

# DELAWARE MARINE SPATIAL PLANNING Offshore Wind Context

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*FINAL REPORT*



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## INTRODUCTION

Mid-Atlantic ocean waters host countless recreational, commercial, scientific, and security-related activities that often occur near the areas determined as and managed for resource protection and conservation goals (The White House Council on Environmental Quality, 2010). Today, human activities - fishing, commercial shipping, cable crossings, pipelines, and recreational activities - require a considerable amount of ocean space and place stress on marine ecosystems (MARCO, 2010). Developers of proposed offshore renewable energy developments and existing users of the ocean space will have to work to accommodate each other's needs. Marine Spatial Planning (MSP), which considers the interaction among various uses of the ocean in spatial and temporal scales, has recently gained support in Europe and is gaining momentum in the United States. MSP represents a powerful method for reconciling diverse and often seemingly overlapping needs of ocean users. It aspires to be future-oriented rather than reactionary, making it an effective means for implementing ecosystem-based management that provides guidance in determining appropriate sites for future uses. Particularly when supplemented with stakeholder input, MSP can satisfy the goals of offshore wind developers, the commercial shipping industry, the fishing community, the conservation community, and local recreational users by facilitating a transparent, engaging and empowering approach to ocean planning.

In the United States, Coastal and Marine Spatial Planning is an important priority objective under the National Ocean Policy, and efforts to implement the new initiative in the mid-Atlantic are underway. Although these efforts focus on eliminating conflicts and reconciling tensions among a vast variety of users in specific regions, it is important to recognize the limited scope of the present study, which focuses on offshore wind development off the coast of Delaware. In this initial one-year, limited budget project, existing uses and features were mapped to the extent feasible and as geo-referenced data were available. This research collected data from disparate sources, which varied in spatial extent, scale, and quality. Data sources included GIS files, paper maps, written descriptions, and published coordinates that were subsequently digitized, geo-referenced, analyzed, and layered using ESRI ArcMap 10.0. All maps are shown in Geographic Coordinate System and the data is unprojected. Areas in which offshore wind development is likely to highly conflict with existing uses are described, although areas that are specifically recommended for development are not identified. This is due to the early stage of this endeavor, the variety of complex factors that must be considered, and the need for more stakeholder insight and input prior to identifying the best sites for development. The resulting product provides policy-makers with a starting point for a more complete MSP effort in the mid-Atlantic region, including Delaware, and will help to identify where data gaps remain. A follow-up MSP effort at the state or regional level will benefit from this collected data and analysis; it should also consider additional activities, features, users, and offshore wind energy development locations, and engage and more formally consult the public.

## BACKGROUND

### Offshore Wind Energy Potential in the US and the mid-Atlantic

Development of offshore energy, particularly offshore wind energy, is a major driver of current MSP efforts in the mid-Atlantic (Eastern Research Group, 2010). Along the US Atlantic coast, offshore winds contain an estimated 1,000 GW of energy, which, if fully developed, is equivalent to the country's current generation capacity (U.S. DOE, 2011). The resource is close to large, densely populated areas where electricity rates are high, demand for power is growing steadily, and where land-based wind development is constrained (NREL, 2010). Even though no offshore wind projects have been built in the U.S. to date, approximately 20 projects totaling 2,000 MW of capacity are in the planning and permitting stages, four of which totaling 1500 MW of capacity are planned off the coast of New Jersey and Delaware (NREL 2010). Bluewater Wind was preparing to build a commercial scale offshore wind project off the coast of Delaware, but at the end of 2011, it announced that the development is on hold for the near term and opted out of the 200-MW power purchase agreement (PPA) with the Delmarva Power and Light Company (NRG Bluewater Wind, 2011). Bluewater Wind stated that the termination was the result of Congress' decision to eliminate funding for the U.S. Department of Energy's (DOE) loan guarantee program that was beneficial to offshore wind and the potential expiration of the Federal Investment and Production Tax Credits at the end of 2012 (NRG Bluewater Wind, 2011). However, Bluewater Wind is still working with federal agencies to maintain its development rights and obtain a federal lease for the site. It also continues to seek equity investors and development partners. Thus, it is feasible that a project will be built off Delaware sometime in the future.

### Offshore Wind Development Goals

In the *National Offshore Wind Strategy: Creating an Offshore Wind Energy Industry in the United States*, announced in February 2011, the DOE stated that "Offshore wind energy can help the nation reduce its greenhouse gas emissions, diversify its energy supply, provide cost competitive electricity to key coastal regions, and stimulate revitalization of key sectors of the economy" (U.S.DOE, 2011, p.11). However, the report also stated that numerous challenges, including high costs, challenges surrounding transmission and grid interconnections, and permitting barriers need to be overcome. Overcoming these challenges will take considerable effort, but the report ultimately emphasized the objectives to develop 10GW of offshore wind energy by 2020 and 54GW by 2030 (U.S. DOE, 2011). Even with the commendable objective to develop large amounts of offshore wind infrastructure, large-scale deployment off the U.S. Atlantic Coast and in the mid-Atlantic will need to be balanced with the current uses of the ocean. Employing the MSP framework for this task will help to mitigate potential user conflicts, establish a practice of responsible and future-oriented

planning, and, through analysis of geospatial data, advise on best suited sites for rapid and least confrontational development of offshore wind industry.

## Marine Spatial Planning

Marine Spatial Planning (MSP) was started as a management approach for nature conservation in the Great Barrier Reef Marine Park (Australia) over 30 years ago, but recently it has been used to reconcile uses in the more crowded European seas (UNESCO, 2009). Several Asian countries, including China and Vietnam, are using MSP to achieve both environmental and economic objectives (UNESCO, 2009). MSP offers nations an operational framework to preserve the value of their marine biodiversity while also allowing sustainable and well-planned use of the economic potential of their ocean space (Ehler & Douvère, 2009). By definition, MSP is a public process of allocating and analyzing the spatial and temporal distribution of human activities in marine areas to fulfill economic, social and ecological objectives that are commonly specified through political process (UNESCO, 2010). MSP has six major characteristics: it is adaptive, ecosystem-based, place or area-based, strategic and anticipatory, integrated, and participatory (Ehler & Douvère, 2009). Developing a governing framework is also critical and needs to be accomplished before an MSP project can be executed. This includes determining a set of priorities, goals, and standards; establishing a legal basis for authority and funding; defining the planning process, the lifetime and extent of the plan; and ensuring public and stakeholder participation at all project levels (Ehler & Douvère, 2009; Madsen et al., 2011).

Executing MSP initiatives also requires a substantial data-compilation effort (Madsen et al., 2011). Information requirements must be identified and data gathered from disparate sources and later checked for quality and synthesized into a common platform where they can be analyzed. Further, data gaps must be identified and results processed and presented in a user-friendly format (Ehler & Douvère, 2009). For effective MSP implementation, the majority of data must be spatial in nature, meaning that the data used for analysis consists of data points in which information is a function of its geographic location vertically and horizontally (Madsen et al., 2011). The data is commonly manipulated and represented with Geographic Information Systems (GIS) software that allows users to view, analyze and interpret data in a variety of ways to reveal patterns, relationships, and conflicts in various formats including maps (Ehler & Douvère, 2009). Thoughtfully designed, these outputs allow for efficient visualization of complex and overlapping uses of the marine environment.

## European Experiences with Marine Spatial Planning

Examples of Marine Spatial Planning can be derived from European processes, where early examples of MSP have been initiated. Several European counties have implemented MSP as a



framework for the development of offshore wind power, including Germany, the United Kingdom, Belgium, and the Netherlands. Two of the early examples of MSP have been selected to provide examples of MSP methods, Belgium and the Netherlands.

### *Belgium*

With renewable energy targets of 13% by 2020 (Degraer et al., 2010) and an early example of marine spatial planning employing an ‘ad hoc’ method (Douvere et al., 2007), Belgium is a global leader in implementing Marine Spatial Planning as a method of ecosystem-based management of the marine environment. Although Belgium does not have specific legislation requiring MSP of the Belgian Part of the North Sea (BPNS), several Acts and Royal Decrees have set the foundation for such a process to occur. Belgium shares coastline and jurisdiction of the North Sea with the UK, Norway, Sweden, Denmark, Netherlands, Germany, and France. The North Sea is one of the most heavily utilized seas in the world, seeing heavy pressure from fisheries, aquaculture, shipping, recreation and tourism, military activities, and sand/gravel extraction. Furthermore, the impacts of these demands on wildlife have become increasingly apparent, prompting European Union legislation on habitat protection as well as ocean-based policies for sustainable planning and development. It is this anthropogenic demand for space and resources of the sea that prompted planning for long-term sustainability in the marine environment (Douvere et al., 2007).

Belgium slowly implemented the ‘Master Plan’ of the BPNS beginning in 2003. The first phase of the Master Plan used GIS to delineate a zone for offshore wind development and sand/gravel extraction, followed by the designation of Marine Protected Areas in the second phase, culminating in a single spatial plan (Douvere et al., 2007). The spatial plan includes a map demarcating acceptable uses of the sea, including an area for offshore wind development (Douvere et al., 2007; Madsen et al., 2010). Belgium subsequently conducted a multi-year study to set the framework for future MSP efforts. Maps of ocean use, physical properties and infrastructure were mapped, and recommendations for an adaptive planning regime were made (Maes et al., 2005; Madsen et al., 2011).

The initial stage of the process and the subsequent production of GIS maps required substantial data collection on the characteristics of the marine environment. Initial GIS maps included zoning of the marine environment, existing infrastructure of the BPNS, and human uses. With exception of tourism, a geo-referenced map was generated for each component listed. Furthermore, a separate intensity map of each use of the BPNS was produced to visualize the relative effort of each activity (Maes et al., 2005). Upon completion of mapping the ocean, a second phase resulted in an ‘interaction’ map, where spatial and temporal overlaps in use were indicated. When suitable areas for offshore wind energy projects were determined, benthic sediments, geophysical constraints, hard exclusion zones, shipping, viewshed, distance, depth, and important environmental areas were considered (Maes et al., 2005). The MSP process in Belgium is set apart from others through the final vision of the GAUFRE project, which entailed production of structure maps that can be manipulated to meet the changing needs of the Belgians. Rather than a final, end-use spatial plan, this MSP process offers a strategic vision for development of the marine environment, incorporates the interconnectedness of each use, and allows for continual adaptation over time (Maes et al.,

2005). The process and longevity of a MSP vision makes Belgium a global leader in integrated, ecosystem-based Marine Spatial Planning.

### *The Netherlands*

The Netherlands has jurisdiction of approximately 58,000 km<sup>2</sup> of the North Sea, a heavily utilized space with numerous economic and recreational activities. Through several legislative acts and subsequent policy documents, the Netherlands has adopted spatial planning policies to enhance the economic importance while maintaining ecological features in the North Sea. The North Sea policy establishes a framework for spatial management, with specific areas designated for uses of the sea. A key element to the North Sea policy is the goal of installing 6,000 MW of offshore wind capacity within the Exclusive Economic Zone (EEZ) (12-200 nautical miles from shore) by 2020 (IMPNS, 2005), which requires over 1,000 km<sup>2</sup> of space (National Water Plan (NWP), 2009). To realize the development of offshore wind projects, the Netherlands government recognized the need to delineate appropriate areas for development. Two stages of spatial planning for offshore wind development have occurred with relation to developing spatial boundaries: the Integrated Management Plan for the North Sea 2015 (IMPNS) in 2005 and the National Water Plan (NWP) in 2009. Three themes emerged from the 2005 effort: a sea that is healthy, safe and profitable (IMPNS, 2005). Through the IMPNS (2005), Netherlands established a controlled, free market policy pertaining to development in the EEZ, allowing developers to set the scope of offshore wind project development within a framework. By delineating large wind turbine opportunity areas, the government created conditions for efficient use of space and sustainable development practices.

Spatial data were used to create individual maps of the current uses of the Netherlands' territorial sea (0-12 nautical miles from shore) and the EEZ. These maps include shipping lanes, surface minerals and dredge material dumping, fishing vessel effort, recreational vessel use, cables and pipelines, and areas of special ecological value and areas of protected ecological features. Data layers were chosen in effort to exclude the most critical conflicting uses. A wind turbine opportunity map was generated based upon a set of exclusionary criteria, including shipping lanes, clearways for safety, and a 12 nm distance boundary (IMPNS, 2005). The resulting map indicates opportunity areas likely for near-term offshore wind project development as well as potential areas for further development. The central government has acknowledged that the policy choice to install offshore wind projects has spatial ramifications, but was given priority over other uses, being an issue of national importance (IMPNS, 2005). In refinement of the Spatial Planning policy for developing offshore wind projects, the National Water Plan (NWP) provides more stringent restrictions. A reassessment of the uses of the North Sea was necessary to evaluate space for large-scale renewable energy, among other developments, with a goal of delineating efficient use of space to develop and protect biodiversity of the marine environment (NWP, 2009). An updated map of current uses was produced in 2009 including wind energy development areas with landing points for electric cables, and wind energy search areas for greater capacity (NWP, 2009). The Dutch government has adapted its management strategy as data layers become available and conflicting uses arise.

## United States: Presidential Initiative and MSP

On July 19, 2010, President Obama signed an Executive Order (E.O. 13547) establishing a National Policy for the Stewardship of the Ocean, Coasts, and Great Lakes. The Executive Order strengthens ocean governance and coordination, establishes guiding principles for ocean management, and adopts a flexible framework for effective coastal and marine spatial planning (CMSP) to address conservation, economic activity, user conflict and sustainable use of the offshore areas.

CMSP is one of the nine National Ocean Policy priority objectives. It is an ecosystem-based spatial planning process for analyzing current and anticipated ocean uses and identifying areas most suitable for various types or classes of activities. CMS Plans will be prepared and implemented over the next five years using a regional approach to allow for variability of economic, environmental and social aspects among different areas of the US. CMSP at the regional level will be stakeholder driven, engaging local, state, regional and tribal entities and stakeholders. The planning scale for CMSP is Large Marine Ecosystems (LMEs), and there are nine proposed planning areas across the US (The White House Council on Environmental Quality, 2010).

The emphasis on the importance of coastal and marine spatial planning as part of the National Ocean Policy framework is well placed. Differing views about which activities should occur and where, and overlapping uses can generate conflict and tensions among the plethora of stakeholders. CMSP can fully incorporate the principles of ecosystem-based management and can provide the means to transparently and objectively guide and balance allocation decisions for uses of coastal, ocean and Great Lakes waters and resources (The White House Council on Environmental Quality, 2010). Considering such a high level of trust in marine spatial planning as a potent tool to achieve a balanced designation of the ocean and coastal uses, the CMSP framework is expected to play a critical role in the development of offshore wind energy off the mid-Atlantic coast, where five projects totaling 1500 MW of capacity are planned off the coast of New Jersey and Delaware (NREL, 2010).

## Mid-Atlantic Regional Council on the Ocean's (MARCO) Vision and Activities

In 2009, the Governors of New Jersey, New York, Delaware, Virginia and Maryland signed the Mid-Atlantic Governors' Agreement on Ocean Conservation, committing to regional cooperation to advance strategic areas to protect the ocean and coast (MARCO, 2011). Four priority areas - ocean habitat protection, climate change adaptation, offshore renewable energy and water quality improvement - were established, while the fifth priority issue (MSP) was added as a tool to accomplish the other four objectives. Additionally, the Council's vision to build capacity for effective MSP process and enhance development of the MARCO Mapping and Planning Portal as a robust decision support system incorporates ecosystem-based, adaptive and scientifically informed management tools (MARCO, 2011). Thus, the collaborative and iterative nature of MSP is

embedded in MARCO's goal, which is to initiate and implement a Mid-Atlantic CMSP planning process that engages all stakeholders, such as scientists, conservation organizations, local, state and federal agencies, the regional fisheries management council, and all ocean users (MARCO, 2011).

Furthermore, MARCO has initiated the collection and analysis of data in the Mid-Atlantic region, with the development of a regional GIS portal with publicly viewed data layers as significant portion of the initiative. The portal currently offers data in several data layers: administrative, decision support, human use, biological, geophysical, and state specific (MARCO, 2011). Additionally, new data layers have recently been added, including regional ocean council boundaries, submarine cables, wind energy areas, ship traffic separation zones, selected marine mammal data, and selected data from the New Jersey Offshore Wind Baseline Study. The portal gives users an ability to view data in an interactive manner, create and print maps, and display fact sheets for each data layer. These and other ongoing efforts, such as the Delaware Marine Spatial Planning Project, which is independent from MARCO, are transparent, user-friendly, and collaborative tools to engage stakeholders, ocean space users and regional planning agencies to ensure the above listed objectives to adapt to climate change, improve water quality, protect ocean habitats and develop offshore renewable energy resources are met in a thoughtful and sustainable manner.

## Examples of Marine Spatial Planning in the United States

Marine Spatial Planning in the United States is a nascent process, although similarities exist with both the European MSP experiences as well as with land use planning. Rhode Island and Massachusetts are two states engaged in MSP efforts nationally, although other states and regions are also working through this process. Rhode Island and Massachusetts face similar challenges and provide useful background for the MSP process in the mid-Atlantic.

### *Rhode Island*

The State of Rhode Island has long utilized ecosystem-based management of coastal areas. In 2004, Rhode Island passed the Renewable Energy Standard, requiring that 16% of its electrical needs must be generated from renewable sources by 2019. In 2007, a siting analysis was completed to evaluate the offshore wind potential in state and federal waters, with recommendations based upon technical, financial, environmental, and public acceptance issues (Applied Technology and Management, Inc. (ATM), 2007). Furthermore, Governor Donald Carcieri mandated that 15% of energy produced was to come from offshore wind by 2020. This mandate prompted the formation of the Ocean Special Area Management Plan (SAMP) in effort to outline policies and make recommendations for the siting of offshore renewable energy. A study area of 1,467 mi<sup>2</sup>/3,800km<sup>2</sup> commenced, including state and federal waters starting from 500 feet offshore (Rhode Island Coastal Resources Management Council (RI-CRMC), 2010).

The Ocean SAMP is an adaptive ecosystem-based management tool to guide the development and protection of Rhode Island's ocean resources. The overall objectives include mitigation and

adaptation to global climate change through development of offshore renewable energy, with a high degree of public involvement (RI-CRMC, 2010). Through the development of the Ocean SAMP, extensive baseline data was collected and analyzed relative to the planning area including ecological resources, climate change factors, cultural and historic resources, commercial and recreational fisheries, recreation and tourism, navigation, renewable energy technology, and future ocean uses. With an end goal of producing policies and recommendations for the development of renewable energy, the Ocean SAMP designated a 2km-wide Renewable Energy Zone as the area most suitable for offshore wind development. The foundation of siting under the Ocean SAMP is a technical analysis of wind resource, bathymetry and seabed geology, and exclusionary criteria.

Upon determination of general areas suitable for offshore wind development, siting was refined using a series of exclusionary criteria. Each of the criteria was added as a data layer, progressively eliminating incompatible areas. These exclusionary data layers include: transportation routes including shipping, ferry routes, precautionary and preferred routes; regulated uses including disposal sites, unexploded ordinances, protected areas and conservation zones, and military areas; areas currently licensed for extractive development, airport setbacks, and a coastal buffer zone (RI-CRMC, 2010).

As the Renewable Energy Area was determined, special consideration was given to important natural resources and wildlife habitat, commercial and recreational fishing grounds, areas of cultural and historical value, areas of high recreation and tourism, transport and navigation routes, existing infrastructure, Areas of Particular Concern, Areas Designated for Preservation and other important uses such as dive sites, shipwrecks, and fisheries habitat zone (RI-CRMC, 2010).

Although a Renewable Energy Zone has been delineated as a special use area within a broad multi-use zone, renewable energy may be developed in other areas within state waters, provided no significant conflicts with existing human uses and natural resources are found in the zone (RI-CRMC, 2010). Furthermore, the SAMP has designated areas for potential development with neighboring states (Massachusetts) in federal waters (RI-CRMC, 2010), acknowledging that geospatial planning is not limited to state boundaries. This plan has been approved by NOAA and is incorporated into the state's coastal zone management program.

### *Massachusetts*

The Commonwealth of Massachusetts, under Governor Deval Patrick, passed legislation and set goals for the state to increase renewable energy generation. The 2008 Global Warming Solutions Act mandates that greenhouse gas emissions be reduced 80% below 1990 levels by 2050, with a target of 10-25% reduction by 2020, prompting Governor Patrick to set a goal of 2,000 MW of installed wind power by 2020 (Massachusetts Executive Office of Energy and Environmental Affairs (EEA), 2009a). Massachusetts passed the Oceans Act of 2008 in an effort to lay the framework for managing human activities on the ocean in an ecosystem-based approach. The Oceans Act required the EEA to develop an Ocean Management Plan with a number of directives including the identification of appropriate locations for renewable energy projects. Also included was the identification of goals and priorities, compilation of information on current uses with

valuation of those activities, incorporation of scientific data and setting forth plans cognizant of biological and physical processes, the incorporation of public input in the planning process, and identification of locations and standards for activities allowable under the Oceans Sanctuaries Act. This Act specifically allows for development of renewable energy in the ocean, which must be consistent with existing laws and with the Ocean Management Plan (EEA, 2009a).

