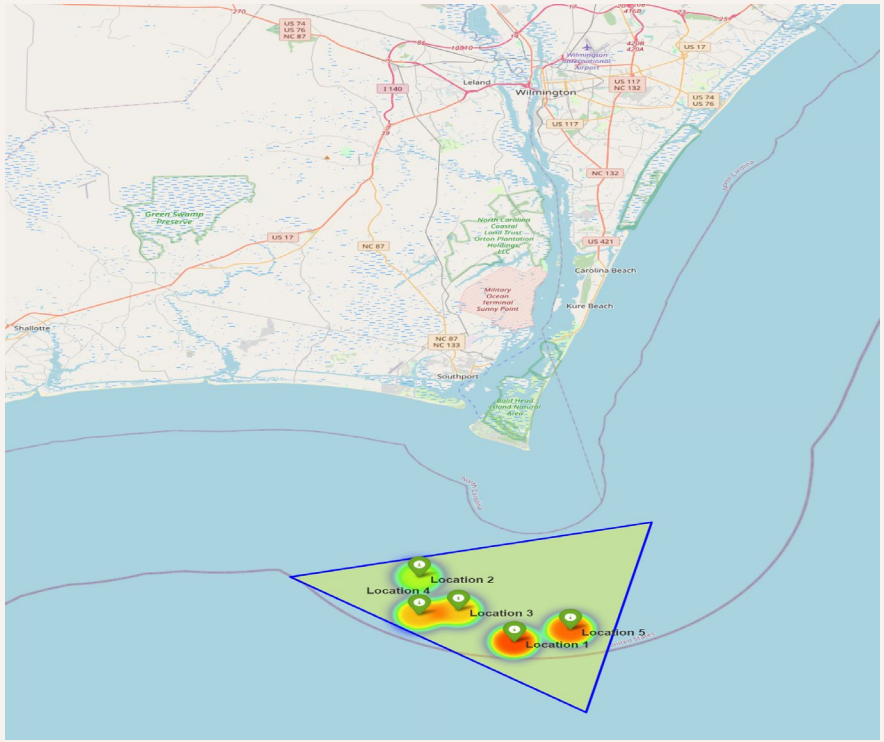


Omnidirectional wave power for 5 locations in Kitty Hawk Lease Area



Omnidirectional wave power for 5 locations in Carolina Long Bay Lease Area

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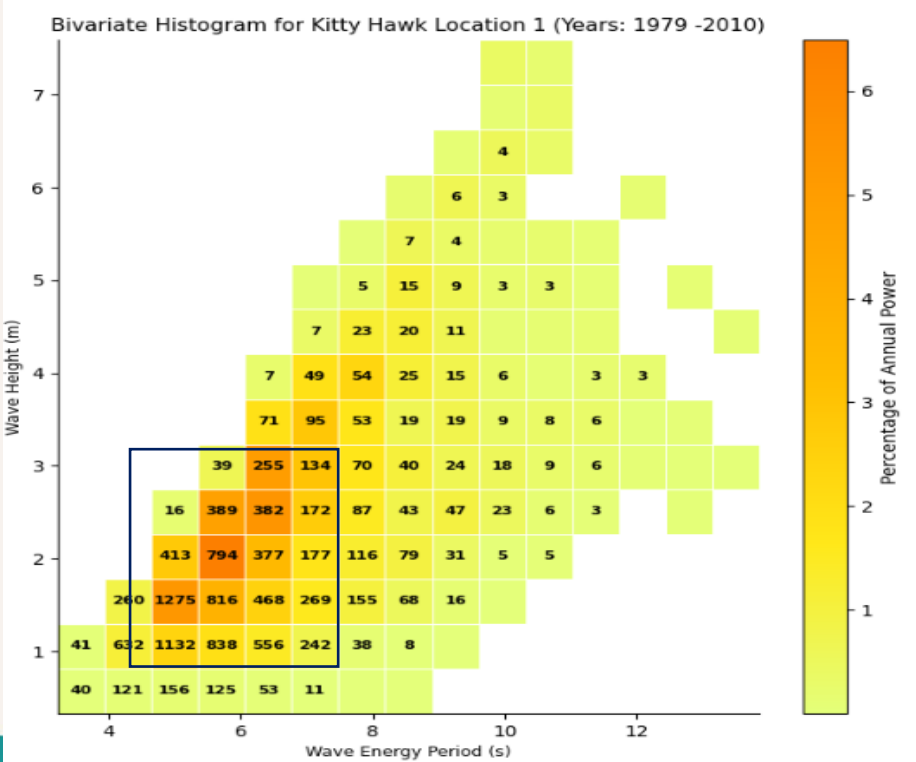
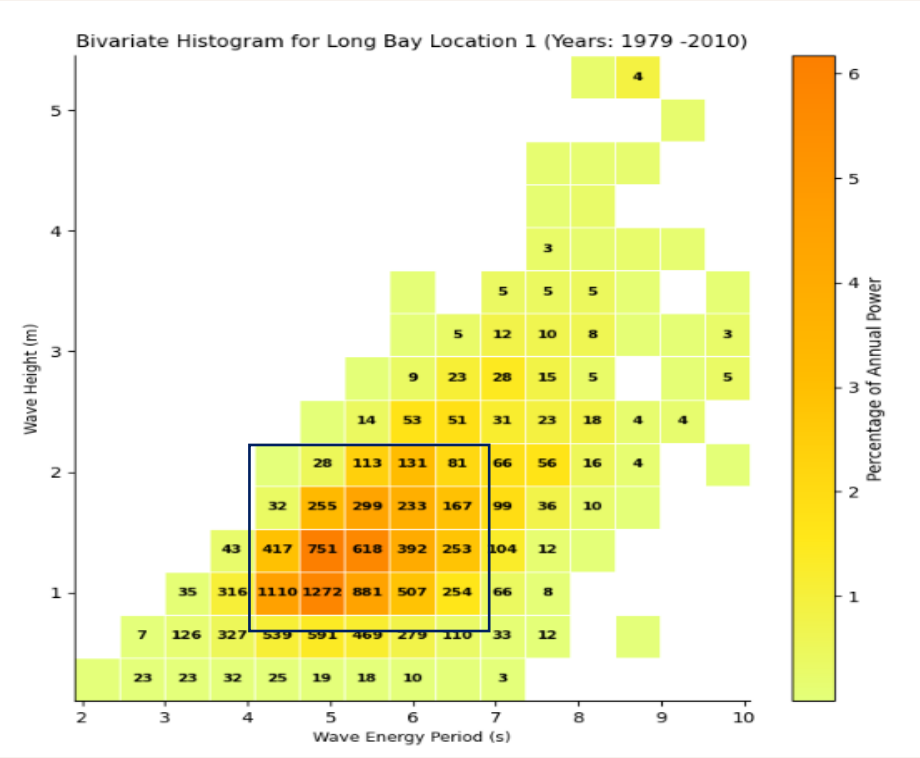


Bivariate Histogram - Kitty Hawk Location 1



Bivariate Histogram – Carolina Long Bay Location 1

Kitty Hawk		
Locations	Occurrences (Days)	Contribution to Annual Power (%)
1	1275	5.8
2	1273	5.6
3	1249	5.3
4	1235	5.2
5	1199	4.8

Most Frequent Sea State: 1.5 m and 5 s

Carolina Long Bay		
Location	Occurrences (Days)	Contribution to Annual Power (%)
1	1272	5.8
2	1402	5.0
3	1363	5.2
4	1407	5.5
5	759	3.0

