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

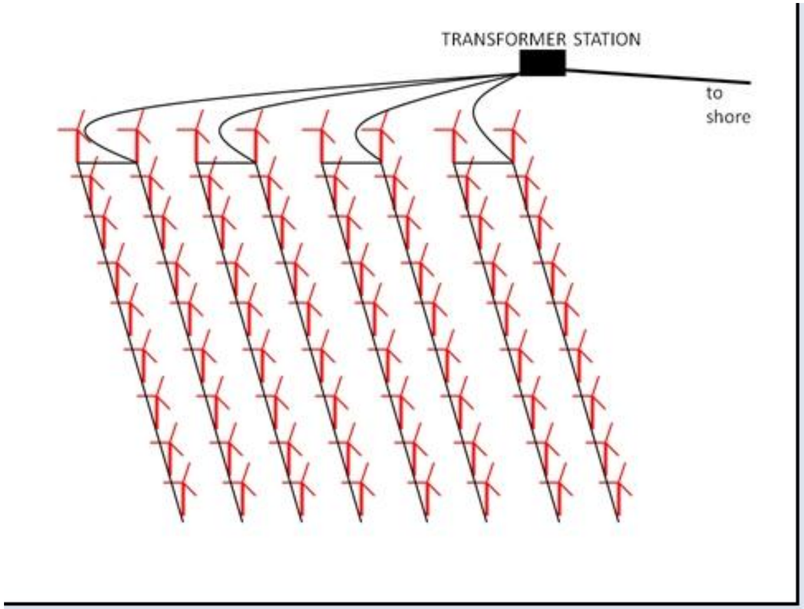
THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

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

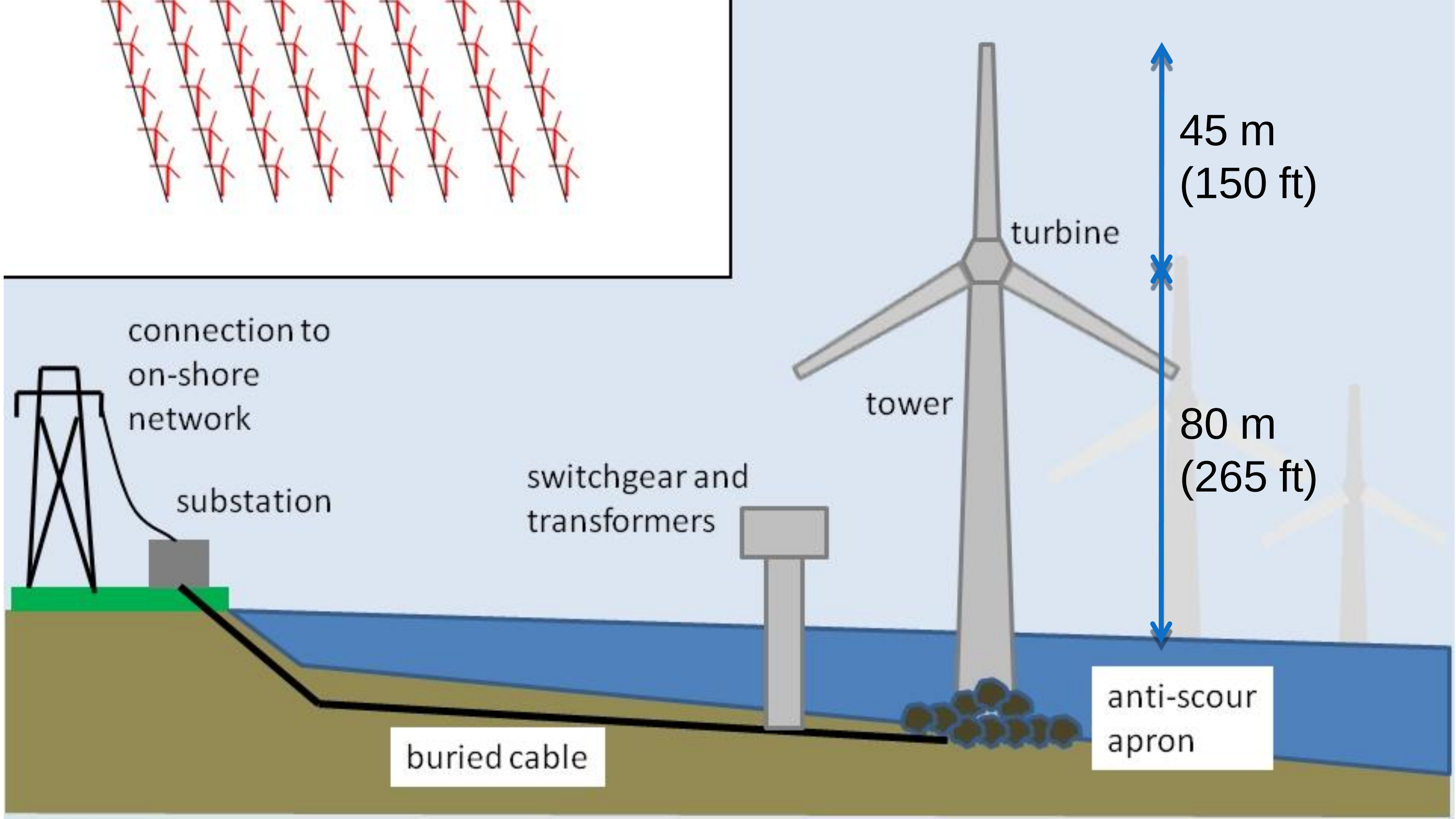
Coastal Wind Energy Study

- Requested by the North Carolina General Assembly
- University of North Carolina at Chapel Hill designated to conduct the study
  - C. Elfland, Associate Vice Chancellor for Campus Services, project leader
- Study area
  - Pamlico and Albemarle Sounds
  - Offshore over waters less than 30 meters in depth (wind to 50 meters in depth)

Potential wind farm layout



Dimensions:
1) ~700 m between turbines*
2)MMS leases are 3 mi by 3 mi
3)49 turbines per lease block



Coastal Wind Energy Study

Study Components (from legislation)

