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Analyzing offshore wind collaboration opportunities for North and South Carolina

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Abstract

Due to the strong presence of wind resources in the South Atlantic, the Carolinas have emerged as the new frontier in the development of offshore wind energy. The two states have moved in parallel, completing research and establishing committees to explore their offshore wind potential. This paper presents the opportunities and challenges for the Carolinas to collaborate in offshore wind energy planning. This is done using a three-part approach. First, the paper reviews existing scientific literature to describe the case for interconnecting wind farms. Secondly, it analyzes the existing policy frameworks of the federal government and the two states. Lastly, it demonstrates the utility of marine spatial planning and ArcGIS in siting offshore wind farms, transmission lines and aiding in collaboration.

This paper concludes that in order to move forward with stronger collaboration the Carolinas must streamline the policy realm, shift towards a regional perspective, increase marine spatial planning initiatives, develop economic incentives and further involve stakeholders. With respect to marine spatial planning, this study includes a sample GIS analysis that provides three transmission configurations for the Carolinas. These include i.) a backbone parallel to shore ii.) a backbone with onshore injection at Georgetown and North Myrtle Beach, SC and iii.) a radial configuration that considers Department of Defense exclusions.

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I. Introduction

In the face of increasing energy demands and evidence for climate change, the United States seeks to expand its renewable energy sources. Amongst the renewable sources, wind energy continues to demonstrate the highest growth rate (Renewable & Alternative Fuels: Wind, 2011). Wind has been developed onshore throughout the United States, but much of the country's most valuable wind potential lies offshore (Dennis Elliott, 2011). The U.S. has begun planning the use of the vast offshore wind potential for New England and the Mid-Atlantic. The states in these regions have not only selected wind energy areas (WEAs) for potential development, but also have initiated plans for their connectivity through the Atlantic Wind Connection (AWC) project (Renewable Energy: State Activities, 2012). However, many development and transmission projects, including the AWC project, end at the Virginia/North Carolina border (The Atlantic Wind Connection: A Bold Plan That Makes Sense, 2011). The wind potential of the Atlantic continues beyond this boundary (Dennis Elliott, 2011), and the South Atlantic's wind potential warrants development. Because of its vast potential, the South Atlantic has emerged as the new frontier in offshore wind energy planning for the United States.

According to a 2011 report by the National Renewable Energy Laboratory (NREL), the South Atlantic Bight contains up to 190.7 GW of wind potential, with 70% of that potential occurring in waters less than 30m in depth (Dennis Elliott, 2011). Within the South Atlantic, North Carolina and South Carolina hold 33% of the east coast's wind resources within 50 miles of their shoreline. This vast potential should attract investment by utilities and businesses to develop the resource in the region (Shannon Helm, 2011). Because of their wind resources and infancy in offshore wind development, North Carolina and South Carolina will be the research focus of this paper. More specifically, this paper seeks to address the potential for collaboration in offshore wind development between the Carolinas. This concept will be analyzed in three sections. First, this paper will describe the case for wind farm interconnection more generally, citing existing scientific research as evidence. Secondly, it will analyze the existing law and policy framework utilized in planning offshore wind energy, and discuss the political climates of the two states. Lastly, it will explore the role of marine spatial planning and demonstrate planning methodology using ArcGIS.

II. The Rationale for Interconnecting Wind Farms

Under the current framework, offshore wind energy in the United States is planned on a state-by-state basis under a Federal framework outlined by the Bureau of Ocean Energy Management (BOEM). The details of the legal context will be further discussed in the next section of this paper. However, the focus on state-by-state development has important implications for the scale of offshore wind planning in the Atlantic. Perhaps we should not be thinking about our wind resources at a scale of individual states, but instead consider larger planning areas to maximize efficiency and economic benefit. It has been suggested that by interconnecting wind farms and integrating larger areas, we can ensure the most efficient use of our wind resources (Milligan & Factor, 2000). The idea of integrating large catchment basins is not a novel one, and decades of research have provided evidence for the advantages of large-scale wind development.

The interconnection of wind farms seeks to address one of the largest obstacles to wind development, intermittency. Intermittency makes wind difficult to integrate into an existing power grid, dramatically reducing the market value of wind (Archer & Jacobson, 2007). A 2010 study summarizes the issue by saying: "As wind power becomes a higher proportion of all generation, it will become more difficult for electric system operators to effectively integrate additional fluctuating power output" (Kempton, Pimenta, Veron, & Colle, 2010). Kempton and his colleagues go on to describe the four ways to deal with fluctuating wind resources. These include: (i.) Expand the use of existing control mechanisms (reserve generators, redundant power lines etc.); (ii.) build energy storage; (iii.) make use of distributed storage loads and (iv.) combine remote wind farms via electrical transmission (Kempton, et al., 2010). The focus of this paper will be on the connection of wind farms via electrical transmission. The earliest study of wind farm interconnection comes from a 1979 study by Edward Kahn. He determined that increases in the area under consideration increase the reliability of the wind farm (Kahn, 1979). This is the fundamental finding that provides the argument for integrating wind farms.

Kahn's findings are supported by research in two contexts, onshore wind and European wind development. In the onshore context, a study in Iowa sought to optimize the geographic distribution of wind plants while achieving maximum economic benefit and reliability. They found that geographic spread of wind generators not only provides a smoothing benefit in terms of power output, but also yields the greatest economic benefit (Milligan & Factor, 2000). In the European context, a study concluded that "the fluctuations decrease with an increased number of turbines, since their production is never entirely correlated", and that short-term fluctuations are decreased even in small areas by increasing the number of turbines associated with the wind farm (Czisch & Ernst, 2001).

In recent years, studies specific to the offshore context have analyzed interconnection in greater detail, and found that it can provide a series of advantages. A 2010 study found that interconnection could lead to output that fluctuates more slowly. These slower output fluctuations allow other generators or transmission to be ramped up with plenty of time to compensate for wind's intermittency. Moreover, they suggested that if more fully integrated, wind power would be easier to manage, higher in market value, and capable of being a higher portion of electric generation (Kempton, et al., 2010). This was supported by a 2012 study that selected four wind areas for their synergistic meteorological characteristics and modeled the effects of integrating them. They found that interconnecting them reduced no-power events from 9% to 4%. They also found that substantial reductions in low/no-power hours can be made by interconnecting wind farms approximately 450 kilometers apart (Dvorak, Stoutenburg, Archer, Kempton, & Jacobson, 2012). These findings support the notion that extensive interconnection will reduce the intermittency of wind power. These studies also crucially noted a few general benefits of transmission. Transmission is far more cost-effective than utility-scale electric storage (such as pumped hydro) (Kempton, et al., 2010) and extensive offshore transmission lines could bypass onshore congestion in existing terrestrial transmission systems (Dvorak, et al., 2012). These benefits are emphasized in a 2012 study that states, “Scenarios with penetrations of wind energy up to 30% were feasible if long-distance and high-capacity transmission infrastructure was constructed to improve balancing area cooperation” (Hart, Stoutenburg, & Jacobson, 2012). Transmission is a key component of successful wind energy development on the Atlantic coast.

Although transmission provides some of the greatest opportunities for offshore wind, it also provides some of the largest challenges. Where do we site transmission lines so they do not interfere with other ocean uses? How should we connect our wind farms? Where should these transmission lines come onshore? These problems are primarily spatial in nature, and thus, marine spatial planning (MSP) can be a crucial tool in beginning to address these challenges. MSP has been shown to produce benefits when dealing with use conflicts. These include: “management efficiency, greater stakeholder involvement and outcomes that better achieve management goals” (White, Halpern, & Kappel, 2012). These benefits will allow us to plan for a transmission system that minimizes intersectoral conflicts. MSP is particularly suited for large-scale wind planning because “the value of MSP increases with the greater number of management strategies that are considered […] MSP will create, greatest benefits when done at a large scale”(White, et al., 2012).

