Off Shore Wind Turbine Suitability in Oregon using Multi-Criteria Analysis

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Geog 493 Digital Terrain Analysis

Research Questions

- What determines a “suitable” location for an offshore wind turbine project? Where do we deem the most suitable area to place a wind farm?
- Do wind turbines settle the argument over aesthetics? What will the offshore wind farms look like from a distance away, and do we believe the turbines will be visible?

Background and Relevance

- December 12, DOE announced award funding of $43 million for seven proposed "Offshore Wind Demonstration Projects" off the Nation's coasts. (BOEM)
  - See this link for DOE funding distribution and project map of the nation: http://energy.gov/eere/wind/offshore-wind-research-and-development
- Project proposed by Principle Power, a 30 MW floating offshore wind project approximately 15 miles off the coast of Coos Bay, Oregon consisting of 5 turbines
- Principle Power claims the project will be "barely, if at all" visible from the shore (windfloatpacific.com)
- Windfloat Project expected to be fully commissioned by the end of 2017

Sources

Data Sets

- NOAA/ NGDC/ MGG
  - North, North Central, Central, South Central, and South Oregon Coast, OR 1/3 arc-second MHW DEM
- Marinecadastre.gov
  - Maritime border, wrecks and obstructions
- NREL
  - Wind Speeds m/s at 90m
- Oregon Image Explorer
  - Aerial Imagery

Multi-Critera Methodology

- Study Area: state of Oregon, focal “suitable” area on Central Oregon
- Points of Analysis: ocean depth, distance from shore, wind speed
- Constraints for offshore turbines: transmission feasibility, areas with shipwrecks, protected aquatic habitats, permits for developments in federal waters (begin at 3 nautical miles)

Land Based Vs. Offshore Wind Turbines

- Development of floating turbines (best for West coast locations with steep faults)
- Shallow water turbines prevalent on East coast (optimal for current turbine designs)
- Size and design of the turbines able for onshore assembly and comparatively low deployment costs (Principle Power)
- Ongoing technology developments for floating turbines

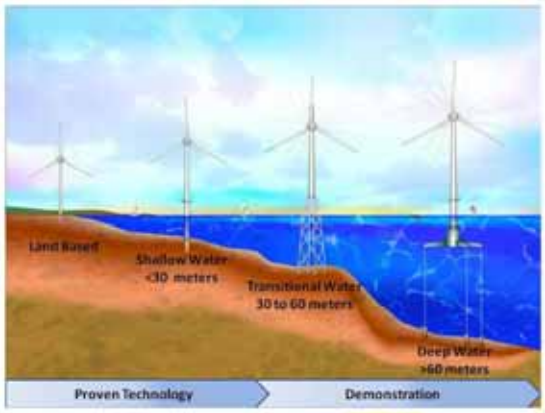
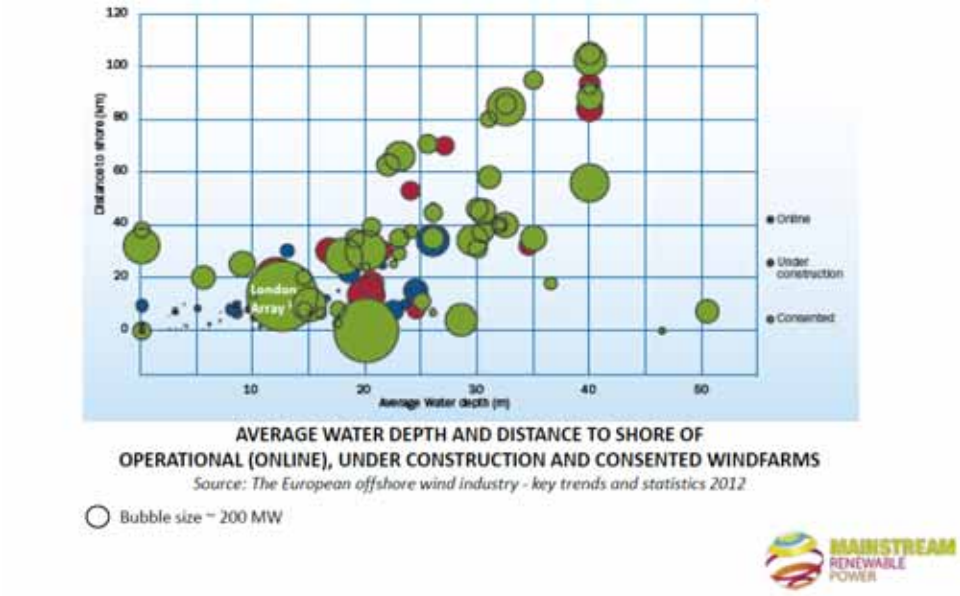