- 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

Foundation Concepts

J. Schuett (Affiliated Engineers, Chapel Hill)

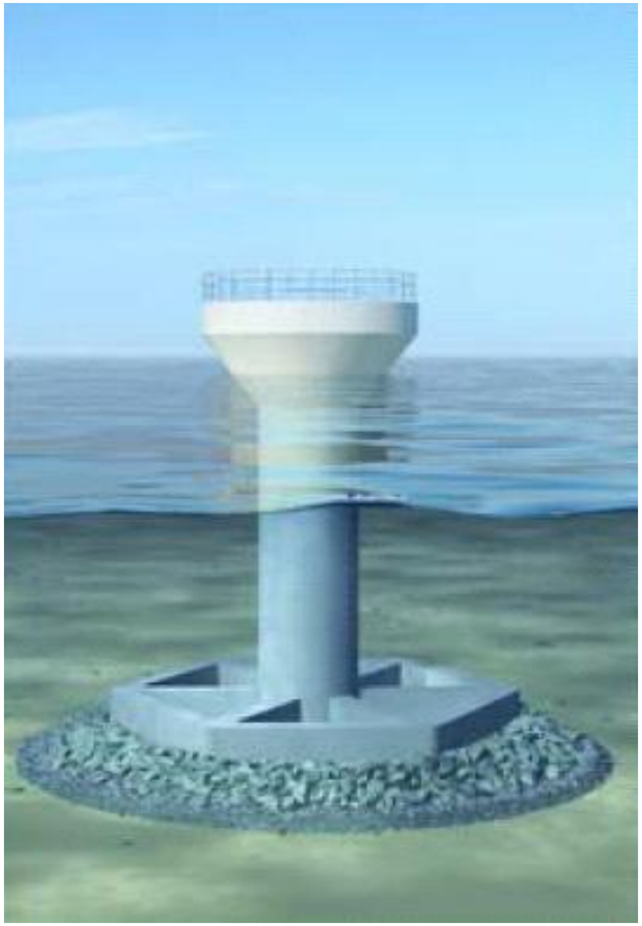
S. Petersen (Ramboll Wind, Denmark)

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. 200-300
tons



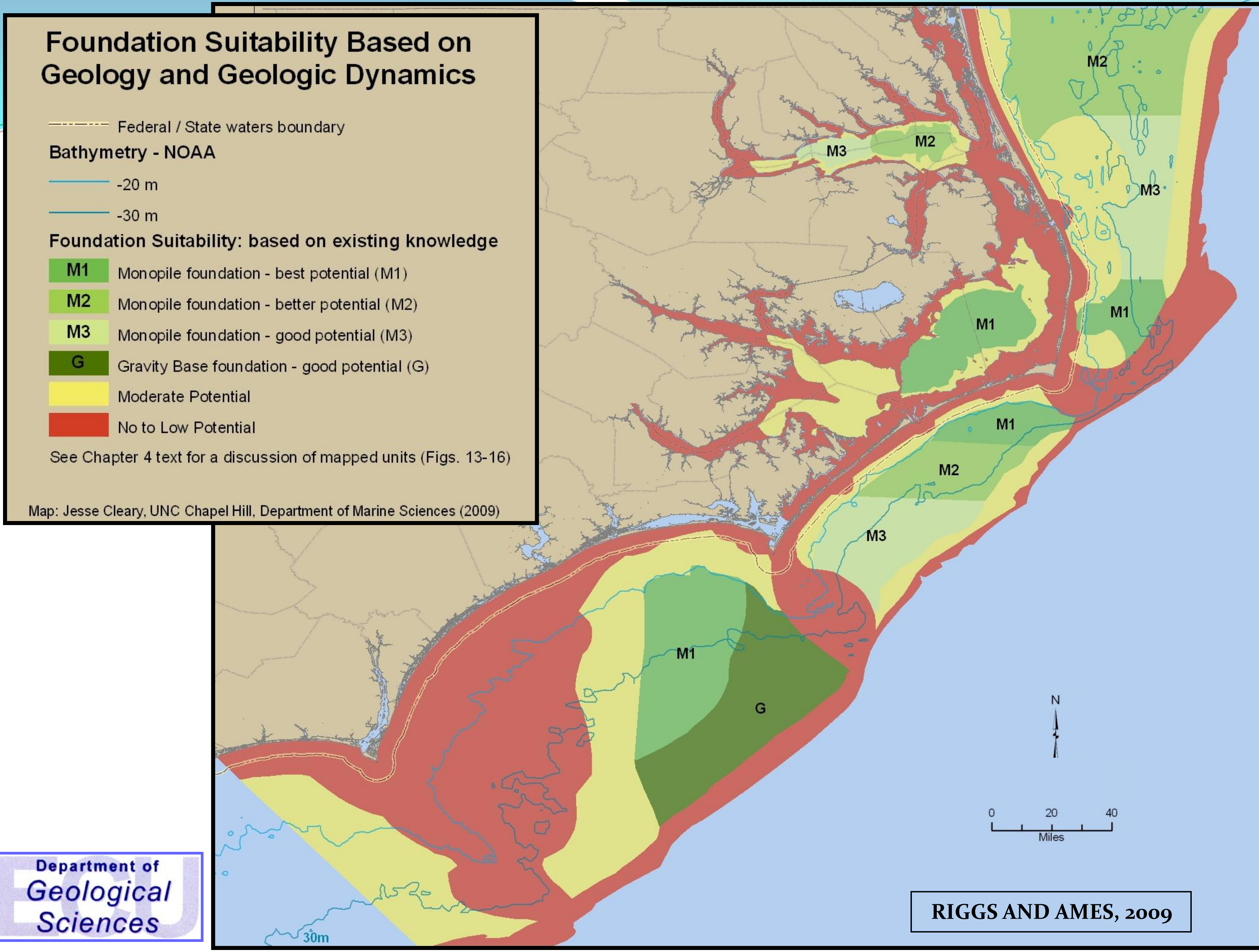
Open gravity-based structure without ballast and at water depth of approximately 20 meters. The design shown includes an ice deflection cone. 2000-5000 tons

