Ocean SAMP Offshore Renewable Energy

University of Rhode Island

Narragansett, RI 02882

ATM(2007) Potential Wind Farm Sites

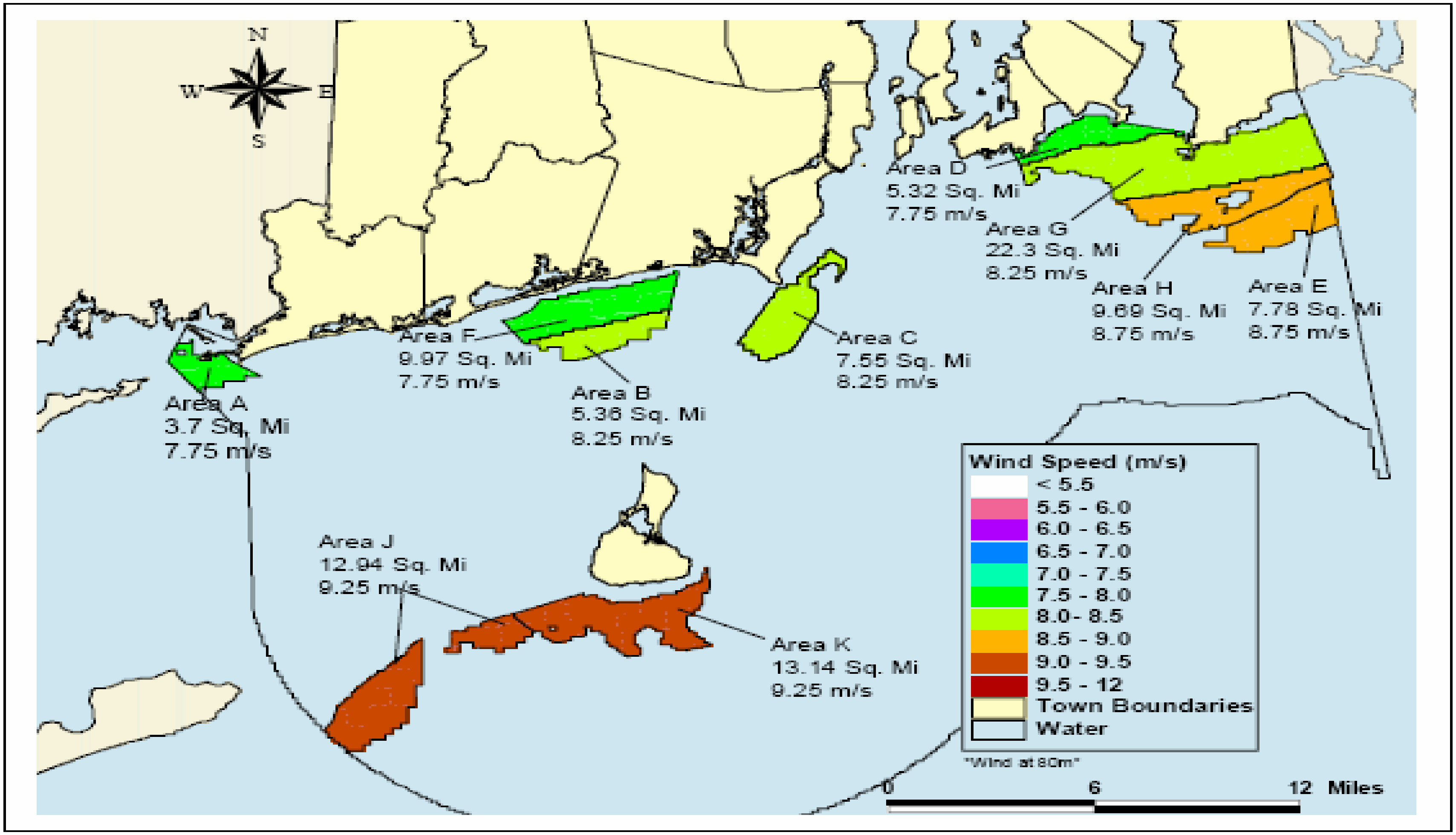
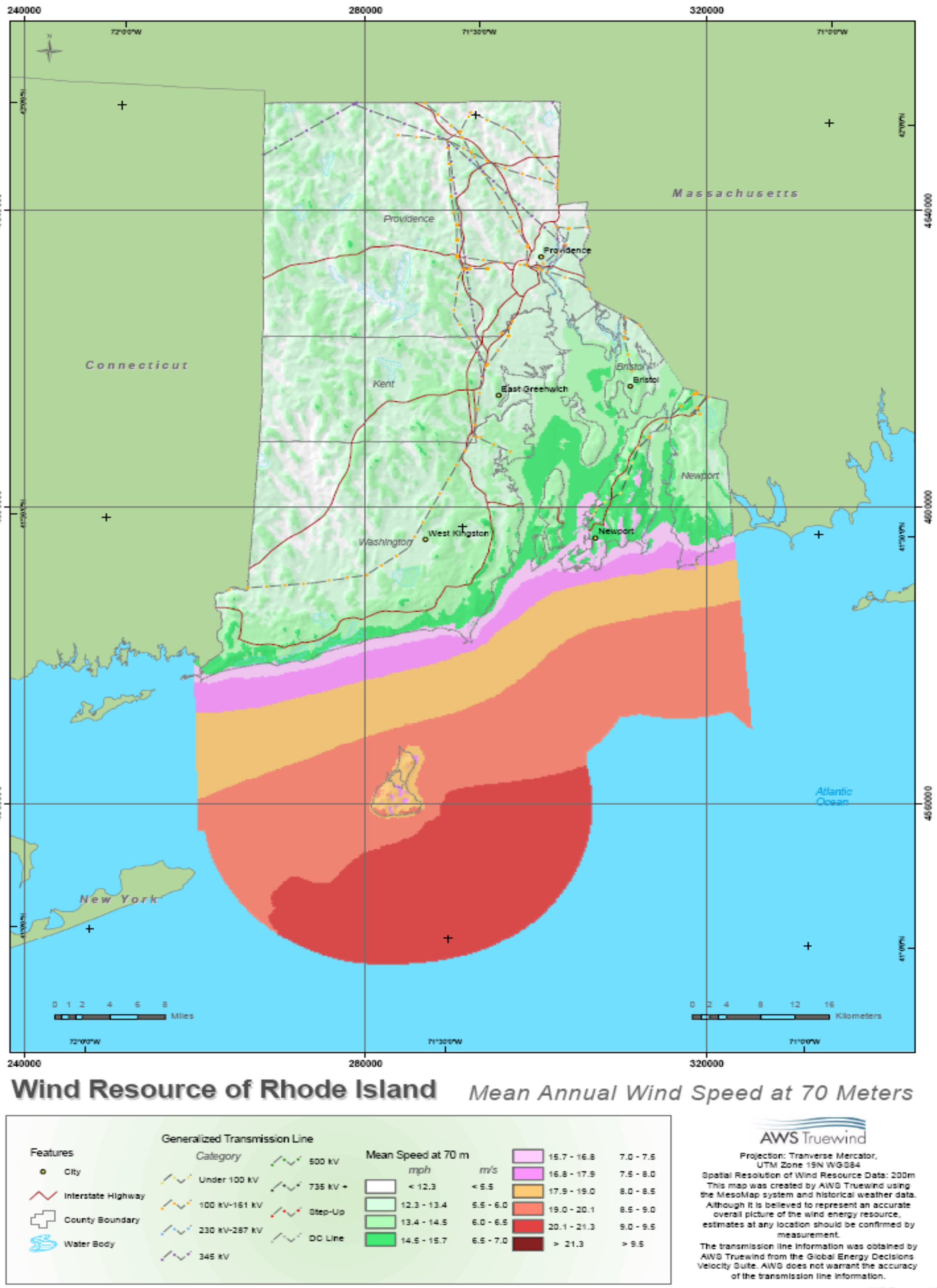
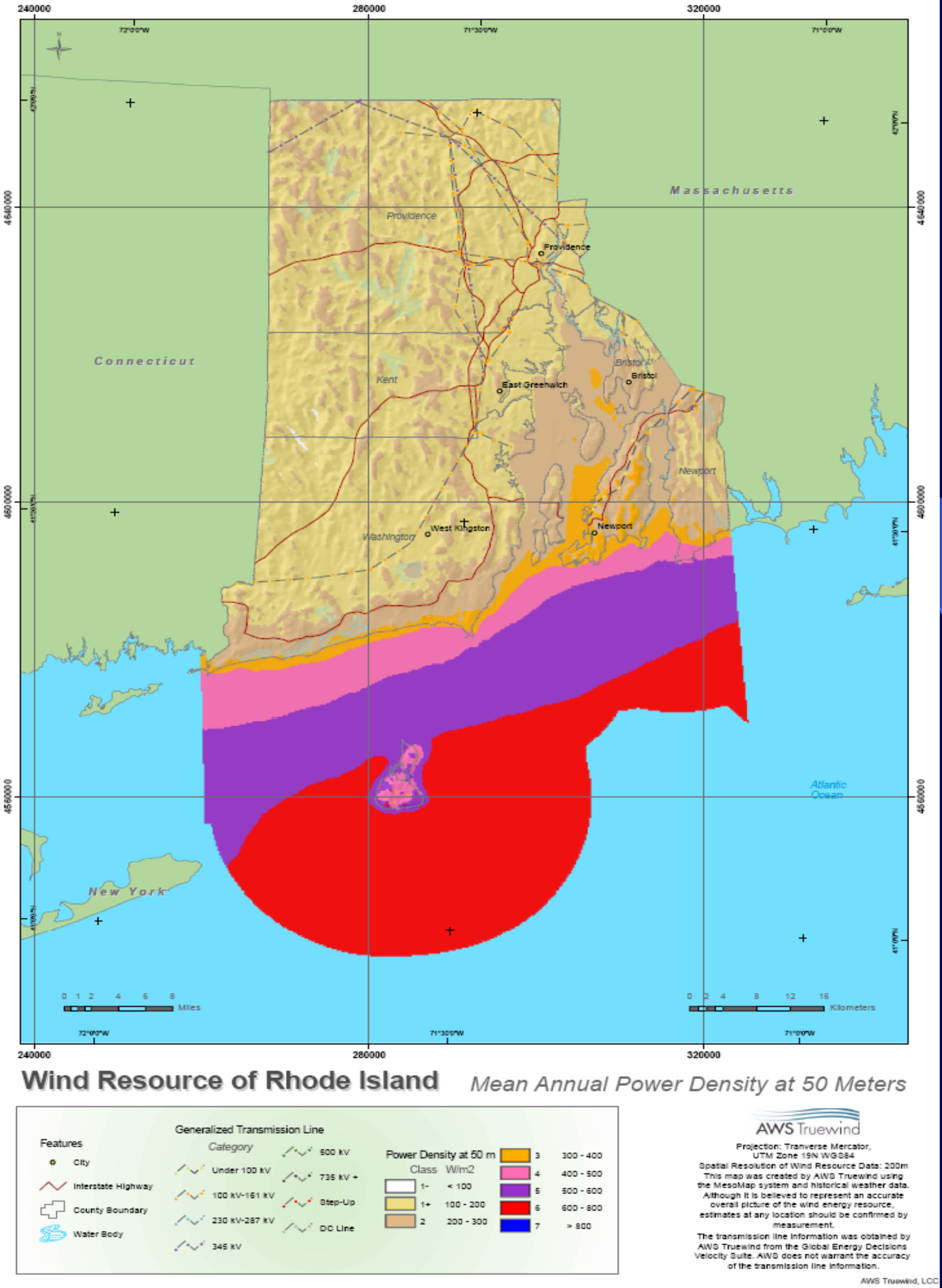


Figure 1 - RIWINDS Report Figure 3.20: Map Showing Post Level 2 Screening Areas Separated by Wind Speed and Final Area Designation

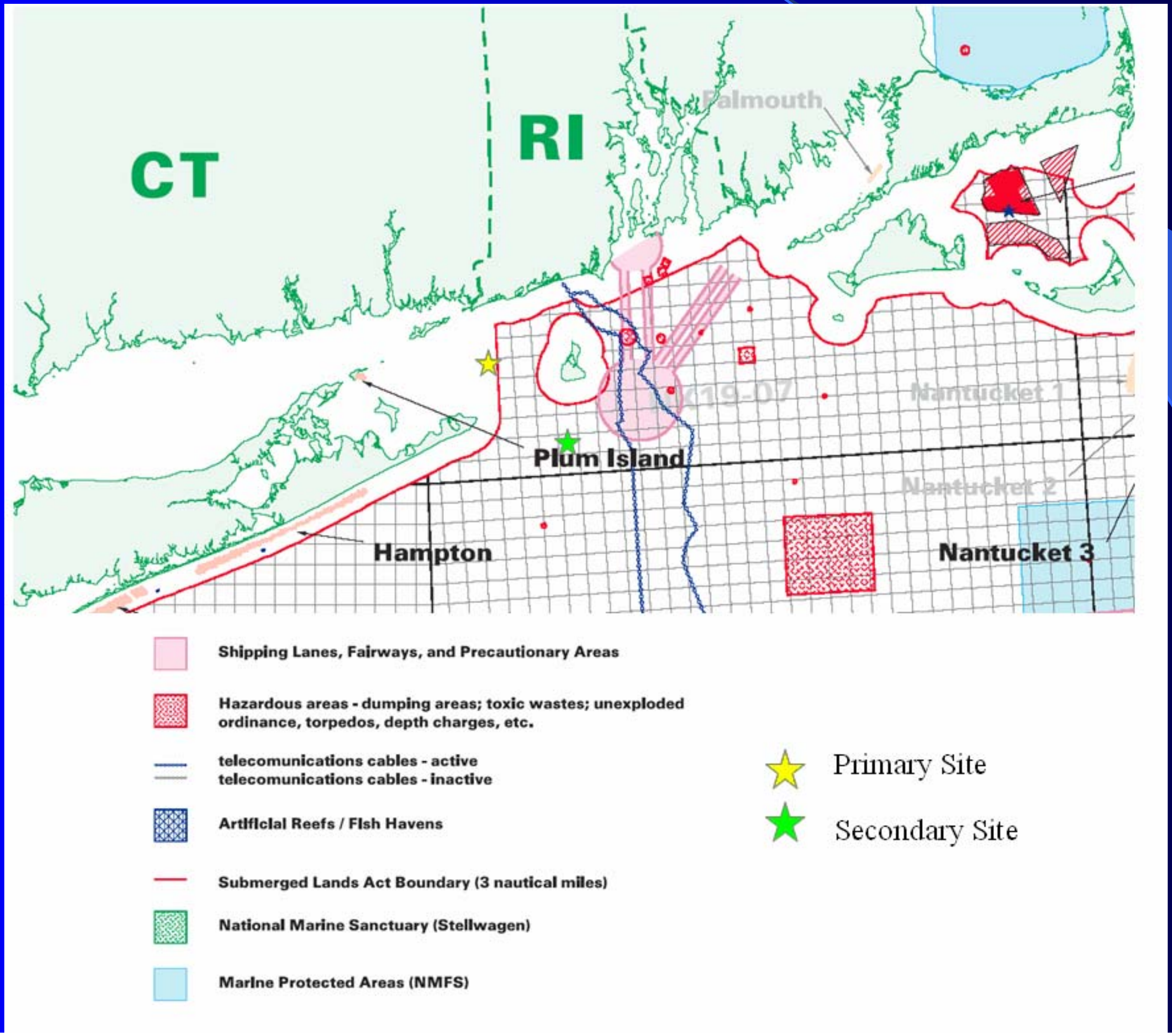
70 m winds


240000
280000
320000
Massachusetts
Connecticut
New York
Providence
Kent
Bristol
Newport
Washington
East Greenwich
West Kingston
Atlantic Ocean
Miles
Kilometers
Wind Resource of Rhode Island
Mean Annual Wind Speed at 70 Meters
Features
City
Interstate Highway
County Boundary
Water Body
Generalized Transmission Line
Category
Under 100 kV
100 kV-161 kV
230 kV-287 kV
345 kV
500 kV
735 kV +
Step-Up
DC Line
Mean Speed at 70 m
mph
m/s
< 12.3
< 5.5
12.3 - 13.4
5.5 - 6.0
13.4 - 14.5
6.0 - 6.5
14.5 - 15.7
6.5 - 7.0
15.7 - 16.8
7.0 - 7.5
16.8 - 17.9
7.5 - 8.0
17.9 - 19.0
8.0 - 8.5
19.0 - 20.1
8.5 - 9.0
20.1 - 21.3
9.0 - 9.5
> 21.3
> 9.5
AWS Truewind
Projection: Tranverse Mercator, UTM Zone 19N WGS84
Spatial Resolution of Wind Resource Data: 200m
This map was created by AWS Truewind using the MesoMap system and historical weather data. Although it is believed to represent an accurate overall picture of the wind energy resource, estimates at any location should be confirmed by measurement.
The transmission line information was obtained by AWS Truewind from the Global Energy Decisions Velocity Suite. AWS does not warrant the accuracy of the transmission line information.
AWS Truewind, LLC