Most Frequent Sea State: 1.0 m and 4.5 s

Most Frequent Sea States and their Contributions to Annual Wave Power

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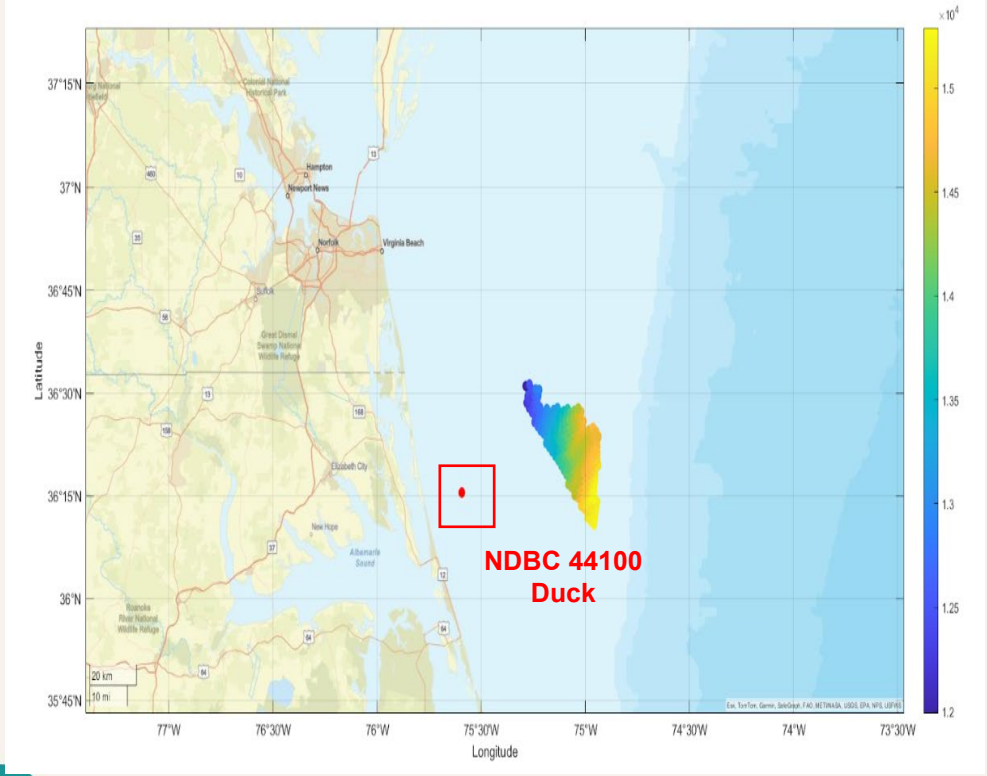
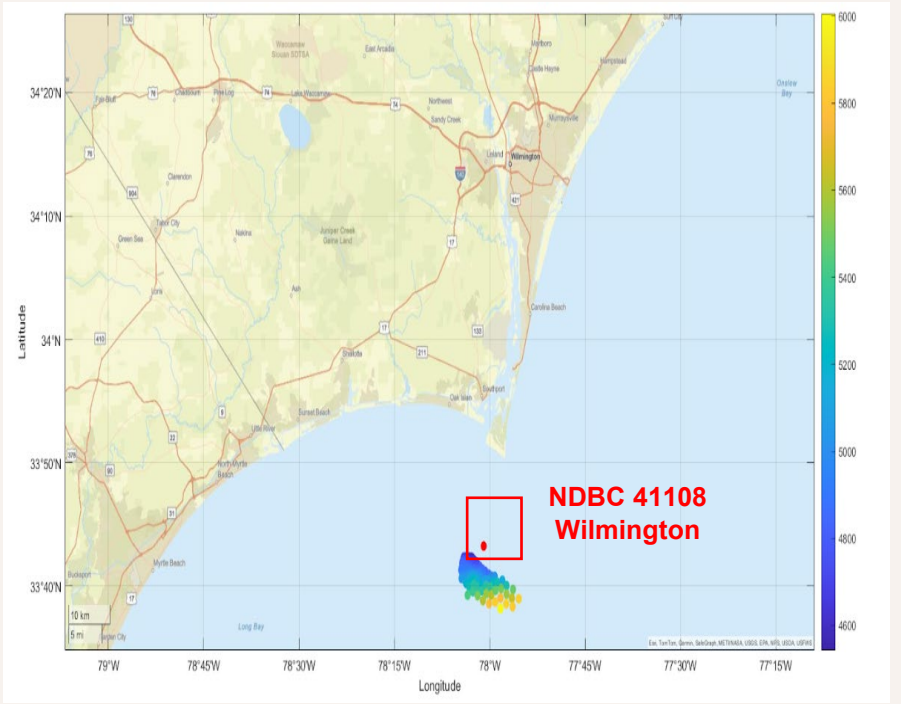


Kitty Hawk Lease Area map with NDBC Station 44100 – Duck, NC



Carolina Long Bay Lease Area map with NDBC Station 41108 – Wilmington Harbor

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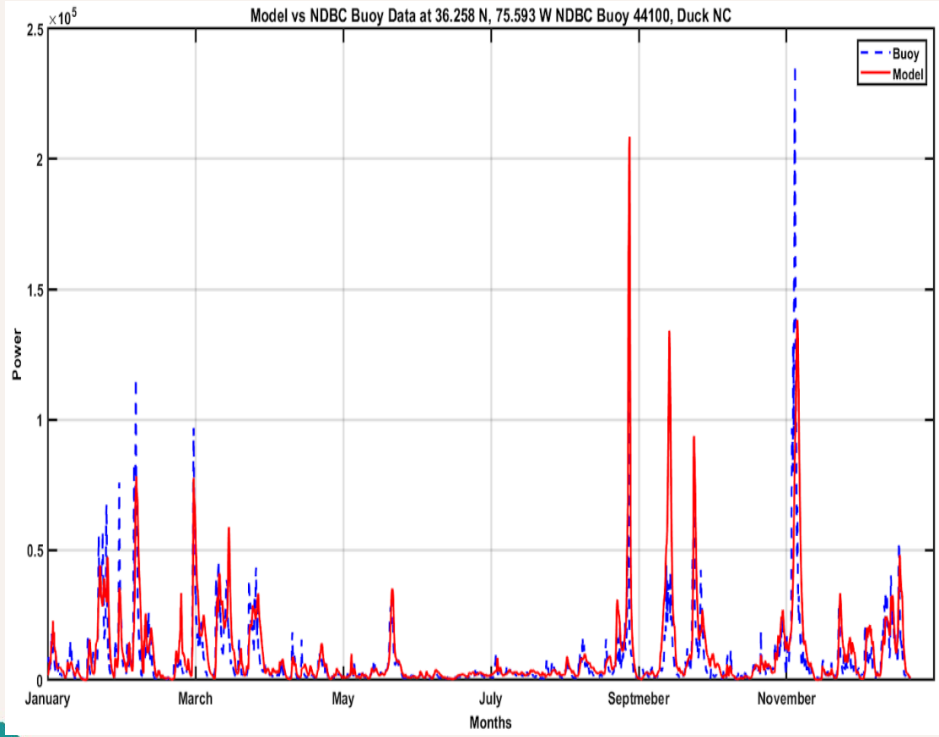