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



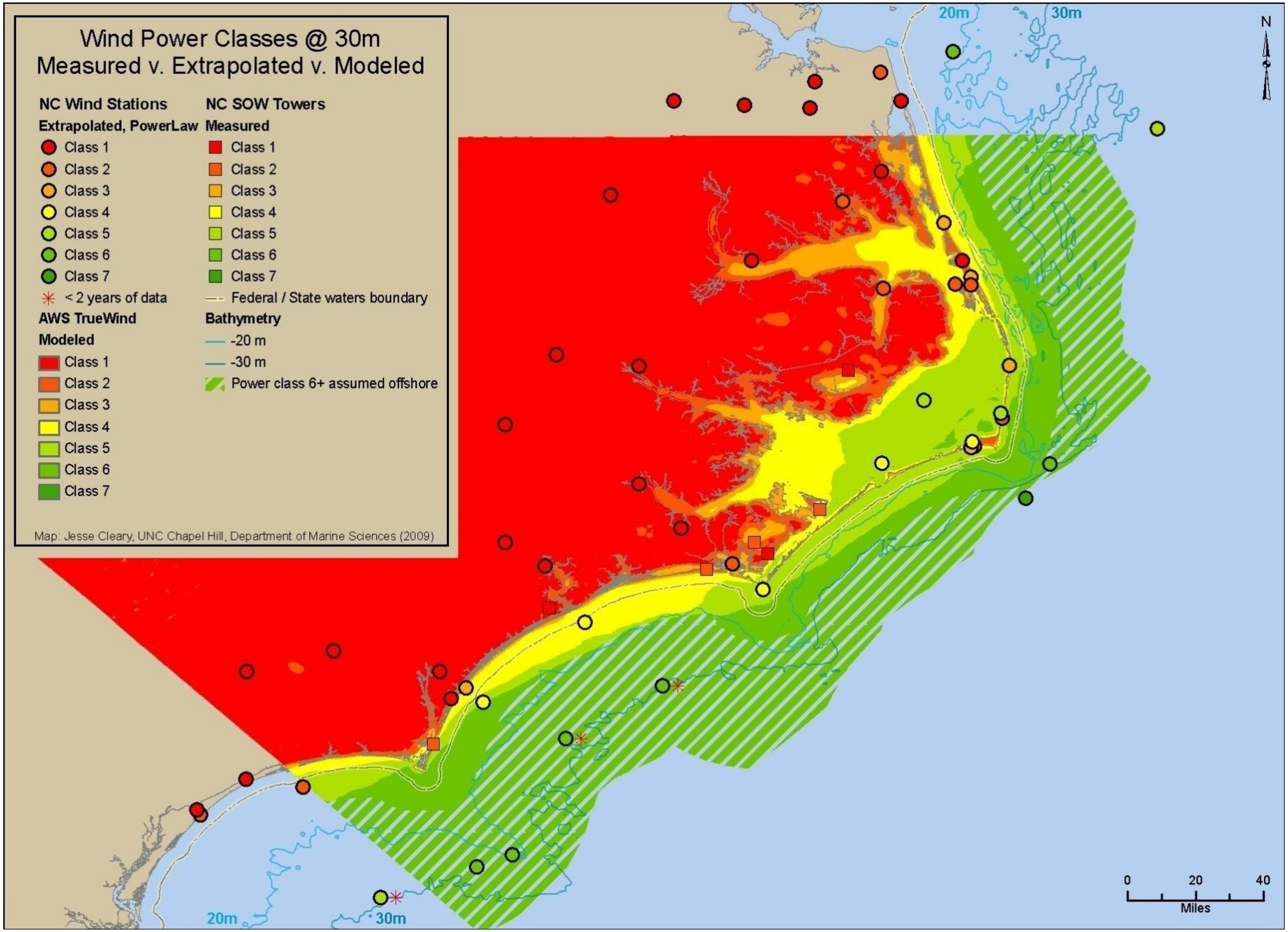
Department of Geological Sciences

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
- Found Truewind product to be biased high, worst at low wind speeds but still have favorable offshore wind

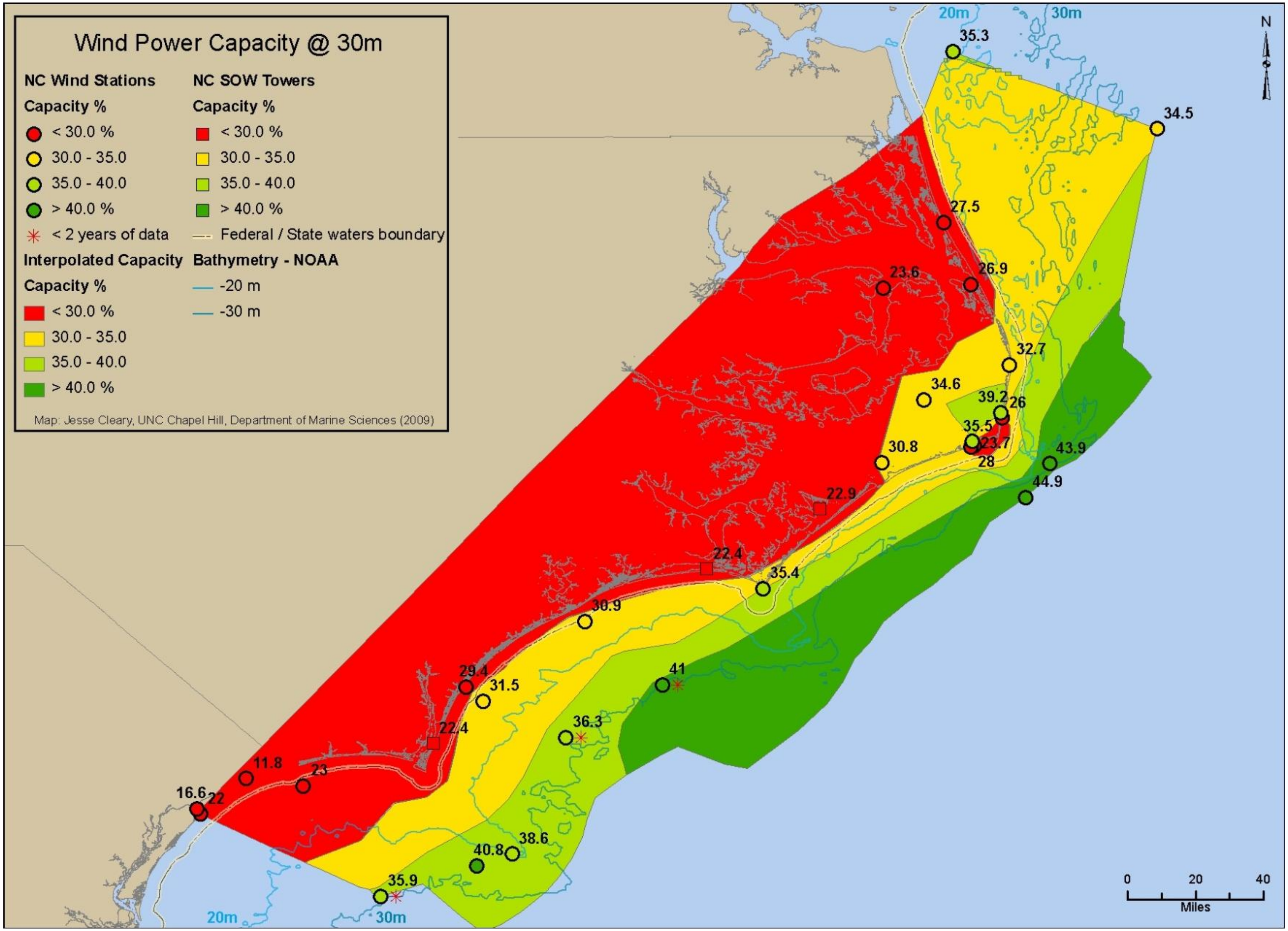
Wind Power Class



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 are 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



Ecological impacts, synergies, use conflicts

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

- Risk to birds, bats, and butterflies and the loss or fragmentation of their terrestrial habitat
- Risk to marine mammals, sea turtles, fish, and bottom-dwelling invertebrates
- Synergies with other ecosystem services
- Conflicts with military, mining, cultural, and ocean dumping uses

Procedure for estimating risk

Interview experts, managers, bird watchers, fishermen, and duck hunters:

- 54 in-person interviews
- 5 phone interviews

Review relevant literature:

