Preliminary Screening Analysis for Ocean SAMP

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Stakeholder Council Meeting
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Geology support
Jon Boothroyd, Geosciences and John King, GSO

Rhode Island OCEAN samp

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

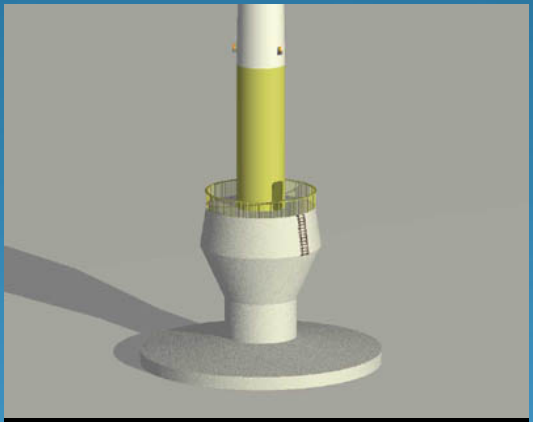
Fixed Bottom Substructure Technology

Proven Designs

Future

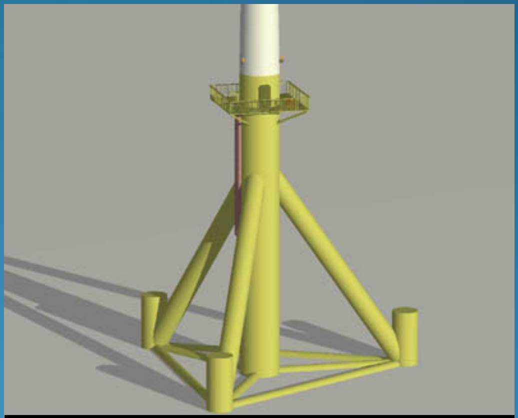
Monopile Foundation

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



Gravity Foundation

- Larger Footprint
- Depth Limit?
- Stiffer but heavy

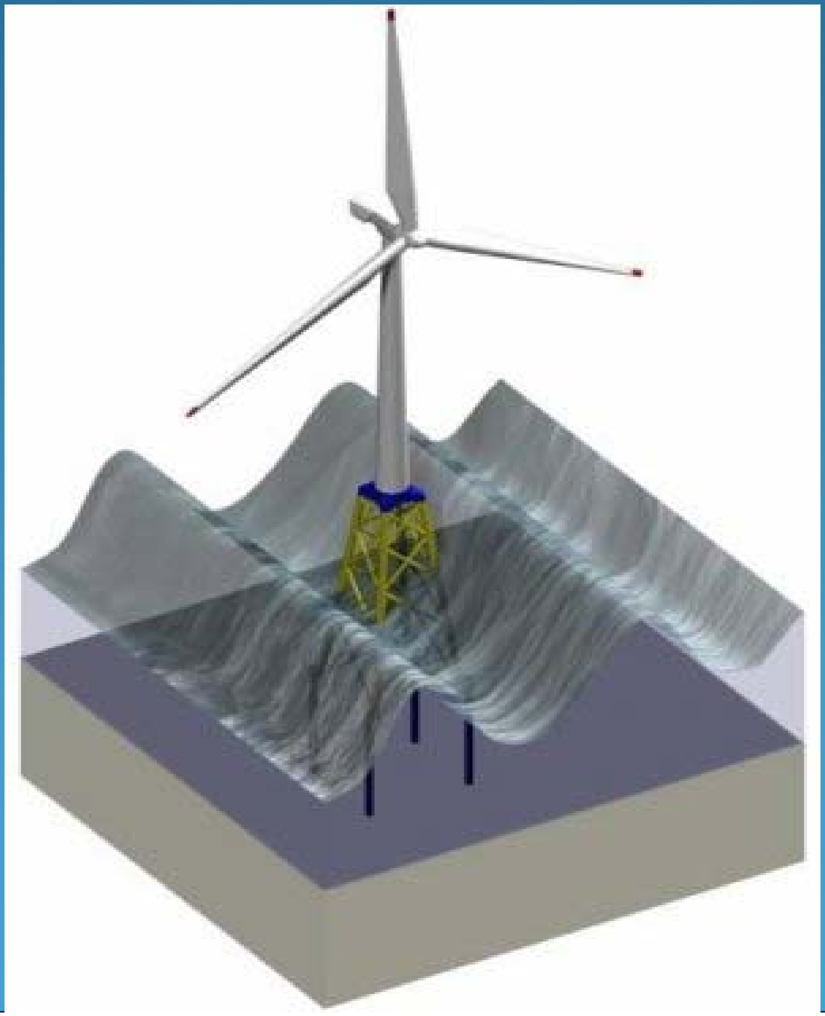


Tripod/Truss Foundation

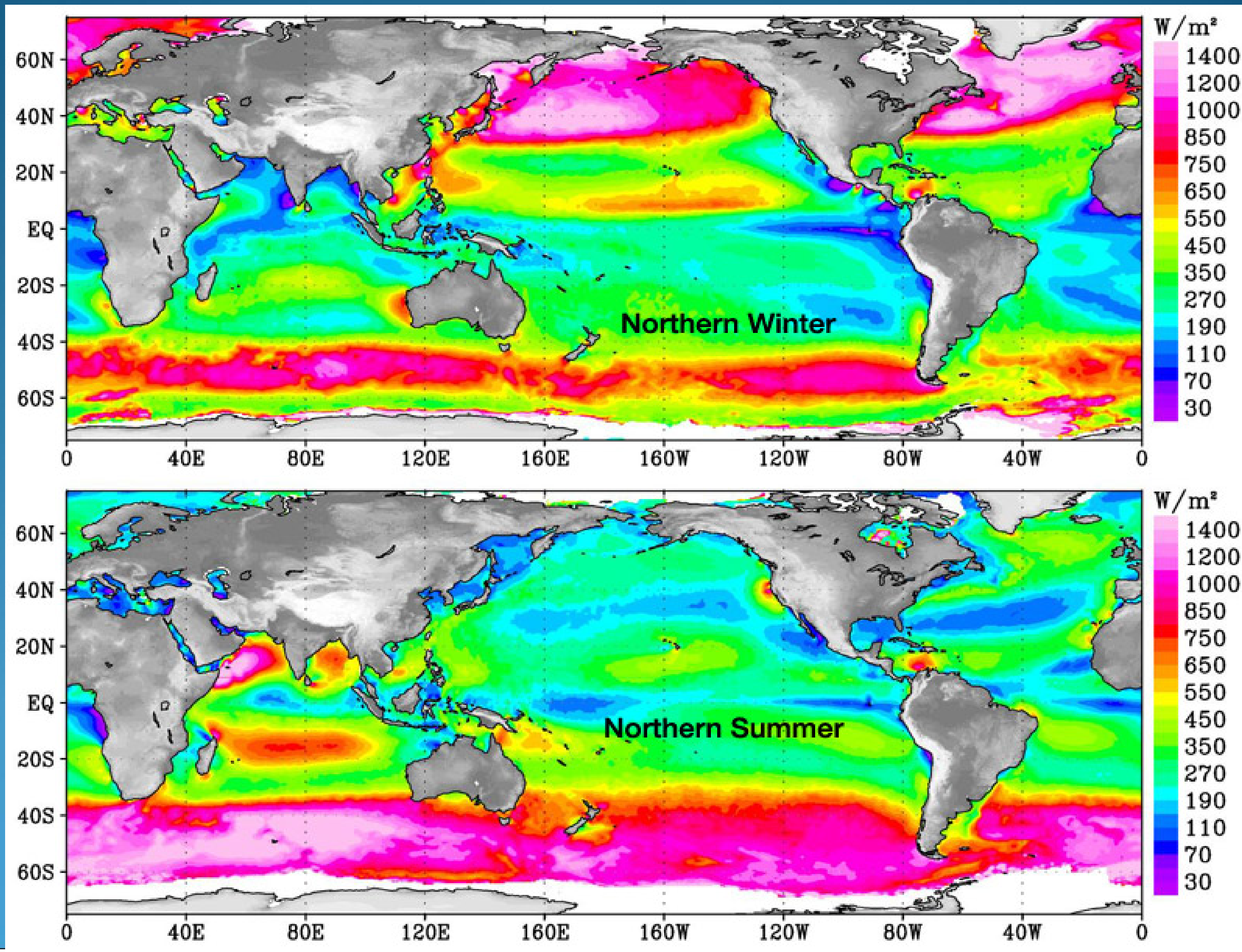
- No wind experience
- Oil and gas to 450-m
- Larger footprint
- Talisman project

Graphics source: http://www.offshorewindenergy.org/

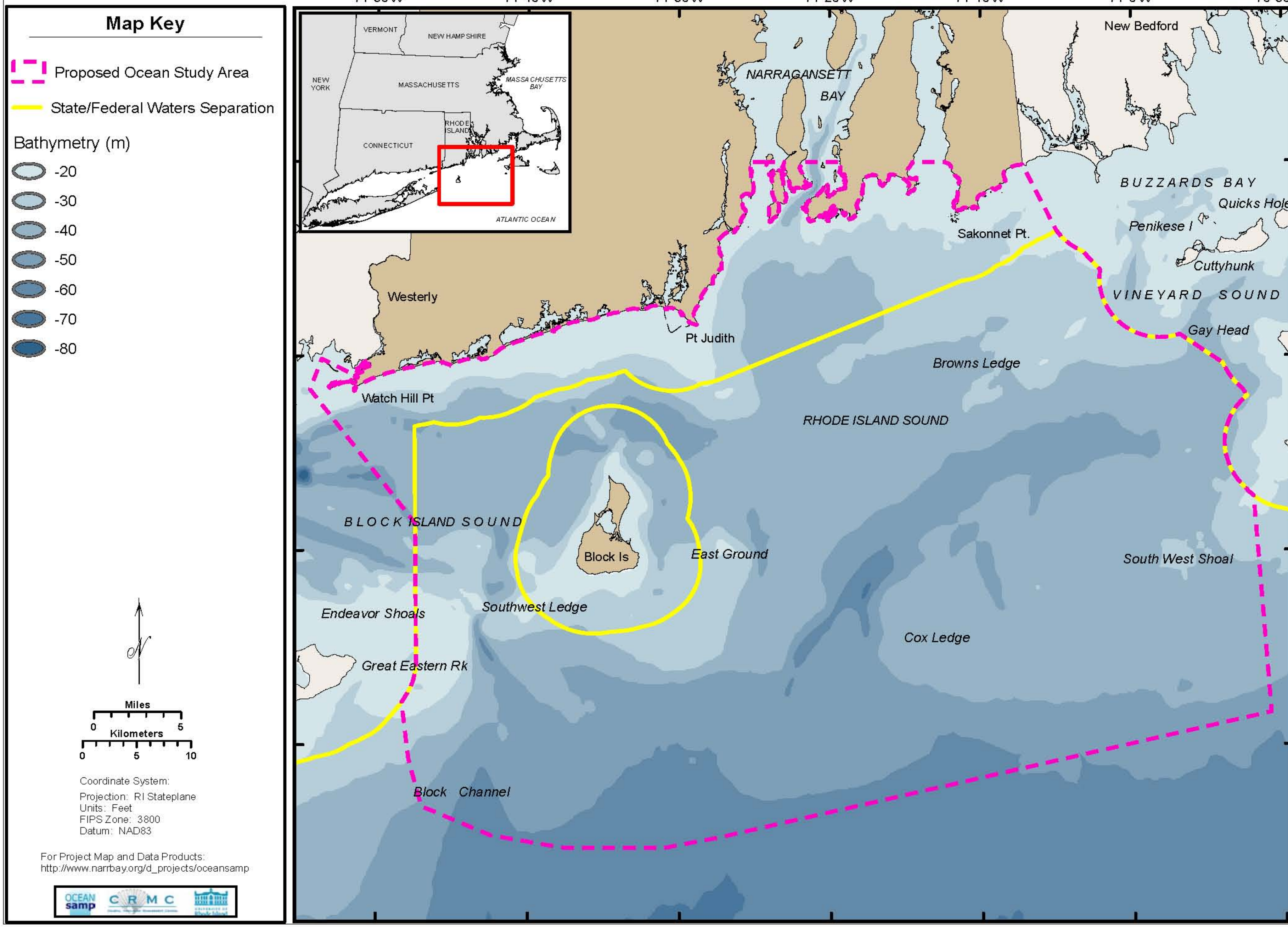
DeepWater Wind Technology, OWEC (Norwegian)



NASA Quik Scat Winds



Rhode Island Ocean Special Area Management Plan (SAMP)



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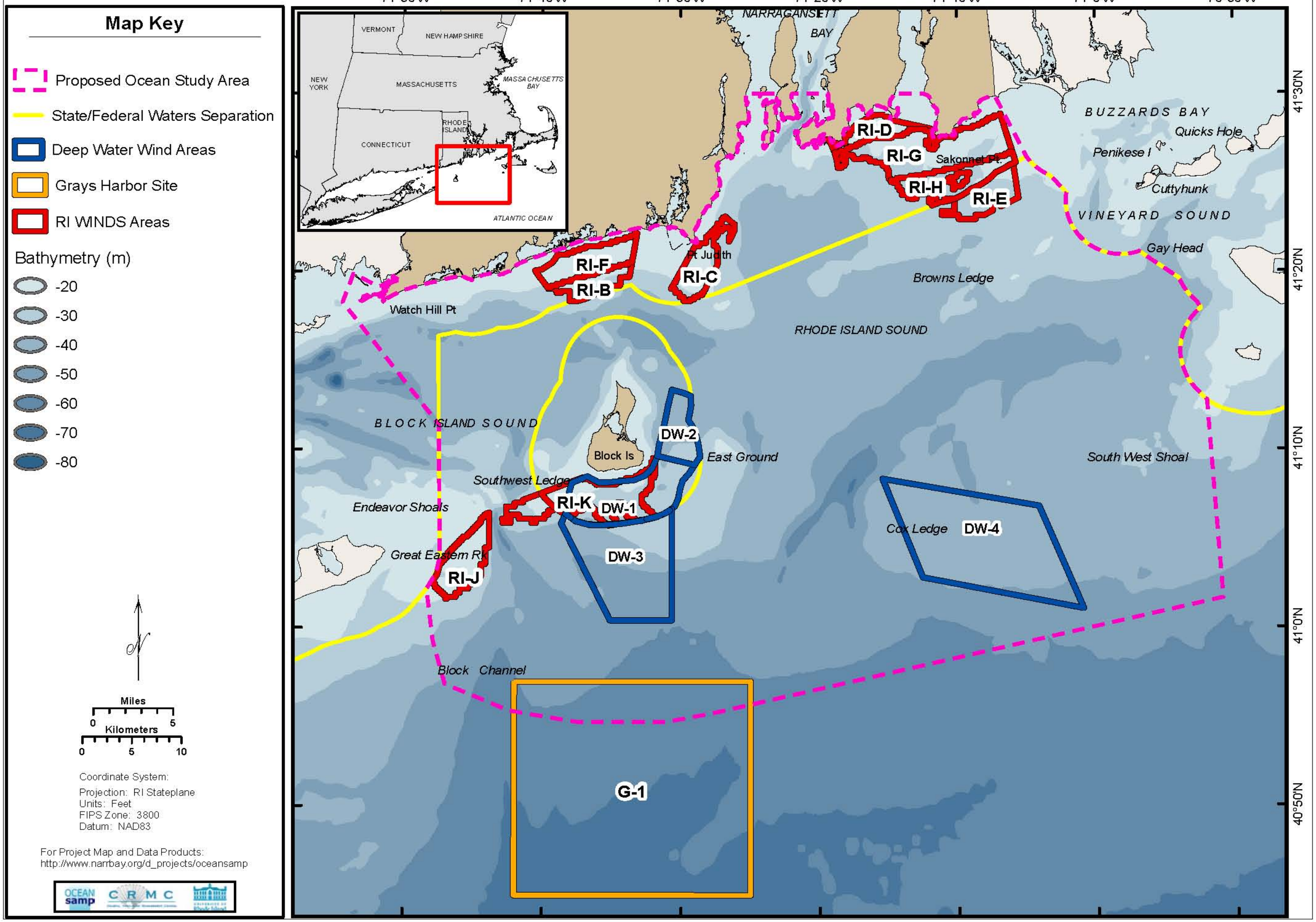
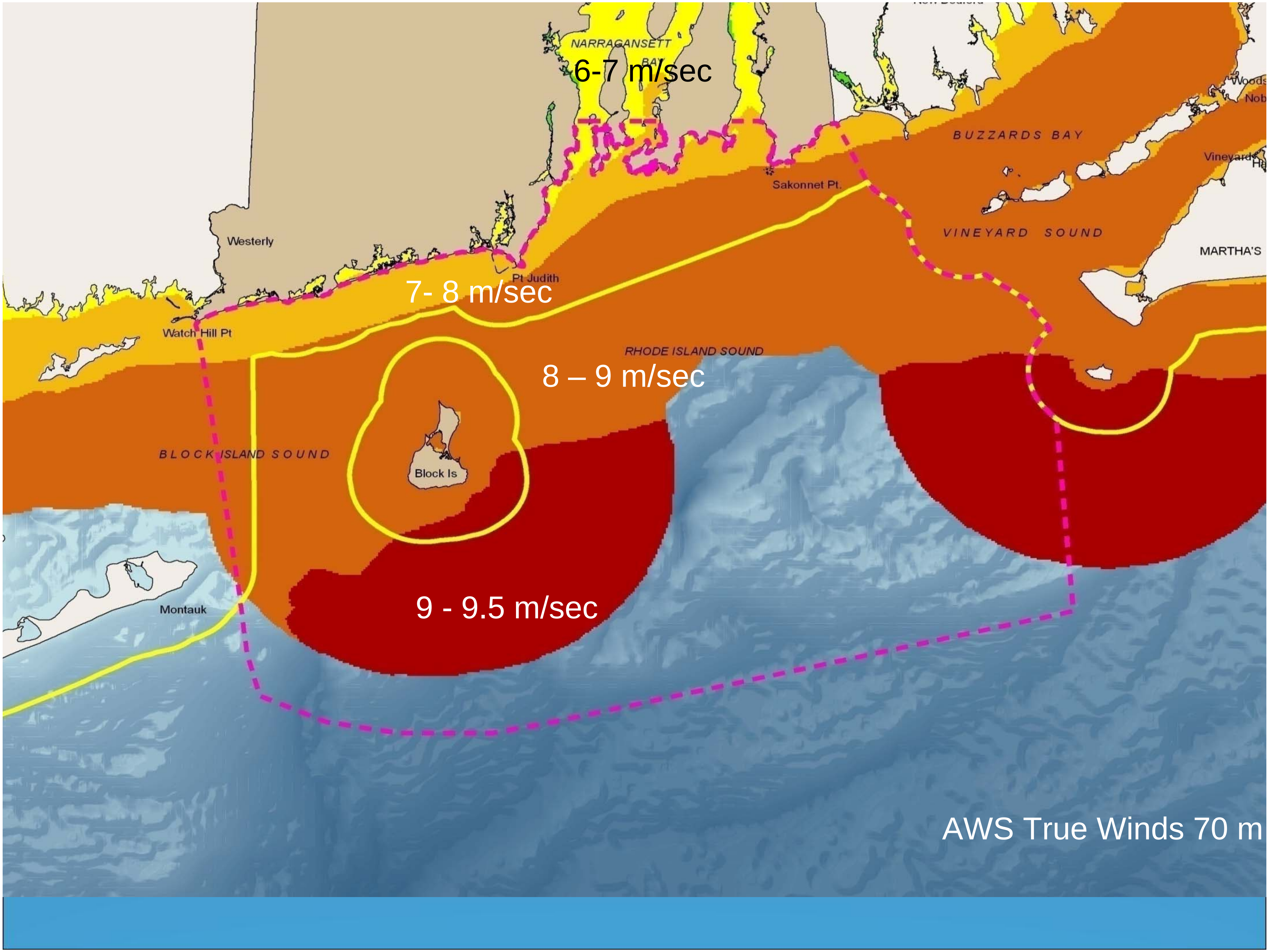
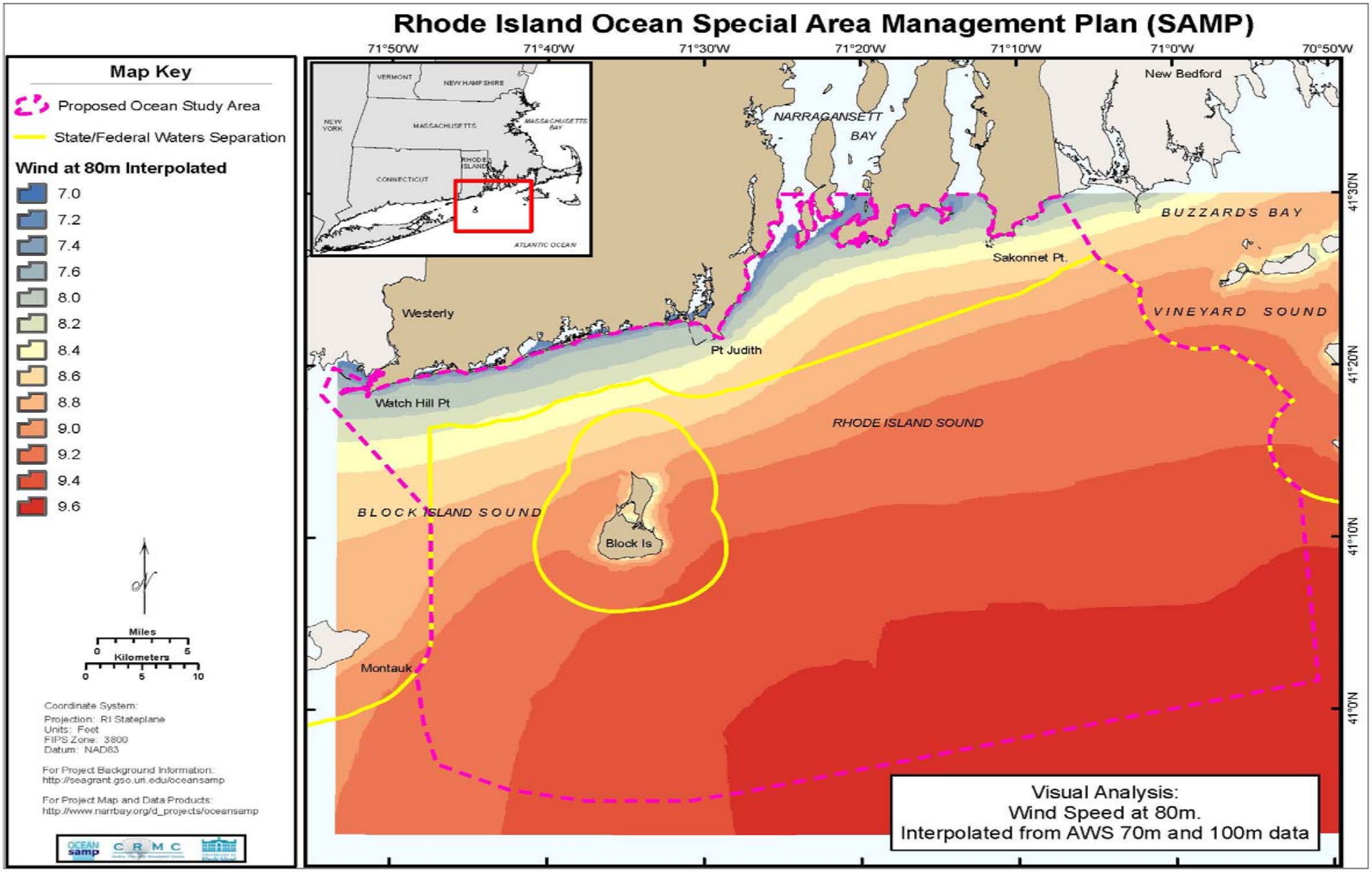
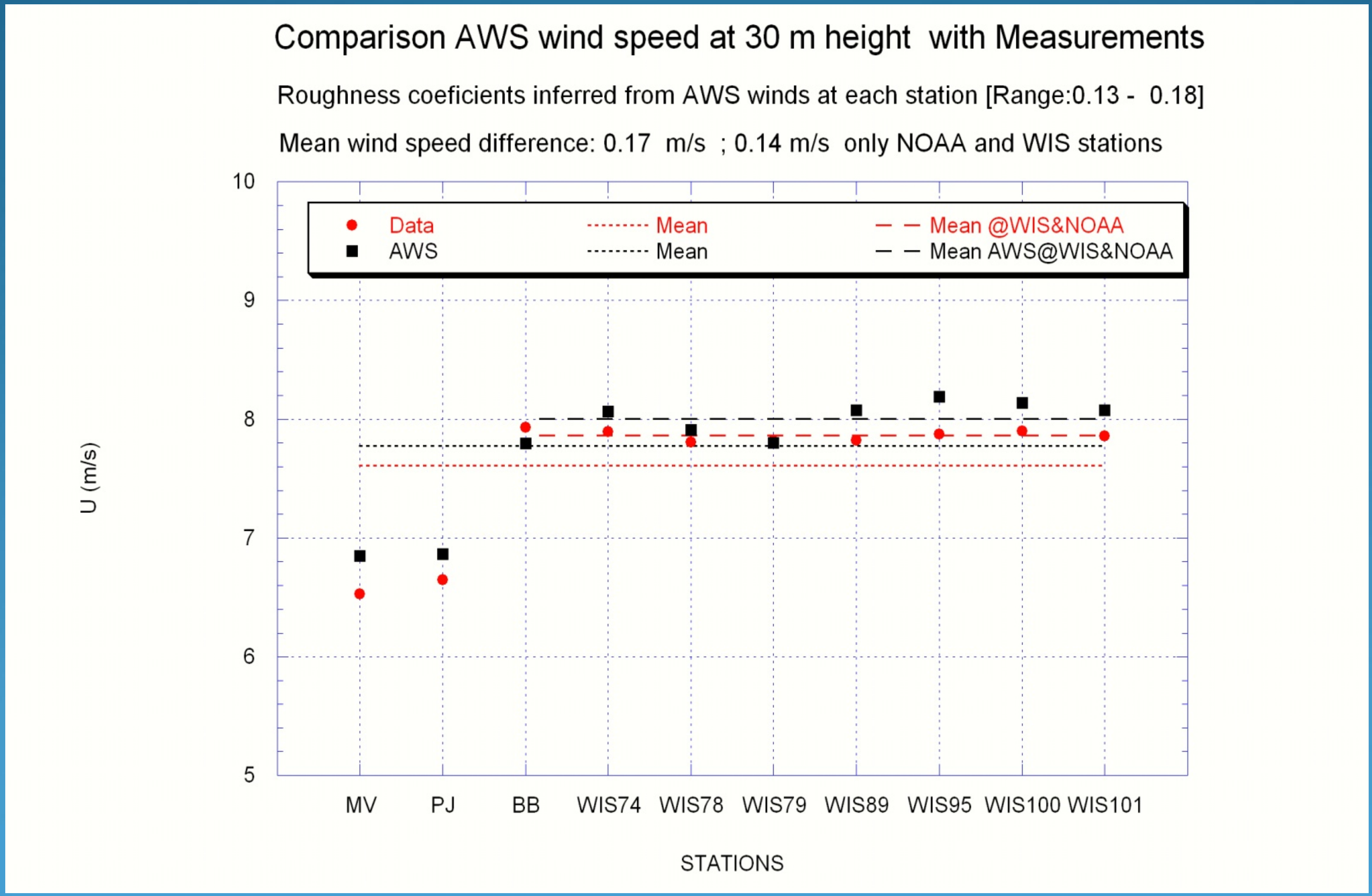



