Ocean Power: Wave of the Future?

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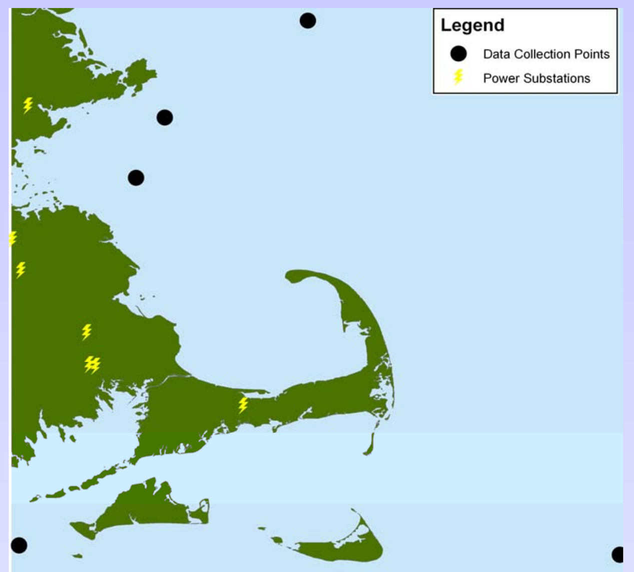
In 2005, world energy consumption stood at 16 terawatt years, with 85% of the energy generated by fossil fuels. The heavy dependence on fossil fuels is highly problematic due to their finite supply, contributions to global climate change, and environmental degradation. It is estimated that ocean wave power can generate up to 2 terawatt years of energy annually and unlike fossil fuels, it produces no greenhouse gasses or pollution and is completely renewable. Techniques for capturing and converting wave motion into useable energy have been attempted for over a century, though issues of economic feasibility have prevented their implementation until very recently. The coast of Massachusetts, which has relatively high wave energy, could potentially be a candidate for wave power installations. The purpose of this poster is to determine ideal locations for placing wave power installations off of the Massachusetts coast and to estimate their technical and economic characteristics*.

*Ideal locations and technical and economic characteristics of sites were calculated for hydroelectric turbine power collection systems such as the Aquabuoy. These systems consist of moored buoys that use the oscillatory motion of the waves to compress seawater and drive it through a turbine to generate power.



Kriging

$$P = \frac{\rho g^2}{64\pi} H_{m0}^2 T \approx \left(0.5 \frac{\mathrm{kW}}{\mathrm{m}^3 \cdot \mathrm{s}}\right) H_{m0}^2 T,$$

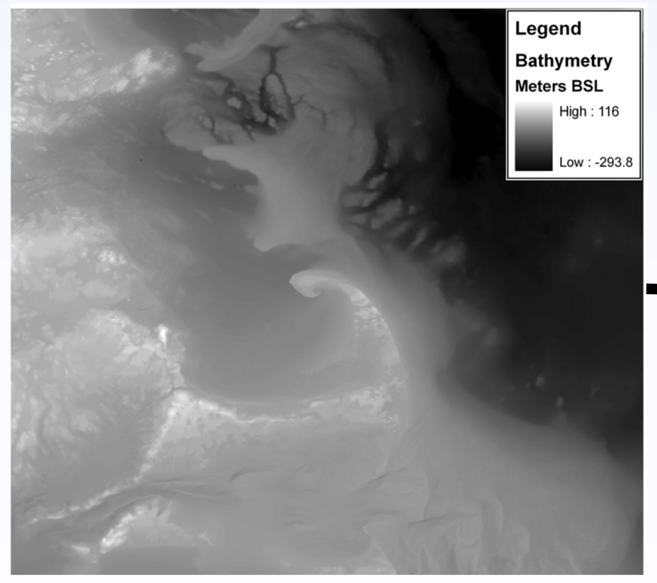
Wave power formula, where H is wave height and T is wave period.