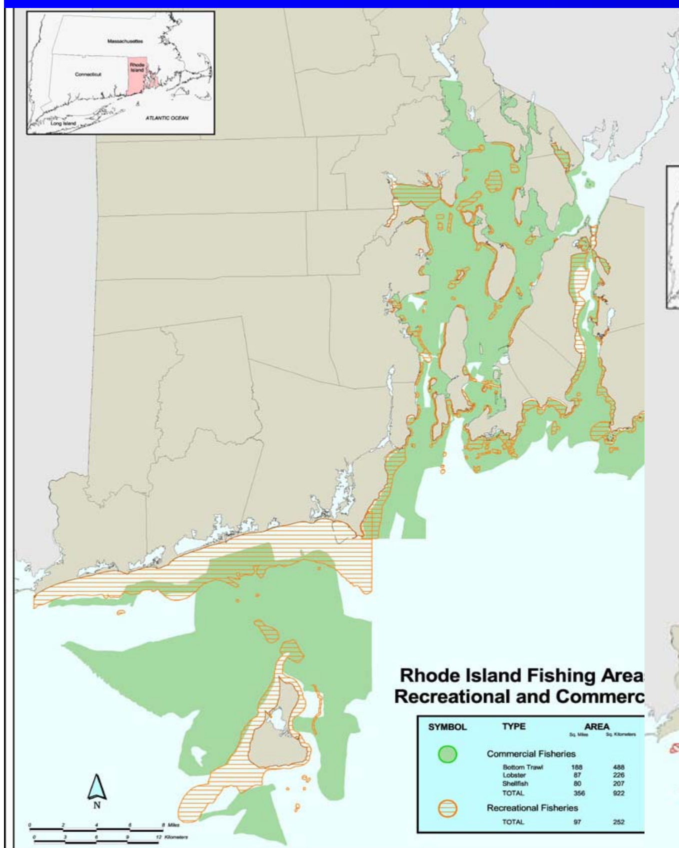
50 m power density

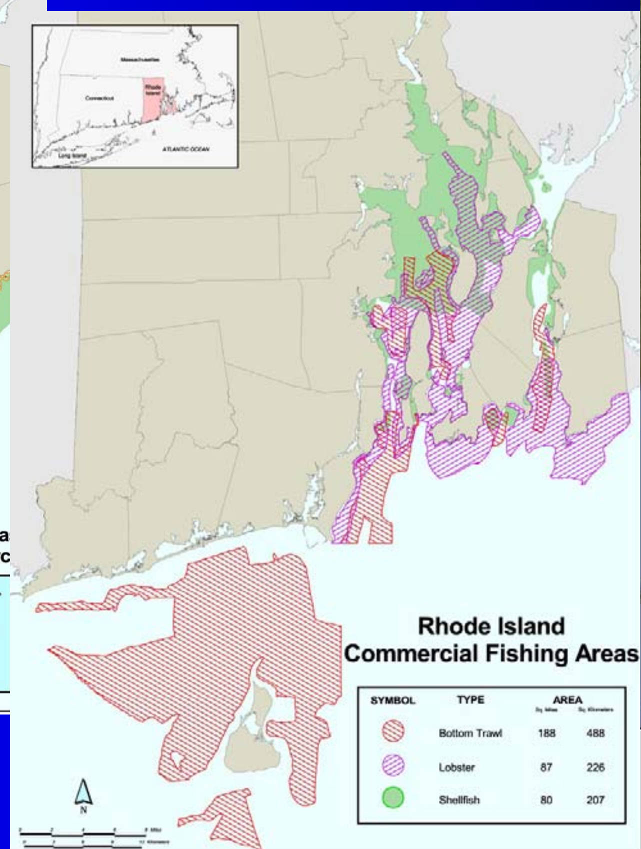


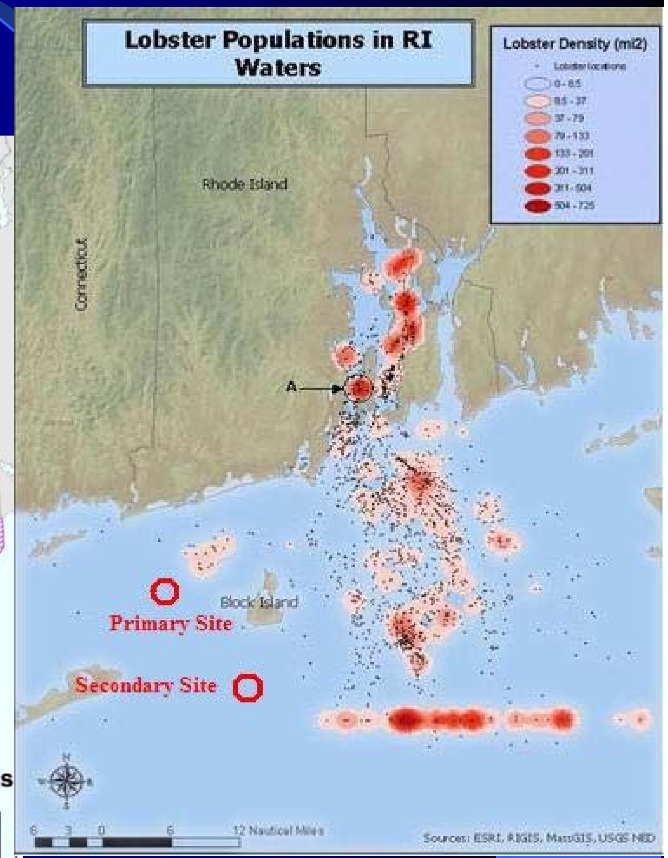
MMS Use Summary



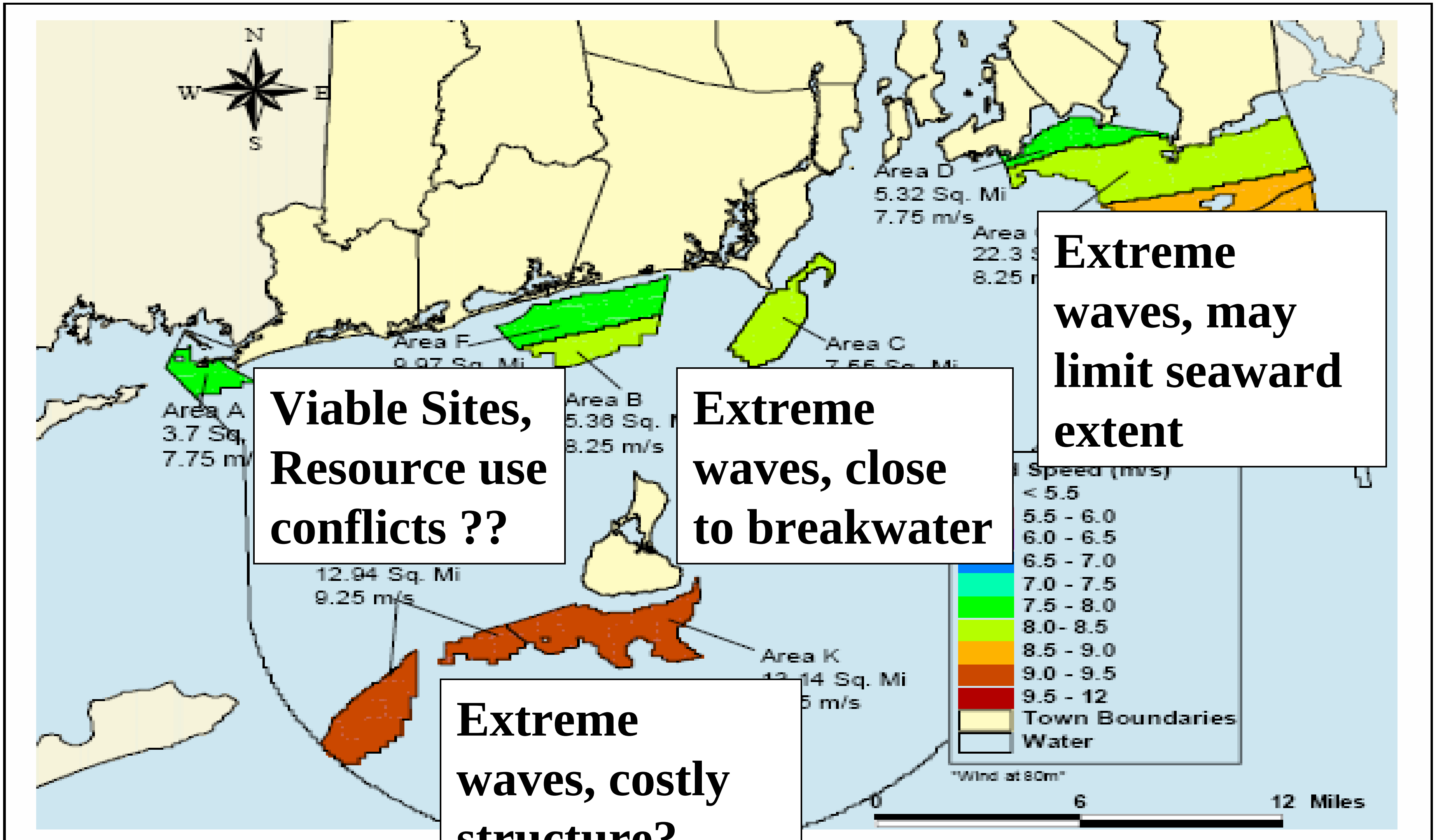
Major Fishing Areas (URI, EDC)







Initial Concerns with Some Sites



Viable Sites, Resource use conflicts ??

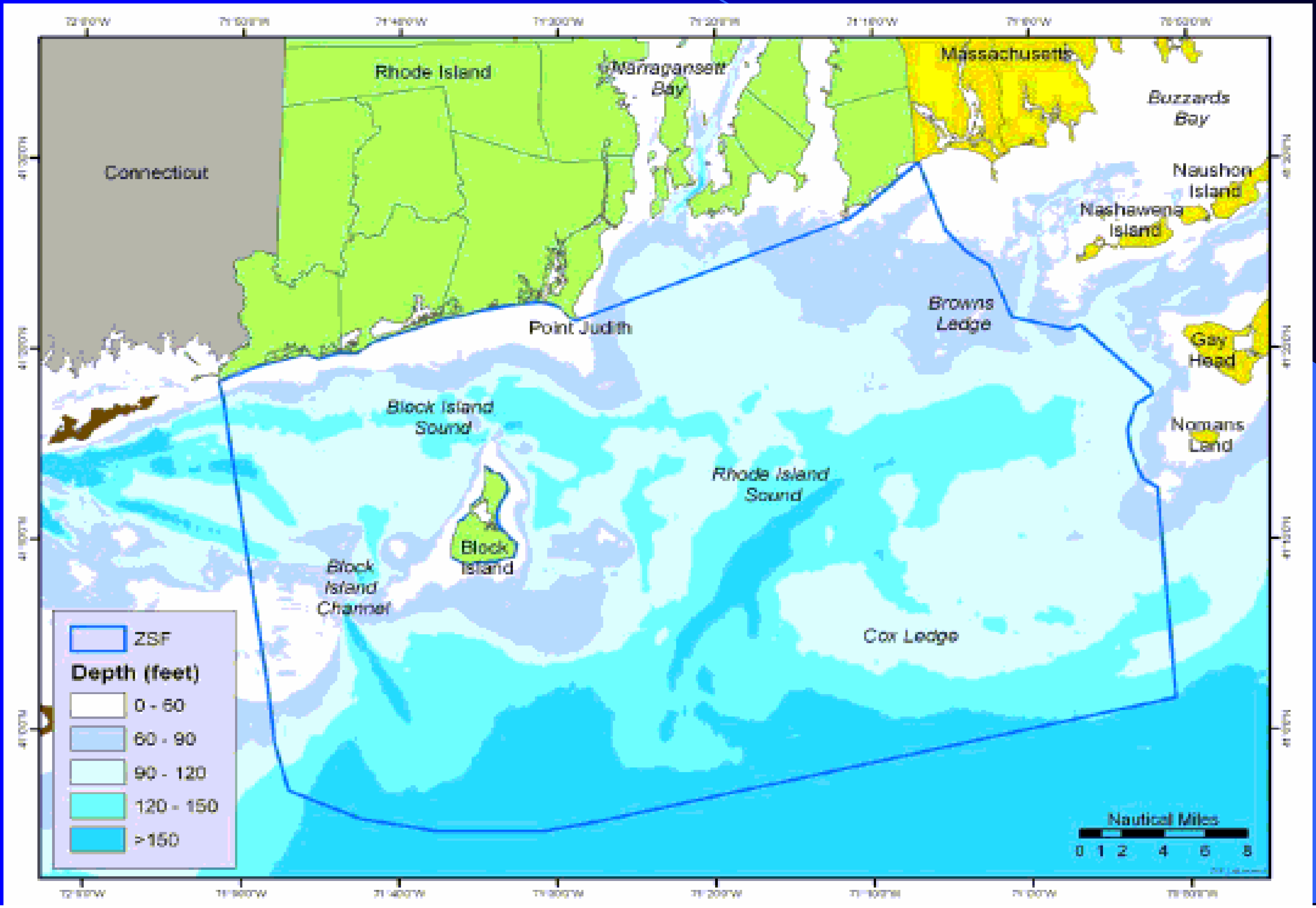
Extreme waves, close to breakwater

Extreme waves, may limit seaward extent

Extreme waves, costly structure?