As mandated in the Oceans Act, a baseline assessment was conducted to characterize the current state of the ocean, both ecological and scientific data as well as human demands on the ocean (EEA, 2009b). A Scientific Advisory Council and several task groups were assembled to compile this data, as well as to identify data gaps and long term research goals. Information was compiled in seven areas: the water column, seabed features, habitat areas, archeological and cultural features, human uses, economic valuation, and climate change (EEA, 2009b). This baseline assessment provided the framework from which to determine future uses with the creation of 26 spatial maps with individual data layers as was available and appropriate.

After establishing baseline conditions, assessing priorities, and analyzing data, three zones (prohibited, renewable energy and multi-use) were determined. The designation of two appropriate wind energy areas within the Renewable Energy zone was developed through a screening process applying the resources assessment data, absence of conflict, exclusionary criteria, and constraint criteria of potential impacts. Prohibited Areas were those already protected under the Oceans Sanctuaries Act (EEA, 2009a). Renewable Energy Areas were delineated to guide the best location for both commercial and community scale renewable energy, including offshore wind development. Two areas have been designated appropriate for commercial-scale wind energy, selected after a screening process including wind resource, water depth, and absence of conflicts with sensitive estuarine and marine resources. Additionally, provisional and federal sites have been located as potentially suitable locations for offshore wind development (EEA, 2009a). A multi-use area was also developed, which is open to a number of projects, such as community scale wind, that meet performance standards rather than spatial boundaries (Madsen et al., 2011). Exclusionary criteria included a one-mile coastal buffer, Coast Guard-designated navigation areas, important biological habitats, areas of significant commercial fishing effort and value, direct transit navigation routes for shipping and fishing, and regulated airspace. Also removed from consideration were areas determined to have excessive cumulative effects, constraints of wind turbine technology, visual impacts, and other existing uses as determined through qualitative assessment, public input, and stakeholder feedback (EEA, 2009a).

## The 'Smart from the Start' Initiative

Under the Energy Policy Act of 2005, and regulations promulgated by the U.S. Department of the Interior's (DOI) Minerals Management Service (MMS), now known as the Bureau of Ocean Energy Management (BOEM), leases can be issued for renewable energy development on the Outer

Continental Shelf (OCS) beyond the federal-state water boundary (generally three nautical miles). On November 11th, 2010, Secretary of the Interior Ken Salazar launched the ‘Smart from the Start’ wind energy initiative to facilitate siting, leasing and construction of new projects, and to spur the rapid and responsible deployment of offshore wind on the Atlantic OCS (DOI, 2010).

Based on the preliminary research and through its state task forces and consultation with tribes, local and state governments and federal agencies, BOEM identified “wind energy areas” (WEAs), areas best suited for development off Delaware, Maryland, New Jersey, and Virginia with a total area of 912 square miles (DOI, 2010). As outlined in the Smart from the Start Initiative, BOEM will assist in developing site assessment data and will evaluate potential impacts associated with site assessment activities in the identified WEAs (DOI, 2010). BOEM subsequently issued a draft environmental assessment (EA) of the site characterization activities in the designated WEAs. BOEM also has been actively engaged in collecting crucial baseline information about offshore areas and marine uses and compiling existing site assessment data. If no significant impacts are found in the WEAs, BOEM intends to offer leases to developers (DOI, 2010).

The initial designation of the WEAs was not without controversy. Within the initial site selection, some WEAs, such as in Maryland, were proposed to be located either in or at the seaward terminus of existing navigational Traffic Separation Schemes (USCG, 2011c), while others were placed near or in the traditional vessel routes used on Atlantic coastwise transits. This created confusion among the shipping industry, offshore wind developers, and the public, stalling offshore wind development in some areas. Concerns over navigational safety issues and future increase in ship traffic density in the region has subsequently led the US Coast Guard (USCG) to identify wind lease blocks in Maryland that should not be developed or where further study is needed. Consequently, the Maryland area was reduced by more than half of the proposed allotted WEA from 207 to 94 square miles (79,706 acres) (BOEM, 2012). Similar concerns were voiced regarding the westernmost part of the Virginia WEA (Hagerman, 2011), which can potentially result in the removal of these overlapping areas from the WEA.

These issues highlight the importance of more comprehensive data collection and stakeholder engagement in order to make informed siting determinations. In fact, the USCG is preparing to conduct a *Port Access Route Study: The Atlantic Coast from Maine to Florida (PARS)* (USCG–2011–0351) specifically to address potential shipping conflicts and to evaluate the need for modifications to the current vessel routing measures to accommodate offshore wind energy development.

## **PROJECT OBJECTIVES**

The Delaware Marine Spatial Project focuses on one priority issue – development of offshore renewable energy, and specifically offshore wind energy. The effort has been undertaken to focus on the potential for offshore wind power development of Delaware state and adjacent federal waters up

to 60 meters depth<sup>1</sup>. The objectives for the project include: synthesizing existing data, identifying data gaps, and establishing methods for collecting missing data to develop an initial framework for MSP that could act as a basis for stakeholder engagement (Madsen et al., 2011). The results include multi-layered maps that display information such as bathymetry, ecological features, wind resource, marine geology and existing uses of the ocean space. The maps also identify zones that should be excluded from wind development and zones where wind development is feasible based on the available data. These results will aid Delaware efforts and direct initial proposals for locating new offshore wind projects.

In addition to the mapping exercise, a stakeholder engagement workshop was held on November 14, 2011. The purpose of the workshop was to engage interested citizens and stakeholders in the MSP process, which has been gaining momentum both regionally and nationally. This workshop was intended for stakeholder groups such as policymakers, existing ocean users and community leaders. Participants had the opportunity to engage through the process of MSP in a hands-on, participatory workshop. By bringing together the interested parties across the spectrum of ocean users, participants had a chance to dialog about an ecosystem-based approach to the sharing of marine resources, setting the stage for conflict resolution early-on, outline conservation measures, and the vitality of considering community needs that are specific to Delaware. Engaging citizens early in the process, providing the stage for them to voice concerns and suggestions is a critical step to ensure the MSP process will gain public backing. Addressing concerns upfront can help avoid problems in the future, reducing the need to reevaluate methods and results, which can affect both the public support and satisfaction with the process.

## **DATA COLLECTION & ANALYSIS**

### **Marine Boundaries**

#### *Study Area*

The study area for the Delaware Marine Spatial Planning project was chosen to incorporate the coastal region of Delaware offshore to the continental shelf, north into New Jersey, and south throughout Maryland. Please refer to Map 1.

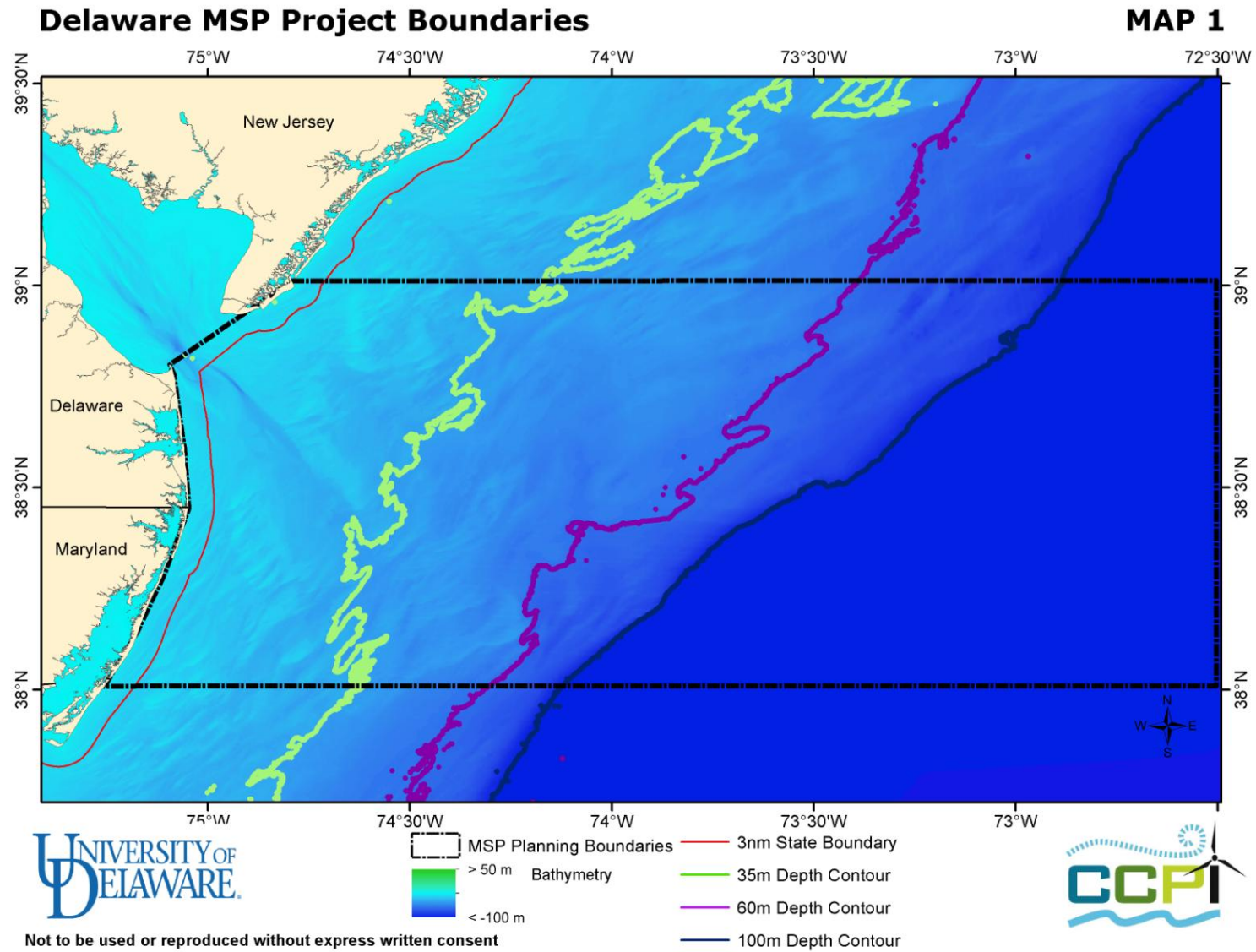
The northern terminus and southern terminus were chosen to coordinate with the Delaware Coastal Management Program under the Coastal Zone Management Act (CZMA), for renewable energy development in state waters (Delaware Coastal Management Program, 2011), allowable under the

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<sup>1</sup> The 60-meter depth limit was chosen based on the limits of currently available offshore wind turbine foundation technology.



Map 1: Boundaries



Coastal Zone Management Act (16 USC 1451 et seq.). Each proponent of federal action (such as funding, permitting, leasing and other approvals) affecting land, water, or natural resource use in the coastal zone is required to seek certification that the action proposed will comply with Delaware's Coastal Management Program. This applies to offshore wind leasing and permitting in state waters (0-3 nautical miles) and in federal waters (3-200 nautical miles). In June of 2011, Delaware updated its coastal program through a routine program change, as permitted by section 306 of the CZMA. This routine program change includes an interstate consistency review process for several coastal activities, including offshore alternative energy development (Delaware Coastal Management Programs, 2011). Under this program change, the siting, placement, construction and decommissioning of offshore wind (among other technologies) in state waters from Hereford Inlet, New Jersey south to the Maryland/Virginia border, will be subject to such review (Delaware Coastal Management Programs, 2011).

To maintain consistency with Delaware's jurisdiction over renewable energy development, the same north/south bounds were chosen for the study area. The eastern terminus follows the Maryland coast, Delaware coast, across the Delaware Bay, and up the New Jersey Coast to Hereford Inlet. With the focus of renewable energy in the open ocean and the limited budget and timeframe of this project, the Delaware Bay was not considered within the project study area. The eastern border to the continental shelf was chosen due to the prevalence of human use and biological activity along the shelf break and canyons, and the potential for future floating wind technologies to be installed in that vicinity. The north/south/east/west points were thus chosen as 39.0N/38.0N/-75.5W/-72.5W decimal degrees.

### *Depth Contour Lines*

Depth contour lines are displayed in addition to the bathymetric detail to indicate three zones of importance for offshore wind power development. The relevant contour lines are the 35-meter, 60-meter, and 100-meter depth contours.

The 35-meter interval was chosen to display the upper bounds of existing monopile foundation wind turbine technology and also gravity base foundations. Monopile foundations have been used extensively in the North Sea and are best suited for shallow depths up to 35 meters (Baker, 2011). Gravity base foundations have also been used in shallow waters. Beyond 35 meters, monopile and gravity base foundations are insufficient due to excessive costs of materials, construction limits and structural instability of these foundations (Musial et al., 2005). For tripod and jacket structures, the commonly cited 60-meter depth was chosen (Musial et al., 2005; NREL, 2010). Jacket structures are adapted from those used in the oil and gas industry, consisting of a lattice-type foundation secured to the seafloor at four points. These structures are suited for installation in depths of up to 60 meters. Beyond the 60-meter contour interval, technology is generally limited to the nascent floating turbine technology, with only prototypes being deployed to date. Consequently, the 35-meter and 60-meter contour indicates the depth limitations of offshore wind technology currently available on a commercial scale. Lastly, the 100-meter interval was chosen as a demarcation providing a visual reference point and as a potential depth to which future tripod and jacket structures may be adapted.

These contour lines were adapted from US Geological Survey (USGS) 10-meter contour lines, with the specific contours retrieved for display purposes (USGS, 2011).

### *US Maritime Zones*

Marine Jurisdictions are established zones under which certain activities or boundaries are represented. The boundaries provide useful delimitations in data analysis, as specific state or federal laws pertain to these zones. The State Waters Boundary at 3 nautical miles (nm), and the Exclusive Economic Zone at 200 nm are included. These areas have different agencies administering permits and specific actions within each zone. Notably, the 3 nm Federal-State waters boundary is relevant to offshore wind development because the lead federal agency overseeing offshore wind leasing changes from the US Army Corps of Engineers (USACE) to the BOEM, which may have implications for the ease and speed of permitting.

### *Outer Continental Shelf Lease Blocks*

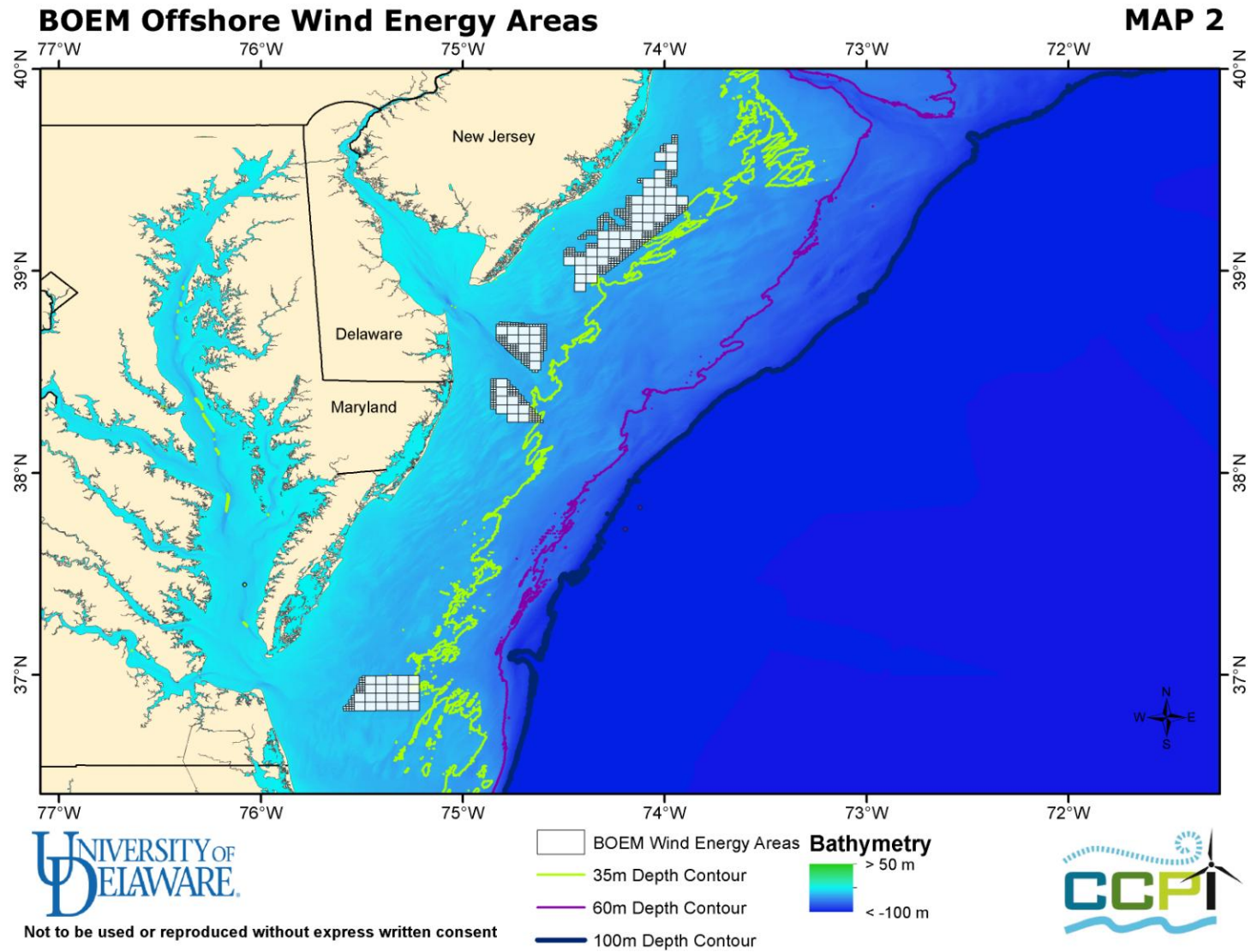
These areas provide the boundaries for outer continental shelf lease blocks, as administrative boundaries defining an area of federal land that may be leased in the offshore environment. They are produced in accordance with 30 CFR 256.8 (leasing maps and diagrams). These lease blocks allow the federal agencies to identify specific tracts on the outer continental shelf, as specified in the Outer Continental Shelf Lands Act (OCSLA) (43 U.S.C. 1301) (BOEM Mapping and Boundary Branch, 2010).

### *Wind Energy Areas under Consideration by BOEM*

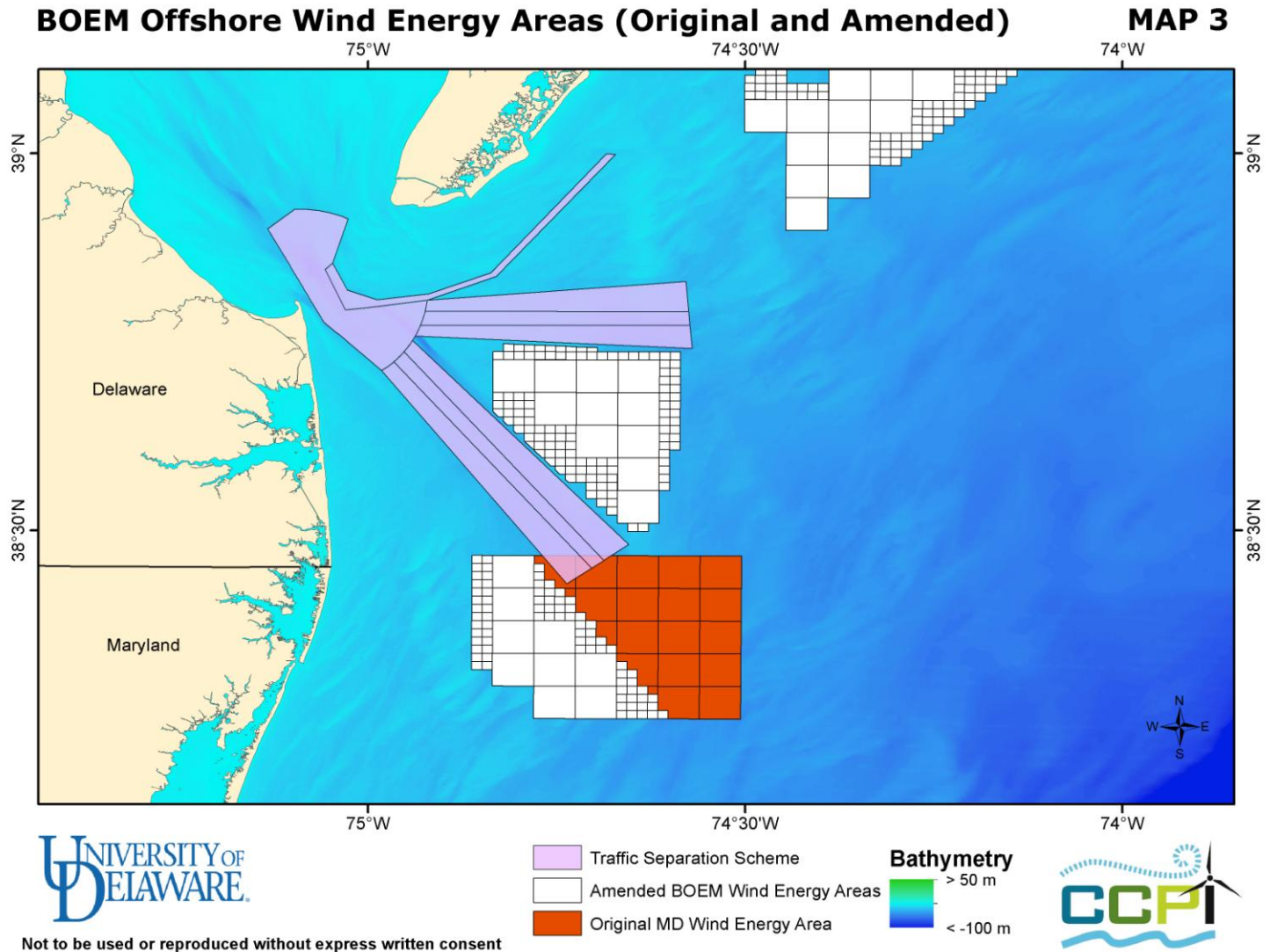
After Secretary of Interior Salazar announced the ‘Smart from the Start’ Initiative, BOEM identified four areas in the mid-Atlantic states that would be suitable for offshore wind development (Commercial Wind Lease Issuance and Site Characterization Activities; Atlantic Outer Continental Shelf Offshore NJ, DE, MD, and VA, 76 FR 7226). These four areas had initially been identified as likely having few use conflicts, although subsequent refinement has occurred (BOEM, 2012). Under the Energy Policy Act of 2005, the Secretary of Interior has the mandate to issue offshore wind leases on OCS blocks, which was subsequently delegated to BOEM. The lease blocks on Map 2 are represented after the most recent refinement. The shapefile was downloaded from the BOEM/NOAA Multipurpose Marine Cadastre.