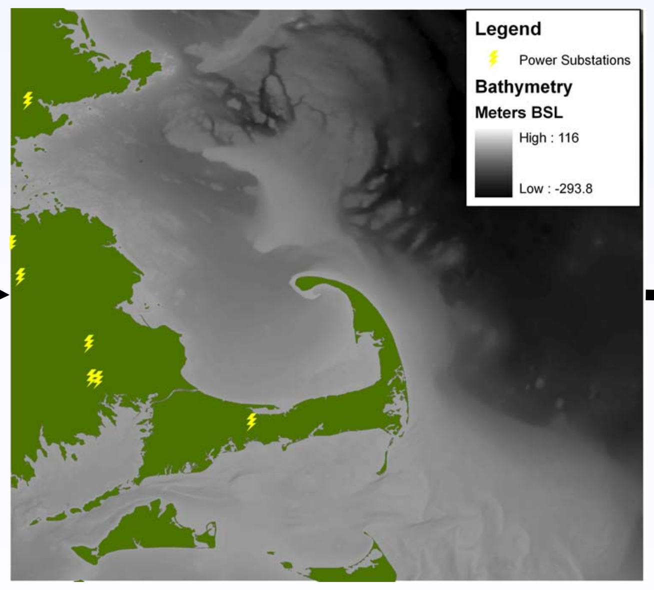
Analysis

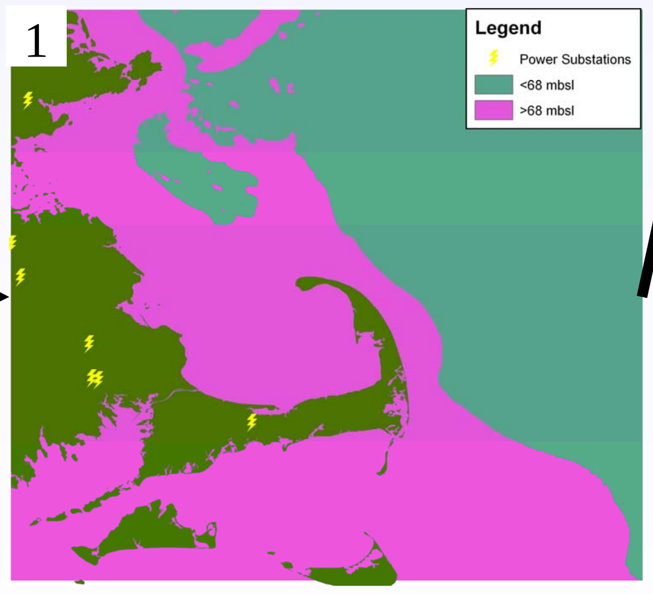
Ideal locations for the placement of moored buoy wave power installations need to meet four major criteria: Water depths of less than 68 meters, high wave energy, located within 9km of the shore, and sandy seafloor sediment.

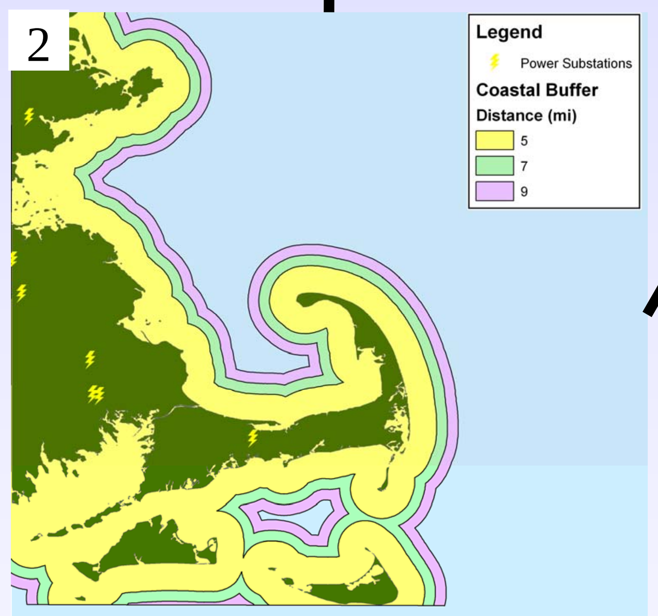
1. Using combined bathymetric and DEM data from the National Oceanic and Atmospheric Administration (NOAA), areas above and below sea level were classified into land and water respectively. Power substations located near the coast were then placed onto the land surface. Finally the water was classified into areas of suitable and unsuitable water depth.

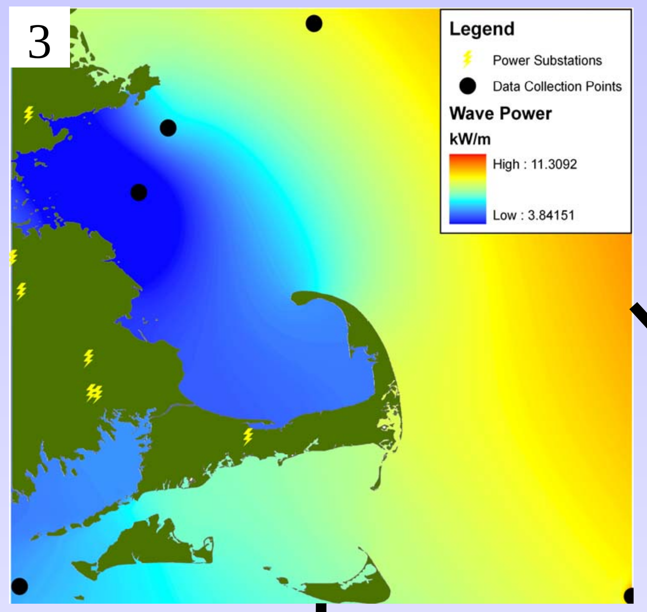
2. Using the basemap developed in step (1) a buffer was created around the coast that identified areas that were within an acceptable distance to the shore.