Figure 5-3. Substructure technology classes for offshore wind turbines



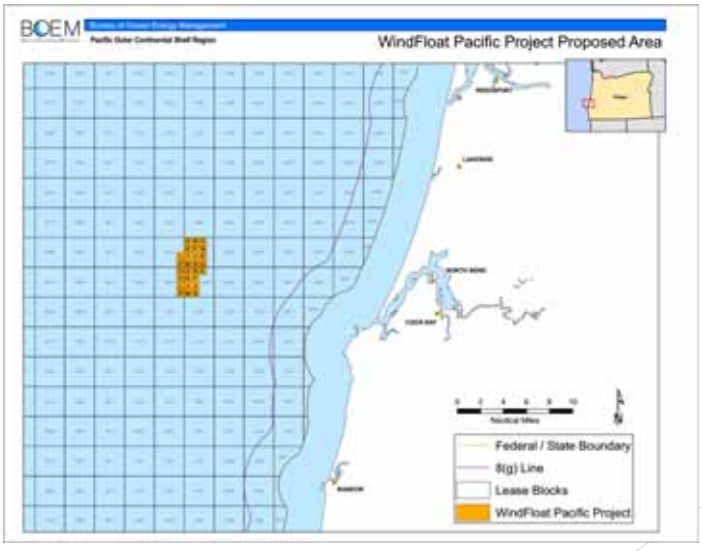
AVERAGE WATER DEPTH AND DISTANCE TO SHORE OF OPERATIONAL (ONLINE), UNDER CONSTRUCTION AND CONSENTED WINDFARMS

Source: The European offshore wind industry - key trends and statistics 2012

○ Bubble size ~ 200 MW

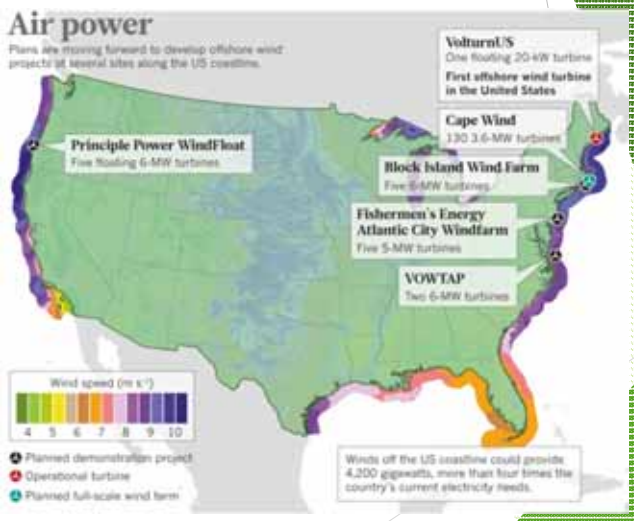
Source: 2013 ESRI Europe, Middle East, and Africa Conference October 23-25, 2013 Munich, Germany
Available: http://proceedings.esri.com/library/userconf/emea13/papers/emea_45.pdf