Wind energy areas also have been designated in Massachusetts and Rhode Island, though recent amendments were made due to concerns over impacts on commercial fishing and the North Atlantic Right Whale habitat (BOEM, 2012). Off Maryland, the WEA was significantly amended due to potential conflicts with commercial shipping (Map 3). The fact that three WEAs – MA, RI, and MD – have been significantly amended emphasizes the importance of public input during MSP process; learning during these initial efforts should help to ensure that future offshore wind siting is done with minimum amendments and the majority of conflicting uses are identified and balanced early in the decision-making process.

Map 2: BOEM Wind Energy Areas (After amendments)



Map 3: Maryland Wind Energy Area (Before and after amendments)



## Biological Data

The potential environmental impacts of the construction, operation and decommissioning of offshore wind projects are important to consider in the siting of offshore wind turbines. Potential impacts include avian mortality and displacement, habitat displacement, acoustic impacts on marine mammals and sea turtles, disruption of migratory routes, and sensitive fish habitat disturbance, including impacts on endangered, threatened, and rare species. Data on the distribution and abundance of endangered, threatened, and protected species were compiled to evaluate the use of the marine environment by wildlife that may be affected by offshore wind development. Information on abundance, migration and residency, and extent of habitat can be analyzed for geographical overlap and the degree to which biologically significant impacts and dislocation of competing users may occur. From a scientific standpoint, biologically significant impacts can be considered to individuals or to populations. Impacts to individuals occur when the animal's ability to grow, survive, and reproduce is compromised, while population-level effects can affect the viability of the species (National Research Council, 2005). Here, it is logical to consider biologically significant impacts at the population level, as many activities in the ocean can impact individuals and not every biologically significant impact to an individual will necessarily trigger the preparation of an EIS (as opposed to an EA) under NEPA. Further, while wildlife protection laws regulate impacts to individuals, they focus management attention at the population level. For example, the Marine Mammal Protection Act (MMPA) ensures that stocks, or interbreeding groups of the same species, remain above the optimal sustainable population (16 USC 1361 et seq.) The Endangered Species Act (ESA) likewise manages for species, subspecies or distinct population segments (16 USC 1532). Lastly, benefits from CO<sub>2</sub> reductions resulting from decreased use of fossil fuels are generally thought of on a large scale, in which benefits to wildlife would be assessed on a population level rather than individual level. From a management perspective, it is important that we consider impacts to groups larger than the individual as we look towards long-term viability of each species.

### *Marine Mammals*

A growing body of research has accumulated regarding the implications of construction and operation of offshore wind projects on marine mammals. Studies have been conducted throughout the planning, construction, and post-construction monitoring stages of project development at several European offshore wind locations. In summary, research has shown that the primary concern with respect to marine mammals is the effect of noise during pre-construction surveys, turbine installation, turbine operations, and decommissioning. Specifically, surveys characterizing the geophysical conditions, employing side-scan sonar and seismic seafloor profiling devices may produce harmful sounds during surveys (Richardson et al., 1995). In addition, installing turbine foundations may require the use of a pile driver, which produces intense sounds in the immediate vicinity (Bailey et al., 2010, Brandt et al., 2011, Dong Energy, 2006, Nedwell & Howell, 2004; Nedwell et al., 2007; Tougaard et al., 2008). If regulators and developers do not account for noise, it may cause behavioral changes, hearing loss, injury, disruption of communication, navigation, and displacement (Bates et al., nd). Marine mammals do not respond to sound uniformly, and therefore

effects from sound will vary with noise intensity, frequency, and duration (Richardson et al., 1995). Nonetheless, NMFS has established uniform guidelines as to when any species is expected to exhibit a behavioral (Level A harassment) or injury (Level B harassment) resulting from exposure to the sound (70 Fed. Reg. 1871-1875, 11 January 2005). Impacts from installation vessels, habitat changes, and other impacts may also be of concern. One effective mitigation strategy is to advise the siting of turbines with consideration for the temporal and spatial habitat use by marine mammals (Gordon et al., 2007; Nehls et al., 2007; Wursig et al., 2000).

The North Atlantic Right Whale Consortium (NARWC) database (Kenney, 2001) was developed in 1986 around the core of the Cetacean and Turtle Assessment Program database (CETAP) (CETAP, 1982). The database has been continually updated and actively managed, incorporating aerial and shipboard survey data and opportunistic sightings from a variety of contributing organizations, as well as from surveys conducted by the National Marine Fisheries Service (NMFS). The NARWC database, which includes data from the region from the Nova Scotian shelf to Florida, is probably the most extensive long-term collection of survey and sighting data for any comparable area of the world. Records from this database were obtained with confidentiality agreements to not release the underlying data. All marine mammals have been assessed for overlap with potential offshore wind development sites. Importantly, the most commonly sighted species within the study area have been corrected for effort, therefore areas that do not show sightings are areas that have been searched and no animals have been found. These data show areas where marine mammals have been sighted both on survey and opportunistically, providing indications of habitat preferences and areas frequently used in residence and migration. Although correcting for effort is useful, detection of marine mammals can be missed, and errors can occur in species identification. Therefore, the effort-corrected sightings cannot be considered the only locations where marine mammals may be present, but are the best representations of where species are likely to have been present.

To assess areas frequently used by marine mammals, the dataset was further refined by including sightings within the north/south bounds of the study area, and determining sighting frequency by species for all years. Any species with over 50 sightings for all years combined was chosen as an indicator species for mapping: bottlenose dolphin (*Tursiops truncatus*), fin whale (*Balaenoptera physalus*), Risso's dolphin (*Grampus griseus*), pilot whale (*Globicephala sp.*), common dolphin (*Delphinus delphis*), sperm whale (*Physeter macrocephalus*), and unidentified large whale. The sightings of these species are displayed as aggregate over all years, as well as individually by species. All sightings indicated as strandings were removed from the dataset before mapping. Point data were converted to raster in order to display relative sighting frequency. The raster data is displayed in 5-minute by 5-minute grid cell resolution. Please refer to Map 4.

Distribution of marine mammals in the mid-Atlantic varies spatially and temporally. Selected marine mammals included here have a relatively high number of sightings in the study area (i.e., over 50 sightings, all years combined). The six selected species are displayed in Table 1. In addition to the species selected, records of unidentified large whales are displayed, because a large number of sightings were recorded in the study area, even though the specific species was not identified.

*Table 1: Selected Marine Mammal Species for Analysis.*

Species most commonly sighted in the mid-Atlantic region. Habitat preferences, regulatory preferences and seasonal presence are described for each species.

Marine Mammal Species	Habitat Preference*	Regulatory Protections	Mid-Atlantic Presence**
<b>Fin Whale</b>	Continental shelf	Marine Mammal Protection Act (MMPA); Endangered Species Act (ESA): Endangered	Presence primarily in summer and spring
<b>Sperm Whale</b>	Continental Shelf and Slope	MMPA, ESA: Endangered	Year-round
<b>Pilot Whale</b>	Continental Shelf break.	MMPA	Year-round
<b>Bottlenose Dolphin</b>	Separate onshore and offshore stocks. Onshore: coastal to 25 meters depth Offshore: 50 meters depth and beyond	MMPA	Strong summer and fall presence, very little winter presence
<b>Risso's Dolphin</b>	Continental shelf; associated with shelf features	MMPA	Occupies mid-Atlantic year-round, including winter
<b>Common Dolphin</b>	Continental slope; 100-2,000 meters depth	MMPA	Year-round

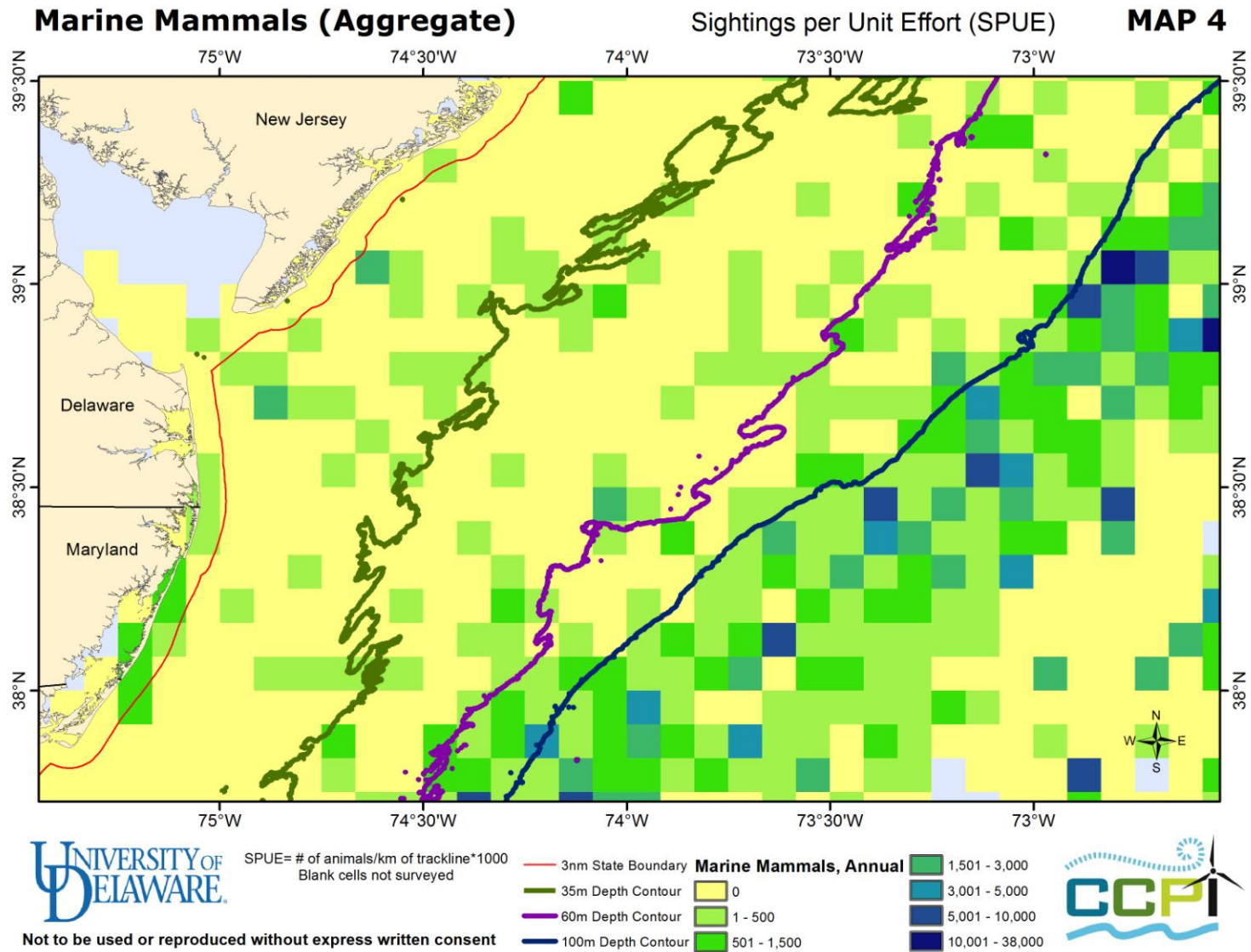
\* Habitat preferences derived from Waring et al. (2009) with exception of Loggerhead sea turtle, obtained through NOAA Office of Protected Resources (2010).

\*\* Presence in mid-Atlantic derived from Kenney et al. (2001)

Marine mammal species are distributed throughout the study area, with a greater number of sightings beyond the continental shelf break. Many of the combined records are from summer and spring sightings, although both fall and winter occurrences are substantial. Approximately 4% of the selected species observed in the study area are inshore of the 35-meter contour, 96% were sighted beyond the 35-meter contour. Federal protections for each of these species come from the MMPA, which places a moratorium on “takes” of marine mammals. Some marine mammal populations are also protected under the ESA, which safeguards threatened and endangered species and their critical habitats. Under MMPA, ‘take’ is defined as “harass, hunt, capture, kill or collect, or attempt to harass, hunt, capture, kill or collect” (16 USC 1361 et seq.). The definition under the ESA is similar, although somewhat more broad. Takes of endangered species are automatically prohibited under the ESA, although takes of threatened species must be specifically prohibited on a species by species basis (16 USC 1533 et seq.) Federal agencies granting permits or leases or other approvals (e.g., BOEM or USACE) and wind project developers, as appropriate, must consult with the proper federal regulatory agency – NOAA/NMFS and/or US Fish and Wildlife Service (USFWS) regarding suitable measures to minimize, mitigate and/or



Map 4: Aggregate Whale Sightings



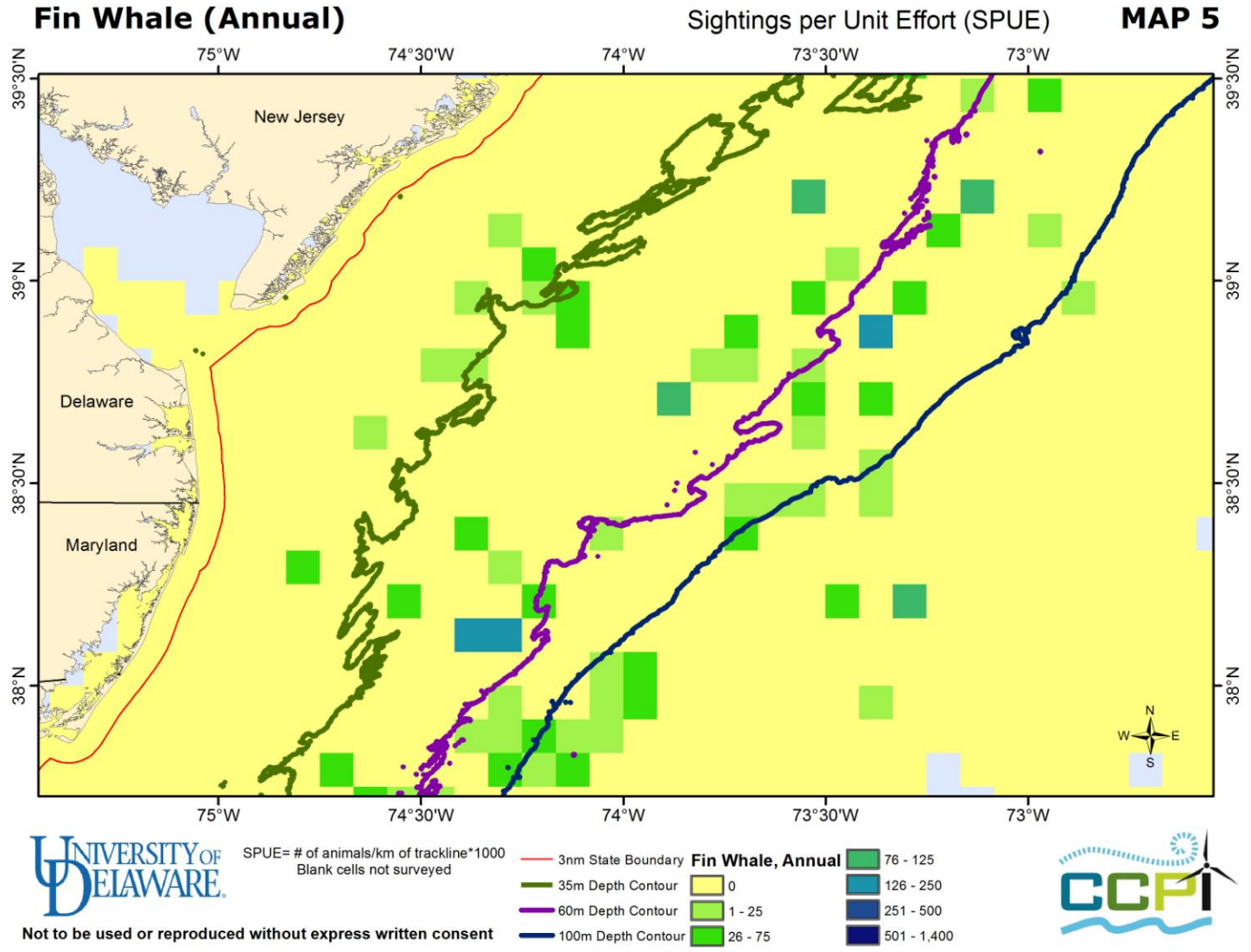
prevent disruption and takes of these species. Potentially detrimental impacts to marine mammals are often unavoidable during some aspects of offshore wind development, and therefore, Incidental Take Permits can be acquired under both MMPA and ESA for unintentional takes that are incidental to the activity.

State and permitting agencies can utilize these distribution maps to assess areas that may be more or less suitable for development. Given that many of the impacts to marine mammals associated with wind turbines occur during specific activities such as pile driving, seasonal maps should be consulted to minimize impacts by either avoiding certain seasons or undertaking other appropriate mitigation measures during high use seasons.

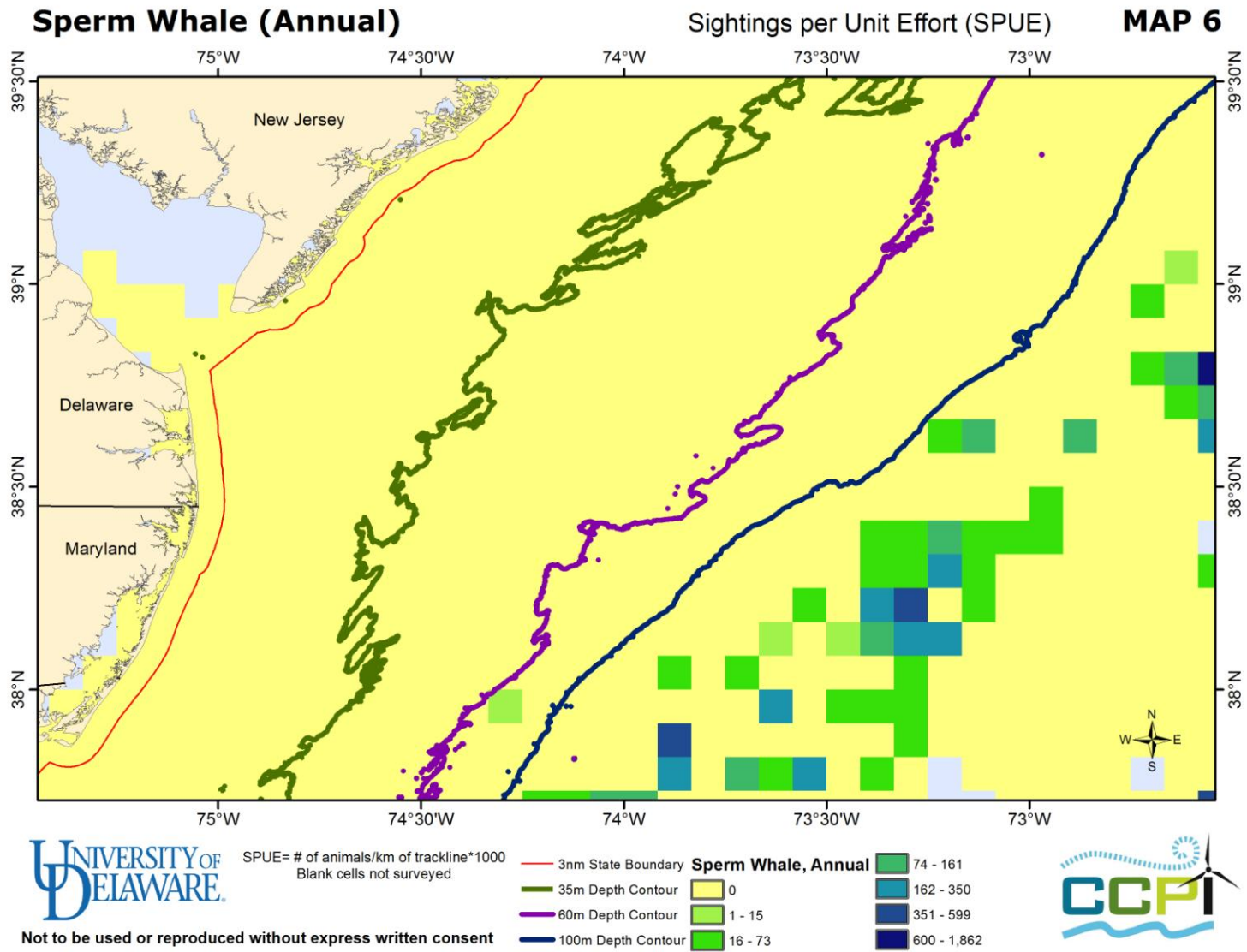
Species-specific maps are provided to display the distribution of a species that occupies the area seasonally, or to identify the distribution of an ESA-listed species. Both large cetaceans and small cetaceans are included in the analysis. Among the large cetaceans, fin whales are the most prevalent species in the study area. Fin whales comprise the largest standing stock size of all cetaceans in all seasons in many areas of the United States EEZ from Cape Hatteras to Nova Scotia, and are one of the most ecologically significant cetaceans due to the significant food requirements (Waring et al., 2010). This ESA-listed endangered large whale was chosen for mapping due to the high abundance in the study area, with 415 sightings of 1370 individuals. Over half of the sightings occurred in summer. As depicted on Map 5, although fin whales have been observed close to shore, they are more prominent beyond the 35-meter depth contour, where 93% of the sightings are beyond 35 meters. Given a near-shore bias that comes from observational data, if anything, one would expect that the ratio of fin whales on either side of the 35-meter depth contour is even greater than the depicted. In addition to fin whales, other large cetaceans displayed include sperm whales and unidentified large whales. Sperm whales were sighted exclusively beyond the 35-meter contour in the study area, and 11% of unidentified whales were inshore of this contour. Please refer to Maps 5, 6, 7.