MSP is a crucial planning tool, not only on a state-by-state basis, but also across larger regions of the Atlantic. Although the full planning of offshore wind for NC and SC is beyond the scope of this paper, the third section of this paper will introduce the utility of MSP in this context. This paper will conduct a preliminary MSP analysis for collaboration between the Carolinas. This MSP will provoke thoughts about the logistics of interconnection and demonstrate the power of MSP as a planning tool for large regions. However, before we can explore the spatial dynamics of the Carolinas, we must understand the political constraints, challenges and incentives in place. In order to gain this information, we will first explore the regulatory context of the two states.

III. The Legal Context

The Role of the Federal Government

Energy responsibilities in the United States fall under two federal agencies: the Department of Energy (DOE) and the Department of the Interior (DOI). The DOE is largely responsible for research, development, innovation and education of energy resources (Department of Energy: Mission, 2012). The most relevant group under DOE is the National Renewable Energy Laboratory (NREL). They conduct and report research on wind capacities, existing technologies and energy trends (About NREL, 2012). These data from the NREL are crucial to the regulatory process for renewables. On the other hand, within the DOI, The Bureau of Ocean Energy Management (BOEM) is the most relevant for the purposes of wind energy regulation. The BOEM "manages the exploration and development of the nation's offshore resources. It seeks to appropriately balance economic development, energy independence and environmental protection through oil and gas leases, renewable energy development and environmental reviews and studies" (About BOEM, 2012). More specifically, the BOEM is responsible for offshore renewable energy programs that grant leases, right-of-ways and easements for renewable energy activities (About BOEM, 2012).

The responsibilities of the BOEM were laid out in April 2009 in the Final Renewable Energy Framework (Renewable Energy and Alternate Uses of Existing Facilities on the Outer Continental Shelf, 2011). The framework lays out a series of specific responsibilities for the BOEM. First off, the BOEM's regulations apply to activities that: "(a) Produce or support production, transportation or transmission of energy from sources other than oil and gas; or (b) Use, for energy-related purposes or for other authorized marine-related purposes, facilities currently or previously used for activities under the OCS Lands Act" (30 C.F.R. § 585.100). These regulations are in place to carry out the BOEM's authority to ensure that activities are conducted in a safe and environmentally friendly manner (30 C.F.R. § 585.101). According to the final rule, one cannot "construct, operate or maintain any facility to produce, transport or support generation of electricity" without a BOEM permit (30

C.F.R. § 585.104). The BOEM will not only establish practices and procedures with regards to leasing but also "provide coordination and consultation with the Governor of any state or the executive of any local government or Indian tribe that may be affected by a lease, easement or ROW under this subsection" (30 C.F.R. § 585.102(e)). Building upon this, the BOEM may invite these interested parties to "join in establishing a task force or other join planning or coordination agreement in carrying out responsibilities under this part" (30 C.F.R. § 585.102(e)).

The first area of BOEM responsibility worth expanding upon is its authority with respect to leasing. All areas of the Outer Continental Shelf (OCS) are available for leasing by the BOEM (except for National Parks, National Marine Sanctuaries, National Monuments and National Wildlife Refuges) (30 C.F.R. § 585.204). The BOEM will generally issue leases on a competitive basis, but if there is no competitive interest after public notice, the leases will be issued non-competitively (30 C.F.R. § 585.200). The size of the lease will be based on the area required to accommodate the planned activities (30 C.F.R. § 585.206). The BOEM will issue two types of leases: commercial and limited. Commercial leases are intended for commercial production while limited leases are for testing, research or small pilot projects. Before issuing either type of lease, the BOEM must consult with relevant federal agencies, the Governor of any affected state, the executive of any affected local government and any affected Indian Tribe (30 C.F.R. § 585.203).

The Renewable Energy Framework outlines a specific process for the selection of leasing areas. First the BOEM will publish a Request for Interest for all areas of the OCS to gauge general interest (30 C.F.R. § 585.210). Next, the BOEM will issue a Call for Information and Nomination; this calls for indication of interest in specific areas (responses could include areas that should undergo special analysis or geological considerations for example). Next, the BOEM moves into Area Identification. This involves identifying areas for environmental analysis and consideration for leasing. The BOEM selects areas in consultation with appropriate federal agencies, states, local governments, affected Indian tribes and other interested parties. Once areas have been selected, and comment periods have passed, the BOEM will publish a Proposed Sale Notice; receive comments, and then a

Final Sale Notice*.* Public comments are considered in final sale terms (30 C.F.R. § 585). As an alternative to the BOEM-selected areas, interested parties may also submit an unsolicited request for a commercial or limited lease under part 585.230 of the Framework. If this is the case, the BOEM will issue a public notice of the request to determine if competitive interest exists. If competitive interest exists, the framework above is followed. If not, the party with the unsolicited request may be granted the lease non-competitively (30 C.F.R. § 585.231).

The BOEM is also responsible for planning and granting right-of-way (ROW) and right-of-use and easement (RUE) grants. "An ROW grant authorizes the holder to install on the OCS cables, pipelines, and associated facilities that involve the transportation or transmission of electricity or other energy product from renewable energy projects" (30 C.F.R. § 585.300(a)). Similarly, "An RUE grant authorizes the holder to construct and maintain facilities or other installations on the OCS that support the production, transportation, or transmission of other energy product from any renewable energy source" (30 C.F.R. § 585.300(b)). ROW and RUE grants are considered on a case-by-case basis and they may be issued competitively or noncompetitively, depending on interest (30 C.F.R. § 585.306).

The crucial point in outlining leasing procedures is that the BOEM has control over leasing, most importantly area selection. The BOEM has the ultimate authority in planning offshore wind areas, but their decisions are often guided by state advice. It is the BOEM's responsibility to seek out state advice. The BOEM collaborates with the states in three ways: revenue sharing, public comment and task forces. Revenue sharing only takes place if the states are within 15 nautical miles of the project (30 C.F.R. § 585.542). Public comment is available to the states throughout the regulatory process. However, this right is not unique to the states (30 C.F.R. § 585). State task forces are the most significant method of collaboration between the federal government and the states. These task forces are instrumental in shaping offshore wind planning in the Atlantic.

State task forces fall under the "Smart from the Start" initiative, which allows us to think about the implementation of the Renewable Energy Framework in practice. Secretary of the Interior Ken Salazar launched the "Smart from the Start" initiative in 2010 (Kendra Barkoff, 2010). The goals of the program are to "allow us to identify priority Wind Energy Areas for potential development, improve our coordination with local, state and federal partners, and accelerate the leasing process" (Kendra Barkoff, 2010). Wind Energy Areas (WEAs) are offshore locations that appear to be the most suitable for offshore wind development. The identification of WEAs will allow focused data collection to better inform industry and government, leading to more efficient processing and permitting (Kendra Barkoff, 2010). In order to determine WEAs, State-Federal task forces are set up in coastal states interested in their offshore wind resources. The initiative also emphasized moving forward "aggressively, on a parallel track, to process applications to build offshore transmission lines" (Kendra Barkoff, 2010). The overarching goal of the initiative is to spur the development of offshore wind in the Atlantic, primarily through the use of task forces.

