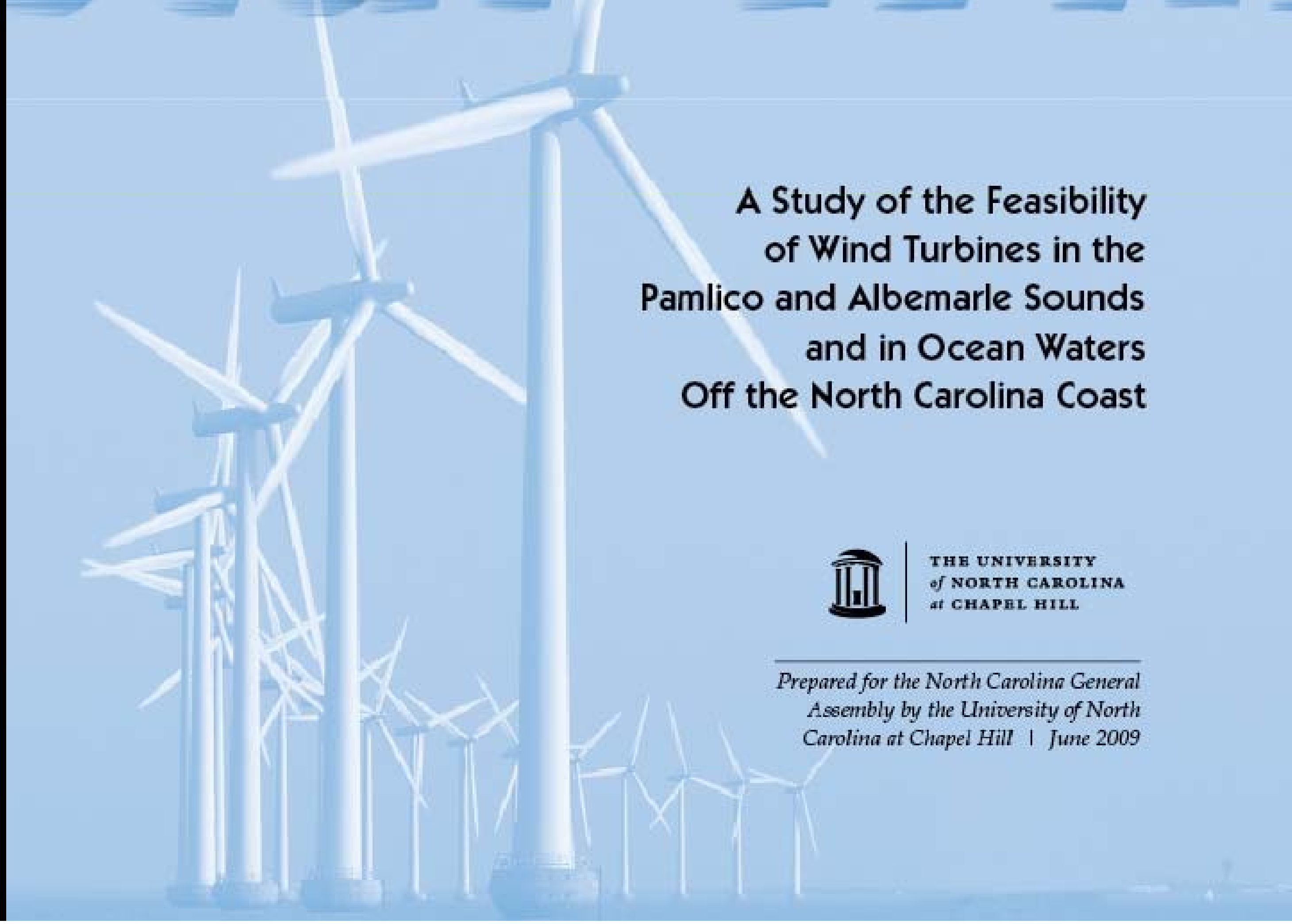


COASTAL WIND

Energy for North Carolina's Future

A Study of the Feasibility
of Wind Turbines in the
Pamlico and Albemarle Sounds
and in Ocean Waters
Off the North Carolina Coast

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

Prepared for the North Carolina General Assembly by the University of North Carolina at Chapel Hill | June 2009

Coastal Wind Energy Study

- Requested by the North Carolina General Assembly
- University of North Carolina at Chapel Hill designated to conduct the study
- Study area
  - Pamlico and Albemarle Sounds
  - Offshore over waters less than 30 meters in depth (wind assessment to 50 meters in depth)

Coastal Wind Energy Study

Study Components

- Wind resource evaluation
- Ecological impacts, synergies, use conflicts
- Foundation concepts
- Geologic framework
- Utility transmission infrastructure
- Utility-related statutory and regulatory barriers
- Legal framework, issues, and policy concerns
- Carbon reduction
- Preliminary economic analysis

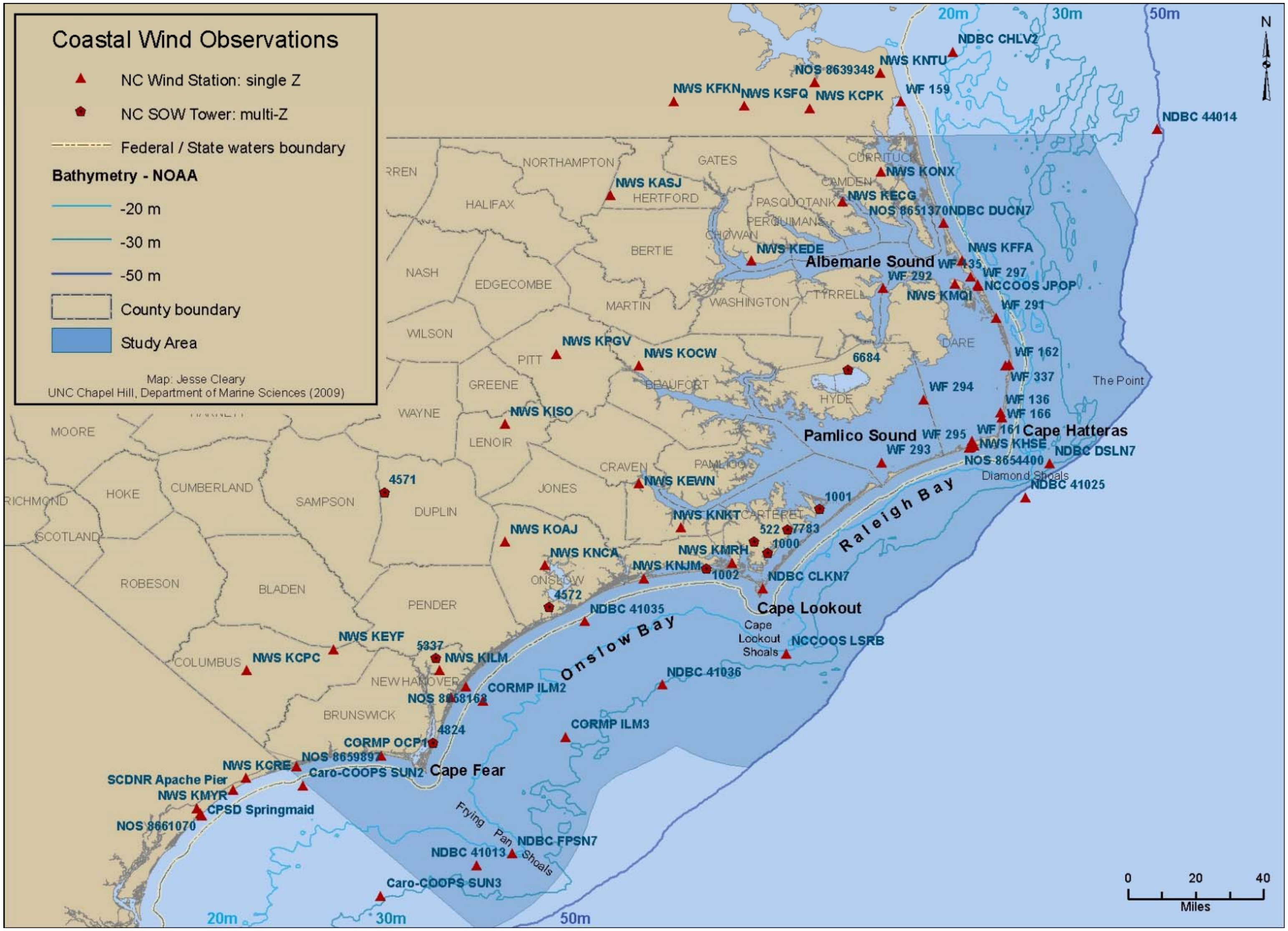
Presentation includes summaries of each component

Wind Resource Evaluation

H. Seim (Marine Sciences, UNC Chapel Hill)
G. Lackmann (RENCI, NC State)

- Compare existing wind power estimates from AWS Truewind with available low-level (largely 10 meter) wind observations
- Extrapolate low level winds to height – use NC SOW meteorological tower data to examine power-law and log layer fits
- Collect new observations with a sodar wind profiler
- Initiate archive and evaluation of regional wind models being run by NC Climatology Office and RENCI

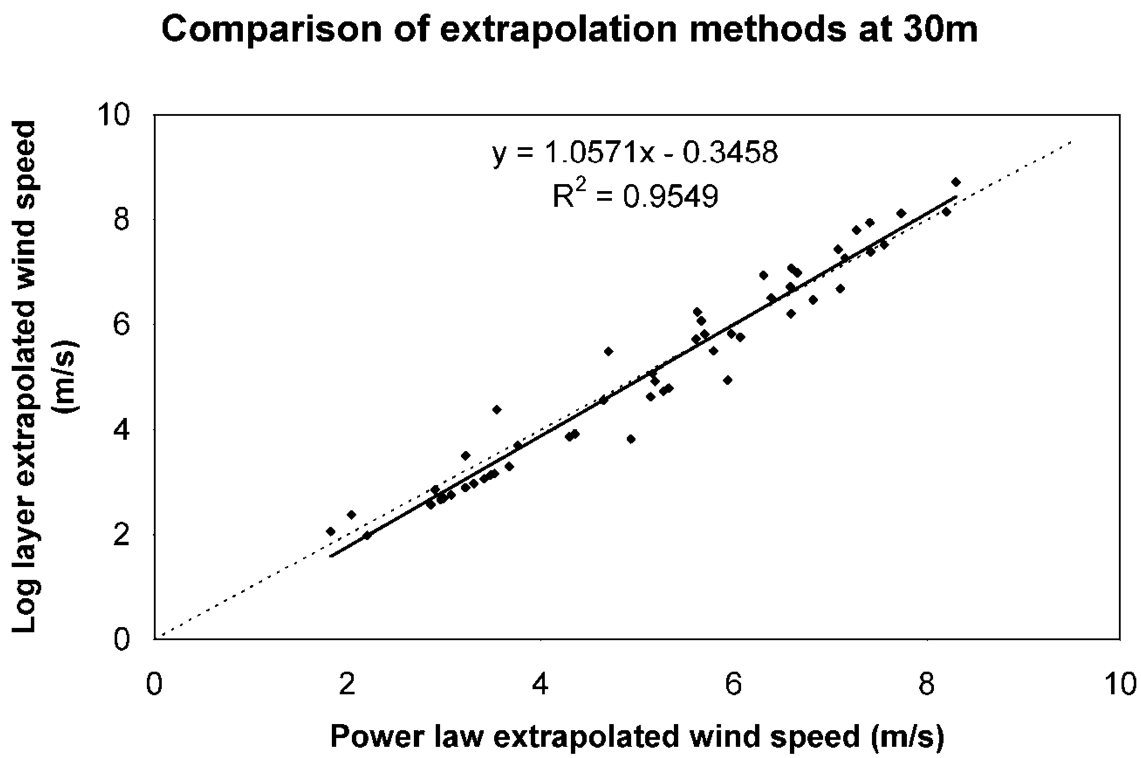
Observations Used in the Study



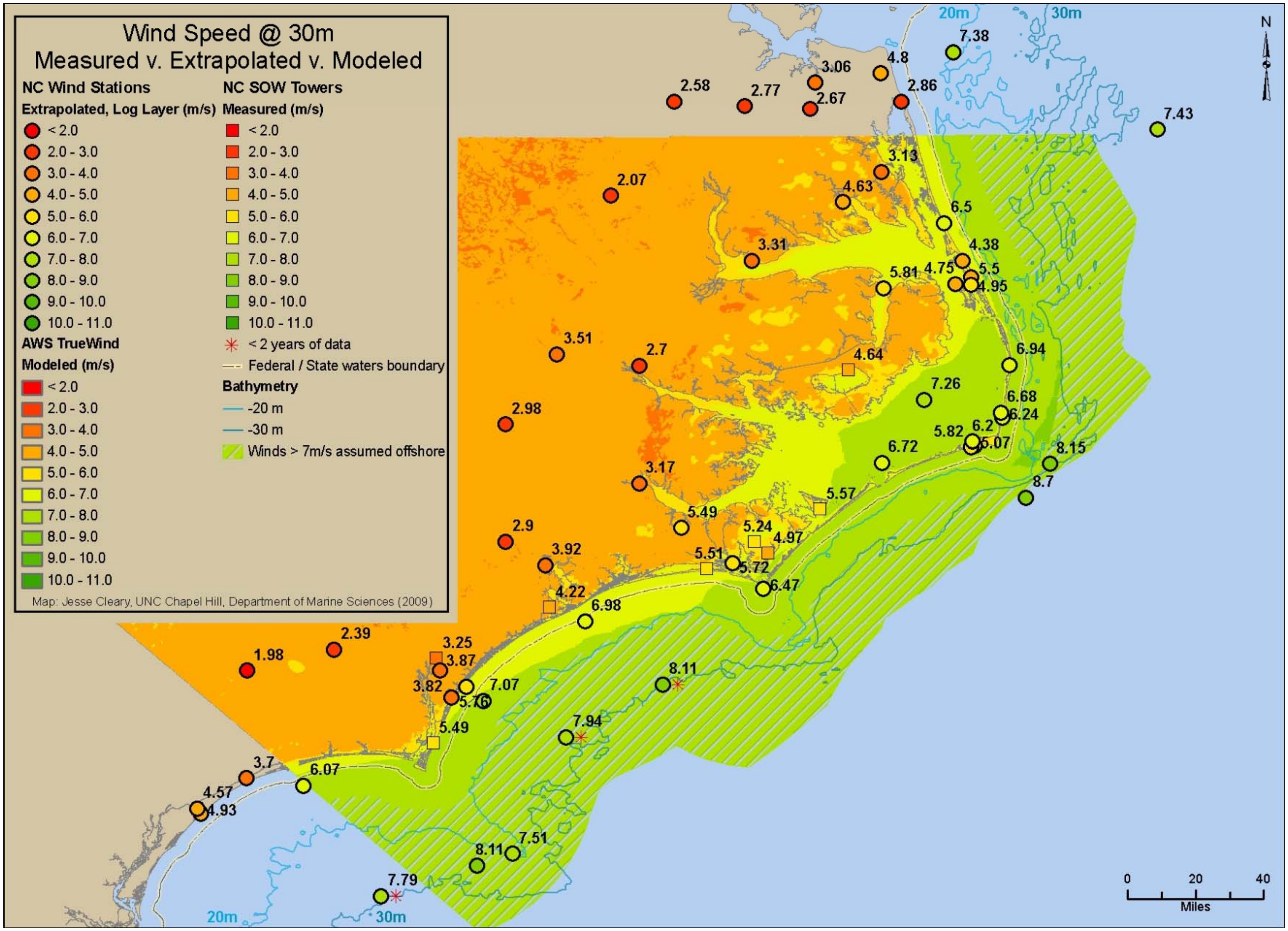
Vertical Extrapolation

- Extrapolation required to estimate winds at turbine height
- Must account for varying roughness of lower boundary. Used two simple techniques – log layer and power law fits
- Assess validity of extrapolation techniques using existing vertical wind profile observations