Small cetaceans also are common in the study area. The most numerous are the bottlenose dolphins in Delaware's coastal waters. Over the past decade, NOAA has made the distinction between a coastal and an offshore morphotype and NOAA manages them as separate stocks. The offshore stock generally lives in waters >50 m deep, although they have been seen in waters as shallow as 13 m deep, 7 km from shore. The coastal morphotype is generally seen in water <25 m deep. Furthermore, the coastal morphotype is delineated into northern and southern migratory stocks, with the northern migratory stock summer migration being the only stock off Delaware. Coastal bottlenose dolphins have year-round status in the mid-Atlantic (Waring et al., 2010). As can be seen, bottlenose dolphins have been sighted both very close to shore as well as beyond the 100-meter contour. Eighteen percent of bottlenose dolphins sighted were within the 35-meter contour, 82% beyond. In addition to bottlenose dolphins, other small cetaceans relatively common in the study area include Risso's dolphins (100% beyond the 35-meter contour), pilot whales (100% beyond the 35-meter contour), and common dolphins (less than 1% inshore of the 35-meter contour). Please refer to Maps 8, 9, 10, and 11.

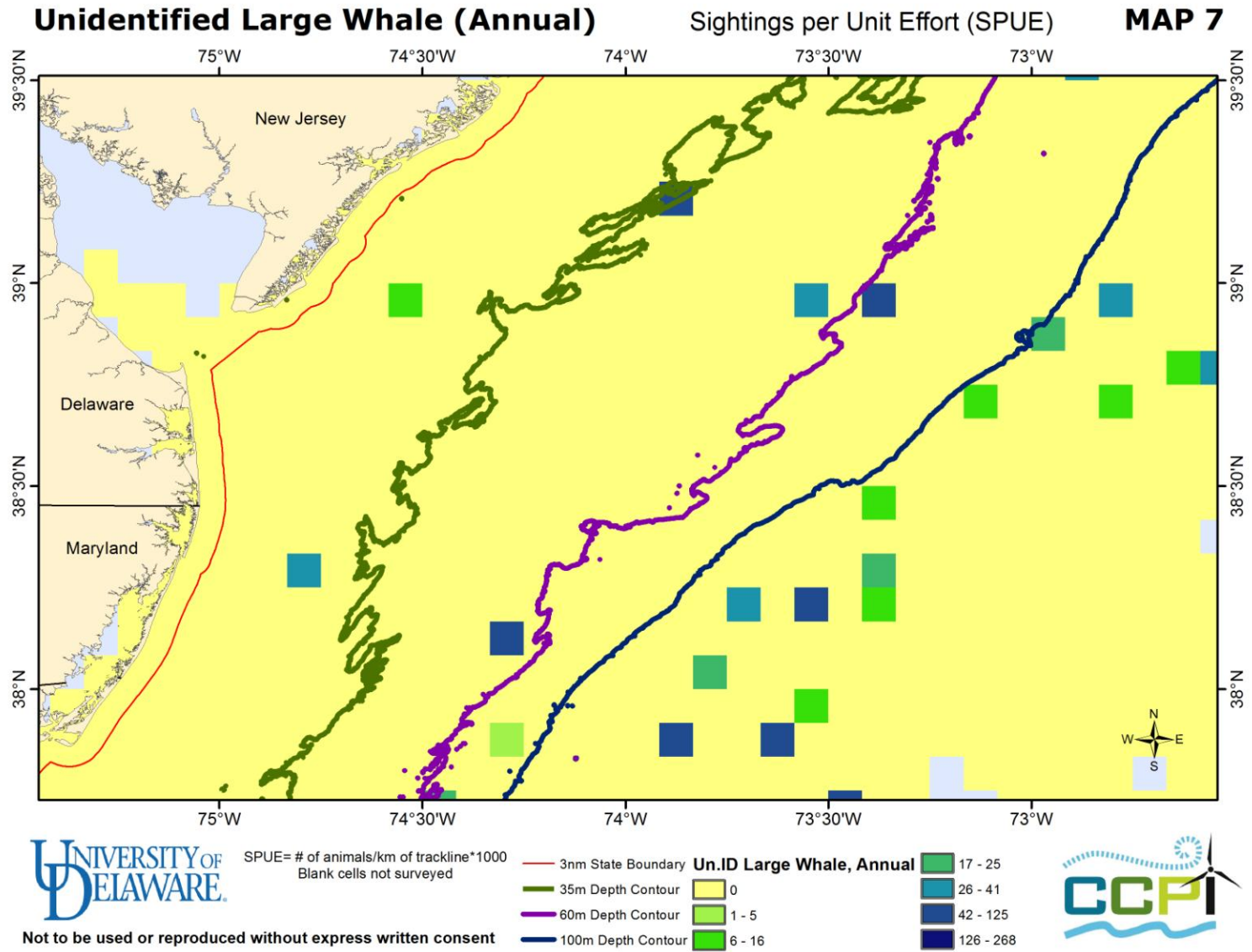
Map 5: Fin Whales



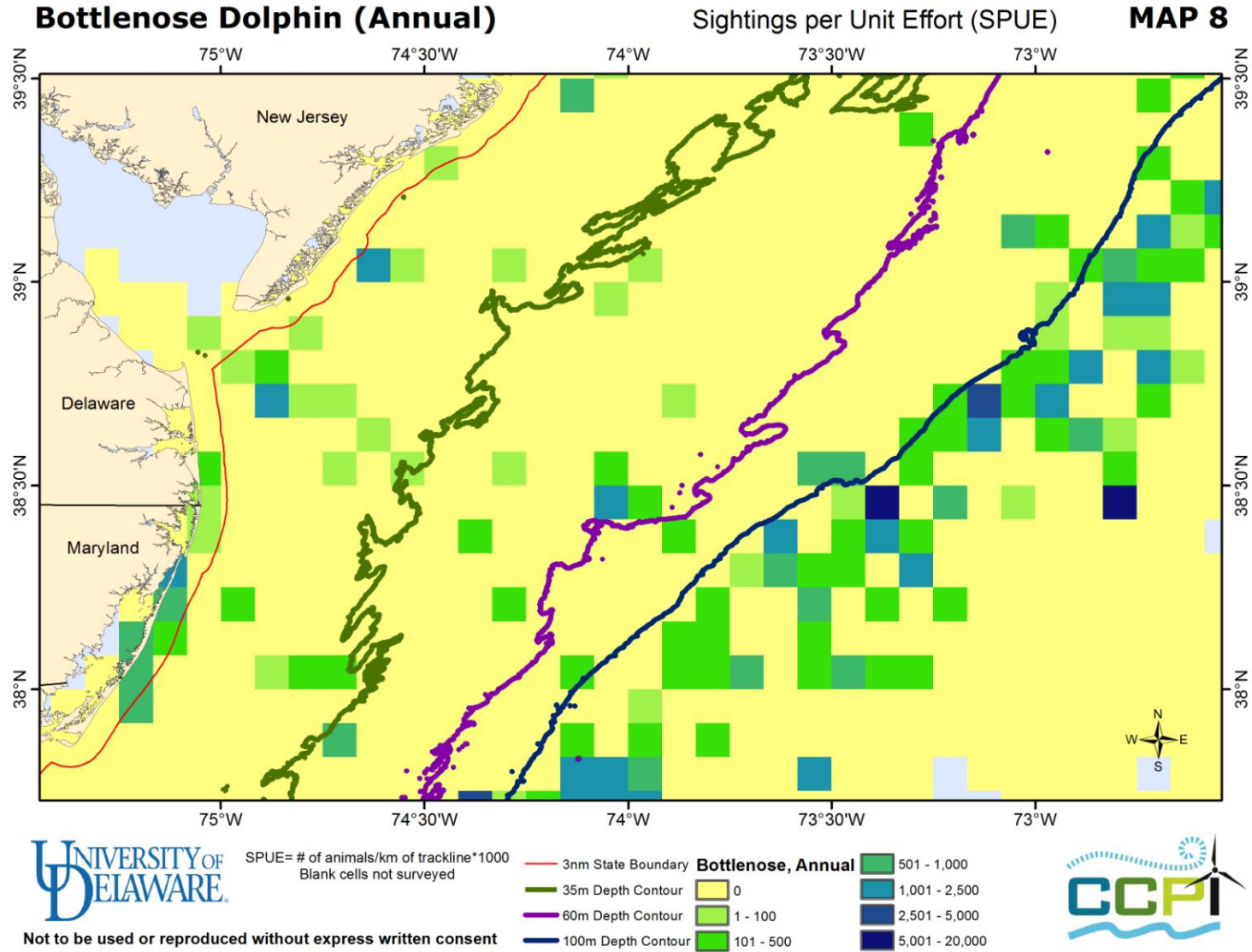
Map 6: Sperm Whales



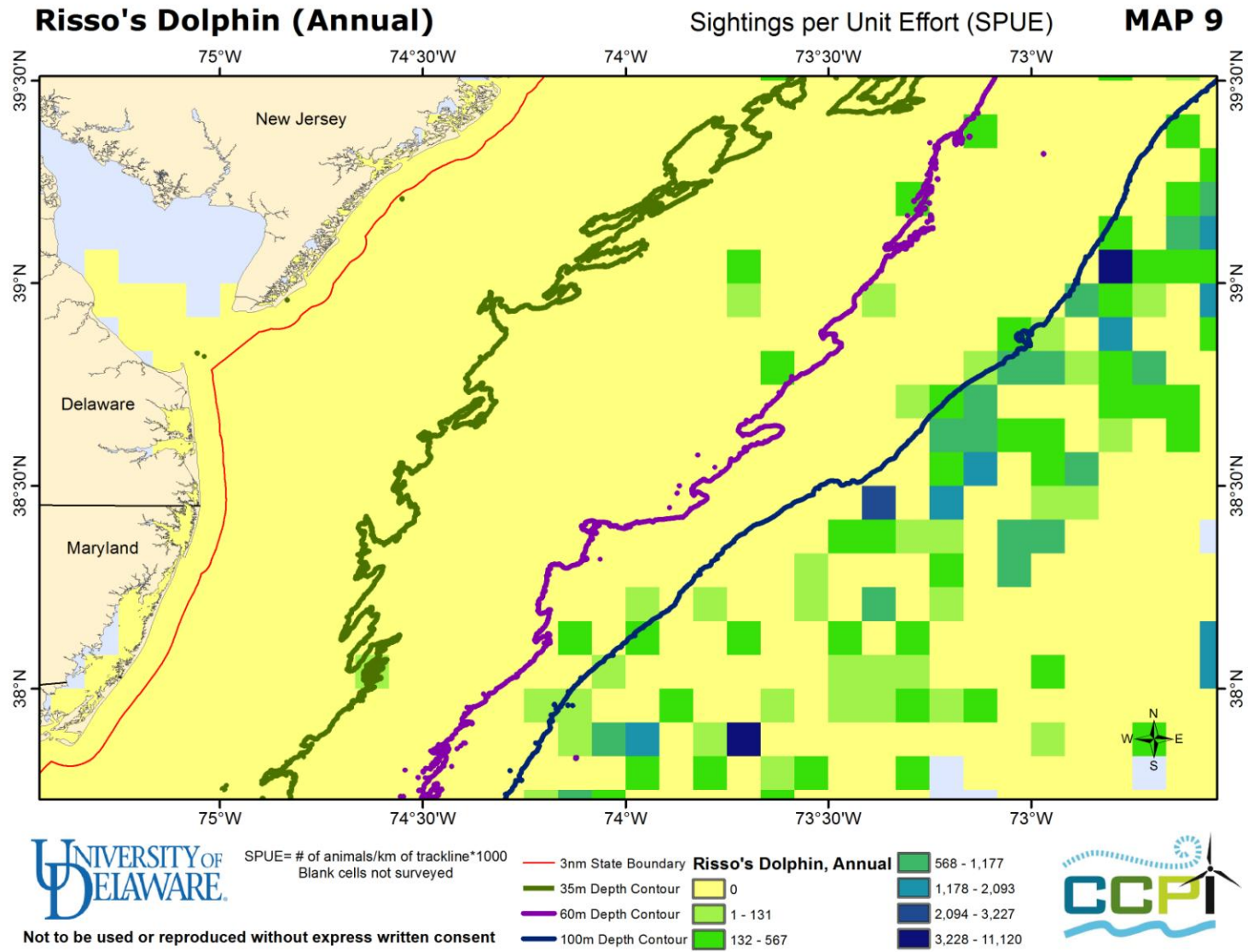
Map 7: Unidentified Large Whales



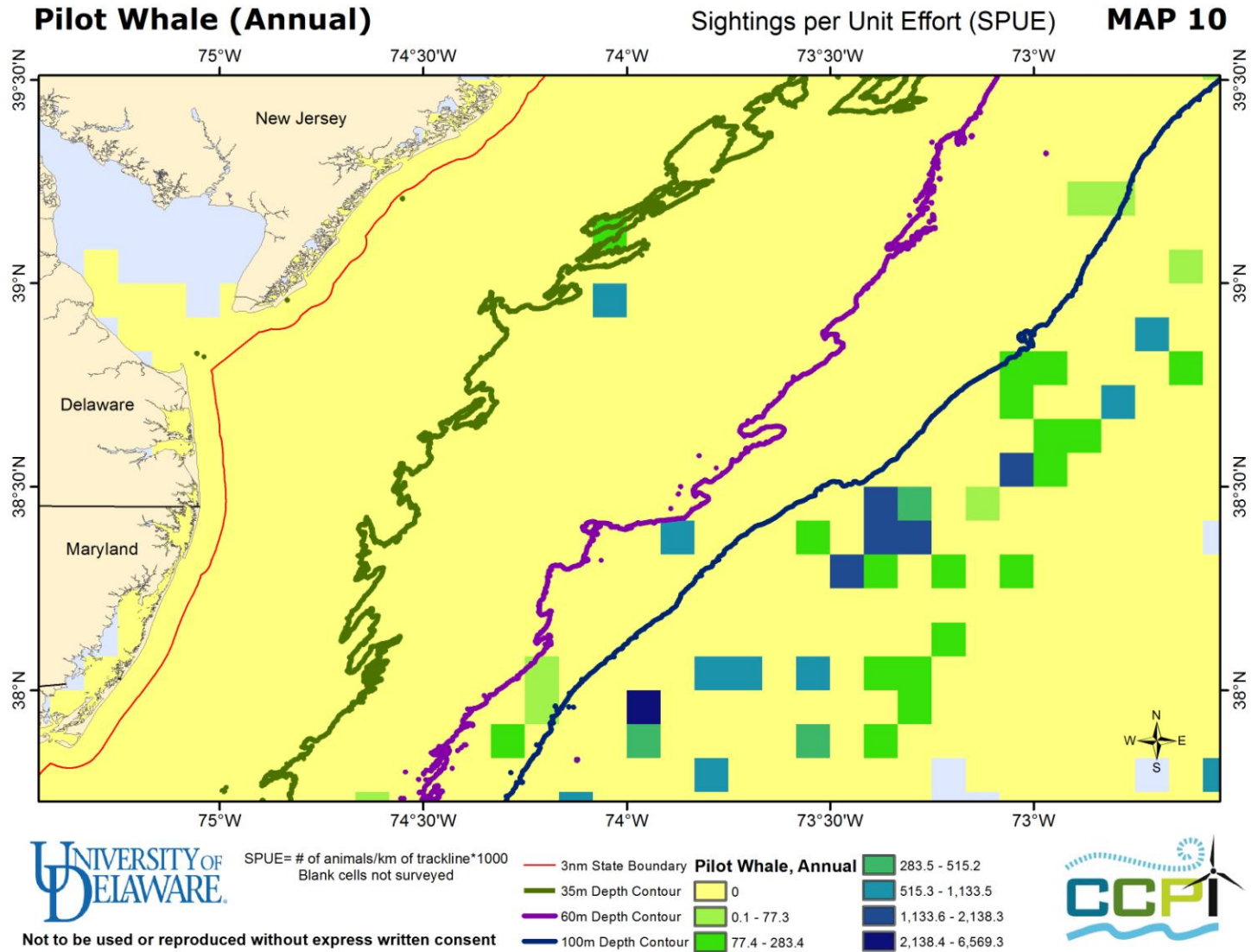
Map 8: Bottlenose Dolphins



Map 9: Risso's Dolphins

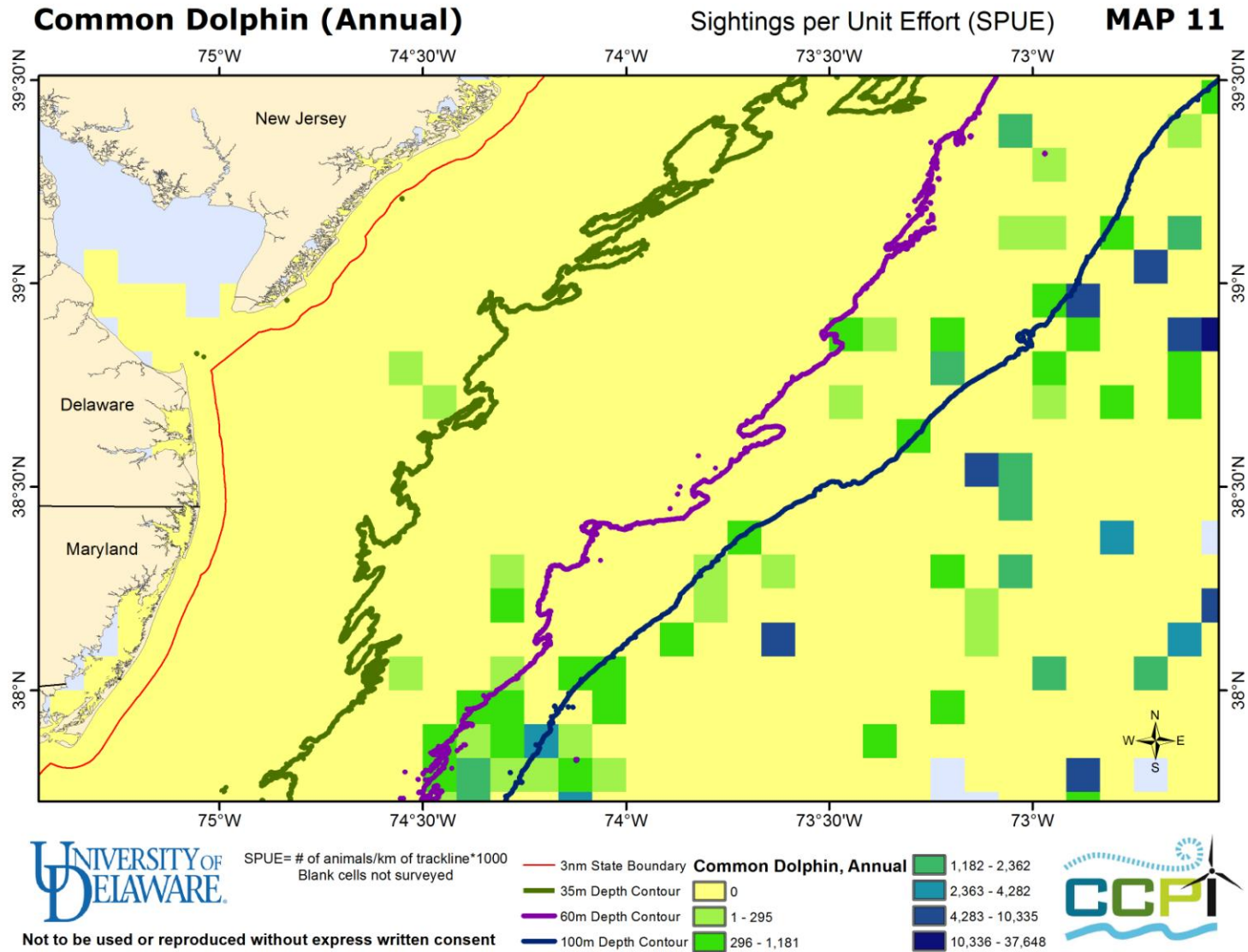


Map 10: Pilot Whales





Map 11: Common Dolphins



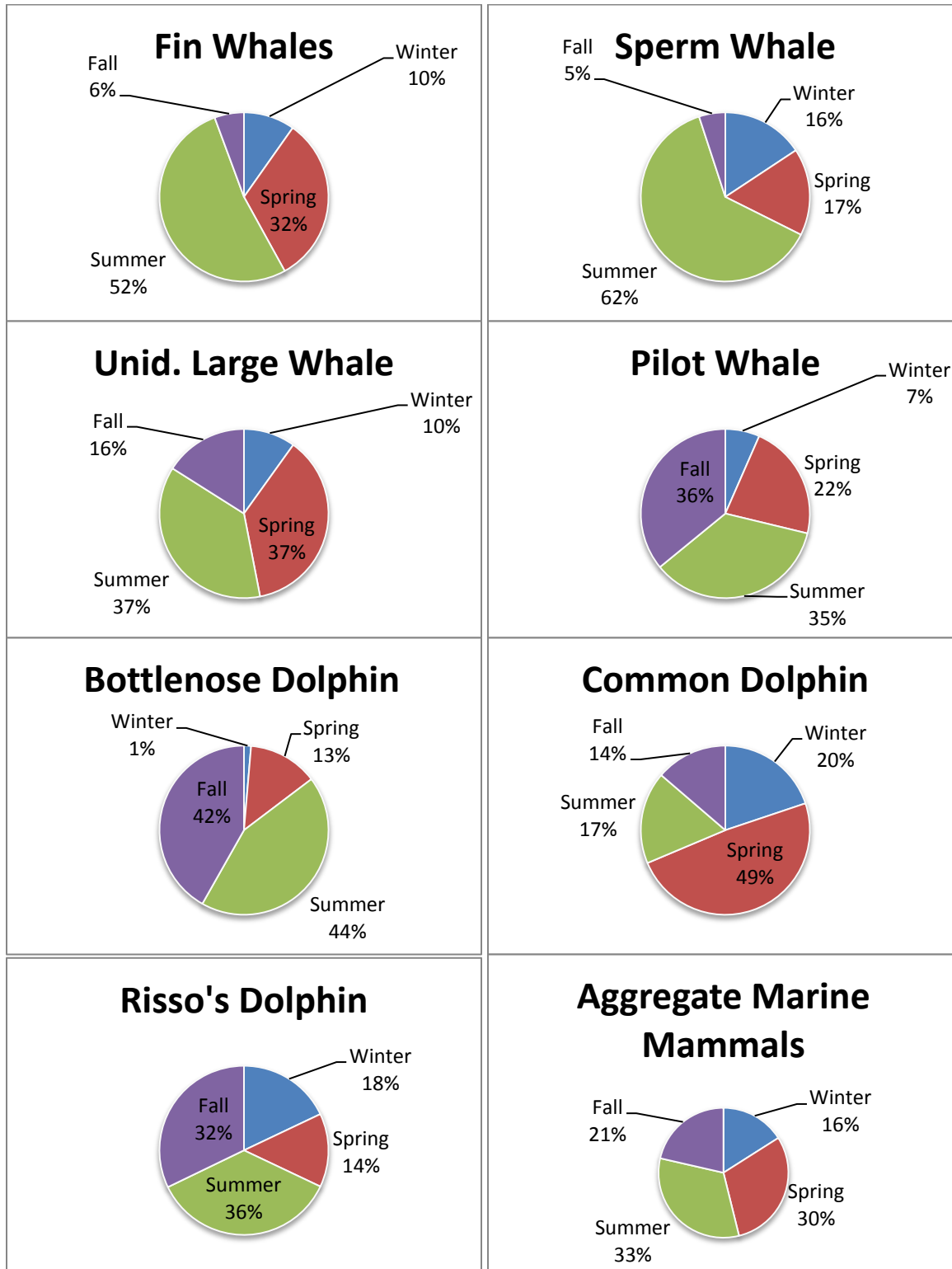
It is important to consider the migratory timing and corridor of marine mammals, which sheds lights on the seasonal abundance of species. Consider for example, North Atlantic right whales, one of the most critically endangered species in North America, with a population size of approximately 360 individuals (Waring et al., 2009). Mortality and injury due to vessel strike and entanglement with commercial fishing gear is a leading cause of injury and mortality of these great whales, which is an ongoing threat as human use of the marine environment intensifies (Laist et al., 2001). North Atlantic right whales are well known to migrate between feeding grounds in the Gulf of Maine and calving grounds off the Florida coast. The mid-Atlantic region therefore comprises an important segment of the migratory corridor, with sightings in late fall/winter travelling south, and early spring moving north (Knowlton et al., 2002). The migration patterns of North Atlantic right whales can be narrowed to a finer time scale. Analysis of survey data can provide estimates of the temporal and spatial scale of migration.

A relevant study was completed by Firestone et al. (2008) to determine the departure date of whales leaving the winter calving grounds to the summer feeding grounds using statistical methods. After analyzing data between the years of 1762 to 2004, results indicate that the migration departure date could be determined within a 30-day window, departing early to mid-March (Firestone et al., 2008). Although the migration route can be predicted, North Atlantic right whales have been spotted throughout the mid-Atlantic year-round. In a recent two-year study off the New Jersey coast, right whale sightings occurred in each season except summer, and acoustic recordings indicated the presence of right whales in all seasons (Geo-Marine, Inc., 2010). Furthermore, the majority of North Atlantic right whale survey and opportunistic detections in the mid-Atlantic (94%) are within 30 nm of shore, with over half of detections (63%) are within 10 nm from shore (Knowlton et al., 2002). Although there could be a near shore effort bias to these sightings, whales that were tagged and tracked show a similar pattern, although less pronounced, with the majority of tagged individuals within 25 nm from shore (Knowlton et al., 2002).