The task forces expedite the leasing framework by: (i) identifying WEAs, (ii) "organizing, financing and implementing the gathering of information from key agencies regarding the environmental and geophysical attributes and other uses of the WEAs; and (iii) assembling that information in a publically available format that potential investors and applicants can access and BOEMRE can use in evaluating lease sales in the WEAs" (Overview: Offshore Wind Energy Development off the Atlantic Coast, 2010). The members of these task forces come from federal, state, local and tribal government but they have no interstate representation. Although NGOs and public observers are not members of the task forces, they are often in attendance at task force meetings (Overview: Offshore Wind Energy Development off the Atlantic Coast, 2010). These task forces remain one of the main drivers in analyzing and selecting areas for wind energy, and are advisors to the BOEM on the area selection portion of the leasing process.

Once task forces and the BOEM have selected WEAs, the BOEM will prepare environmental assessments (EAs) for the WEAs. These EAs aim to determine the foreseeable consequences if the BOEM was to issue leases within the WEA (Overview: Offshore Wind Energy Development off the Atlantic Coast, 2010). BOEM EAs are only preliminary and further NEPA assessments will be conducted before the development of the region. More specifically, NEPA assessments are conducted with the submission and processing of Site Assessment Plans as well as Constructions and Operations Plans (Overview: Offshore Wind Energy Development off the Atlantic Coast, 2010). Thus, the selection of a WEA does not guarantee its development. However in selecting the WEAs, the “Smart from the Start” initiative gives the states considerable power in development planning. With this power dynamic in mind, we can discuss the state-specific frameworks and the regulatory climates of North and South Carolina.

The Role of North Carolina

Stakeholder meetings with the BOEM and NC began in 2010 when the BOEM emphasized its commitment to work with states in identifying their leasing areas. The BOEM and NC share the goal of wanting to utilize inter-agency planning activities to encourage compatible multi-use and coordinate with all stakeholders (Jessica Bradley, 2010). The first step in NC’s offshore wind planning was research. The NC general assembly requested a wind study, which was conducted at the University of North Carolina-Chapel Hill in 2009 and 2010. The study focused primarily on Pamlico and Albemarle sounds. It studied waters out to 30 meters in depth but measured wind potential out to 50 meters. The study explored a variety of subjects including: wind farm layout, foundation alternatives, geology, wind resource evaluation, ecological impacts, use conflicts, risk estimation, critical fish habitats and fishing use, military conflicts, and transmission infrastructure. The collected information was then integrated into a geographical information system and marine spatial planning (MSP) techniques were employed. The spatial analysis emphasized identifying any severe constrains that could lead to no-build areas. Even with the consideration of constraints, the spatial analysis found that large offshore areas of NC are well suited for wind energy development (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, 2009).

In the wake of these findings, Governor Perdue of NC requested the creation of a Renewable Energy Task Force for the state by issuing Executive Order 96. The

Task Force was to consist of 15 members appointed by the Governor. Each member would bring a specific skill set or area of knowledge to the Task Force. The primary stated purpose of the NC Task Force was to study the economic costs and benefits of developing the offshore wind industry. More specifically, the Task Force should study the benefits of the state establishing a non-binding goal of developing 5,000 MW of wind energy by 2030. They would also examine existing laws and regulations in NC and other states to determine the necessary policy framework. Additionally, the order stated the Task Force would identify potential benefits and incentives for communities in which wind industry development will take place. Lastly, they would create guidelines that provide information on viable areas for offshore wind development. All of their findings would be reported back to the governor (Perdue, 2011). Though seemingly useful in its construction, the task force designed by Governor Perdue was never appointed, leaving NC state efforts somewhat fragmented.

In parallel to efforts by Perdue, a governmental task force for NC was established by the BOEM. The first NC Task Force meeting was held in January of 2011 to discuss the basics of the Task Force's relationship with the BOEM. The NC Task Force serves as a mechanism for the BOEM to share information and for interested parties (including states) to provide meaningful and timely input. The NC Task Force cannot alter the leasing process but it can provide input on its implementation and this input will be considered in leasing decisions. The Task Force is coordinated by the BOEM through an adopted charter and its membership is dynamic. The NC Task Force has opportunities for input in: the preparation of required BOEM notices and announcements, scoping and commenting on NEPA documents, identification of data gaps and information needs, development of protocols, lease terms and conditions, and mitigation measures (Pless, January 19, 2011).

The NC Task Force has met 4 times since its first meeting in January 2011 (Renewable Energy State Activities: North Carolina, 2012). These meetings bring forth new research and policy updates (highlight new guidance documents etc.). The primary purpose of the meetings is to review and discuss concerns from Task Force members with the ultimate goal of identifying areas for feasible wind development (BOEMRE North Carolina Task Force Meeting Update, May 11, 2011). Examples of topics discussed and considered in NC meetings include: wind technology development, risks to birds, US Coast Guard issues, Department of Defense exclusions, and National Park Service concerns. However, more recent meetings have focused on navigation concerns, the use of Automatic Identification System (AIS) data and viewshed oppositions (Renewable Energy State Activities: North Carolina, 2012). Through these meetings, the Task Force has selected 5 preliminary planning areas for further research in NC, not yet official WEAs under the BOEM. In December of 2012, three of these areas were selected as call areas and a Call for Information and Nomination was published in the Federal Register (Renewable Energy State Activities: North Carolina, 2012). These call areas will be utilized in the MSP portion of this paper.

Despite advances in the regulatory process with the BOEM, NC is facing several challenges with its offshore wind energy development. First off, it appears the state of NC is fragmented in its planning bodies. There is no single entity responsible for standardizing and compiling analyses. Rather, a series of groups, non-profits and academic institutions conduct research, often without collaboration or standardized methodology. The BOEM Task Forces is the closest group to a central planning entity, but membership is limited and the frequency of meetings is low. In order for NC to effectively collaborate with neighboring states, it must be collaborating internally and forming a single state voice.

Secondly, North Carolina's transmission infrastructure presents a set of unique challenges. NC does not yet have the infrastructure for "distributed generation", a system for delivering energy close to the source. Moreover, the existing infrastructure is almost entirely controlled by large utilities (Diane Cherry, 2008). These challenges require a build-up of transmission. Building transmission infrastructure near the coast creates environmental concerns in addition to traditional economic costs. However, these cost considerations are partially reconciled by North Carolina's competitive labor markets and low cost of manufacturing (North Carolina Offshore Wind Coalition: Economics, 2012). Despite these challenges, the academic and economic strengths of North Carolina allow it to continue to move forward in the development of a new offshore wind industry with great enthusiasm.

The Role of South Carolina

The first offshore wind energy initiatives in SC took place in 2005 when the SC Energy Office and Santee Cooper released a series of wind maps which demonstrated that wind energy was viable for the state of SC (Paul Campbell Jr., 2010). In 2007, the Southeast Region Offshore Wind Symposium brought together South Carolina, North Carolina and Georgia to discuss the potential for wind development in the Southeast (Southeast Regional Offshore Wind Symposium, 2007). These two events initiated the offshore renewables dialogue in SC. The first major action took place in 2008, and was entitled the Wind Energy Production Farms Feasibility Study. This project established a committee with the sole purpose of analyzing SC's potential and role in the development of offshore wind. The committee received a series of presentations on existing offshore wind research from academic institutions, as well as businesses and environmental interest groups. Based on the presentations of existing research, the committee published a final report with a series of recommendations for state action. These recommendations dealt primarily with the policy, research and state initiative needs for the development of an offshore wind industry. The report did not provide specific recommendations with respect to areas of SC that should be developed or explored further. However, it did identify the ports of Charleston and Georgetown as key areas for wind development that warrant more research (Paul Campbell Jr., 2010).