Figure 1 - RIWINDS Report Figure 3.20: Map Showing Post Level 2 Screening Areas Separated by Wind Speed and Final Area Designation

Ocean SAMP Study Area



Study Area Selection

- Include all state and contiguous federal waters
- Include sites for alternative tradeoff analysis required for permitting process
- Consistent with Army Corp Dredged Material Disposal Assessment

Phased Study

- Phase I - Ocean SAMP and associated supporting studies
- Phase II- Detailed investigations

  (meteorological and oceanographic observations, high resolution bottom, sub-bottom, archeological, and fish habit mapping)

Study Design

- Follow state (CRMC) and MMS regulatory framework for Offshore Alternative Energy Development and Production
- Maximize the use of existing data and access to local expertise (data)
- Minimize cost by contracting with state entity
- Perform supporting studies to fill data and information gaps, only as absolutely required
- Build on ***Lessons Learned*** from siting of offshore wind farms
- Collect sufficient data to allow Ocean SAMP to be developed and defended

Study Schedule

• Final site selection study	8 months*
• Selection of met. tower site	10 months
• Floating zone tool	12 months
(Developers identified, EIS initiated)	
• Kick-off of Phase II, Detailed Investigations (meteorological tower**) (optional)	13 months
• Completion of Ocean SAMP	24 months

* Time from project initiation

** Meteorological observations typically required for 2 (3?) yrs

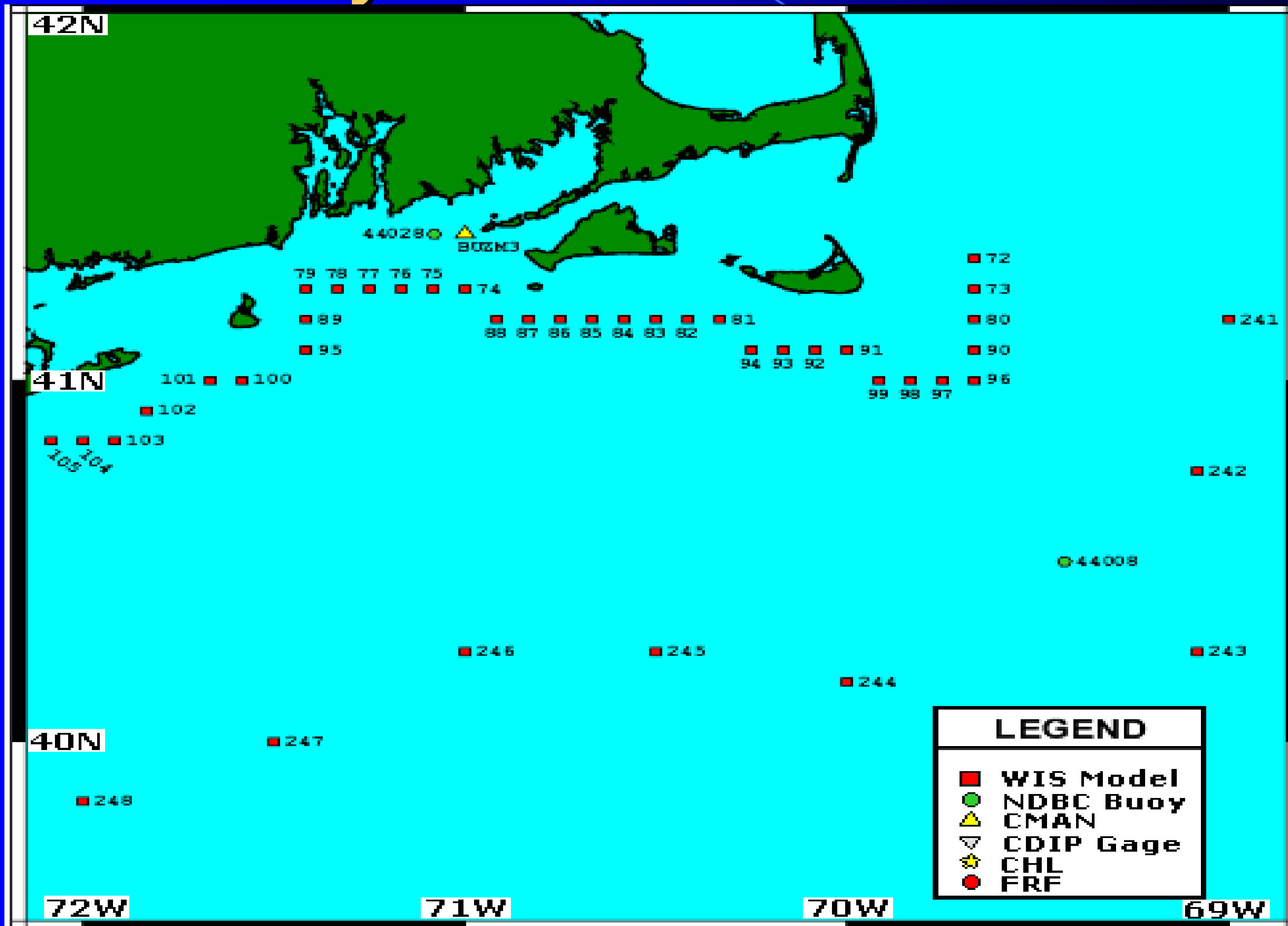
Phase I - Ocean SAMP

- Development of Plan and Stakeholder Involvement
  - Legal analysis
  - Commercial and recreational fisheries (Biological oceanography)
  - Visualization
  - Technical and advisory council
  - Outreach and communications

Major Supporting Studies PHASE I Ocean SAMP

- Refinement of Site Selection
  - Wind, wave, and surge analysis
  - Marine transportation (AIS)
- Wind Farm Technology Assessment
- Geology (surficial and sub-bottom), sea bed mapping
- Physical oceanography

US Army Corp Wave Information Study Hindcast Locations



myiw | WIND & FORECASTS | FORUMS | CAMS | EVENTS | BUY / SELL | MEMBERSHIP

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RI- Rhode Island

Real-Time Data

- > Dynamic Map
- > Wind Obs Map
- > Radar + Satellite Map
- > Wind Obs Summary

Computer Forecasts

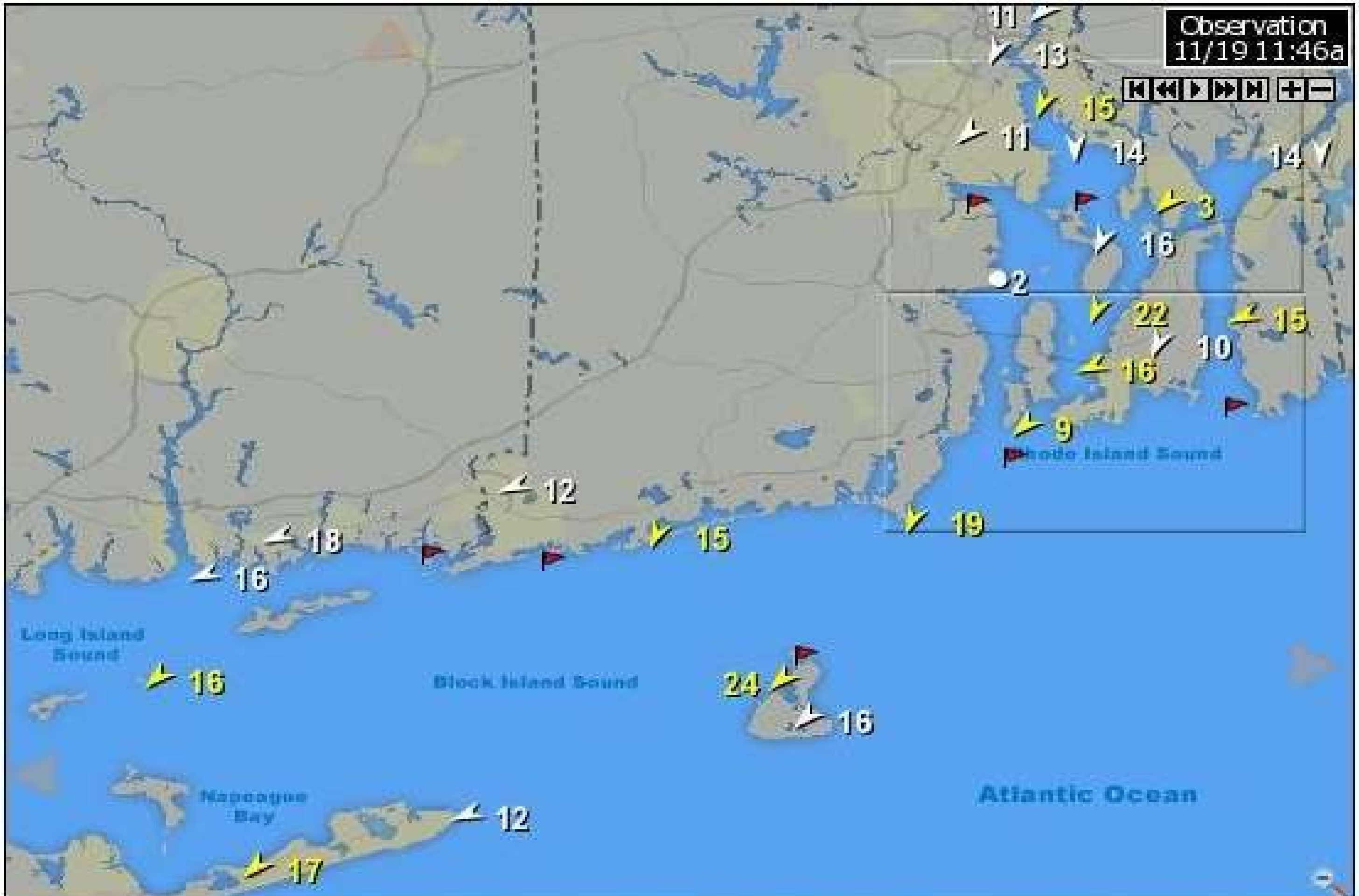
- > Model Tables
- > Wind Vector Fx Map

More Maps
Other Resources
Wind Graphs
Meteograms

Switch Region

Home : CT : RI : xt_Atl_MA : RI- Rhode Island : Wind Obs

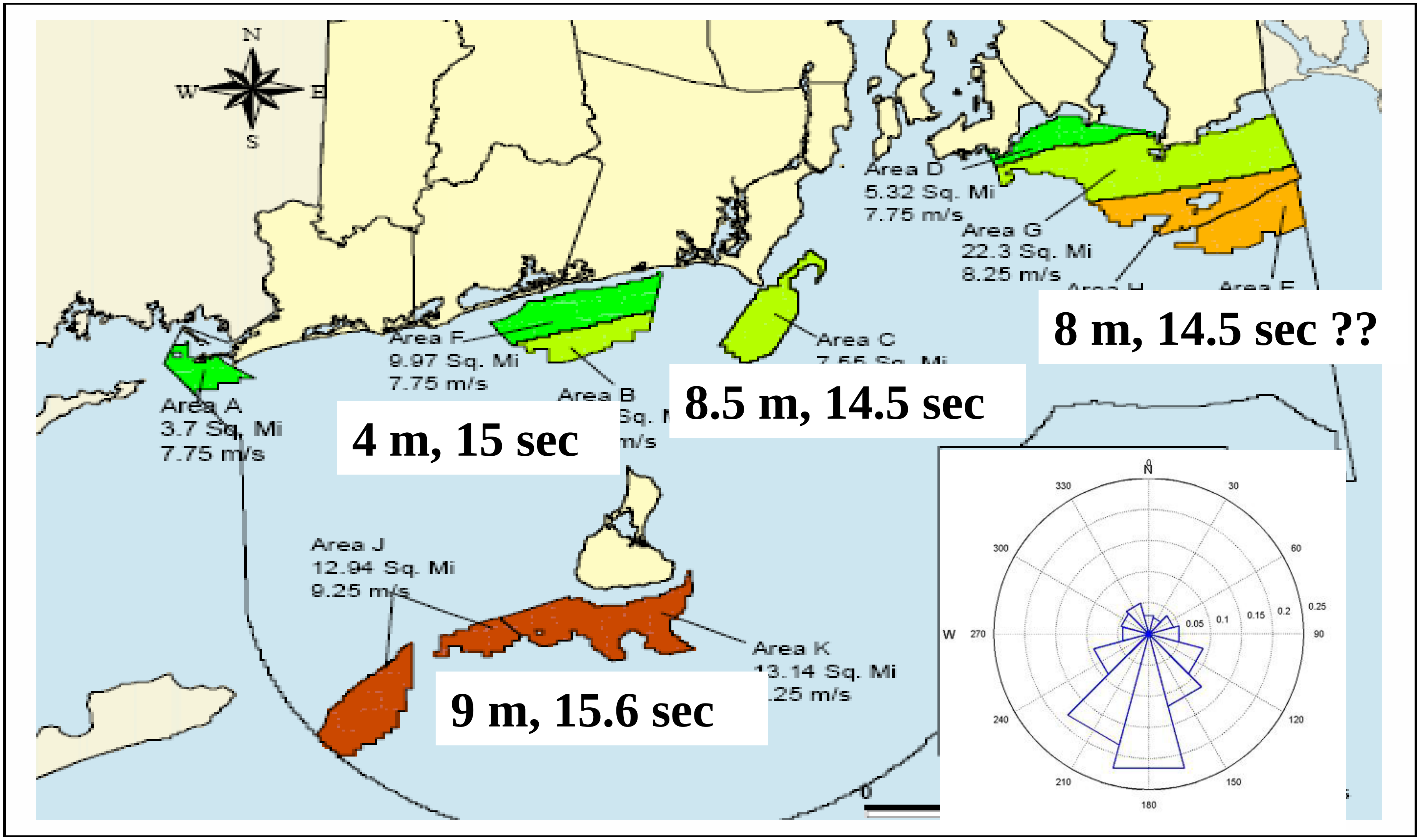
Map Time: LATEST OBSERVATIONS



WeatherFlow Sensor | Non-WeatherFlow Sensor | WeatherFlow Forecast | Forecast Only Site

iWindsurf Forum | Start a New Topic | View all Topics	Author	Latest Post

Extreme Wave Heights and Periods (1/100yr)