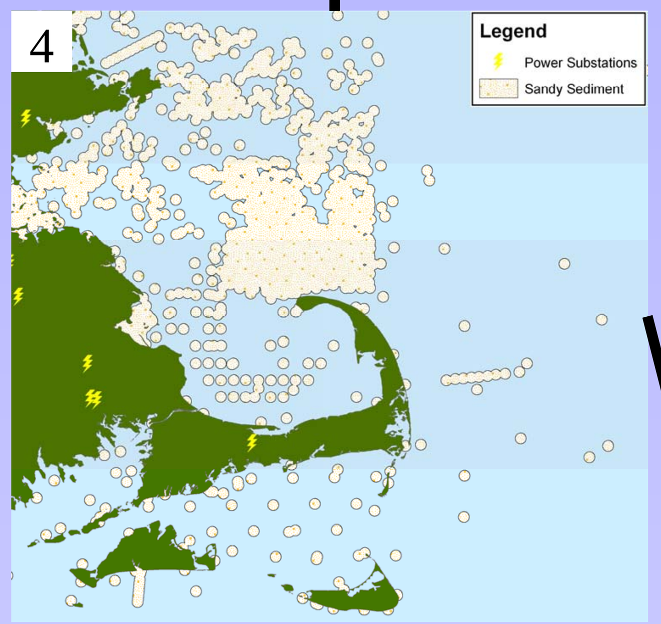












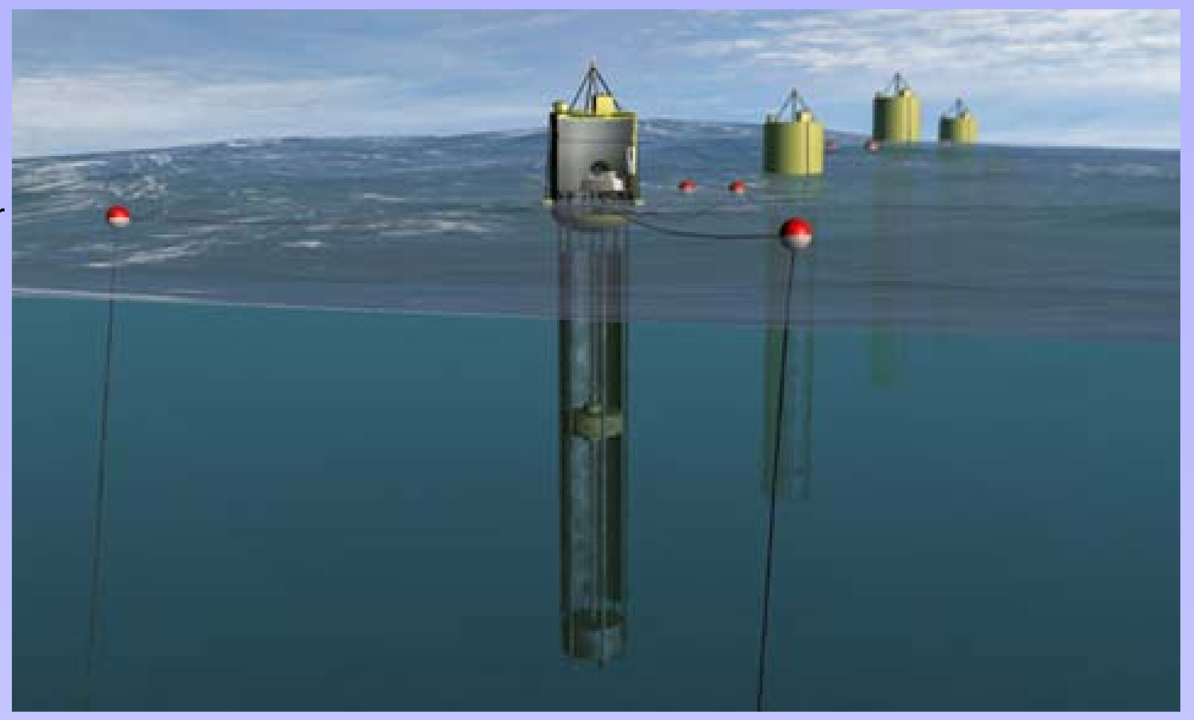
Analysis (Continued)