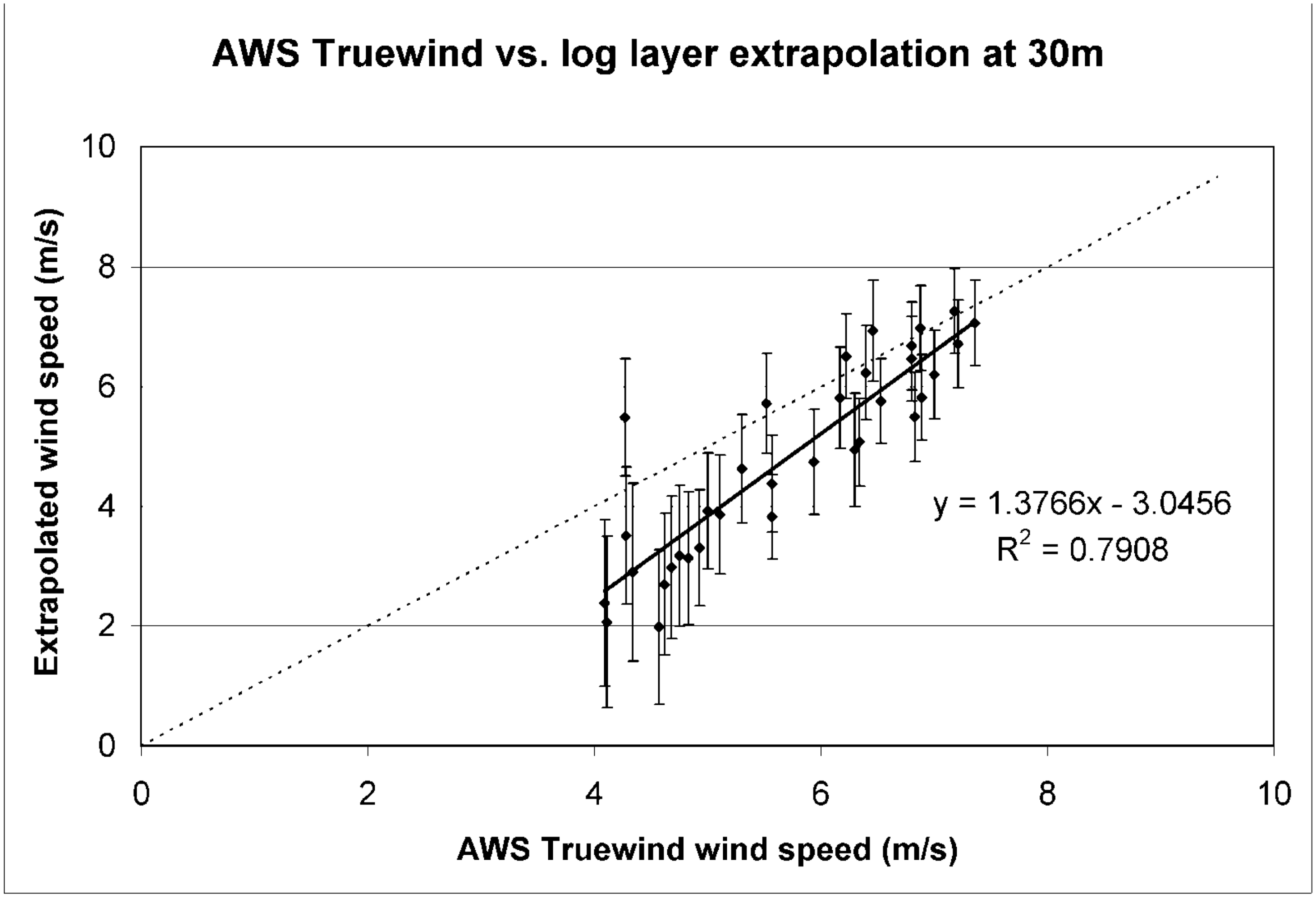
Power-law vs log layer extrapolation



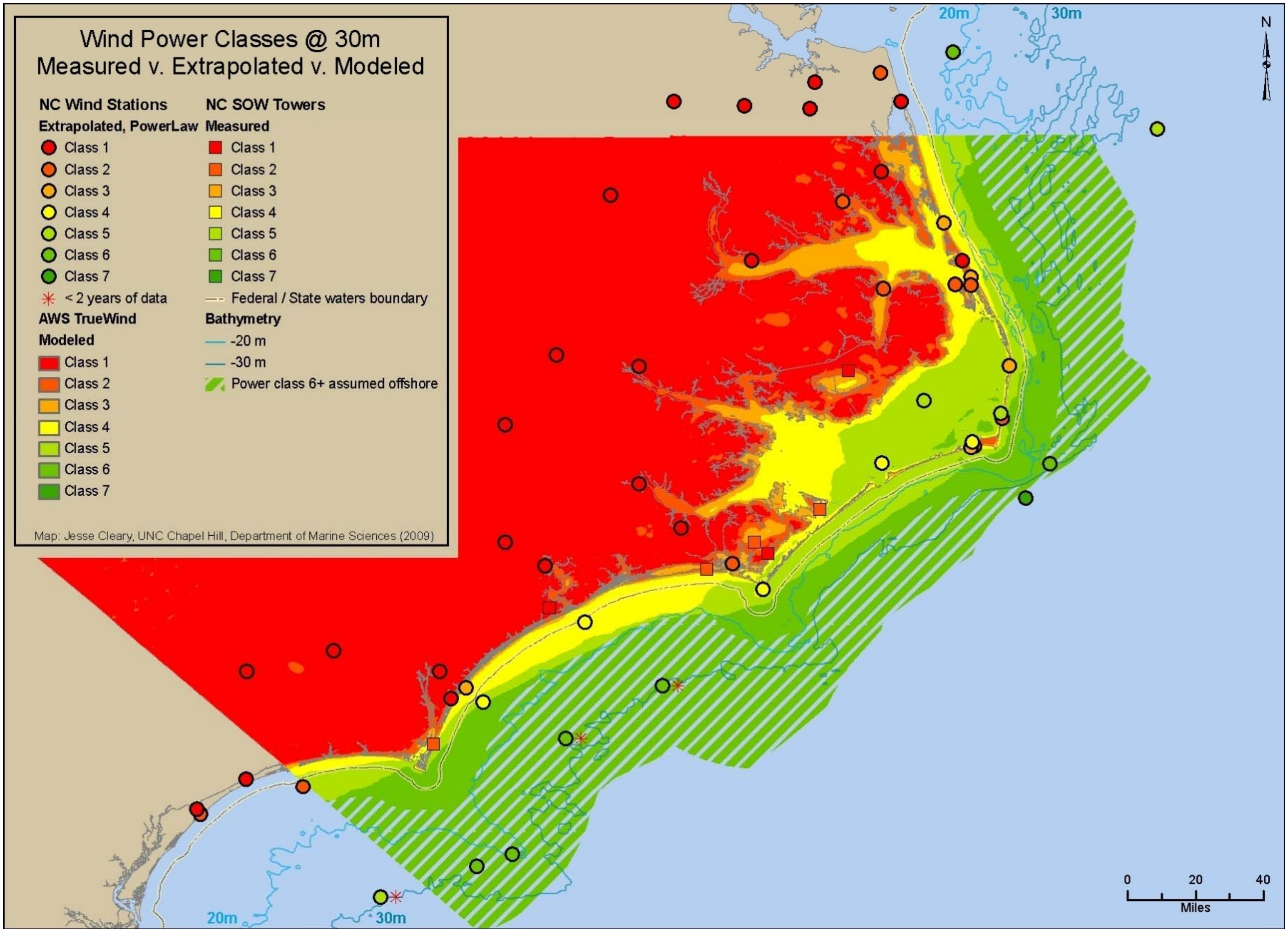
Log-layer to AWS Truewind Comparison



Log-layer to AWS Truewind Comparison



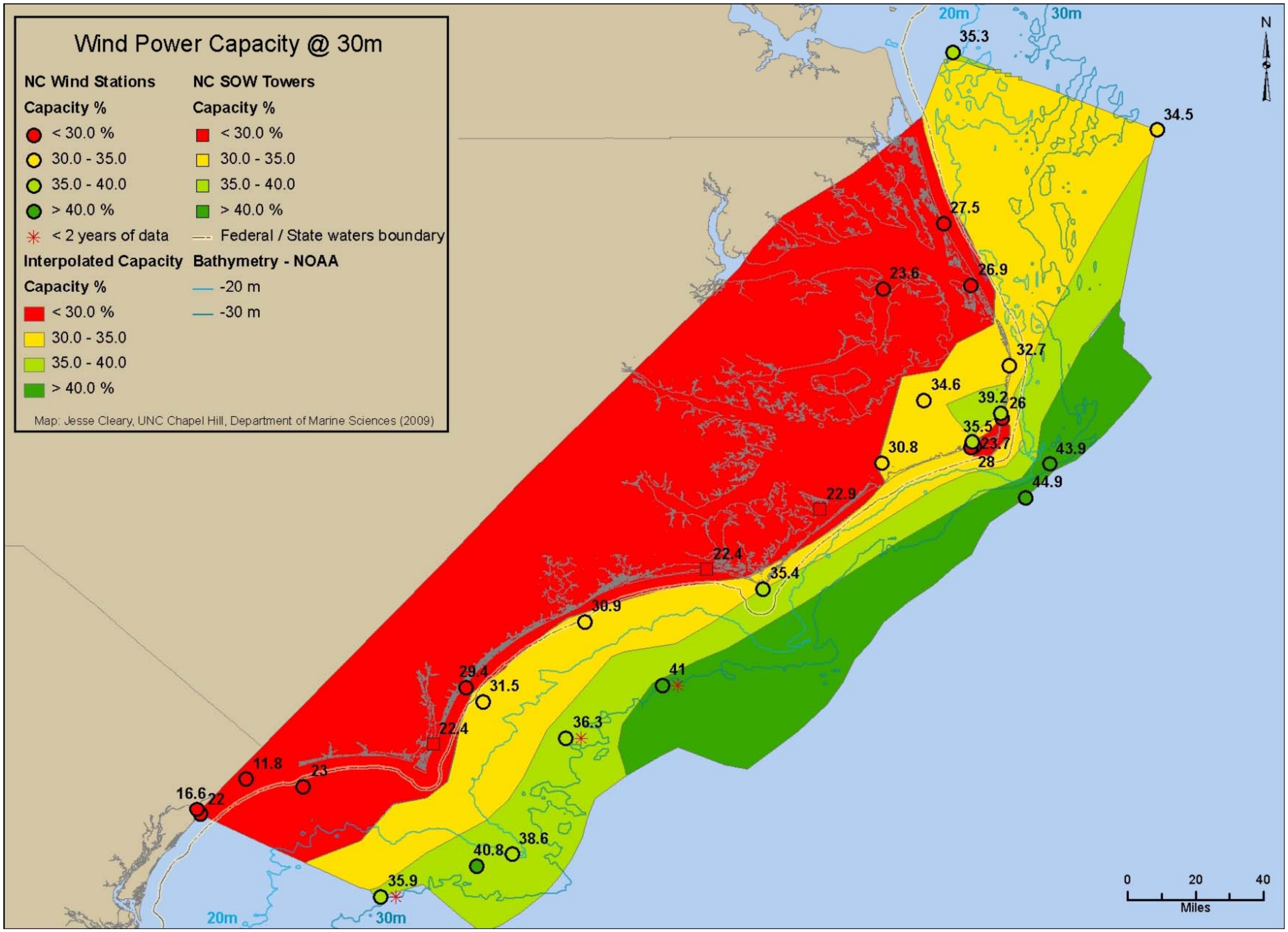
Wind Power Class



Capacity Factor

- Power generation is dependent on the generator used
- Simple but realistic approach is to use power curve for common wind turbine to convert wind speed to power
- Power curves for 3-3.6 MW turbines all similar – kick-in speed of 3-5 m/s, rated power at 15 m/s, no output above 25 m/s.
- Capacity factor is simply the average output from a generator divided by its maximum output, expressed as a percentage.
- Used measured over-water wind records to estimate capacity factor

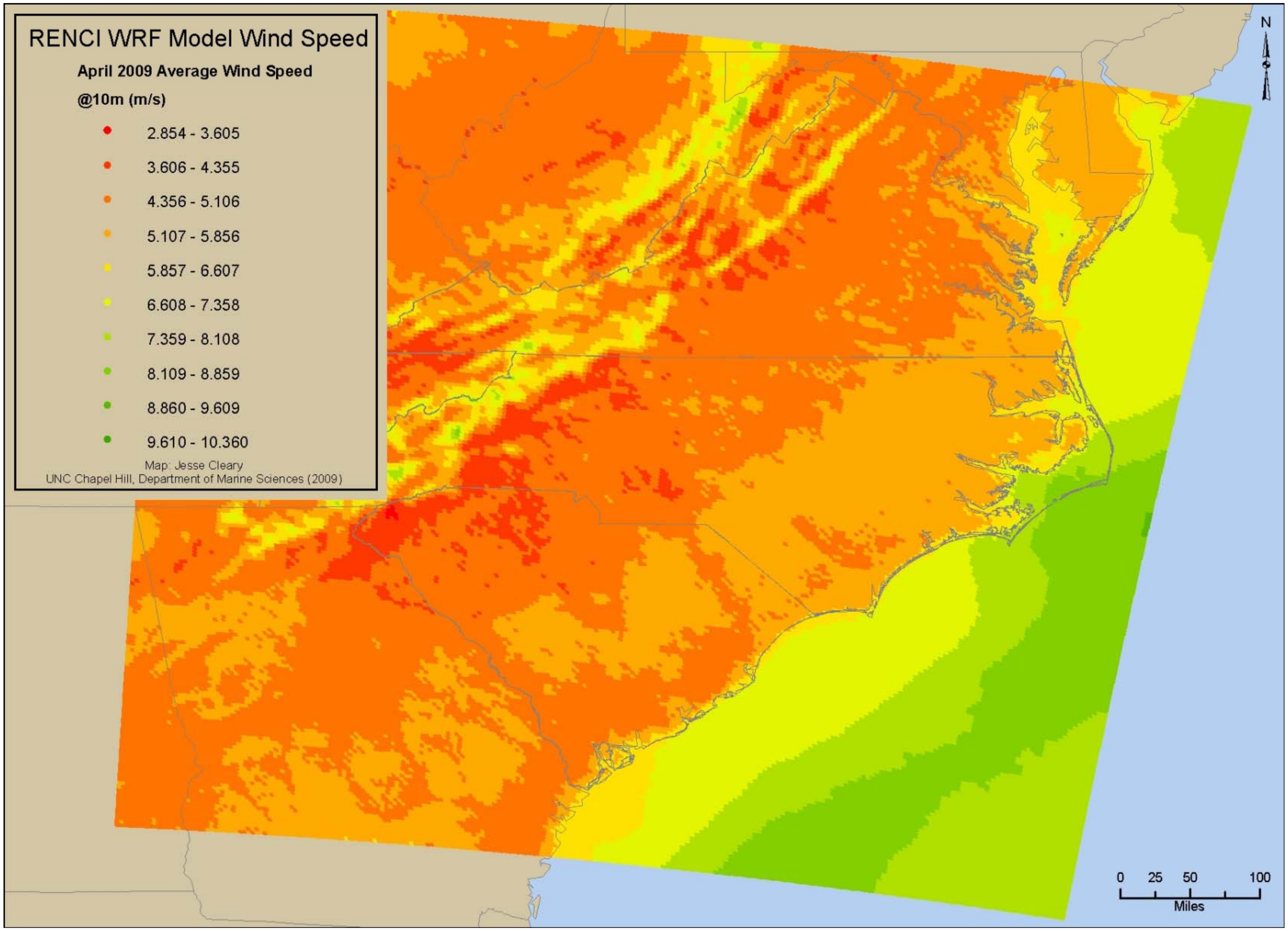
Capacity Factor Map



RENCI 4-km Operational WRF Model Forecasts

- Daily average winds computed as average of 24 hourly values
- Computed monthly averages
- Missing data: Computing facility down in fall 2008 limits valid monthly averages to 2009
- Have sufficient vertical information (stability, wind at different levels) for accurate interpolation to any level
- Utility: (i) cross-check other wind maps, (ii) explore feasibility of high-resolution wind predictions (could go to 1 km grid or smaller)

Example model winds – April '09

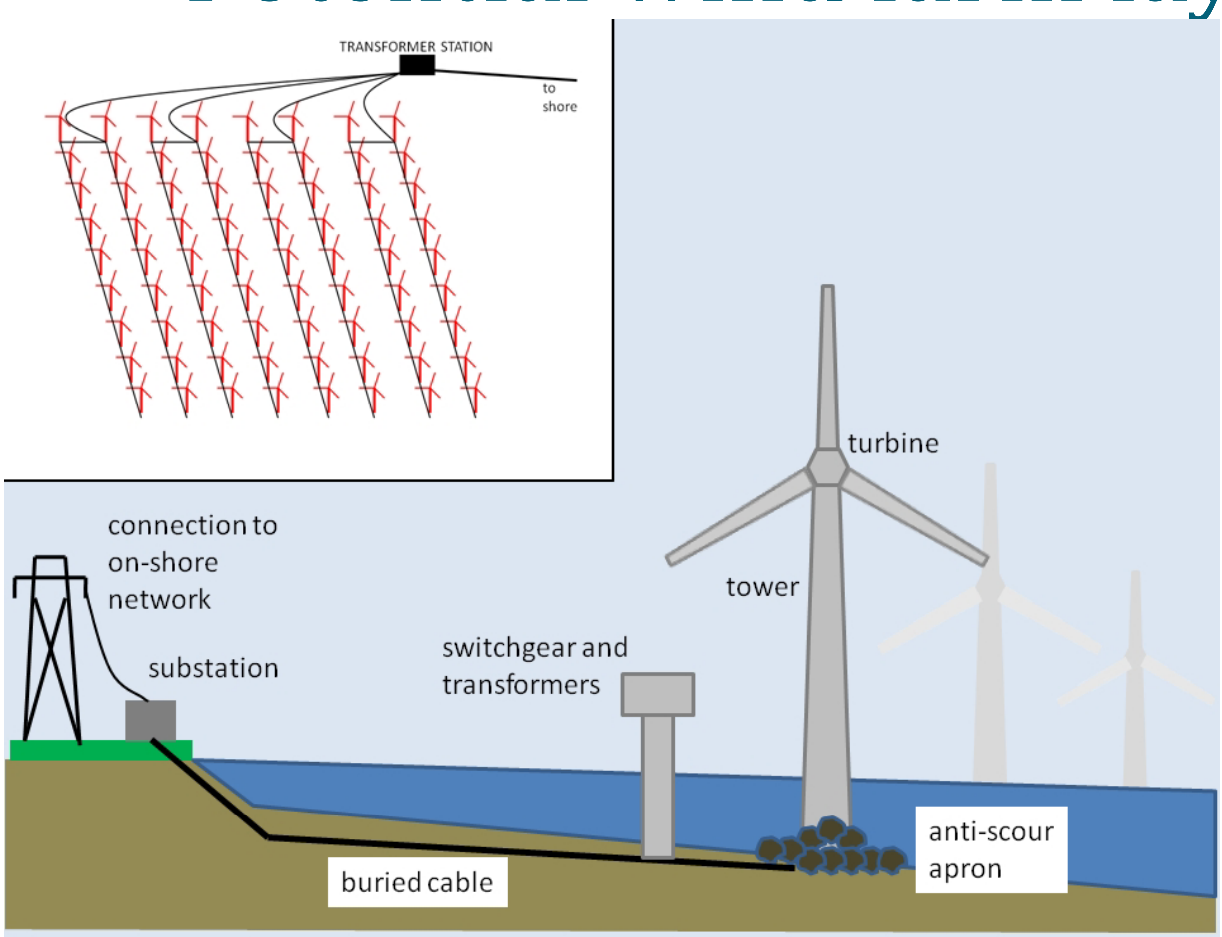


Ecological impacts, synergies, use conflicts

C. Peterson (Marine Sciences, UNC Chapel Hill)
S. Fegley (Marine Sciences, UNC Chapel Hill)
Joan Meiners (Marine Sciences, UNC Chapel Hill)

- Mortality risks to birds and bats from direct contact with rotors and vortices
- Conflicts with commercial fishing and recreation
- Risks to marine mammals, sea turtles, fish, and bottom-dwelling invertebrates and key habitats
- Synergies with other ecosystem services
- Conflicts with military, sand mining, and cultural (including NPS viewscapes and shipwrecks) uses

Potential wind farm layout



Dimensions:

1) ~700 m between wind mills*
2) MMS leases are 3 mi by 3 mi
3) 49 mills per lease

* The space between wind mills is a function of wind mill size, larger mills need more space (between mill distance = 7.6 x rotor diameter). The numbers presented here are for mills with 90 m rotors.

The consequences of bringing the power produced by wind mills to land (laying of cables, construction of substations, etc.) need to be considered. Avoiding critical habitats and mitigating unavoidable SAV and wetland injury will be required. Any additional land-based transmission towers and lines also increase risk to birds.