Beyond the report from the Energy Production Farms Feasibility Committee, a DOE grant in 2008 furthered offshore wind research in SC. The project involved Santee Cooper, Coastal Carolina University and the SC Energy Office and consisted of three components (Liz Kress, 2008). The first component was a buoy study for coastal South Carolina. This part of the project became titled the Palmetto Wind Project and its primarily goal was to collect wind, wave and current data for offshore SC (Santee Cooper: Wind Power, 2012). The second part of the DOE grant created the State Regulatory Task Force (also known as the Regulatory Task Force for Coastal Clean Energy), which operates under the State Energy Office and continues to be a major player today. The goal of the State Task Force is to cultivate a regulatory environment conducive to offshore renewable development in state waters. It is populated by federal and state agencies, private industry, utilities and universities (SC Energy Office: Regulatory Task Force for Coastal Clean Energy, 2012). The State Task Force works in parallel to the BOEM Task Force, hoping to achieve similar goals, but working exclusively in state waters. The third part of the DOE grant funded a transmission study out of Clemson University. The study looked at the feasibility of utility scale electric production from wind for Horry and Georgetown counties. The study found that adequate wind resources exist close to shore and in areas with reasonable depth. The study also considered technologies, siting, regulatory processes and cost, allowing SC to continue its dialogue on offshore wind (Clemson: Offshore Wind Feasibility Study, 2012). Also at Clemson, a 2009 grant is funding the construction of a Wind Drivetrain Testing Facility in North Charleston, SC. This facility will have the capability of testing drivetrain systems, full nacelles, and simulation of blade forces. The primarily goal of this project is to lower the cost of wind energy by providing a high-value and high-quality testing services within the state (Wind Turbine Drivetrain Testing Facility, 2012).

In addition to formal studies, SC has made great progress in data availability to inform spatial planning. In 2011, SC launched the Comprehensive Spatial Mapping of South Carolina Resources and Activities project (R.F. Van Dolah, 2011). This project created and gathered all available spatial datasets for SC coastal and offshore resources and activities. These data were then published in a geodatabase online, making them publicly available. On top of the Comprehensive Spatial Mapping Project, SC also launched a viewer on which the public can view existing data. This viewer is run using ArcGIS explorer. However, the viewer does not include data from the Comprehensive Spatial Mapping Project, it remains extremely basic data (R.F. Van Dolah, 2011). Despite these shortcomings, the availability of data is a great first step in encouraging site suitability analysis.

In parallel with state efforts, the BOEM has established a South Carolina Renewable Energy Task Force that is wholly governmental (includes representatives from federal, state, local and tribal governments) (Renewable Energy State Activities: South Carolina, 2012). The Task Force will move wind energy in the state forward by: identifying lead permitting authorities, timeframes associated with regulatory permitting and regulatory gaps. The first and only meeting to date of the SC Task Force took place in March 2012 (Houten, March 29, 2012). This meeting explored the existing offshore wind energy initiatives described above as well as the role of the task force in wind development.

Unfortunately, based on my research, there appears to be little collaboration between the state initiatives and Federal efforts. Despite this apparent disconnect, localized areas of SC are showing extensive enthusiasm in moving forward with wind energy. The greatest example of enthusiasm towards wind energy is North Myrtle Beach. The city of North Myrtle Beach has shown a strong desire to become an onshore injection point for offshore wind. They first demonstrated their enthusiasm by establishing the North Strand Coastal Wind Team. This team hopes to facilitate wind energy initiatives as well as partner with other pro-wind organizations throughout the development process (North Strand Coastal Wind Team, 2012). Moreover, a series of wind demonstration projects initiated by the city of North Myrtle Beach and the Chamber of Commerce have allowed the area to become acclimated to wind energy and develop strong positive perceptions about offshore wind (North Strand Coastal Wind Team: Technology and Testing Archive, 2012). To emphasize their commitment to offshore wind, the area of North Myrtle Beach, under the North Strand Coastal Wind Team, has published a business diagram, which details their plan to become a receptacle for offshore wind power (Business Diagram: A Community-Based Wind Program, 2012). This commitment to the development of an offshore renewable energy industry illustrates action at the community level within SC.

Despite the strong regional efforts, SC continues to lack a unified voice with respect to wind power. There is little evidence of state and federal interactions and local efforts remain some of the state's most powerful initiatives. To further complicate things, South Carolina does not have strong developed incentives for renewable energy; the state does not have a Renewable Energy Portfolio Standard (DSIRE, 2012). Economic incentives such as REPS are crucial in gaining investor involvement and interest. Lastly, little comprehensive spatial planning information is publically available, especially information about site suitability in offshore waters. In the next section, we will discuss challenges for the Carolinas more generally.

Regional Challenges and Shortcomings

The first problem with the status quo is that we are fundamentally looking at planning on the incorrect scale. We should be focusing on synoptic scale interconnection and not individual state development. This is supported by decades of scientific articles which identity great advantages from interconnecting wind farms and creating larger catchment basins (Kempton, et al., 2010). The need for synoptic scale integration allows us to see the shortcomings in the state task force system. Although task forces may be extremely effective for state involvement, there is no interstate representation. Planning is getting siloed by state and the development of Wind Energy Areas is not considering neighboring state's resources. This is often true in the collection of baseline data. Task forces are responsible for the collection of baseline data, however, some of this data crosses state boundaries and thus, state-specific task forces may not be the most effective at analyzing uses that expand beyond the state's waters (e.g. shipping and AIS data). The second issue with the task forces is that of strict governmental presence. By opening task force membership to representatives from NGOs and private industry, the task forces would receive expertise crucial to wind energy development that may be lost on a strictly governmental task force. The presence of non-governmental members would also allow greater stakeholder involvement and a reduction of use conflicts.

Beyond the task forces, the Carolinas face major hurdles towards collaboration. These are related to the challenges of the individual states and include: fragmented planning bodies within the states, costs of transmission and infrastructure development (both economic and environmental) and major competition between the states. If the Carolinas maintain a competitive mindset towards each other, dialogue between the two states will be nearly impossible. Lastly, there are challenges with respect to spatial planning. Mapping provides a powerful tool for collaboration and integration of large areas, yet it is vastly underutilized in the planning process. Moreover, the lack of standardized methodologies and criteria for siting wind farms and transmission infrastructure leads to a mismatch in analysis results, hindering collaboration.

Recommendations

First and foremost, the Atlantic coast should shift the scale of planning away from the state level. States should think about offshore planning in terms of regions of the Atlantic (Mid-Atlantic, South Atlantic) instead of considering only their states offshore resources. Secondly, the task forces must be integrated with one another. There are two suggested methods for achieving better integration of the task forces. The first is to have interstate representation on the task forces. Having representation from neighboring states on the task force allows for consideration of neighboring resources in large-scale planning. However, the primary challenge with this approach is it could raise concerns about proprietary information and competition (states may not want to share latest research etc.). The second method is to create a committee, which brings together all task force chairs for a particular region (e.g. South Atlantic) with BOEM representatives. The goal of this committee would be to discuss the state's individual progress and explore ways in which collaboration could be facilitated. This would include the planning and investigation of proposed transmission lines that would cross state boundaries. Larger interstate meetings between neighboring states would supplement this committee. The purpose of committee meetings would be large scale planning and informing the BOEM, while the purpose of the large interstate meetings would be to facilitate sharing of new research and technologies across state borders.