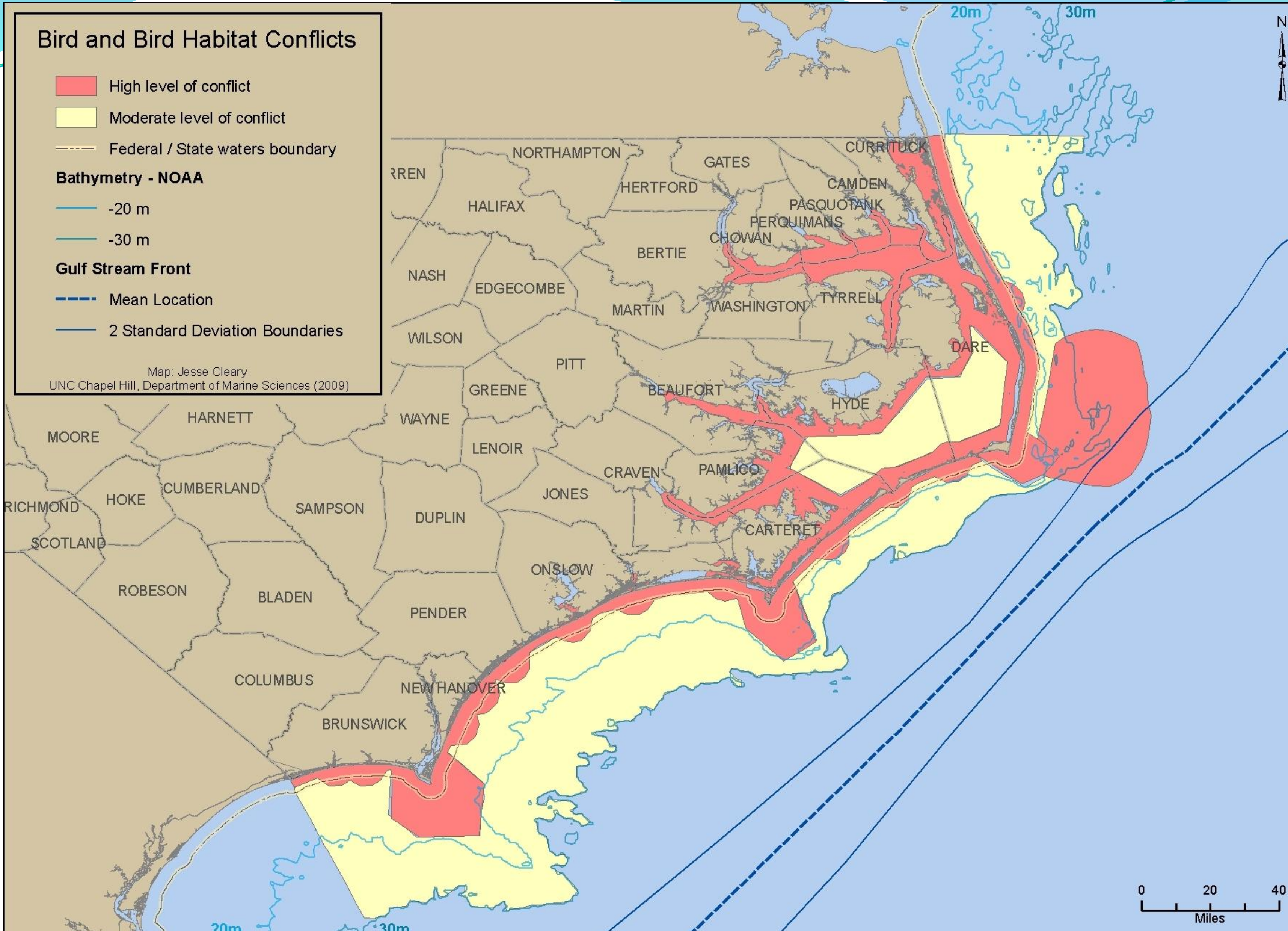
- 21 environmental assessments
- 21 government reports
- 40 peer-reviewed articles
- 14 unpublished manuscripts

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

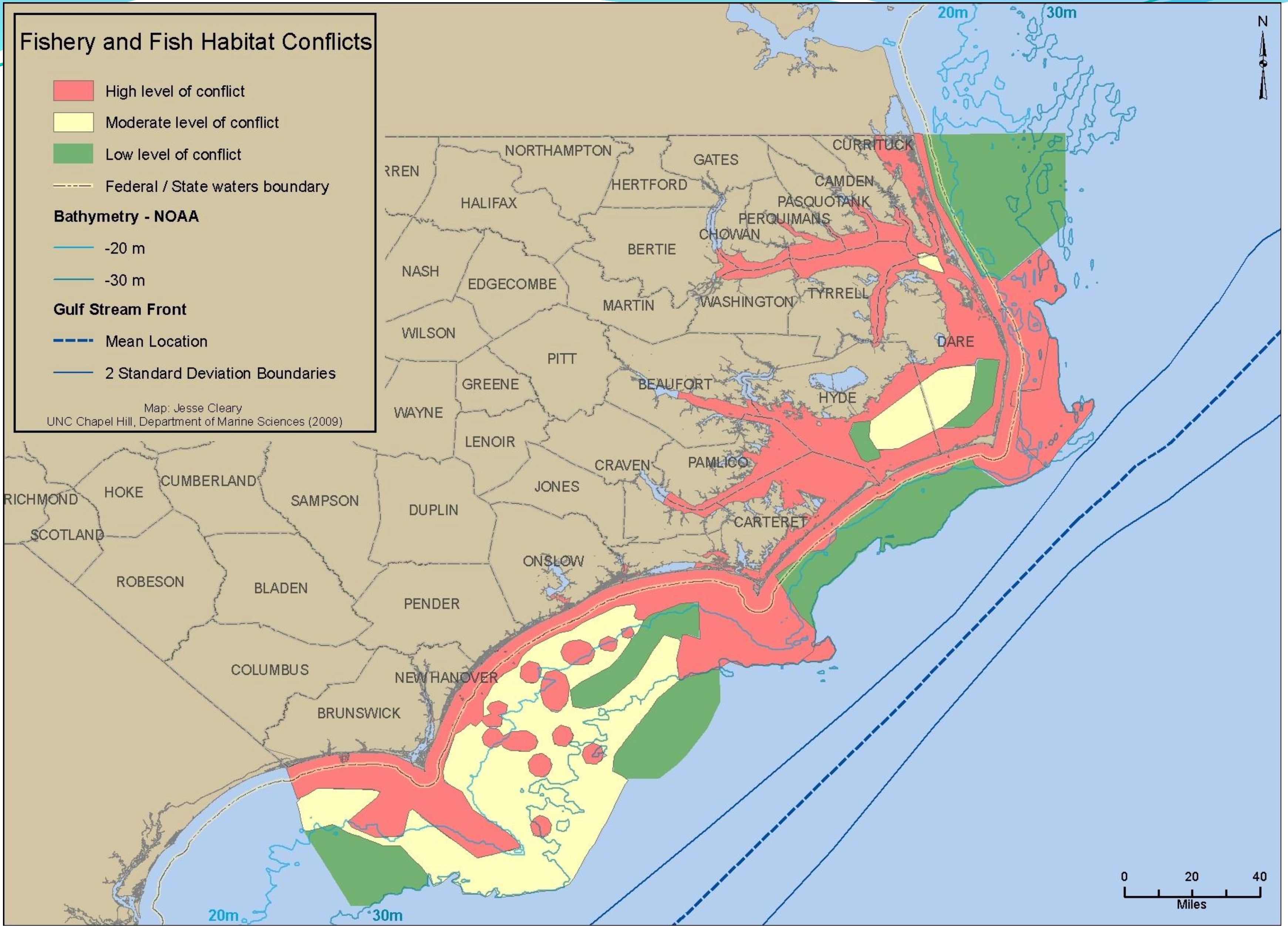
Estimation of risk:

