Preliminary Screening Analysis for Ocean SAMP

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Geology support
Jon Boothroyd, Geosciences and John King, GSO
Context

• Focus of present effort to establish areas that are suitable for renewable energy development in RI coastal waters (*one portion* of the larger Ocean SAMP planning exercise)

• Sources of renewable energy from ocean: waves, in-stream tidal currents, mean currents, ocean thermal energy conversion, and wind). Wind only viable energy resource for grid scale power production in RI
Overview

Tier #1 Analysis (Hard Constraints)
  Energy Resource (wind, waves, tidal/mean currents, OTEC)
  Exclusions
  Technology Type
  Extended (TDI, Visualization, Marine Transportation)

Tier #2 Use conflicts/collaboration and environmental impacts (NOT ADDRESSED IN THIS PRESENTATION TO BE COVERED IN FOLLOW-ON WORK)
Tier #1 Screening (Hard Constraints)

**Wind Resource**
- Adequate Wind Resources (greater than 7 m/sec at 80 m, hub height)

**Exclusions**
- Navigation Areas - Regulated (shipping lanes, precautionary areas, preferred routes)
- Vessel tracks (AIS data)
- Ferry Routes
- Regulated areas (disposal site, military areas, unexploded ordnance, marine protected areas)
- Airport buffer zones
- Coastal buffer zone (1 km)
- Cable Areas (?)
Tier #1 Screening (cont’d)

- Water depth
  Minimum depth – 5 m (access by barge and heavy construction equipment)
  Maximum depths
    - Mono-piles
      20 m typical depths in Europe
      25 m DNV suggested limit (RI WINDS study choice – 75 ft)
      30 m Limit of shallow water (deepest depth in Europe)
Tier #1 Screening (cont’d)

- Water Depths
  
  Maximum Depths –

  *Jacket structures*

  50 to 60 m DeepWater Wind

  (45 m for Beatrice Demonstration Project in Scotland)

  *Floating*

  No depth limit
Fixed Bottom Substructure Technology

Proven Designs

- **Monopile Foundation**
  - Most Common Type
  - Minimal Footprint
  - Depth Limit 25-m
  - Low stiffness

- **Gravity Foundation**
  - Larger Footprint
  - Depth Limit?
  - Stiffer but heavy

Future

- **Tripod/Truss Foundation**
  - No wind experience
  - Oil and gas to 450-m
  - Larger footprint
  - Talisman project

Graphics source: http://www.offshorewindenergy.org/
DeepWater Wind Technology, OWEC (Norwegian)
Estimates of 80 m wind speeds
AWS TrueWinds data

Rhode Island Ocean Special Area Management Plan (SAMP)

Map Key
- Proposed Ocean Study Area
- State/Federal Waters Separation

Wind at 80m Interpolated:
- 7.0
- 7.2
- 7.4
- 7.6
- 8.0
- 8.2
- 8.4
- 8.6
- 9.0
- 9.2
- 9.4
- 9.6

Visual Analysis:
Wind Speed at 80m,
Interpolated from AWS 70m and 100m data
Comparison of AWS Winds and Observations

Comparison AWS wind speed at 30 m height with Measurements

Roughness coefficients inferred from AWS winds at each station [Range: 0.13 - 0.18]

Mean wind speed difference: 0.17 m/s ; 0.14 m/s only NOAA and WIS stations

Mean AWS @ WIS & NOAA
Wind Observation Station Locations (WIS, BUZ, PJ)
Ice Flow Directions

EXPLANATION

TERMINAL MORaine
Exposed

Submerged

RIDGE CREST

DIRECTION OF ICE FLOW

INTERLOBATE ZONE

CONNECTICUT
Hudson-Champlain lobe

RHODE ISLAND

MASSACHUSETTS
Narragansett Bay-Buzzards Bay lobe

NEW YORK
LONG ISLAND

NOMANS LAND

MARATHA'S VINEYARD

ATLANTIC OCEAN

Base from U.S. Geological Survey, Digital Line Graphs, 1:100,000, 1983

Stone and Sirkin, 1996
Depth Intervals
5-20 m
5-25 m
5-30 m
5-35 m
Exclusion Areas
- Coastal buffer
- Navigation areas
- Regulated areas
- Airport Buffer
AIS Vessel Tracks

September 2007 – July 2008
AIS Vessel Tracking:
Sept. 2007 -- July 2008
5-25 m, AIS data overlay (50 count), RI WINDS sites shown
5-25 m, exclusion areas, AIS vessel data
Preliminary Tier 1 Results: Potential Development Areas, 5 - 25 Meters Depth