With the ability to understand the spatial and temporal patterns of migration, offshore wind siting and construction plans can be optimized to adjust for these considerations. In the example of the North Atlantic right whale, it would be wise for regulatory authorities to require mitigation measures of offshore wind developers particularly during late fall through spring to minimize impacts during migration. Charts indicating the percentages of species sightings by season are represented in Figure 1. Furthermore, both the fin whale and bottlenose dolphin are represented by season in Maps 12-19. Seasons were delineated as spring (March – May), summer (June – August), fall (September – November), and winter (December – February). Management challenges are evident by because, unlike the North Atlantic right whale, the plurality of both fin whales and bottlenose dolphins were sighted in the summer months.

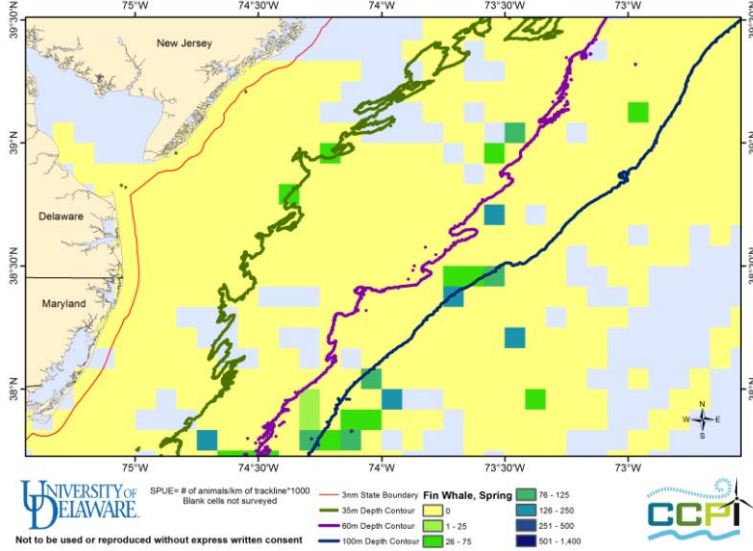
Figure 1: Species-specific seasonal distribution of marine mammals in the mid-Atlantic region

Seasonal distribution of each selected species of marine mammals and combined species in the study area. Seasons are as follows: winter (December – February), spring (March-May), summer (June-August), and fall (September – November). Total number of individuals were counted and summed for all years. Range includes Virginia through New Jersey.

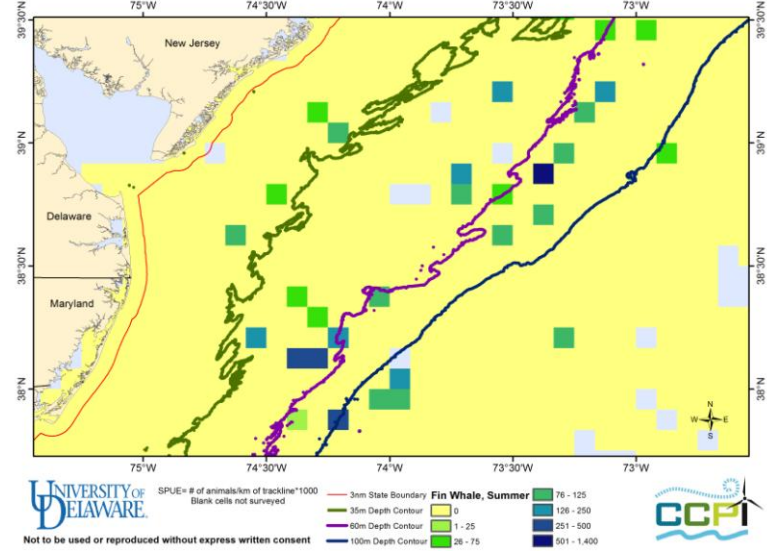


Maps 12-15: Fin Whale Seasonal Distribution

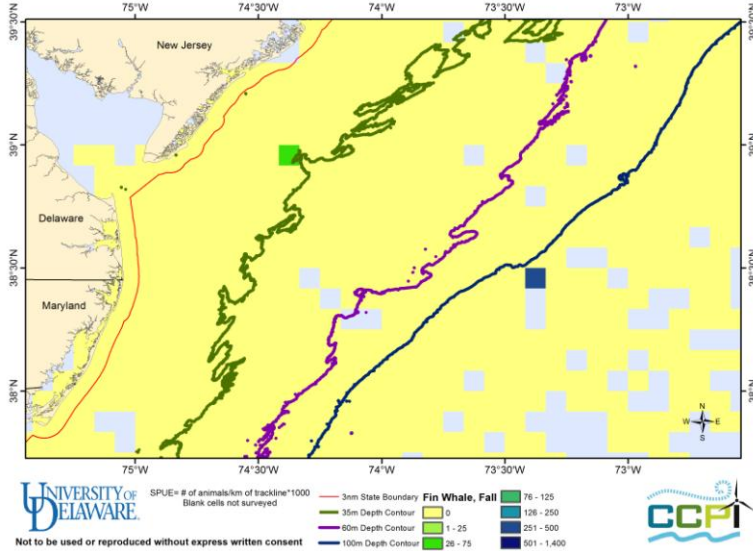
**Fin Whale (Spring)** Sightings per Unit Effort (SPUE) **MAP 12**



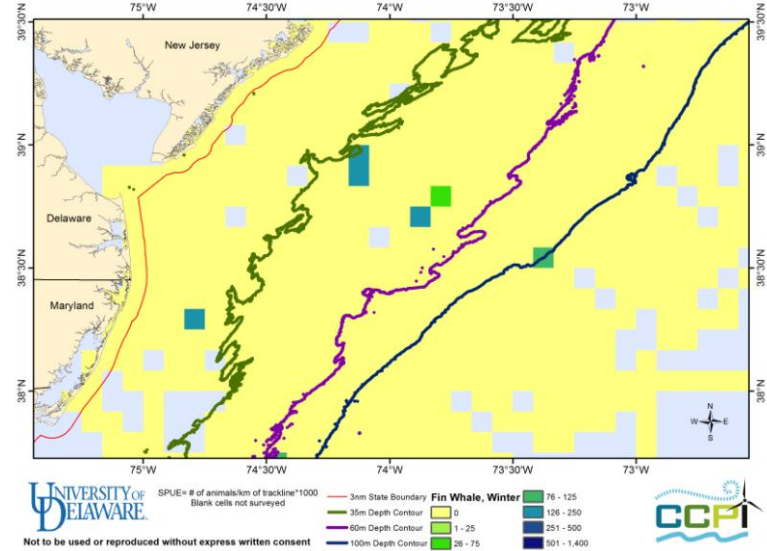
**Fin Whale (Summer)** Sightings per Unit Effort (SPUE) **MAP 13**



**Fin Whale (Fall)** Sightings per Unit Effort (SPUE) **MAP 14**

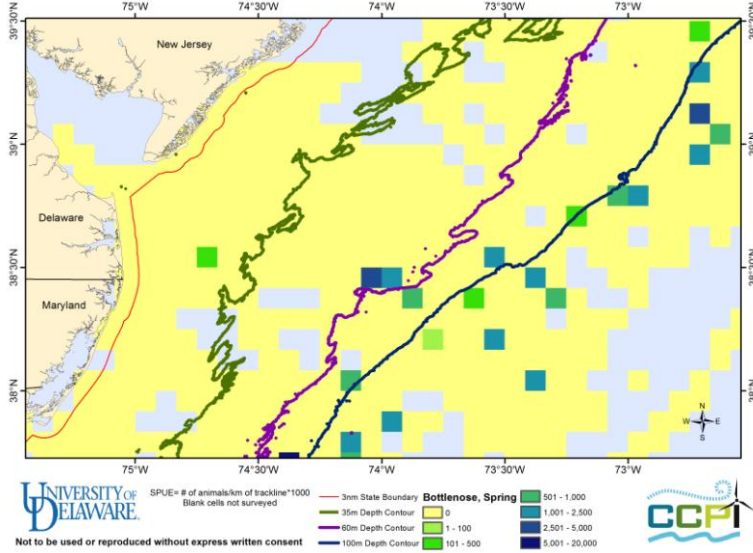


**Fin Whale (Winter)** Sightings per Unit Effort (SPUE) **MAP 15**

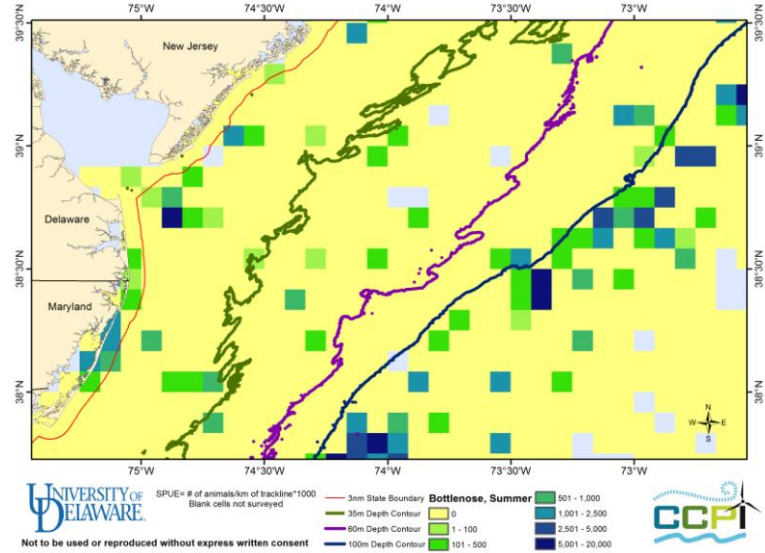


Map 16-19: Bottlenose Dolphin Seasonal Distribution

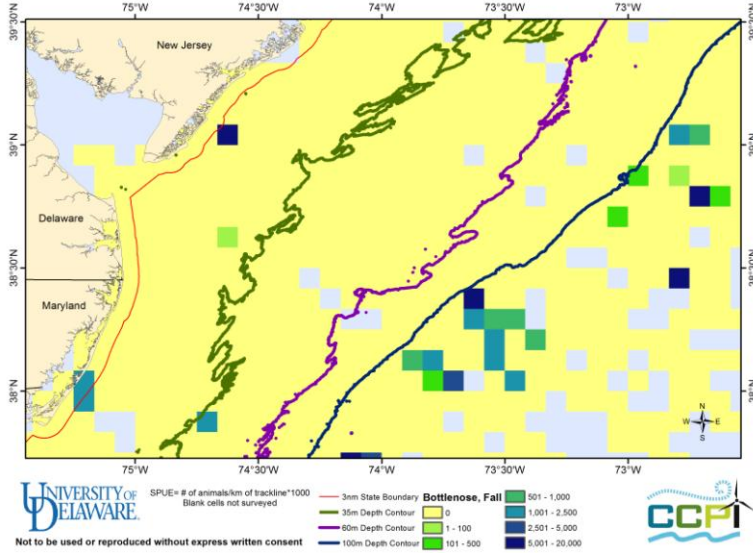
**Bottlenose Dolphin (Spring)** Sightings per Unit Effort (SPUE) **MAP 16**



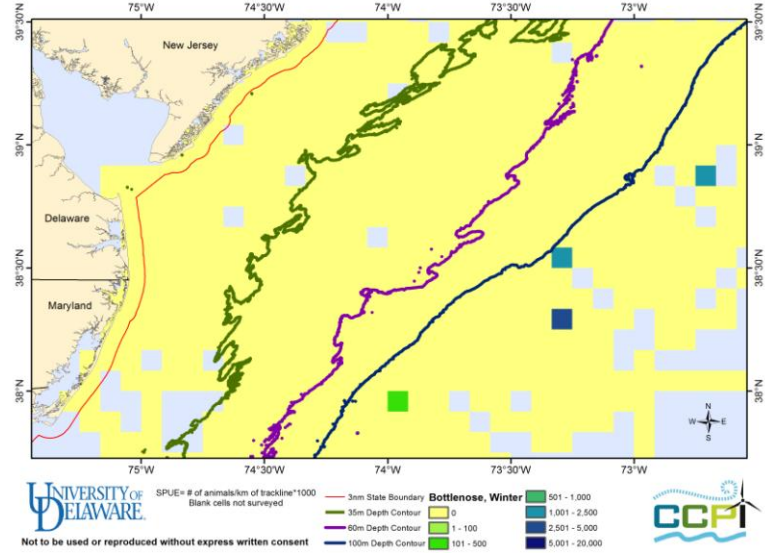
**Bottlenose Dolphin (Summer)** Sightings per Unit Effort (SPUE) **MAP 17**



**Bottlenose Dolphin (Fall)** Sightings per Unit Effort (SPUE) **MAP 18**



**Bottlenose Dolphin (Winter)** Sightings per Unit Effort (SPUE) **MAP 19**



## Sea Turtles

Although little is known of the interactions of sea turtles and offshore wind projects, interactions may be anticipated by applying the spatial and temporal patterns of sea turtles. Sea turtles can be impacted during construction, operations, and decommissioning. Sea turtles can hear, and may be especially sensitive to low frequency sounds (Ketten & Bartol, 2005; O'Hara & Wilcox, 1990). Similar to marine mammals, sea turtles could suffer from increased noise, such as behavioral impacts, habitat displacement, avoidance, and injury (NMFS, 2008). However, it is important to recognize that the extent of this has not been well documented in the offshore wind industry due to the paucity of installations in sea turtle habitat at existing installations in Europe. Pre-construction survey impacts may occur from increased vessel traffic and the use of sonars and seismic profiling devices. Construction impacts include benthic disturbance causing temporary habitat avoidance, as well as noise disturbance or injury from foundation installation. Turbine operation and maintenance can bring increased vessel traffic, and decommissioning in the form of noise and increased vessel traffic. These impacts can be minimized or effectively eliminated through the use of proper planning and understanding of the spatial and temporal distribution of sea turtles species in the mid-Atlantic region.