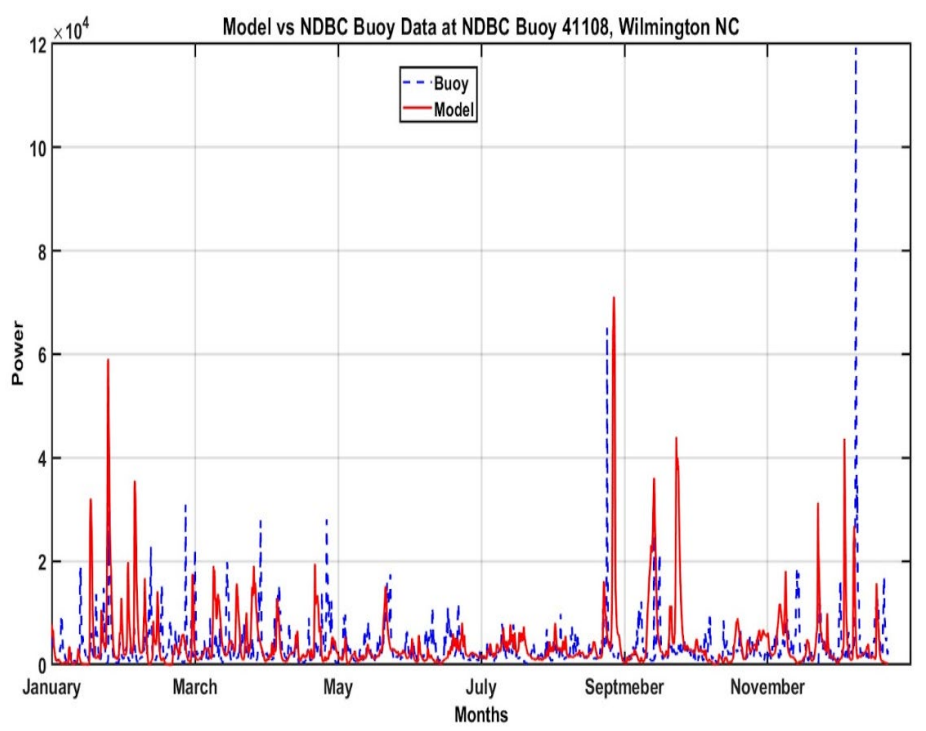

Model data validation with NDBC Station 44100 – Kitty Hawk

Model Data validation with NDBC Station 41108 Carolina Long Bay

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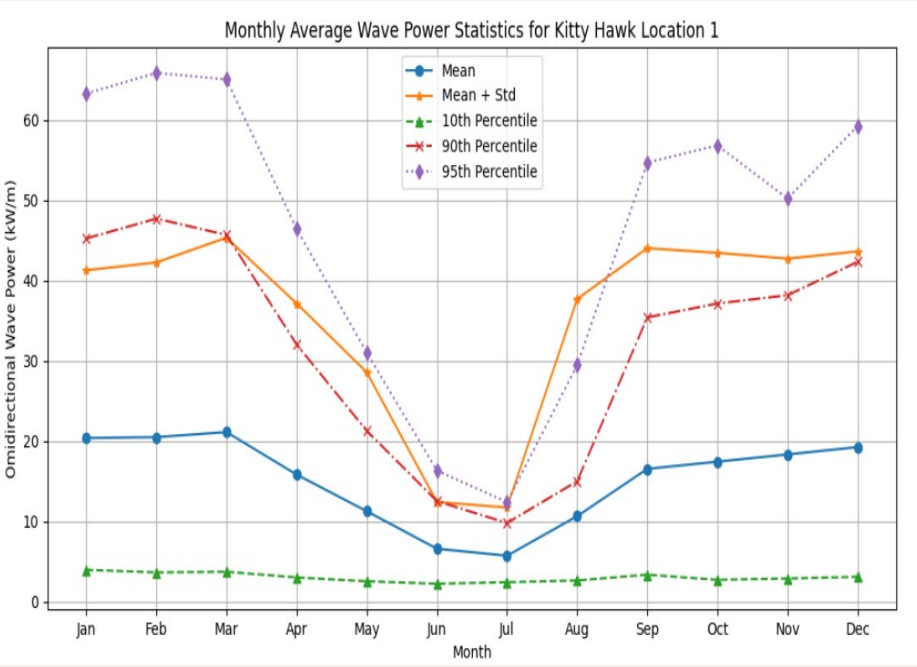
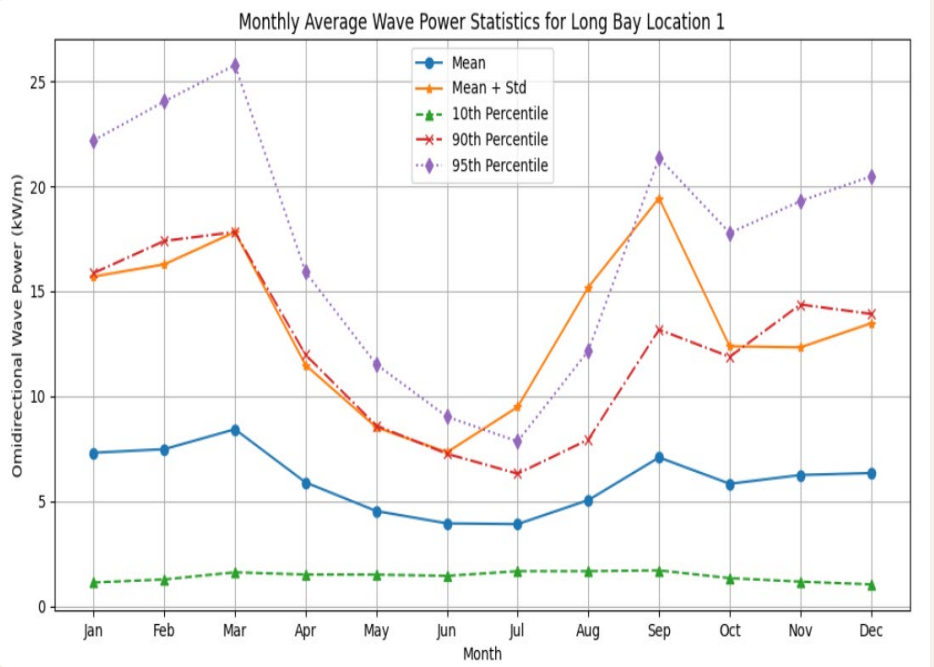
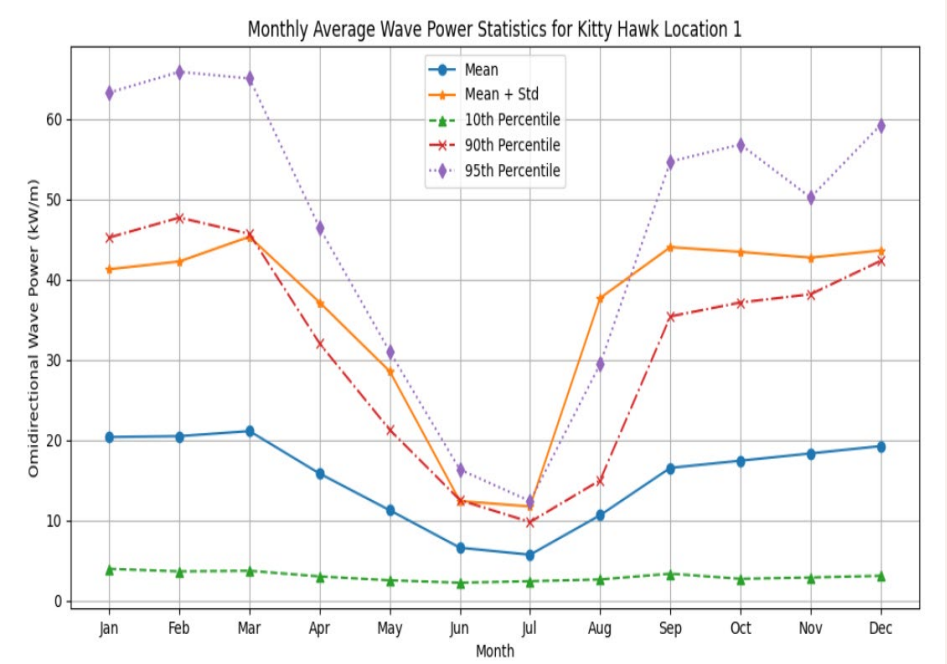
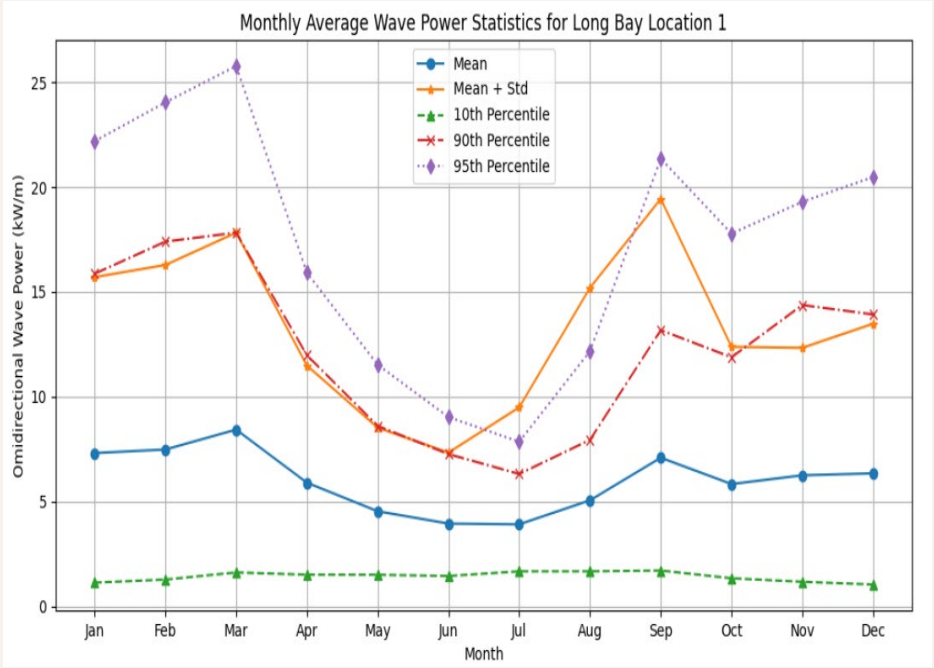