- 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 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
DARE
PITT
GREENE
BEAUFORT
HYDE
WAYNE
HARNETT
MOORE
LENOIR
CRAVEN
PAMLICO
JONES
CUMBERLAND
HOKE
RICHMOND
SAMPSON
DUPLIN
CARTERET
SCOTLAND
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)
- Intense fishing uses
  - Trawling (shrimp, crabs, flounder)
  - Dredging (scallops, oysters)
  - Long hauling (various fishes)
- High productivity regions
  - Gulf Stream, three Capes, all inlets, the “Point”
  - All inlets with 5 mile radius from centerpoint



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
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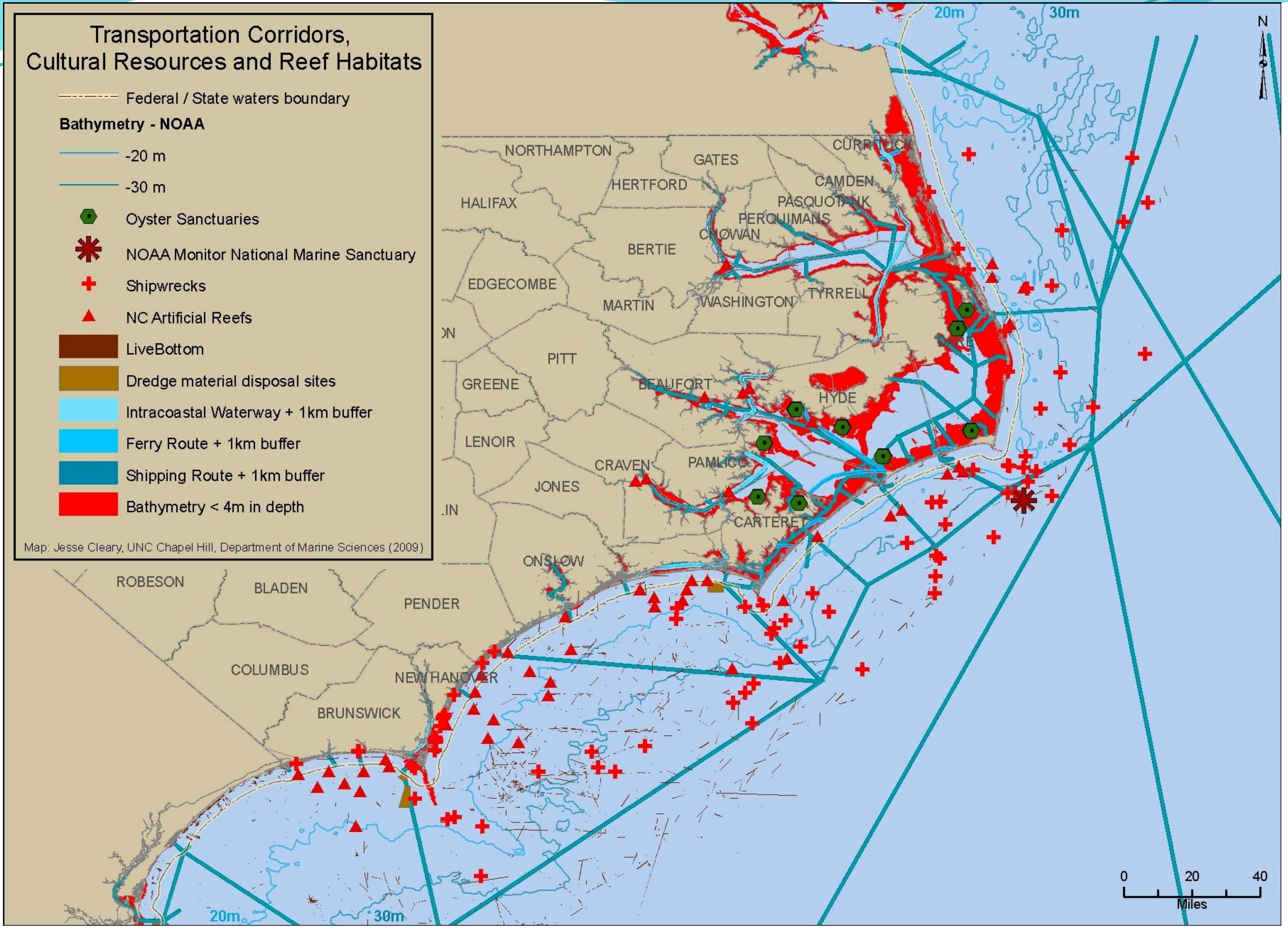
DUPLIN
SCOTLAND
ONSLOW
ROBESON
BLADEN
PENDER
COLUMBUS
NEW HANOVER
BRUNSWICK
0
20
40
Miles

Navigation Corridors, Cultural Resources, Reef Habitats

- All marked navigation channels (ferries, shipping, intercoastal waterway), 1 km buffer on each side
- Shipwrecks, including Monitor National Marine Sanctuary
- Artificial reefs, live bottom and oyster sanctuaries
- Dumping sites
- Areas of National Park Service sensitivity to viewscape impacts (e.g., near lighthouses)