Procedure for estimating risk

Interview experts, managers, bird watchers, fishermen, and duck hunters:
- 54 in-person interviews
- 5 phone interviews

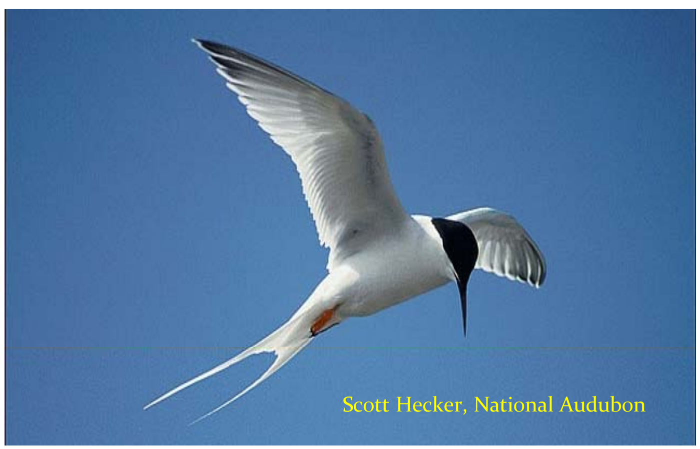
Review relevant literature:
- 21 environmental assessments
- 21 government reports
- 40 peer-reviewed articles
- 14 unpublished manuscripts

Accumulate and organize pertinent information:
- distributions and temporal patterns of organisms
- possible presence of endangered, threatened, or species of concern
- specific behavioral responses to structures, noises, and visual cues
- distribution of fishery habitat and fishing activities

Estimation of risk:
- examine accumulated information for patterns and specific concerns
- use general ecological data and paradigms to reduce uncertainty
- consult with experts again on preliminary assessments

Bird and Bat Risk Distribution

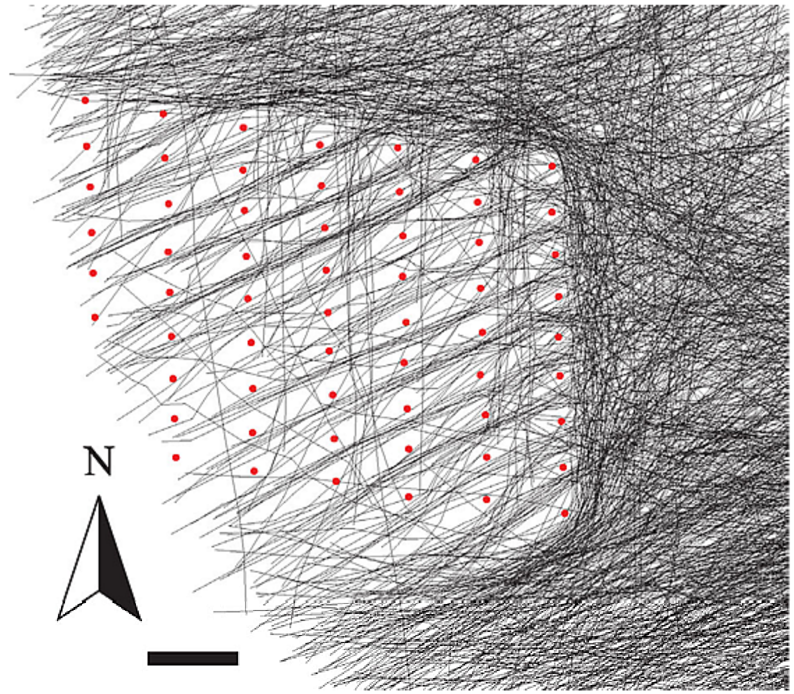
- Risk assessment – combines abundance and behavior
  - Mortality risk from encounter with blades
  - Turbine avoidance can also reduce fitness by loss of foraging habitat or by inducing longer flight paths (especially for migrating shorebirds and ducks)


Scott Hecker, National Audubon


Al Perry

Behavioral responses (an example)

Aerial photograph of a flock (a "raft") of 20,000 common eiders – photograph by Simon Perkins, Mass Audubon



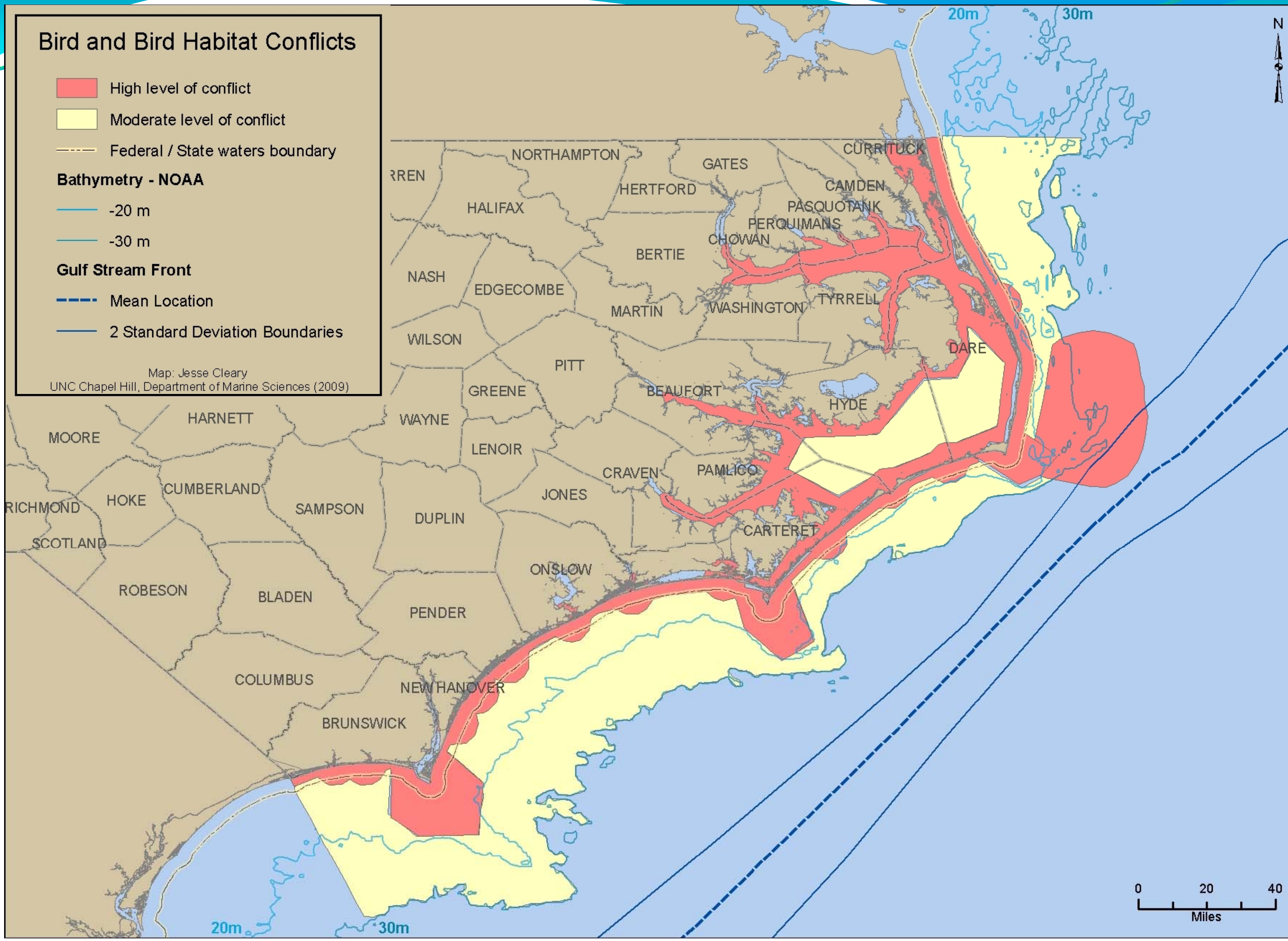
Compilation of radar tracks for common eiders and geese flying near and through an offshore, Danish wind mill farm (individual mills are represented by red dots – Desholm and Kahlert 2005). These results are controversial; the wind mills interfere with the radar used to document flight paths.

Bird and Bat Risk Distribution

- Birds at risk
  - Passerines (songbirds) during their nocturnal, seasonal migrations
  - Threatened and Endangered, plus declining, species (piping plover, red knot, other migrating shorebird species, and roseate tern) during fall/spring migrations and summer/winter residence
  - Large-bodied, low-flying, slow fliers (pelicans, gulls)
  - True pelagic seabirds (albatross) – Gulf Stream risks
- Bats at risk – migrating insectivorous species

Measures to Reduce Risk to Birds and Bats

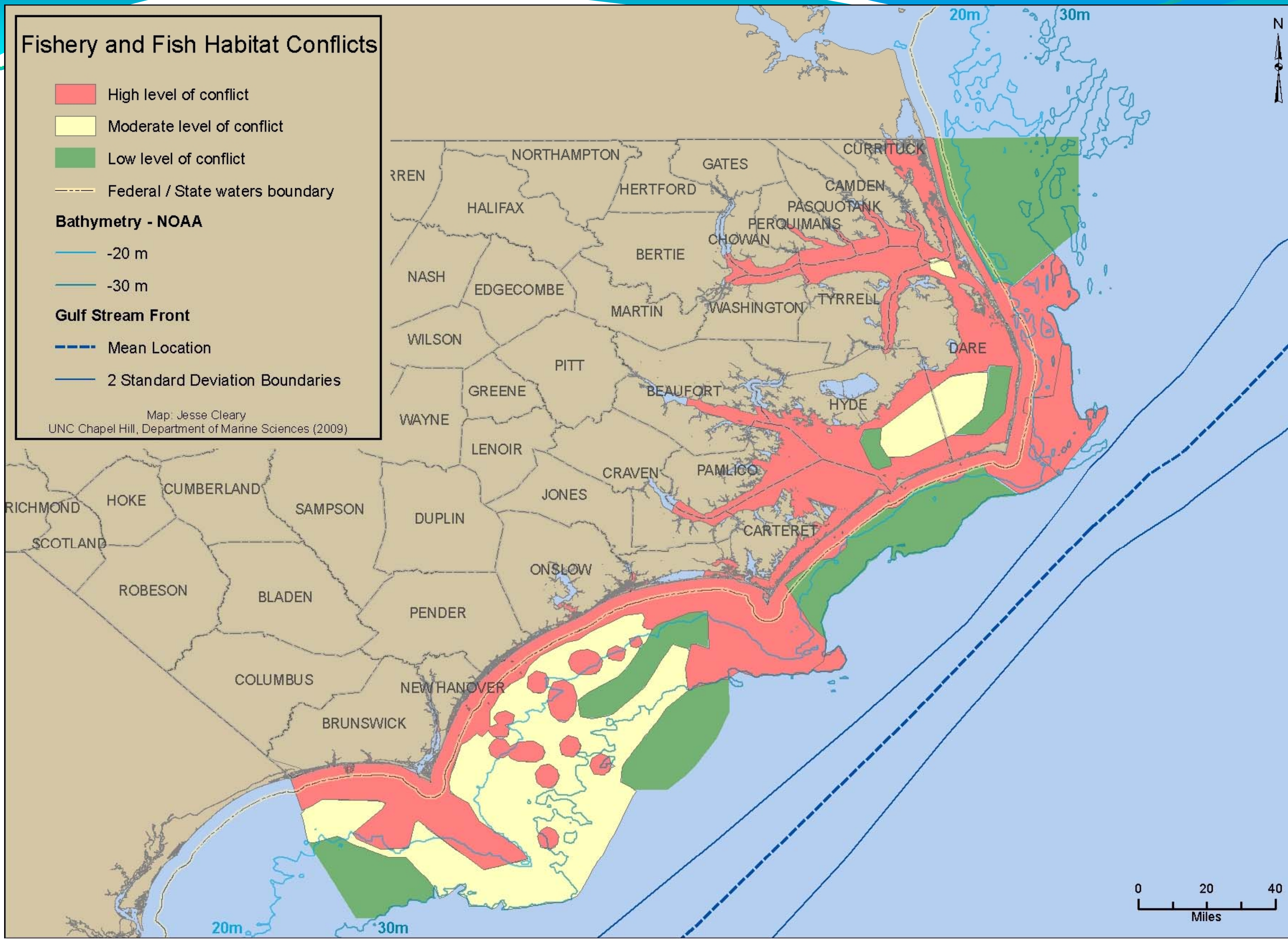
- Do not use continuous lighting
  - Flashing lights attract fewer migrating birds
  - Red lights may be less attractive than white lights
- Reduce or eliminate perches
  - The absence of perches, nesting, and roosting sites decreases the frequency birds and bats closely approach wind mills
- Avoid white colors. Paint wind mill vanes in high contrast patterns.
  - White attracts insects; increased insect abundances attracts bats
  - Tests show that kestrels avoid moving wind mill vanes more readily if they have patterns painted on them
- Pilot studies and impact studies after installation and operation of the first wind farm will demonstrate whether other mitigation procedures are needed



Bird and Bird Habitat Conflicts
High level of conflict
Moderate level of conflict
Federal / State waters boundary
Bathymetry - NOAA
-20 m
-30 m
Gulf Stream Front
Mean Location
2 Standard Deviation Boundaries
Map: Jesse Cleary
UNC Chapel Hill, Department of Marine Sciences (2009)
20m
30m
N
NORTHAMPTON
GATES
CURRITUCK
CAMDEN
HERTFORD
PASQUOTANK
PERQUIMANS
CHOWAN
HALIFAX
BERTIE
NASH
EDGECOMBE
MARTIN
WASHINGTON
TYRRELL
WILSON
PITT
DARE
GREENE
BEAUFORT
HYDE
HARNETT
WAYNE
MOORE
LENOIR
CRAVEN
PAMLICO
CUMBERLAND
JONES
RICHMOND
HOKE
SAMPSON
DUPLIN
SCOTLAND
CARTERET
ONSLOW
ROBESON
BLADEN
PENDER
COLUMBUS
NEW HANOVER
BRUNSWICK
0
20
40
Miles

Critical Fish Habitats and Fishing Uses

- Primary, secondary nurseries, migration paths, strategic habitats, submerged aquatic vegetation, shell bottom, oyster reefs (sounds), and live reefs (ocean)
- Larval fish and blue crab migration corridors (may require seasonal constraint on construction window)
- Intense fishing uses
  - Trawling limited by wind farm presence and made more dangerous (shrimp, crabs, flounder)
  - Dredging incompatible within wind farms (scallops, oysters)
  - Long hauling incompatible within wind farms (various fishes)
- High productivity regions
  - Gulf Stream, three Capes, all inlets, the "Point"
  - All inlets with 5 mile radius from center point



Fishery and Fish Habitat Conflicts
High level of conflict
Moderate level of conflict
Low level of conflict
Federal / State waters boundary
Bathymetry - NOAA
-20 m
-30 m
Gulf Stream Front
Mean Location
2 Standard Deviation Boundaries
Map: Jesse Cleary
UNC Chapel Hill, Department of Marine Sciences (2009)
NORTHAMPTON
GATES
CURRITUCK
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HERTFORD
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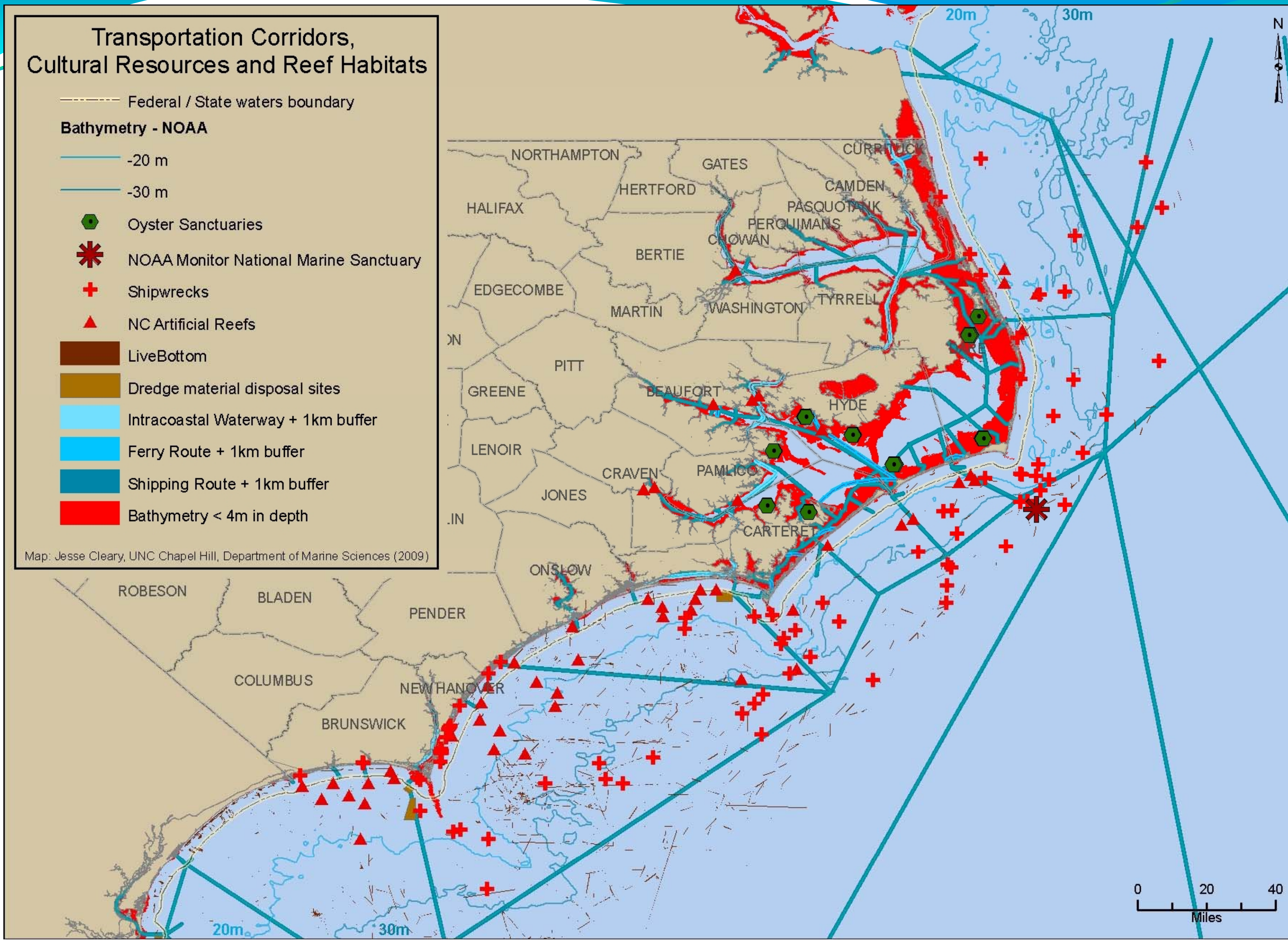
COLUMBUS
NEW HANOVER
BRUNSWICK
20m
30m
N
0
20
40
Miles

Navigation Corridors, Cultural Resources, Reef Habitats

- All marked navigation channels (ferries, shipping, Intracoastal Waterway)-1 km buffer on each side
- Shipwrecks, including Monitor National Marine Sanctuary
- Artificial reefs, live bottom, and oyster sanctuaries
- Viewscapes of National Seashores (NPS), especially National Heritage sites (eg, lighthouses)
- Dumping grounds


Transportation Corridors,
Cultural Resources and Reef Habitats
Federal / State waters boundary
Bathymetry - NOAA
-20 m
-30 m
Oyster Sanctuaries
NOAA Monitor National Marine Sanctuary
Shipwrecks
NC Artificial Reefs
LiveBottom
Dredge material disposal sites
Intracoastal Waterway + 1km buffer
Ferry Route + 1km buffer
Shipping Route + 1km buffer
Bathymetry < 4m in depth
Map: Jesse Cleary, UNC Chapel Hill, Department of Marine Sciences (2009)
NORTHAMPTON
GATES
CURRITUCK
HERTFORD
CAMDEN
HALIFAX
PASQUOTANK
PERQUIMANS
CHOWAN
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COLUMBUS
NEW HANOVER
BRUNSWICK
20m
30m
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20
40
Miles