Comparison Study: WindFloat Pacific Proposed Project in Oregon

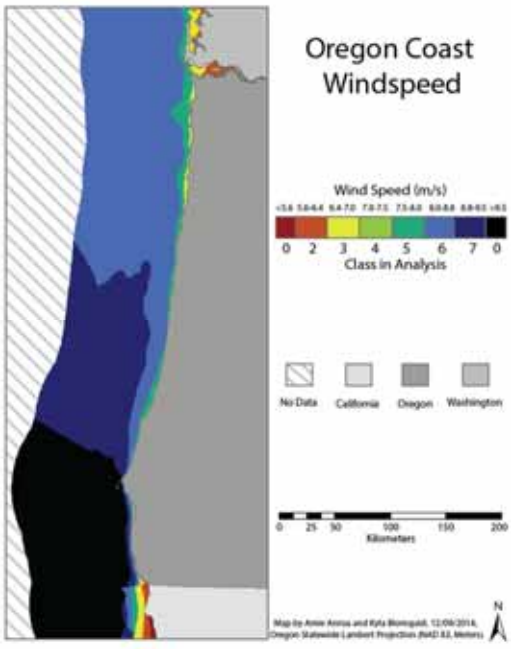


Offshore Wind Turbine, Terms of Suitability

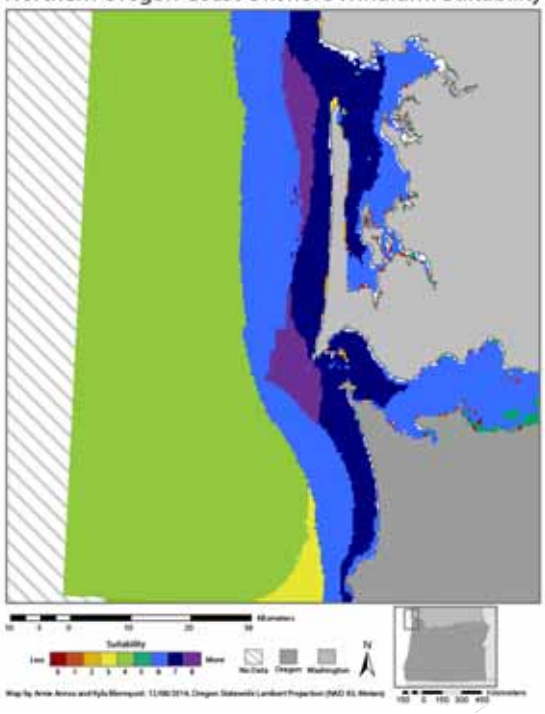
- Wind speed at 90m
  - Optimal: 8.0 - 9.0 m/s
- Ocean depth: >30m
- Distance from shore >10 nm