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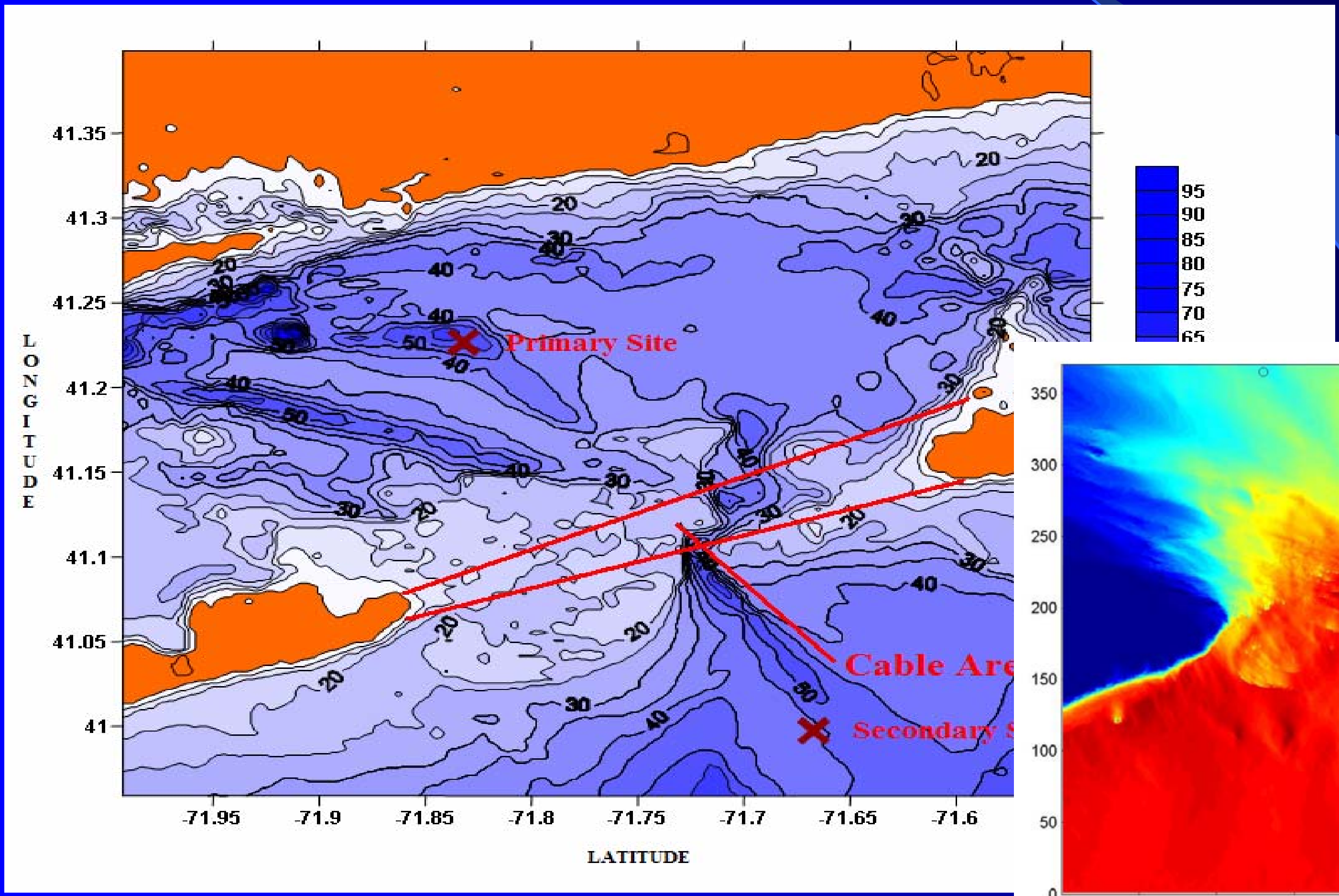
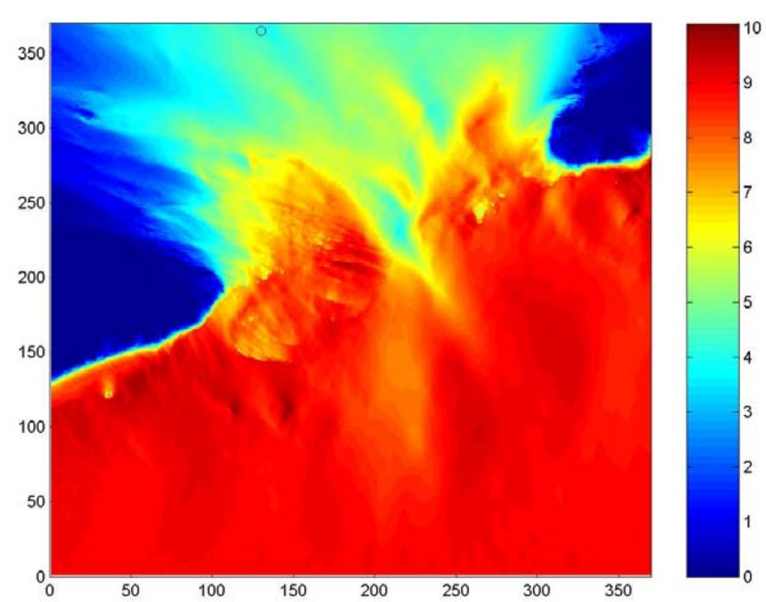
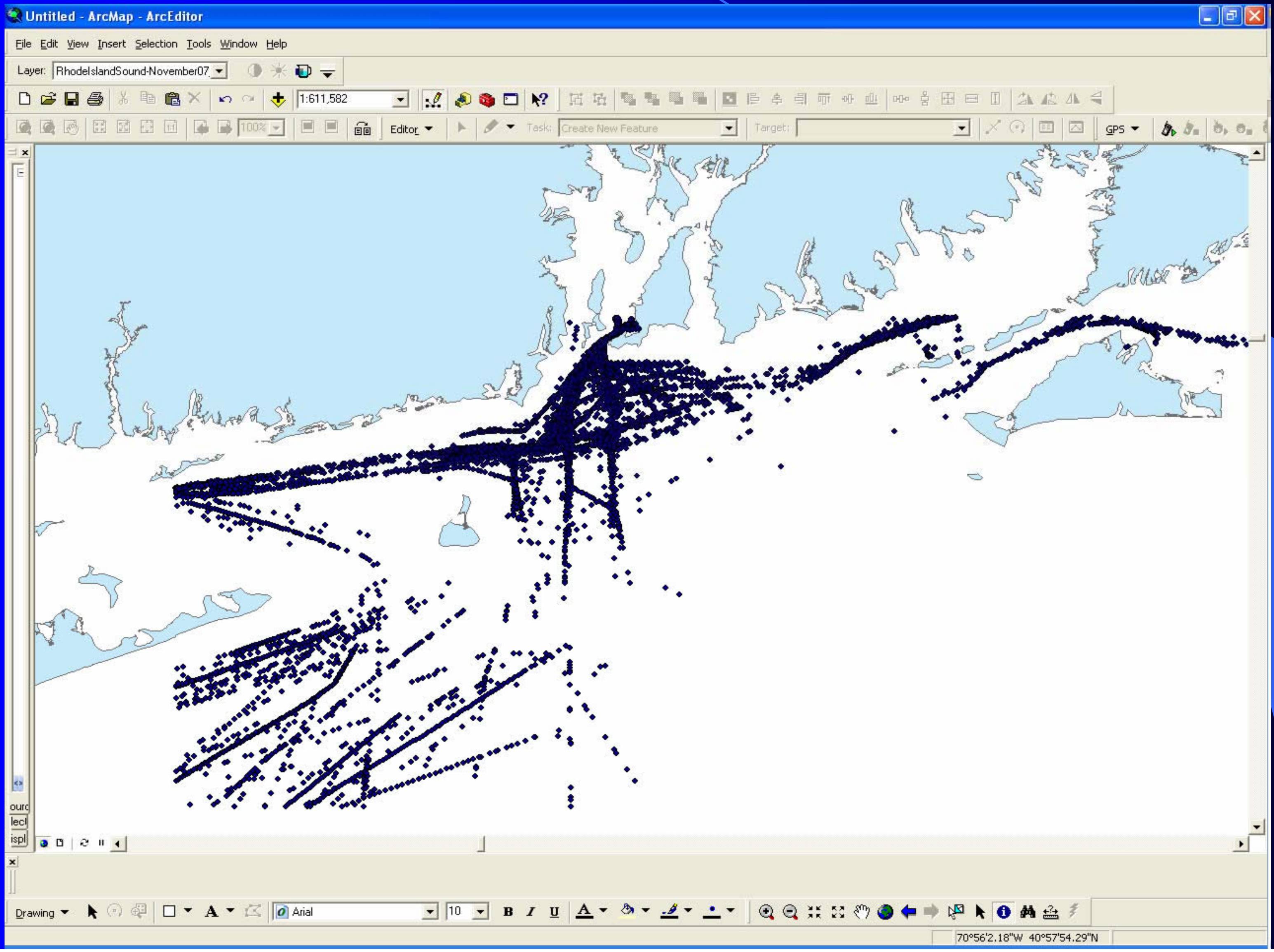
NOAA ENC Bathymetry - Wave Prediction 1/100yr)





AIS Tracks Oct 31 to Nov 26, 2007 (ASA)

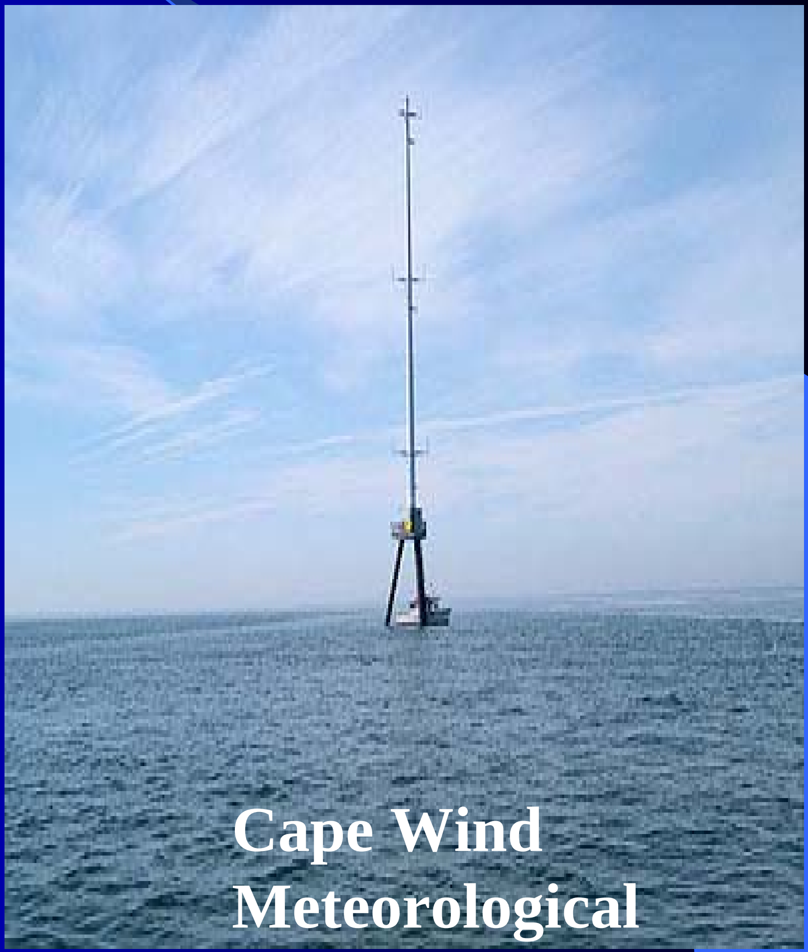


Phase I - Ocean SAMP Supporting Studies

- Meteorology and air quality
- Noise and electromagnetic
- Sea and shore birds
- Marine mammals and turtles
- Cultural and archeological resources

Phase II Detailed Investigations

- High resolution bottom and sub-bottom mapping
- Ocean observations: winds, currents, and waves



Cape Wind Meteorological Tower

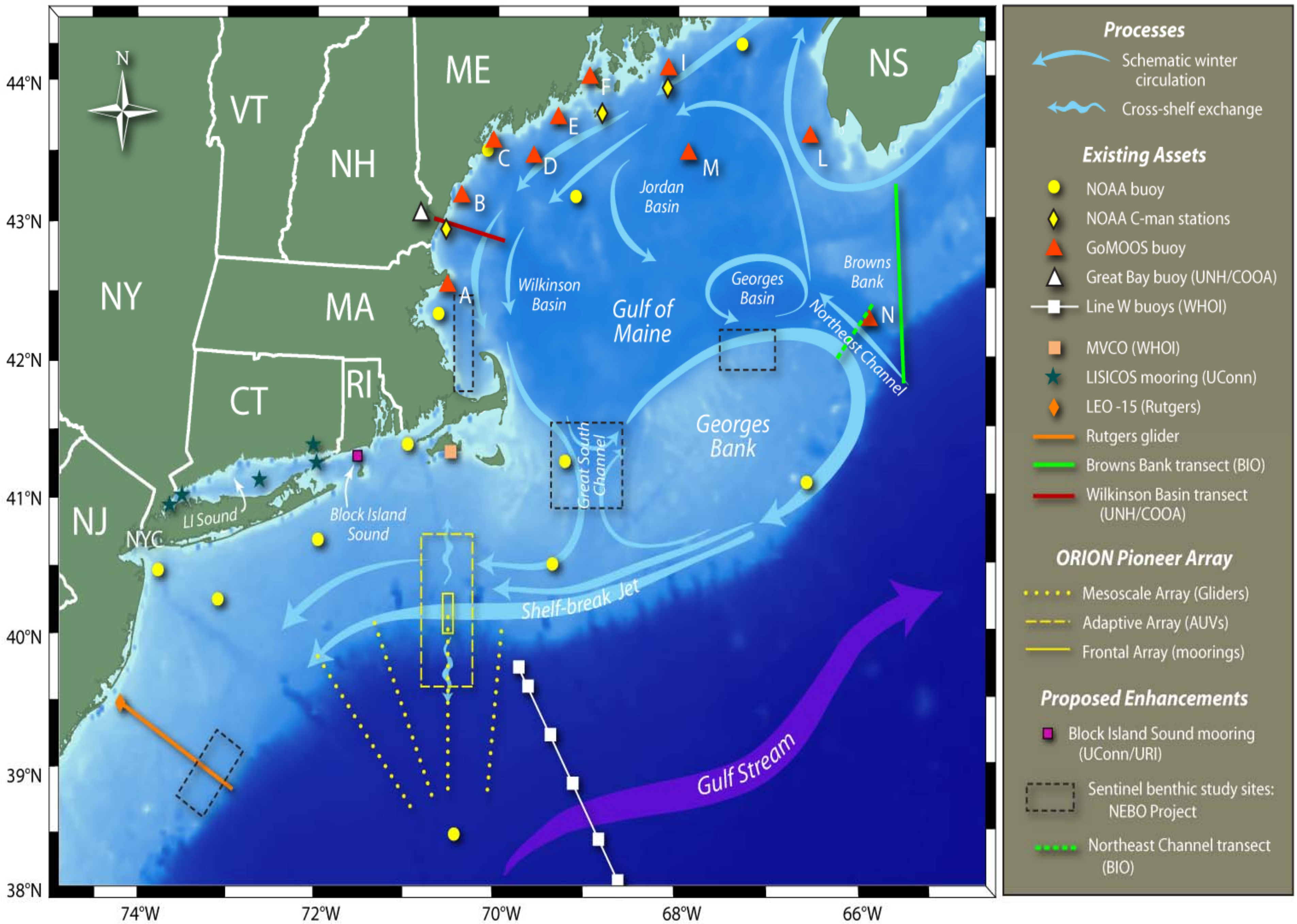
Meteorological and Ocean Observation Tower

- Meet immediate need for wind farm siting
- Long term plan operated by URI as part of the federal initiative on Integrated Ocean Observing System(IOOS) (Regional Associations, Northeast and Mid Atlantic Bight)

  Leverage re-location of GoMOOS buoy

  (Coordination with NOAA Surveying Vessel)