Monthly statistics - Kitty Hawk Location 1

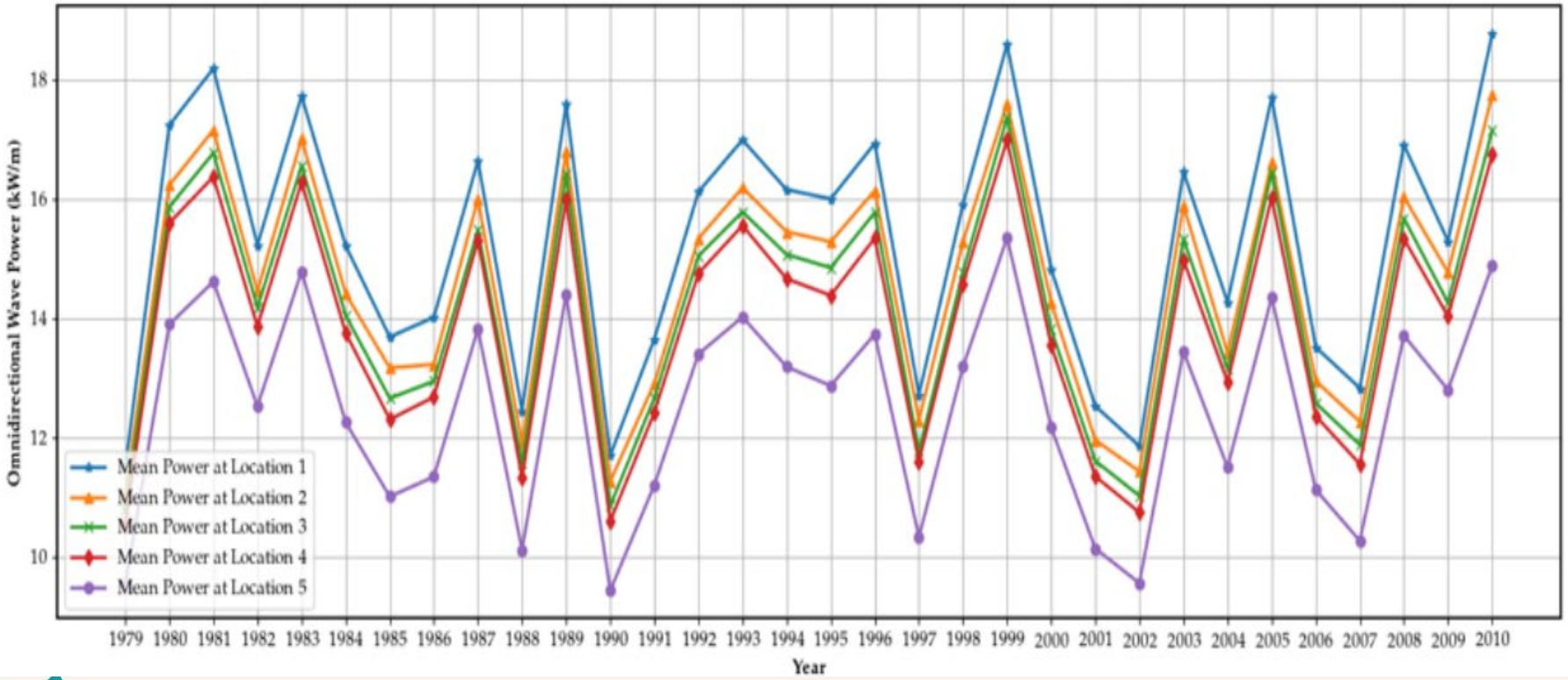
Monthly statistics – Carolina Long Bay Location 1