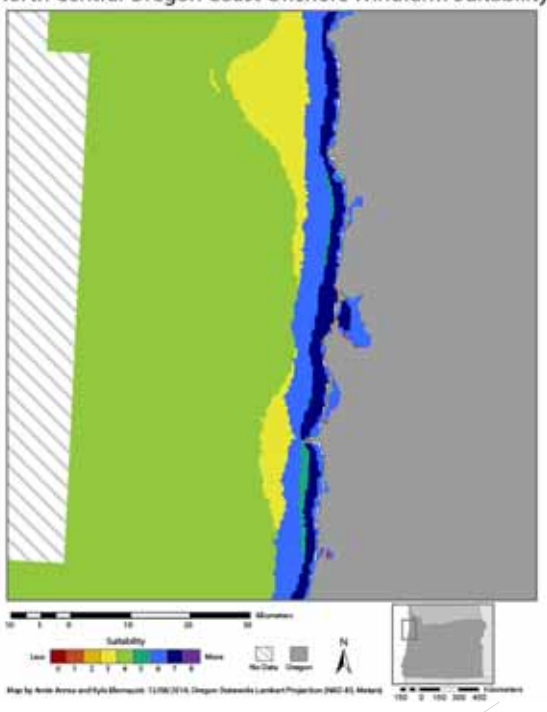
Map of Oregon Wind Speeds



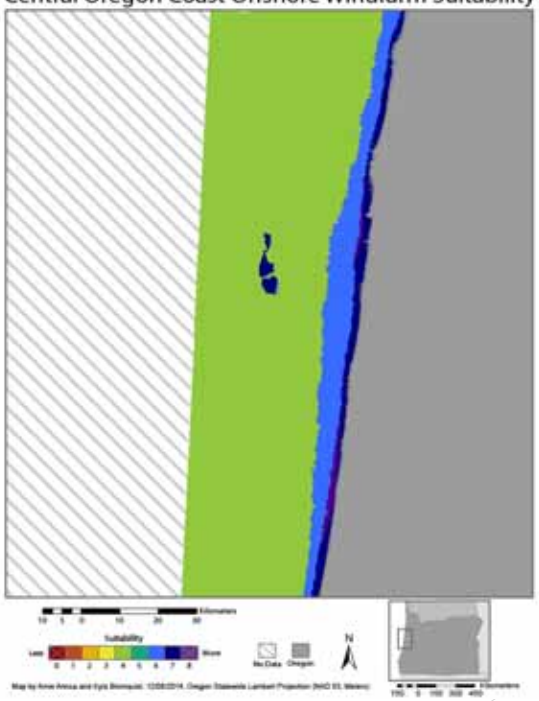
Northern Oregon Coast Offshore Windfarm Suitability



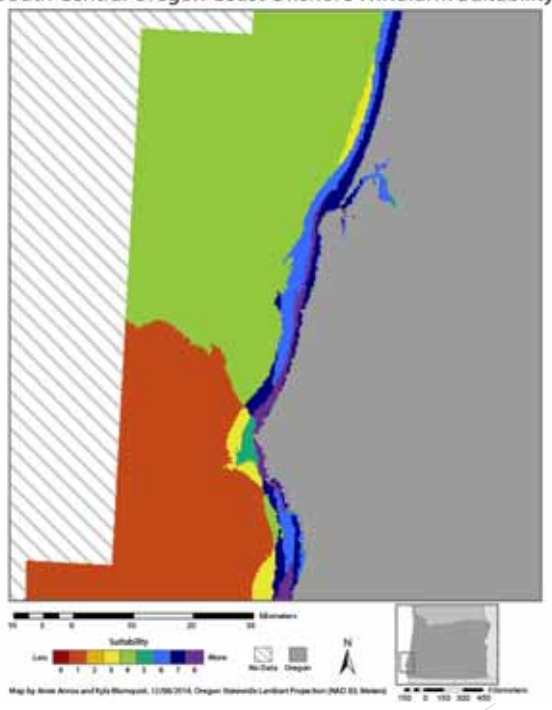
North Central Oregon Coast Offshore Windfarm Suitability