Four species of sea turtles can be found within the study area (Read et al., 2011). The two most commonly seen species are the loggerhead turtle (*Caretta caretta*) (threatened) and the leatherback turtle (*Dermochelys coriacea*) (endangered) (see Table 2). Sea turtles that are seen in the study area infrequently include Kemp's ridley turtle (*Lepidochelys kempi*) (endangered) and the green sea turtle (*Chelonia mydas*) (threatened). All sea turtles in the study area are jointly managed by the NMFS and the USFWS. NMFS and USFWS have not designated critical habitat for any sea turtle species in the mid-Atlantic region, although a green sea turtle did lay eggs on the beach of Cape Henlopen State Park in summer 2011, the first time in recent history (MERR Institute, 2011). With potential impacts to sea turtles during multiple stages of offshore wind development, the spatial and temporal patterns of sea turtle distribution commonly found in the mid-Atlantic were examined for this project. The NARWC database was utilized to determine sea turtle sightings in the mid-Atlantic (Kenney, 2001). The core of this database is the 1982 Cetacean and Turtle assessment Program (CETAP), which was a large effort to characterize the distribution, abundance and seasonality of turtles and marine mammals in New England and the mid-Atlantic (Kenney, 2011). Data has been subsequently added to the database as available. Based on analysis of the NARWC database, sightings for loggerhead sea turtles were the most frequent and therefore used as a proxy to demonstrate the annual and seasonal abundance of sea turtles. Point data were exported to a shapefile, and subsequently converted to a raster dataset to depict relative abundance. Raster grids of 5-minute by 5-minute were used, with the total count per cell summed and displayed as such. Therefore, the spatial locations of sea turtle sightings are depicted relative to one another. The data for loggerhead sea turtles has been effort-corrected to account for survey bias. Please refer to Map 20.

Map 20: Loggerhead Sea Turtles

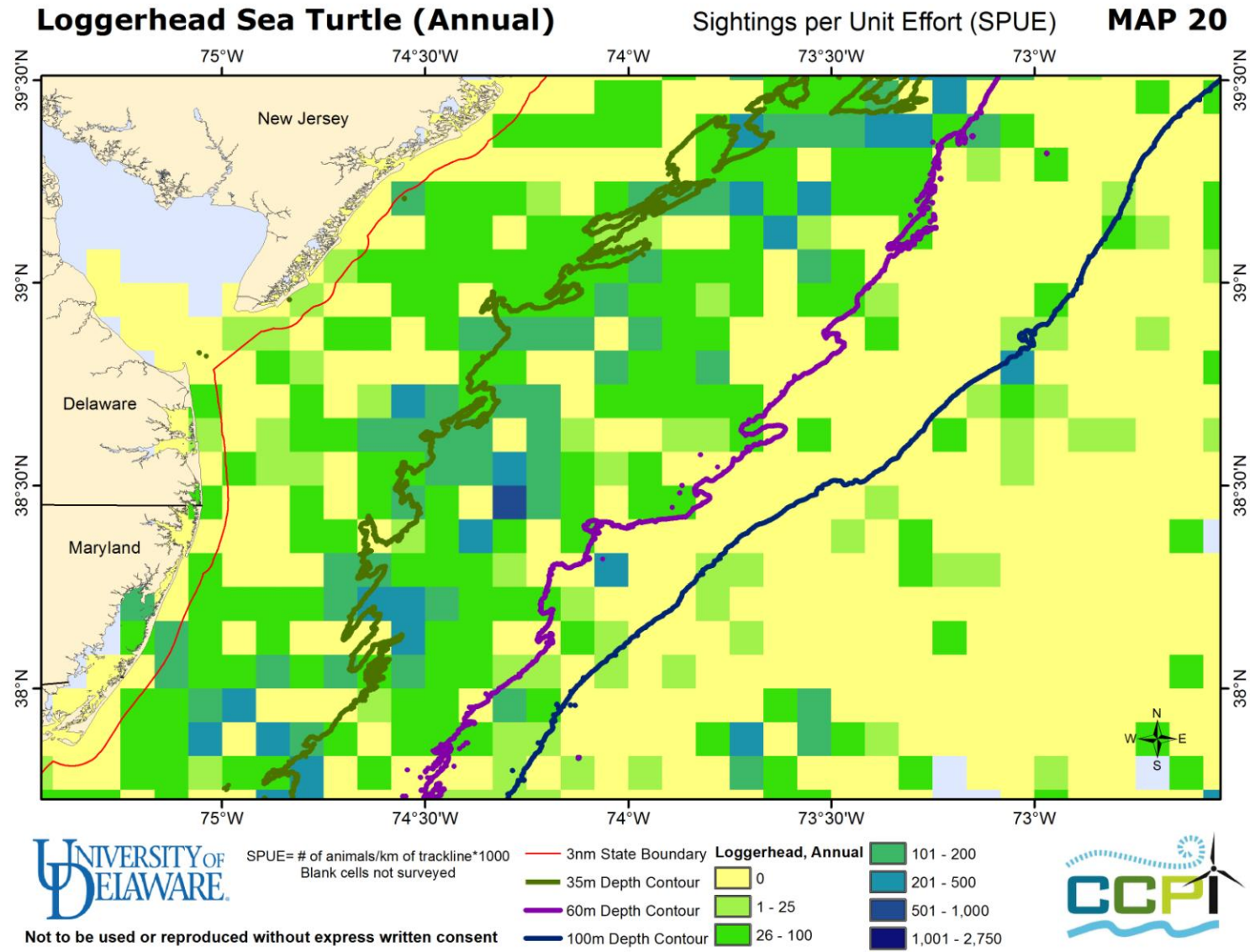


Table 2: Distribution of Selected Sea Turtles in the Study Area

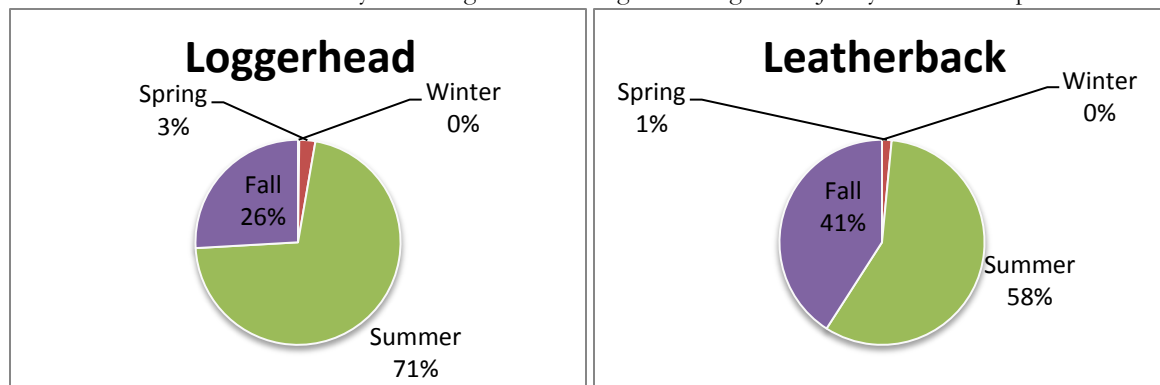
\*\* Presence in mid-Atlantic derived from Kenney et al. (2001)

Sea Turtle Species	Regulatory Protections	Mid-Atlantic Migration Status**
<b>Loggerhead Sea Turtle</b>	ESA: Threatened	Occupy coastal and oceanic areas in summer and early fall
<b>Leatherback Sea Turtle</b>	ESA: Endangered	Occupy coastal and especially pelagic habitats, primarily seen in mid-Atlantic in summer and fall

The loggerhead sea turtle is the most common sea turtle seen in the study area. The loggerhead is managed as nine distinct population segments (DPS). The Northwest Atlantic loggerheads occur within the study area, consisting of five separate nesting groups/sub-populations (50 CFR Parts 223 and 224). The Northwest Atlantic loggerheads are listed as threatened, with a primary threat of entanglement with fishing gear, as well as threats on nesting beaches (NOAA Office of Protected Resources, 2011). Loggerheads are highly migratory on a seasonal basis moving south with cooling sea surface temperatures (Geo-Marine, 2010; Mansfield et al., 2009). Seasonal maps for loggerheads can be found in Maps 21-24. Their abundance in a given area is thus strongly linked to sea surface temperature. Satellite tracking of immature loggerheads has shown that they may migrate in either a neritic or oceanic (beyond the continental shelf) pathway, corresponding with oceanographic features and likely have high site fidelity (Mansfield et al., 2009). Loggerheads are common in neritic environments in the summer months, from Cape Cod south to Florida. They are commonly seen close to shore, which is consistent with recent surveys in which they were identified from 0.8 – 21 nm off the coast of New Jersey (Geo-Marine, 2010). Although loggerhead sea turtles are distributed throughout the study area, a higher density of turtles are near shore, with 26% inshore of 35-meters water depth, 74% in greater water depths, although few beyond the 60-meter contour (Map 20). The inshore areas where sea turtles are more frequently seen coincide with areas where offshore wind turbines are more likely to be installed in the near term. Presence of sea turtles is highly seasonal throughout the study area, with sightings largely skewed towards summer, followed by fall (Figure 2). Impacts from development of wind turbines are also associated with specific activities, thus development should be carefully considered with respect to sea turtles.

Figure 2: Seasonal distribution of loggerhead sea turtles in the mid-Atlantic region

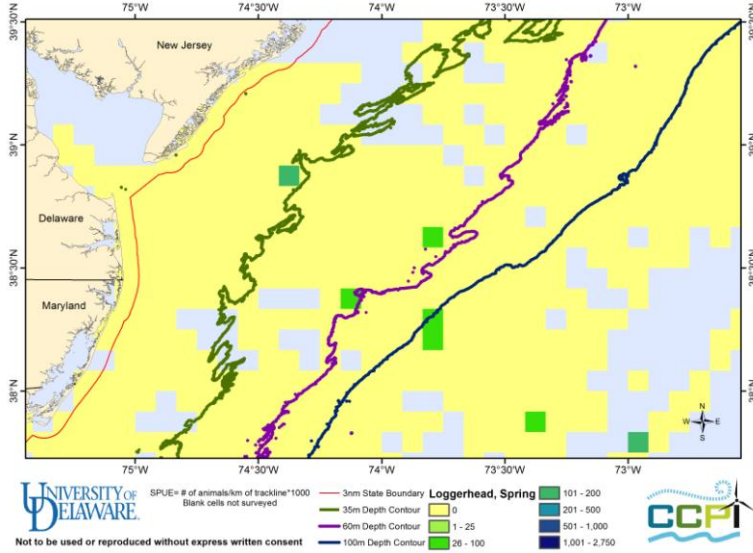
Seasonal distribution of each selected species of sea turtles in the study area. Seasons are as follows: winter (December – February), spring (March-May), summer (June-August), and fall (September – November). Total number of individuals were counted and summed for all years. Range includes Virginia through New Jersey. Refer to Maps 21-24.



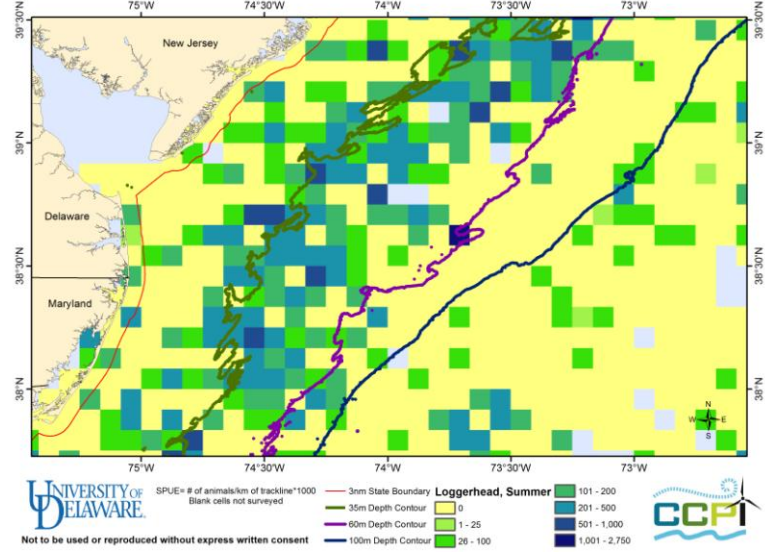


Map 21-24: Loggerhead Sea Turtle Seasonal Distribution

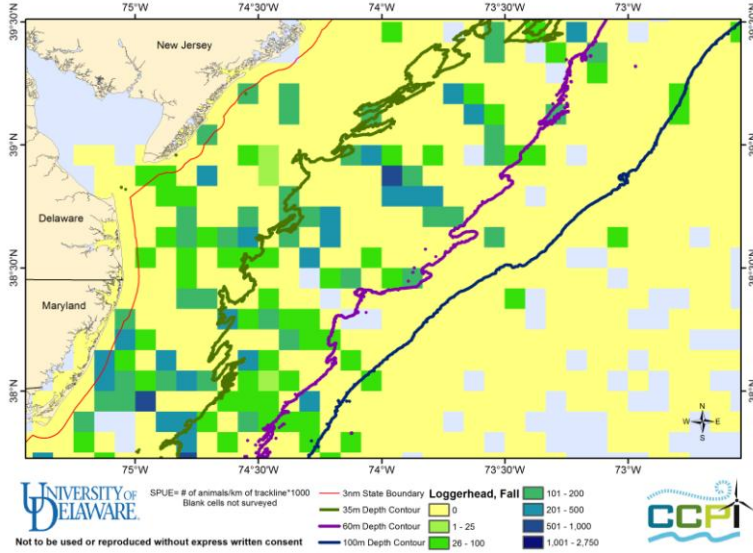
**Loggerhead Sea Turtle (Spring)** Sightings per Unit Effort (SPUE) **MAP 21**



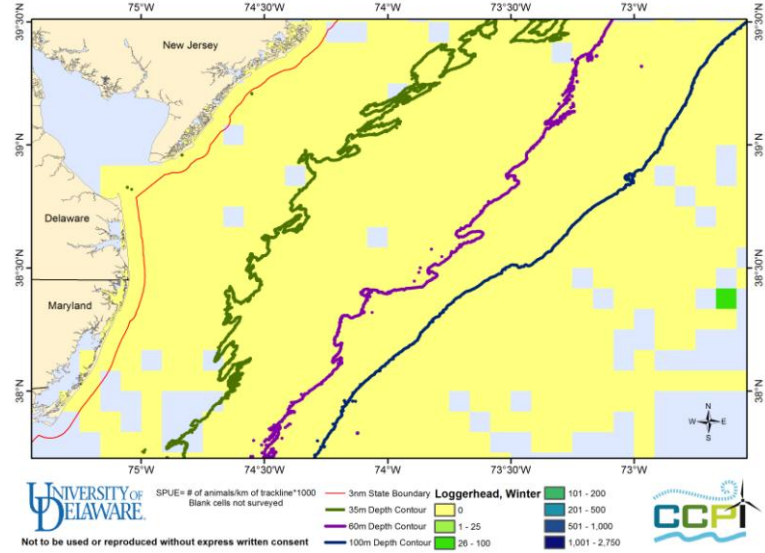
**Loggerhead Sea Turtle (Summer)** Sightings per Unit Effort (SPUE) **MAP 22**



**Loggerhead Sea Turtle (Fall)** Sightings per Unit Effort (SPUE) **MAP 23**



**Loggerhead Sea Turtle (Winter)** Sightings per Unit Effort (SPUE) **MAP 24**

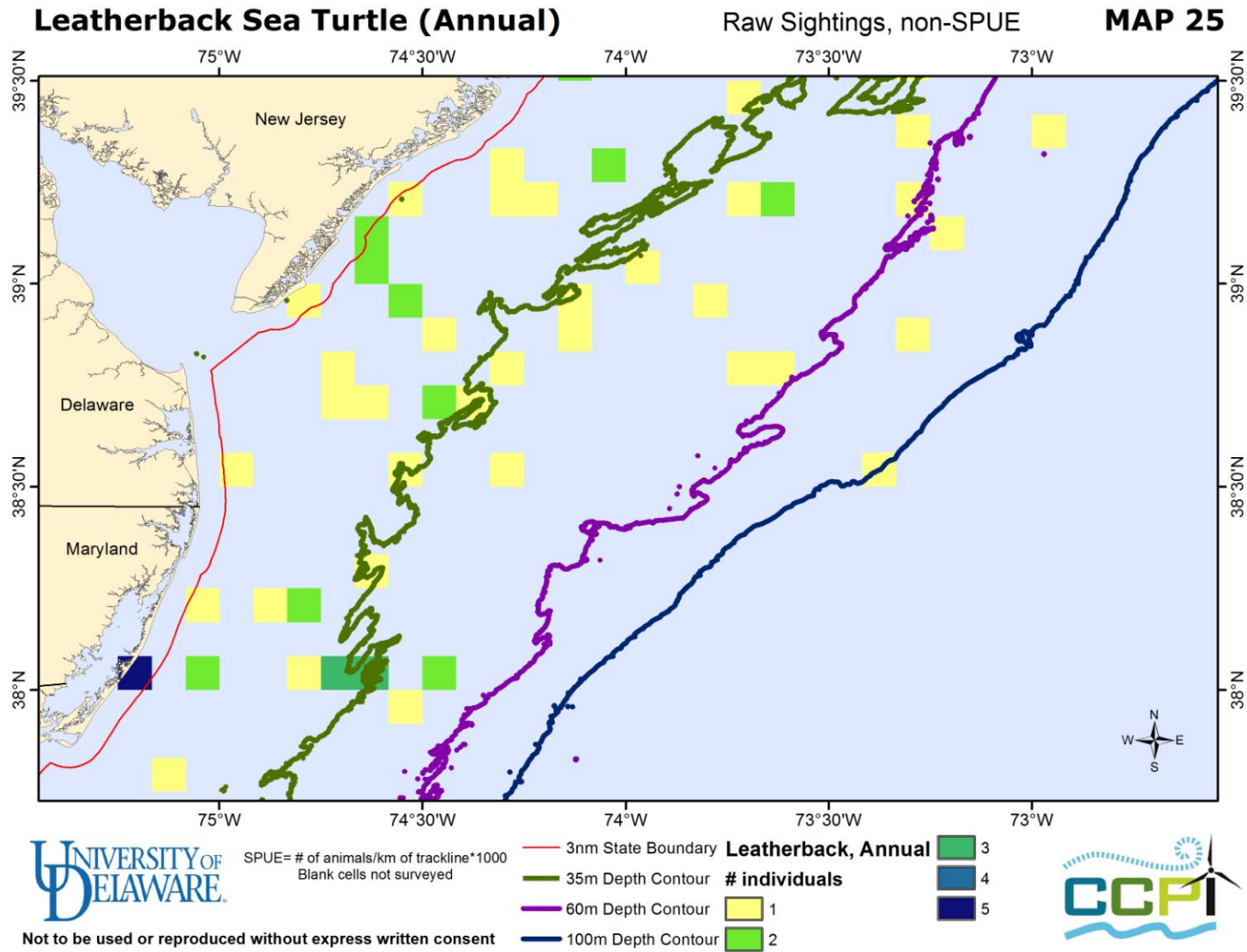


Relatively few sightings of leatherback sea turtles occurred in the study area, though they are the second most common identified turtle. Too few sightings are recorded to complete SPUE calculations. However, leatherback sea turtles are endangered, and have different habitat preferences and distribution than loggerheads, making a useful comparison. Leatherbacks are generally pelagic species, and are very widely distributed (NOAA Office of Protected Resources, 2011). Leatherbacks undergo an annual migration in the northwest Atlantic, leaving the tropics and migrating up the Atlantic coast, with a late spring through summer occurrence in the mid-Atlantic (Geo-Marine, 2010). It is thought that leatherbacks migrate north to feed on jellyfish (Sherrill-Mix et al., 2008). Leatherbacks are found in both neritic and pelagic environments, with high variability in habitat usage in the Atlantic Ocean, which may be linked to multiple oceanographic conditions and hatchling drift scenarios (Fossette et al., 2010), rather than a single migratory corridor. As evidenced, 73% of leatherback sightings are inshore of the 35-meter contour, though survey bias has not been accounted for in this map. Please refer to Map 25.

### *Cold-Water Corals*

Cold-water corals, also referred to as deep-water corals, are prevalent in some parts of the northwest Atlantic Ocean, primarily in canyons and along the continental slope. Generally found below 40 meters, these corals are very long lived, creating important complex habitat for fisheries and other species (Williams, 2009). Although their ecological role is not fully understood, they are considered to form important ecological habitat. Further, due to their sensitivity, cold-water corals act as indicator species for marine threats such as climate change (Stiles et al., 2007). Threats such as commercial fishing, oil and gas drilling, offshore cables, and anchoring activities are also current threats facing cold-water corals (Williams, 2009). Currently, federally funded research that would potentially lead to additional conservation efforts is taking place under the umbrella of the Magnuson Stevens Fishery Conservation Act, among other research programs (NOAA, 2010). Wilmington Canyon and Baltimore Canyon are two major canyons within the study area where cold-water corals are found Wilmington Canyon and Baltimore Canyon (Stiles et al., 2007; Williams, 2009). These areas may be considered important habitat areas supporting an abundance of life beyond cold-water corals. The canyons where known cold water corals exist within the study were drawn as polygons in ArcGIS using canyons as a background reference area. Both of these canyons are over 100 meters deep and are therefore unlikely to conflict with near-term offshore wind development. In the future, deployment of floating turbines, which are anchored to the seafloor, can potentially result in conflicts in these areas and will need to be considered further.

Map 25: Leatherback Sea Turtles in the study area. Sightings are not effort corrected.