Monthly statistics - Kitty Hawk Location 1

Monthly statistics – Carolina Long Bay Location 1



Kitty Hawk: Yearly Variation in Omnidirectional power from 1979 to 2010

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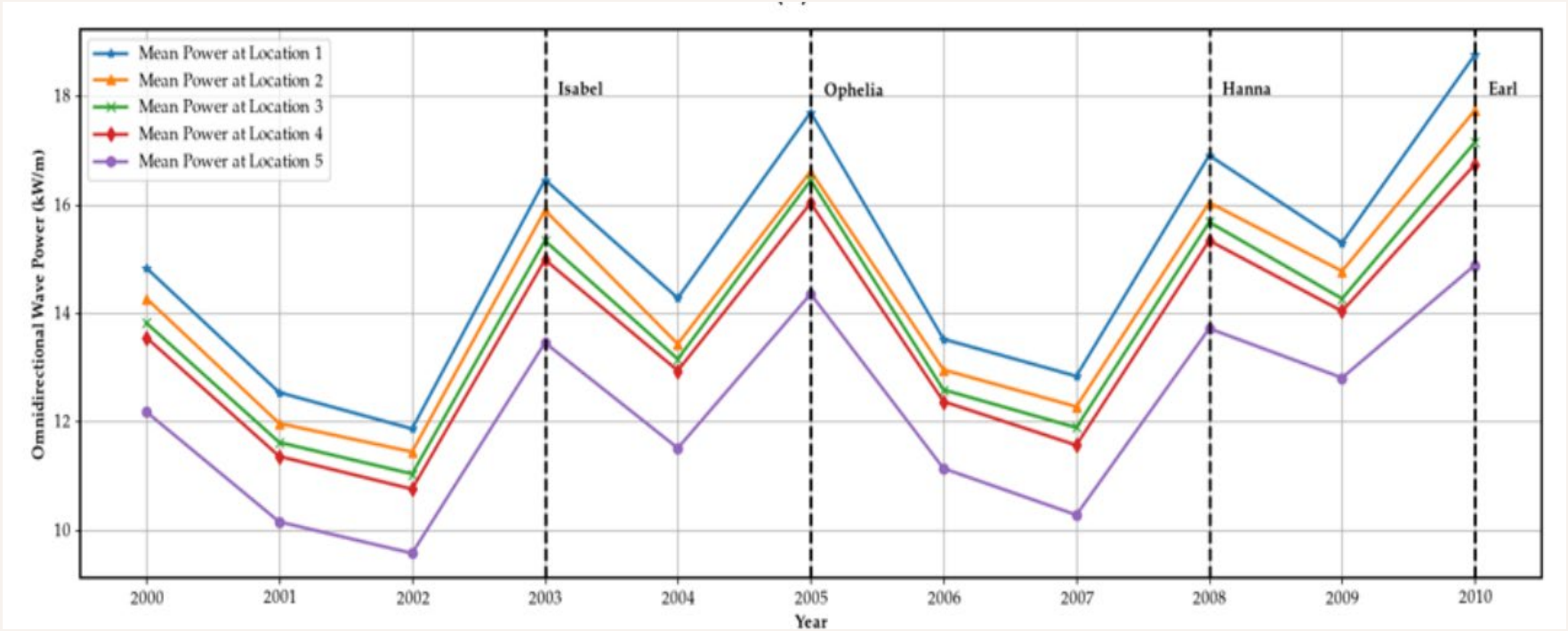

Kitty Hawk: Yearly Variation in Omnidirectional power from 2000 to 2010 including major hurricane events

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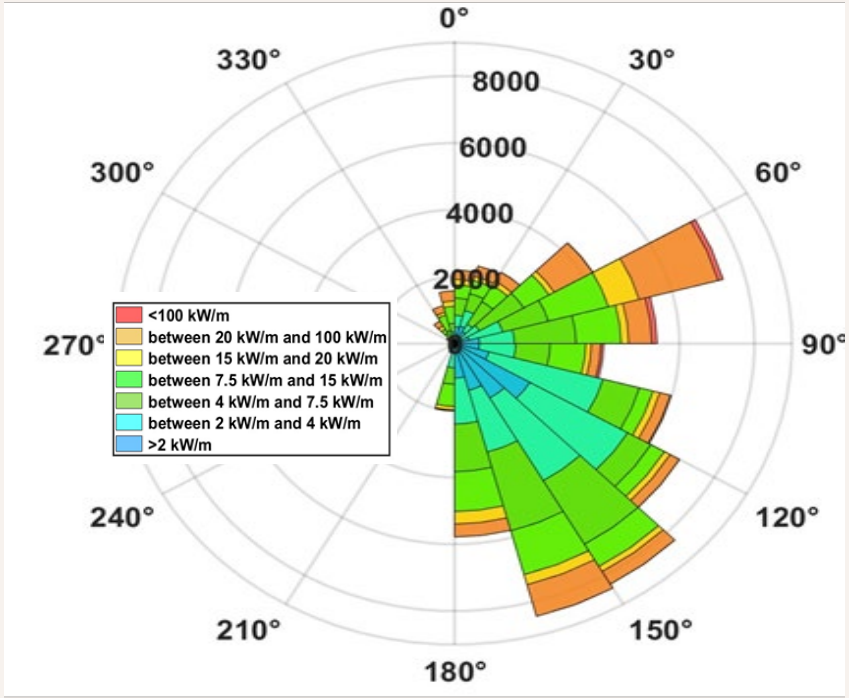
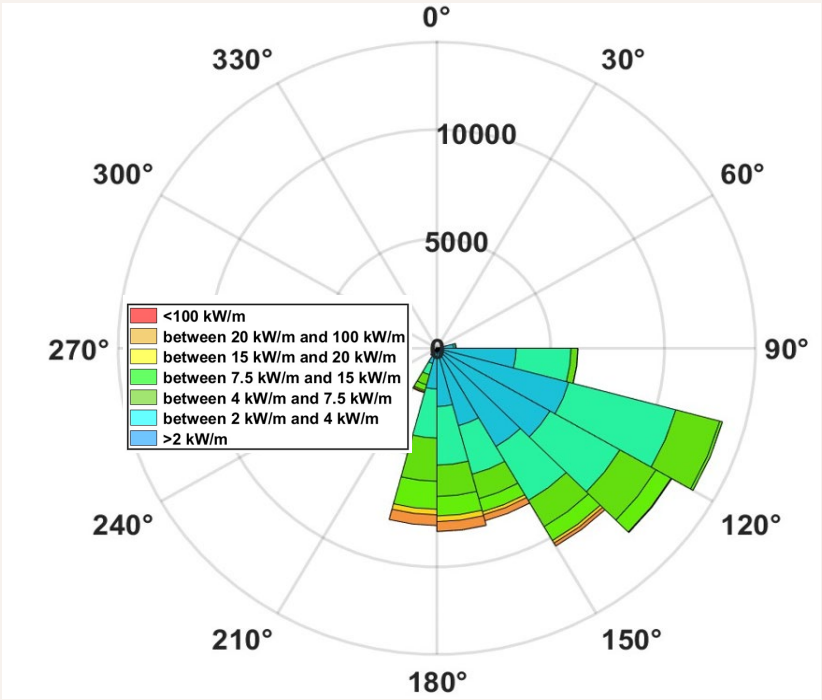