NARRAGANSETT BAY
6-7 m/sec
BUZZARDS BAY
Sakonnet Pt.
VINEYARD SOUND
MARTHA'S
Westerly
Pt Judith
7- 8 m/sec
Watch Hill Pt
RHODE ISLAND SOUND
8 – 9 m/sec
BLOCK ISLAND SOUND
Block Is
Montauk
9 - 9.5 m/sec
AWS True Winds 70 m

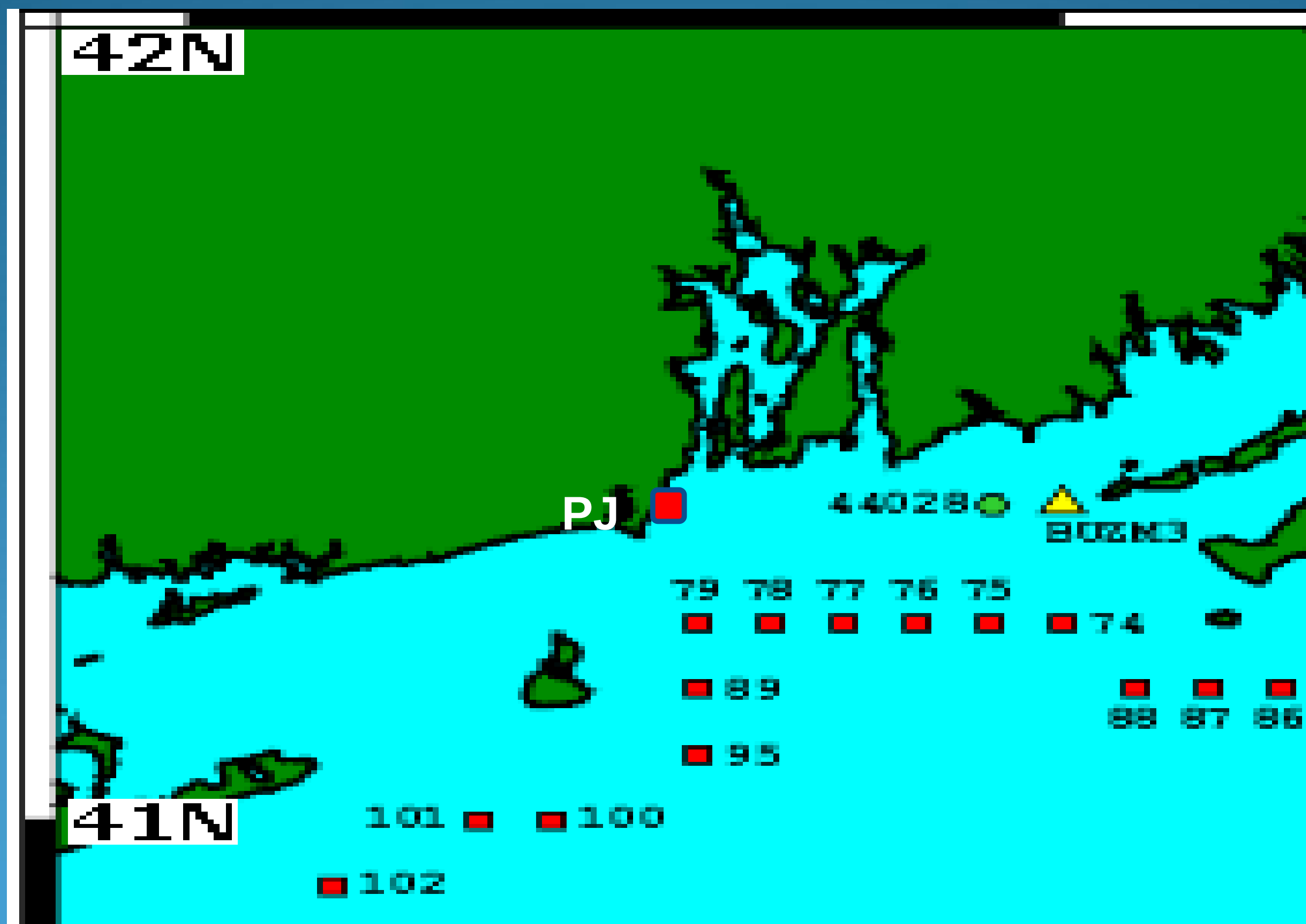
Estimates of 80 m wind speeds
AWS TrueWinds data



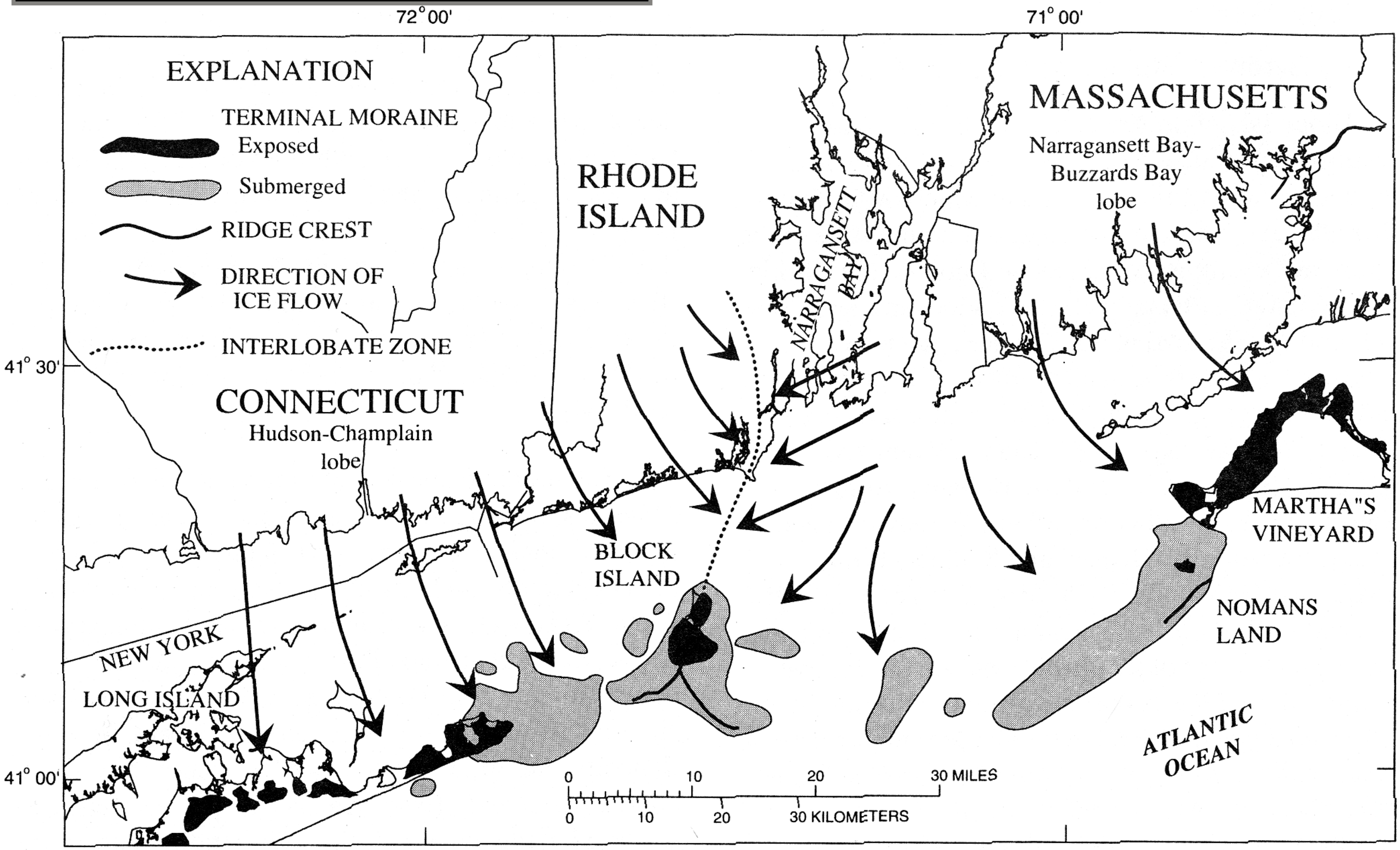
Comparison of AWS Winds and Observations



Wind Observation Station Locations (WIS, BUZ, PJ)