Sea Turtles and Marine Mammals

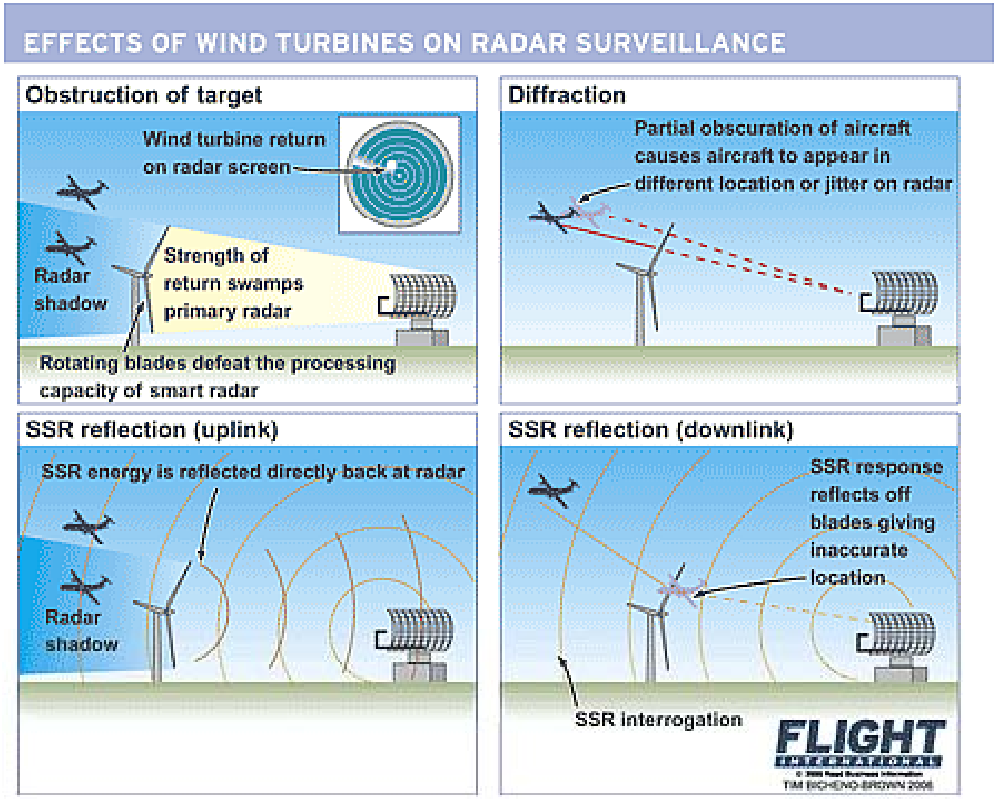
- Protected under Endangered Species Act and/or Marine Mammal Protection Act
- Risk during installation – noise and injury from bottom disturbance
  - Right and humpback whales – winter in ocean
  - Loggerhead, Kemp's Ridley, green – summer/fall in ocean and sound
  - Bottle-nosed dolphin – all year in ocean and sound
  - Manatee – summer/fall in sound
- Risk during operation – noise and electromagnetic fields – unknown and area of current research interest

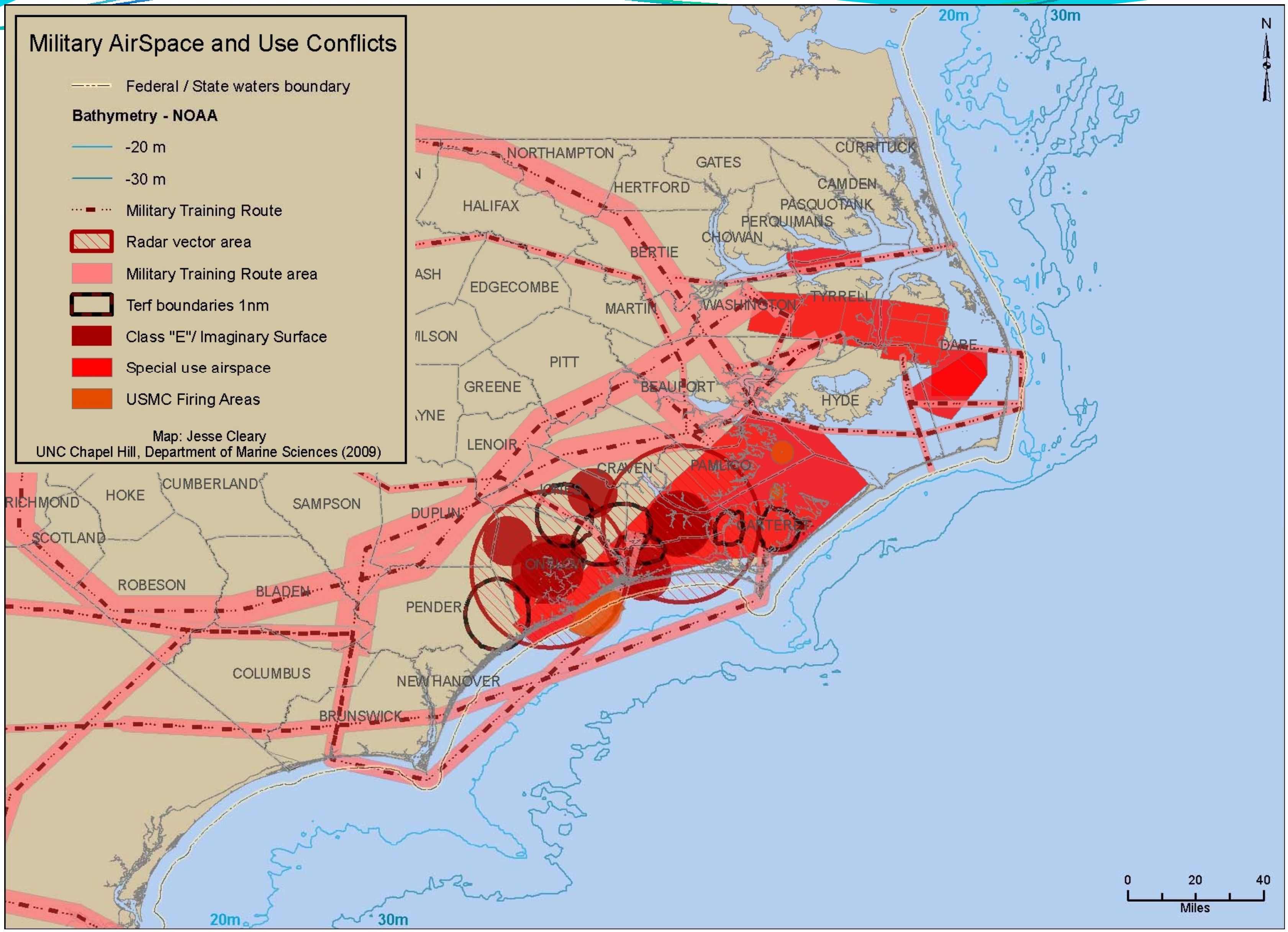
Military Conflicts

- Special use airspace
- Training routes
- Radar vector areas
- USMC firing ranges

Military Use Exclusions

- Marine Corps
  - Air space conflicts with tall structures
  - Interference with radar
  - Amphibious training and live fire
- Navy
  - Oceana air space and radar conflicts
- Army (US Army Corps of Engineers–Duck)




Military AirSpace and Use Conflicts
Federal / State waters boundary
Bathymetry - NOAA
-20 m
-30 m
Military Training Route
Radar vector area
Military Training Route area
Terf boundaries 1nm
Class "E"/ Imaginary Surface
Special use airspace
USMC Firing Areas
Map: Jesse Cleary
UNC Chapel Hill, Department of Marine Sciences (2009)
NORTHAMPTON
GATES
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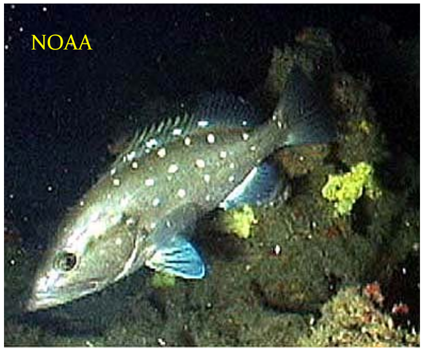
COLUMBUS
NEW HANOVER
BRUNSWICK
20m
30m
N
0
20
40
Miles

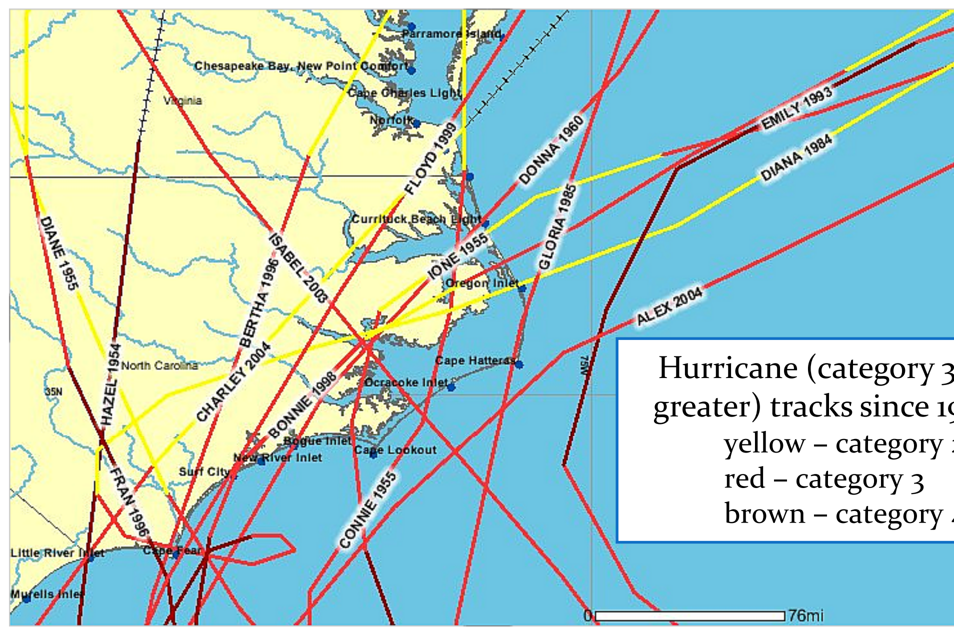
Synergies – Positive Interactions

- A stone, scour apron surrounds the monopile base (12-m radius with stones rising 2-3 m above bottom)
  - Excellent foundation for artificial oyster reef in Pamlico Sound (Albemarle Sound is now too fresh for oysters) – restores oysters and their ecosystem services
  - Excellent foundation for live-bottom reef in coastal ocean
    - Restores reef fish, including aiding recovery of overfished snapper/grouper species complex
    - Requires excluding fishermen to avoid overexploitation
    - The apron and monopile may also serve as substrate for blue mussels north of Cape Hatteras. These would provide food for scoters and could be harvested.
- Wind farms may induce upwelling downstream
  - In the sounds this could mitigate seasonal hypoxia and anoxia events
  - In the coastal ocean this could enhance local primary production



Hurricane Risk

- Wind turbines and foundations engineered to withstand category 3 hurricane
- Hurricane risk in NC is high
- Landfalls and storm tracks of large hurricanes (Category 3, 4, or 5) show that the ocean well north of Cape Hatteras represents a region that receives some protection from the projecting cape to the south



Hurricane (category 3 or greater) tracks since 1950
yellow – category 2
red – category 3
brown – category 4

Means to Reduce Uncertainty about Environmental Impacts and Use Conflicts

- Solicit broader public and agency review and input
- Surveys made before, during, and after installation of either a pilot project or a commercial wind farm should be conducted in a scientifically rigorous way to infer impacts (positive and negative) on birds, fishes, fishing, marine mammals, sea turtles, and viewscapes
- Produce meta-population dynamics models to provide predictions of where wind farms could achieve maximum benefits to depleted snapper and grouper populations
- Siting of wind farms should consider the inevitable shore-side and nearshore habitat alterations that will be required to bring wind-generated power to land.
- If wind turbine technologies or designs different from those considered in our report are planned for use, the possible environmental risks and synergies should be reconsidered

Acknowledgements:

INTERVIEWS -

Tom Bachman, charter boat owner (habitat, fisheries)
Jeremy Braddy, waterman (birds)
Mike Bryant, USFWS(birds, habitats)
Rich Carpenter, NCDMF (fish, fisheries)
James Casey, US Navy (military conflicts)
Mary Clark, NC State Natural History Museum (bats)
David Cobb, NCWRC (birds, fish)
B.J. Copeland, NCMFC (fish, fisheries)
Barry Costa-Pierce, Rhode I. Sea Grant, URI (synergies)
Jack Cox, commercial fisherman (fisheries, habitats)
Louis Daniel, NCDMF (fish, fisheries)
Ann Denton, NCDMF (fish, fisheries)
Wendy Dow, DUML (marine mammals, sea turtles)
NC Ferry crew (anonymous, habitats, fish, transportation, birds)
Bert Frost, US Natl. Park Serv. (conflict maps)
John Fussell III, author (birds)
David Gaskill, waterman (birds, fishing)
Walker Golder, NC Audubon Vice-director (birds)
Tilman Gray, commercial fisherman (fish, fisheries)
Nathan Hall, waterman (birds)
J. Christopher Haney, Defenders of Wildlife (birds)
Craig Hardy, NCDMF (fish, fisheries)
Jess Hawkins, NCMFC (fish, fisheries)
Herb Hendrickson, Professor Emeritus UNCG (birds)
Eileen Hoffman, Old Dominion Univ. (synergies)
Richard W. Lawrence, NC Dept of Cultural Resources (wrecks)
David S. Lee, retired from NC State Natural History Museum (birds)
Mike Marshall, NCDMF (fish, fisheries)
Catherine McClellan, DUML (marine mammals, sea turtles)
Carol McCoy, US Natl. Park Serv. (conflict maps)
Red Munden, NCDMF (birds, fish, fisheries)
Francis O'Beirn, Marine Inst, Galway, Ireland (synergies)
Jeff Oden, commercial fisherman (fish, fisheries)
James Parnell, UNCW (birds)
Brian Patteson, offshore bird and fishing cruise leader (birds, fish)
Willie Phillips, formerly NC Marine Fish. Commission (fish)
David Plummer, USMC (military air space)
Andrew Read, DUML (marine mammals, sea turtles)

INTERVIEWS (continued) –

Steve Ross, UNCW (fish)
Paul Spitzer, Cooperative Oxford Laboratory (birds)
David Taylor, NCDMF (fish, fisheries)
Paul Thompson, Univ. of Aberdeen (marine mammals)
Billy Carl Tillet, commercial fisherman (fish, fisheries)
David Vela, Regional director, SE Region, US Natl. Park Serv. (conflict maps)
Danielle Waples, DUML (marine mammals, sea turtles)
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Mark Wilde-Ramsing, NC Dept of Cultural Resources (wrecks)
Lynne Williams, DUML (marine mammals, sea turtles)
Sara Winslow, NCDMF (fish, fisheries)
Jerry Wright, former Chair of the NC Wildlife Resources Commission (birds)

GATHERING LITERATURE-

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Robert Vogt, IE student, UNC
Steve Wall, NC Dept. of Env. Natural Resources
Brianna Young, IE student, UNC

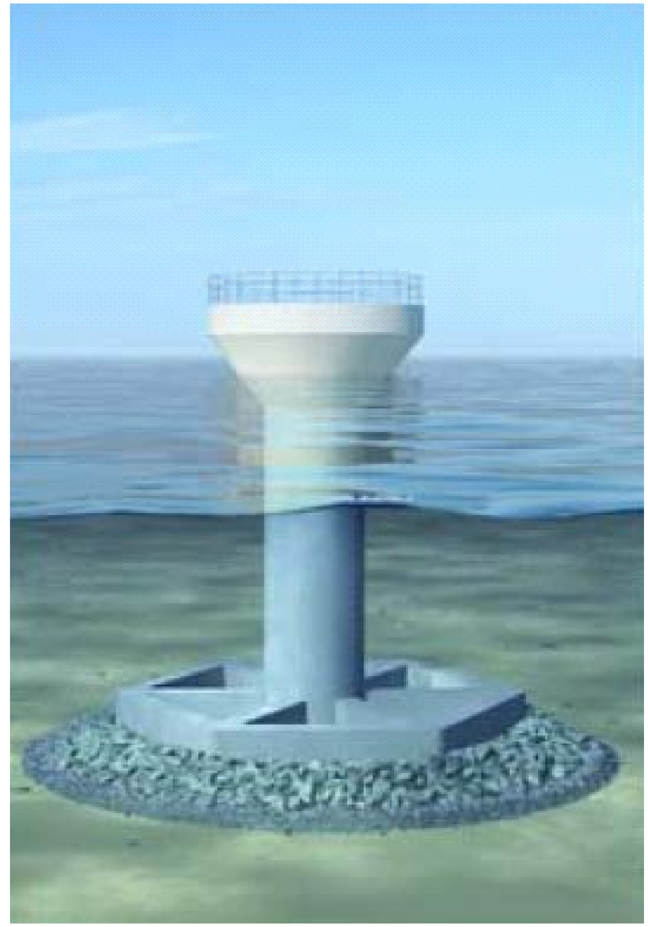
Foundation Concepts

J. Schuett (Affiliated Engineers, Chapel Hill)
S. Petersen (Ramboll Wind, Denmark)
K. Jensen, (Ramboll Wind, Denmark)

- Structural systems
- Appropriateness for sound and coastal ocean bottom geology

Foundation Alternatives

Monopile foundation with transition piece and scour protection. Flange height above sea level approximately 20 meters.

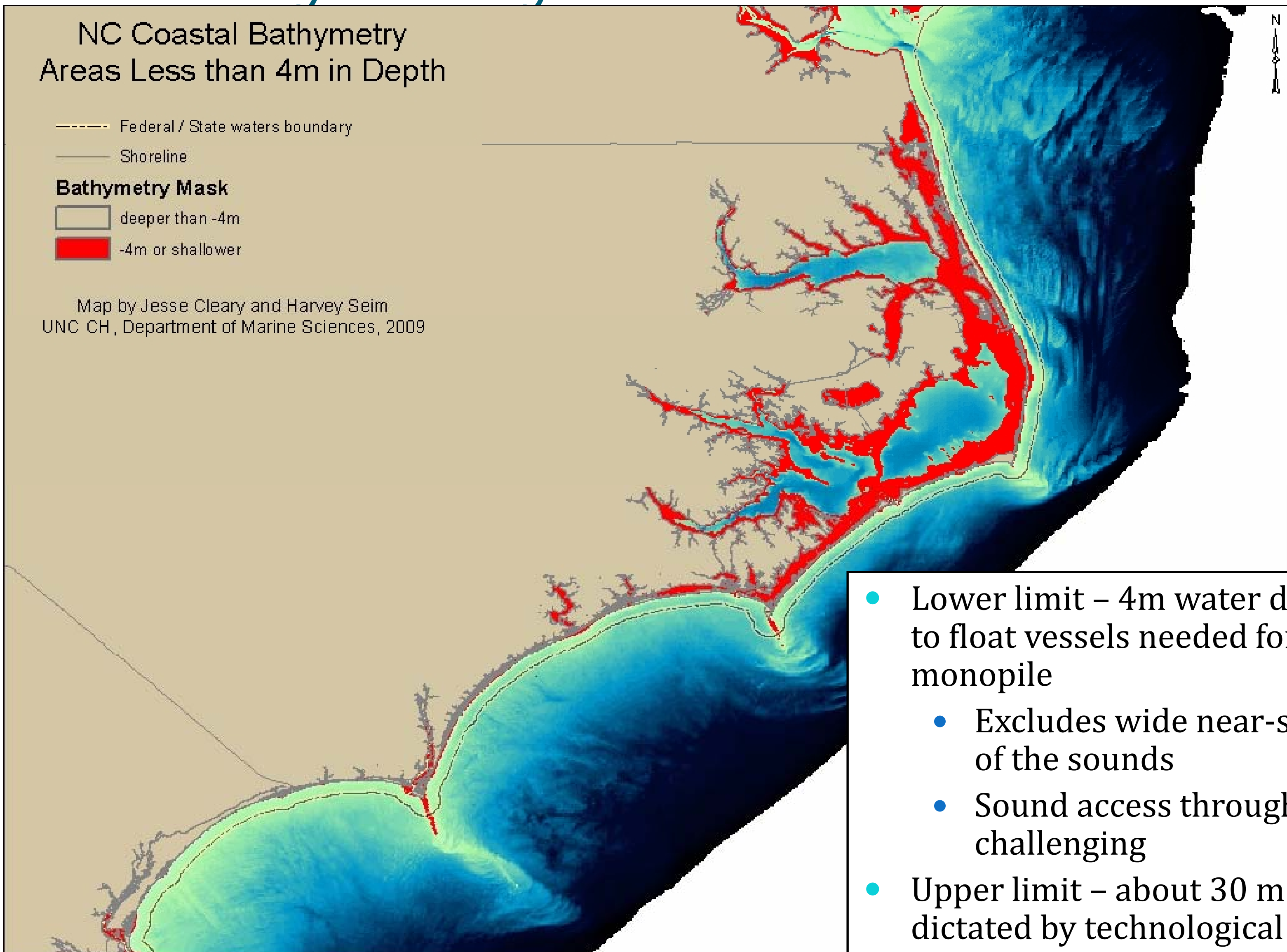


Open gravity-based structure without ballast and at water depth of approximately 20 meters. The design shown includes an ice deflection cone.