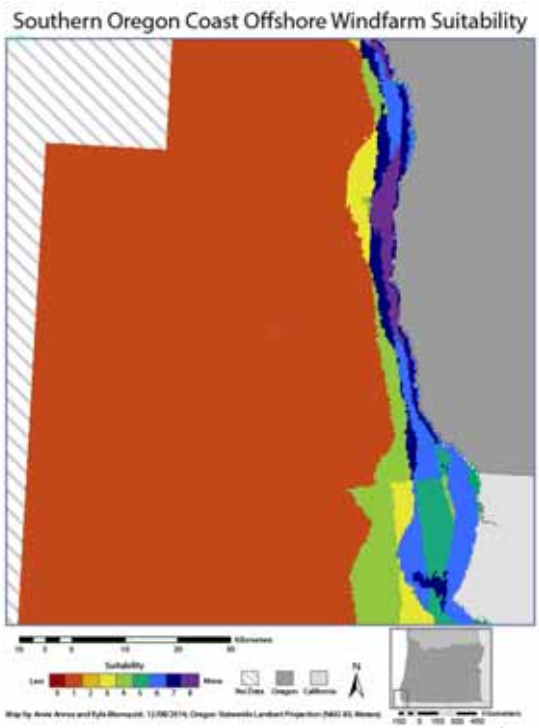


Central Oregon Coast Offshore Windfarm Suitability



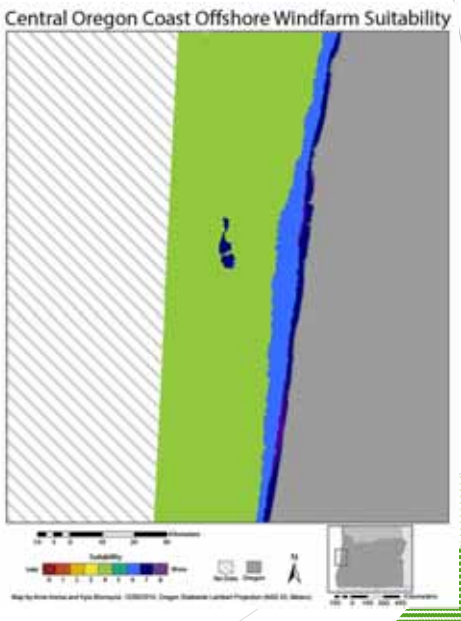
South Central Oregon Coast Offshore Windfarm Suitability