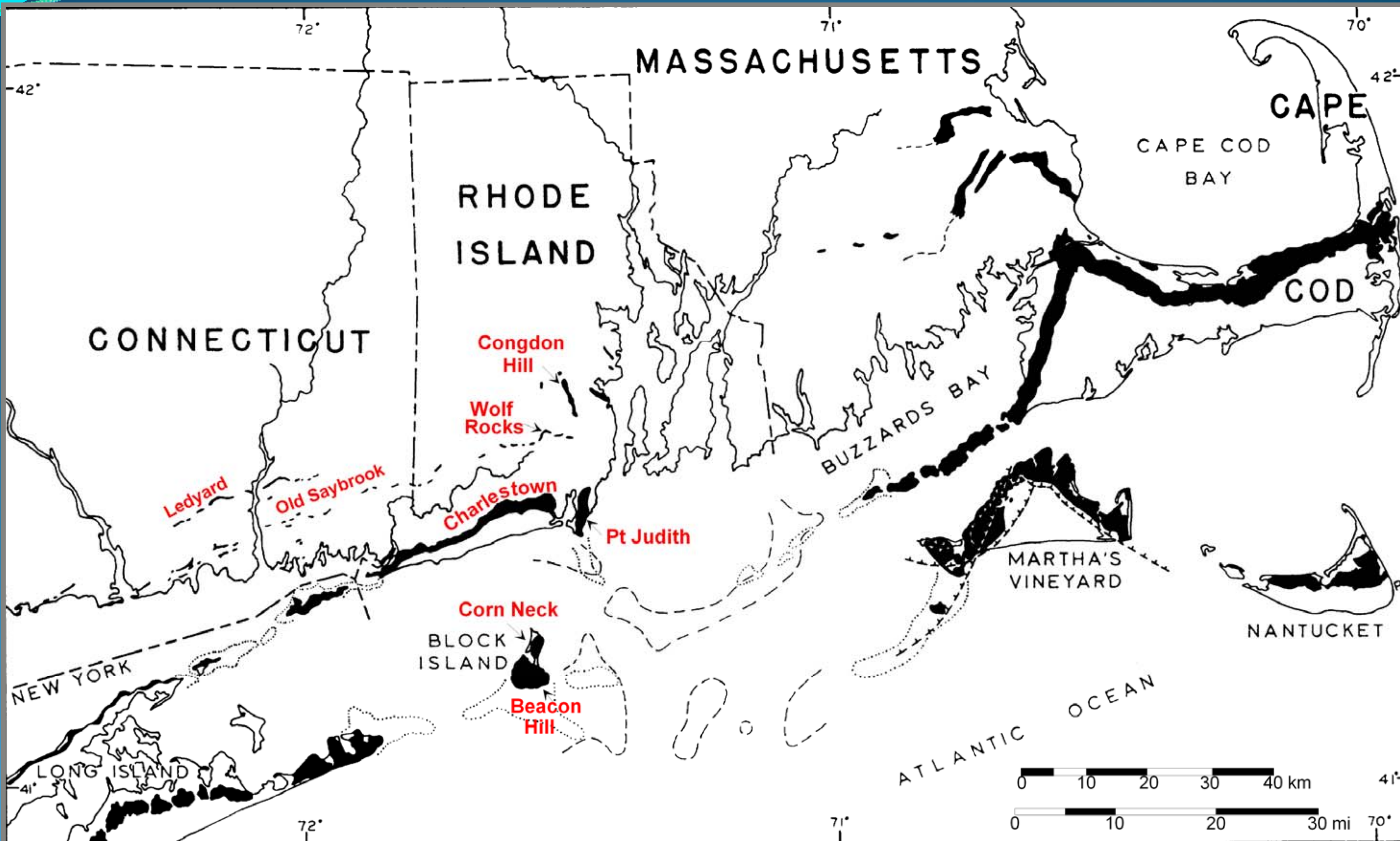
Ice Flow Directions



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

Stone and Sirkin, 1996

End Moraines of Southeastern New England



Schafer and Hartshorn, 1965; Sirkin, 1982

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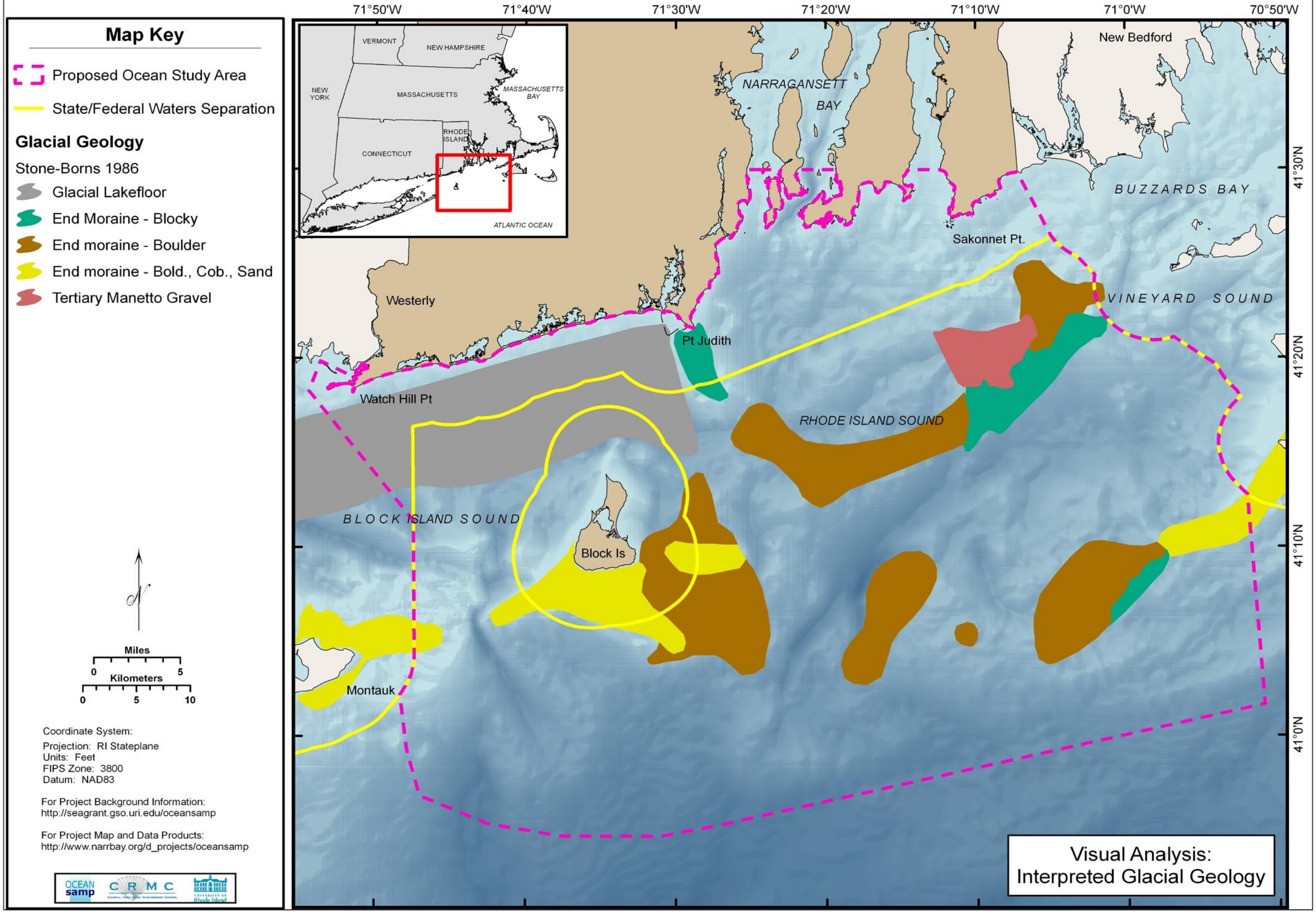
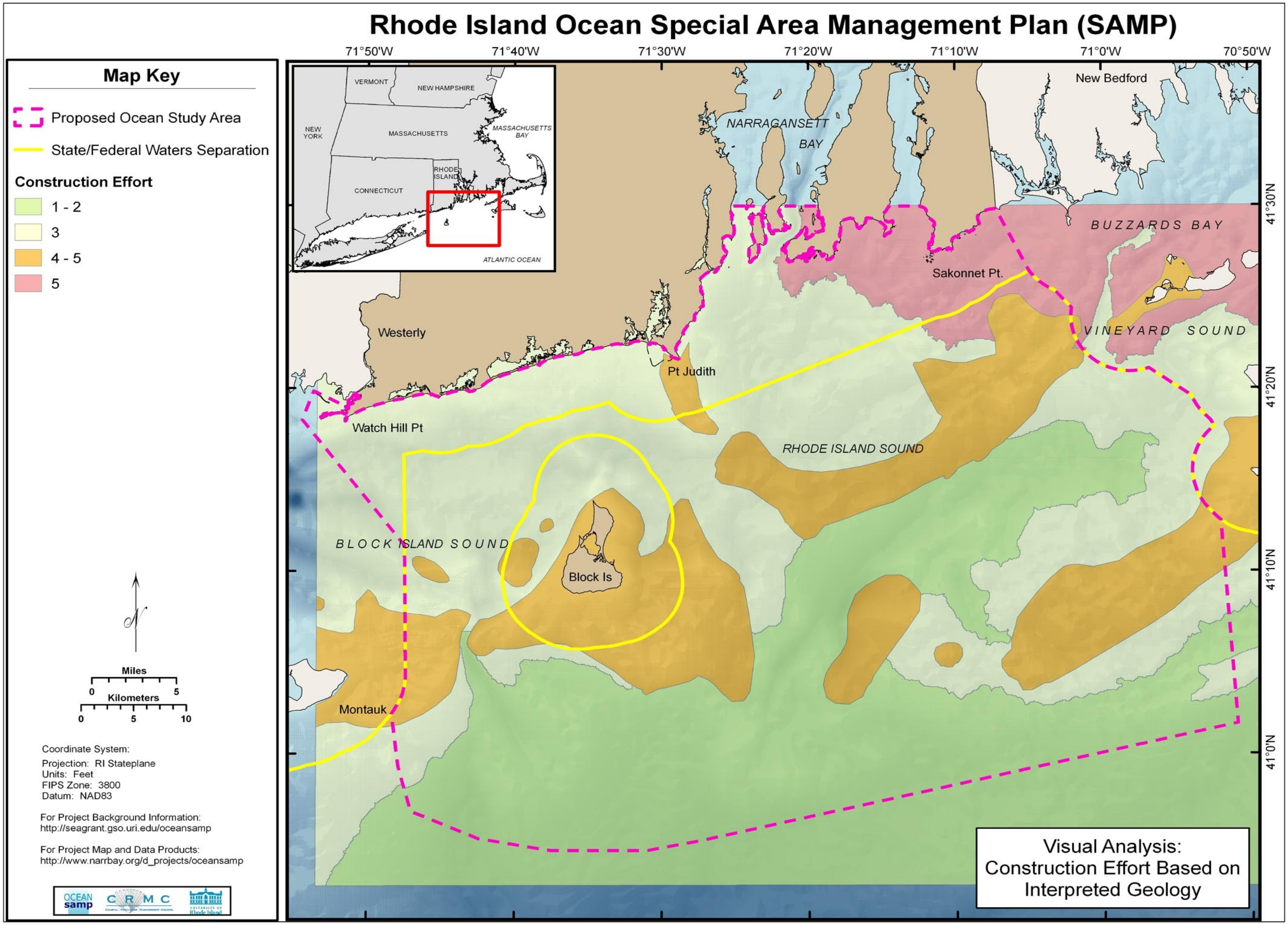
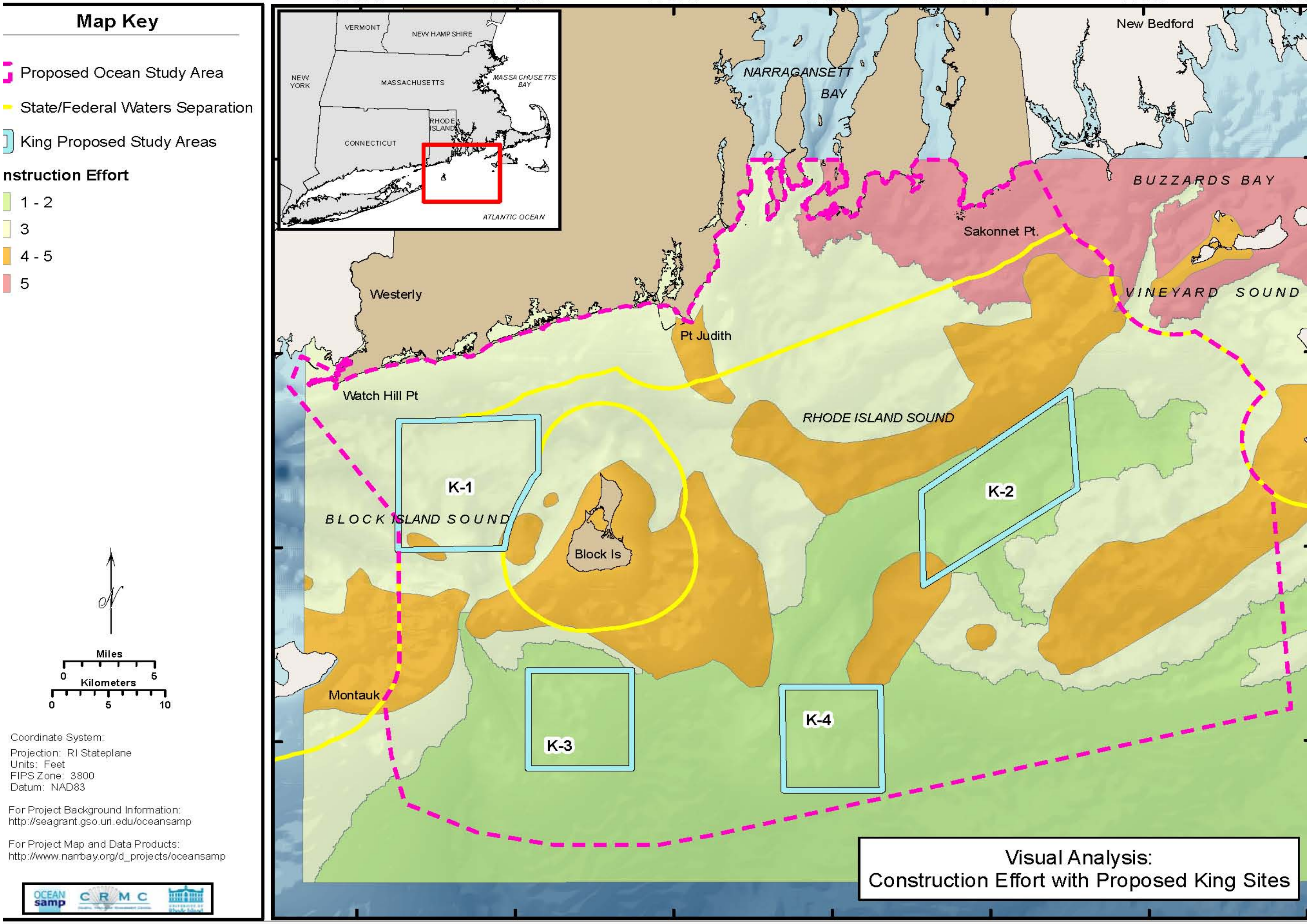
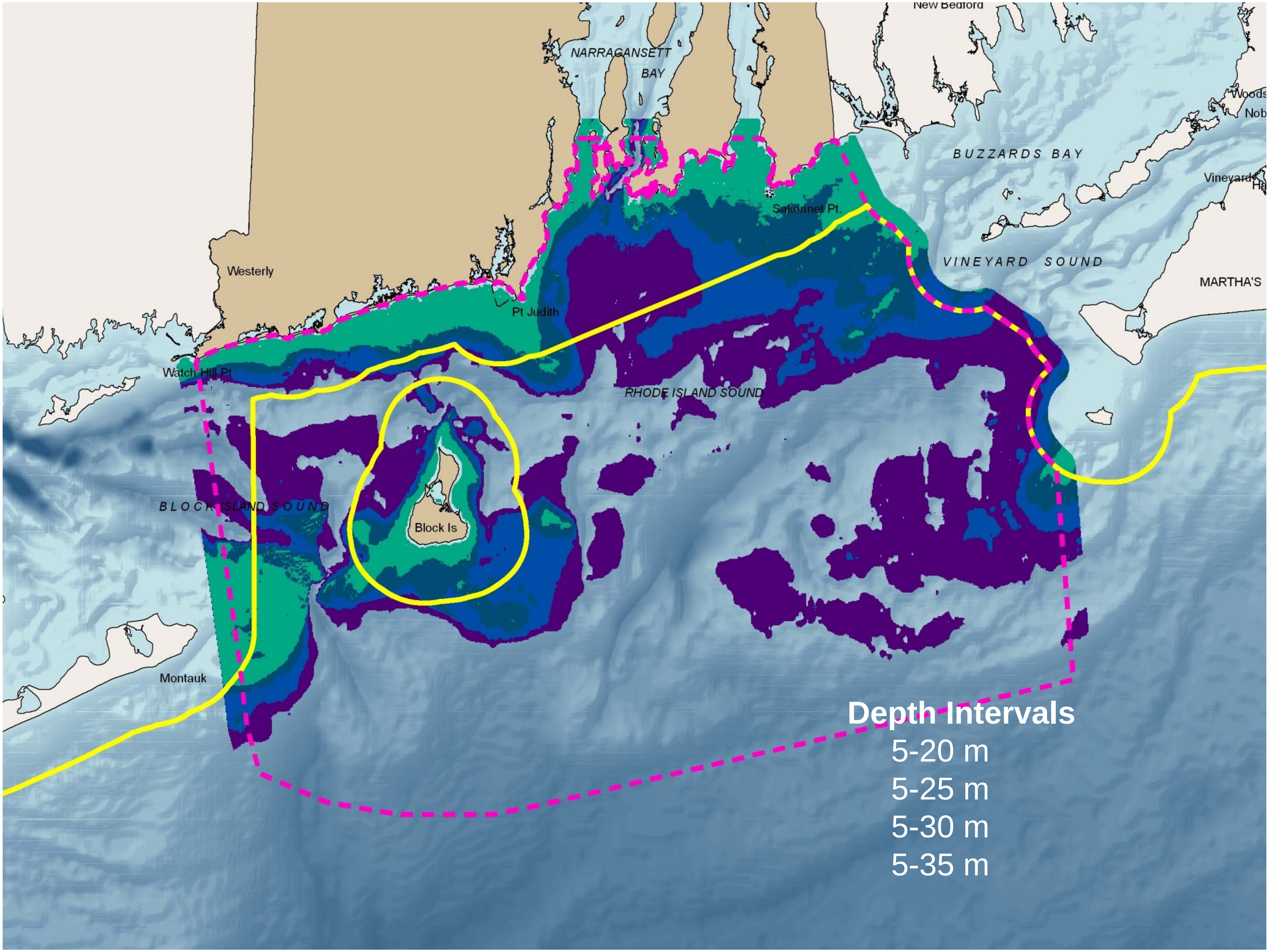
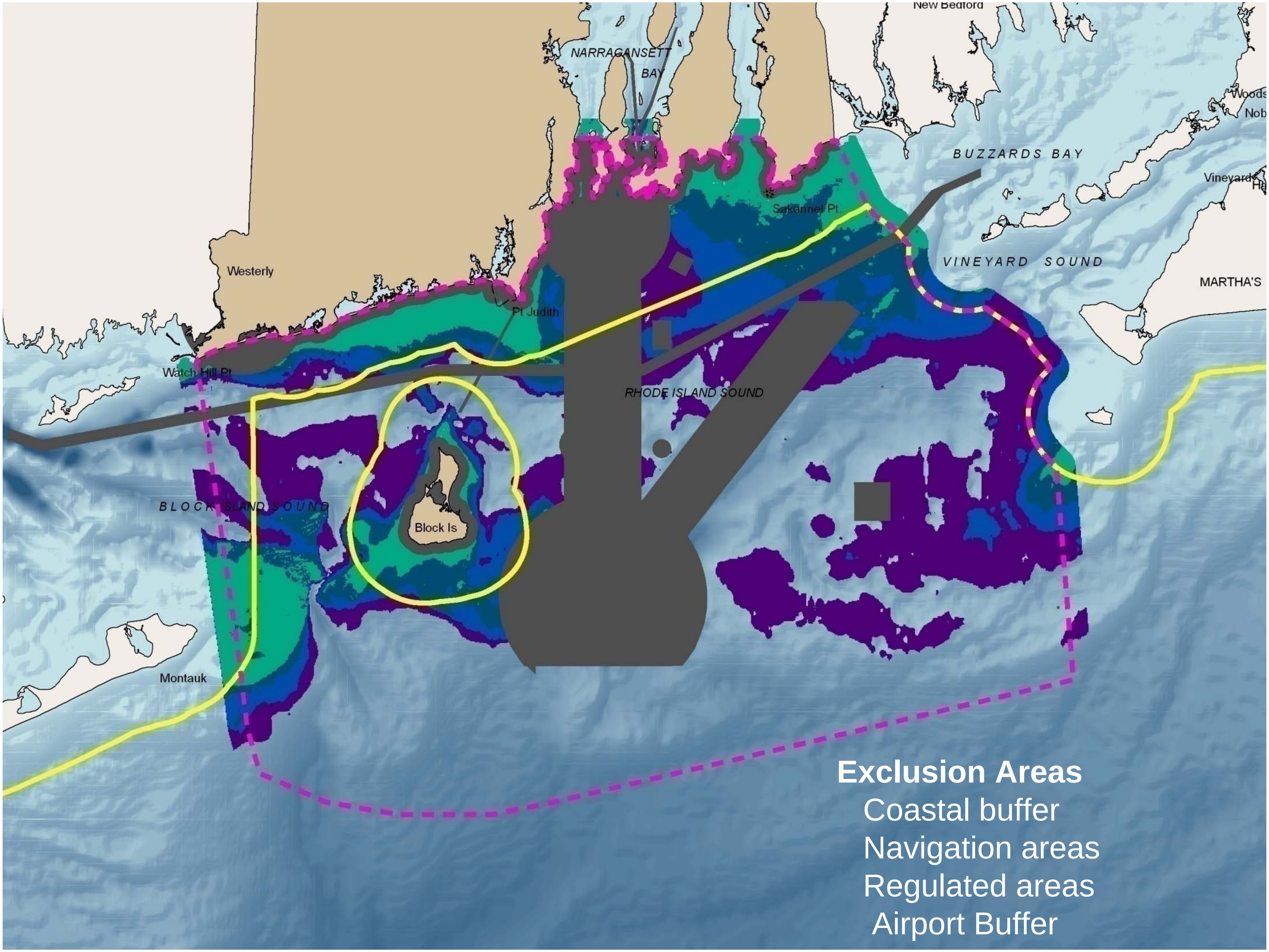



Rhode Island Ocean Special Area Management Plan (SAMP)
Map Key
Proposed Ocean Study Area
State/Federal Waters Separation
Construction Effort
1 - 2
3
4 - 5
5
Miles
0 5
Kilometers
0 5 10
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
OCEAN samp
CRMC
71°50'W
71°40'W
71°30'W
71°20'W
71°10'W
71°0'W
70°50'W
41°30'N
41°20'N
41°10'N
41°0'N
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
MASSACHUSETTS BAY
RHODE ISLAND
CONNECTICUT
ATLANTIC OCEAN
New Bedford
NARRAGANSETT BAY
BUZZARDS BAY
Sakonnet Pt.
Westerly
VINEYARD SOUND
Pt Judith
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Visual Analysis:
Construction Effort Based on
Interpreted Geology

Rhode Island Ocean Special Area Management Plan (SAMP)




New Bedford
NARRAGANSETT
BAY
BUZZARDS BAY
Woods
Nob
Vineyard
MARTHA'S
VINEYARD SOUND
Sakonnet Pt.
Westerly
Pt Judith
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Depth Intervals
5-20 m
5-25 m
5-30 m
5-35 m