In order to align incentives and aid in collaboration, greater consideration must be allotted to the economics behind collaboration. One of the most important aspects of wind energy planning, especially in the political sector, is the economic sphere of influence. The motivation to move aggressively on offshore wind needs to come from an incentive to create a new industry. With a desire for a strong market that will create jobs across the Carolinas, the states can work together to improve development. The largest challenge facing the region is cost, but by increasing the sphere of influence we can dissipate that cost to a larger area. It is crucial to remember that there are no fuel costs associated with offshore wind. Because there are no fuel costs, the Carolinas can construct, operate and maintain their wind farms cheaply assuming labor markets remain competitive and the cost of living low. (North Carolina Offshore Wind Coalition: Economics, 2012). This will outweigh some of the costs from infrastructure development. Additionally, the Carolinas should standardize economic incentives across the two states to ensure that utilities and corporations developing in both states are facing a single economic scenario.

In thinking about how to develop transmission projects, it is useful to look to the Atlantic Wind Connection (AWC) project's strengths. The AWC is a plan for a transmission backbone that will connect New Jersey, Delaware, Maryland and Virginia. The plan is structured into a series of phases that will connect the various areas over time. The design of the phases is dynamic, allowing for the adaptation to changes in economic and political climates. The largest stakeholder in the AWC project is PJM, a major electricity provider for 13 states, including all of the states involved in the AWC. AWC maintained their focus on a single Regional Transmission Organization (RTO), knowing that the utility company is the most valuable stakeholder (Wall, 2011). The AWC is a well-designed interconnection project because it is dynamic with response to power markets, and it involves utilities, focusing on a single RTO. This well-designed project utilized marine spatial planning to design the path of the transmission backbone.

Thus, the last set of recommendations deals with marine spatial planning and data availability. Spatial data on resource use and coastal/offshore environments needs to be made publicly available. States will continue to struggle in considering surrounding states in the planning process if they do not have adequate access to regional data. With greater data transparency, states can incorporate regional knowledge into their Wind Energy Area selection and facilitate the installation of transmission lines in the future. Transparency is required not only for data but for methodology of analyses. It is impossible to seamlessly integrate planning analyses if they are individually influenced by data availability and the political climate. Working towards standardized methodology will help facilitate collaborative planning.

In beginning to explore the spatial data for SC, the case for collaboration becomes clear. From the view point of NC, the state has selected three call areas, two of which are near the SC border and are isolated from the third by a DOD Exclusion Zone. From the view point of SC, their strongest wind resources exist at the NC border and this area is most feasible for development. With this in mind, the next section will explore the spatial relationships of ocean use and natural resources in the Carolinas. This will be illustrated through a sample ArcGIS analysis for the region.

IV. The Role of Marine Spatial Planning

As previously mentioned, marine spatial planning allows us to involve various stakeholders and describe a problem in space with the ultimate goal of minimizing conflict. More specifically, MSP allows us to map ocean uses as well as natural resource data, with the ultimate goal of selecting wind energy areas with the lowest environmental and human impact. The primary goal of this section is to detail an analysis, which demonstrates methodology for wind infrastructure site selection using ArcGIS 10.1. This analysis does not represent an actual or accurate suggestion for where transmission lines and turbines should be located. Instead, it utilizes the limited existing data to illustrate the major steps required to site offshore wind farms and their associated infrastructure.

The analysis was divided into two major components: i.) The selection of suitable lease blocks for offshore wind and ii.) the selection of paths for transmission. For the first portion of this analysis, NC suitable lease blocks were assumed to be the three NC call areas, which have been identified by the BOEM. These call areas were available from boem.gov as a shapefile of polygons which represent aggregations of suitable blocks. This analysis focuses exclusively on the two NC call areas near the SC border. Selecting suitable leasing areas for SC was more complex. Because SC has not yet identified areas for wind development, the selection had to be done from scratch. The analysis was done using GIS data downloaded from the SC Department of Natural Resources and is described below.

The analysis began with a polygon layer that showed all blocks in federal waters for SC, regardless of suitability. Suitable sites were then selected from this layer using a tool developed in python. The tool (named the SC Wind Site Selector), allows the user to input criteria for suitable sites and the tool outputs a shapefile of blocks that meet the specified criteria. The user criteria were separated into two tiers. The first tier of variables/criteria dealt with areas that should be excluded from the analysis. These areas, if specified by the user, would be completely excluded from the potential sites. The tier 1 variables included: Department of Defense Wind Exclusion Zones, hard bottom areas and potential hard bottom areas. The tier 2 variables allowed the user to input ranges and cut-offs upon which to query the blocks after the exclusion of tier 1 variables. The tier 2 variables included: distance from shore (in kilometers measured from the centroid of each block), water depth (in meters), and wind power at 100m (in Watts/s^2). Figure 1 below illustrates the tool used to select SC blocks.

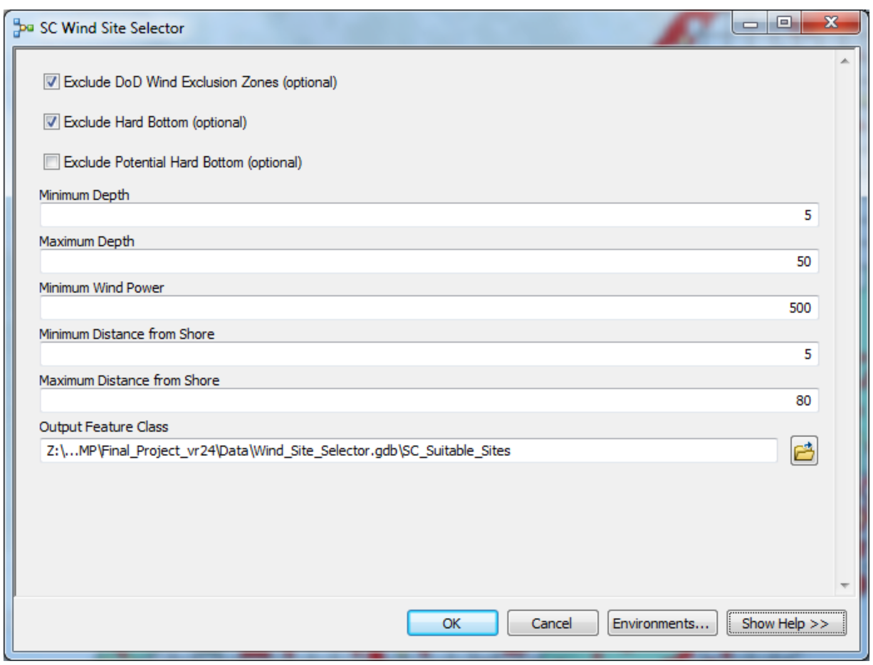

Figure 1: SC Wind Site Selector

This tool was used to select the SC blocks for further analysis. This was done with the following criteria:

- DoD Wind Exclusion Zones and Hard Bottom were excluded
- Depth was limited to areas 5-50 meters in depth, the recognized depths for use with bottom-mounted turbine foundation (Dvorak, et al., 2012)
- Distance was limited to areas 5-80 km from shore
- Wind power was limited to areas with 500 or more W/s^2 (Class 5 and higher as categorized by the NREL)

The tool was run with these criteria and placed alongside the NC call areas; this can be seen in Figure 2.