Foundation Alternatives

Installation vessels need at least 4 meters water depth

Bathymetry Constraints



- Lower limit – 4m water depth required to float vessels needed for installation of monopile
  - Excludes wide near-shore margins of the sounds
  - Sound access through inlets is challenging
- Upper limit – about 30 m water depth dictated by technological and financial constraints associated with installation

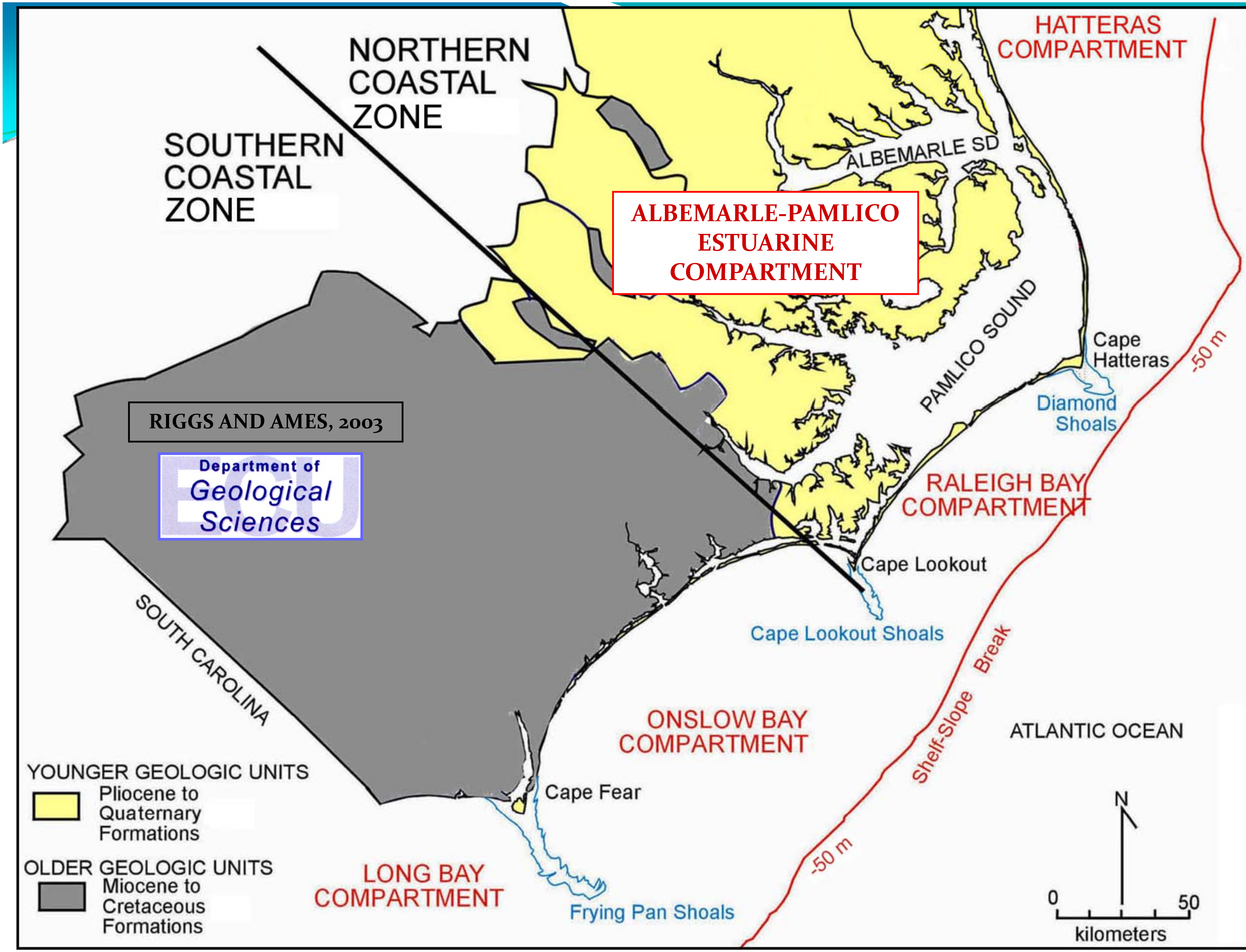
Geology

S. Riggs (Geological Sciences, East Carolina)

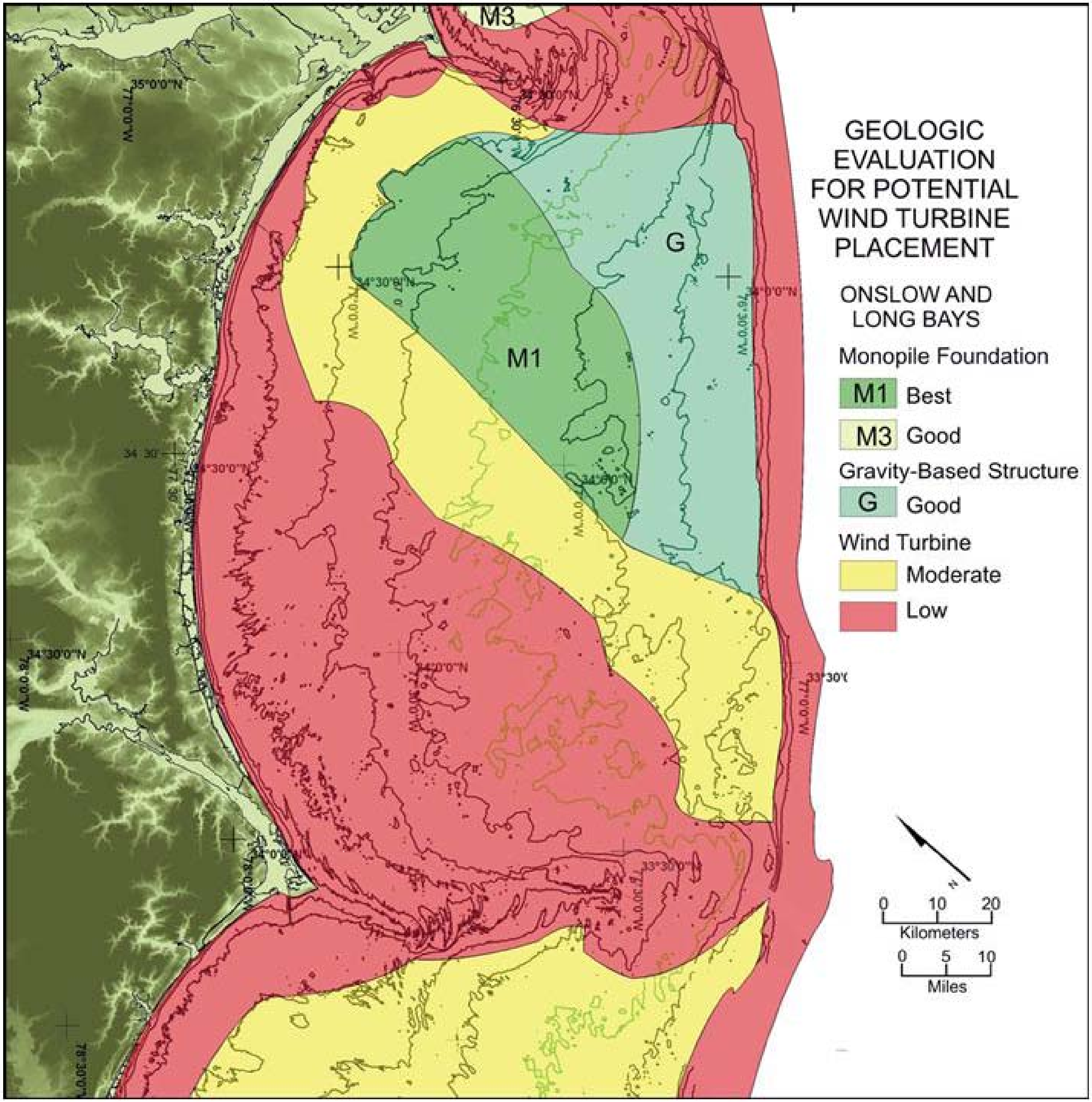
D. Ames (Geologic Sciences, East Carolina)

- Sound and ocean bottom geology
- Suitability for various types of wind turbine foundations


Chesapeake Bay
VA
NC
Hatteras Bay
Albemarle-Pamlico Estuarine System
Cape Hatteras
Raleigh Bay
Cape Lookout
NC
SC
Onslow Bay
Cape Fear
NASA ORBIMAGE 10-3-2000
Long Bay
Department of Geological Sciences
Cape Romain


NORTHERN COASTAL ZONE
SOUTHERN COASTAL ZONE
HATTERAS COMPARTMENT
ALBEMARLE SD
ALBEMARLE-PAMLICO ESTUARINE COMPARTMENT
PAMLICO SOUND
Cape Hatteras
-50 m
Diamond Shoals
RIGGS AND AMES, 2003
Department of Geological Sciences
RALEIGH BAY COMPARTMENT
Cape Lookout
Cape Lookout Shoals
SOUTH CAROLINA
Shelf-Slope Break
ONSLOW BAY COMPARTMENT
ATLANTIC OCEAN
YOUNGER GEOLOGIC UNITS
Pliocene to Quaternary Formations
Cape Fear
OLDER GEOLOGIC UNITS
Miocene to Cretaceous Formations
LONG BAY COMPARTMENT
-50 m
Frying Pan Shoals
N
0
50
kilometers