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Watch Hill Pt
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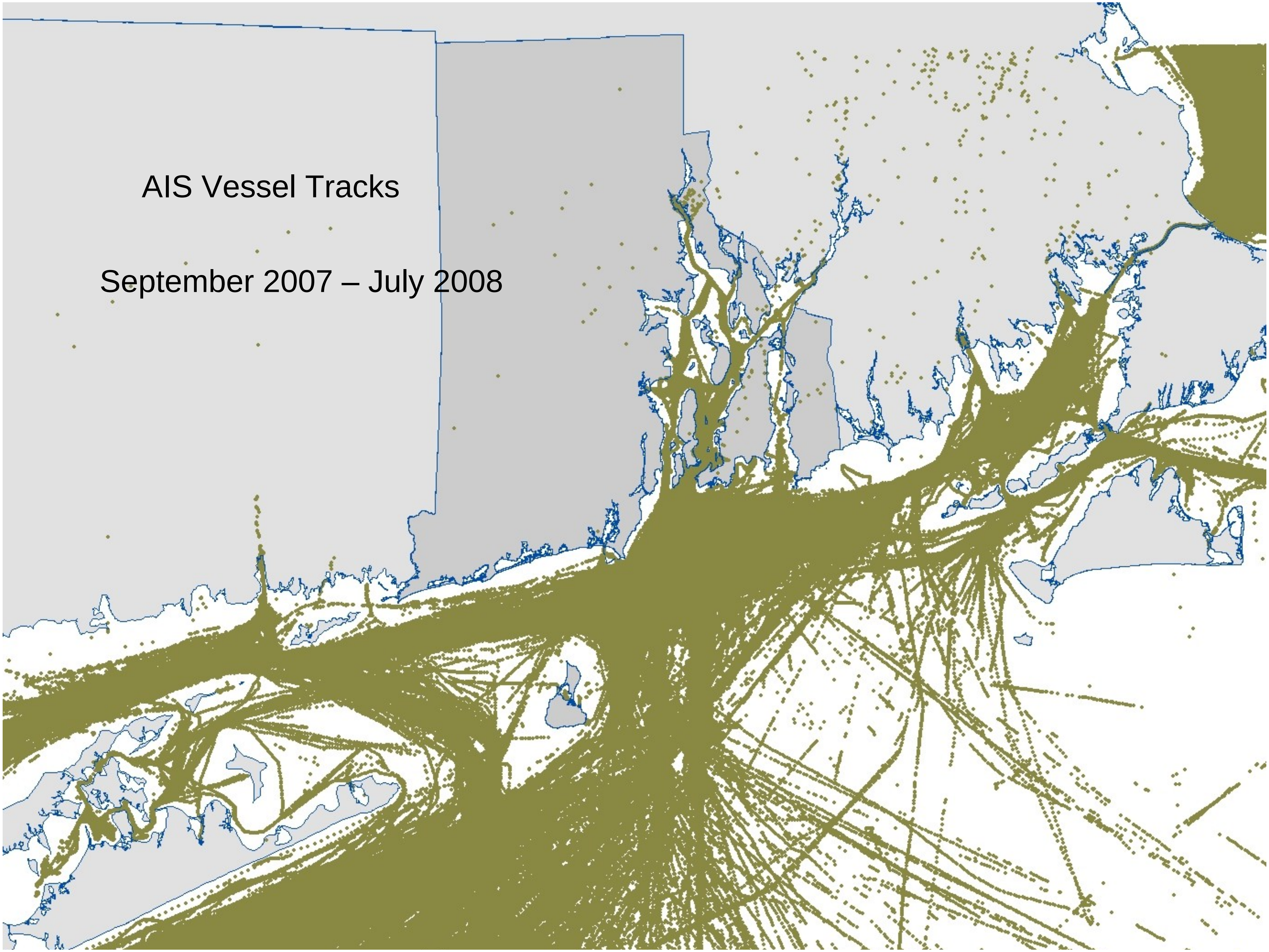
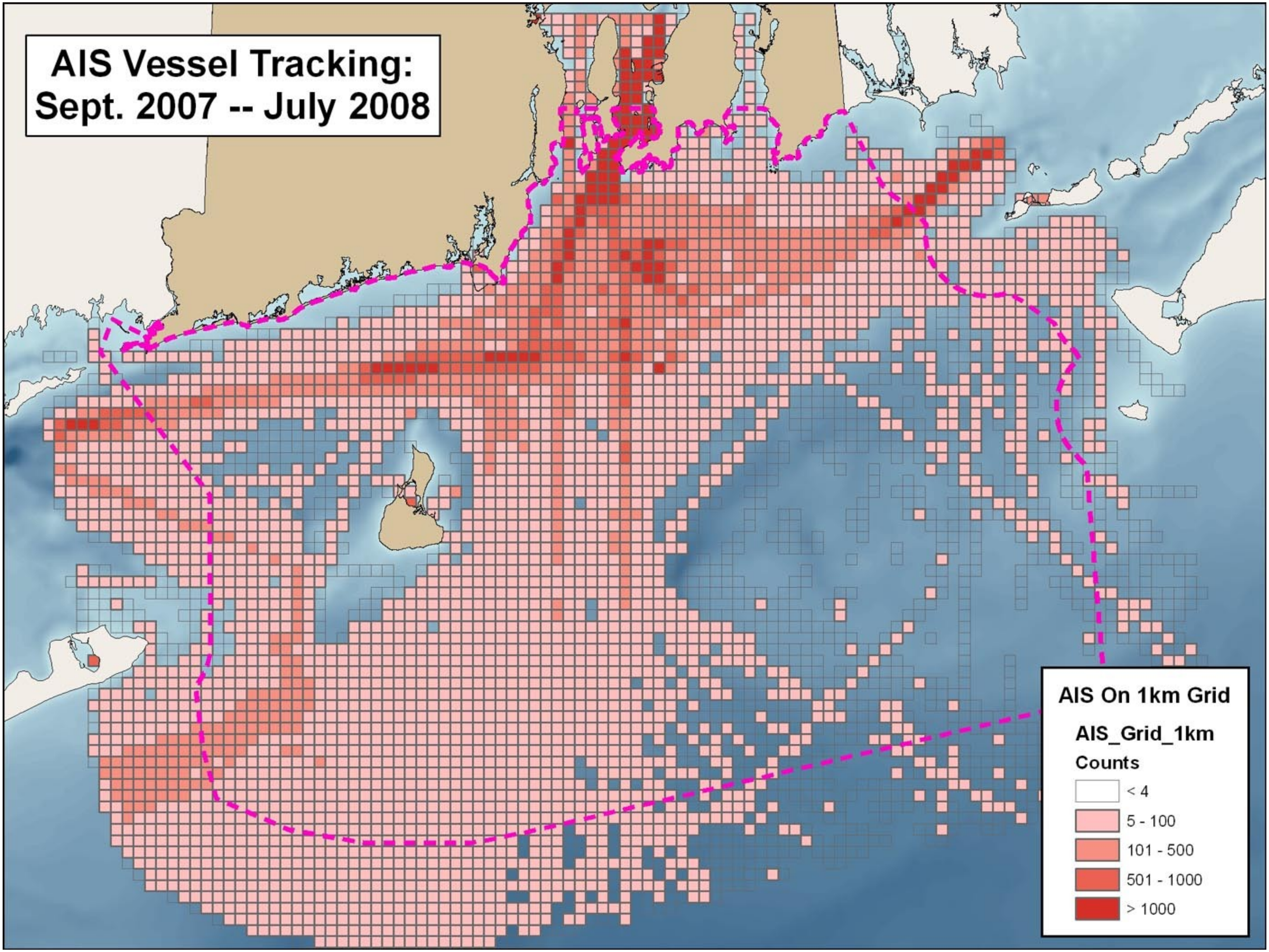
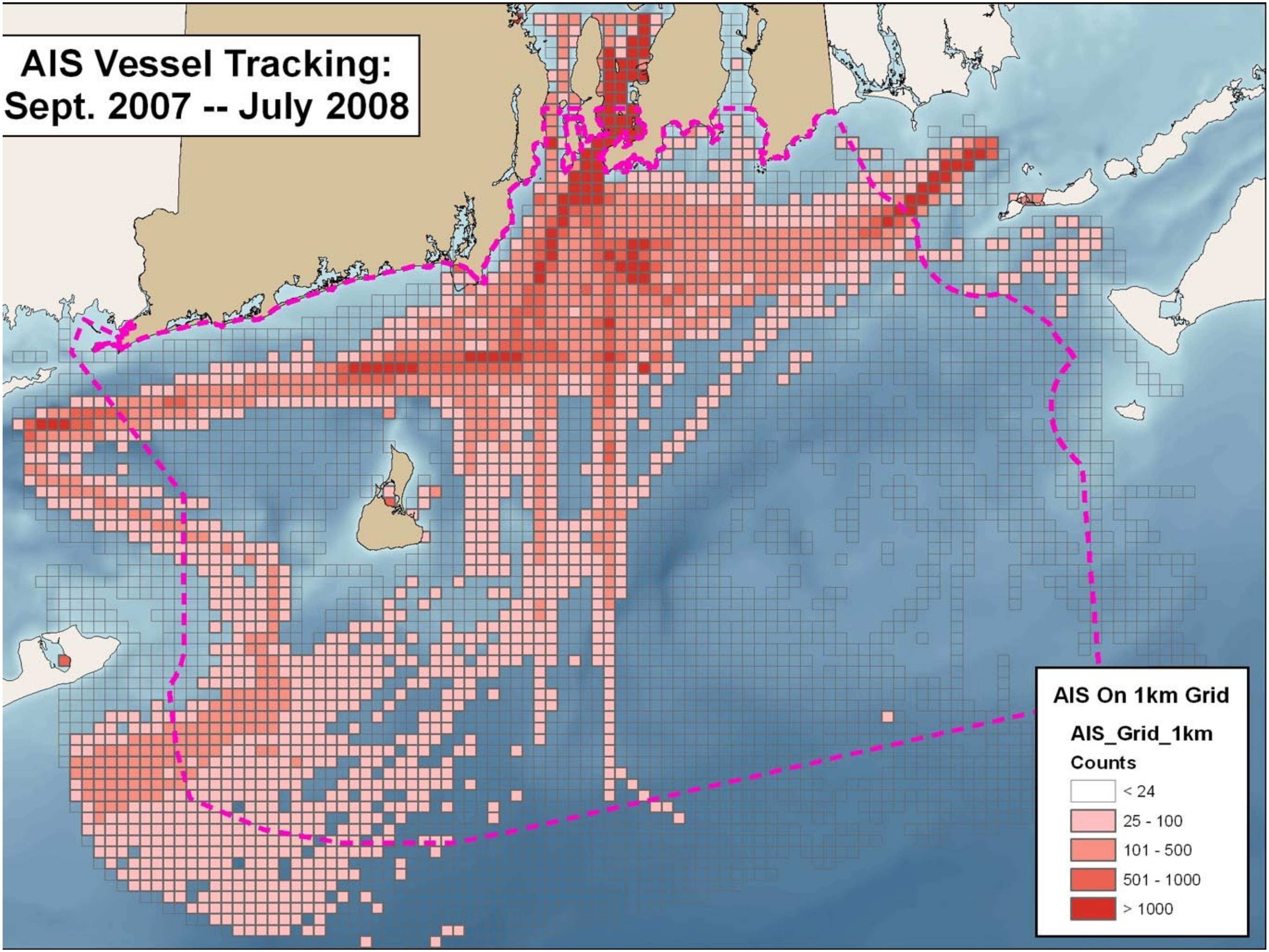
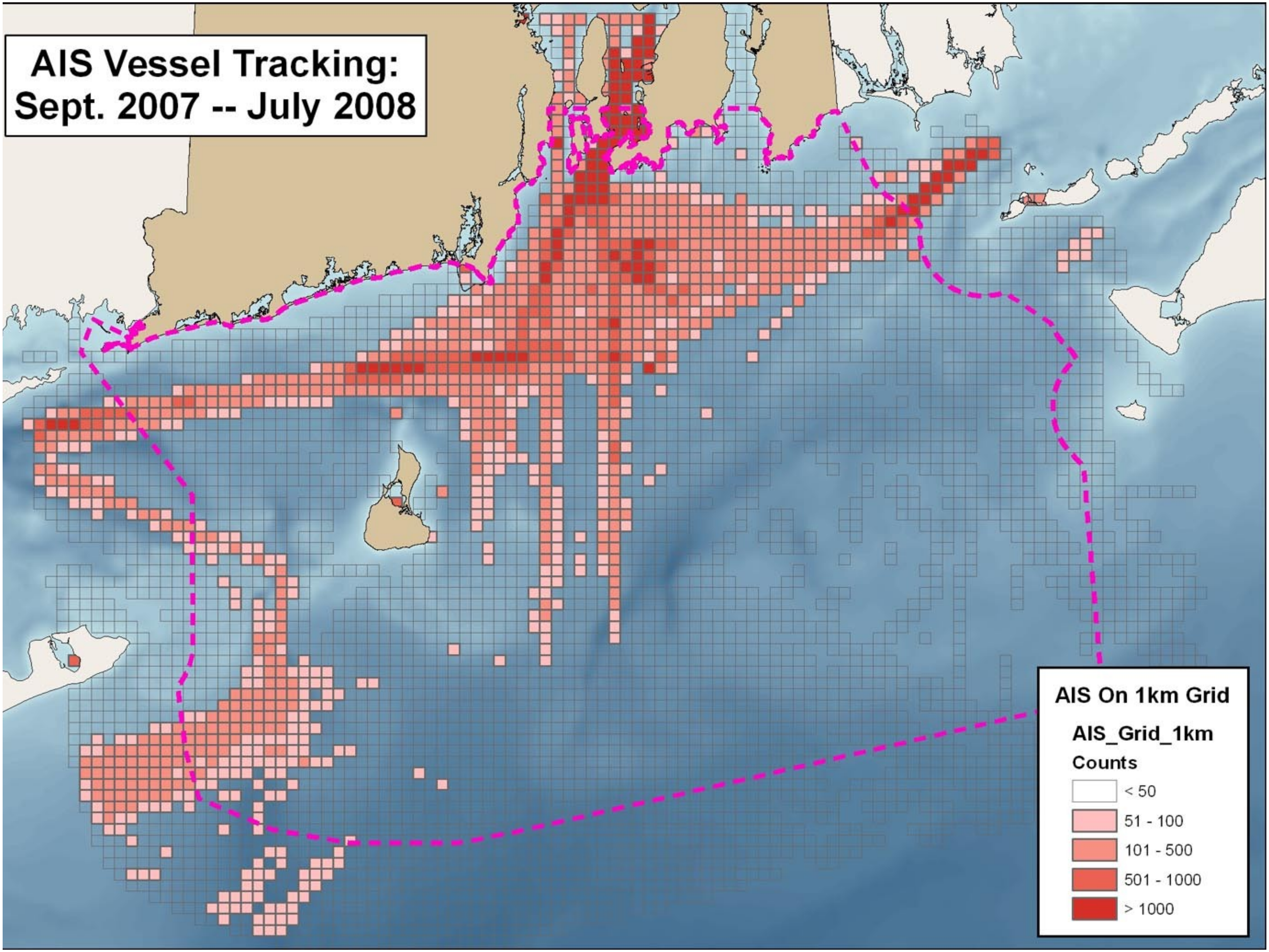
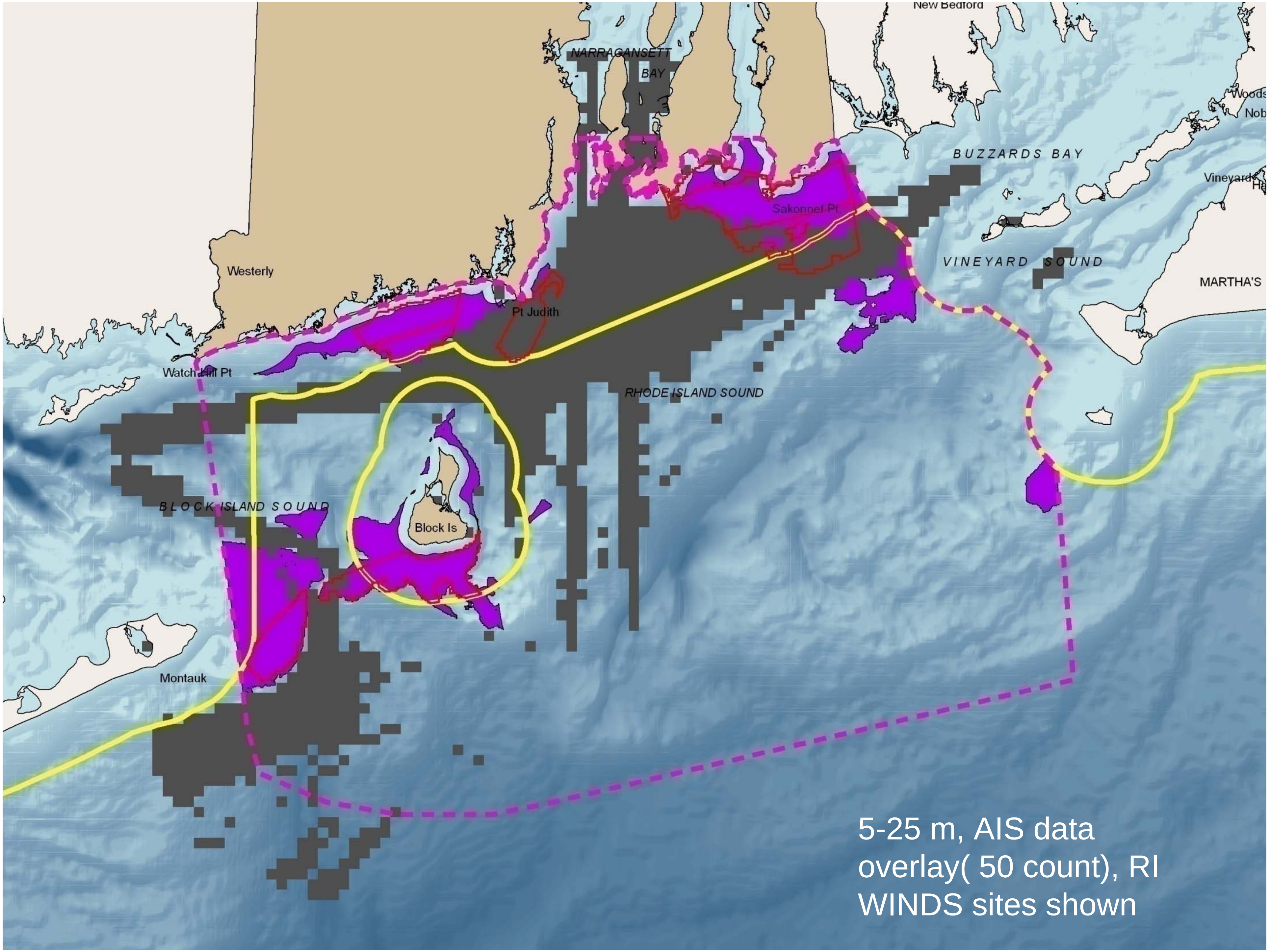
Exclusion Areas
Coastal buffer
Navigation areas
Regulated areas
Airport Buffer


AIS Vessel Tracks
September 2007 – July 2008


AIS Vessel Tracking:
Sept. 2007 -- July 2008
AIS On 1km Grid
AIS_Grid_1km
Counts
< 4
5 - 100
101 - 500
501 - 1000
> 1000


AIS Vessel Tracking:
Sept. 2007 -- July 2008
AIS On 1km Grid
AIS_Grid_1km
Counts
< 24
25 - 100
101 - 500
501 - 1000
> 1000


AIS Vessel Tracking:
Sept. 2007 -- July 2008
AIS On 1km Grid
AIS_Grid_1km
Counts
< 50
51 - 100
101 - 500
501 - 1000
> 1000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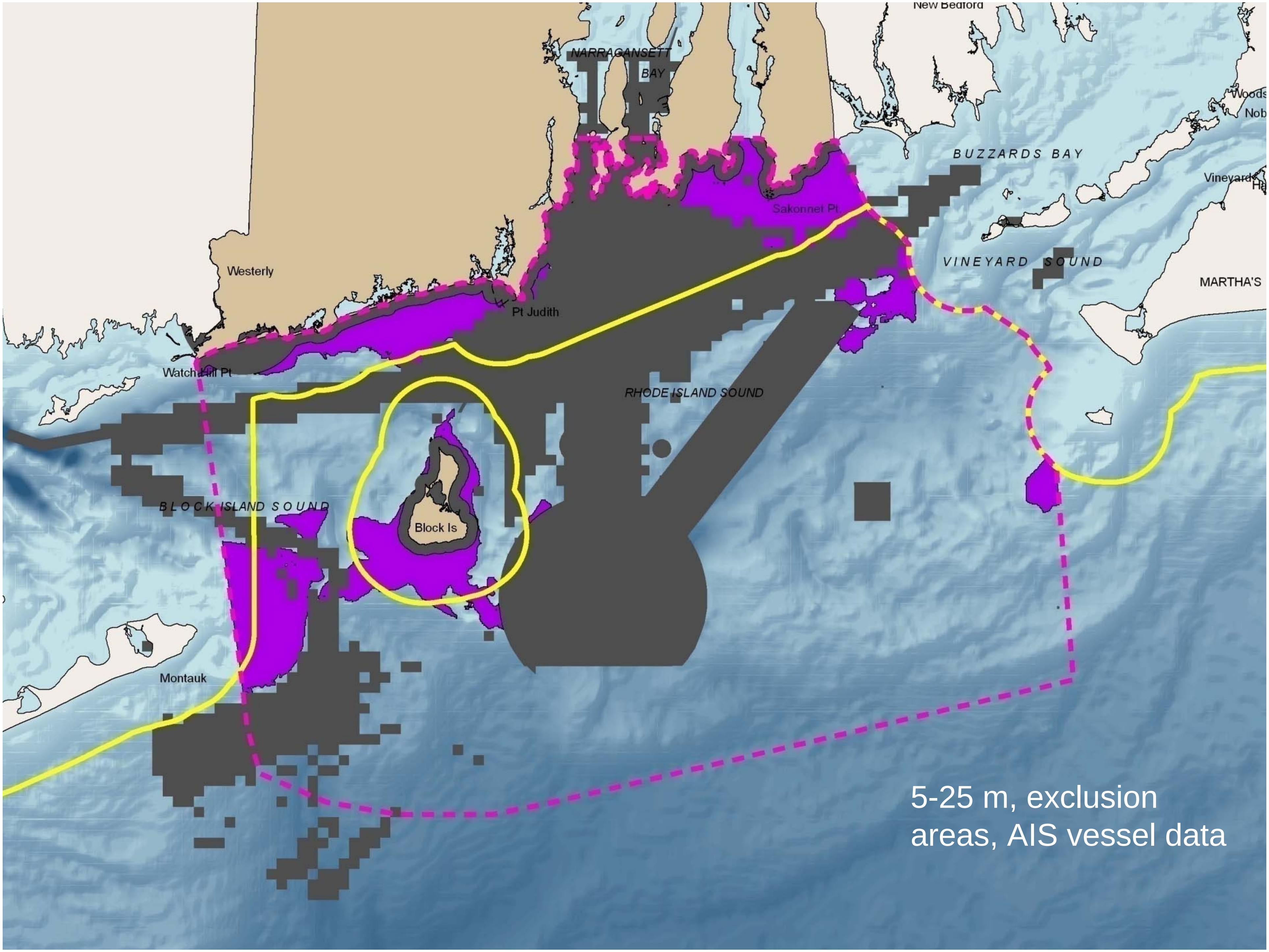
Pt Judith
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
5-25 m, AIS data
overlay(50 count), RI
WINDS sites shown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Block Is
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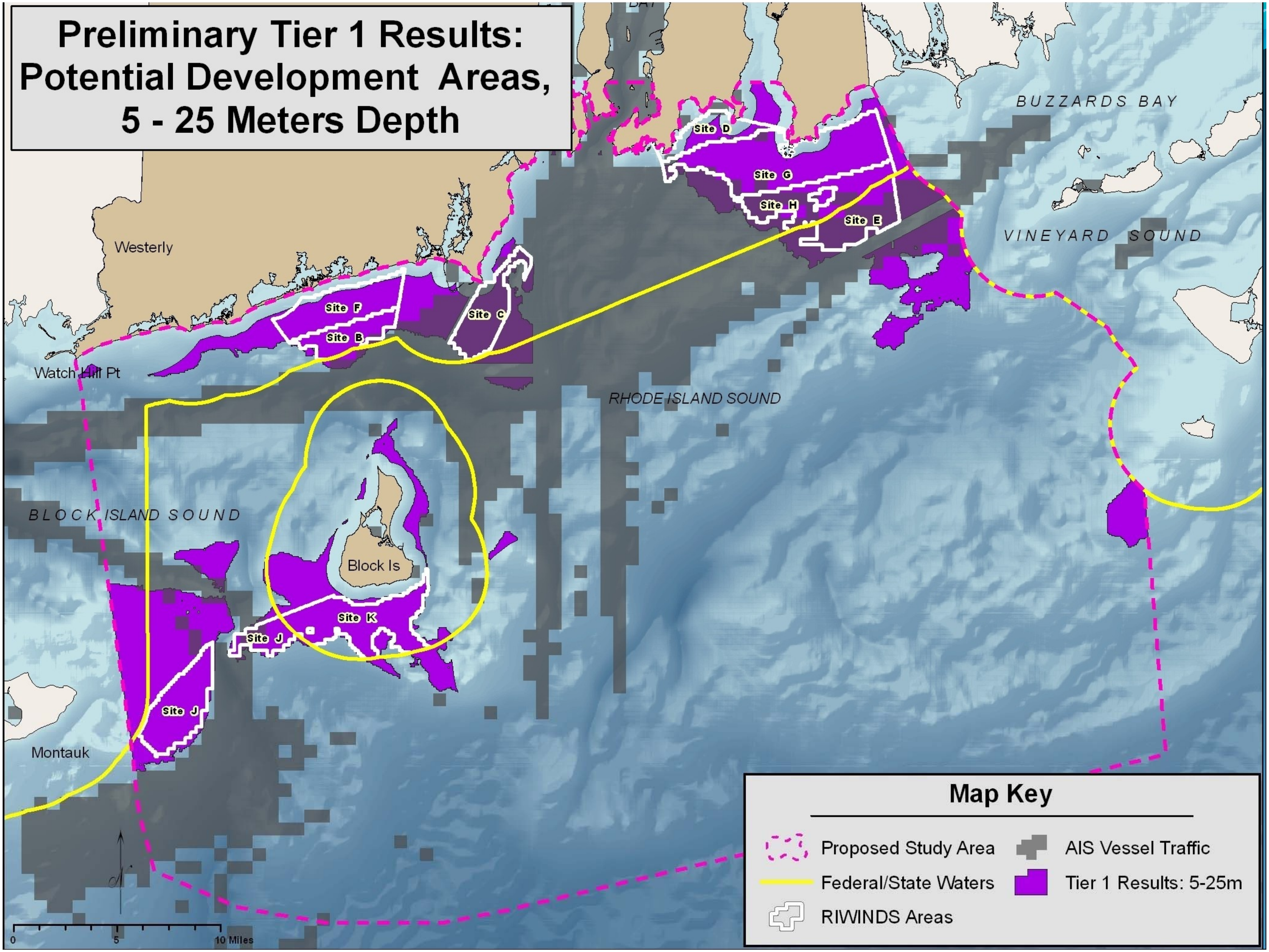
5-25 m, exclusion
areas, AIS vessel data


Preliminary Tier 1 Results:
Potential Development Areas,
5 - 25 Meters Depth
BUZZARDS BAY
VINEYARD SOUND
Westerly
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Site D
Site G
Site H
Site E
Site F
Site B
Site C
Site K
Site J
Site J
0
5
10 Miles
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.

$$TDI = TCI/PPP$$

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

PPP= W*CF

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

CF- capacity factor (35 %)