Northeastern Regional Coastal Ocean Observing System



GoMOOS Buoy Relocated to RI

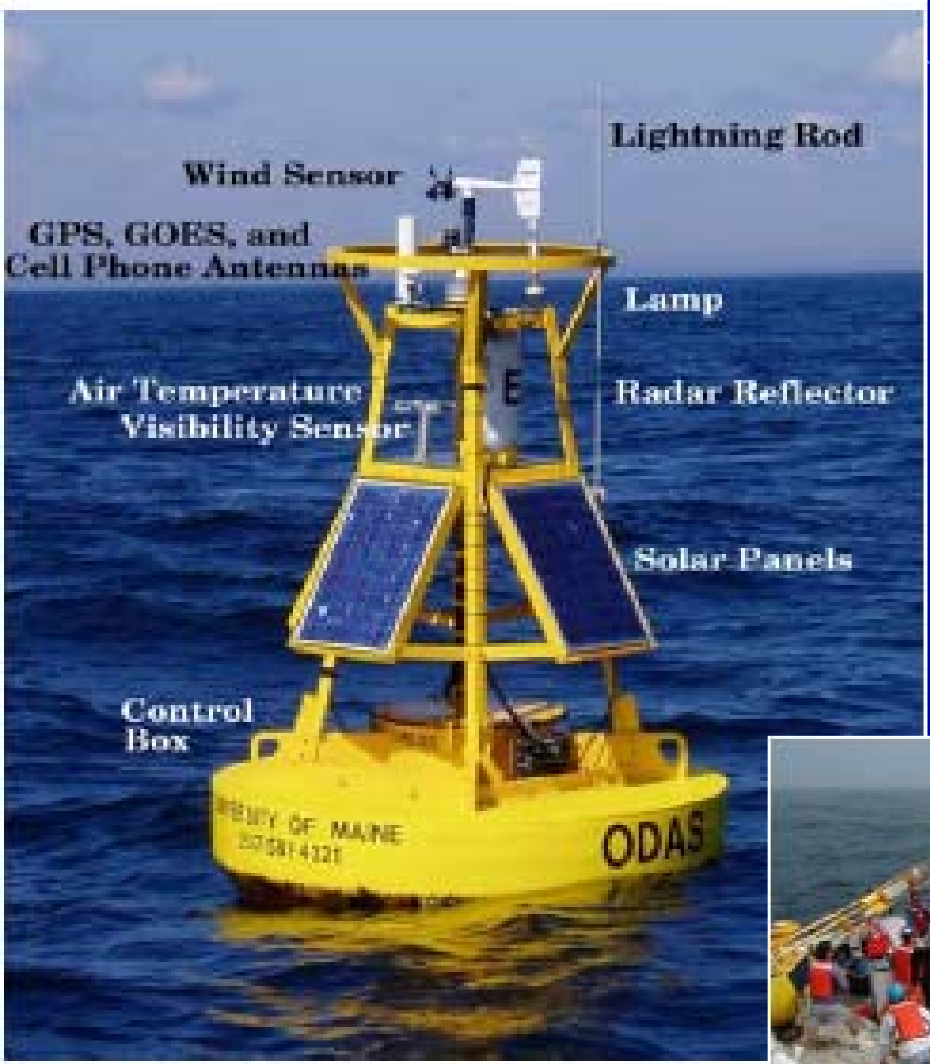
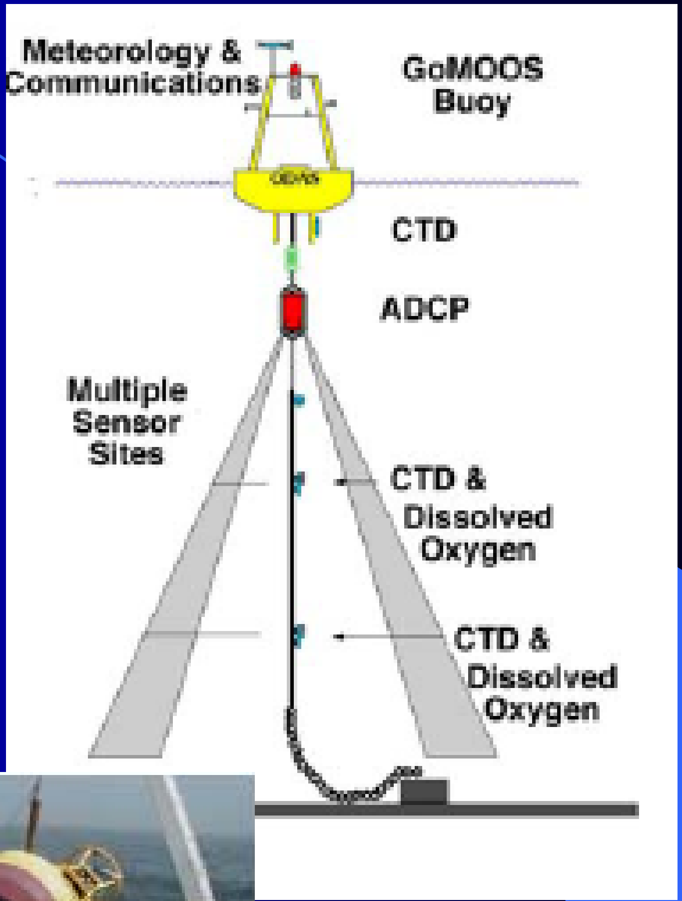
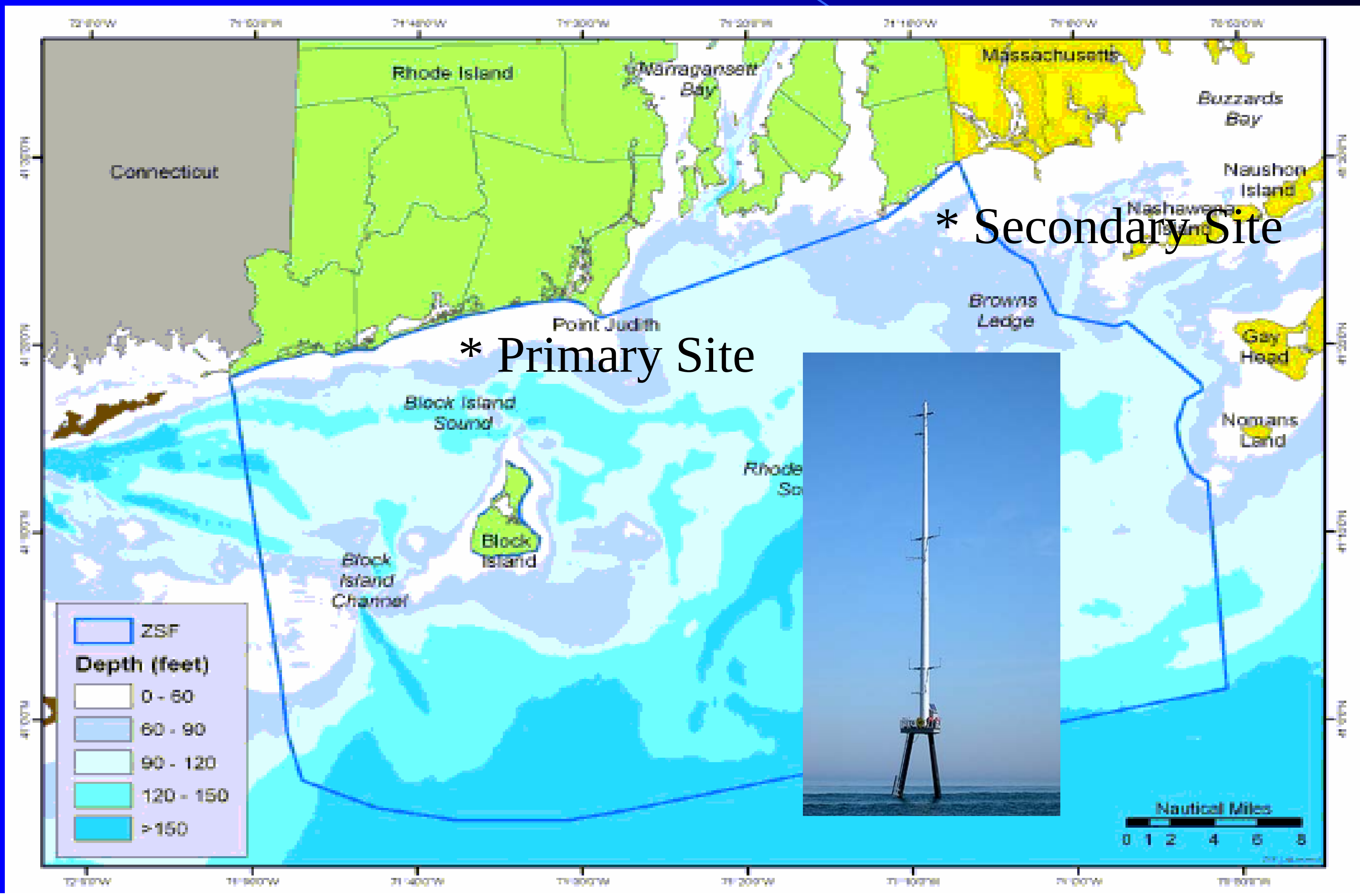


Figure 1. A GoMOOS buoy



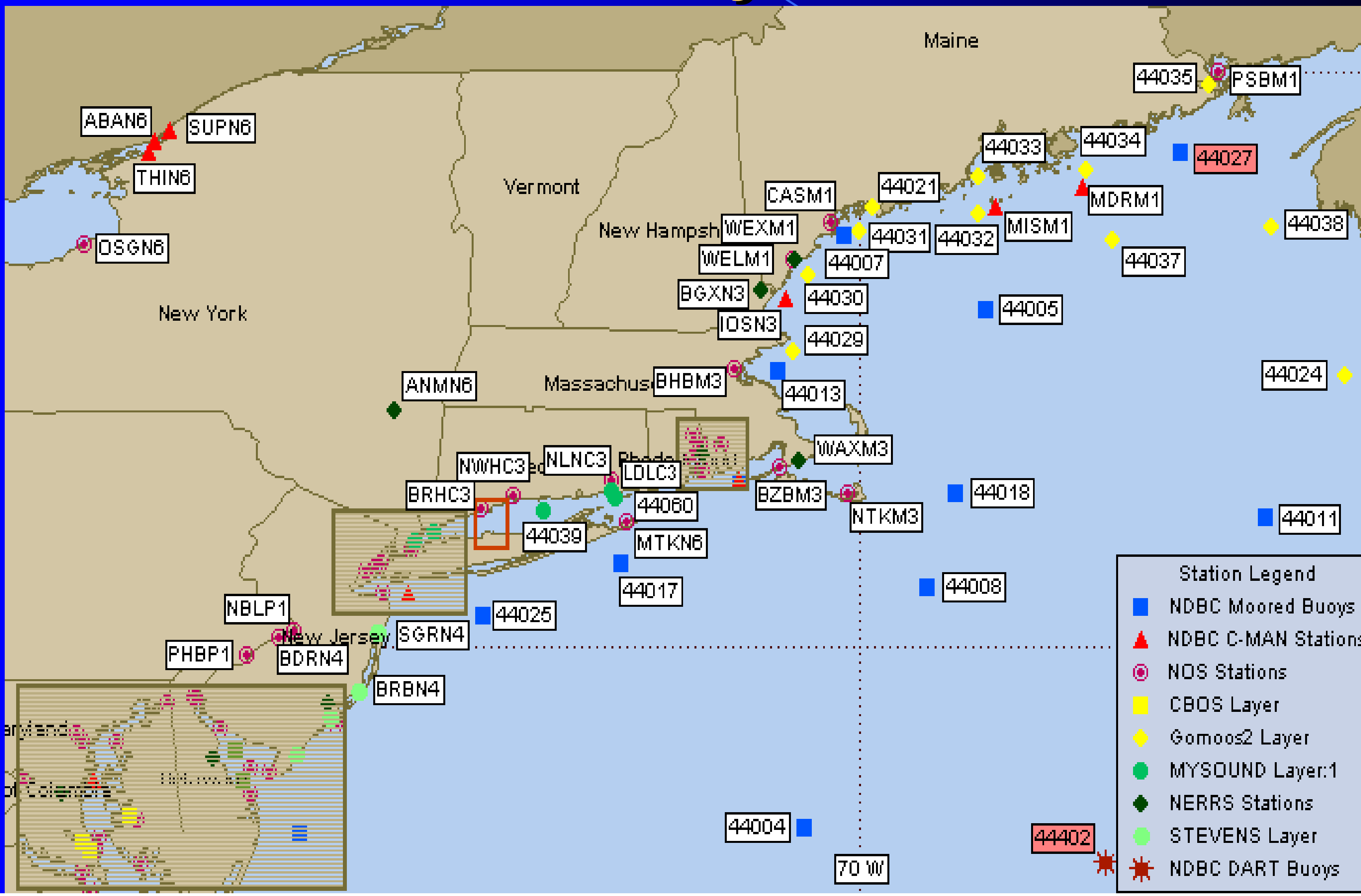
Ocean and Meteorological Observation Tower (Tentative site)



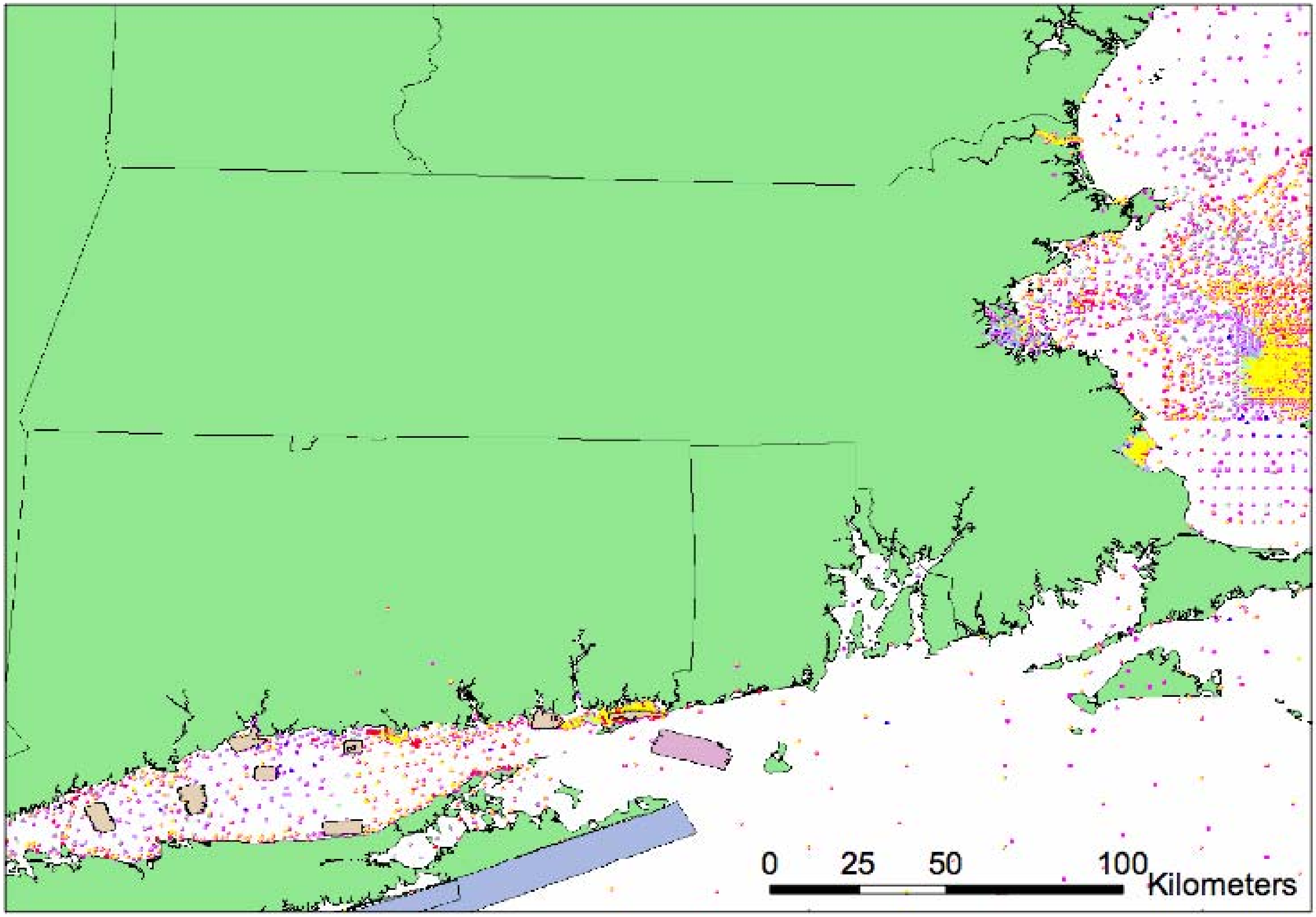
Availability of Supporting Environmental Data

- Winds – none in RI coastal waters
- Waves and currents – none in RI coastal waters
- Geological parameters – limited, sampling too coarse
- Birds - only coastal observations (Sachuest and Napatree Points), none offshore
- Marine Mammals – limited data, needs to synthesized
- Marine Archeological Sites – few observations