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
PASQUOTANK
HALIFAX
PERQUIMANS
CHOWAN
BERTIE
EDGECOMBE
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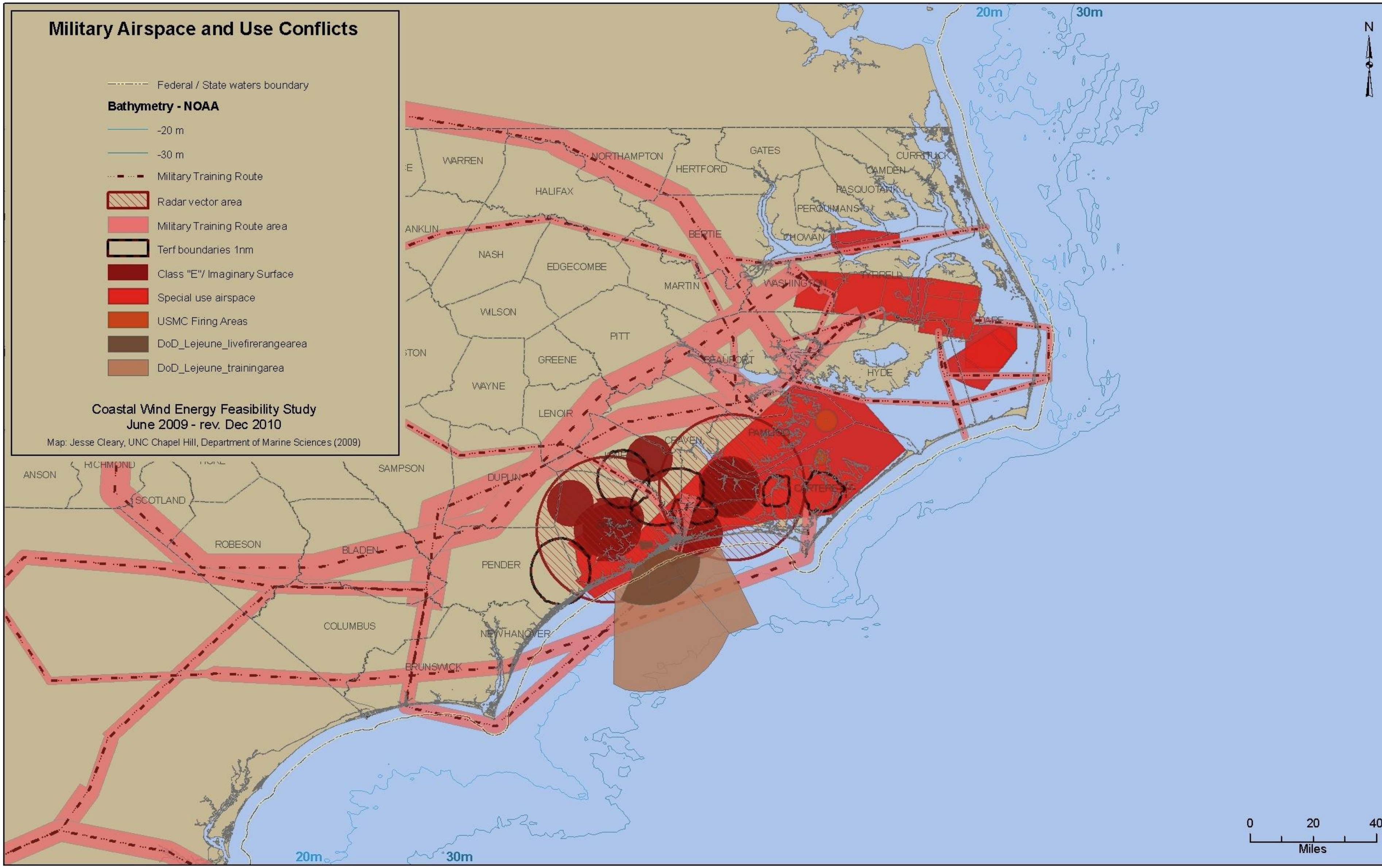
ROBESON
BLADEN
PENDER
COLUMBUS
NEW HANOVER
BRUNSWICK
20m
30m
N
0
20
40
Miles

Military Conflicts

- Special use airspace
- Training routes
- Radar vector areas
- USMC firing ranges
- Training areas (new as of Dec. 2010)



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
DoD_Lejeune_livefirerangearea
DoD_Lejeune_trainingarea
Coastal Wind Energy Feasibility Study
June 2009 - rev. Dec 2010
Map: Jesse Cleary, UNC Chapel Hill, Department of Marine Sciences (2009)
20m
30m
N
WARREN
NORTHAMPTON
HERTFORD
GATES
CURRITUCK
CAMDEN
PASQUOTANK
PERQUIMANS
HALIFAX
BERTIE
CHOWAN
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BLADEN
PENDER
COLUMBUS
NEW HANOVER
BRUNSWICK
0
20
40
Miles