Components of TDI

- TCI – Technical Challenge Index

TCI = TT + CD

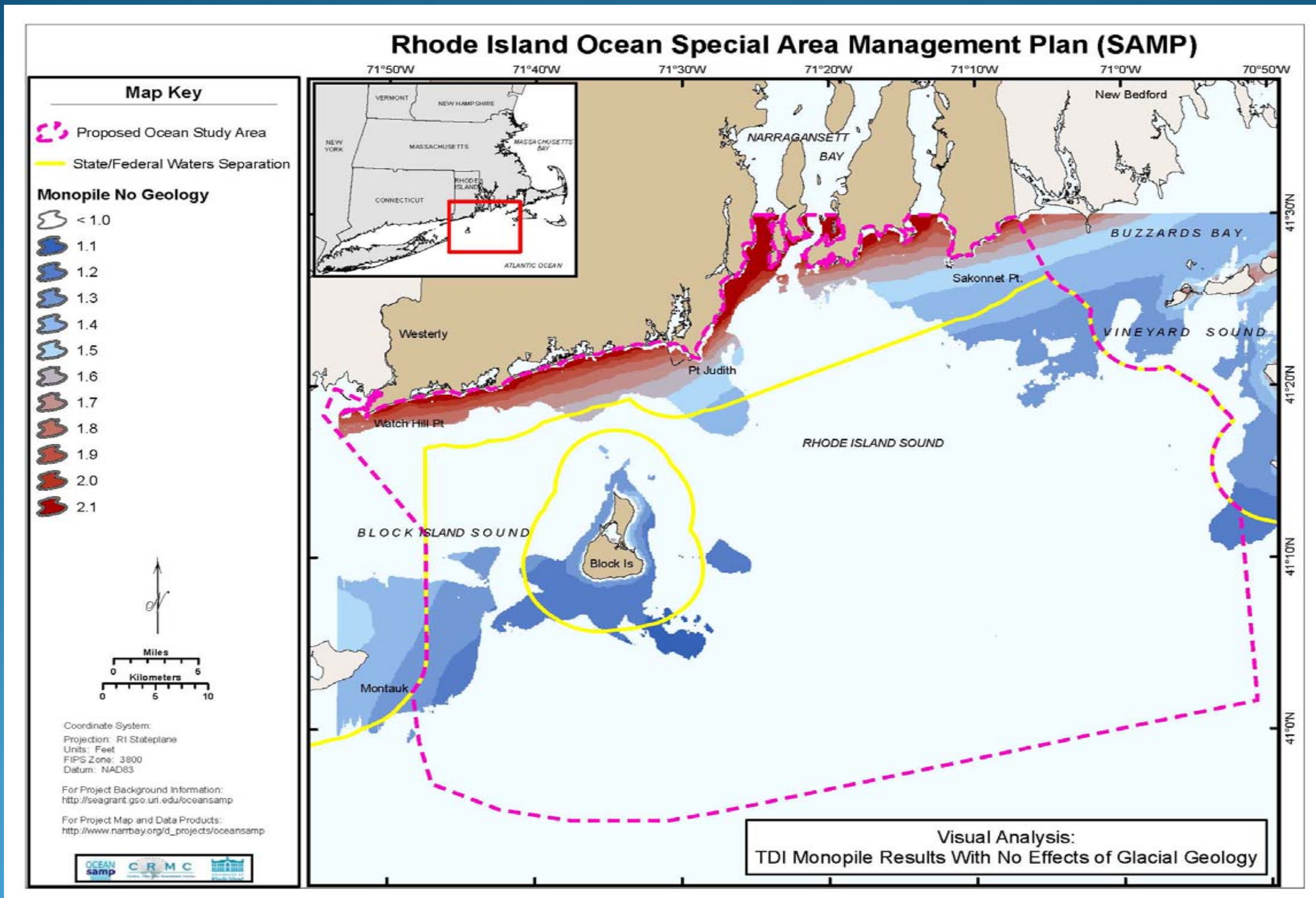
Where TT- Technology Type

CD- pro-rated distance to nearest electrical grid

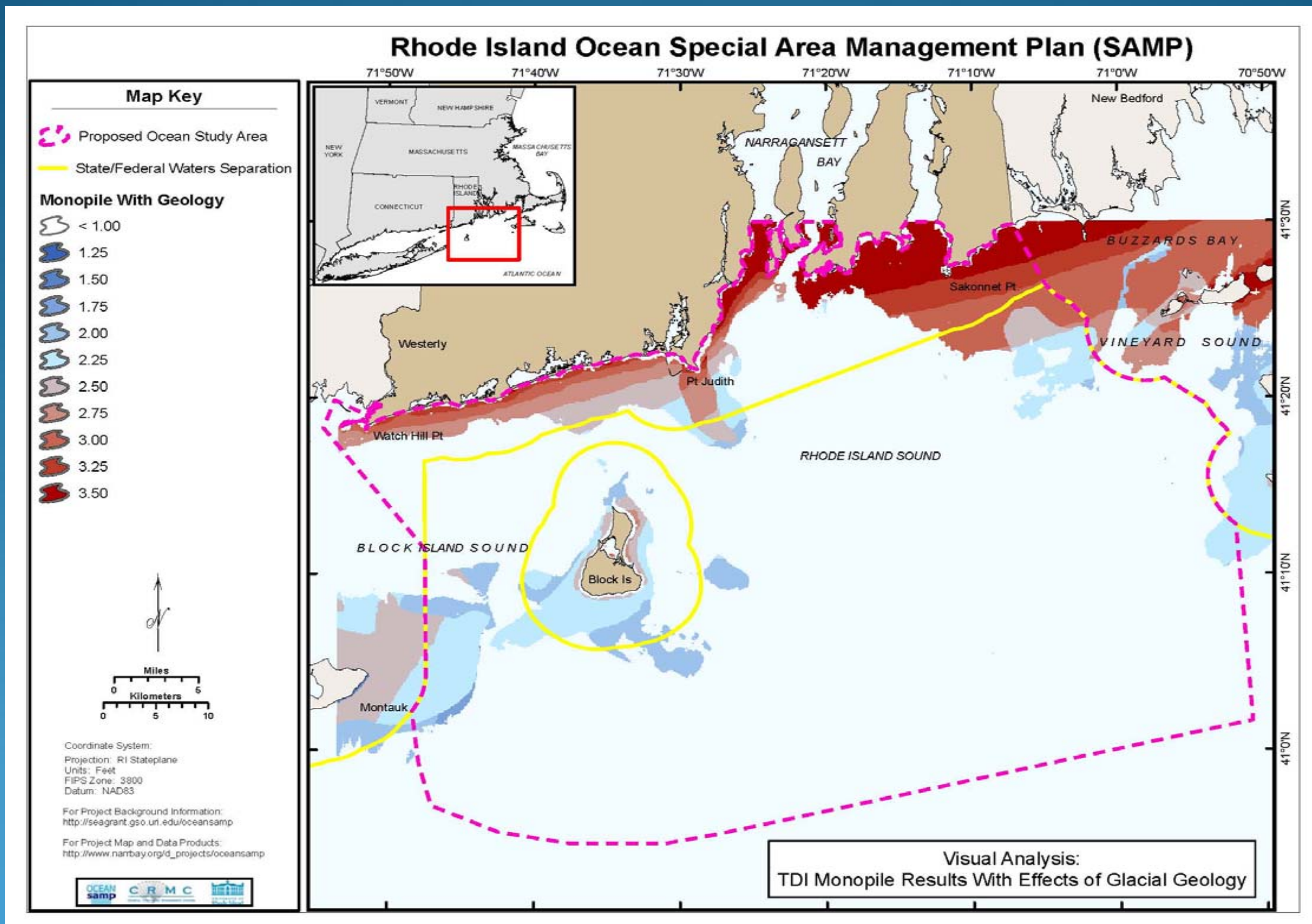
(distance to grid * SF/ number of turbines in wind farm)

SF- scale factor that assesses technology challenge for cable (nominal – 0.8)

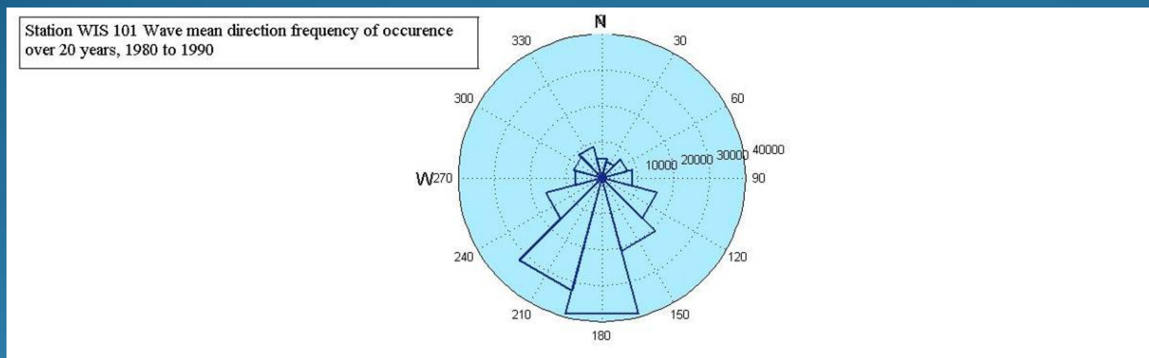
TDI Monopile (0 -25m), no geology



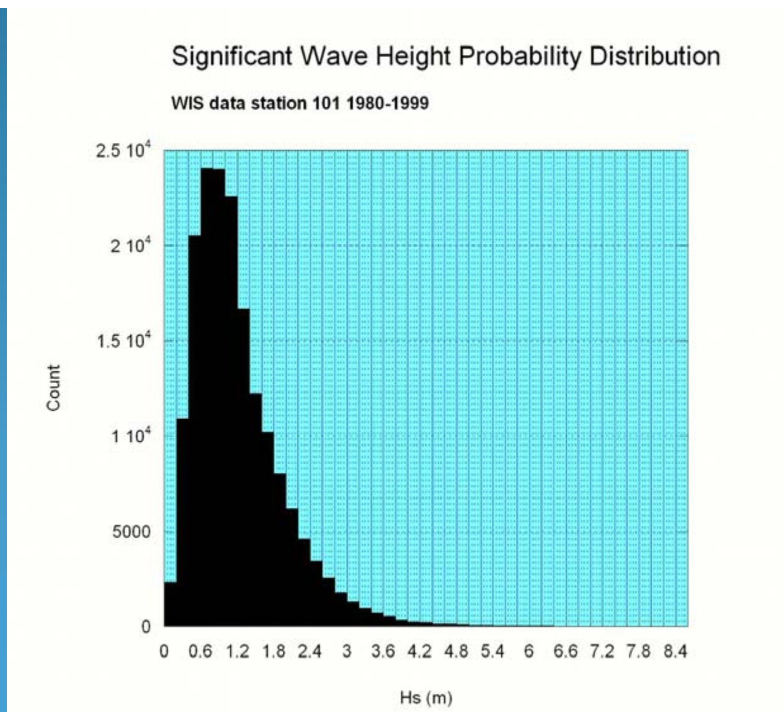
TDI Monopile (0-25m) with geology

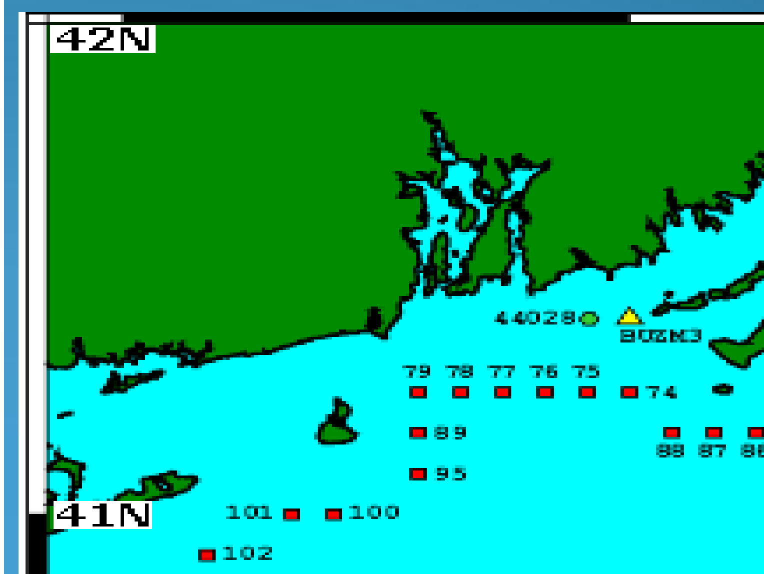


Wave Rose and Wave Height Histogram, WIS 101

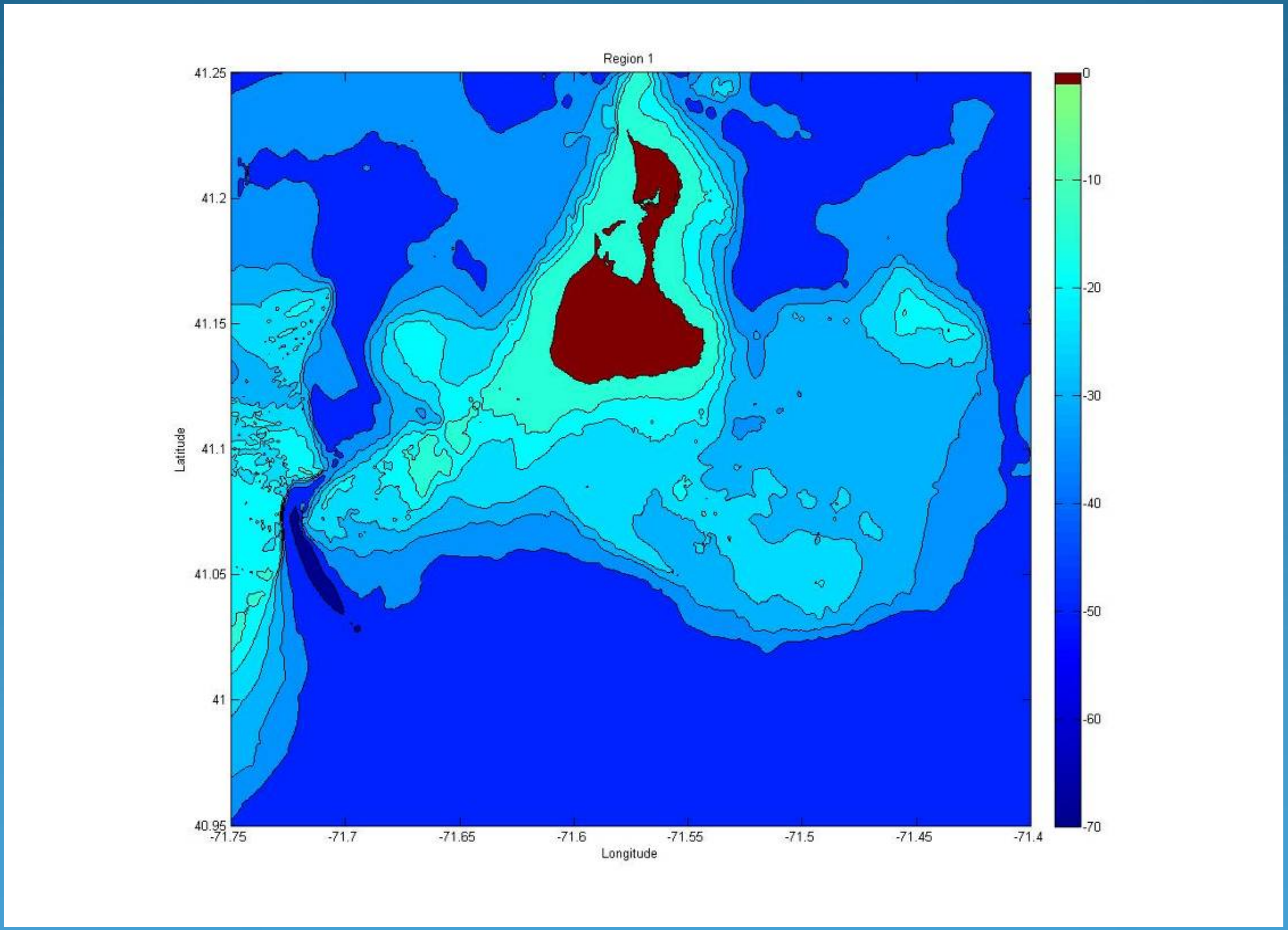


Waves Primarily from South and Southwest

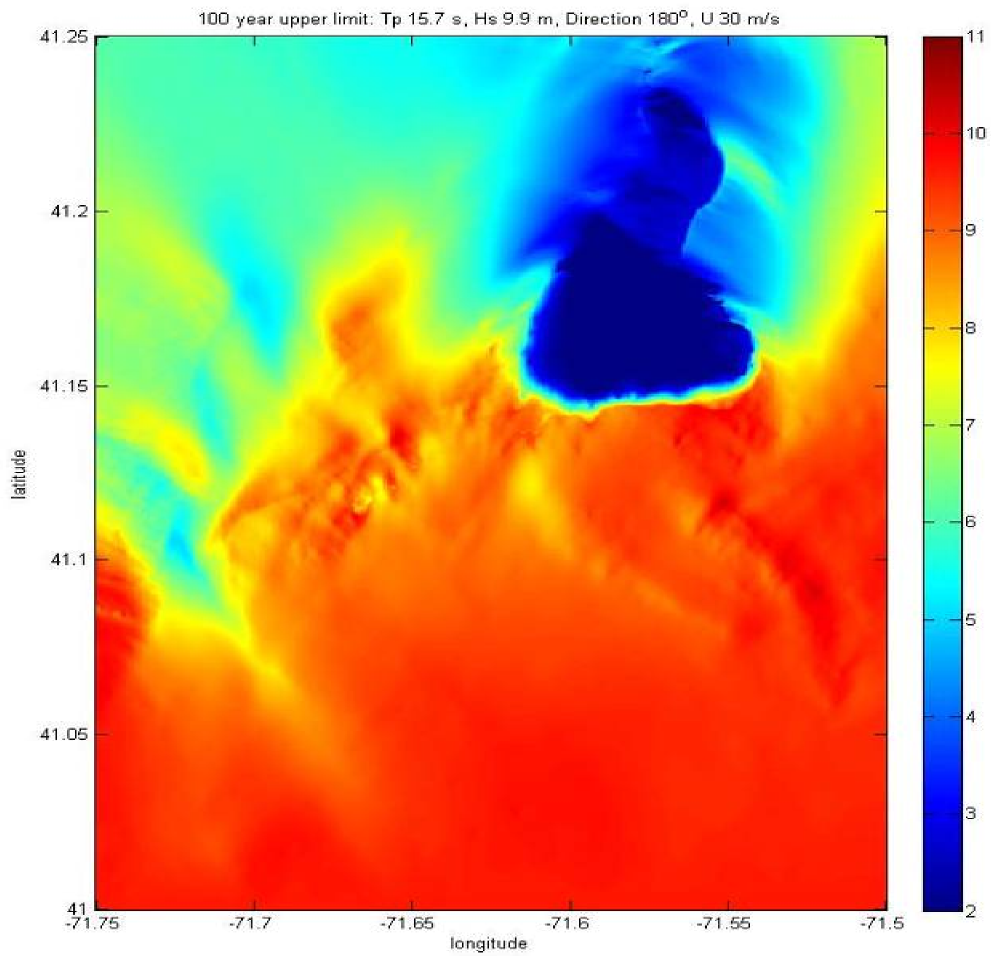


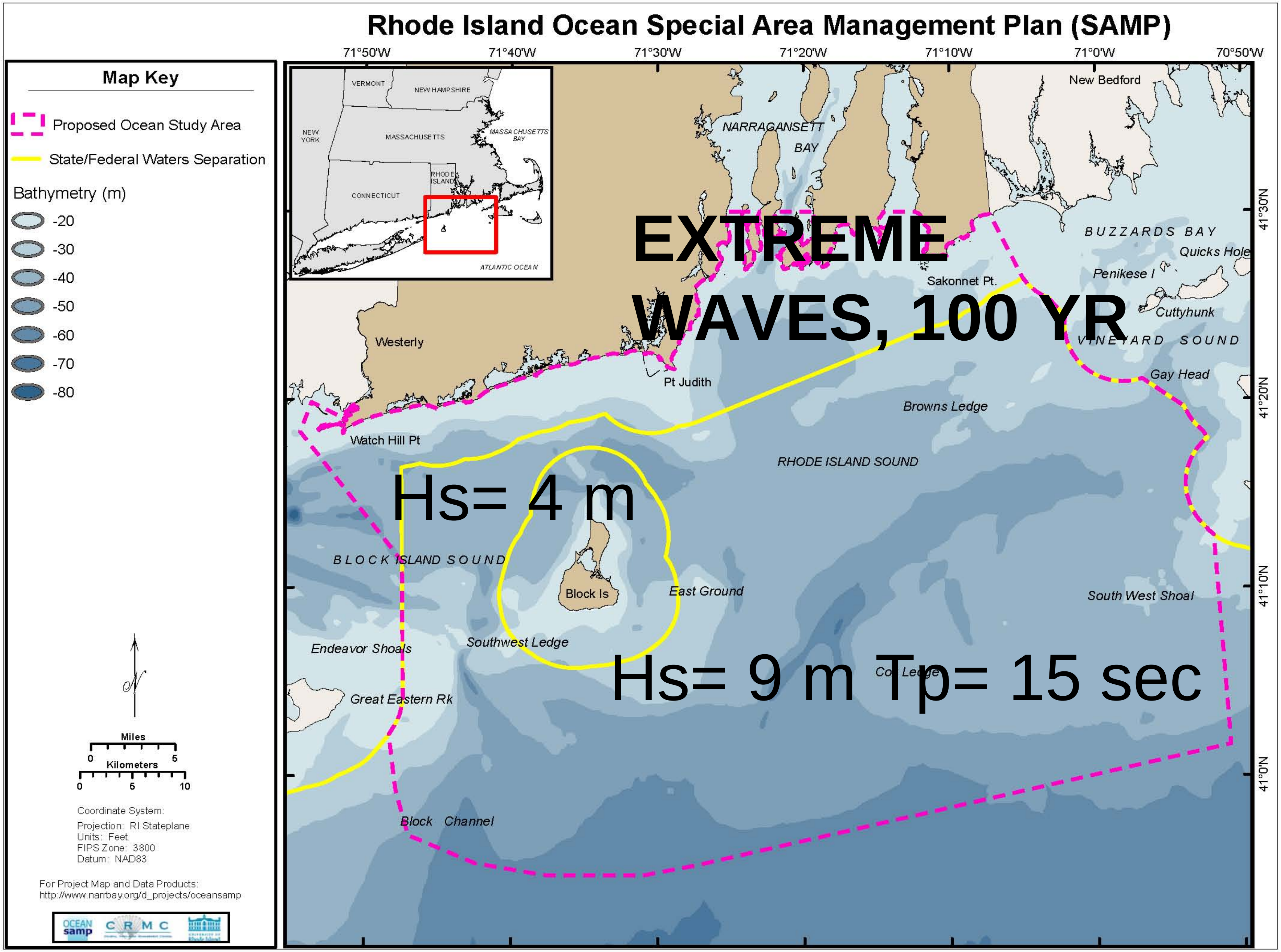


Bathymetry in vicinity of Block Island



WAVE Analysis, Return Period 100 yrs (upper 95% limit) Hs=9.9 m, Tp=15.7 sec, South




Rhode Island Ocean Special Area Management Plan (SAMP)
EXTREME WAVES, 100 YR
Hs= 4 m
Hs= 9 m Tp= 15 sec
Map Key
Proposed Ocean Study Area
State/Federal Waters Separation
Bathymetry (m)
-20
-30
-40
-50
-60
-70
-80
71°50'W
71°40'W
71°30'W
71°20'W
71°10'W
71°0'W
70°50'W
41°30'N
41°20'N
41°10'N
41°0'N
VERMONT
NEW HAMPSHIRE
NEW YORK
MASSACHUSETTS
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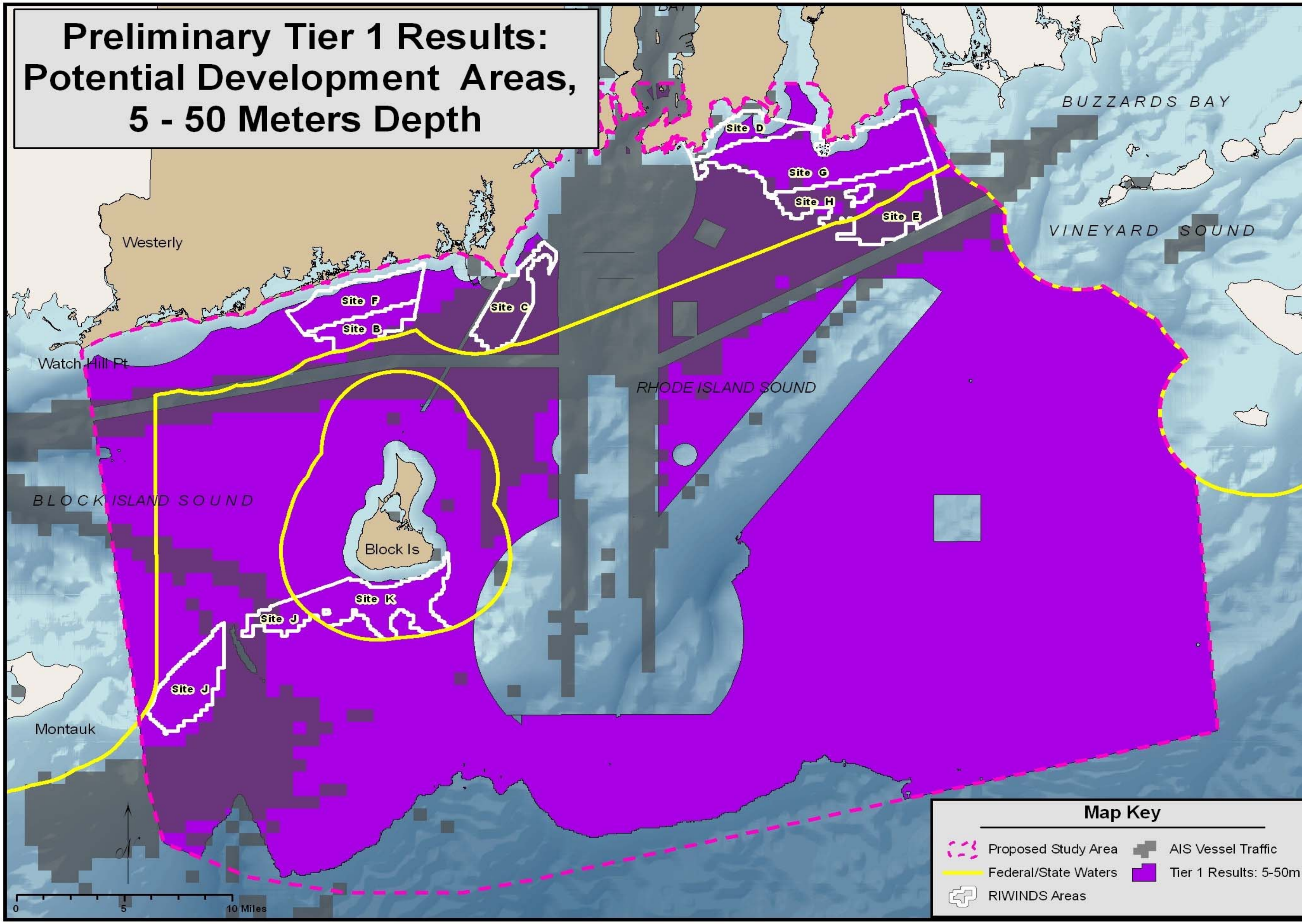
ATLANTIC OCEAN
New Bedford
NARRAGANSETT BAY
BUZZARDS BAY
Quicks Hole
Penikese I
Sakonnet Pt.
Cuttyhunk
VINEYARD SOUND
Gay Head
Westerly
Pt Judith
Browns Ledge
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
East Ground
South West Shoal
Endeavor Shoals
Southwest Ledge
Cox Ledge
Great Eastern Rk
Block Channel
N
Miles
0
5
Kilometers
0
5
10
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp


Preliminary Tier 1 Results:
Potential Development Areas,
5 - 50 Meters Depth
BUZZARDS BAY
VINEYARD SOUND
Westerly
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Site D
Site G
Site H
Site E
Site F
Site B
Site C
Site K
Site J
Site J
0
5
10 Miles
Map Key
Proposed Study Area
AIS Vessel Traffic
Federal/State Waters
Tier 1 Results: 5-50m
RIWINDS Areas

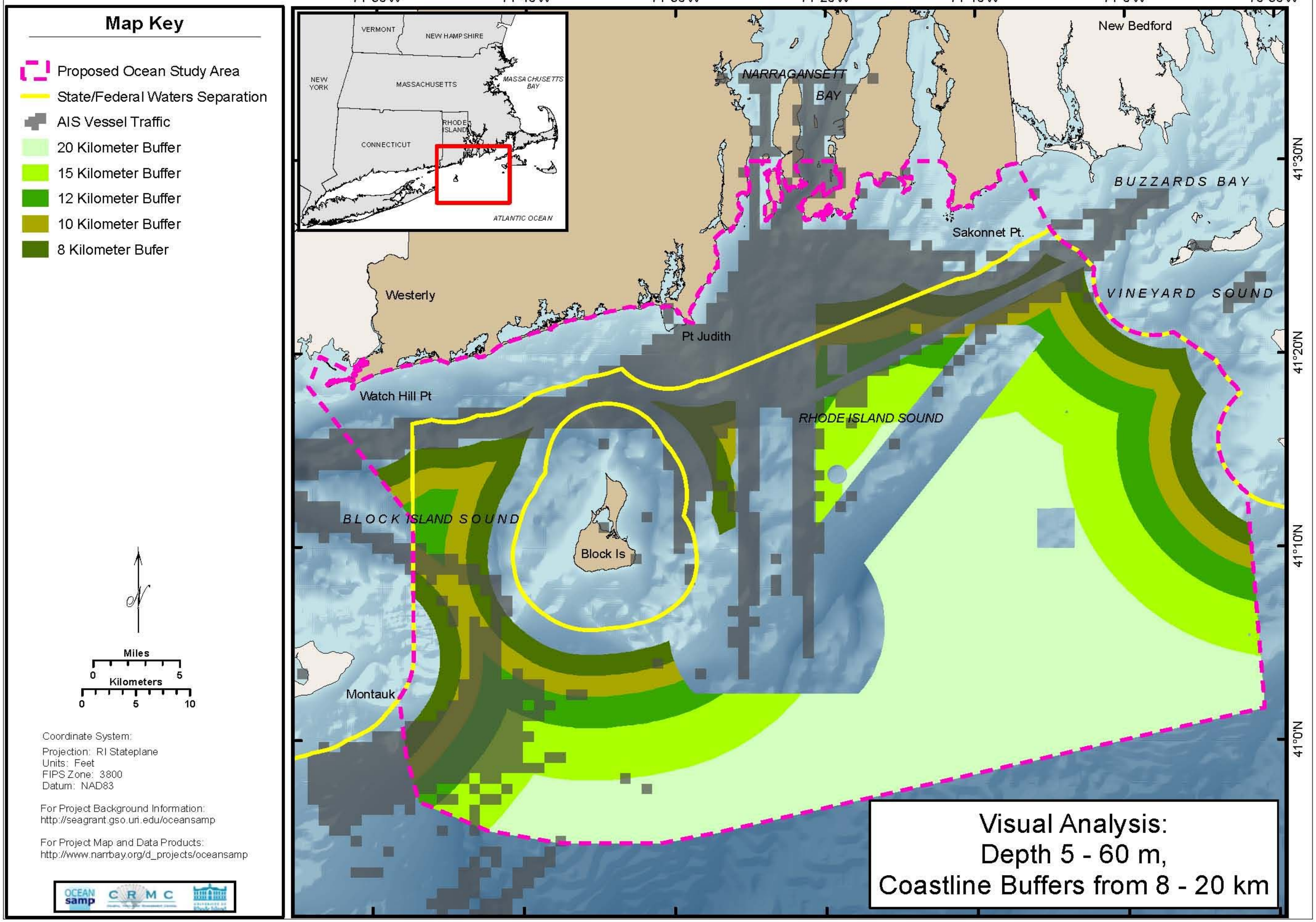
Approach to Identify Sites in Deep Water (25 to 60 m)

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

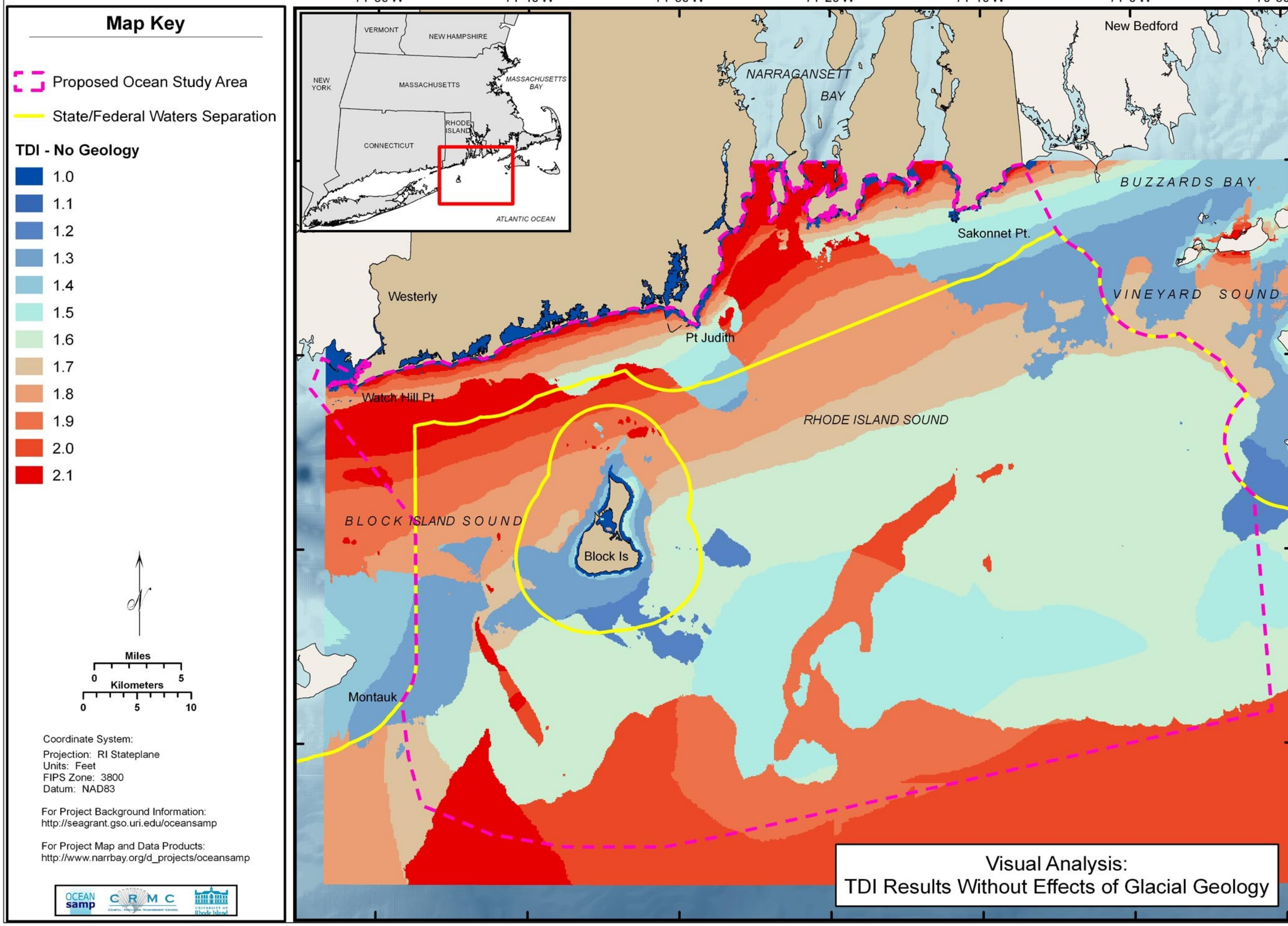
Visualization Assessment

- 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

Rhode Island Ocean Special Area Management Plan (SAMP)



Rhode Island Ocean Special Area Management Plan (SAMP)



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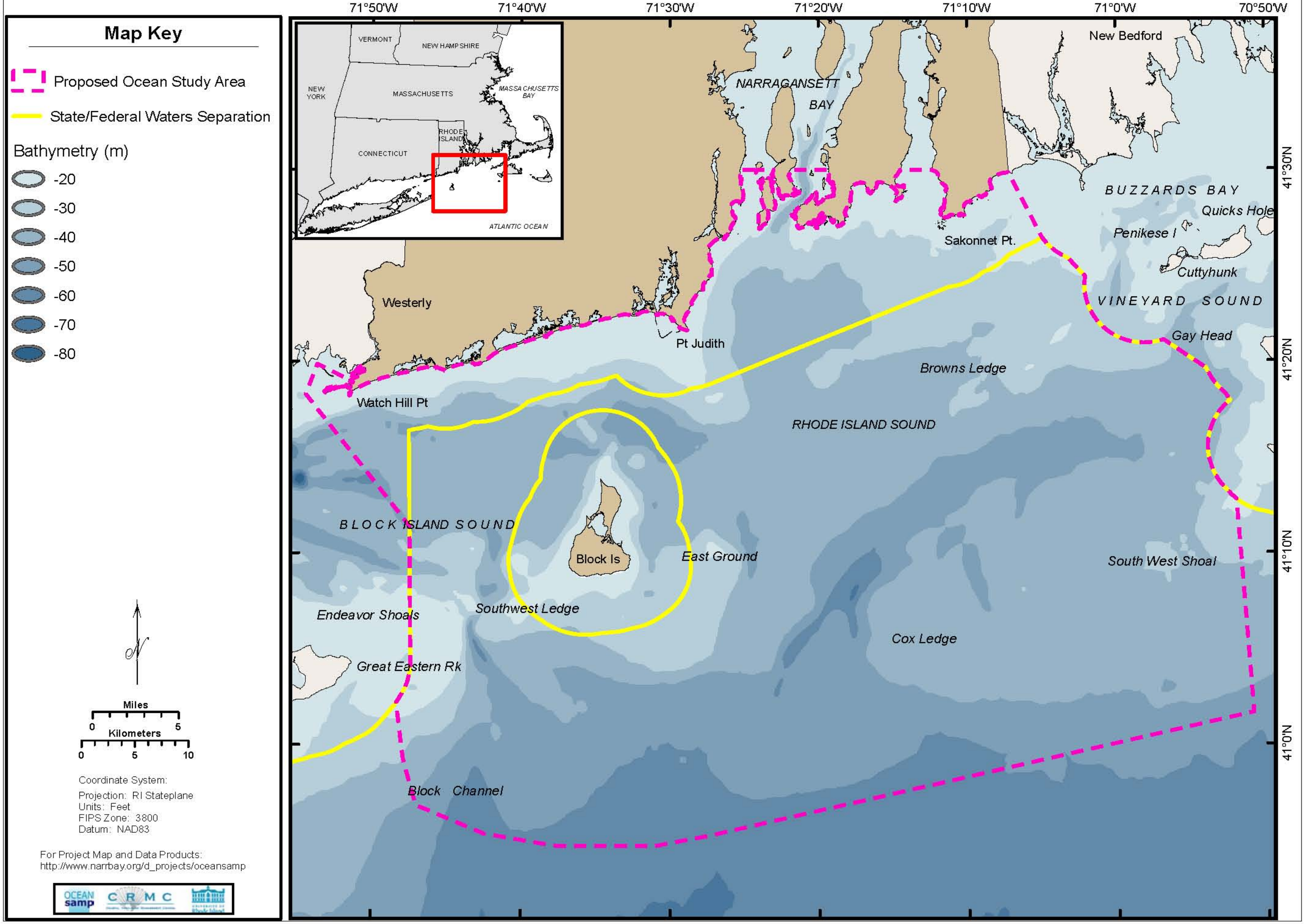

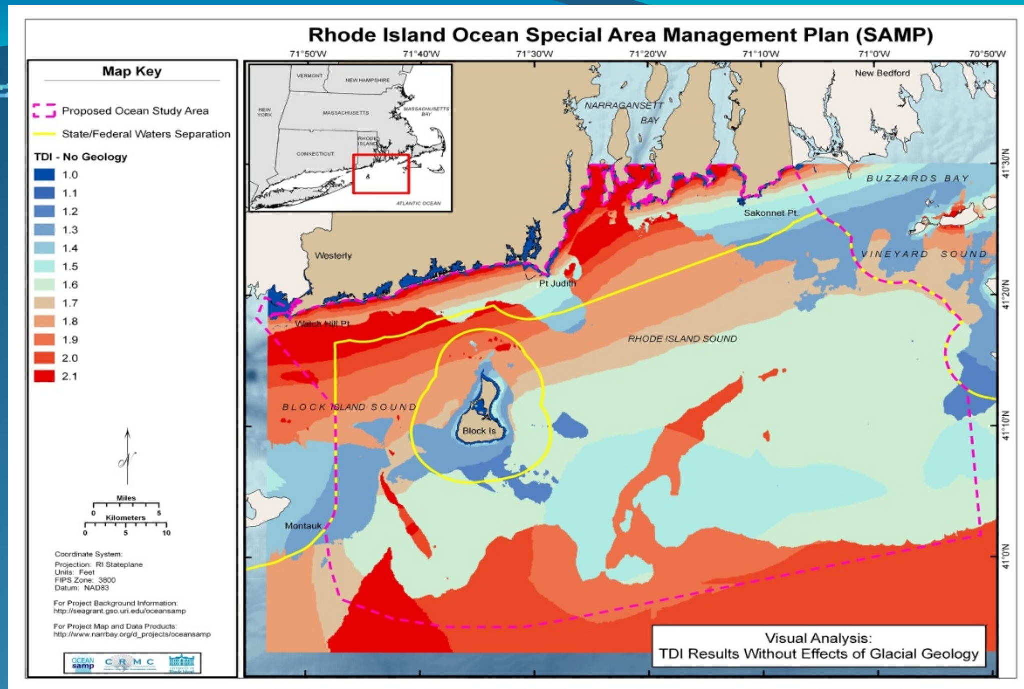
Rhode Island Ocean Special Area Management Plan (SAMP)
Map Key
Proposed Ocean Study Area
State/Federal Waters Separation
TDI - No Geology
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
Miles
Kilometers
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
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71°30'W
71°20'W
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Westerly
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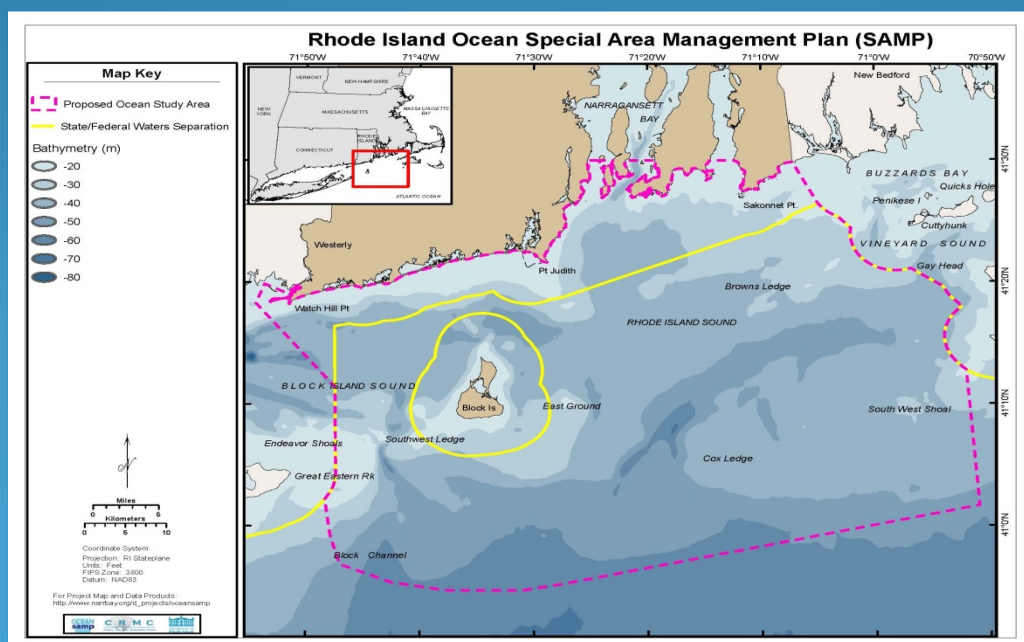
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Visual Analysis:
TDI Results Without Effects of Glacial Geology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State/Federal Waters Separation
Bathymetry (m)
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70°50'W
41°30'N
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New Bedford
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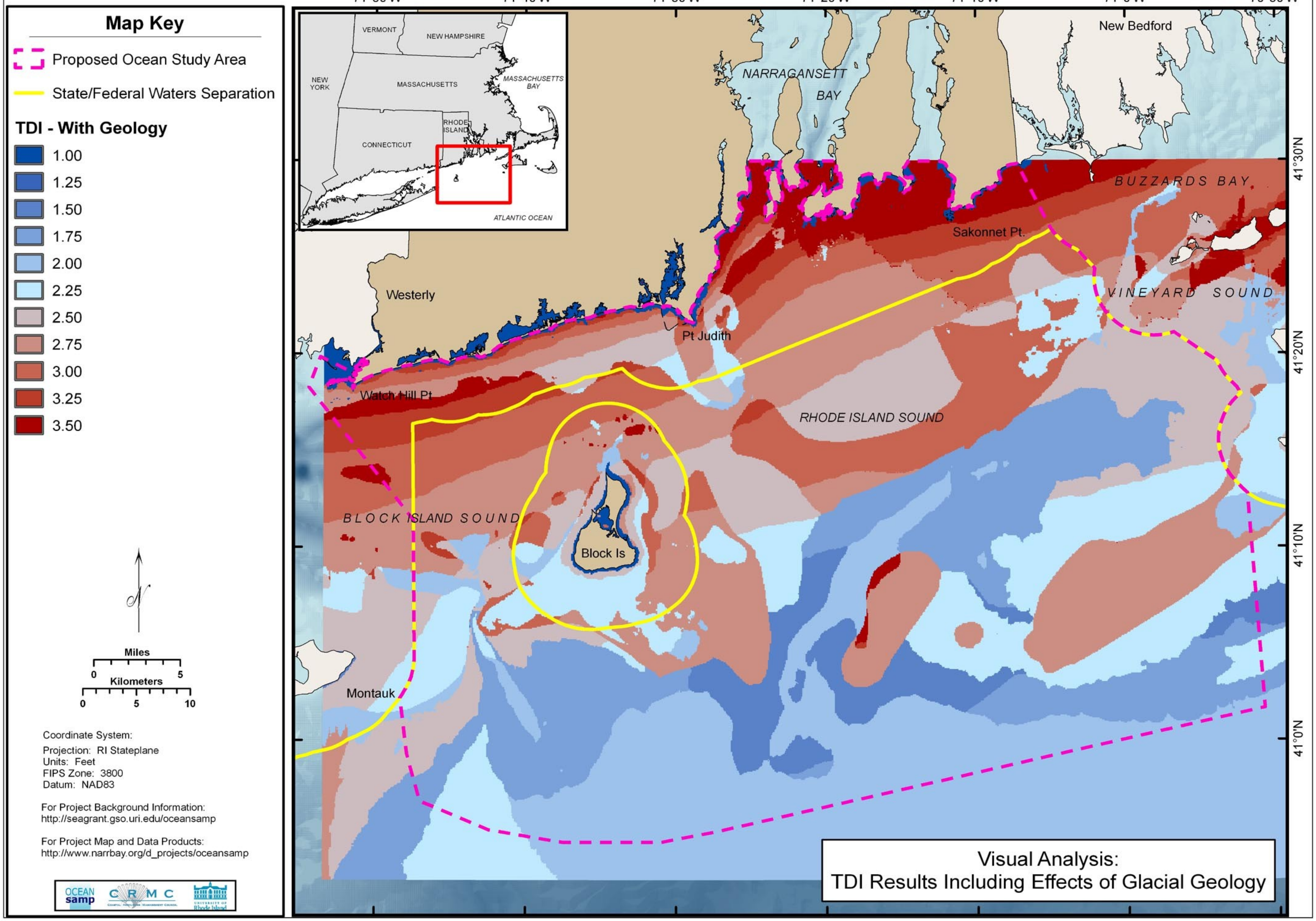
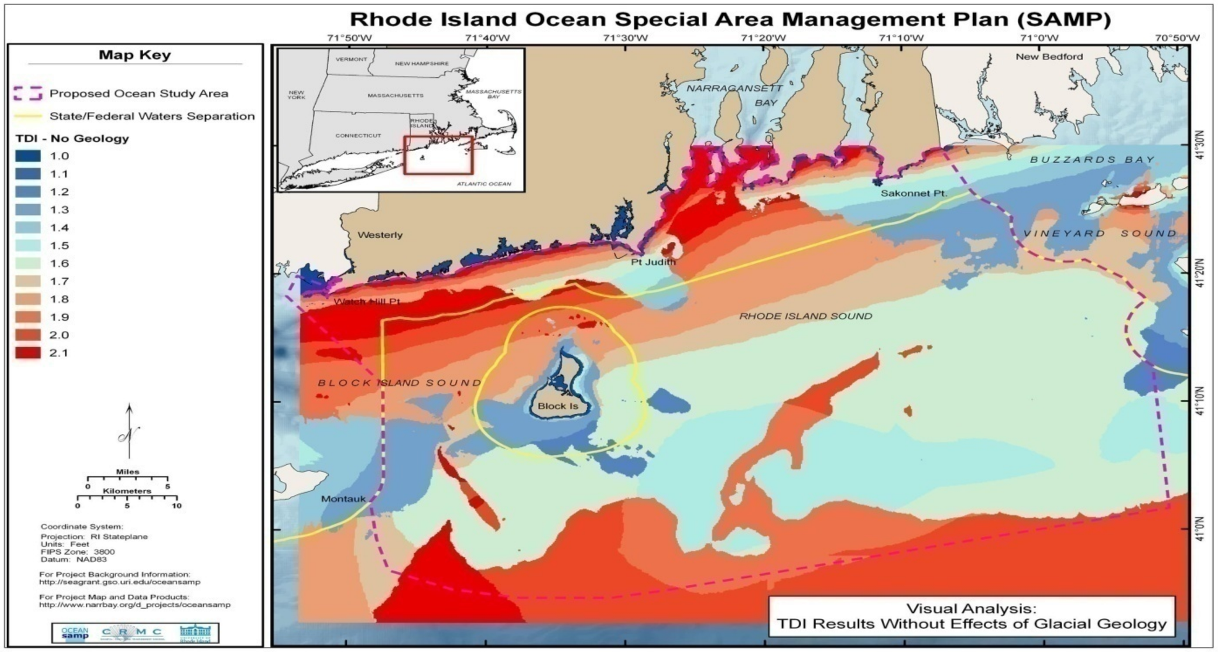
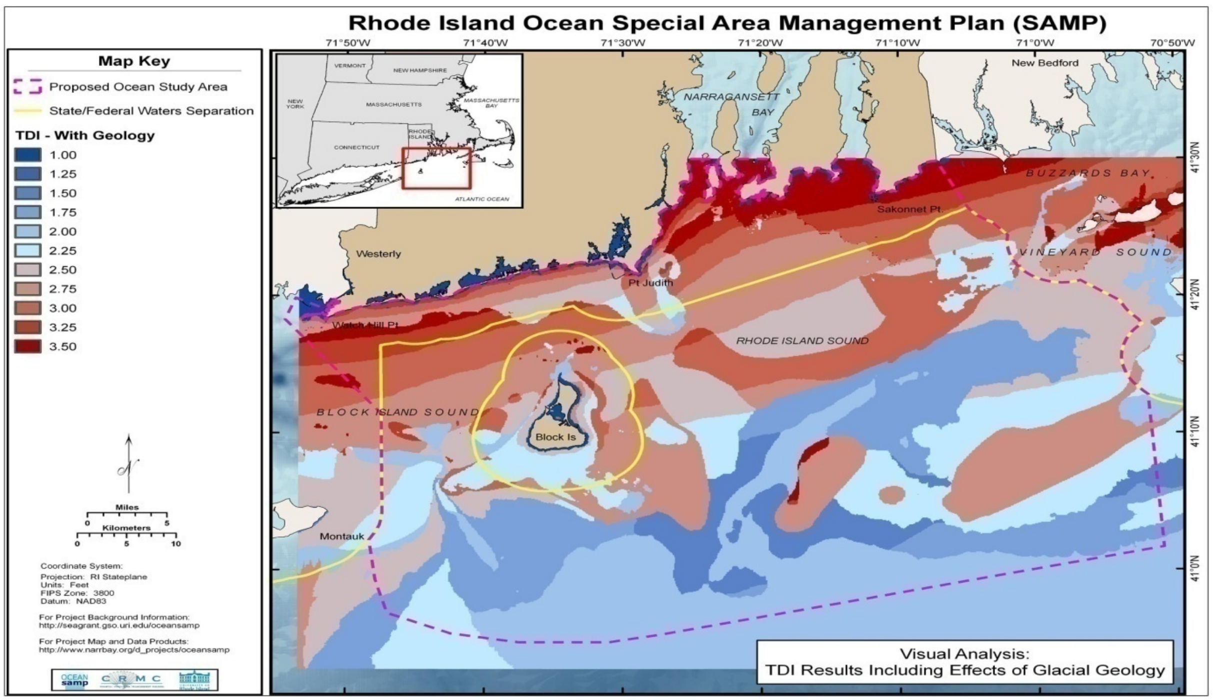
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
East Ground
South West Shoal
Endeavor Shoals
Southwest Ledge
Cox Ledge
Great Eastern Rk
Block Channel