### *Essential Fish Habitat*

Under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), NOAA has jurisdiction to designate and manage essential fish habitat (EFH). EFH includes "waters and substrate necessary for fish spawning, breeding, feeding, or growth to maturity" (50 CFR Part 600). EFH exists in the study area for one or more life stages of several federally managed species. The distribution of fish with designated EFH varies widely both spatially and seasonally. Many of the species are migratory, and are only present in the location for a period of time. Furthermore, species occur in different habitats during different life stages. EFH exists in the study area for the following species during one or more life stages: Atlantic cod, haddock, red hake, witch flounder, winter flounder, yellowtail flounder, windowpane flounder, Atlantic sea scallop, ocean pout, Atlantic sea herring, monkfish, bluefish, tilefish, Atlantic butterflyfish, summer flounder, black sea bass, king mackerel, Spanish mackerel, cobia, sand tiger shark, Atlantic angel shark, Atlantic sharpnose shark, dusky shark, sandbar shark, scalloped hammerhead shark, and tiger shark. The sandbar shark also has habitat of particular concern (HAPC) in this region (NOAA Fisheries, 2011). For listings of each life stage of EFH by 10-minute square, the reader is directed to the NOAA Fisheries Habitat Conservation Division Guide to EFH Designations (<http://www.nero.noaa.gov/hcd/>).

Within states waters in the mid-Atlantic, the respective state fisheries management program is responsible for the management of fisheries with coordination by the Atlantic States Marine Fisheries Commission (ASMFC). The Mid-Atlantic Fishery Management Council (MAFMC) manages species from 3-200 nm from shore. The ASMFC coordinates conservation and interstate fisheries management of the American eel, American lobster, Atlantic croaker, Atlantic herring, Atlantic menhaden, Atlantic sturgeon, black sea bass, bluefish, horseshoe crab, northern shrimp, red drum, scup, shad and river herring, Spanish mackerel, spiny dogfish and coastal sharks, spot, spotted seatrout, striped bass, summer flounder, tuatog, weakfish, and winter flounder (ASMFC, 2011). The MAFMC manages Atlantic mackerel, squid, butterflyfish, bluefish, spiny dogfish, summer flounder, scup, black sea bass, surfclam, ocean quahog, tilefish, and monkfish (MAFMC, 2011). Proposed federal actions that may adversely affect areas that contain EFH must consult with NOAA's National Marine Fisheries Service (NMFS) for conservation recommendations (NOAA Fisheries, 2011). Fish living within the study area, including those with EFH or HAPC, may be affected by offshore wind development through changes to habitat, entrainment, auditory impacts, and indirect effects, some of which may be positive effects (Danish Institute for Fisheries Research, 2000; Dong Energy, 2006; Leonhard & Pederson, 2006; Wilson et al., 2010). Offshore canyons - Lydia, Oceanographer, Veatch and Norfolk - all have fishing restrictions due to EFH for tilefish, Atlantic mackerel, squid, and butterflyfish. Within the study area, a shapefile for tilefish EFH was downloaded from NOAA Fisheries (2011). This area is supplemented by the addition of canyons off the continental shelf. In addition to being habitat for cold-water corals, these canyons host significant biodiversity, some of which are limited from certain fishing practices. Vector data for submarine canyons was downloaded as a polygon shapefile from the MARCO Portal.

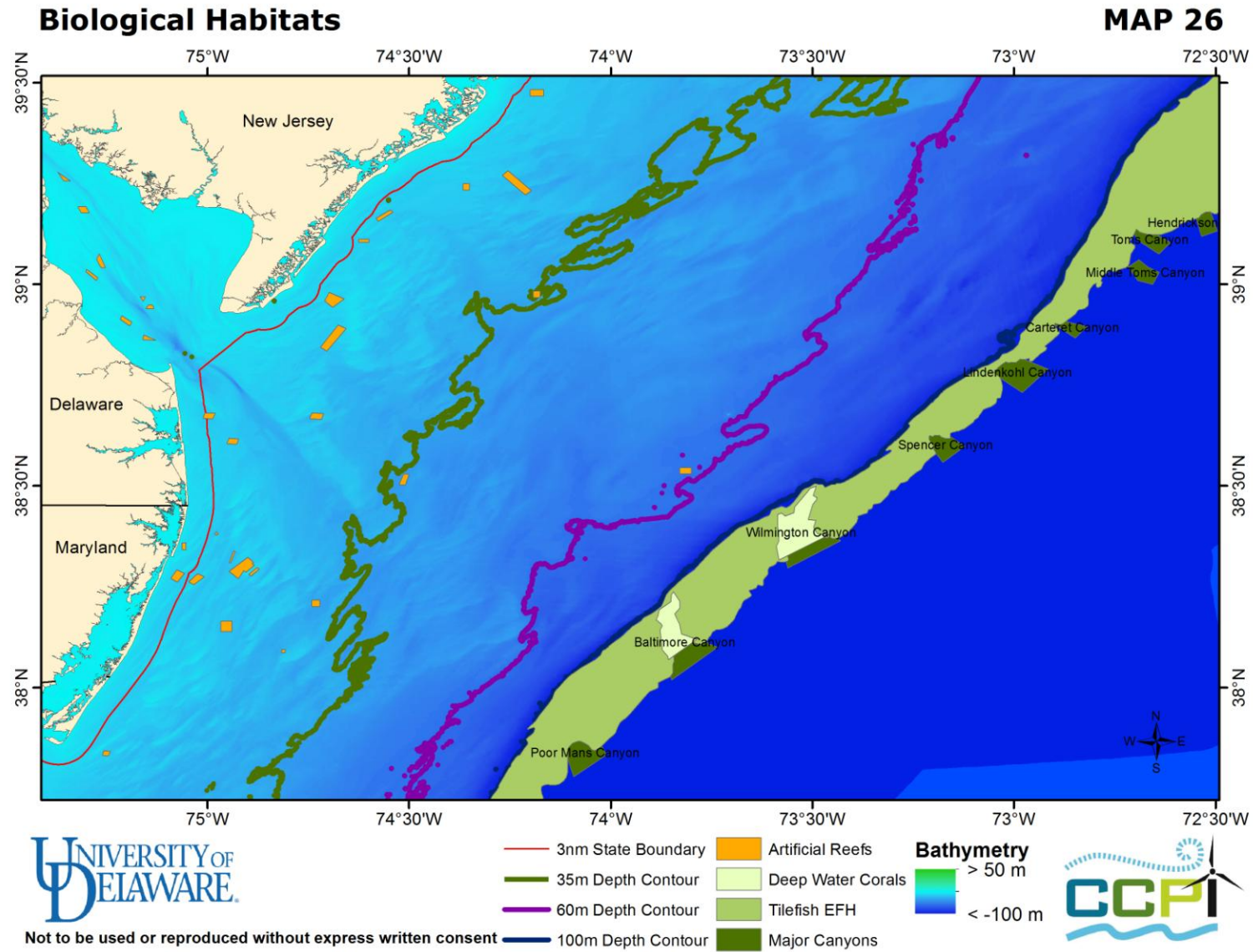
Selected important benthic habitat features are displayed to demonstrate areas where infrastructure development in the offshore environment may be conflicting. Please refer to Map 26. As indicated, features associated with the continental shelf break are rich habitat areas. Important habitat features also exist in the near-shore environment. Essential fish habitat (EFH), for example, exists throughout the study area for a number of species in one or more life stages. EFH for tilefish is displayed, which follows the shelf break. Other digital information of EFH has not been made available, and thus the reader is referred to the MARCO Portal ([http://www.midatlanticocean.org/map\\_portal.html](http://www.midatlanticocean.org/map_portal.html)) for a display of marine habitats within the study area. Importantly, cold-water corals are known to be associated with Baltimore and Wilmington Canyons and thus they are biological hot spots, while other canyons in the area host high biodiversity as well. These areas are beyond near-term wind development, but should be considered as technology pushes turbine development into deeper waters. Artificial reefs have been added to this map as well to indicate areas of high density.

### *Avian*

The study area is located within the avian Atlantic Flyway. Delaware Bay and Atlantic nearer-shore waters, areas, which are potentially valuable for offshore wind power, are also likely to have significant avian activity. Risks of collision, habitat displacement, and travel changes have been quantified at several European wind projects, with many species having shown avoidance behaviors (Desholm & Kahlert, 2005; Huppopp et al., 2006; Pettersson, 2005). Although a growing body of literature highlights impacts to avians from land-based wind turbines in the U.S., seabirds are exposed to different conditions, and land-based impacts should not be extrapolated. There is a need to integrate information that identifies the potential primary wind production areas with seabird distribution and abundance (Michel et al., 2007). A recent report has highlighted the potential build out in the mid-Atlantic, identifying trends of avifauna across the region inclusive of population estimates and species/subspecies and population-specific potential biological removal levels, which are each based on an estimate of the level of incidental take that will not jeopardize the given population (Watts, 2010). To address the potential for avian impacts, this portion of the project followed the Northwestern Atlantic Birds at Sea Conservation Cooperative's ranking of priority species for assessment and has identified avifauna within the study area that should be considered when planning for offshore wind projects. Please refer to Maps 27-37.

Avian data were acquired from the USGS as an ArcGIS geodatabase that includes the compilation of at least 62 different data sources from 1978-2009 (O'Connell et al., 2009). These data include more than 85% of all seabird occurrence information for the U.S. Atlantic currently known to exist. The datasets varied in spatial and temporal scale as well as in quality. Some data were obtained from surveys with standardized sampling frames while others were collected opportunistically independent of a probabilistic sample. Data types and fields were standardized across datasets to make the data as consistent as possible. Sampling effort was calculated in units of five-minute equivalents either as surveys that were conducted as discrete-time transects (typical of surveys prior to 1990) or as continuous-time transects (typical of modern surveys with GPS technology).

Map 26: Biological Habitats



Discrete time transects were calculated so that each five minute equivalent equals the number of five minute survey periods. Continuous time transects were calculated so that each five minute equivalent equals a survey segment of 0.8333 of a nautical mile, which is the distance traveled by a vessel traveling 10 knots for five minutes and which is equivalent to 1.85 km. The total number of five-minute equivalents was calculated for each 1/4-degree grid cell of a grid and effort was summarized by season (winter, spring, summer, and fall) (O'Connell et al., 2009).

The effort-adjusted counts (collected over a 30-year period), however, do not account for detection probability. Therefore, maps should be used only to provide guidance as to potential for occurrence of a species during a season in each grid cell; a cell without data does not necessarily mean that avifauna does not occur within that cell, but rather, that avifauna has not been identified in that cell. The data can be used to understand general patterns of distribution in the U.S. Effort-corrected seabird distributions are overlain with grid cells with effort as polygon vector files. These are color-coded to indicate the level of occurrence.

Species depicted were chosen based on access to data, their known occurrence in the study area, and their conservation status (see Table 4): Audubon's Shearwater (*Puffinus lherminieri*), Common Loon (*Gavia immer*), Cory's Shearwater (*Calonectris diomedea*), Black Scoter (*Melanitta nigra*), Razorbill (*Alca torda*), Double-crested Cormorant (*Phalacrocorax auritus*), Dovekie (*Alle alle*), Great black-backed gull (*Larus marinus*), and Great Shearwater (*Puffinus gravis*), and Northern Gannet (*Morus bassanus*). Please refer to Maps 28 – 37.

Both the Great Shearwater and the Audubon's Shearwater have been identified as a species in need of conservation due to population declines and threats to breeding grounds (USGS, 2010a; USGS 2010b). Both migrate across the Atlantic Coast in spring and summer. Of the alcids, both Razorbills and Dovekies have been increasing in abundance in the mid-Atlantic (Veit & Guris, 2008). Razorbills overwinter south of their breeding range in the coastal waters primarily along New York and New Jersey, and very occasionally along Virginia and the coast south of Virginia (Lavers et al., 2009). Razorbills sightings have dramatically increased off the mid-Atlantic coast since the 1990s, hypothesized to be linked to changing climate and oceanographic features in the North Atlantic, as well as changes to prey abundance (Veit & Guris, 2008). Dovekies winter in the low-arctic and boreal waters of northeastern North America. Dovekies also often travel south of their typical range along the east coast of the United States (Montevecchi & Stenhouse, 2002). In fact, Dovekies have been increasing in the mid-Atlantic since the 1990s, with large overwintering numbers in the New York Bight, possibly extending the winter range in a southerly direction (Veit & Guris, 2008). The Black Scoter, Common Loon, and Double-crested Cormorant breed in the North American inland regions and overwinter along the North American coasts (Bordage & Savard, 1995; Evers, Paruk, McIntyre, & Barr, 2010; Hatch & Weseloh, 1999). The Common Loon ranges throughout North America (Evers et al., 2010), migrating to marine environments along the North American coasts during the winter and spring seasons (Evers et al., 2010). Double-crested Cormorants live along seacoasts and inland waters of the U.S. and Canada (Hatch & Weseloh, 1999). The Great Black-backed Gull is common in the northeastern United States and northern Europe (Good, 1998),

migrating south to the southern United States in winter (Good, 1998). Cory's Shearwater is found feeding along the east coast of North America May through August (NAS, 2011). The Northern Gannet breeds during the summer along the North Atlantic, particularly in New Hampshire, Vermont, Maine, and part of Canada (Waterbird Conservation for the Americas, 2011). During the remainder of the year, gannets spend most of their time foraging at sea (Cornell Lab of Ornithology, 2011). They range from the Gulf of Mexico to the Northern parts of the open Atlantic Ocean, extending toward Europe. Gannets plunge-dive for fish, often within flocks of hundreds of birds (Cornell Lab of Ornithology, 2011).

In addition, recent studies on Red Knots (*Calidris canutus*, ESA candidate), piping plovers (*Charadrius melodus*, threatened Atlantic coastal breeding population), and roseate terns (*Sterna dougallii*, endangered North American breeding population) provide insights to the risk of offshore wind projects to these species. These species were studied in detail as ESA-listed or candidate species that are likely to be exposed to offshore wind development in the AOCS (Normandeau Associates, Inc. 2011). Researchers analyzed historic data and generated new data to determine collision risk and exposure at the macro scale (occurrence of species on the region), mesoscale (flight altitude), and micro scale (behavioral avoidance/susceptibility) (Normandeau Associates, Inc. 2011).

Piping plovers were widely dispersed throughout the AOCS, indicating macroscale exposure. Elevated exposure in the nearshore/coastal environments is possible due to the affinity of this species to these environments. Micro- and mesoscale exposure are not well known due to limited knowledge of flight height and avoidance behavior of piping plovers (Normandeau Associates, Inc. 2011). Roseate terns migrate pelagically, and therefore are likely to have macroscale exposure during migration as well as breeding, although this does not indicate high risk due to the limited observational data.

Migratory patterns of Red Knots were studied in greater detail, in part to analyze the risk of exposure to offshore wind turbines on the AOCS (Normandeau Associates, Inc. 2011). Red Knots were fitted with geolocators to track both the northern and southern migration. Three birds captured in Delaware Bay, and eight birds captured in Massachusetts returned with migration data. All birds spent the breeding season in the Arctic, migrating south to over-winter in a number of locations, with many stops along the route. Red Knots were found to generally migrate in a non-coastal pattern, although there may be a coastal migration of a minority of Red Knots along the Atlantic coast of the US. The low resolution of geolocators limits the data analysis, reported from two sources as 150 km to 250-300 km resolution, although errors can be reduced with analytical advances. This research indicates that macroscale exposure of Red Knots is concentrated to the south and southeast of Delaware Bay in spring, and south and southeast of Massachusetts in fall. Exposure to turbines beyond 3 nm may occur during the long migratory flight. Significantly higher exposure may occur in coastal or nearshore environments because Red Knots spend much more time in these environments. Although Red Knots are likely to be exposed to turbines, they are not necessarily at risk of collision, given a lack of understanding microscale and macroscale factors (Normandeau Associates, Inc. 2011).



Table 3: GIS Datasets used for seabird distribution

Large spatial-scale scientific surveys
Manomet Center for Conservation Sciences Seabird Survey
Cetacean and Seabird Assessment Program (CSAP)
South Atlantic Bight (SAB) - Haney
Southeast Fisheries Science Center (SEFSC) Atlantic Surveys, 1992
SEFSC Atlantic Surveys, 1998
SEFSC Atlantic Surveys, 1999
Winter Survey of Mid-Atlantic (FWS)
EcoMon May 2007
Acoustic Herring Survey 2007
Acoustic Herring Survey 2008
EcoMon January 2009
Atlantic Flyway Sea Duck Survey
Mid-winter Waterfowl - USFWS
Programme Integre Recherchessur les Oiseaux Pelagiques (PIROP)

Small spatial-scale scientific surveys
Summer 2004/ Winter 2005 Cape Hatteras
Sargasso cruise - bird sightings
Hatteras Eddy Cruise 2004
Bar Harbor Whale Watch Survey 2005
Bar Harbor Whale Watch Survey 2006
New England Seamount Chain
DUML Vessel-Based Surveys for Monitoring of Proposed Onslow Bay Undersea Warfare Training Range (USWTR) site
Mid-winter Offshore Survey - USFWS
North Carolina off Oregon and Hatteras Inlets – David Lee
Northwest Atlantic Sargasso Sea - Haney
Cape Wind - Nantucket Sound Seabird Survey
Mass Audubon - Nantucket Sound Seabird Survey
Nantucket Shoals - Long-tailed Duck Survey
Aerial survey of Upper Trophic Level Predators on Platts Bank, Gulf of Maine
Long Island Power Authority – Long Island wind power site survey
Bluewater Wind LLC – New Jersey wind power site survey
Bluewater Wind LLC – Delaware wind power site survey

Observational datasets
Brian Patteson Seabirding Pelagic Trips
M. S. Gordon Surveys off Southern New England on Blue Dolphin
New York to France Atlantic Crossings by R.H. Wiley
Rowlett Offshore Maryland
Avalon Seawatch
Seabird Ecological Assessment Network (SEANET)
Seabird Bycatch - Northwest Atlantic

Sargasso Sea 2006
National Audubon Society Christmas Bird Count - New York Harbor to and at the Cholera Bank
National Audubon Society Christmas Bird Count - 130th St. Ferry
National Audubon Society Christmas Bird Count - New York City- New York City Battery - 17 fathoms
National Audubon Society Christmas Bird Count - New York City- Atlantic Ocean
National Audubon Society Christmas Bird Count - L.I. Atlantic Ocean off Fire Island
National Audubon Society Christmas Bird Count - at sea off Monomoy Point
National Audubon Society Christmas Bird Count - at sea off Brooklyn National Audubon Society Christmas Bird Count - L.I. Atlantic Ocean off Fire Island
National Audubon Society Christmas Bird Count - Bay of Fundy
National Audubon Society Christmas Bird Count - Penobscot Bay
National Audubon Society Christmas Bird Count - Merrymeeting Bay
National Audubon Society Christmas Bird Count - Atlantic Ocean off New Jersey
National Audubon Society Christmas Bird Count - Atlantic Ocean off New Jersey
National Audubon Society Christmas Bird Count - Baltimore Canyon
National Audubon Society Christmas Bird Count - Machias Bay
National Audubon Society Christmas Bird Count - Atlantic Ocean off New Jersey
National Audubon Society Christmas Bird Count - Baltimore Harbor
National Audubon Society Christmas Bird Count - Jug Bay
National Audubon Society Christmas Bird Count - Baltimore Canyon
National Audubon Society Christmas Bird Count - Stellwagen Bank
National Audubon Society Christmas Bird Count - NJ: Atlantic Ocean offshore
National Audubon Society Christmas Bird Count - Chesapeake Bay
National Audubon Society Christmas Bird Count - New Jersey pelagic
National Audubon Society Christmas Bird Count - North Penobscot Bay

*Table 4: Selected Seabirds for Analysis.*

Selected species in the mid-Atlantic region. Regulatory protections and seasonal presence in the mid-Atlantic are listed to indicate potential conflicts. Adapted from O'Connell et al. (2009)

Seabird	Regulatory Protections	Mid-Atlantic Presence**
<b>*Common Loon</b>	Migratory Bird Treaty Act (MBTA)	Strong spring and fall presence, winter presence moderate, little to no summer presence
<b>*Great Shearwater</b>	MBTA	Very strong summer and fall presence, little to no winter and spring presence
<b>*Audubon's Shearwater</b>	MBTA	Prevalent in summer and fall, little or no winter and spring presence
<b>Double Crested Cormorant</b>	MBTA	Very strong spring and fall presence, little to no summer and winter presence
<b>Great Black-Backed Gull</b>	MBTA	Prevalent fall, winter and spring, little summer presence
<b>Black Scoter</b>	MBTA	Prevalent winter and spring, little to no presence summer and fall

<b>Dovekie</b>	MBTA	Prevalent in spring
<b>Razorbill</b>	MBTA	Prevalent in summer, some fall and spring presence
<b>Cory's Shearwater</b>	MBTA	Presence in fall, winter and spring, absent summer
<b>Northern Gannet</b>	MBTA	

\*Species considered to be of 'highest concern' by O'Connell et al. (2009)

\*\*Presence determined from mapping results; data source O'Connell et al. (2009)

A total of eleven maps are displayed to demonstrate the relative abundance of seabirds in the mid-Atlantic region. Interpretation of these maps can be difficult. First, grid cells that are outlined without color indicate areas where survey effort occurred with no sightings. Second, results displayed do not account for the probability of detection of a given species, and some seabird species may be easier to detect than others. Third, survey design among the studies aggregated here is not consistent. Therefore, these results should be interpreted with care. It is telling, however, to view areas where seabirds have been detected as this provides regulators and developers with a representation of areas where seabirds and wind turbines may be more likely to encounter spatial conflicts. Seabirds were selected from a list of priority species identified by O'Connell (2009) and by the US Fish and Wildlife Service. The selection criteria include forage strategy, conservation status, and distribution. An aggregate seabirds map is provided for reference, although care should be taken when interpreting these results. Assessing threats generally occurs at a species-specific level, and species-specific maps are more telling from a management perspective. Furthermore, given the differences in seasonality of each species, aggregate distributions do not indicate that all of the birds are present in the study area at the same time.