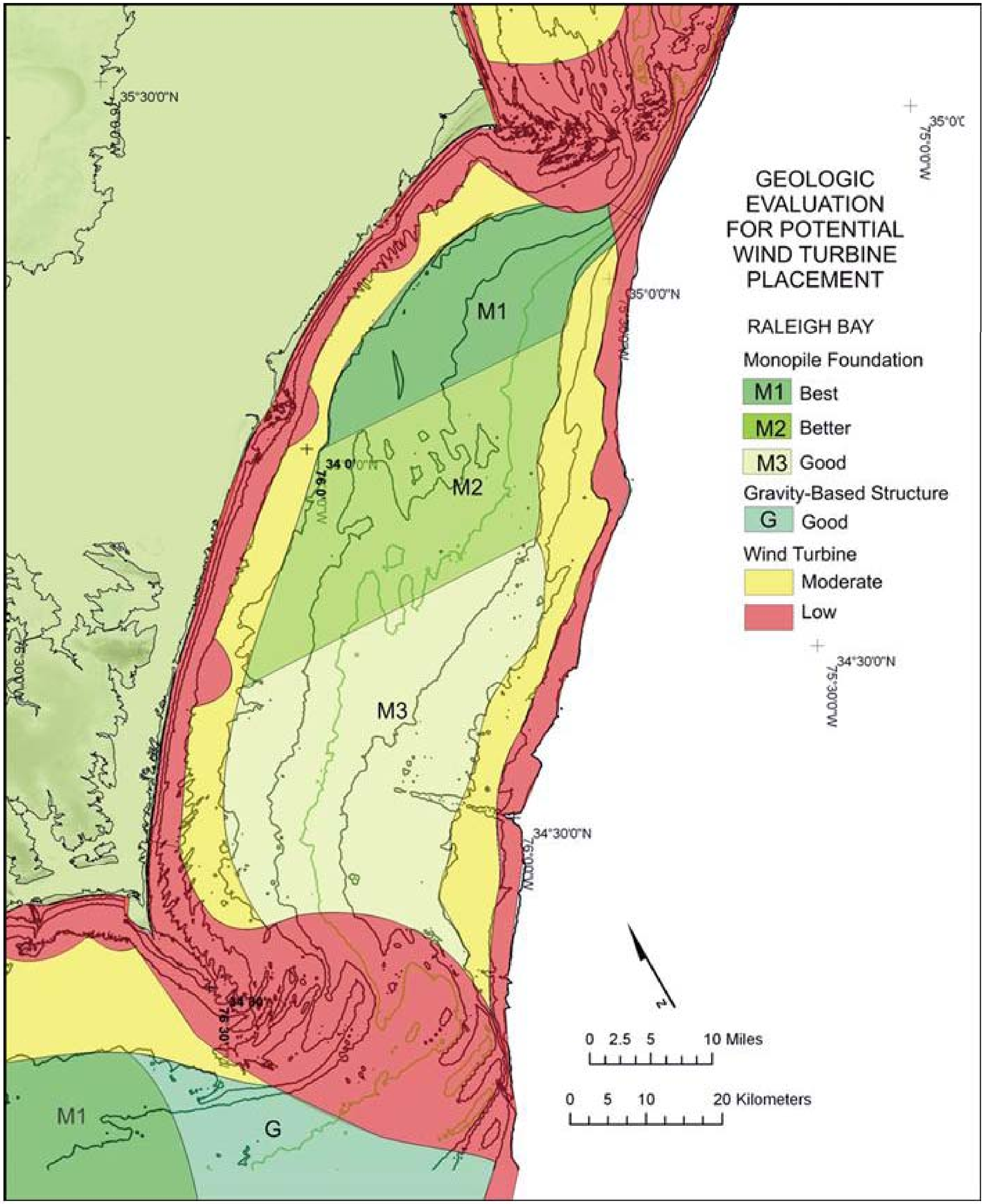
ONSLOW AND LONG BAYS



RIGGS AND AMES, 2009

Department of Geological Sciences

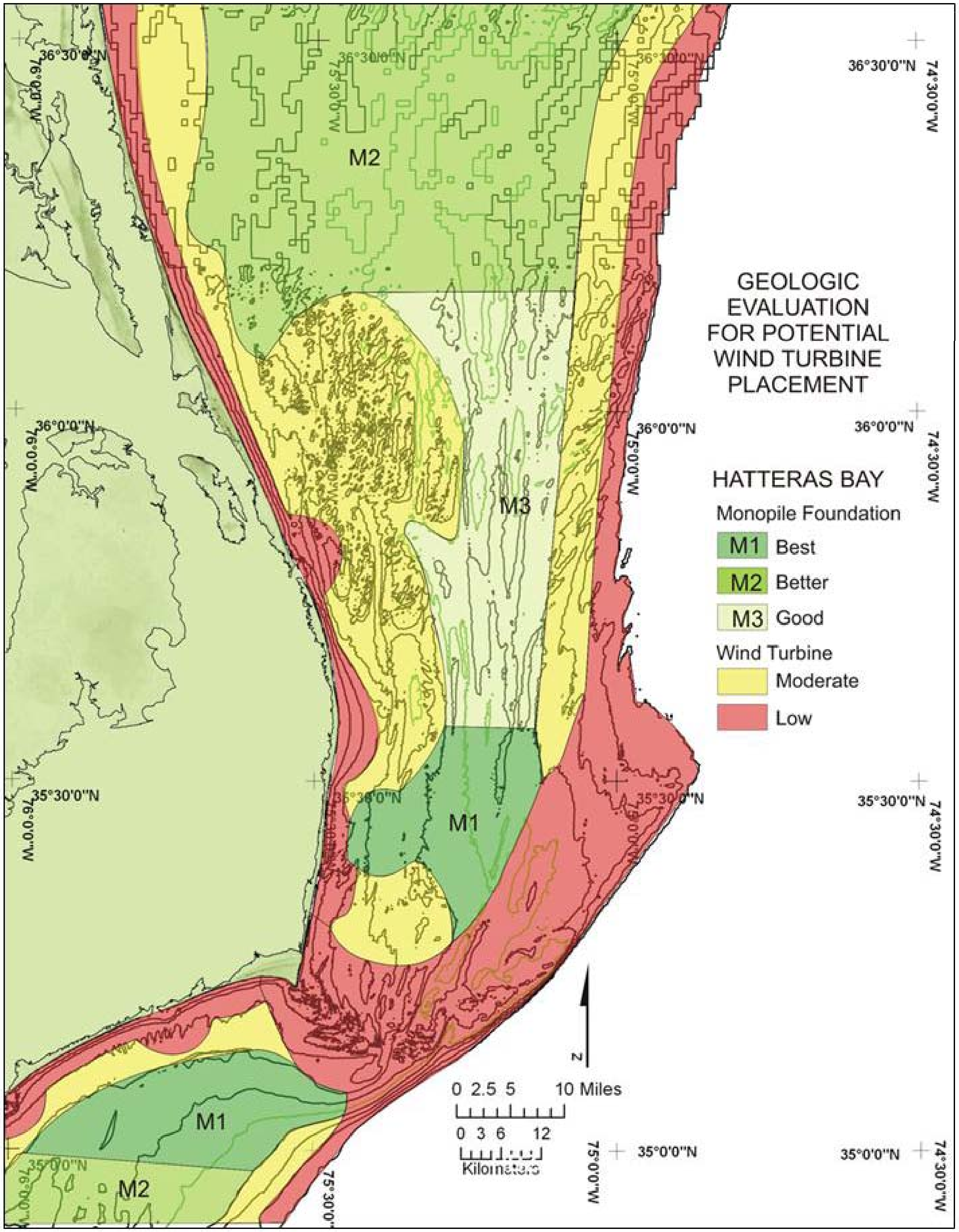
RALEIGH BAY



RIGGS AND AMES, 2009

Department of Geological Sciences

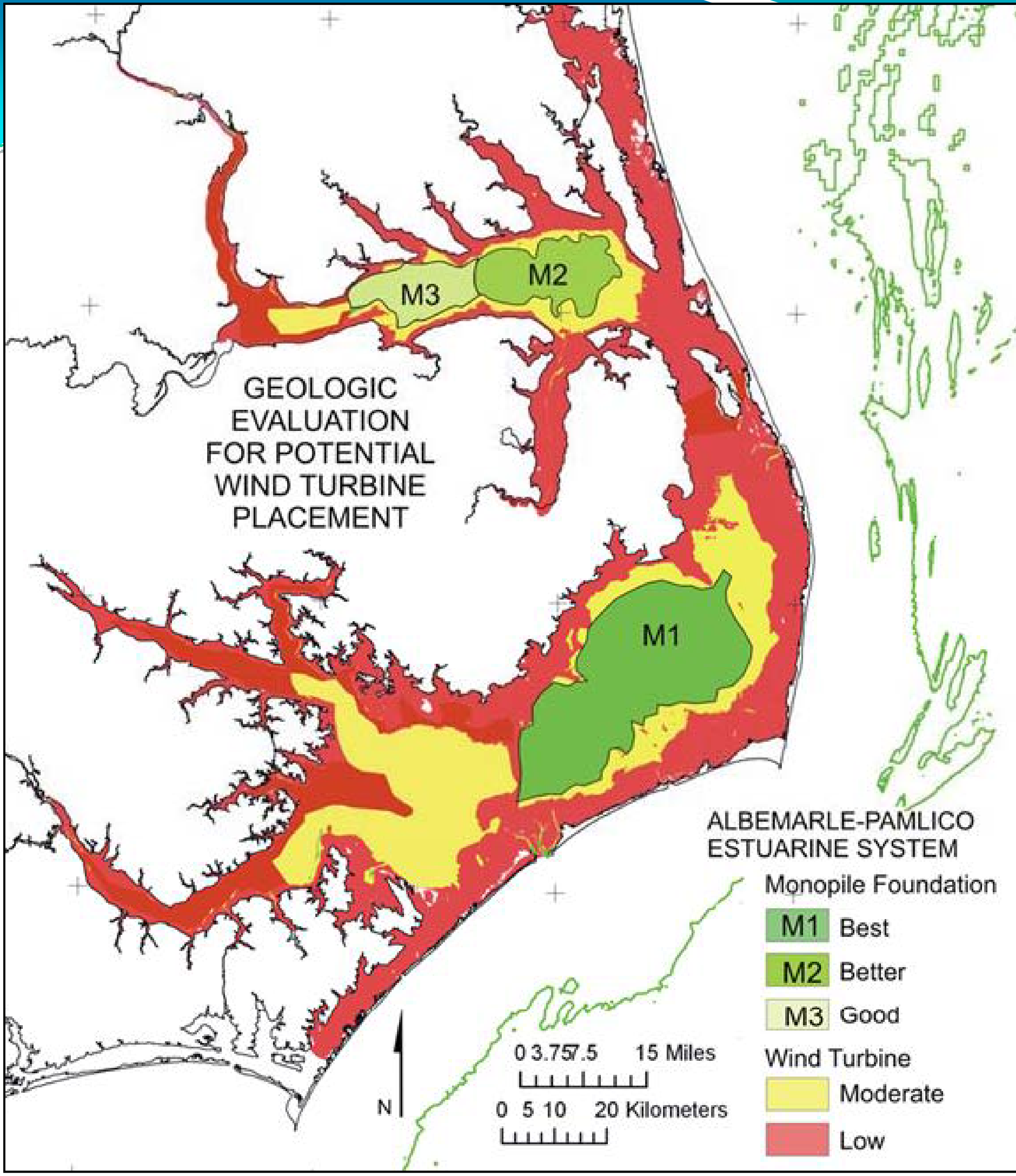
HATTERAS BAY



RIGGS AND AMES, 2009

Department of Geological Sciences

ALBEMARLE-PAMLICO ESTUARINE SYSTEM



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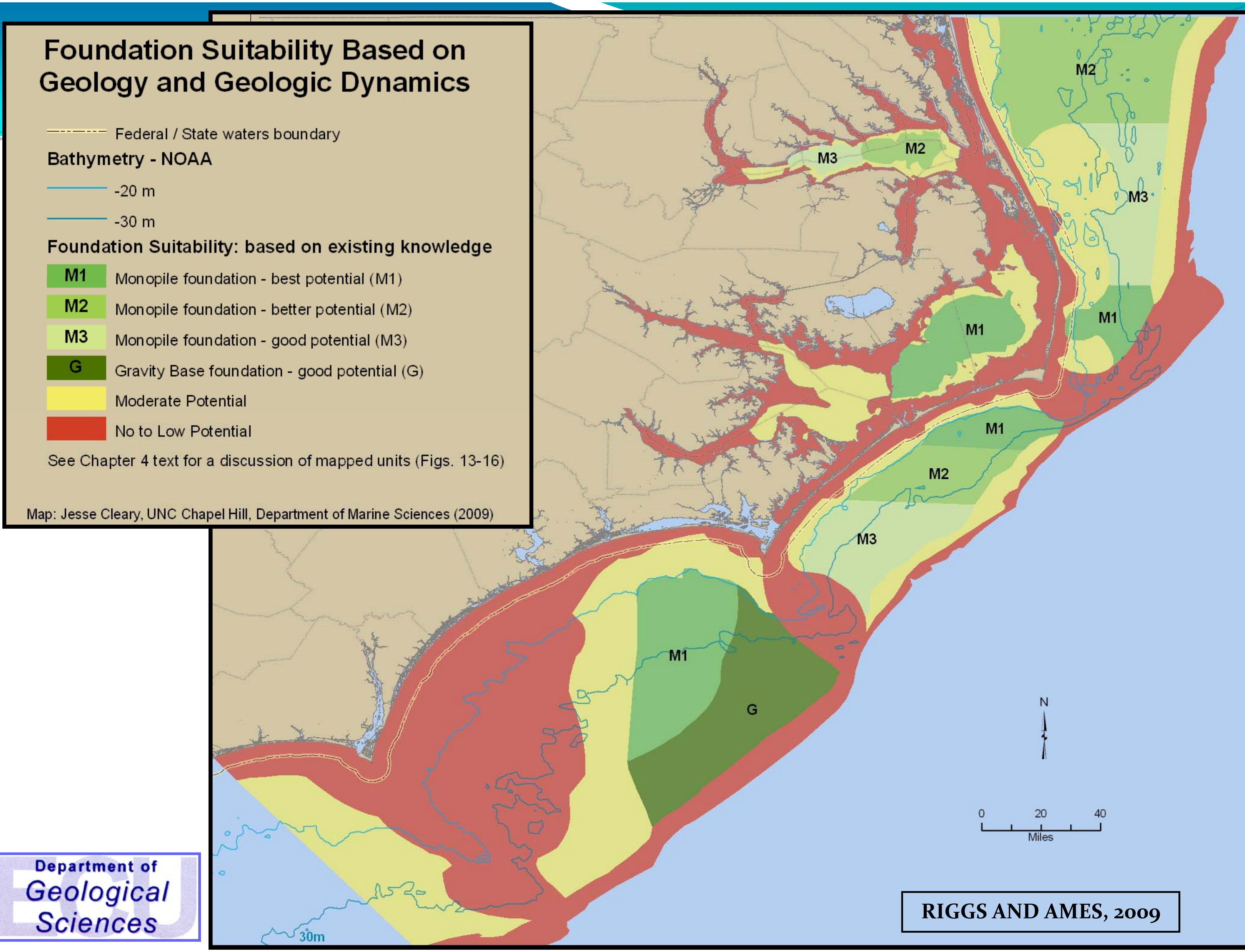

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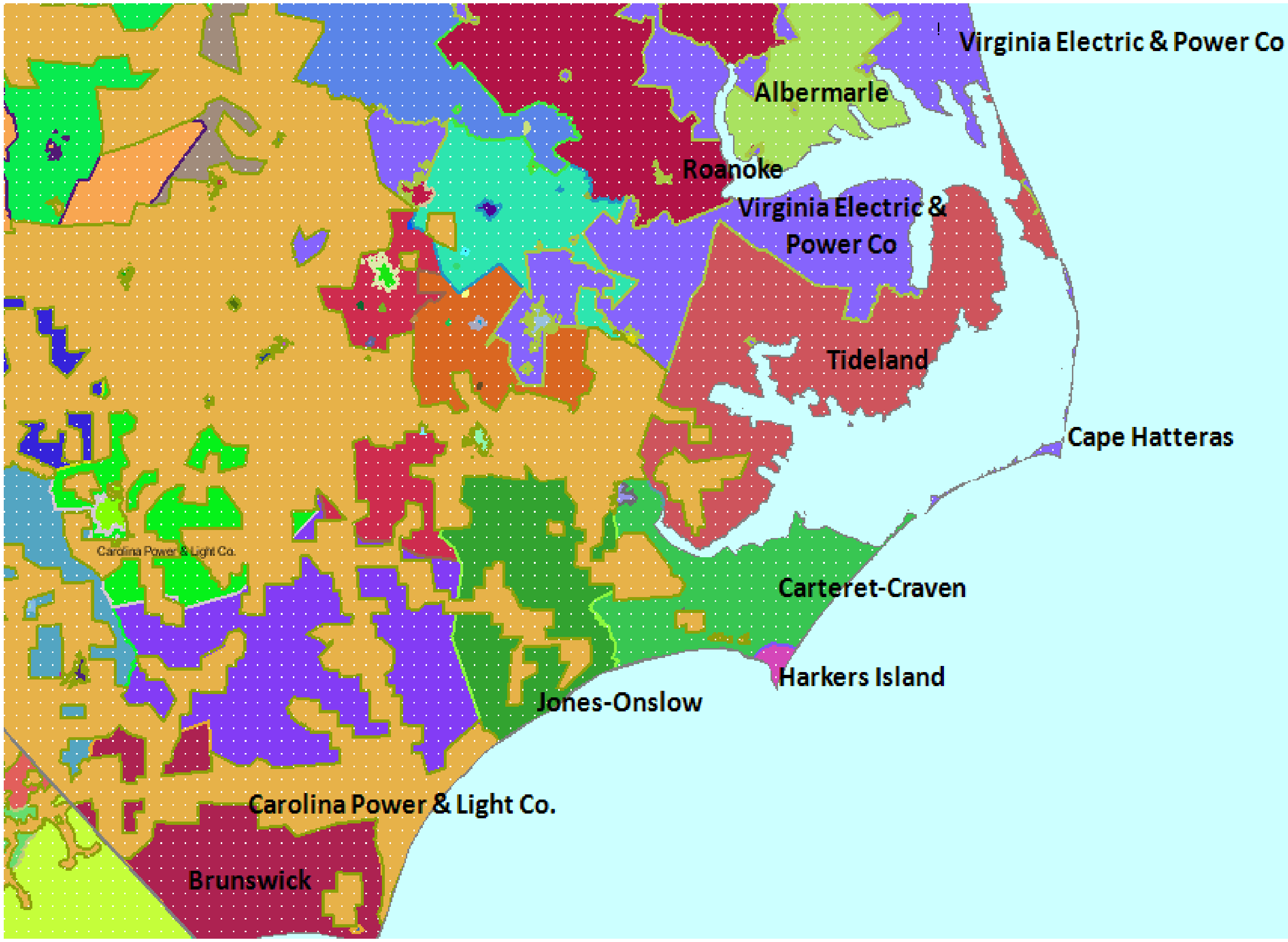
Utility Transmission Infrastructure

K. Higgins, Energy Strategies, Salt Lake City

Caitlin Collins, Energy Strategies, Salt Lake City

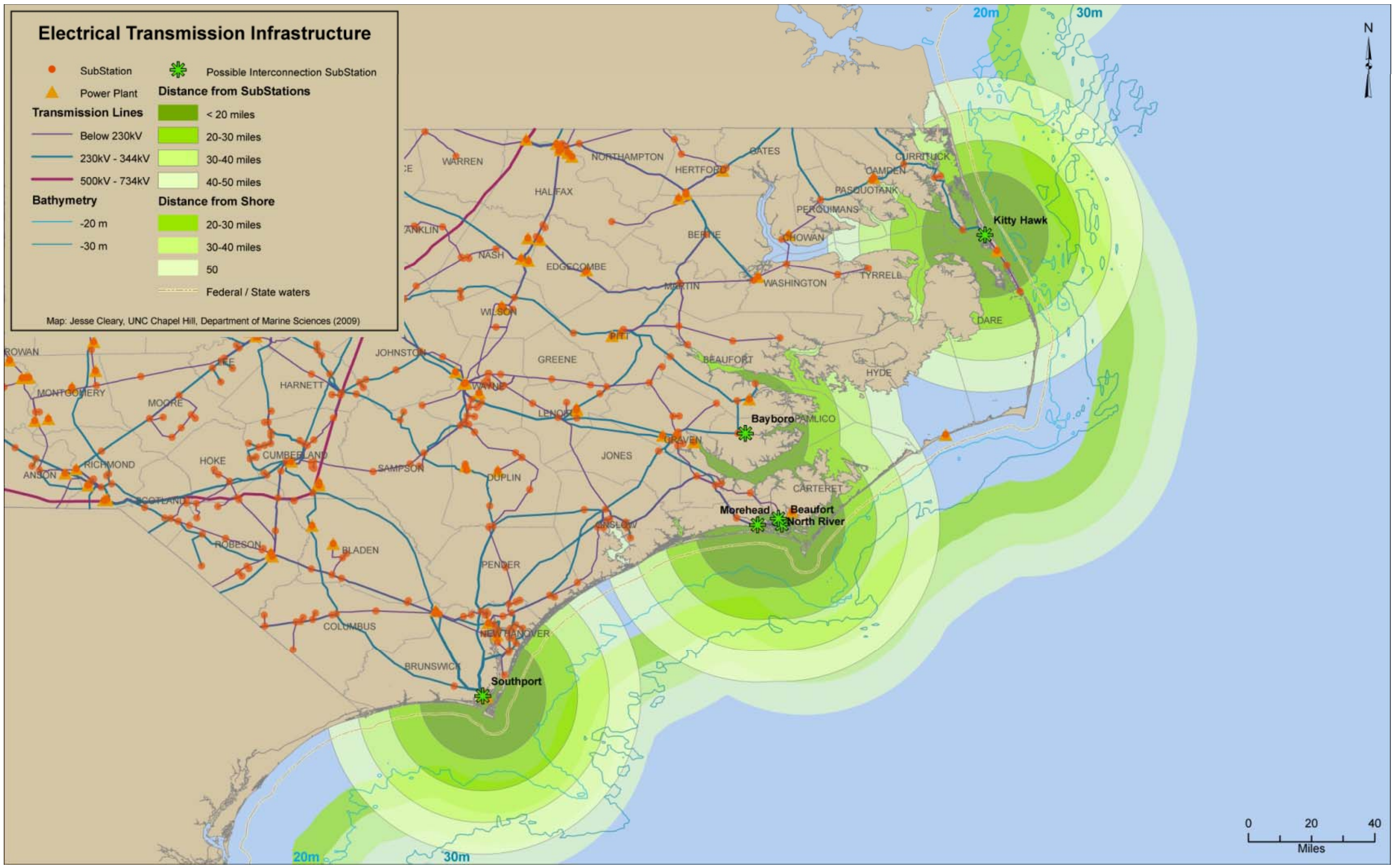
- Assessment of the transmission infrastructure along the coast of North Carolina
- Ability of transmission infrastructure to absorb large-scale offshore wind projects

Electric Services Territories



Source: Platts Energy Advantage

Transmission Lines and Substations



Electric Interconnections

- Dominion North Carolina Power transmission system (northern coast) not designed to accommodate significant offshore wind without a system upgrade, maybe 10 MW capacity available
- North Carolina Electric Membership Cooperatives do not own significant infrastructure
- Progress Energy Carolinas transmission could accommodate up to 250 MW of offshore wind energy generation at certain locations without major upgrades
- The economics are significantly impacted by the distance required to reach the transmission grid from the offshore wind location.

Utility-Related Statutory and Regulatory Barriers

K. Higgins, Energy Strategies, Salt Lake City

N. Townsend, Energy Strategies, Salt Lake City

S. Vale, Nicholas School of the Environment, Duke

- Identification of state and federal statutory and regulatory barriers
- Recommendations for barrier removal

Producer Requirements

- For a utility developer, the fundamental regulatory issue is assurance of cost recovery in rates
- For an independent power producer, the fundamental regulatory issues are
  - access to markets
  - price paid for the generation.

State Regulatory Environment

- Few outright regulatory barriers
- Regulatory incentives for wind energy are not as great as for other forms of alternative energy, resulting in solar energy being pursued more aggressively by the public utilities in spite of its greater cost
- Possibilities for increasing incentives for wind power development are
  - including the cost of externalities (CO_2 related costs) in the avoided cost calculation used for determining the baseline for cost recovery
  - raising the cost caps applicable to meeting the North Carolina Renewable Energy Portfolio Standard

Federal Regulatory Environment

- Production Tax Credit is expiring and needs to be extended beyond 2009.
- Independent power producers need to be ensured of efficient access to markets
  - Begun by the Public Utility Regulatory Policies Act (PURPA) of 1978
  - Needs to continue

Legal Framework, Issues, and Policy Concerns

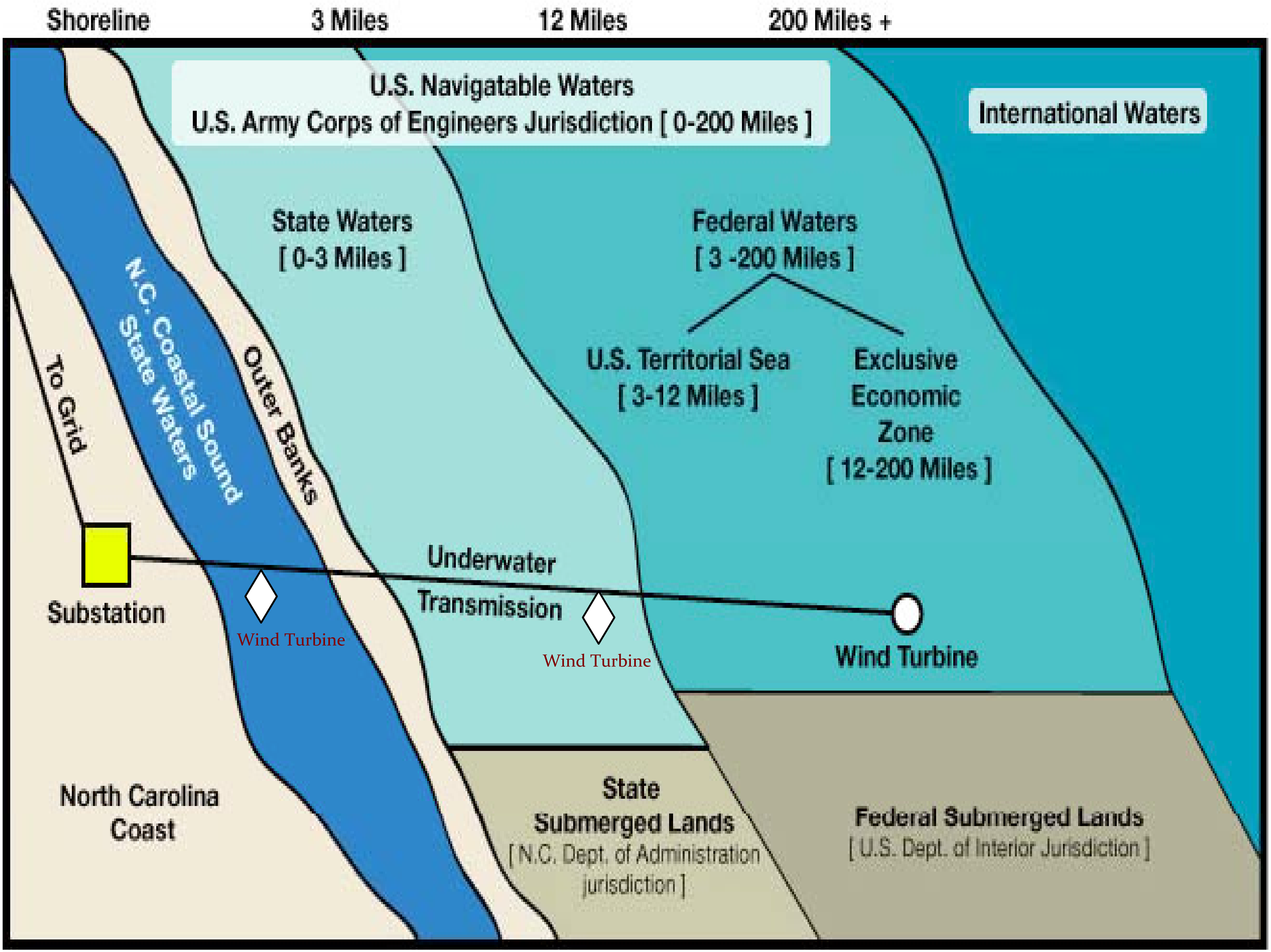
J. Kalo, School of Law, UNC Chapel Hill and

N.C. Coastal Law, Planning, and Policy Center

L. Schiavinato, NC Sea Grant, NC State, and

N.C. Coastal Law, Planning, and Policy Center

- Legal structures that guide wind energy development on the outer continental shelf
- Legal structures applicable to wind energy facilities in State ocean or estuarine waters


Shoreline
3 Miles
12 Miles
200 Miles +
U.S. Navigatable Waters
U.S. Army Corps of Engineers Jurisdiction [0-200 Miles]
International Waters
State Waters
[0-3 Miles]
Federal Waters
[3 -200 Miles]
U.S. Territorial Sea
[3-12 Miles]
Exclusive
Economic
Zone
[12-200 Miles]
To Grid
N.C. Coastal Sound
State Waters
Outer Banks
Substation
Underwater
Transmission
Wind Turbine
Wind Turbine
Wind Turbine
North Carolina
Coast
State
Submerged Lands
[N.C. Dept. of Administration
jurisdiction]
Federal Submerged Lands
[U.S. Dept. of Interior Jurisdiction]

Applicable Federal Laws and Regulations

- Rivers and Harbors Act
- Clean Water Act – Sections 401 and 404 and NPDES
- Coastal Zone Management Act
- National Historic Preservation Act
- Endangered Species, Marine Mammal Protection, Migratory Bird Treaty, and Magnuson Stevens Acts
- Marine Sanctuaries Act
- Military base issues
- Regulations pertaining to FAA, Coast Guard, and MMS

Minerals Management Service

- MMS has developed a regulatory program to lease Federal waters along the Outer Continental Shelf for alternative energy projects.
- MMS leasing process includes site identification, lease issuance, site assessment plan, construction and operations, and decommissioning.