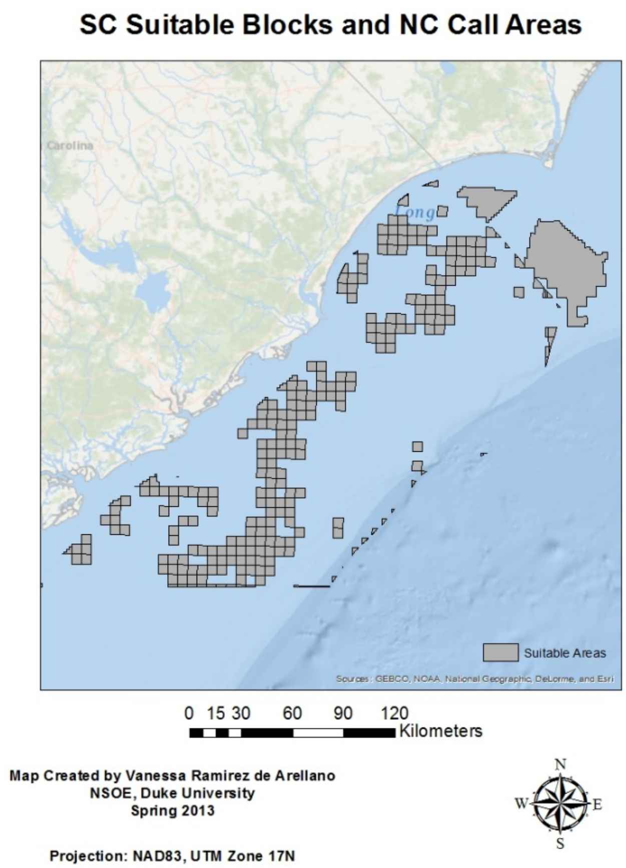

Figure 2: SC Suitable Blocks and NC Call Areas

As illustrated in Figure 2, the SC Wind Site Selector output showed individual blocks and slivers of blocks, while the NC call areas represented larger merged areas. For the sake of consistency, aggregations of blocks from the SC tool output were dissolved together to create hypothetical call areas. It is crucial to note that the selected aggregations are arbitrary, and there are other options that may be equally suitable. The sites that were aggregated are used only for demonstration of methodology and are in no way a precise suggestion. The process of aggregation resulted in four SC call areas, consisting of ten or more contiguous suitable blocks. Ten was utilized as a cutoff based on the proposed WEAs for the Atlantic in other states, the smallest of which (Maryland), deals with nine full blocks (Renewable Energy: State Activities, 2012). Once the call areas were defined for both states, the next step was to define connection points for each call area. These connection points represent the precise locations the transmission lines would connect. These points, representing substations, were drawn arbitrarily for the purposes of this demonstration. The true location of substations would be a determined by a full analysis at the discretion of the engineer on site. Thus, the substations were placed in the chosen locations to simplify the cost path calculations. Figure 3 illustrates the NC and SC call areas along with the selected substations.

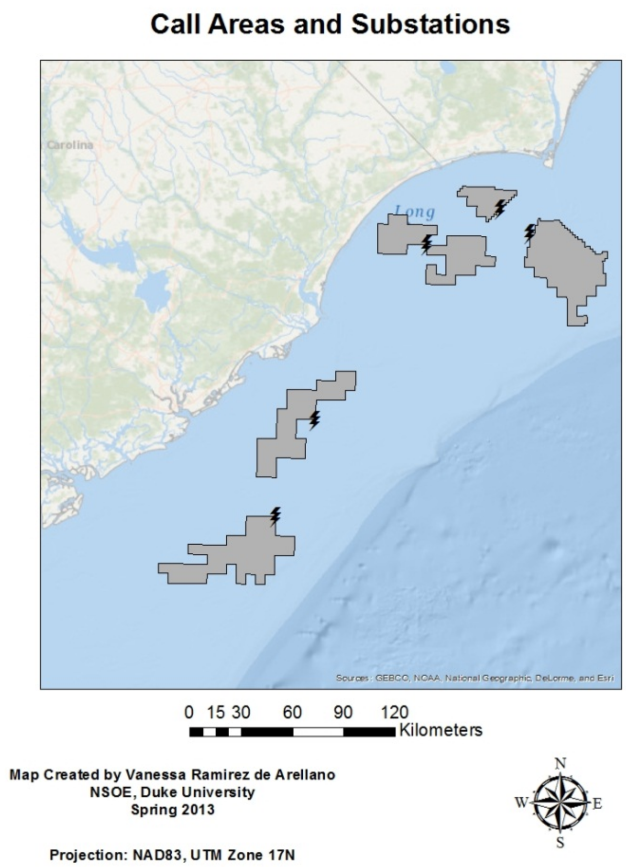

Figure 3: Call Areas and Substations

Once call areas and substations were identified, the next step in the analysis was to determine the transmission path that minimizes conflict (i.e. the least cost path). Before determining a cost path for connection, we needed to create a cost surface that determined the level of conflict at each point. The analysis began with a simple raster that defined our area of interest. This raster was then manipulated to create a cost surface. The analysis techniques and relevant variables were selected under the assumption that transmission cables will be buried 3 to 6 inches underneath the seafloor. The cost surface was created using two tiers of variables.

Tier 1 Variables: These areas were masked out completely from potential transmission areas.

- Hard Bottom Habitat

- Depth- Removed areas outside the 15-35m range
- Wrecks and Obstructions

Tier 2 Variables: These areas were not excluded, but rather costs were assigned for each parameter and then combined to create the final cost surface.

- Seafloor gradient- Areas that are too steep have a higher risk of submarine landslides.
- Distance from shipping lanes- By increasing distance from shipping lanes, risk of anchoring or dredging interfering with cables is minimized.
- Proximity to coastal energy facilities- Served as a proxy for proximity to coastal infrastructure.
- Wind Exclusion Areas- These areas were not masked out entirely because they would have made call areas nearly impossible to connect, but rather they were assigned an extremely high cost value to make them least desirable in the cost path.

Tier 1 variables were masked out from the study area raster. Next, each of the Tier 2 rasters was reclassified on a scale from 1 to 10, representing the cost of each cell. The tables (Figure 4) below illustrate how values were reclassified and why

Parameter	Reclassification Strategy
DoD Exclusion Zones	DoD Zones assigned cost of 10, non-DoD assigned cost of 0
Distance from Shipping Lanes	10 km: cost of 0, 8 km: cost of 2, 6 km: cost of 4, 4km: cost of 6, 2km: cost of 8, <2 km: cost of 10
Distance from Energy Facilities	6 equal classes (range from 0 to 10 with intervals of 2), get more costly with increasing distance
Seafloor Gradient	0.2 appears to be a major drop off (continental shelf), given a cost value of 10. Below 0.2, split into equal intervals and assigned lower costs.

Figure 4: Reclassification Strategy

These reclassified cost surfaces were added together to create an overall cost surface illustrated in Figure 5.

