Electric Current - Siting a Wind Farm off the Coast of the Maine

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Introduction

The University of Maine is developing a two turbine, 12 MW floating deep water offshore wind energy project off the state’s coast as part of their Aqua Ventus Project. It is a first step in building a 500 MW farm, eliminating a significant portion of harmful greenhouse gasses produced by conventional electric power. The coast of Maine provides many uses for the state, from ecological resources of seafood and port areas for international shipping. My project sites a sufficient area that minimizes conflicts with existing coastal resources while keeping close to high wind speeds and existing power distribution networks, a key step in establishing a long term source of sustainable energy. I analyzed these factors using ArcMap to produce tentative locations for a suitably-sized wind farm, narrowing choices to find the least-intrusive coastal site.

Methods

The hill shade, shellfish locations, eel grass beds, bird nesting habitats, boat access areas, and a base raster layer were provided by the Maine Office of GIS. My bathymetry layer was from MassGIS, my layer for power plants was from the U.S. Energy Information Administration, and my World Ports Index layer came from the National Geospatial-Intelligence Agency. Finally, the layer for wind speed came from the National Renewable Energy Laboratory. Once each layer was projected to NAD83 UTM Zone 19N for the state of Maine, I calculated Euclidean distances for each point feature, including power plants, coastal boat launches, water depth, and ports, as well as for the sea bird nesting habitat features.

I generated raster layers using a single designated raster layer as a base, and stacked the new layers after they were reclassified on a scale of 0 – 10 (10 being favorable), depending on whether proximity was desired or not. The nesting island distance layer was reclassified based on seabird avoidance ranges for windfarms, as observed at two offshore wind farms in Denmark. The NREL wind layer was split up as well, based on a criteria table in a review of siting wind farms in Colorado, and each of the subsequent distance layers were normalized as follows:

Seabird Reclassification

Kilometers	New Value
5 +	10
2 - 5	3
1.5 - 2	2
0.5 - 1.5	1
0 - 0.5	0

Wind Reclassification

Class	New Value
7	10
6	10
5	10
4	5.71
3	4.29
2	2.89
1	1.43

Normalization

$$S_i = (X_i - X_{min} / X_{max} - X_{min}) * 10$$

I calculated a new layer giving weight to more important factors based on the Colorado review. Wind speed was the most important, so its layer was weighted by 3. Proximity to existing power structures was also important, so power plants were given a weight of 1.5. Hydroelectric plants had a weight of 2 because they are a preferred energy reserve for periods of decreased wind output, due to their fast start-up time. The three weighted and four other unweighted layers collective value was 10.5, so each layer had its weight divided by the total, then added together. Each pixel thus theoretically had a score between 0 and 10.5, the higher scores being more favorable.

The shellfish layers and eelgrass beds were areas where a potential wind farm could not be sited, due to their economic importance. Their polygon classes were converted to raster, and then reclassified so that any value would become a zero, and all non- and zero values became a one (Figure 3). The layers were all multiplied together, so that if there was a known shellfish area or eelgrass bed, the zero would cancel out any potential score, failing the site (Figure 2).

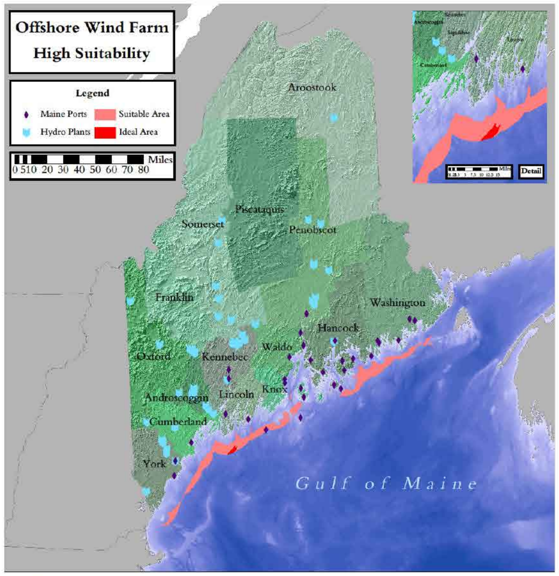

Figure 1: Finalized map indicating select areas of high success factors and minimized conflicts.

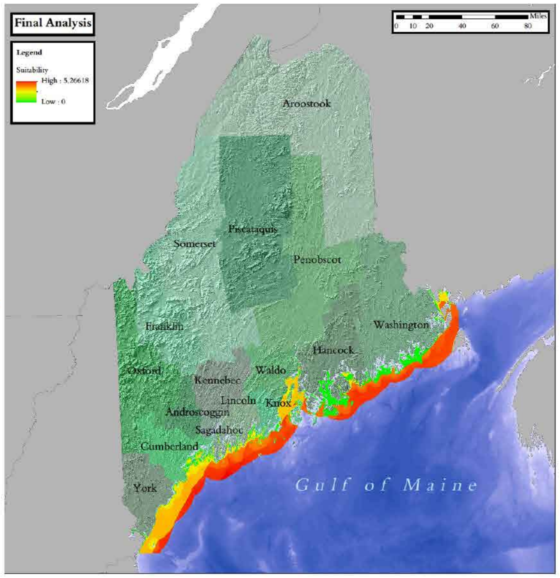

Figure 2: Final analysis layer combining all factors.

Results

Once the final layer was created, I reclassified it so that only the highest scores were highlighted (Figure 1). Based on my criteria, roughly 182 miles of Maine’s coastline is suitable for an offshore wind farm. The notable exception being the bright-red 115 square mile area 8 miles off the coasts of Lincoln and Cumberland counties: this area scored the absolute highest in this model, more than large enough for an average wind farm of 8.7 square miles. Its location is likely due to the large weight placed on high wind speed in the area, as well as its proximity to hydroelectric dams and distance from seaports.

Discussion

The large area of prime siting conditions can allow for creative placement of a windfarm. The Gulf of Maine provides many important uses to the state and input from direct stakeholders is required for a complete location process. Ecological factors were also difficult to account for as well, since freely available geospatial data lacks concrete locations for economically important fish species and whale migration patterns. These factors would have to be mediated on a case by case basis as well. This preliminary study only had access to freely available geospatial data on the internet, and was thus limited.

However, the ideal site does boast distance from known shellfish areas and seabird nesting habitats, as well as from major ports which have high concentrations of shipping routes. Minimizing conflict between these factors is very important, as is the area’s proximity to hydroelectric power plants. While this is only a preliminary mapping exercise, there is potential for an offshore windfarm in this location.

Acknowledgements

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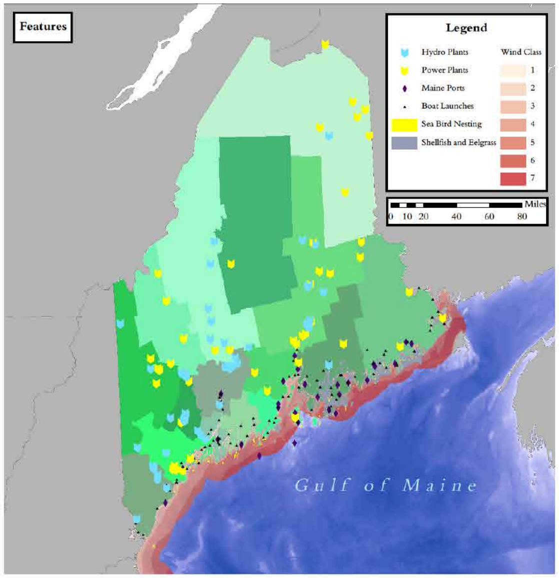

Figure 3: Layers, points, and features used in my analysis.