CZMA Consistency Provision

- Wind energy projects in Federal waters would be subject to the Consistency provision of the Coastal Zone Management Act, which would allow NC to protect its interests in the event such a project would affect its coast.
- The Federal project would need to be "consistent to the maximum extent practicable" with the enforceable policies of NC's coastal management plan.

What is Important to North Carolina

- North Carolina must have in place laws and regulations that govern the development of wind energy in state coastal and ocean waters to receive the maximum benefits under the federal Coastal Zone Management Act.
- These state laws and regulations are needed to provide the framework for federal consistency.
- Therefore the state must review all its laws applicable to such projects to assure that wind energy development in coastal and ocean waters will be done in a manner consistent with state interests and fill any existing gaps.

Coastal Resources Commission and Utilities Commission

- Water-based wind turbines and transmission lines subject to CAMA and the CRC, unless they fall within the exception created by statute.
- Utilities Commission:
  - Certificate of public convenience and necessity – for energy facilities.
  - Certificate of necessity and environmental compatibility – for transmission lines.
  - Presently, Utilities Commission defers to CRC for projects located in AECs.

Environmental Management Commission

- May establish a procedure for evaluating renewable energy technologies that are, or are proposed to be, employed as part of a renewable energy facility.
- May establish standards to ensure that renewable energy technologies do not harm the environment, natural resources, cultural resources or public health, safety or welfare of the State.
- To the extent that there is not an environmental regulatory program, establish such program to implement these protective standards.

H.B. 809 / S.B. 1068

- H.B. 809 was filed in March 2009.
- Sets environmental standards for permitting wind energy facilities.
- Divides authority over wind energy permitting between the CRC (coastal counties) and DENR (rest of the state).
- Issues: water dependency, transmission lines crossing ocean beaches, and submerged lands leasing.

Preliminary Economic Analysis

N. Travis, Energy Strategies, Salt Lake City

D. Hendrickson, Energy Strategies, Salt Lake City

- Preliminary evaluation of the economics of constructing wind farms in the sounds or off the coast

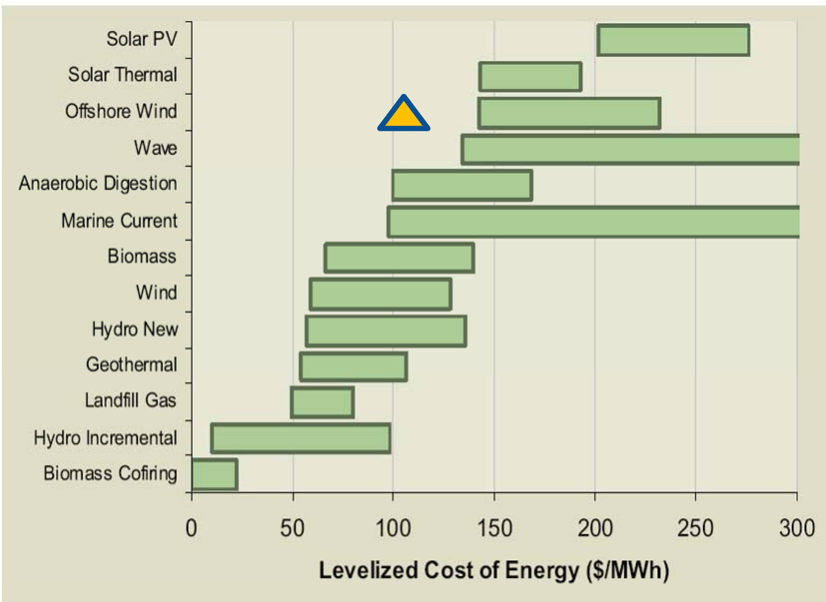
In Shore Scenario

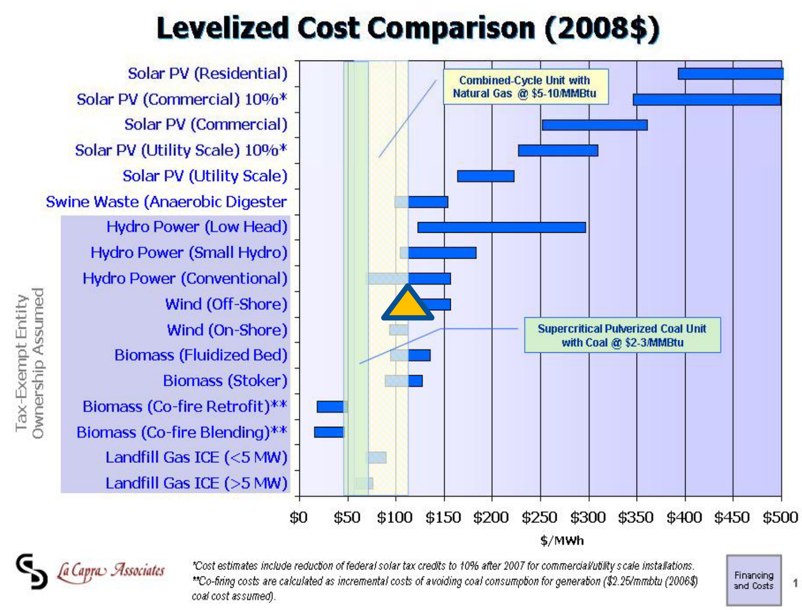
- 30 3.6 MW turbines
- 108 MW of installed capacity
- 35% capacity factor
- Capital cost of $2,800 per kW
- Operation and maintenance cost
  - Fixed - $75 per Kw/year
  - Variable - $4.50 per MWh
- Developer assumed to be an independent power producer
- $106 per MWh LCOG

Offshore Scenario

- 450 3.6 MW turbines
- 1,620 MW installed capacity
- 40% capacity factor
- Capital cost of $3,360 per Kw
- Operation and maintenance cost
  - Fixed - $86.25 per kW/year
  - Variable - $5,18 per MWh
- Developer assumed to be an investor owned utility
- $101 per MWh LCOG

Energy Generation Cost Comparison





Source: "Renewable Energy Transmission Initiative Phase 1A DRAFT REPORT", March 2008 prepared by Black & Veatch Corporation. The relatively high cost attributed to offshore wind results largely from an assumed capital cost of $5,000 to $6,000 per kW (2008$).

△ = study estimate

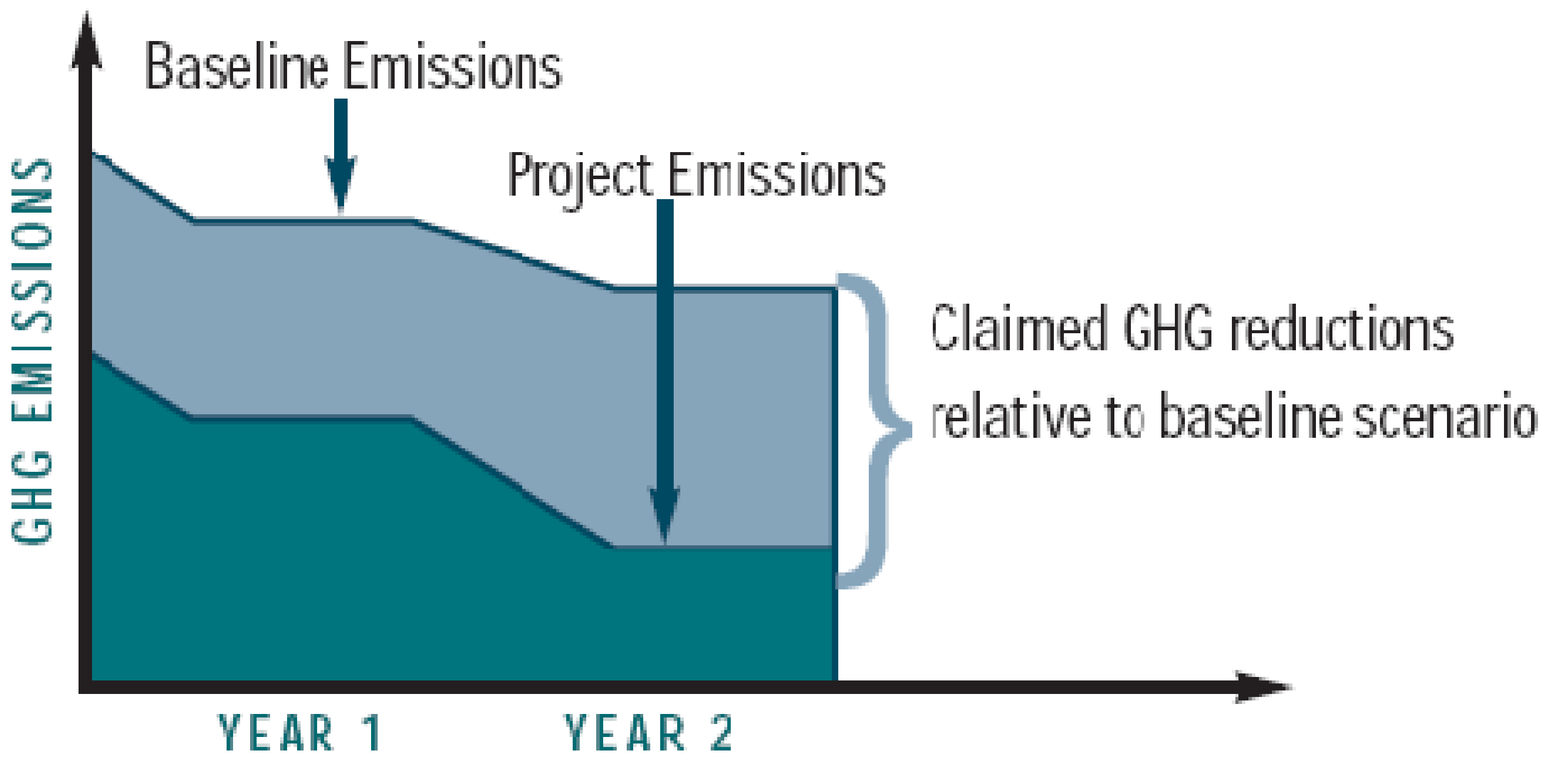
Source: "Analysis of Renewable Energy Potential in South Carolina, Renewable Resource Potential – Final Report", Prepared for: Central Electric Power Cooperative Inc, September 12, 2007, by GDS Associates, Inc. and LaCapra Associates, Inc.. The relatively high cost attributed to offshore wind results largely from a lower capacity factor (30 to 35%) and a financial structure that does not fully capture tax incentives that are currently available.

Carbon Reduction

D. Arneman, Energy Services, UNC Chapel Hill

- Carbon benefits derived from substituting electrical power from wind energy for electrical power generated from fossil fuels

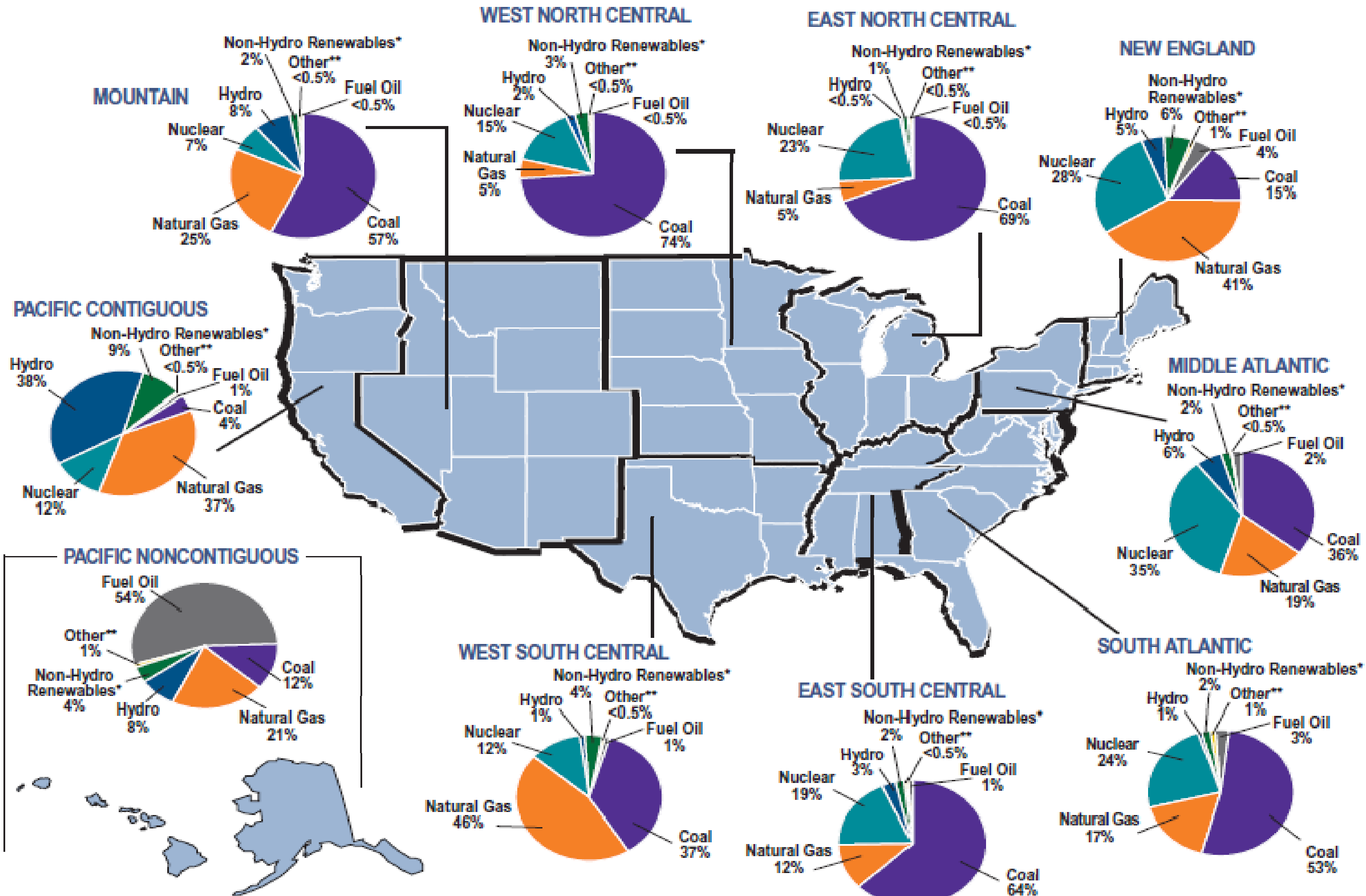
Calculating GHG Emissions Relative to a Baseline Scenario



Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects, World Resources Institute/World Business council for Sustainable Development, P.11