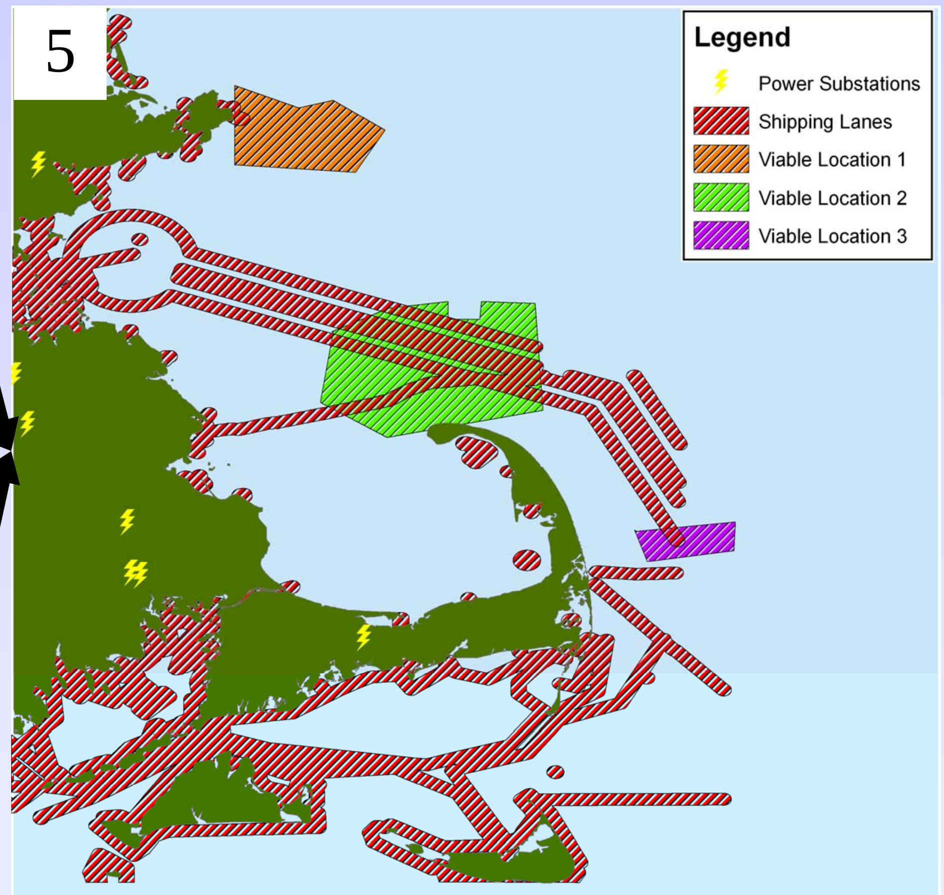
3. To calculate the wave energy, wave data from five buoys placed off the Massachusetts coast by the National Buoy Data Center were used. For each buoy, values for wave height and period were recorded every 30 minutes for the year 2008. Using the equation for wave energy flux the power produced by each wave at a specific buoy location was calculated and then the average yearly wave power for that point was obtained. With average yearly wave power calculated for five points, a wave power raster was created by interpolating the data between the data collection buoys using the geostatistical tool kriging.