Wave Power Directionality - Kitty Hawk Location 1



Wave Power Directionality – Carolina Long Bay Location 1

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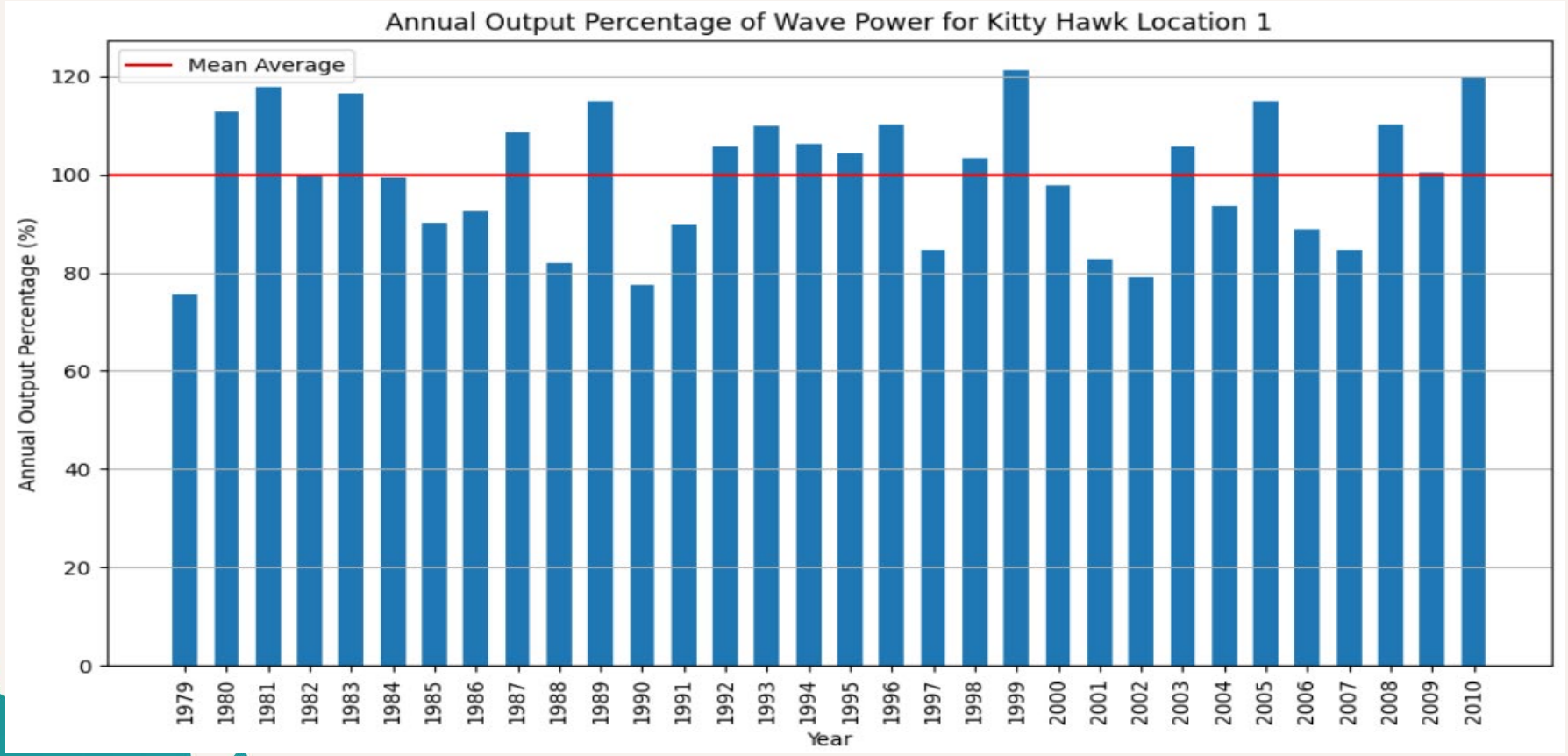

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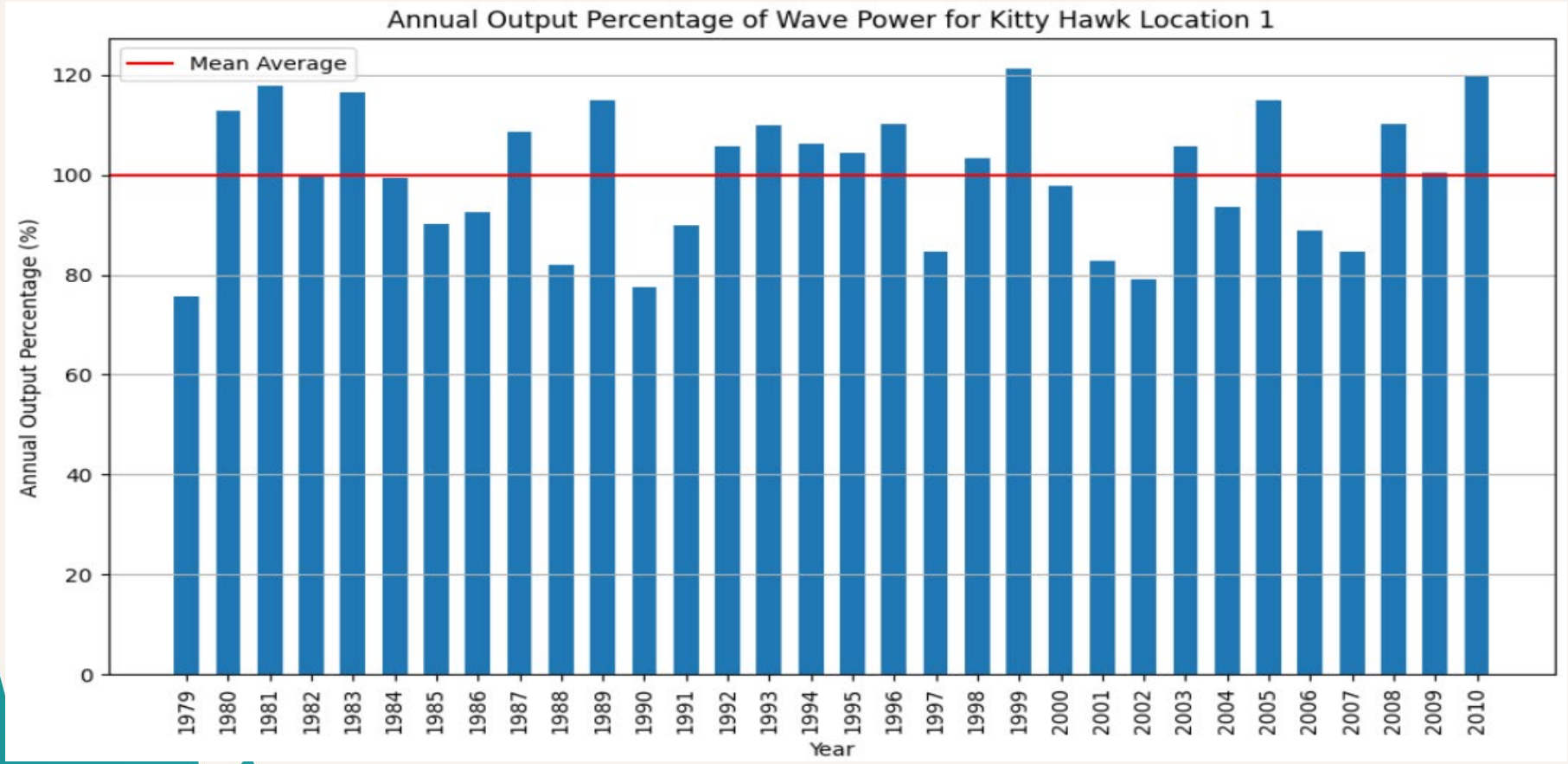