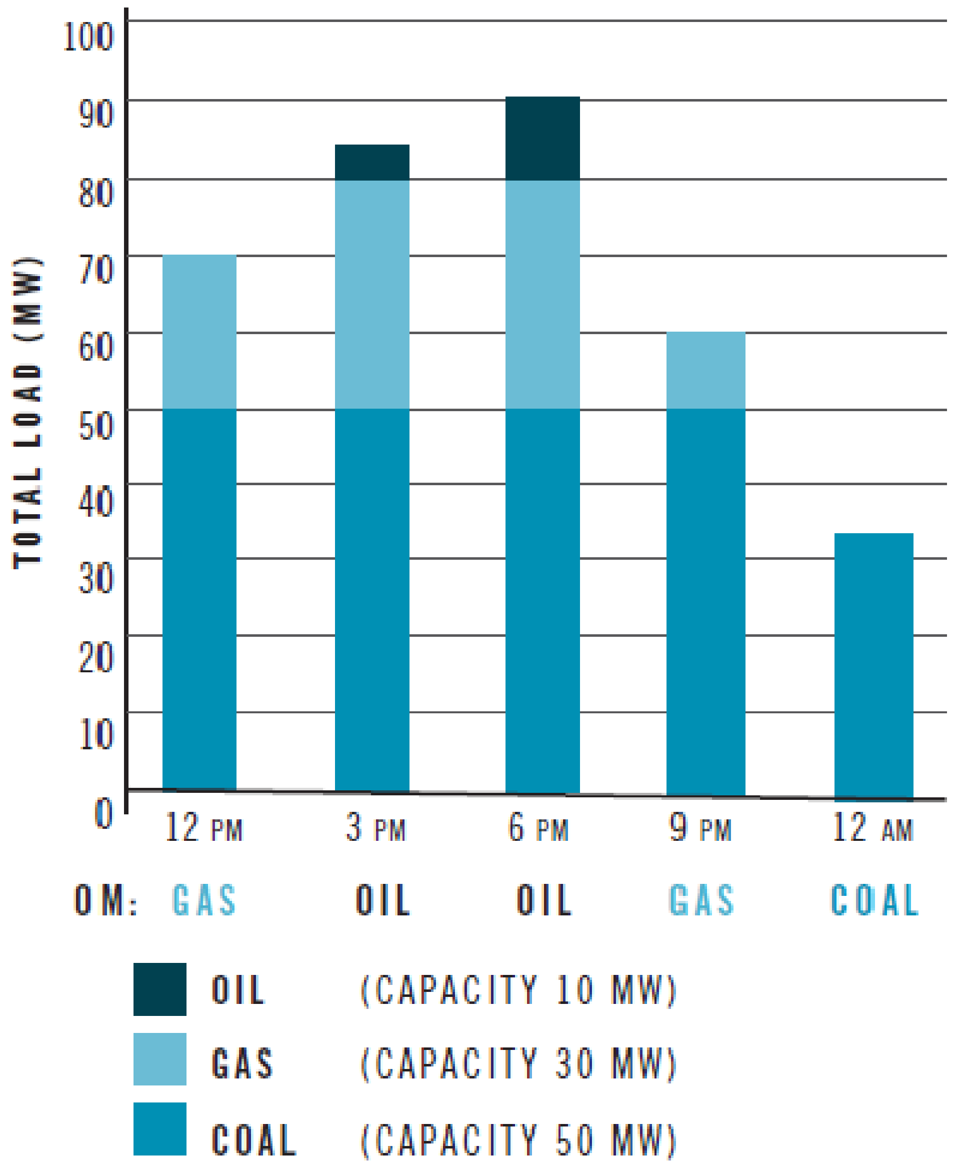
Electric Generation

Fuel Mix by Region



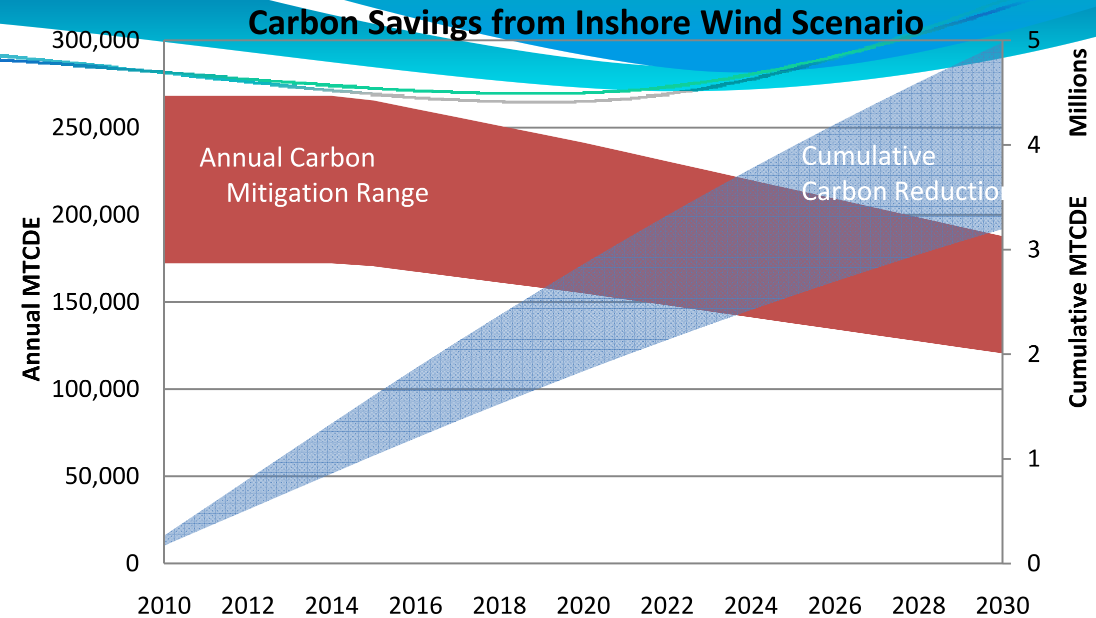
Edison Electric Institute, 2009.

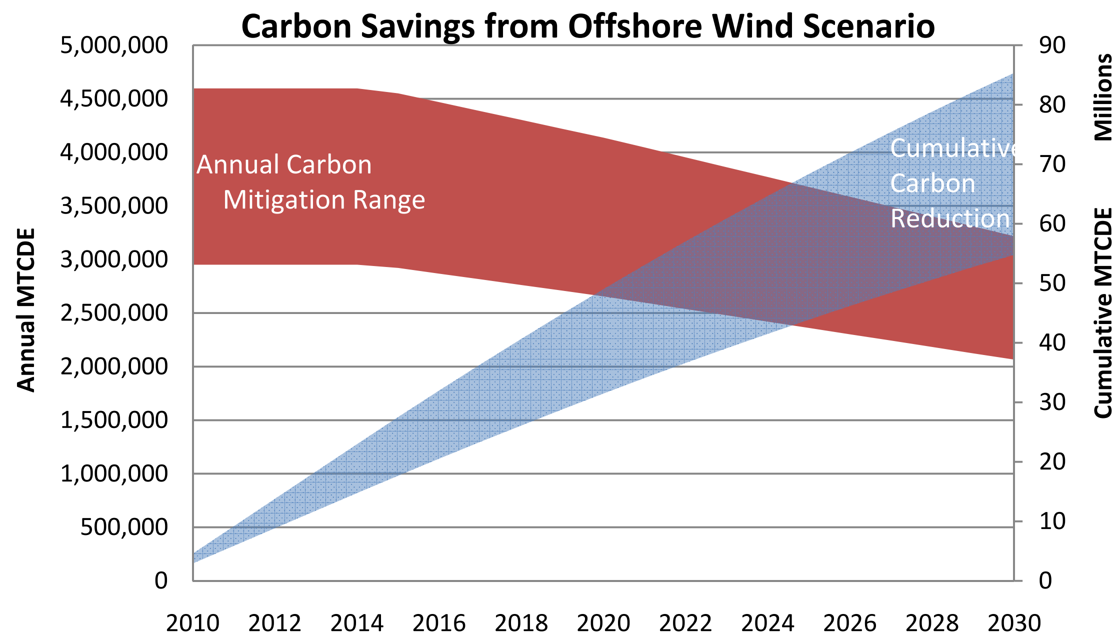
Example of Grid Operating Margin



Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects, World Resources Institute/World Business council for Sustainable Development, P.14

Example Carbon Savings from Proposed Wind Installations





Synthesis

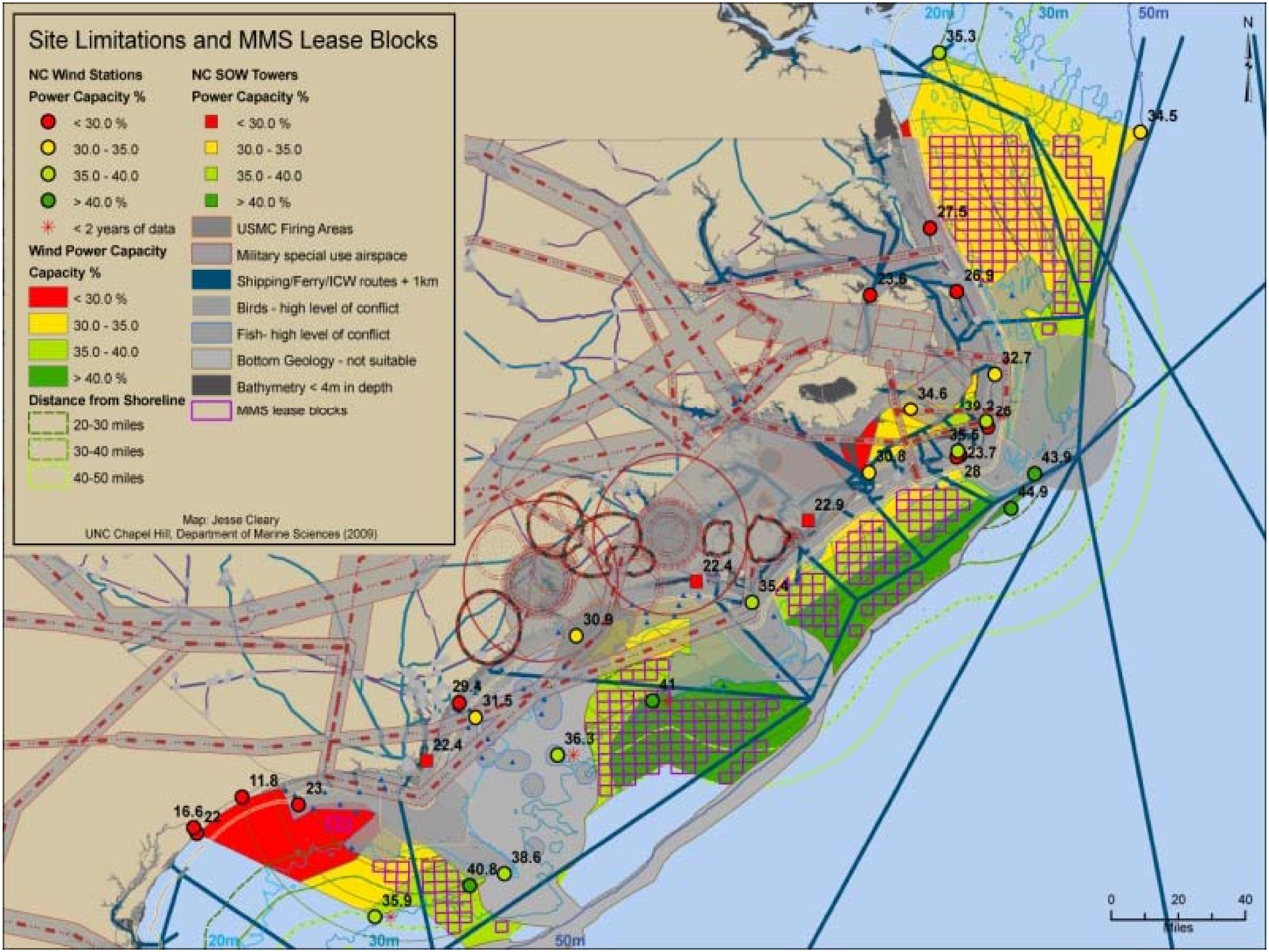
Methodology

- Information from the individual groups was integrated into a geographic information system
- Emphasis was placed on identifying severe constraints likely to preclude any wind energy development
- Areas identified as no-build (e.g. too shallow, reserved for use by the military) and areas identified as having high ecological impact or low suitability for foundation construction were eliminated
- Each constraint equally weighted and an equal degree of certainty as to their extents assumed
- Provides a conservative and introductory look at what areas remain viable for wind power development.

Synthesis

Results

- Limited portion of State waters, restricted to the eastern half of Pamlico Sound, appears feasible for further study
- Large areas offshore are potentially well-suited for wind energy development.
  - More than 2800 square miles of potential development area in waters less than 50 m deep and within 50 miles of the coastline
  - Raleigh and Onslow Bay appear to have the most promising wind resource, with capacity factors exceeding 40% in water depths greater than 30 m
  - Winds over the shelf north of Cape Hatteras do not appear as favorable as those to the south but it is important to note that there are no direct measurements of winds on the northern shelf in water depths less than 45 m
  - 190 federal MMS lease blocks do not intersect with any constraint and have wind power capacity estimated in excess of 35%.



Site Limitations and MMS Lease Blocks
NC Wind Stations
Power Capacity %
< 30.0 %
30.0 - 35.0
35.0 - 40.0
> 40.0 %
< 2 years of data
Wind Power Capacity
Capacity %
< 30.0 %
30.0 - 35.0
35.0 - 40.0
> 40.0 %
Distance from Shoreline
20-30 miles
30-40 miles
40-50 miles
NC SOW Towers
Power Capacity %
< 30.0 %
30.0 - 35.0
35.0 - 40.0
> 40.0 %
USMC Firing Areas
Military special use airspace
Shipping/Ferry/ICW routes + 1km
Birds - high level of conflict
Fish- high level of conflict
Bottom Geology - not suitable
Bathymetry < 4m in depth
MMS lease blocks
Map: Jesse Cleary
UNC Chapel Hill, Department of Marine Sciences (2009)
20m
30m
50m
N
0
20
40
Miles

Recommendations

N. C. Legislature

- Enact comprehensive submerged lands leasing statute
- Enact a single comprehensive environmental permitting process
- Amend SL 2007-397 (SB3) to provide specific wind energy incentives
- Allocate a modest amount of ARRA money for further analysis

Recommendations

Regulatory Changes

- Modify the avoided cost calculation baseline for utility cost recovery
- Amend the CRC's Coastal Energy Policies
- Amend CRC rules impeding use of state waters for wind energy.
- Encourage the NC congressional delegation to support extension of the Production Tax Credit
- Prepare for projects in federal waters.

Strategic Direction

- Develop demonstration turbines
  - no water-based wind turbine pilot projects ongoing in the US at this time
  - Area in the Pamlico Sound identified as potentially suitable
- Support additional wind research
  - More detailed wind resource analysis is needed
  - US Navy has existing offshore platforms that could permit sophisticated wind observations to be collected inexpensively and quickly compared to other coastal areas which will need to first build offshore platforms

Strategic Direction

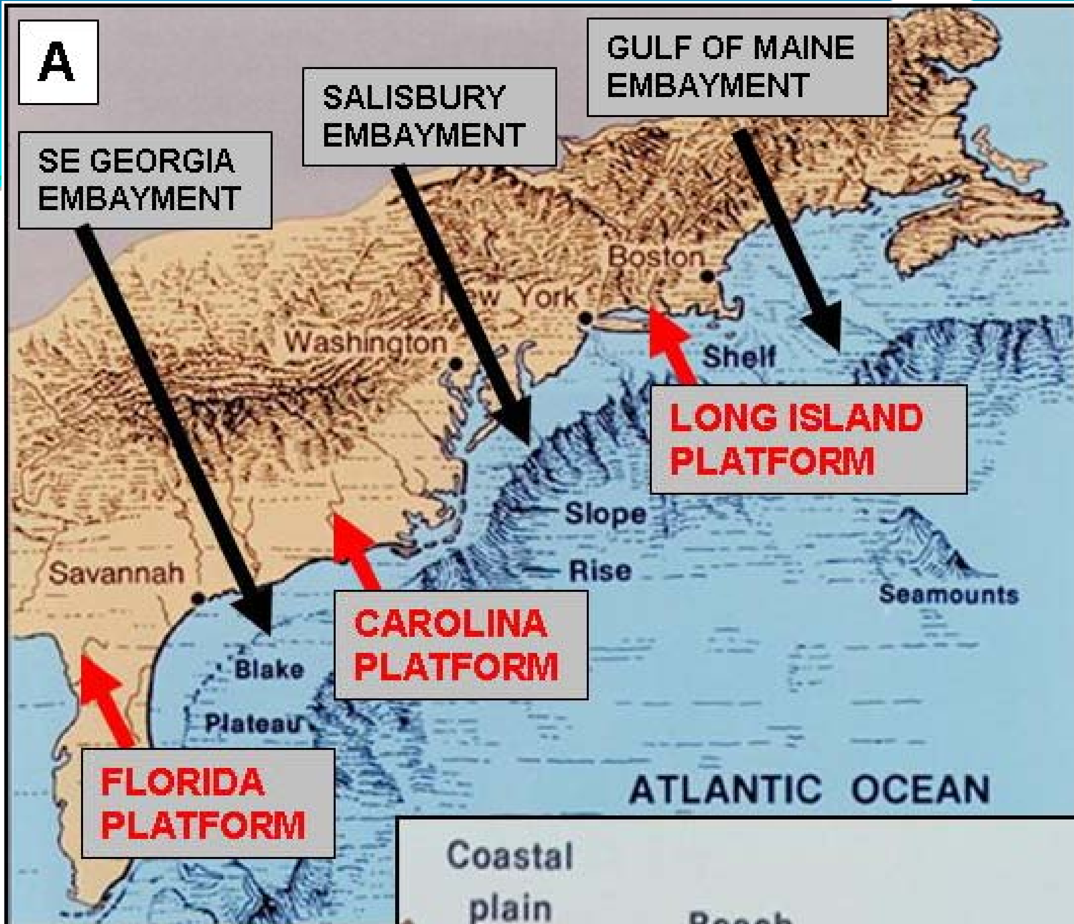
- Support additional utility transmission research
  - North Carolina Transmission Planning Cooperative already exists
  - Could be engaged at no cost to conduct such an evaluation for the central and southern portions of the coast to identify system upgrades
  - NC investor-owned utilities could be asked to evaluate the costs for each to integrate large-scale wind energy into their generation dispatch.

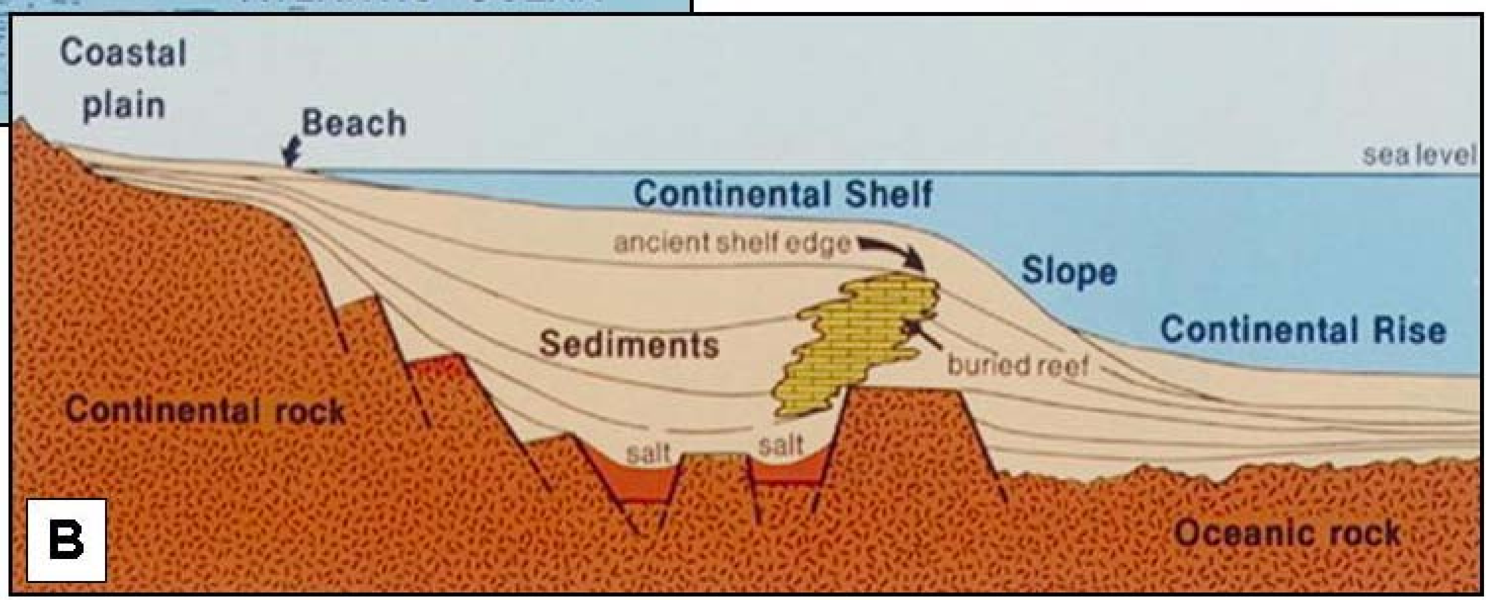
Strategic Direction

- Establish state policy toward utility-scale wind farm development
  - Other states have created incentives for developers to rapidly move towards installation of utility-scale wind farms
  - North Carolina should define an approach to attract investment within the state.
- Leverage the expertise of the public universities

Questions?

www.climate.unc.edu/coastal-wind





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