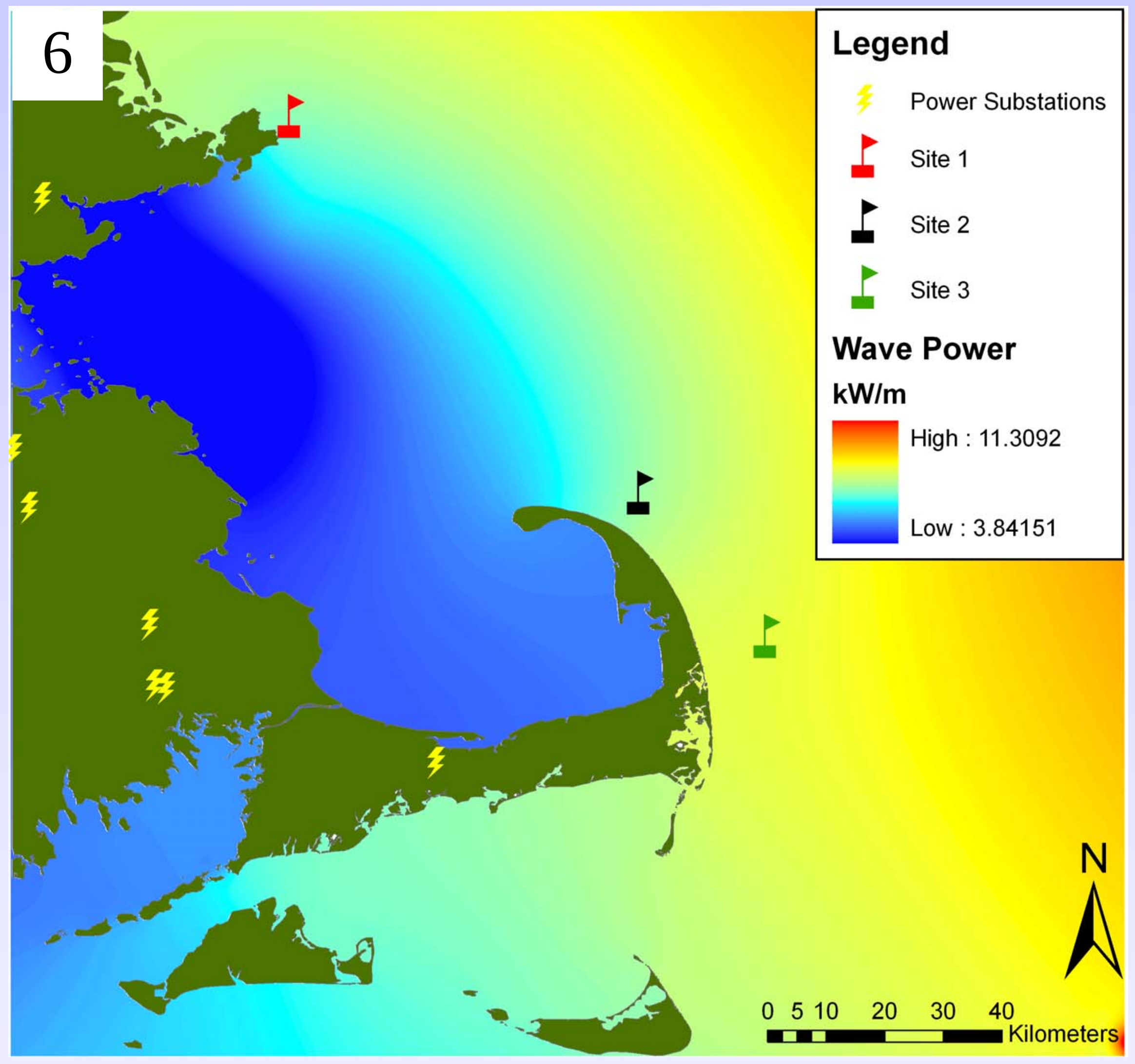
4. A layer displaying suitable seafloor sediment was created using seafloor sediment sampling data from NOAA. Using this layer all points that were sandy sediment were selected, a 400 meter buffer was created around each point, and any points that were not sandy sediment were deleted.

5. The analysis from steps 1-4 were used to determine areas that met all four major criteria for placement of wave power installations. A layer displaying major shipping lanes was then added.

6. From the viable locations identified in step (5) sites for wave power installations were chosen so that they did not interfere with shipping lanes and were as close to shore as possible in order to minimize costs of placing submarine cables.







Conclusions

Wave power installations off the coast of Massachusetts could be economically feasible and may in fact yield profits in the long-run. While the power generated by these installations is both renewable and environmentally sound, it is likely to provide only enough power for small coastal communities.

Site	**Wave Power** (kW/m)	**Energy Generation**[1,2] (MWh)	**Value of Energy** ($1000)	**CO2 Offset**[1,3] (tons)	**Homes Powered**[4]
Site 1	7.5	5256.0	865.66	3524.1	591
Site 2	7.7	5396.2	888.88	3618.2	606
Site 3	8.5	5956.8	981.10	3994.0	670

Site	**Distance to Shore** (km)	**Submarine Cable Cost**[5] ($1000)	**Distance to Power Station** (km)
Site 1	3.5	329	31
Site 2	7	658	64
Site 3	9.5	893	41

1. Calculations made for 20 buoy installation with buoy width at 5m.
2. Assuming 80% efficiency
3. Using U.S. average of 1.341lbs of CO2 per kWh (Source: US DOE)
4. Using U.S. average energy consumption of 8900 kWh (Source: US DOE)
5. Cost of cable installation at $94/m (Source: US DOE)

Data Sources:
NOAA, National Buoy Data Center,
U.S. DOE

Projection WGS 1984