NOAA Offshore Observation Buoys



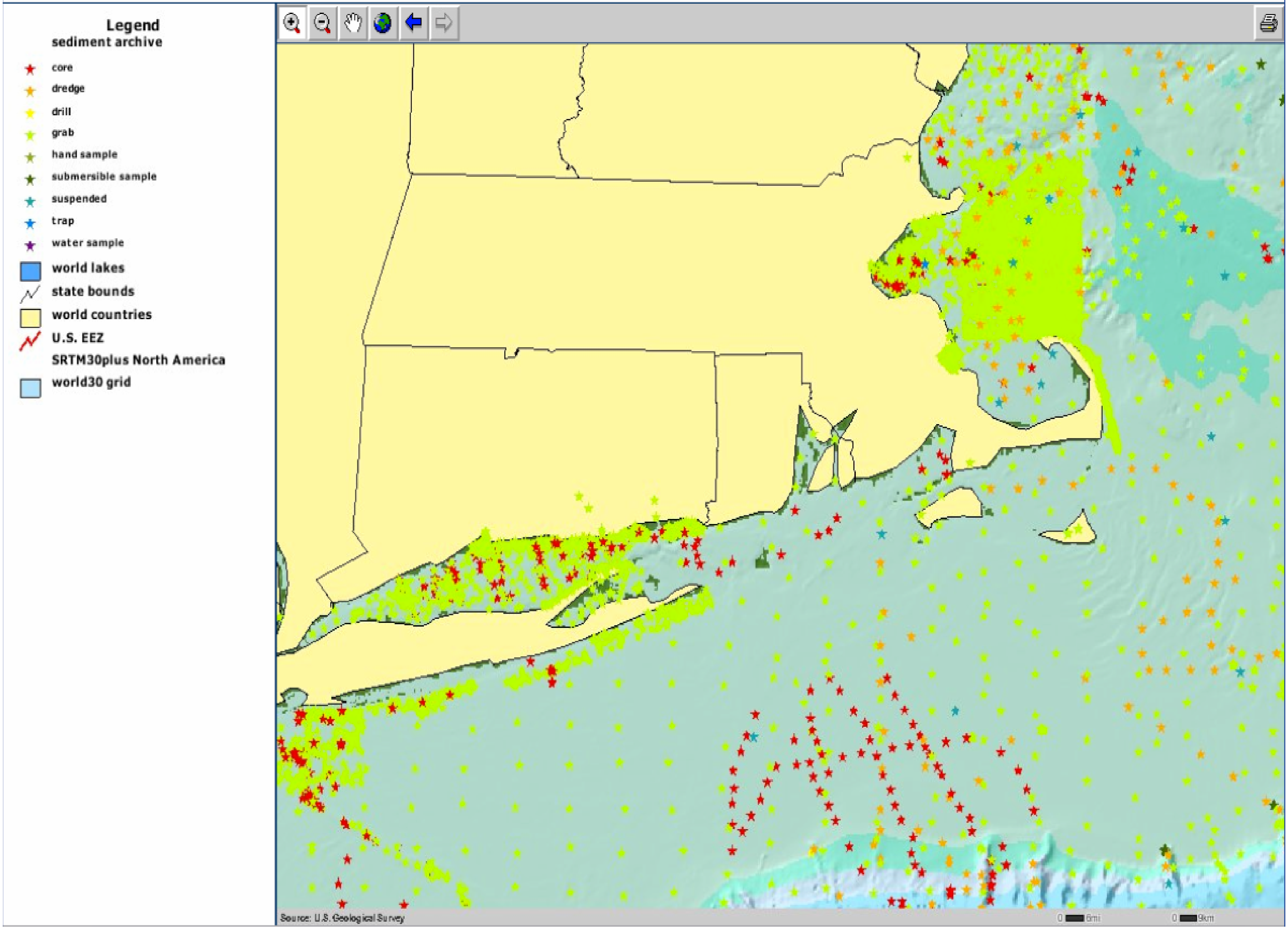
USGS Sediment Sample and sidescan survey locations



USGS Sub-bottom survey locations


Massachusetts
Rhode Island
Connecticut
New York
0 5 10 20 Kilometers

Woods Hole Science Center Core and Sample Locations



Cost Summary - Phase I

Phase I Major Study Elements

• Phase I Ocean SAMP	51.7 %*
• Refinement of Siting Study	8.5 %
• Sea Bed Mapping	13 %
• Birds	17.1 %
• Other Supporting Studies	9.7 %

TOTAL COST -$4 M

* Percent of total cost

Cost Summary - Phase II

Phase II Detailed Site Investigations

- Meteorological and oceanographic observations (Met tower) 77 %
- Sea bed mapping 23 %

TOTAL COST - $2.6 M

Sources of Renewable Ocean Energy in Rhode Island

Malcolm L. Spaulding
Professor, Ocean Engineering
Director, Center of Excellence in Undersea Technology
University of Rhode Island
Narragansett, RI 02882

Briefing to:
Coastal Resources Management Council
March 11, 2008

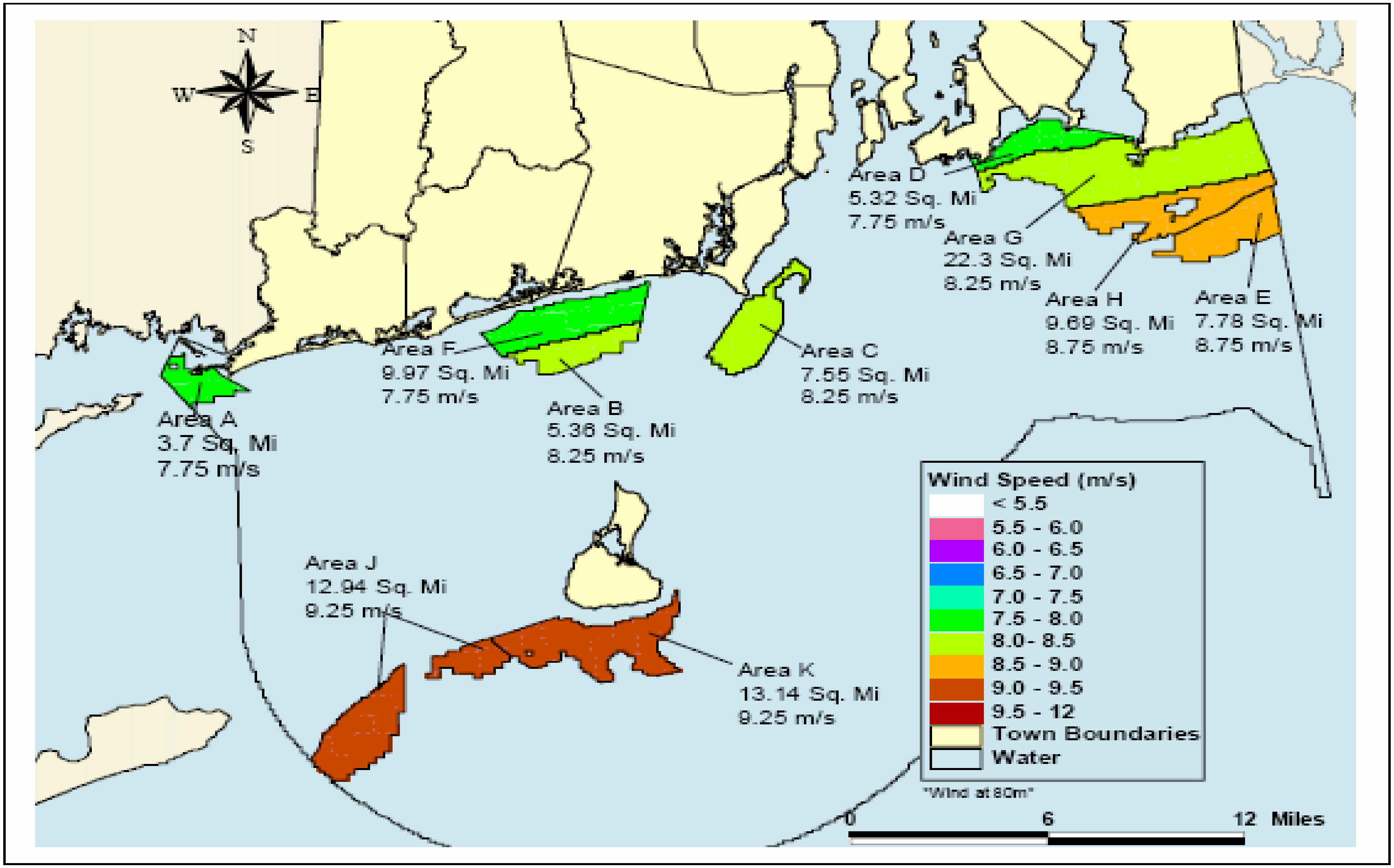
Sources of Offshore Renewable Energy

- Ocean Thermal Energy Conversion(OTEC)
- Offshore winds
- Waves
- Ocean currents
  - In stream and head (impoundment) based tidal
  - Mean current (e.g. Gulf Stream, river flow)

Key Issues with Renewables

- Low energy density, many power units distributed over large areas,
- Intermittent power production (1/3 time for wind and waves)
- Connection grid
- Resource use conflicts
- Environmental impacts

ATM (2007) Offshore Wind Sites



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Summary RI Power Production Potential

- Offshore Energy Production Potential (MW)

OTEC	none
In stream tidal currents	0.01
Waves	
10 to 100 unit farm(s)	0.408-40.8
Winds (all sites)	685
Selected short listed sites	150 - 220

- Renewable Energy Goal 150

Cost Summary

Cost of power production per MWhr

Winds	$96 to 137
Waves*	$630

* Only power generator capital costs; estimated 2.5 times if all project capitals costs

OFFSHORE WINDS!

In Depth Presentation

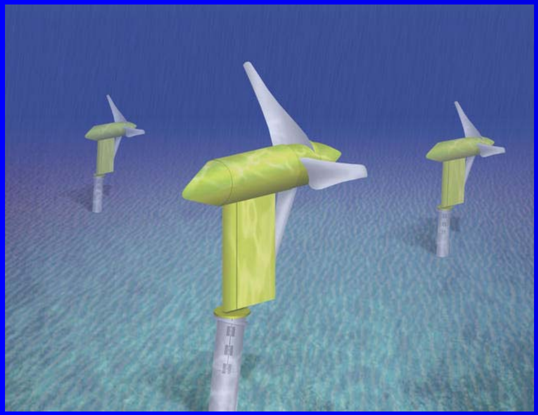
Ocean Thermal Energy Conversion (OTEC)

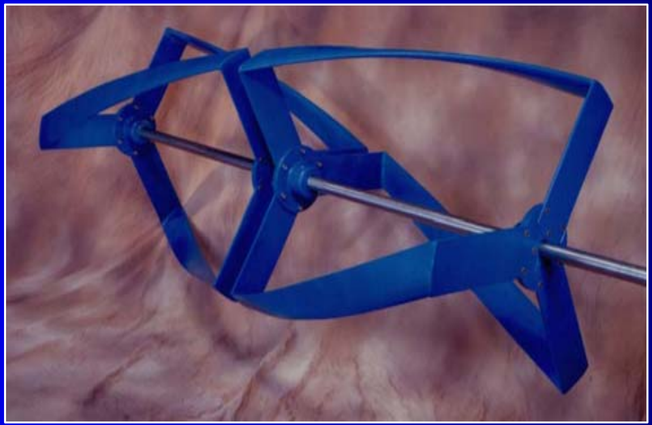
Ocean Thermal Energy Conversion

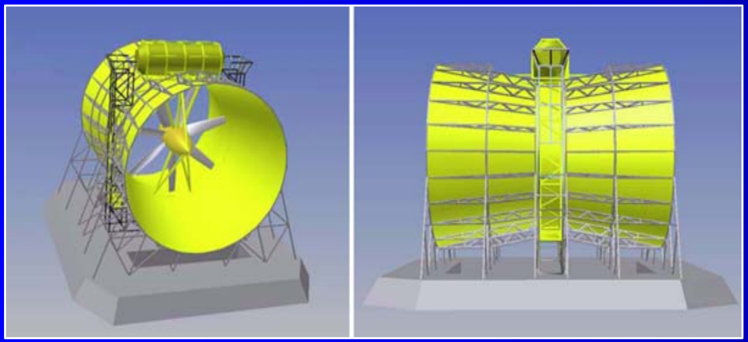
- Requires deep water, source of cold (deep) water and warm surface water
- No deep water sites exist in RI or southern New England shelf

NO POTENTIAL FOR RI

OCEAN CURRENTS







Ocean Currents

- No strong mean currents in RI or adjacent waters
- Tidal range in RI waters is modest (1 m) so no possibility for impoundments
- In stream tidal currents typically require current speeds greater than 1.5 to 2 m/sec (3 to 4 kt) to generate power (Turbine cut in speeds – 0.5 m/sec or 1kt)

In Stream Tidal Currents

- Two potential sites: Sakonnet River Bridge and Warren River (Rte 114 Bridge)
- Sakonnet River not viable, peak current about 1.3 m/sec, no significant power generation potential
- Warren River site limited local potential

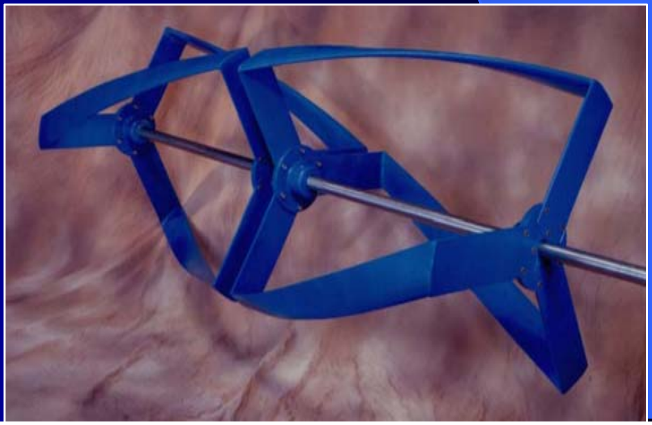
Maximum currents 2.5 m/sec (5 kt)

One turbine (1 m diameter, 2.5 m long)