Rhode Island Ocean Special Area Management Plan (SAMP)




Rhode Island Ocean Special Area Management Plan (SAMP)
Map Key
Proposed Ocean Study Area
State/Federal Waters Separation
TDI - No Geology
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
Miles
Kilometers
Coordinate System:
Projection: RI Stateplane
Units: Feet
FIPS Zone: 3800
Datum: NAD83
For Project Background Information:
http://seagrant.gso.uri.edu/oceansamp
For Project Map and Data Products:
http://www.narrbay.org/d_projects/oceansamp
71°50'W
71°40'W
71°30'W
71°20'W
71°10'W
71°0'W
70°50'W
41°30'N
41°20'N
41°10'N
41°0'N
New Bedford
NARRAGANSETT BAY
BUZZARDS BAY
Sakonnet Pt
Westerly
Pt Judith
VINEYARD SOUND
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Visual Analysis:
TDI Results Without Effects of Glacial Geology


Rhode Island Ocean Special Area Management Plan (SAMP)
Map Key
Proposed Ocean Study Area
State/Federal Waters Separation
TDI - With Geology
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
Miles
Kilometers
Coordinate System:
Projection: RI Stateplane
Units: Feet
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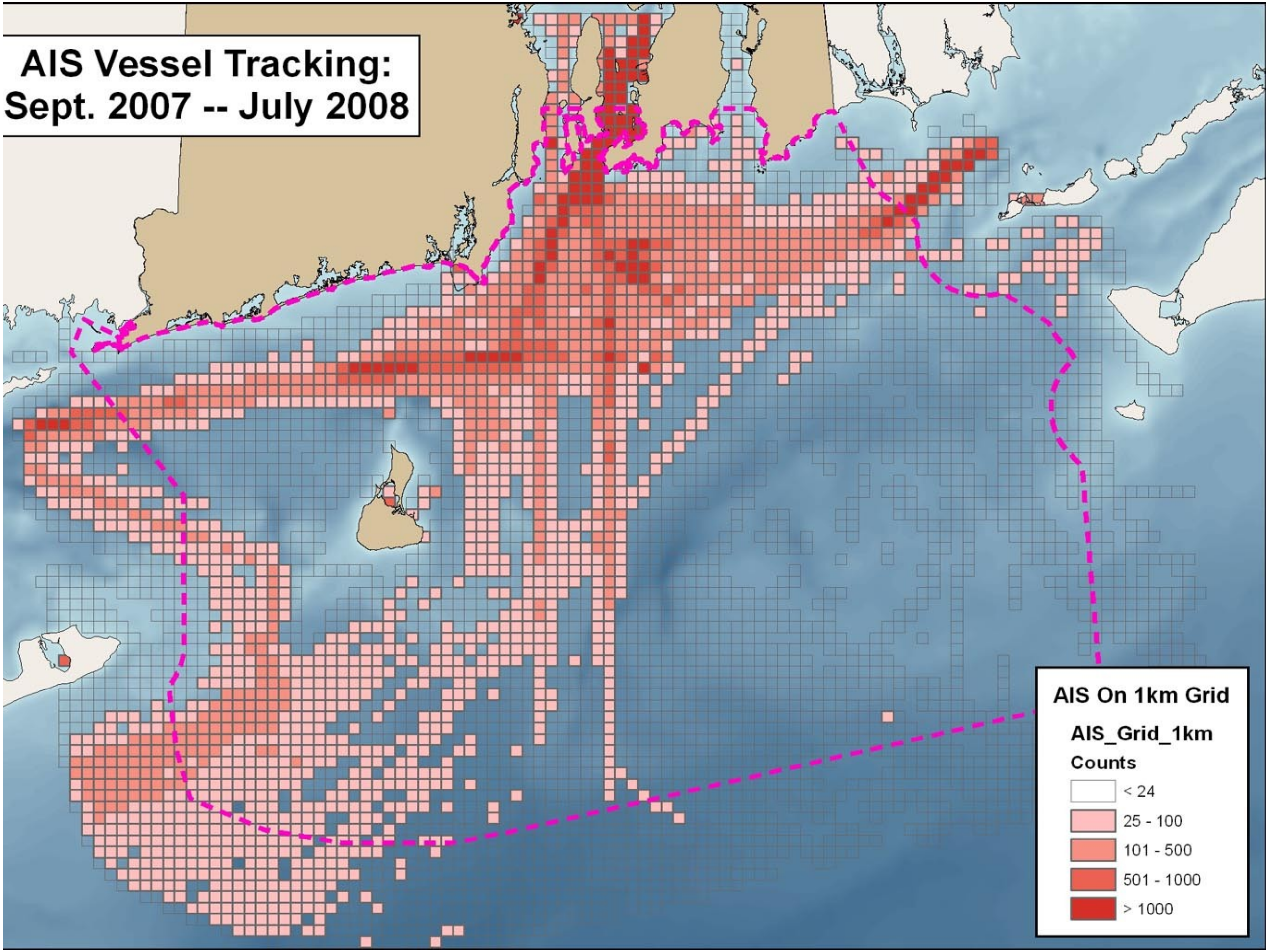
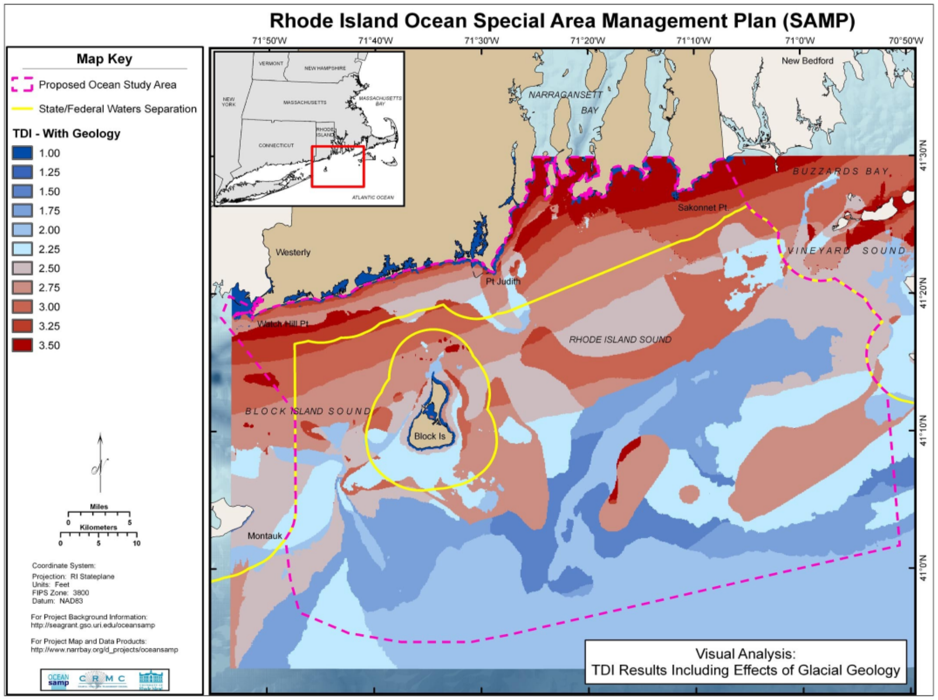
VINEYARD SOUND
Watch Hill Pt
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
Block Is
Montauk
Visual Analysis:
TDI Results Including Effects of Glacial Geology


AIS Vessel Tracking:
Sept. 2007 -- July 2008
AIS On 1km Grid
AIS_Grid_1km
Counts
< 24
25 - 100
101 - 500
501 - 1000
> 1000


Rhode Island Ocean Special Area Management Plan (SAMP)
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TDI - With Geology
1.00
1.25
1.50
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2.00
2.25
2.50
2.75
3.00
3.25
3.50
NARRAGANSETT BAY
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Sakonnet Pt
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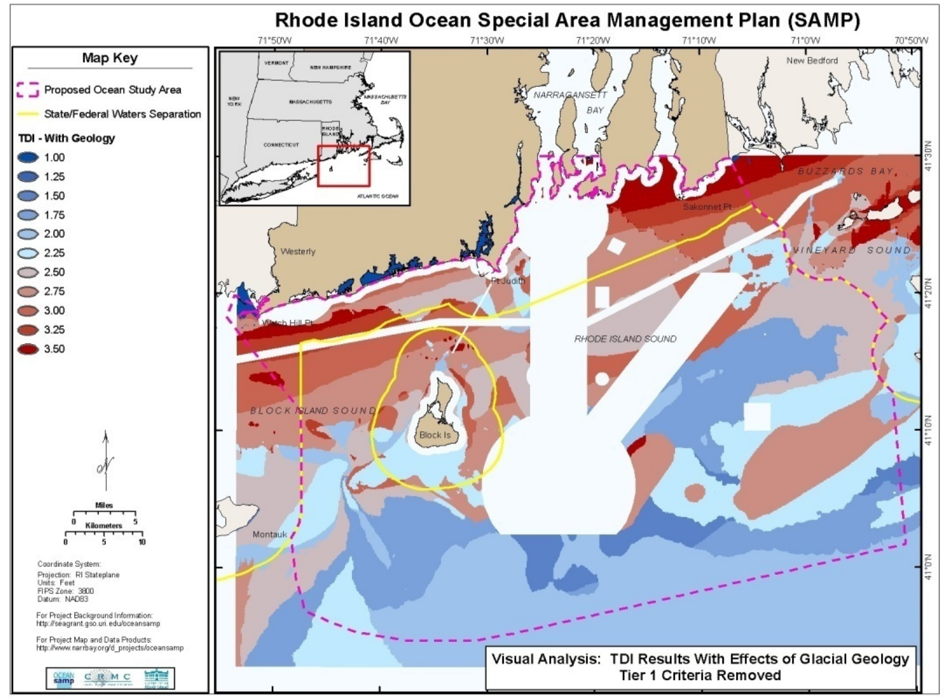
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TDI - With Geology
1.00
1.25
1.50
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2.00
2.25
2.50
2.75
3.00
3.25
3.50
NARRAGANSETT BAY
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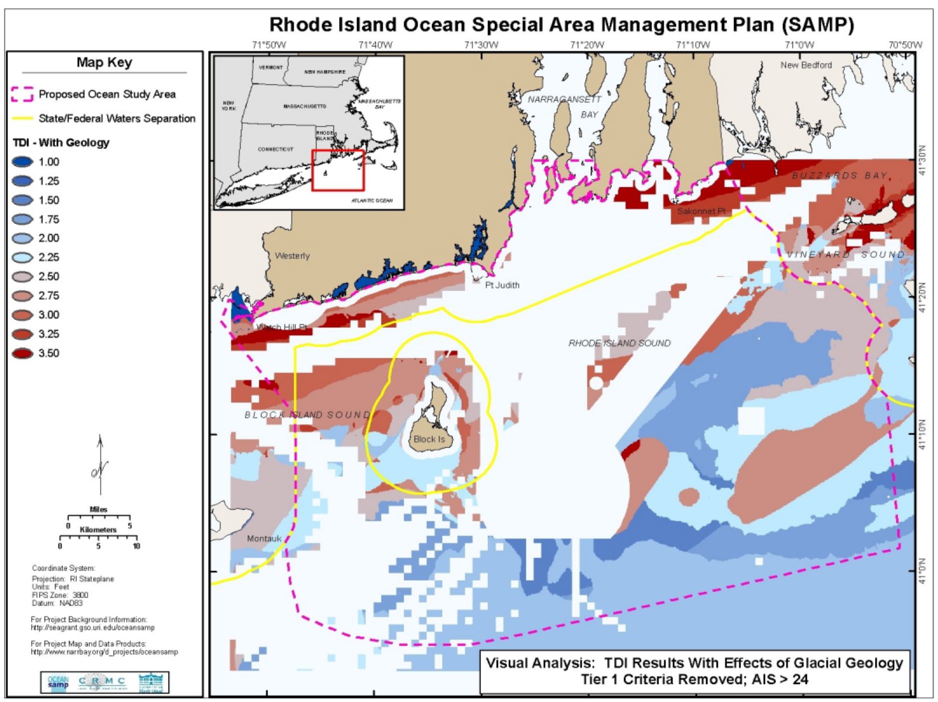
Visual Analysis: TDI Results With Effects of Glacial Geology
Tier 1 Criteria Removed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3.50
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Block Is
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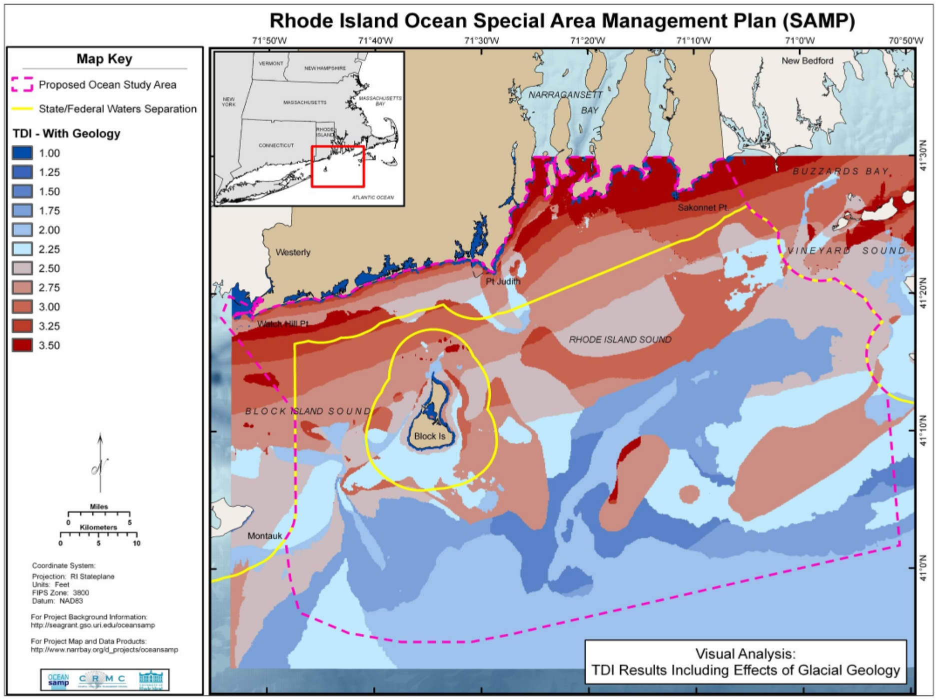
Visual Analysis: TDI Results With Effects of Glacial Geology
Tier 1 Criteria Removed; AIS > 24

AIS SERIES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1.00
1.25
1.50
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2.00
2.25
2.50
2.75
3.00
3.25
3.50
Miles
Kilometers
Coordinate System:
Projection: RI Stateplane
Units: Feet
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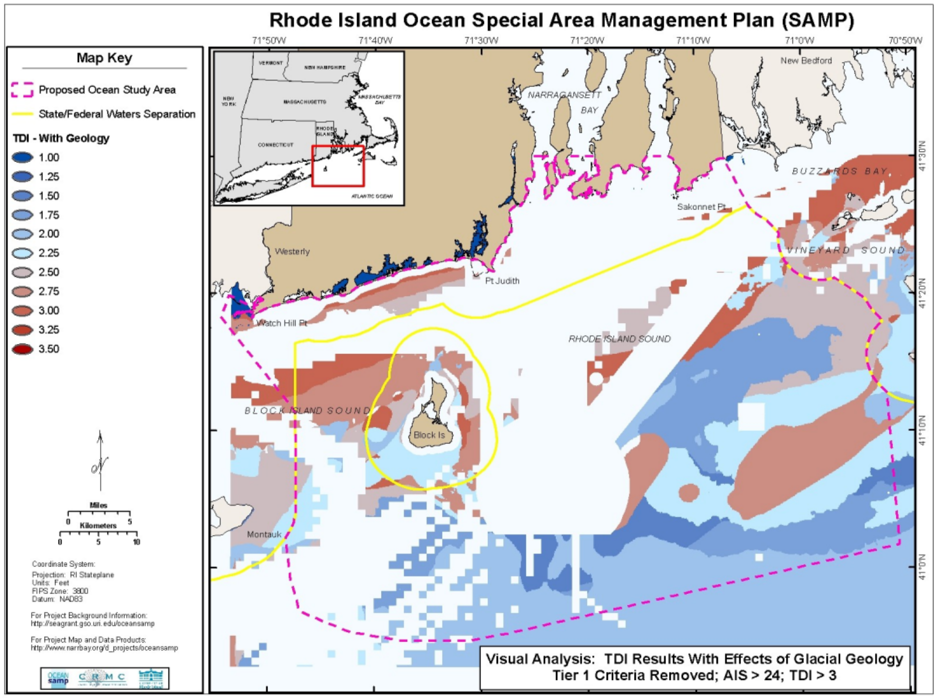
Rhode Island Ocean Special Area Management Plan (SAMP)
Map Key
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TDI - With Geology
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
Miles
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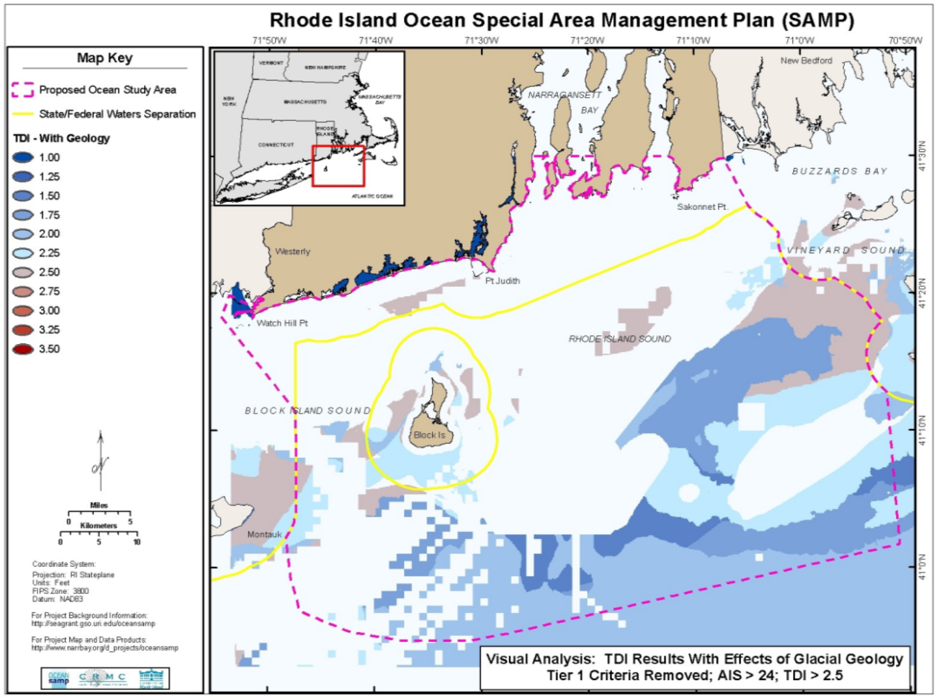
Visual Analysis: TDI Results With Effects of Glacial Geology
Tier 1 Criteria Removed; AIS > 24; TDI > 3