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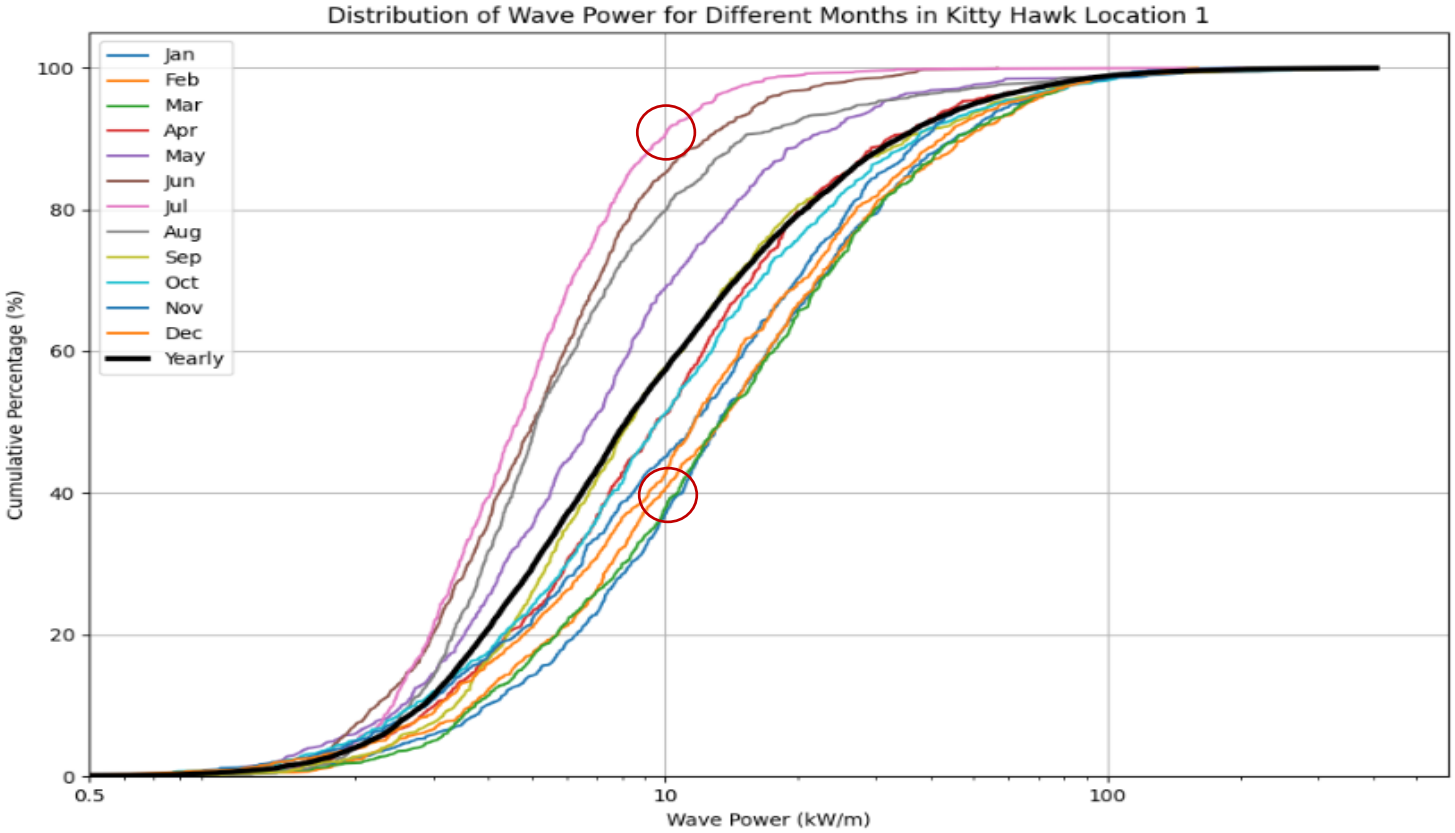
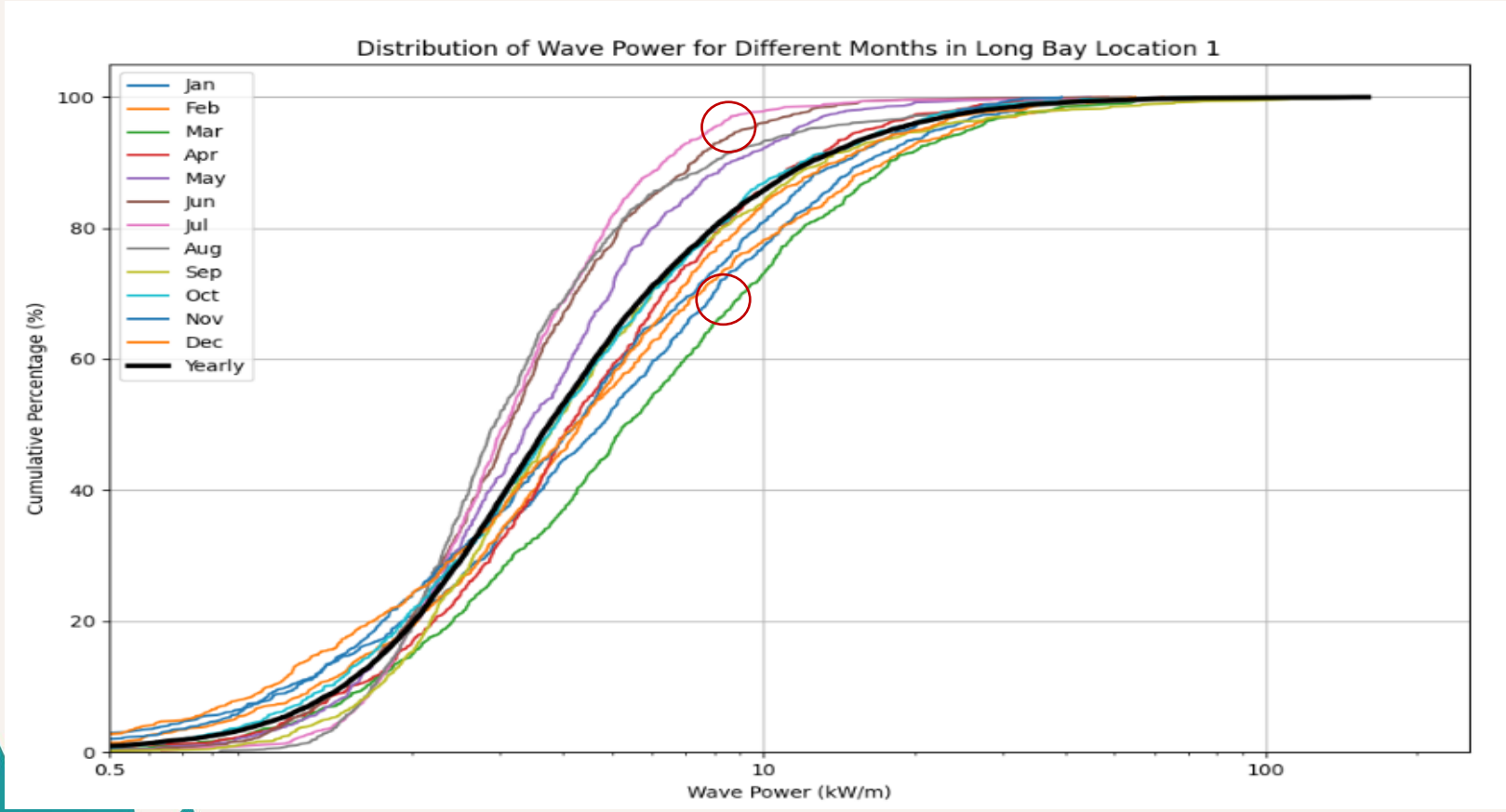
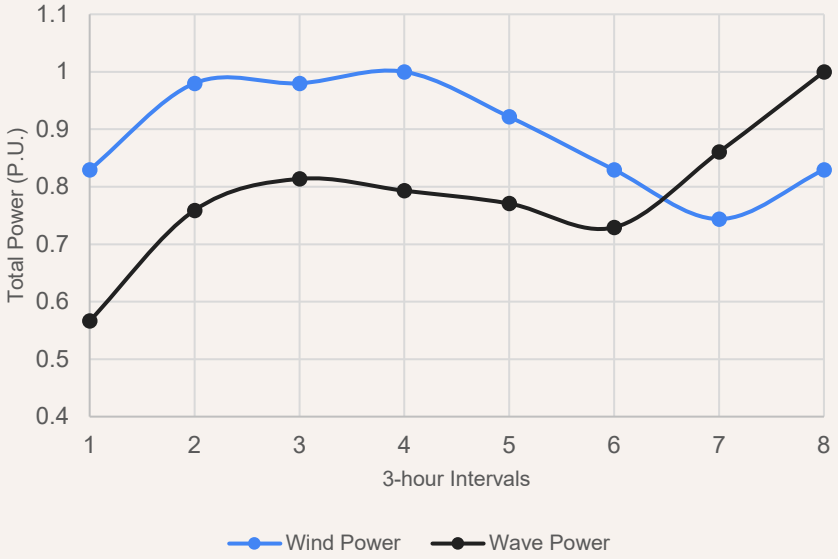
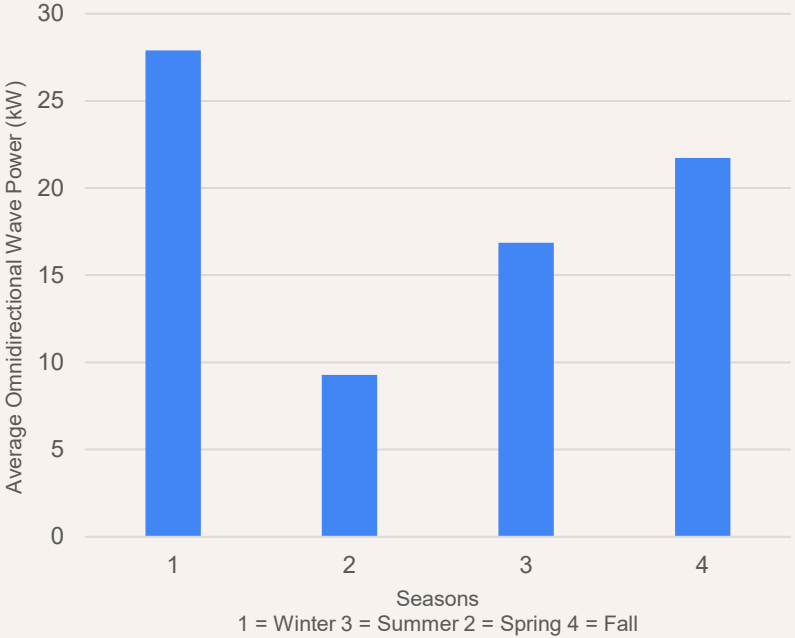