1 kW or 8.7 MWh

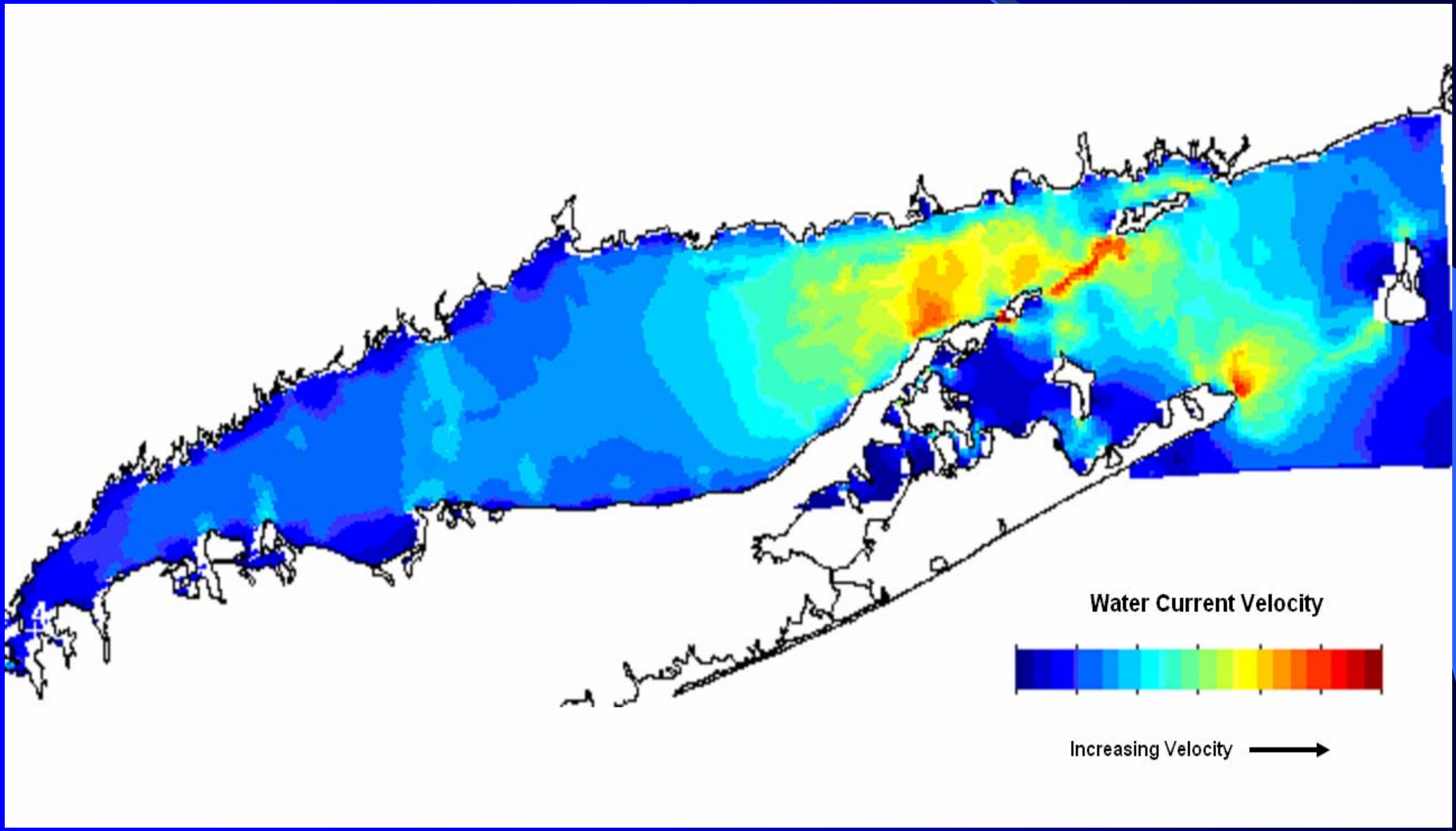
Full build out 10 turbines

10 kW or 87 MWh

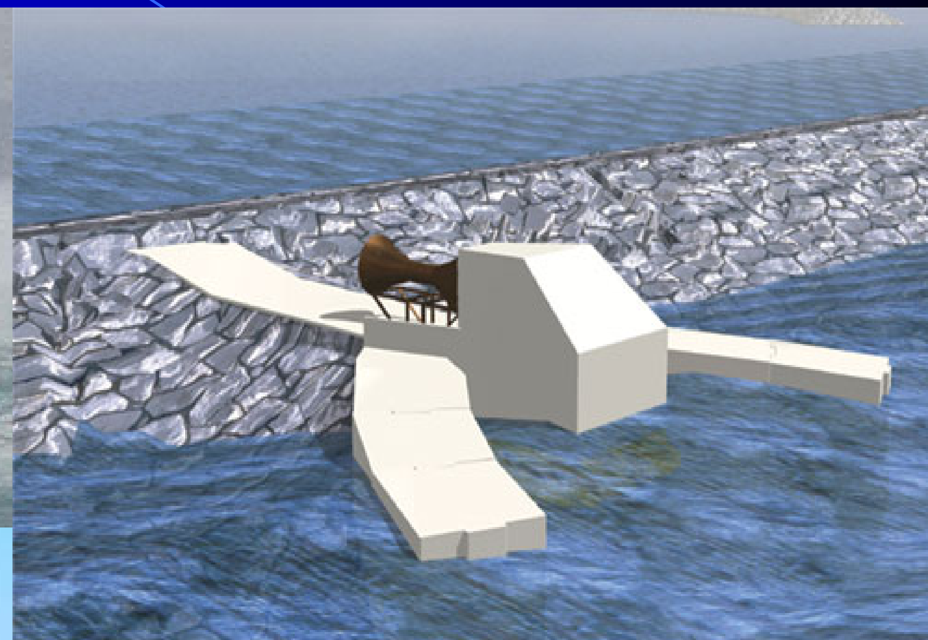


Warren River Bridge Site

Nearby Sites for In-Stream Tidal Current Power

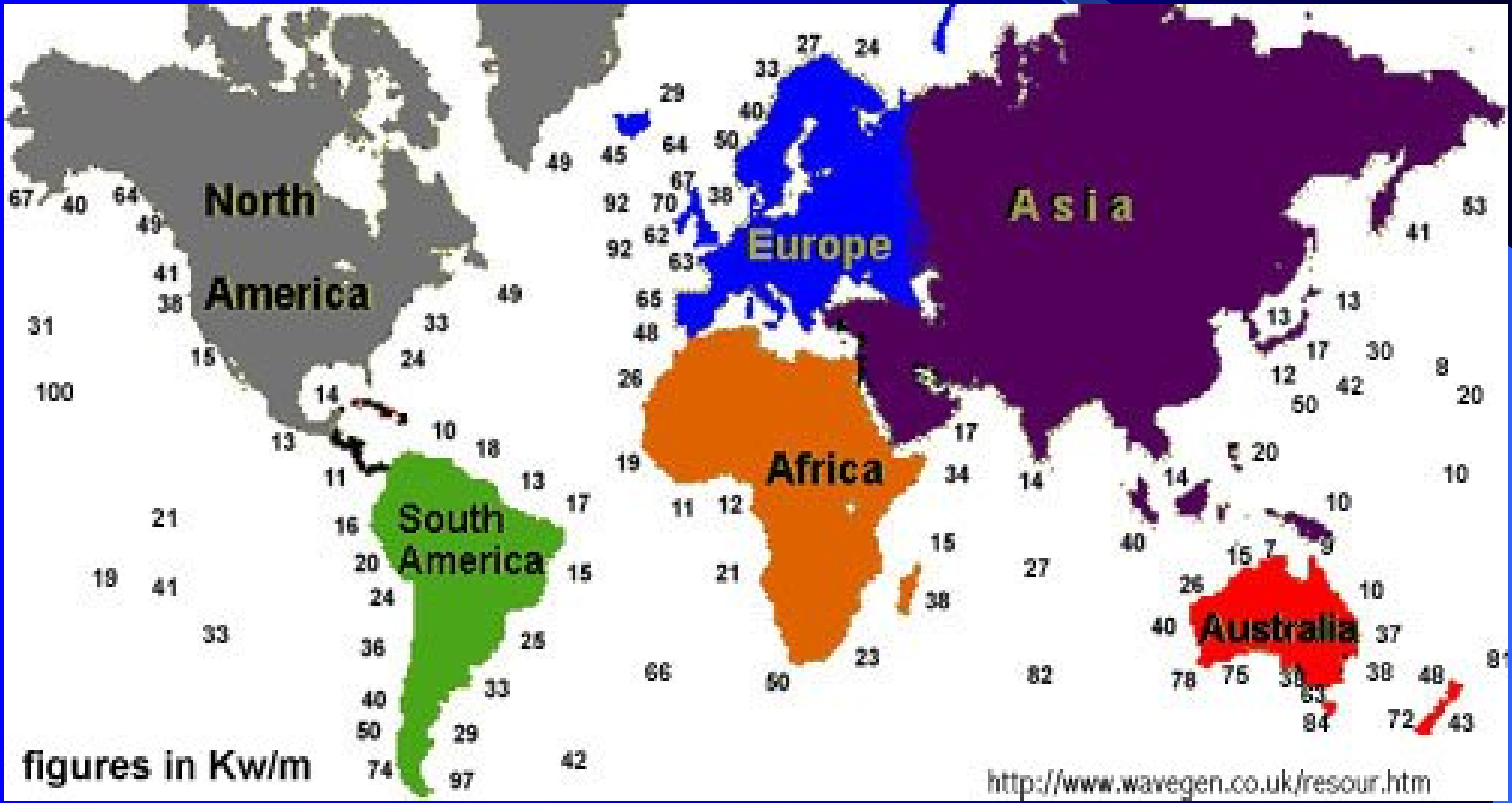


WAVE ENERGY



Worldwide wave energy

http://www.poemsinc.org/FAQwave.html

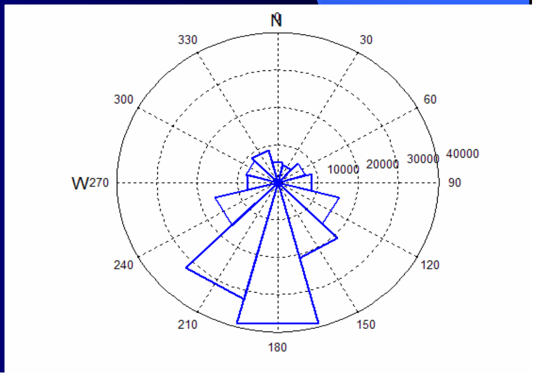


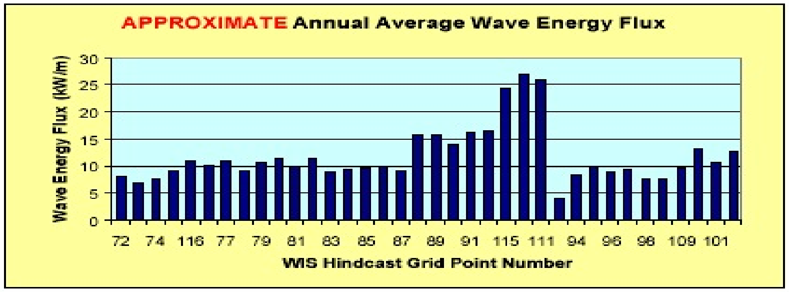
RI Wave Energy Setting

- Low wave energy density, short fetch distances, and wind blows primarily from west
- Largest (most) waves from south and southwest
- Rhode and Block Island Sound waves

    Mean Wave period – 4.5 sec

    Mean amplitude – 1.04 m





Annual Average Wave Energy Flux

Offshore exposed = 25 kW/ m

Nearshore exposed = 15 kW/m

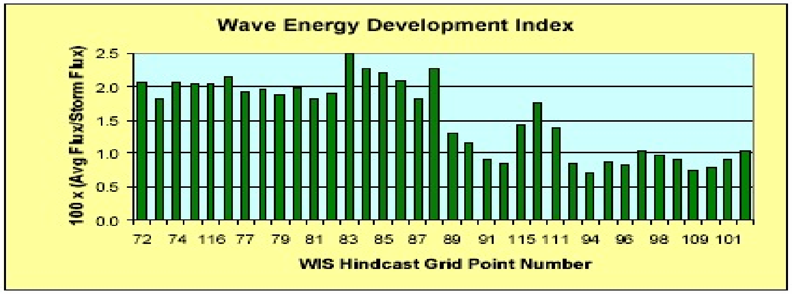
Nearshore sheltered by Nova Scotia or by Cape Cod and the Nantucket Shoals ~ 10 kW/m

Nearshore Wave Energy Development Index

Newport, RI to due south of Nantucket Island = 1.8 to 2.5

West of Newport, RI ~ 2

North of Nantucket Shoals = 1



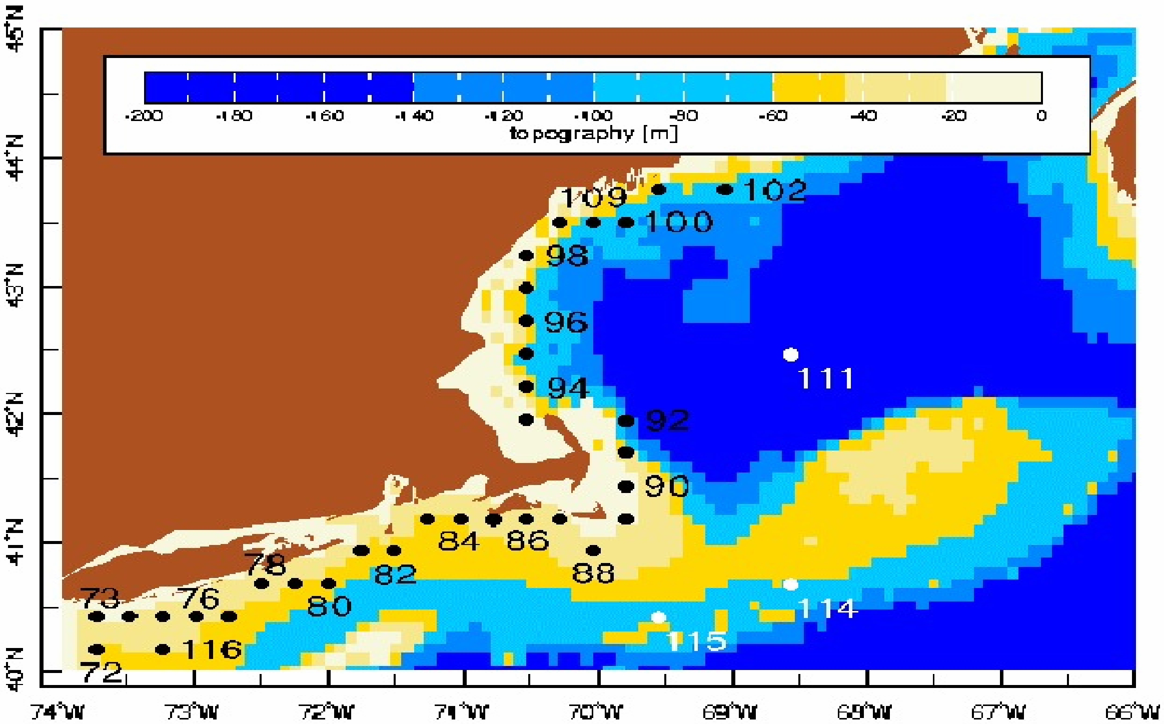


Figure 5. Geographic distribution of mean incident wave energy flux and wave energy development index off southern New England.