Rhode Island Ocean Special Area Management Plan (SAMP)
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TDI - With Geology
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1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
3.50
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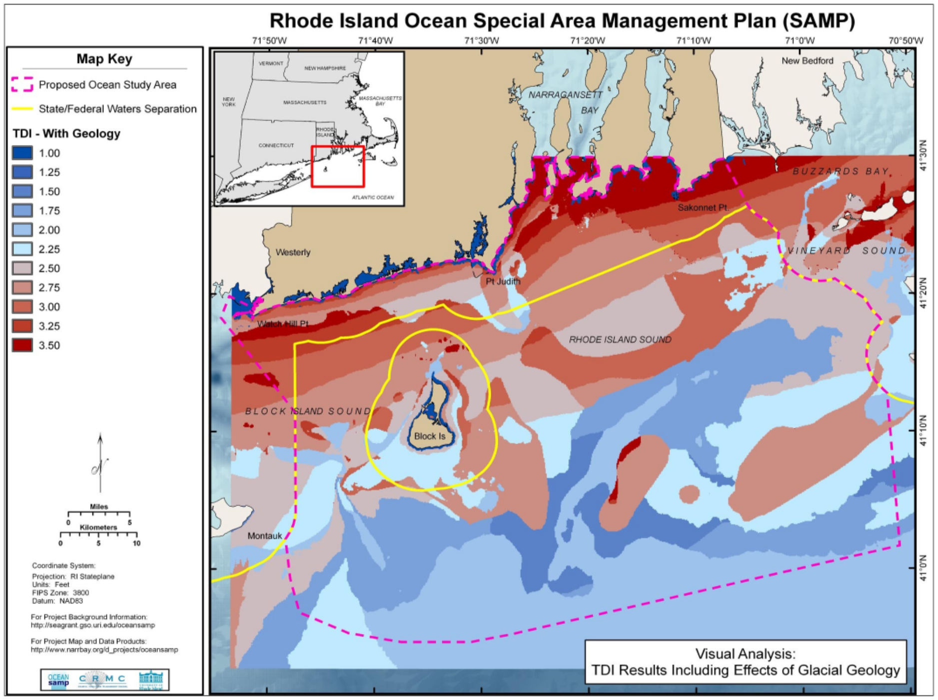
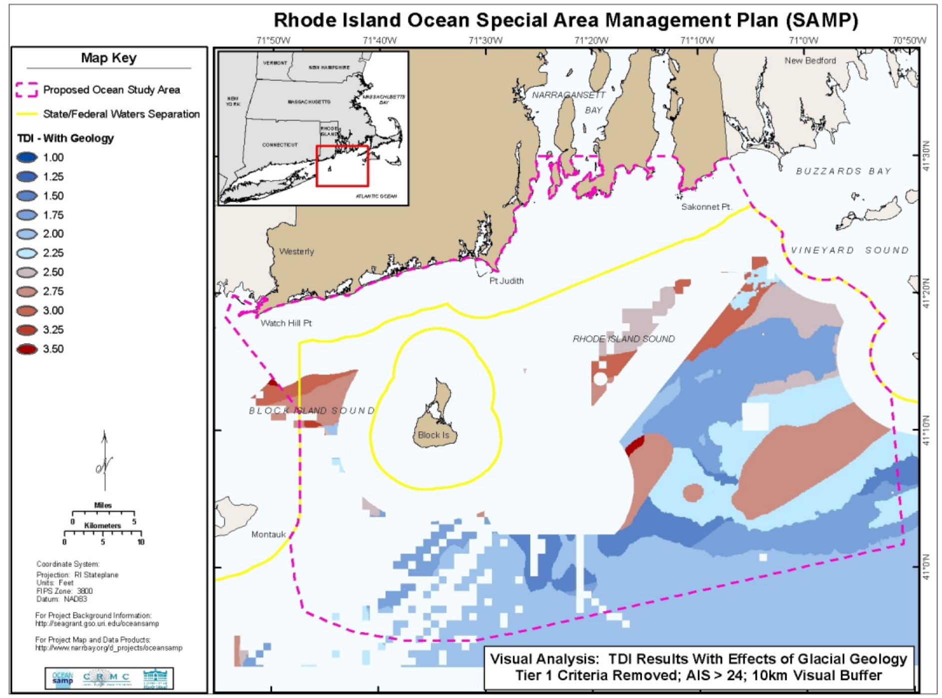
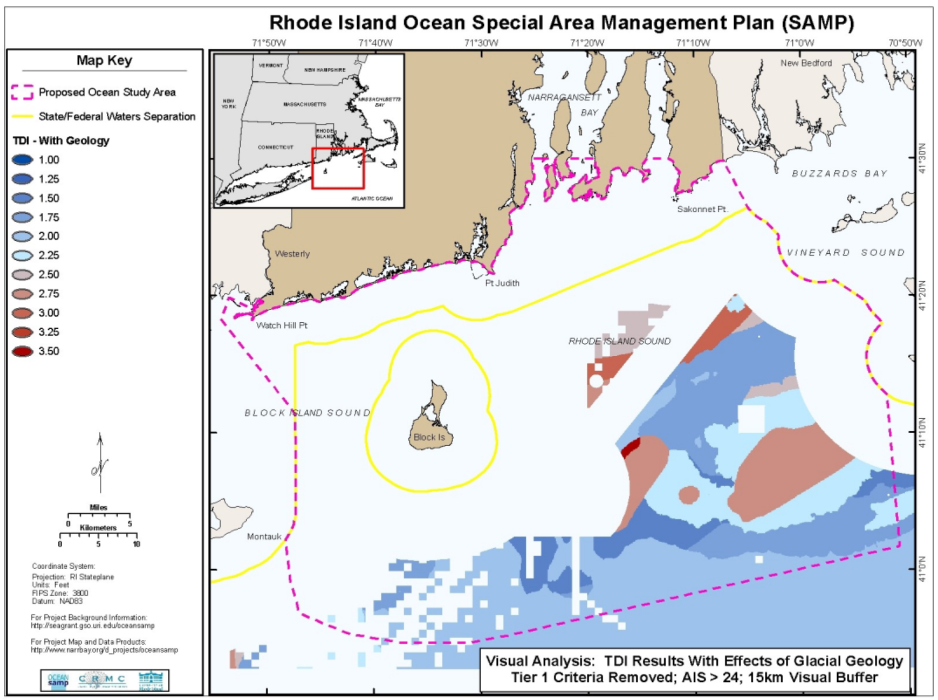
Visual Analysis: TDI Results With Effects of Glacial Geology
Tier 1 Criteria Removed; AIS > 24; TDI > 2.5

TDI Series

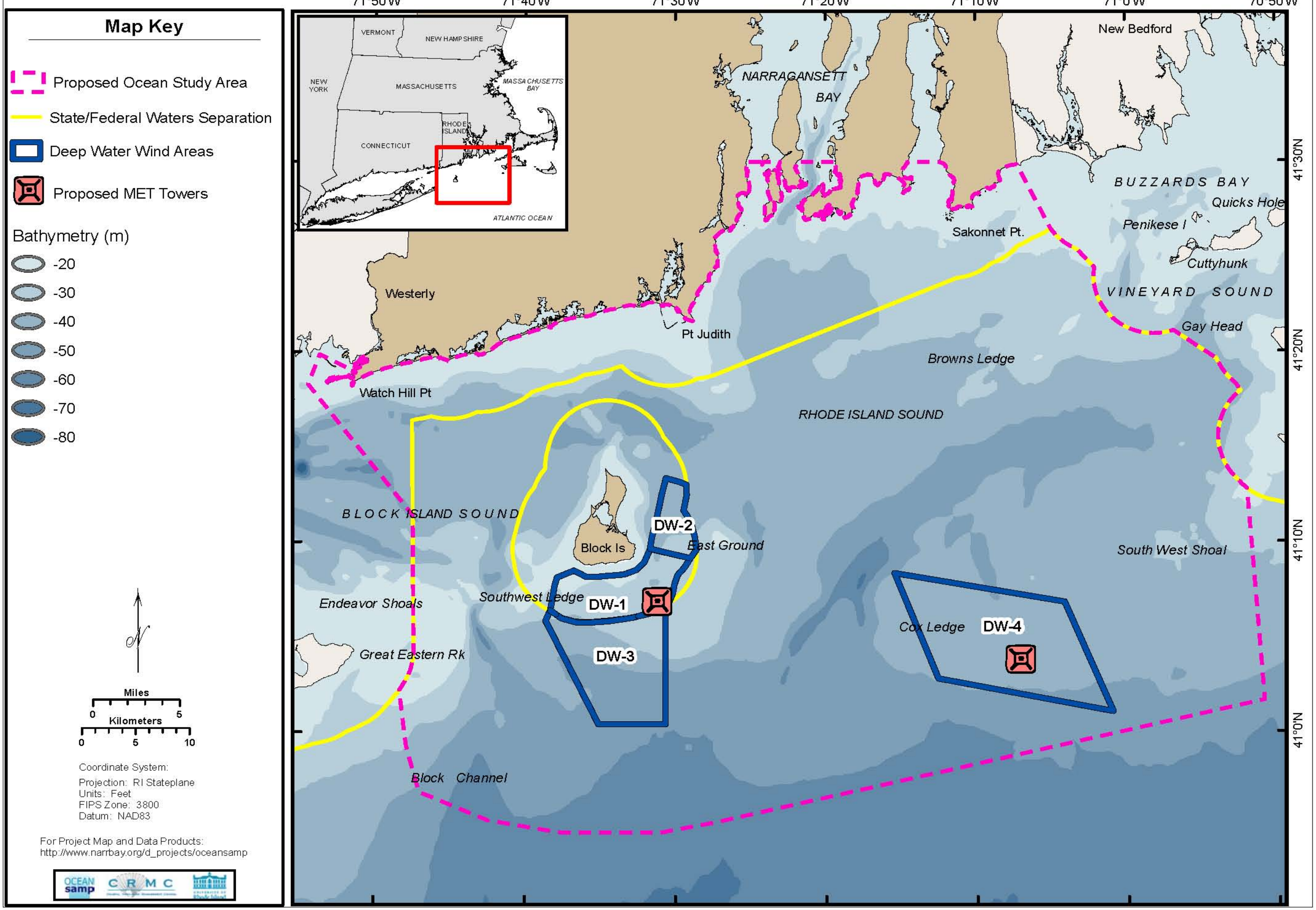




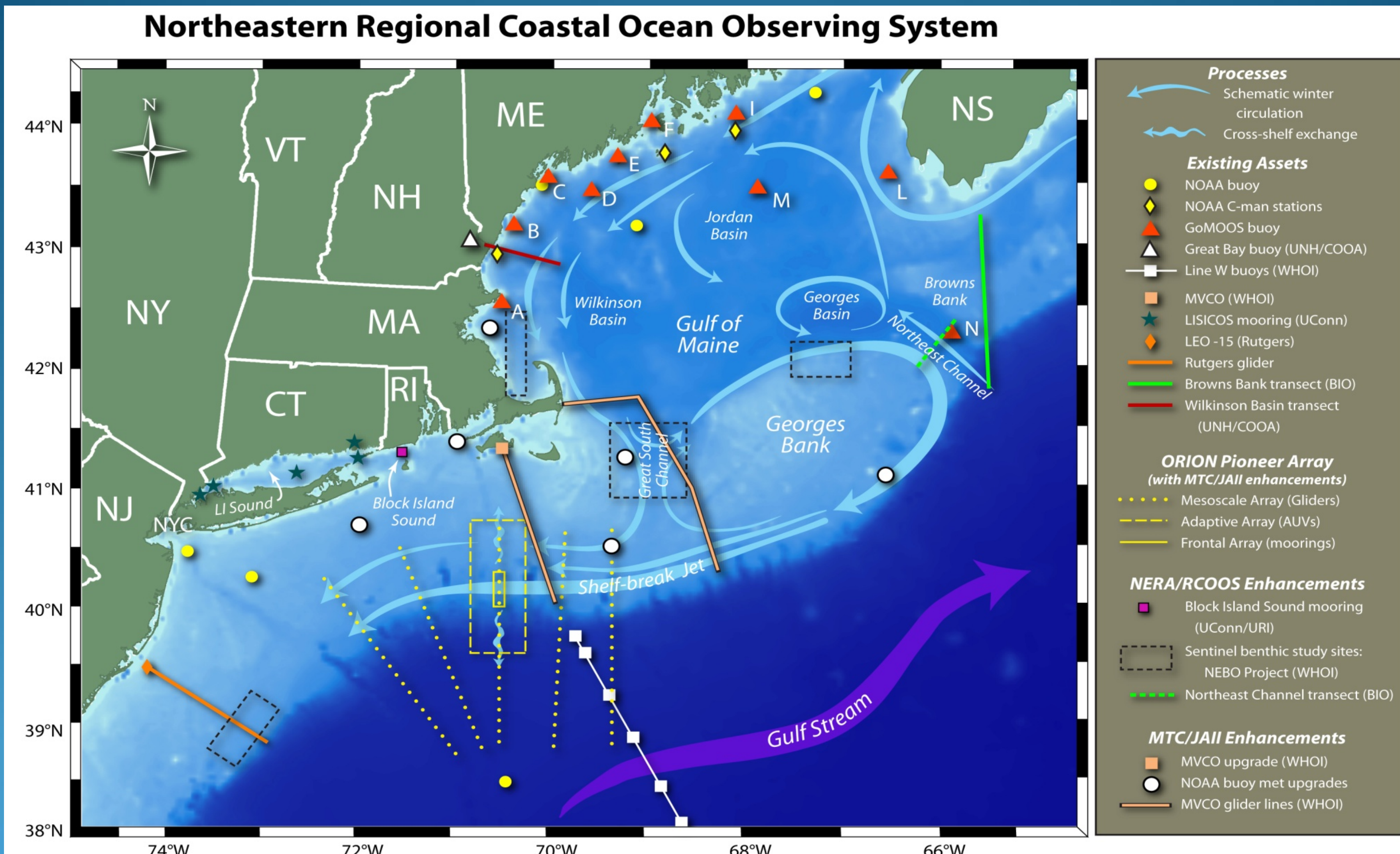


Visualization Series

Rhode Island Ocean Special Area Management Plan (SAMP)



NERACOOS Observation Network



Alternate Strategy Principal Component(PC)-Cluster Analysis(CA)

- Input Variables

  Wind Power

  Water Depth

  Distance to Coast

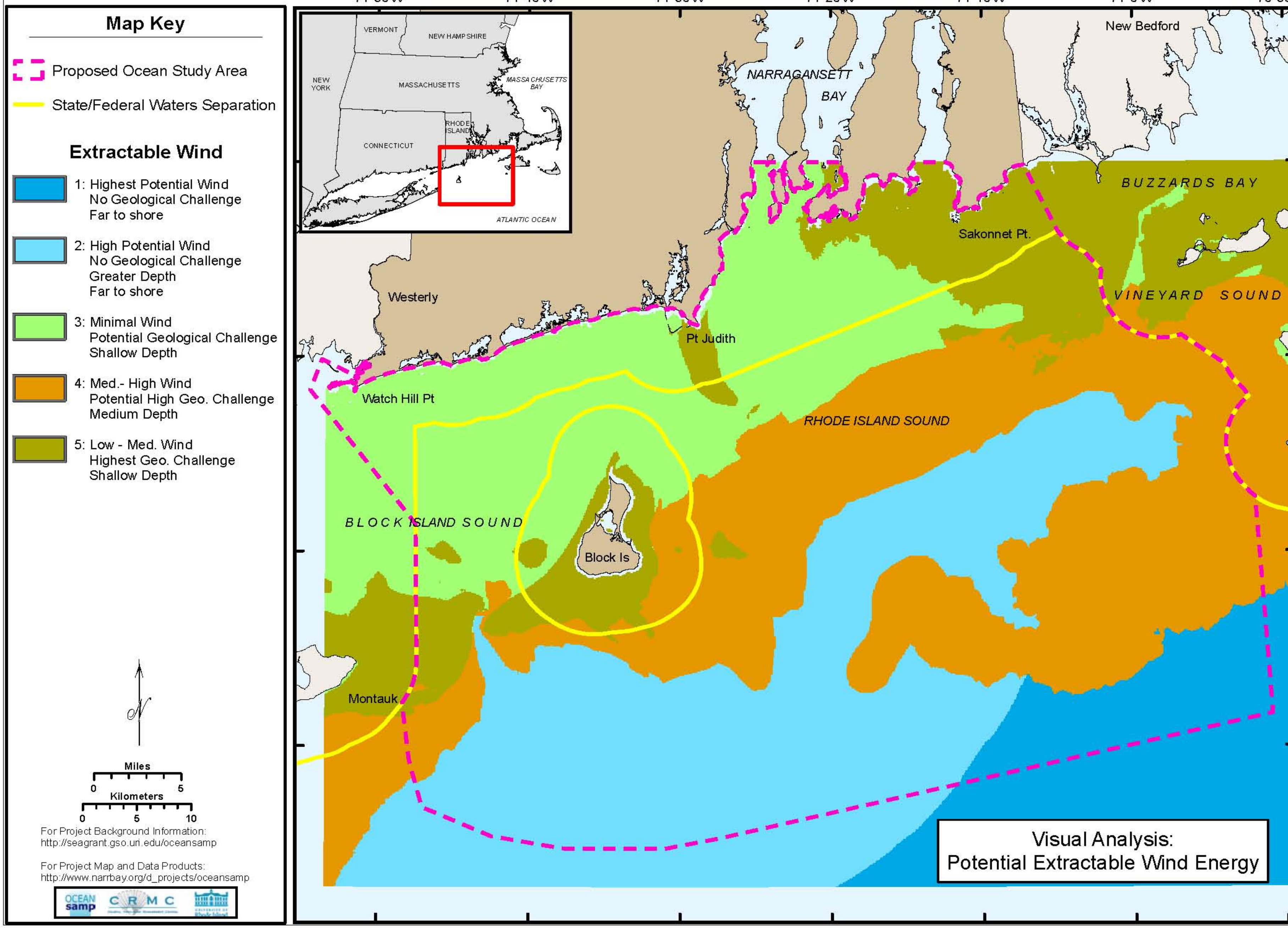
  Geology Type (construction effort)

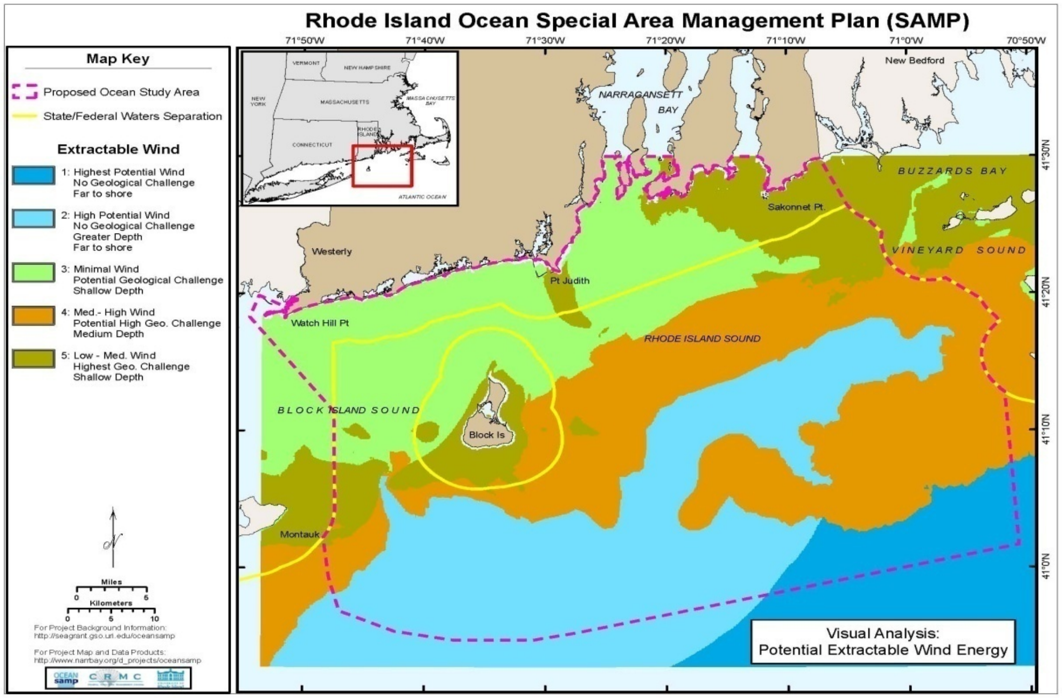
Linear combination of above variables for each 200 m square grid

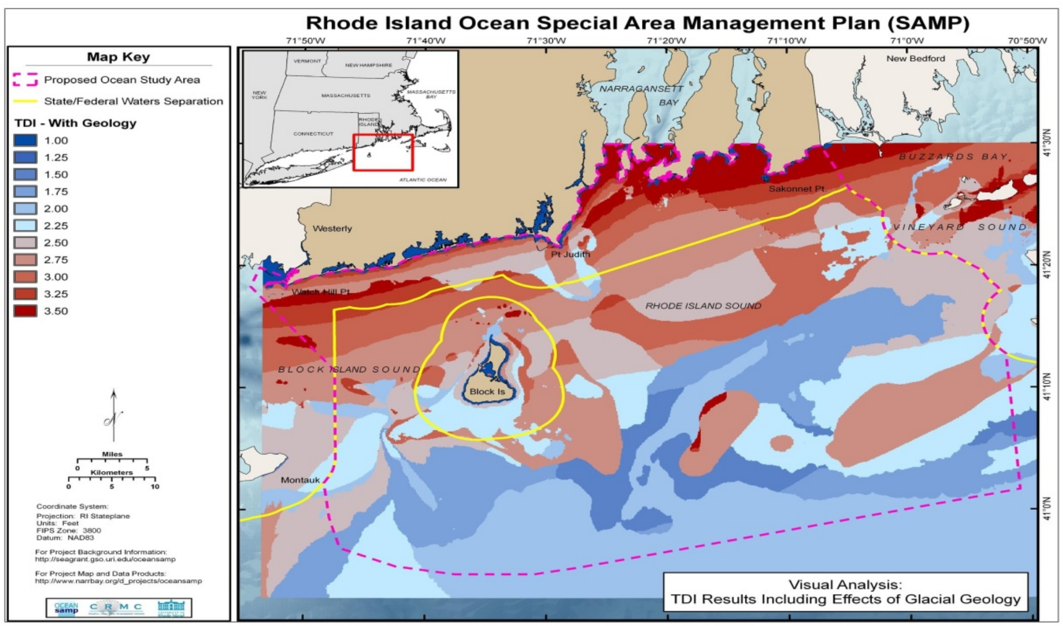
Clusters

	Wind Power	*Depth*	*Distance*	*Geology Challenge*
Cluster 1	Highest	Deep	Far	Low
Cluster 2	High	Mid	Mid	Low
Cluster 3	Lowest	Shallow	Close	Mid
Cluster 4	Mid-High	Mid	Mid	Mid-High
Cluster 5	Mid-Low	Shallow	Close	High

Rhode Island Ocean Special Area Management Plan (SAMP)







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