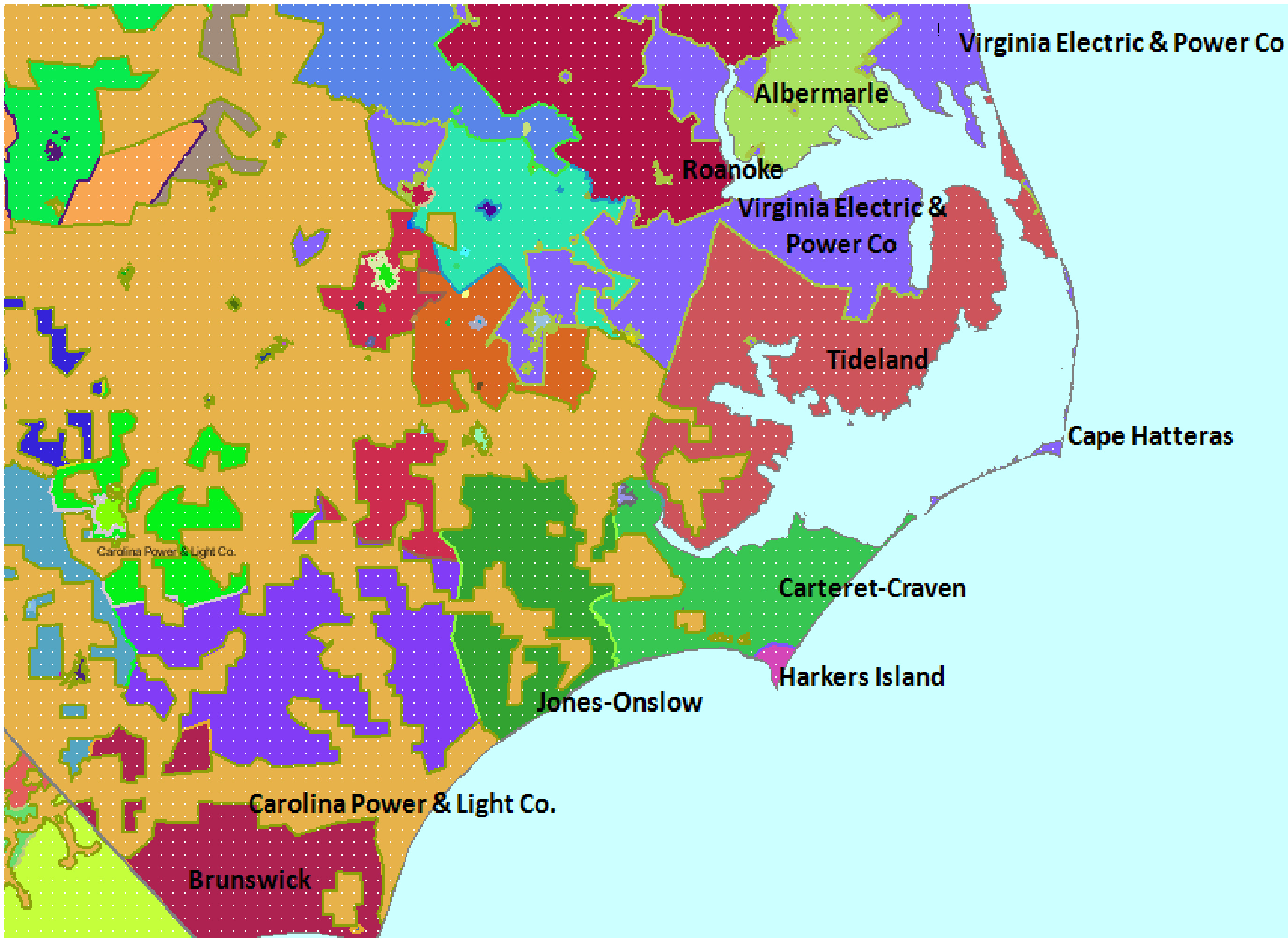
Utility Transmission Infrastructure

K. Higgins, Energy Strategies, Salt Lake City

Caitlin Collins, Energy Strategies, Salt Lake City

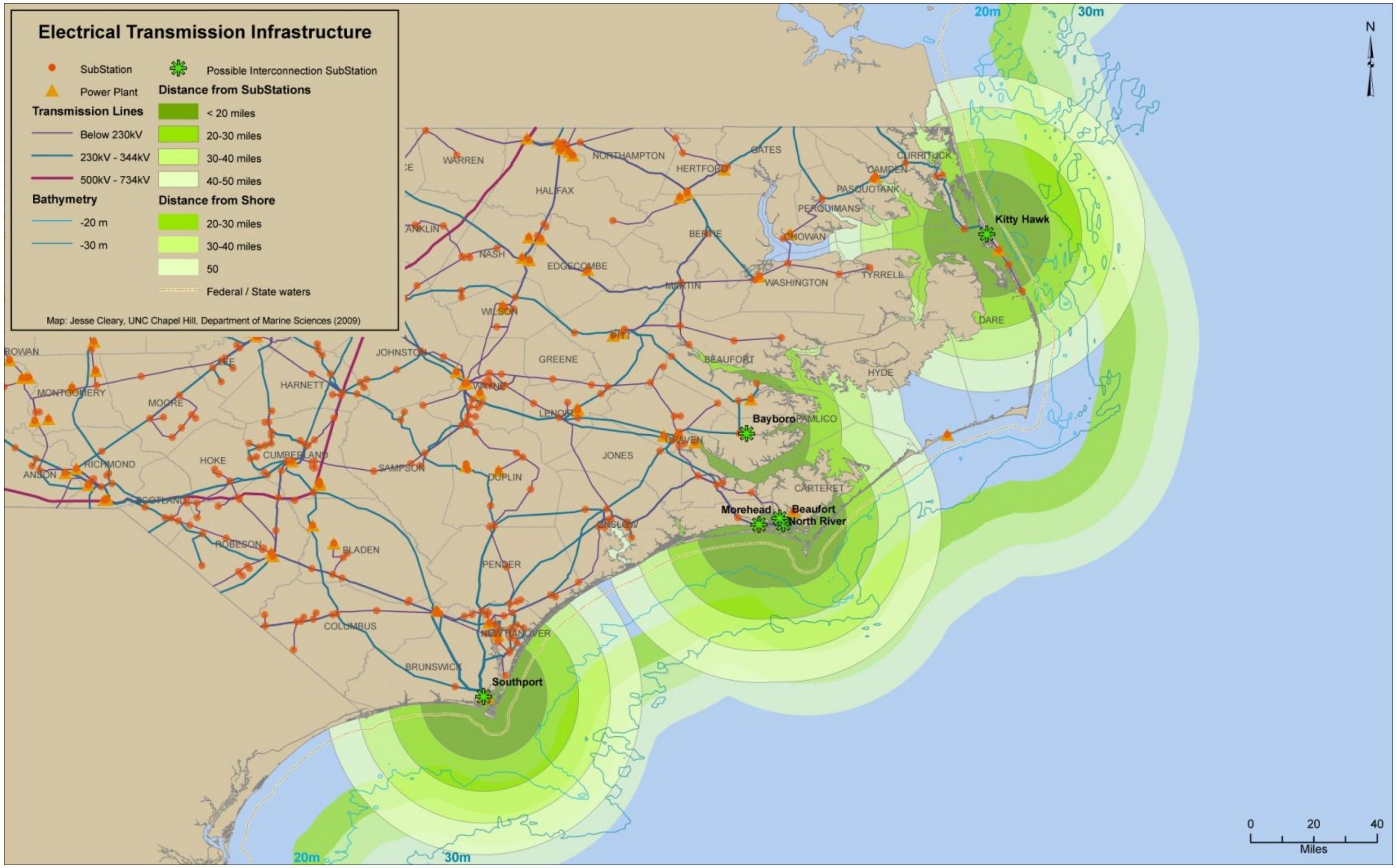
- Assessment of the transmission infrastructure along the coast of North Carolina
- Ability of transmission infrastructure to absorb large-scale offshore wind projects

Electric Services Territories



Source: Platts Energy Advantage

Transmission Lines and Substations



Synthesis

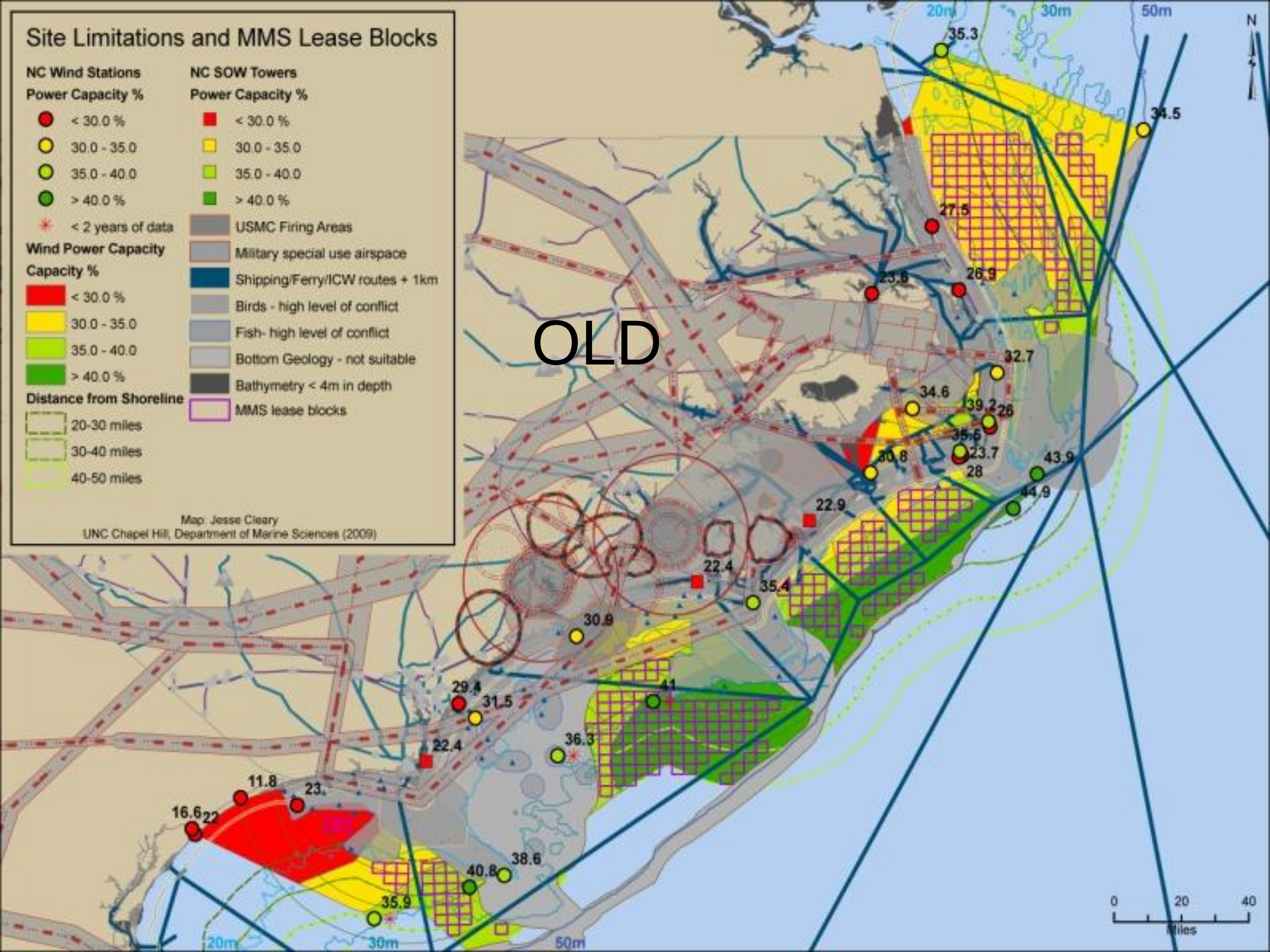
Methodology (Marine Spatial Planning)