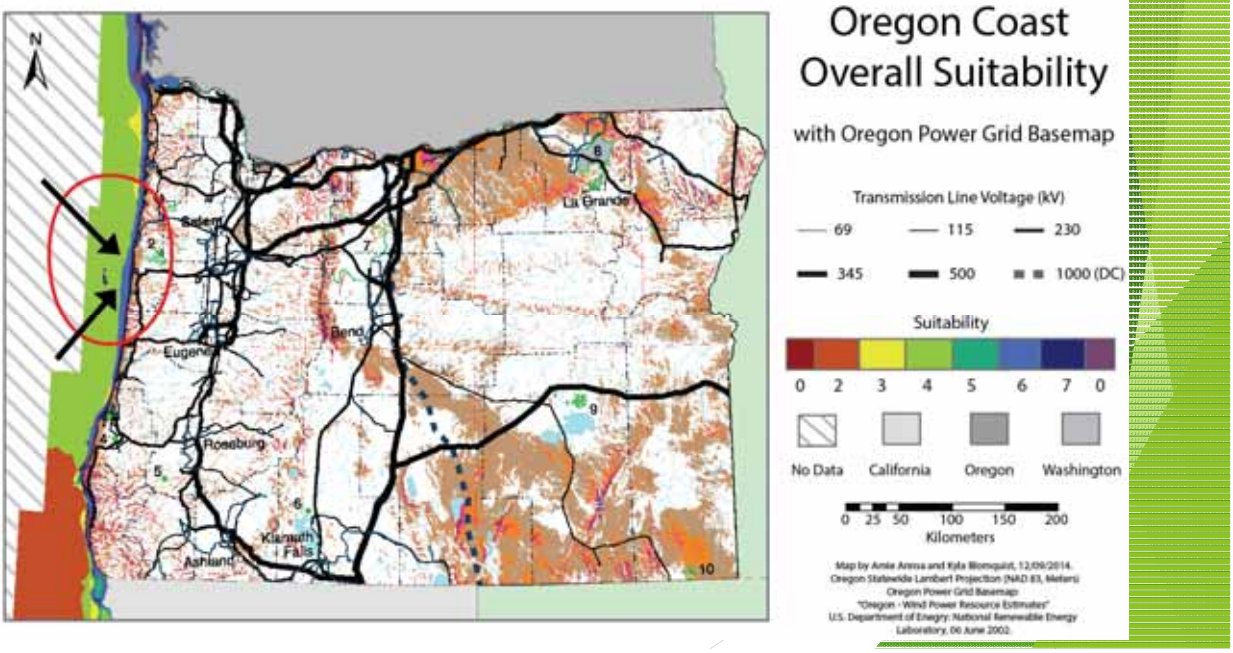


Suitability Results

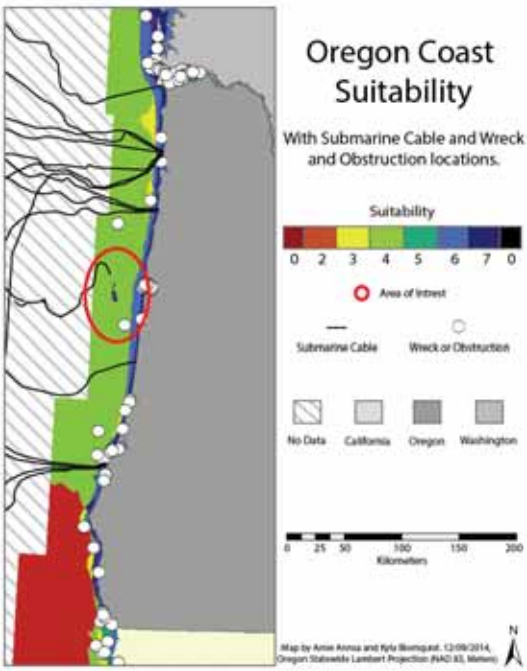
- Central Oregon most favorable
- Distance from shore: ~15nm
- Excellent wind speed (8.8 m/s)
- Favorable ocean depth conditions: -40 meters
- Suitable for a small scale wind farm, but not a large scale production due to steep elevation



Proximity to Transmission Lines



Obstructions to Offshore Development



Wind Farm Visibility Analysis

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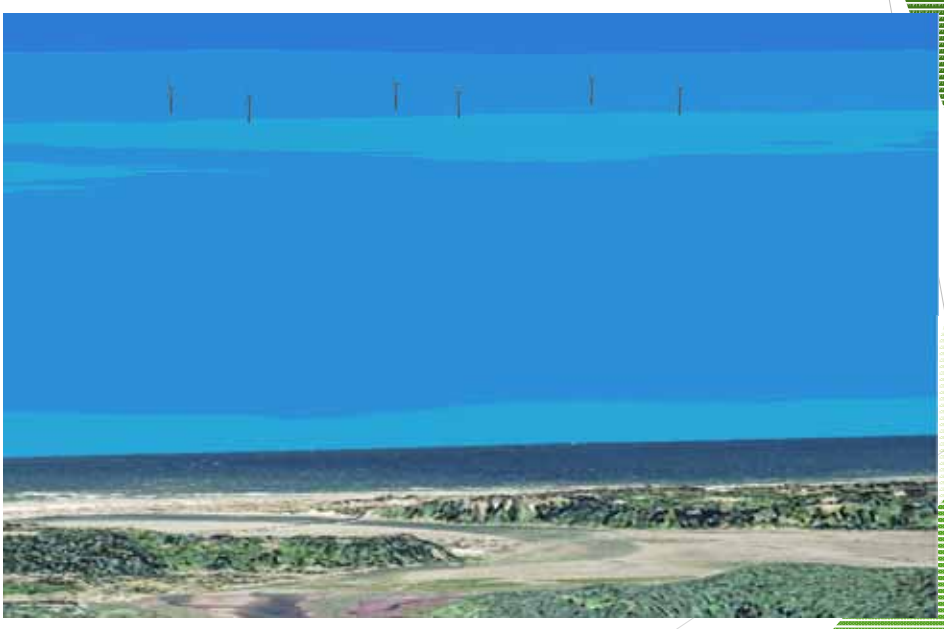

Wind Farm “3D animation”

References

- Carignan, K.S., L.A. Taylor, B.W. Eakins, R.R. Warnken, E. Lim, and P.R. Medley, 2009. Digital Elevation Model of Central Oregon Coast: Procedures, Data Sources and Analysis, NOAA Technical Memorandum NESDIS NGDC-25, U.S. Dept. of Commer
- Wind Energy Resource Atlas of the United States: http://rredc.nrel.gov/wind/pubs/atlas/appendix_A.html#wind
- Musial, Walter. *Large-Scale Offshore Wind Power in the United States: Assessment of Opportunities and Barriers*. DIANE Publishing, 2011. Print.
- Uelmen, Brent H.*Using GIS to Analyze Suitable Locations for Water Wind Turbine Farms in Lake Michigan*. Volume 12, Papers in Resource Analysis. Saint Mary’s University of Minnesota University Central Services Press. Winona, MN: 2010. Web. ce, Boulder, CO, 38 pp.