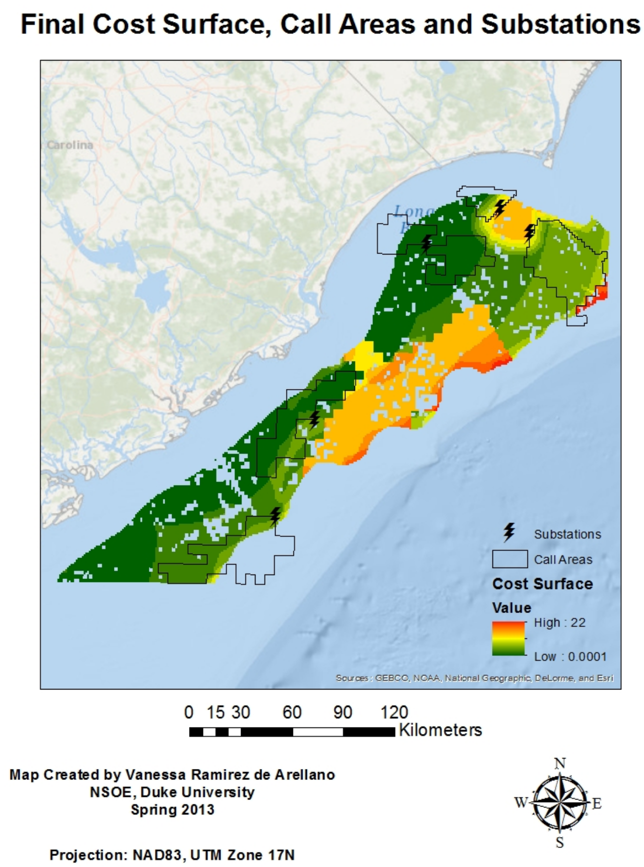

Figure 5: Final Cost Surface, Call Areas and Substations

The last step of the analysis was to create the cost paths. The first configuration illustrates a transmission backbone for the Carolinas with no onshore connection points. In creating this backbone, the cost paths were allowed to go through the call areas, under the assumption that the size of transmission is negligible when compared to the spacing between turbines. The cost paths were calculated using the cost surface from figure 5 using ArcGIS 10.1. The backbone for the Carolinas with no onshore considerations can be seen in Figure 6.

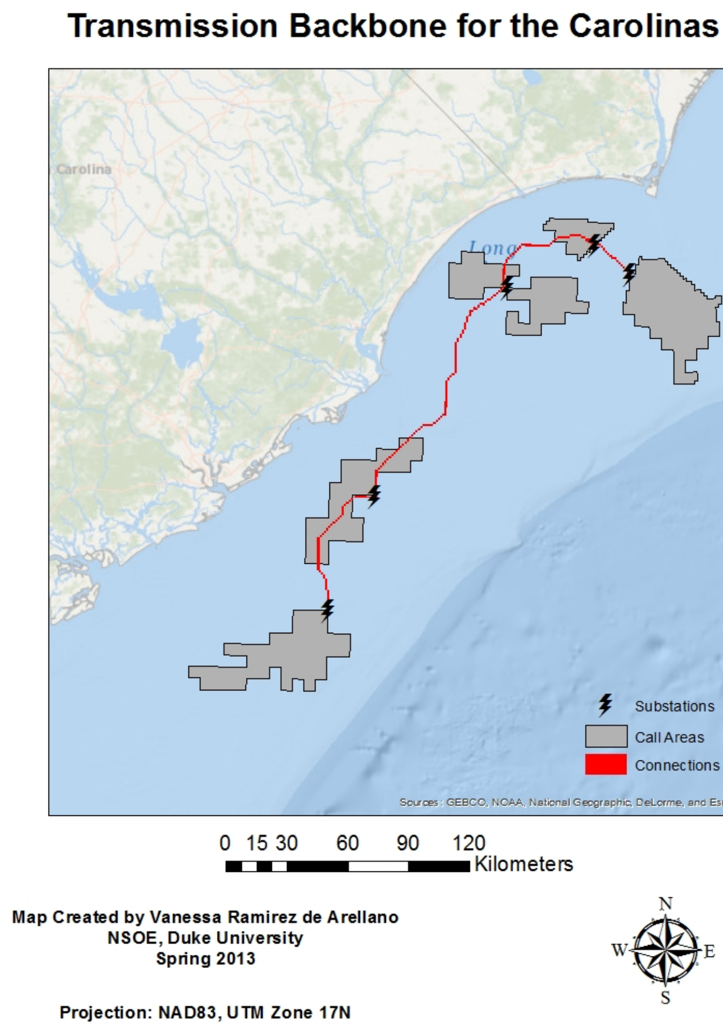

Figure 6: Transmission Backbone for the Carolinas

Next, we hoped to capture a more realistic scenario for the Carolinas. Thus, onshore connection was considered and mapped, despite extreme data limitations. Unfortunately, there was no SC/NC transmission data available for use in this project. Instead, two cities in SC were selected as onshore injection points. North Myrtle Beach and Georgetown were selected for various reasons. North Myrtle Beach was selected due to its interest in becoming an onshore injection point. Georgetown was selected because of the presence of a large port and a relatively low population which limits viewshed issues (Paul Campbell Jr., 2010).

Unfortunately, fine-scale details about injection points were unavailable. Due to the lack of access to transmission infrastructure data, these points were generally placed in ArcGIS in the following way. The central coordinates for the city were mapped in ArcMap. For North Myrtle Beach, this placed the connection point right on the coast. For Georgetown, the connection point was further inland. The point for Georgetown was moved in a horizontal line outward to the coast.

The next challenge in the analysis was that the previously shown cost surface had to be extended to reach onshore areas. Unfortunately, data was not available for state waters near the onshore connection points. Thus, the original cost surface had to be adjusted by assigning an extremely high cost value to all areas outside the original cost surface. The original cost surface ranged from 0.001- 24. All areas outside the cost surface (and holes within it) were assigned a value of 50. With these values, the connection onshore would determine the least cost path within the values from 0.001-24 and then find the most direct route onshore based on distance alone in the shallower parts. Two scenarios with onshore connection were explored and are illustrated here. The first involves a backbone that connects all of the call areas. This backbone then has cables going onshore perpendicular to the backbone. This arrangement is similar to the plans for the Atlantic Wind Connection Project, and can be seen in Figure 7.

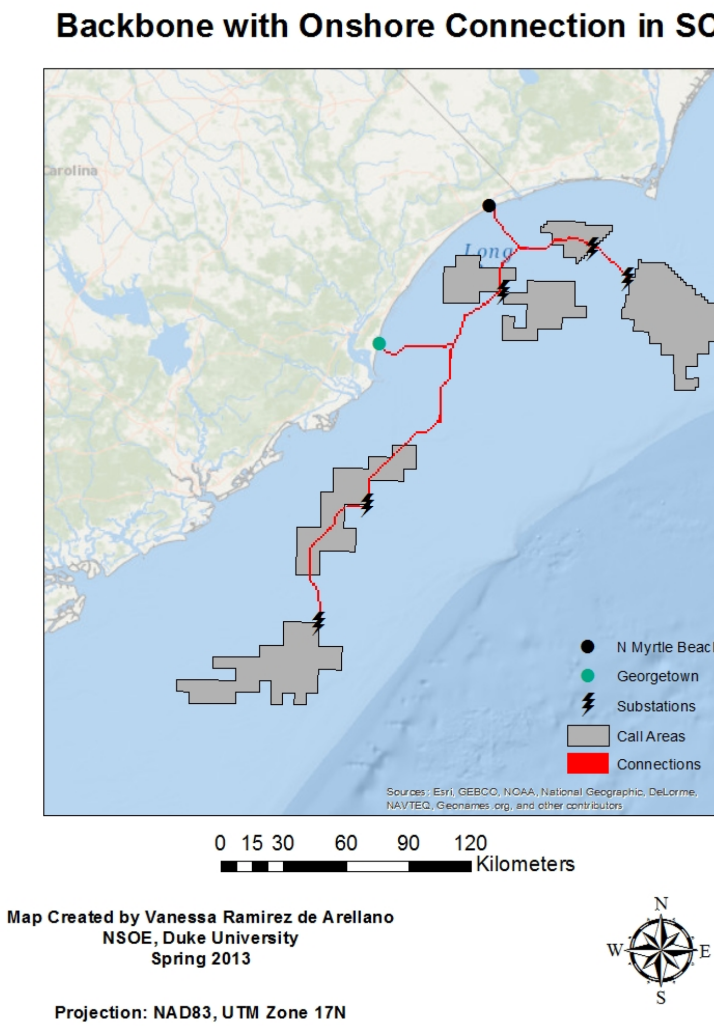

Figure 7: Backbone with Onshore Connection

The second arrangement with onshore connection is a more radial arrangement, in which the backbone is not entirely connected, but instead shows two separate clusters, each with an individual onshore connection point. This arrangement can be seen in Figure 8.