- 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.

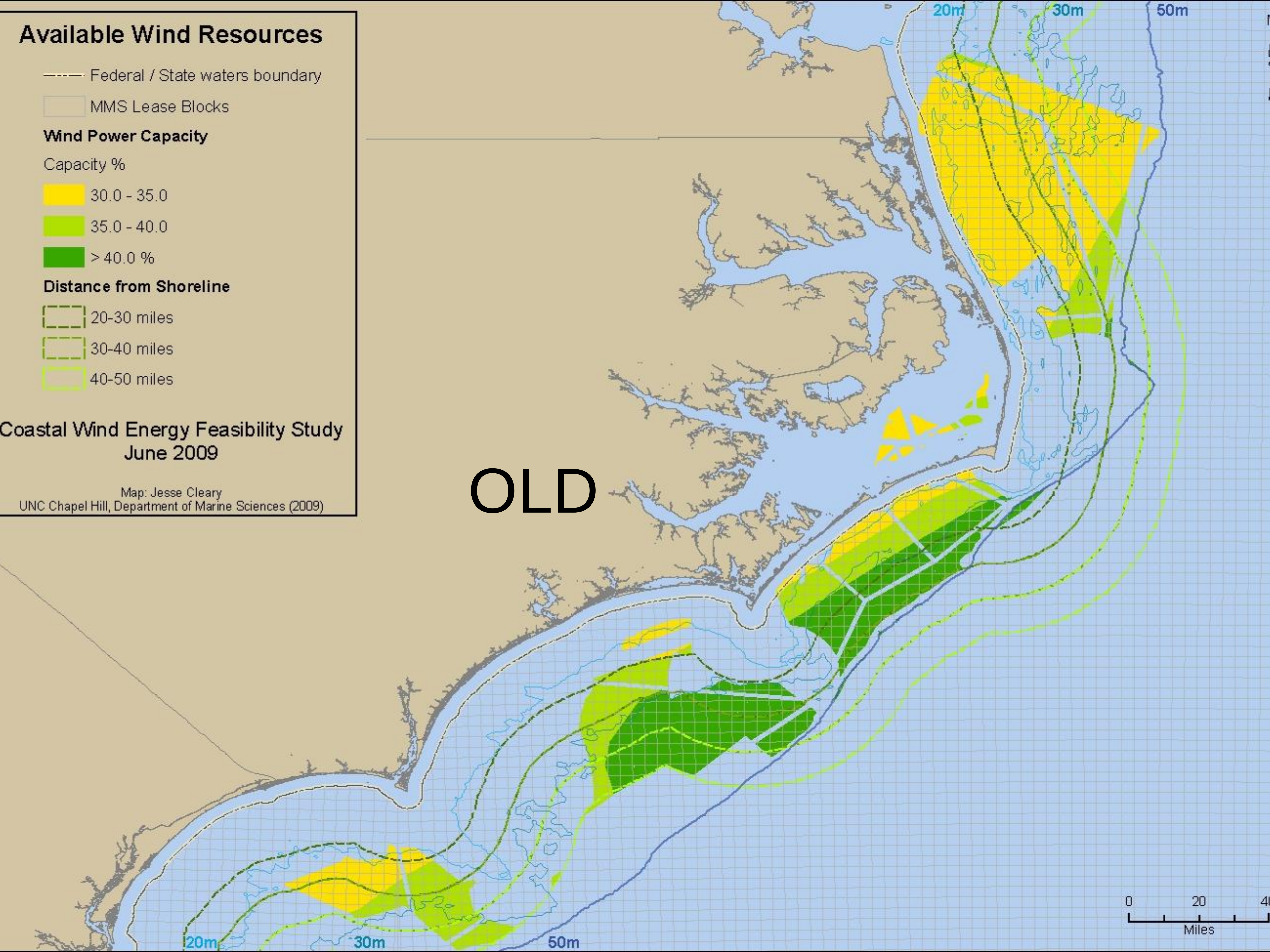
Synthesis

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.



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
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
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
Map: Jesse Cleary
UNC Chapel Hill, Department of Marine Sciences (2009)
OLD
20m
30m
50m
N
Miles
0
20
40


Available Wind Resources
Federal / State waters boundary
MMS Lease Blocks
Wind Power Capacity
Capacity %
30.0 - 35.0
35.0 - 40.0
> 40.0 %
Distance from Shoreline
20-30 miles
30-40 miles
40-50 miles
Coastal Wind Energy Feasibility Study
June 2009
Map: Jesse Cleary
UNC Chapel Hill, Department of Marine Sciences (2009)
OLD
20m
30m
50m
0
20
Miles

Findings

Large areas offshore

- 2800 square miles (311 MMS lease blocks)
  - less than 50 m deep, within 50 miles of the coastline
  - Raleigh and Onslow Bay appear most promising
  - Over the shelf north of Cape Hatteras does not appear as favorable, but lack data
- If all developed, could support 55,000 MW nameplate capacity (average output 130% of total NC use in 2007)
- Developing 45 MMS blocks= 20% of total NC power demand in 2007

Questions