Map Key:
- Proposed Study Area
- AIS Vessel Traffic
- Federal/State Waters
- Tier 1 Results: 5-25m
- RIWINDS Areas
Technology Based Assessment

**Objective:** Develop a metric based on technical challenge to power production potential to screen for sites.

\[
TDI = \frac{TCI}{PPP}
\]

where TDI – Technical Development Index
TCI - Technical Challenge Index
PPP - Power Production Potential

Presented in form of dimensionless values (Predicted TDI divided by lowest TDI possible in area of interest)
Components of TDI

- PPP- Power Production Potential

\[ \text{PPP} = W \times CF \]

Where \( W \)- annual mean wind power at hub height of wind turbine ( -80 m) (\( \text{kW/m}^2 \)) (Data from AWS TrueWinds)

CF- capacity factor (35 %)
Components of TDI

- TCI – Technical Challenge Index

TCI = TT + CD

Where TT- Technology Type

CD- pro-rated distance to nearest electrical grid

(distance to grid * SF/ number of turbines in wind farm)

SF- scale factor that assesses technology challenge for cable (nominal – 0.8)
TDI Monopile (0 -25m), no geology
TDI Monopile (0-25m) with geology

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<td>State/Federal Waters Separation</td>
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</tbody>
</table>

**Monopile With Geology**
- < 1.00
- 1.25
- 1.50
- 1.75
- 2.00
- 2.25
- 2.50
- 2.75
- 3.00
- 3.25
- 3.50

**Rhode Island Ocean Special Area Management Plan (SAMP)**

**Visual Analysis:**
TDI Monopile Results With Effects of Glacial Geology
Wave Rose and Wave Height Histogram, WIS 101

Waves Primarily from South and Southwest
Bathymetry in vicinity of Block Island
WAVE Analysis, Return Period 100 yrs (upper 95% limit) \( H_s = 9.9 \text{ m}, T_p = 15.7 \text{ sec}, \text{ South} \)
EXTREME WAVES, 100 YR

Hs = 4 m

Hs = 9 m Tp = 15 sec
Preliminary Tier 1 Results: Potential Development Areas, 5 - 50 Meters Depth
Approach to Identify Sites in Deep Water (25 to 60 m)

Visual Impacts
Technical Development Index (Principal Component Analysis)
Marine Transportation
Visualization Assessment

- One of principal reasons to move sites offshore is to minimize visual impacts
- Set back analysis (from any land body) performed
  - Set backs of 8, 10, 12, 15, and 20 km
  - 20 km (12 miles) limit of visualization
  - 10 -12 km (5-6 miles) set back for Cape Wind
AIS Vessel Tracking:
Sept. 2007 -- July 2008
TDI Series
Visualization Series
Alternate Strategy
Principal Component (PC)-Cluster Analysis (CA)

- Input Variables
  Wind Power
  Water Depth
  Distance to Coast
  Geology Type (construction effort)

Linear combination of above variables for each 200 m square grid
## Clusters

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Wind Power</th>
<th>Depth</th>
<th>Distance</th>
<th>Geology</th>
<th>Challenge</th>
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<tbody>
<tr>
<td>Cluster 1</td>
<td>Highest</td>
<td>Deep</td>
<td>Far</td>
<td>Low</td>
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<tr>
<td>Cluster 2</td>
<td>High</td>
<td>Mid</td>
<td>Mid</td>
<td>Low</td>
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<td>Cluster 5</td>
<td>Mid-Low</td>
<td>Shallow</td>
<td>Close</td>
<td>High</td>
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</tbody>
</table>
Comparison
Principal Component & Cluster Analysis (upper)

TDI Analysis (with geology) (lower)
Conclusions

- TDI and PC analysis useful in identifying possible sites for offshore wind energy development. Both methods give consistent results; site locations are balance between wind energy resource and technical development challenge.
- Useful to identify sites for more in-depth analysis
- Principal data needed at this step in analysis, sub-bottom geology
Next Steps

- Perform Tier #2 analysis
  Use conflicts
  Commercial and recreational fishing
  Recreational boating
  Existing licenses (leases)
  Aggregate extraction
  Conservation
  Aquaculture
Next Steps (Cont’d)

Tier # 2 Screening
  Environmental Impact
    Birds
    Fish and fish habitat
    Marine mammals and turtles
    Water and air quality
  Historical and cultural resources