RI Coastal Wave Energy Estimate

- Estimate of power production potential
  - 5.7 kW/m Annual avg wave power per m of wave front off Block Island
  - 3.4 kW/m Annual avg wave power for waves greater than 5 sec, 0.5 m height from southern sector(max wave exposure) (produce power)

Wave Power Estimate RI

- 1.36 kW/m Annual avg wave power after adjustment for operational efficiency (40%)
- 40.8 kW for typical unit (30 m ;100 ft) wide
- 357 MWhr per year per unit
- (52 households) (*6909 kWhr per household)

OPERATES ONLY 37% OF THE TIME

SIMILAR TO WIND TURBINES

Wave Power Estimate RI

- Typical Wave Farm in RI – 10 plants

  408 kW(0.408 MW) or 3.570 BWhr
- RI Project, 15 MW Generation Capacity, (6 MW actual generation), 10 units, Total capital cost - $45 M, 1. 5 MW per unit, 20 yr life span (52.560 BWhrs per yr)

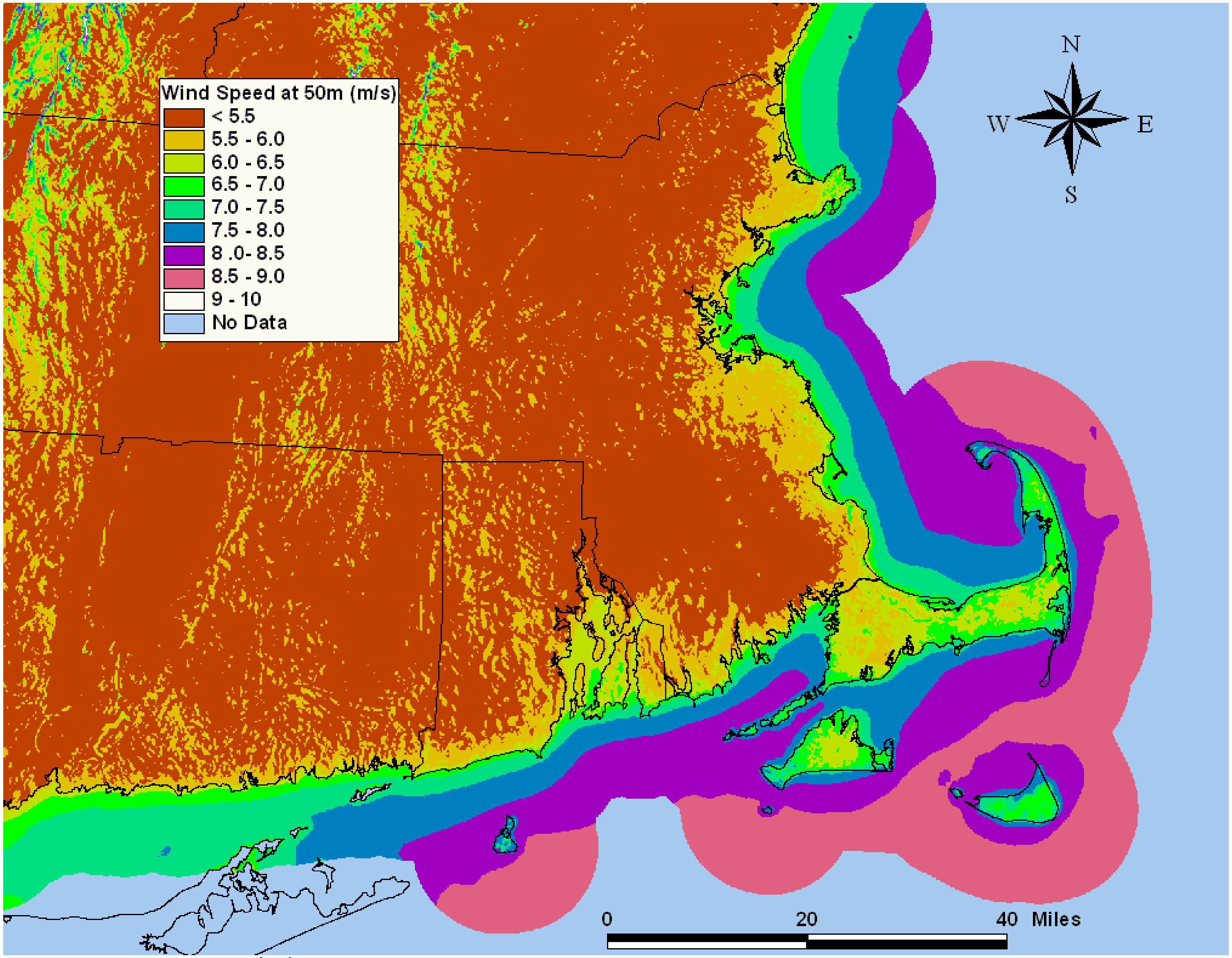
  Cost* = $42.80 per MWhr (**Est -$107 per MWHr)
- Estimated cost using RI wave data

  Cost * = $630 per MWhr (**Est. $1575 per MWhr) ***Difference --- 15***

*Considering facilities costs only ** Total capital cost =2.5 x facility cost

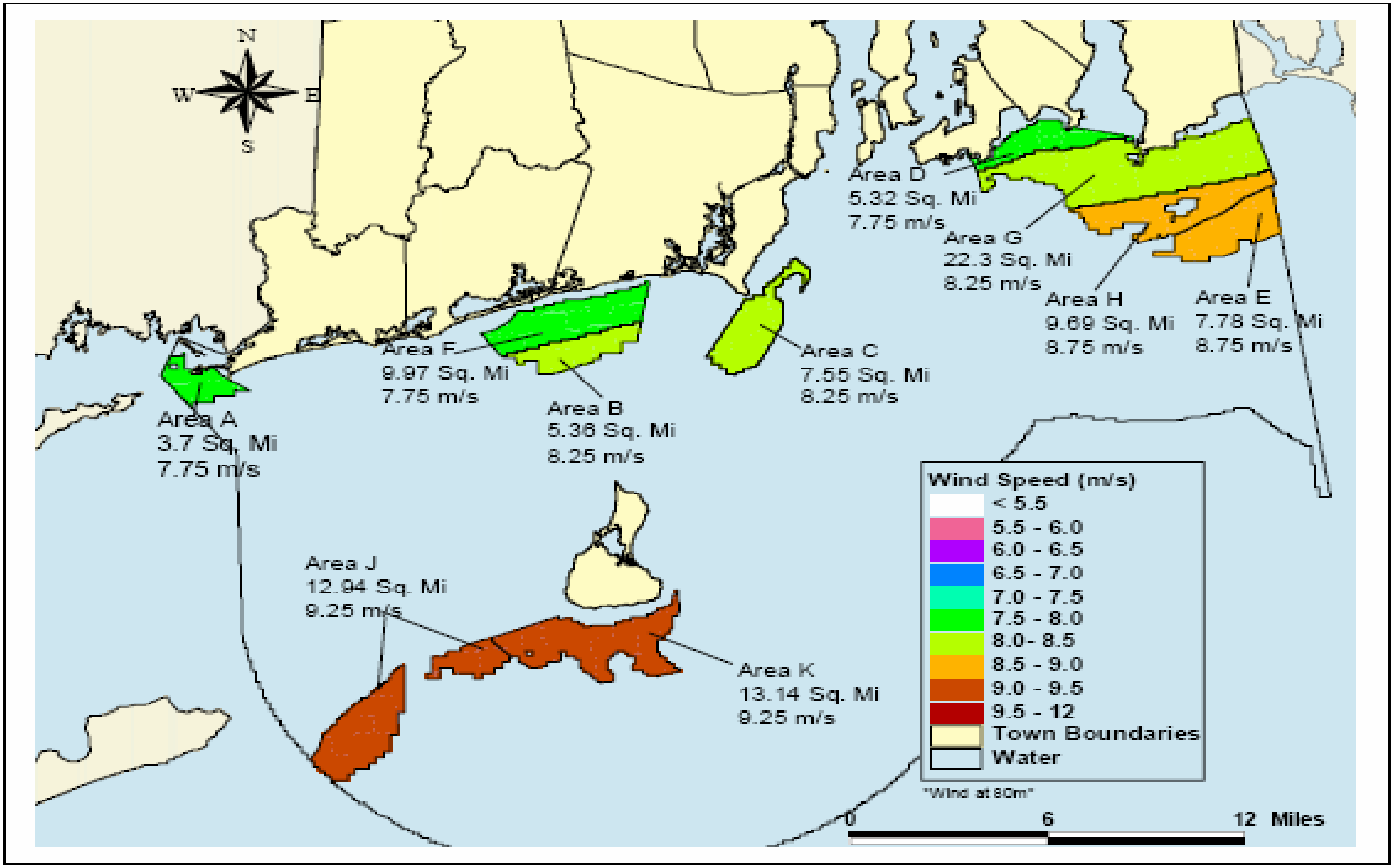
OFFSHORE WINDS

Wind Resource in the Northeast



Source: AWS Truewinds

ATM (2007) Offshore Wind Sites



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ATM(2007) Potential Energy Estimates

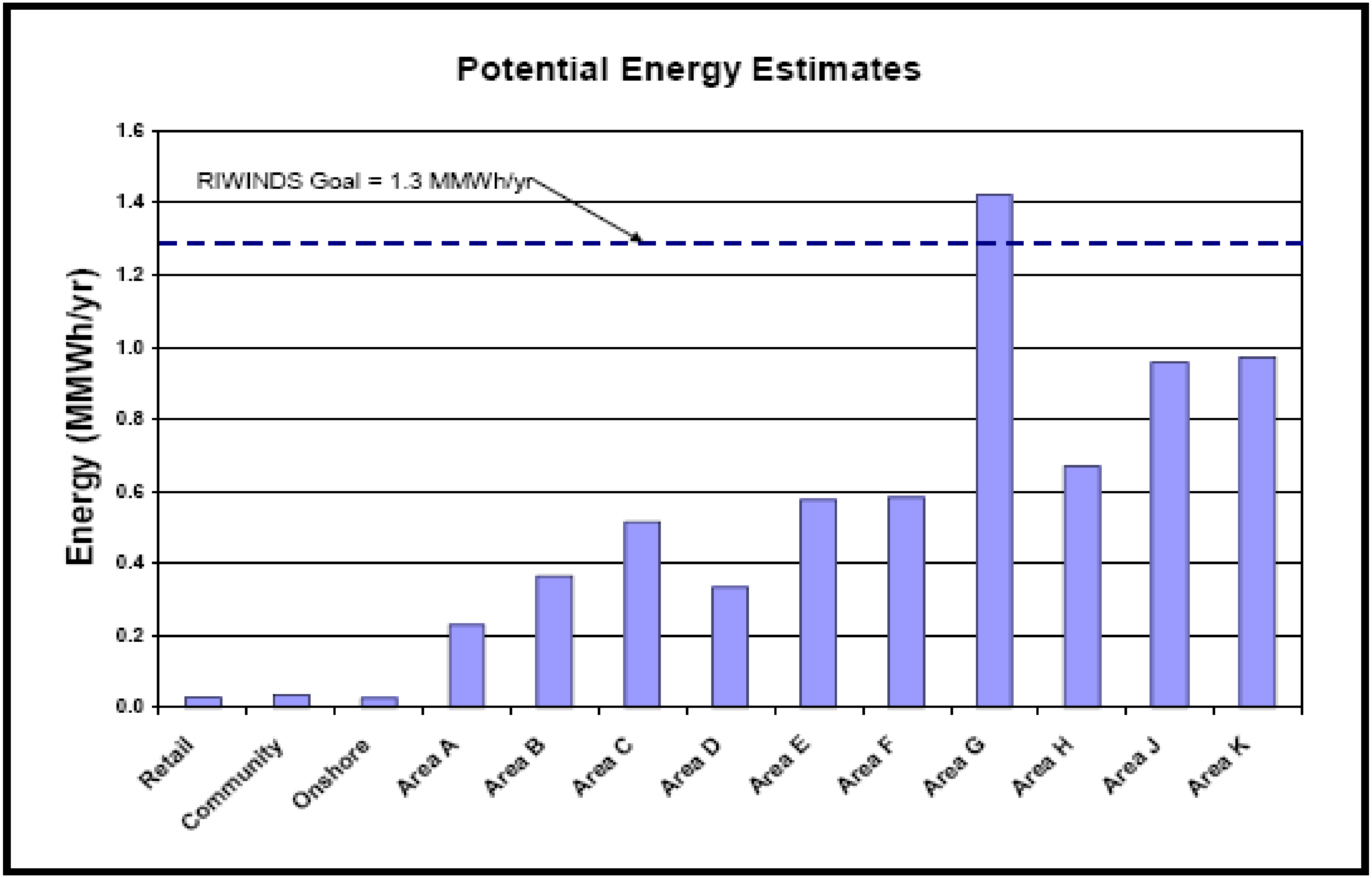

Figure 2 - RIWINDS Estimated Energy Generation for Each of the Identified Offshore Areas

ATM(2007) cost summary

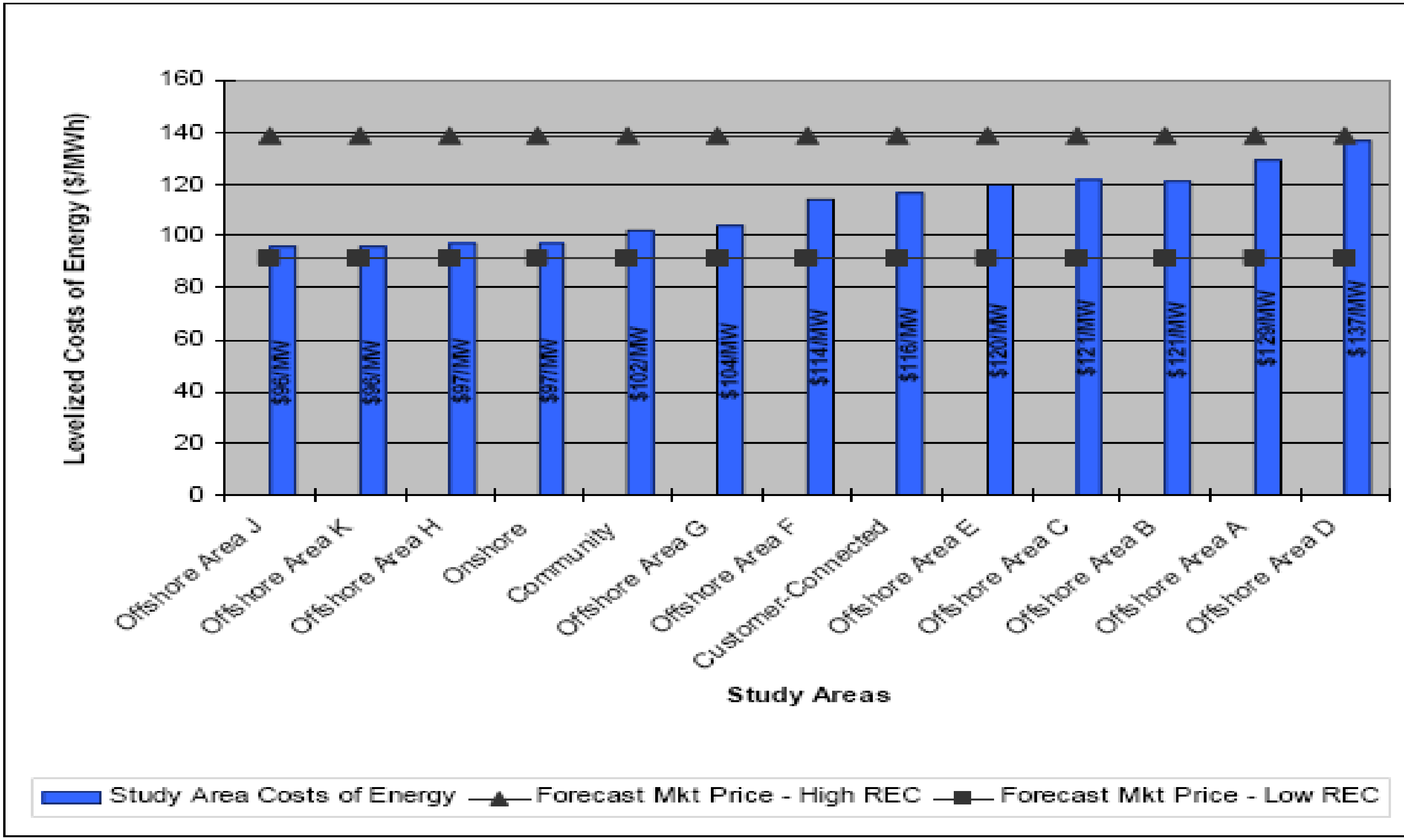

Figure 3 - RIWINDS Report Figure 6.2: Estimated Levelized Cost of Energy Compared to Levelized Wholesale Electricity Price Forecasts

Wind Energy Summary

All offshore areas

685 MW

Sub-areas

J, K - 220 MW

E, H - 140 MW

H, K - 187 MW

Renewable Energy Goal 150 MW

Cost Range - $96 to 137 MWhr

Summary Power Production Potential

- Offshore Energy Production Potential (MW)

OTEC	none
In stream tidal currents	0.01
Waves	
10 to 100 unit farm(s)	0.408-40.8
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Cost Summary

Cost of power production per MWhr

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* Only capital costs for generator

OFFSHORE WINDS!

Turbines at one of Britain's offshore wind farms at Caister on Sea produce electric power.