Distribution of Wave Power for Different Months in Kitty Hawk Location 1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Yearly
Cumulative Percentage (%)
0
20
40
60
80
100
0.5
10
100
Wave Power (kW/m)


Distribution of Wave Power for Different Months in Long Bay Location 1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Yearly
Cumulative Percentage (%)
0
20
40
60
80
100
0.5
10
100
Wave Power (kW/m)



Normalized average daily wind and omnidirectional wave power throughout the day at 3-hour intervals



Average omnidirectional wave power in each season at a grid point in Kitty Hawk lease area

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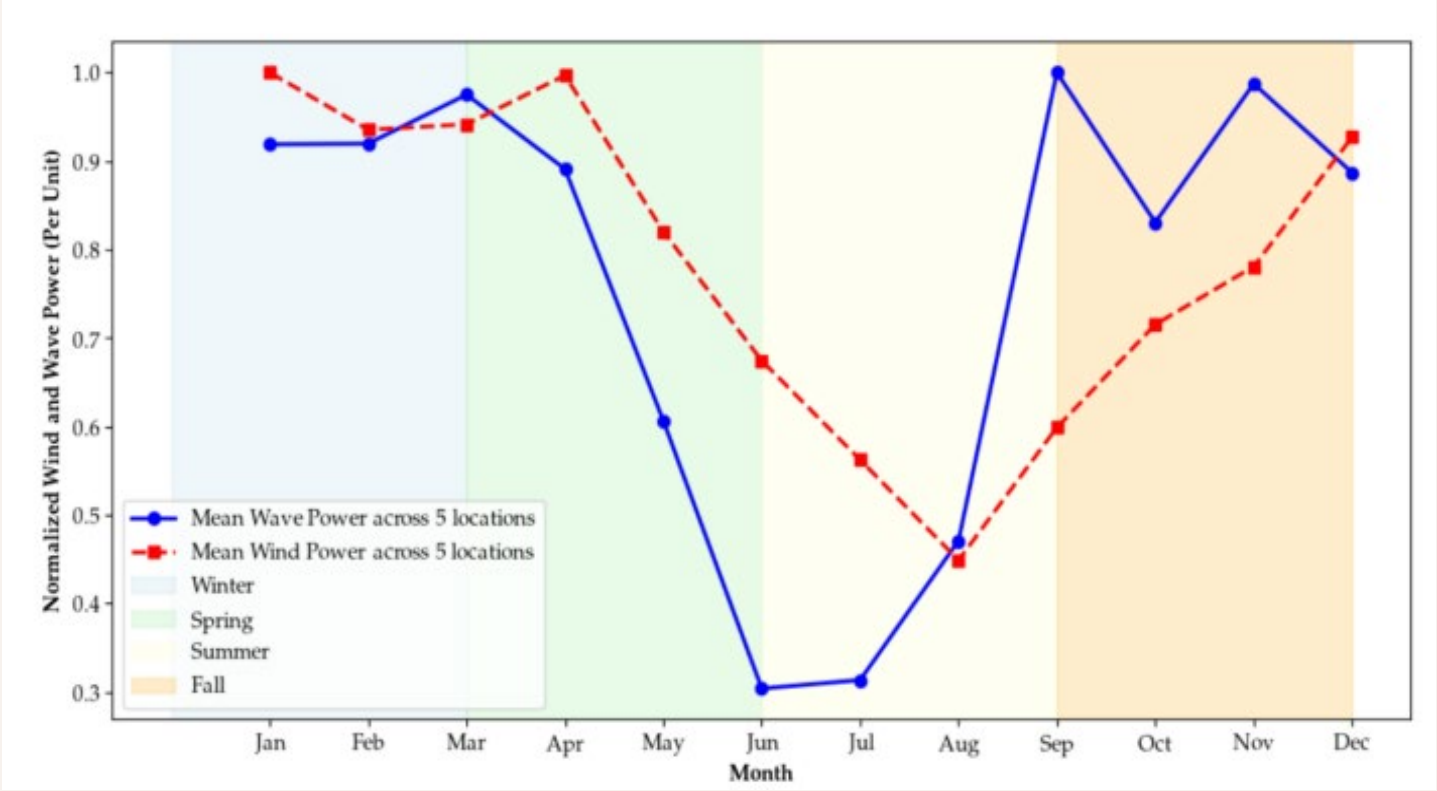

Normalized wind and wave power variations (2000 to 2010)

Findings

- Kitty Hawk Lease area is more energetic compared to Carolina Long Bay with strong wave energy component from south-easterly direction.
- Strong wave action between Nov – March at both locations.
- Wind and Wave can complement each other on daily basis (Stronger waves in the evening hours vs. stronger wind during the rest of the day)
- Good agreement between model data and measured data from NDBC buoys.
- South-eastern points in both locations see energetic wave action.
- Possibility of colocation of wave energy converters with OSW installation.

Acknowledgement

The authors would like to thank the North Carolina Coastal Studies Institute for funding support through the North Carolina Renewable Ocean Energy Program. We would also like to acknowledge the from the Energy Production and Infrastructure Center, University of North Carolina at Charlotte.

Questions?