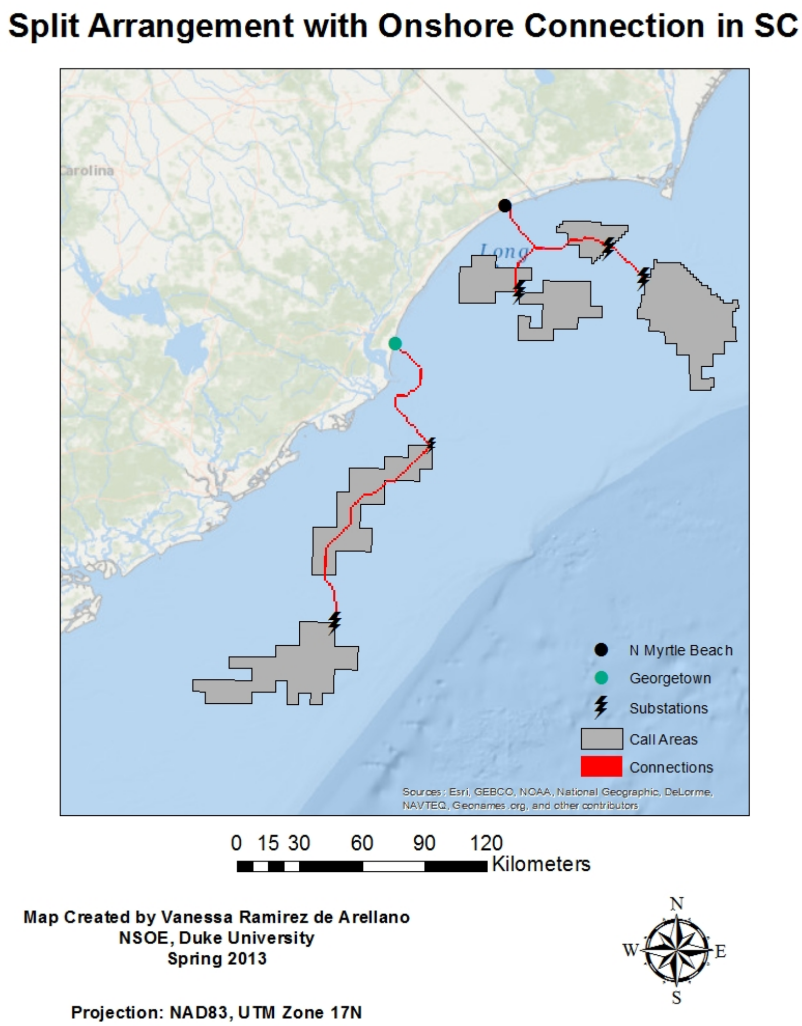

Figure 8: Radial Arrangement

This final radial arrangement may not seem entirely logical. However, it becomes important once we consider the role of the DOD. Figure 9 overlays the DOD wind exclusion zones with the radial arrangement from this study.

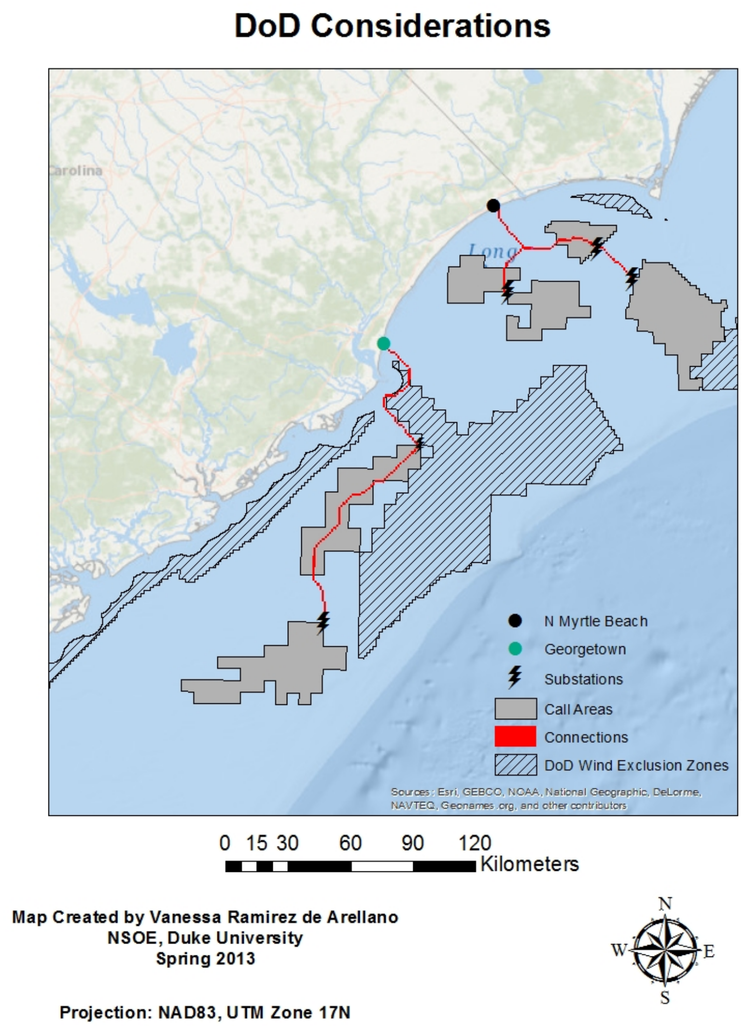

Figure 9: DoD Considerations

In this figure we can see that fully excluding DOD exclusion zones would forcefully split the SC call areas and force us to have two radial arrangements. In fact, it appears, that DOD exclusion could prevent us from connecting southern sites into Georgetown unless they were to enter through Winyah Bay. However, it appears based on the shape of the exclusion zone, that military activity is happening offshore and near-shore areas may only represent a passageway into active areas. Thus, the impact of a transmission line crossing this region may be negligible. However, it is hard to conclude this with limited information about the kind of exercises occurring in these South Carolina waters.

V. Conclusion

As stated throughout this study, the goal of this paper is not to propose arrangements for wind turbines and transmission lines. Rather, this paper aims to demonstrate the utility of marine spatial planning in wind energy development. As the previous analysis demonstrates, GIS can be a powerful tool in determining areas for infrastructure development. Moreover, it illustrates how much influence the user can have on the site selection process. This is primarily through setting thresholds and deciding which areas to exclude. This emphasizes the importance of developing streamlined methodology in order to foster collaboration. Streamlined MSP methodology, combined with collaboration in the political realm, can prove to be extremely powerful in harnessing larger catchment areas. As a result, we can improve the integration of wind into existing power grids with greater confidence in wind power's reliability. The Carolinas are uniquely positioned to collaborate on offshore wind, and marine spatial planning will be instrumental in collaboration and planning efforts moving forward.

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