What is not depicted on the maps is the strong seasonality of seabird distribution within the study area (see Figure 3). As highly migratory species, each of the seabirds exhibits a strong seasonal component. Therefore, conflicts with offshore wind in terms of habitat use or migratory routes will vary by species, by season. In general, species have a strong presence in the summer and fall and little presence in the winter, though this trend is not the same for all species. The species Razorbill and Black Scoter, for example, are most prevalent in the winter and least prevalent in the summer (see Figure 4). Both of these species breed in the boreal regions of the North America and migrate south to the North American coasts during the winter (Lavers, et al. 2009; Bordage & Savard, 1995).

*Figure 3: Aggregate seasonal distribution of selected sea bird species in the study area*

Seasons are as follows: Winter (December – February), Spring (March-May), Summer (June-August), and Fall (September – November). Number of individuals were counted and summed for all years. Range limited to study area.

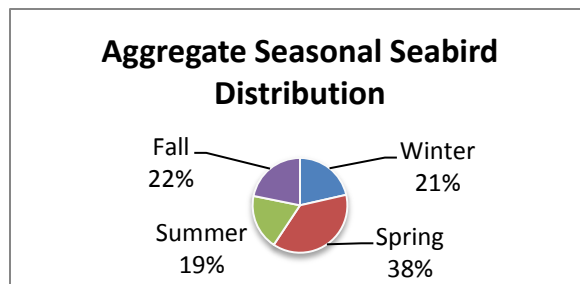
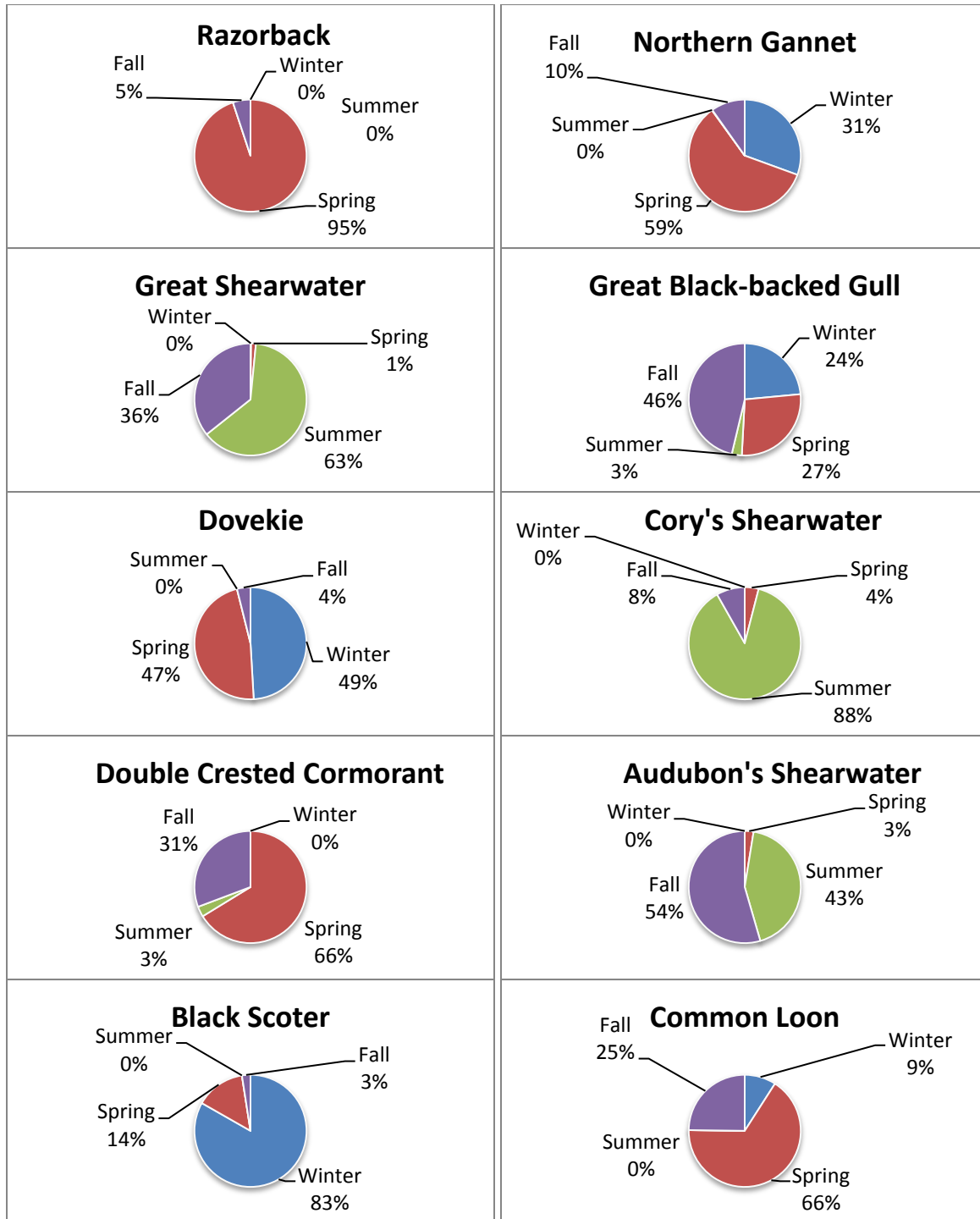
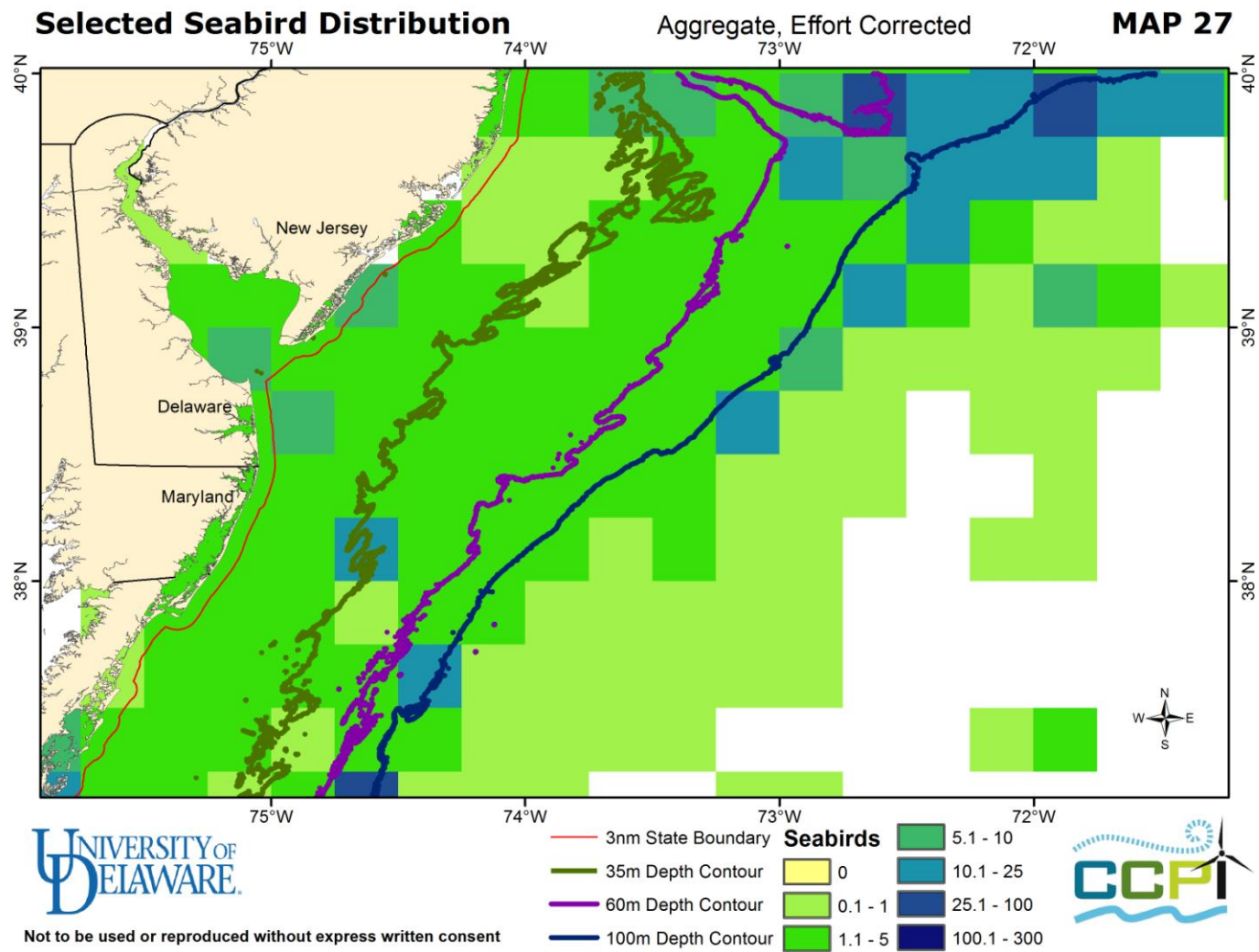


Figure 4: Species-seasonal seasonal distribution of seabirds in the study area

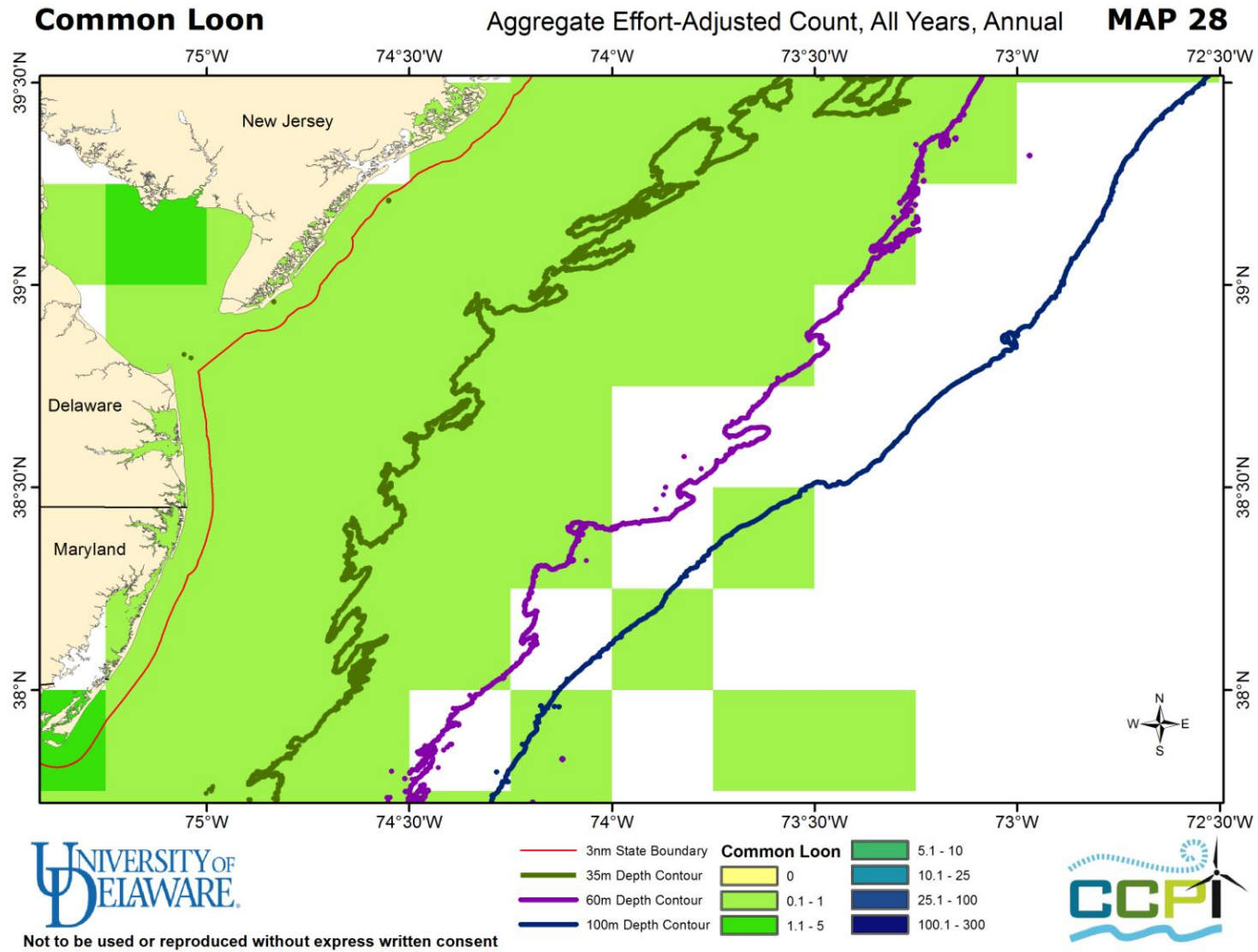
Seasonal presence of individual seabird species in the study area. Several species have a strong presence during at least two of the seasons, and some species are nearly absent at other times.



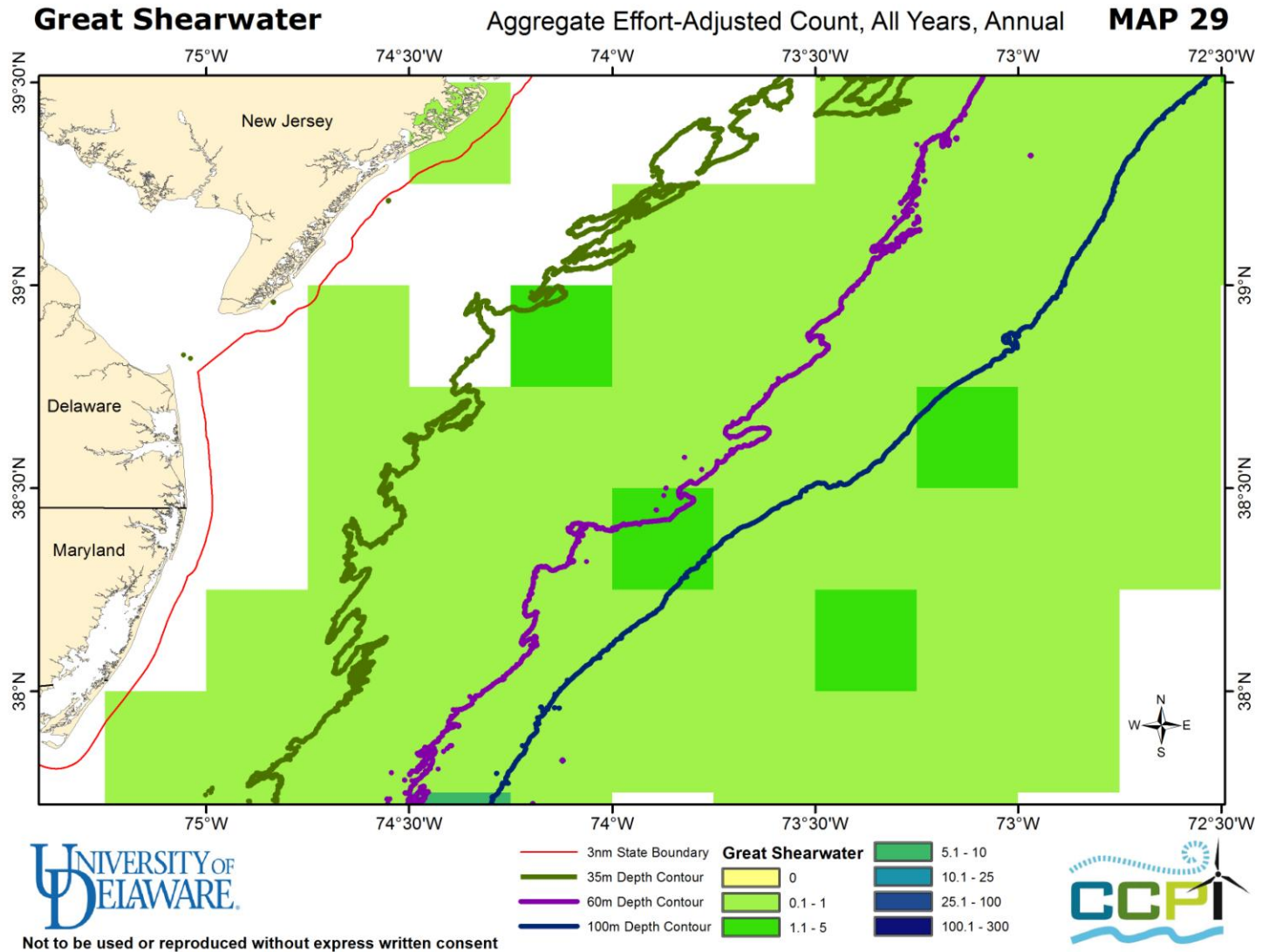
Map 27: Selected Seabirds in Study Area



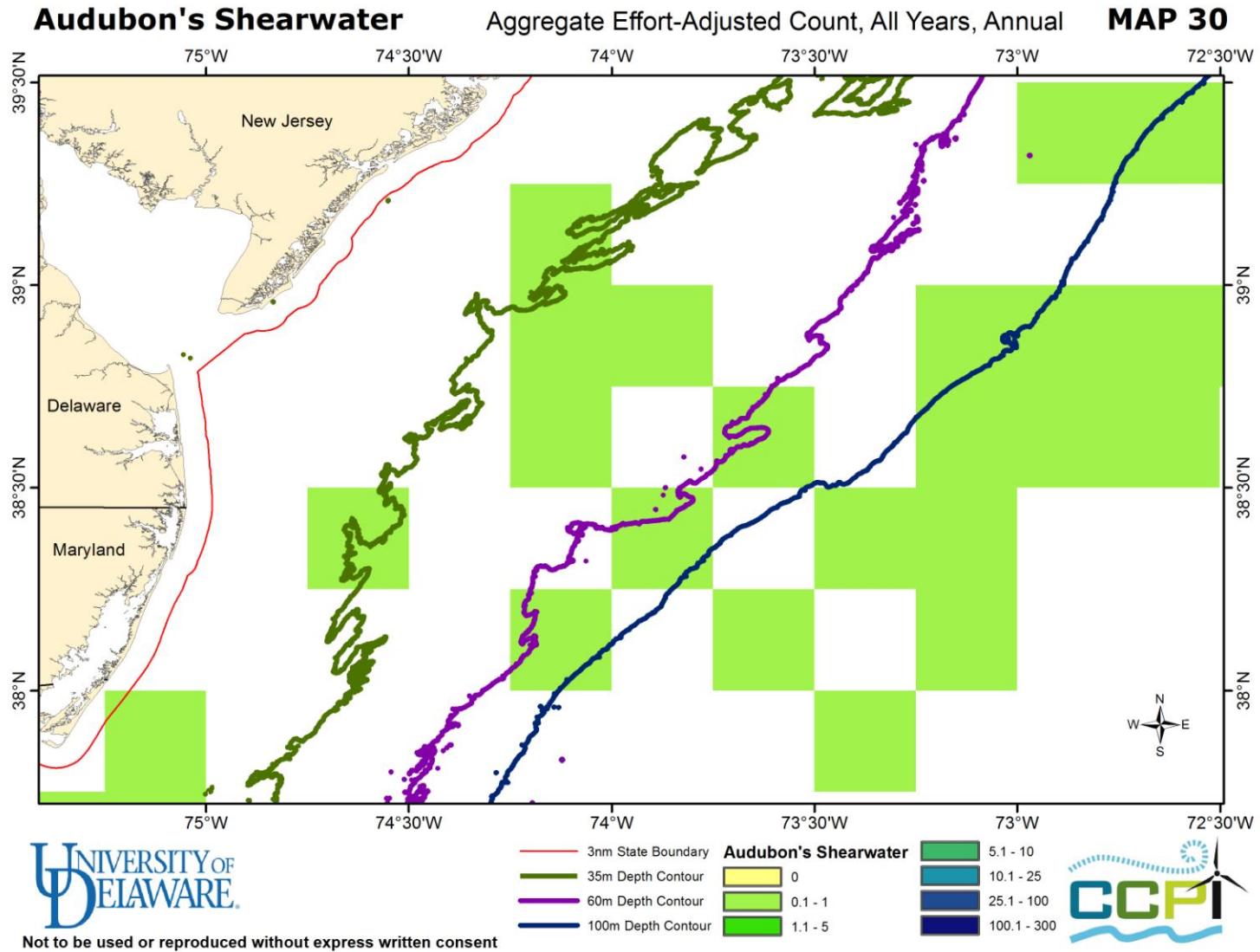
Map 28: Common Loon



Map 29: Great Shearwater

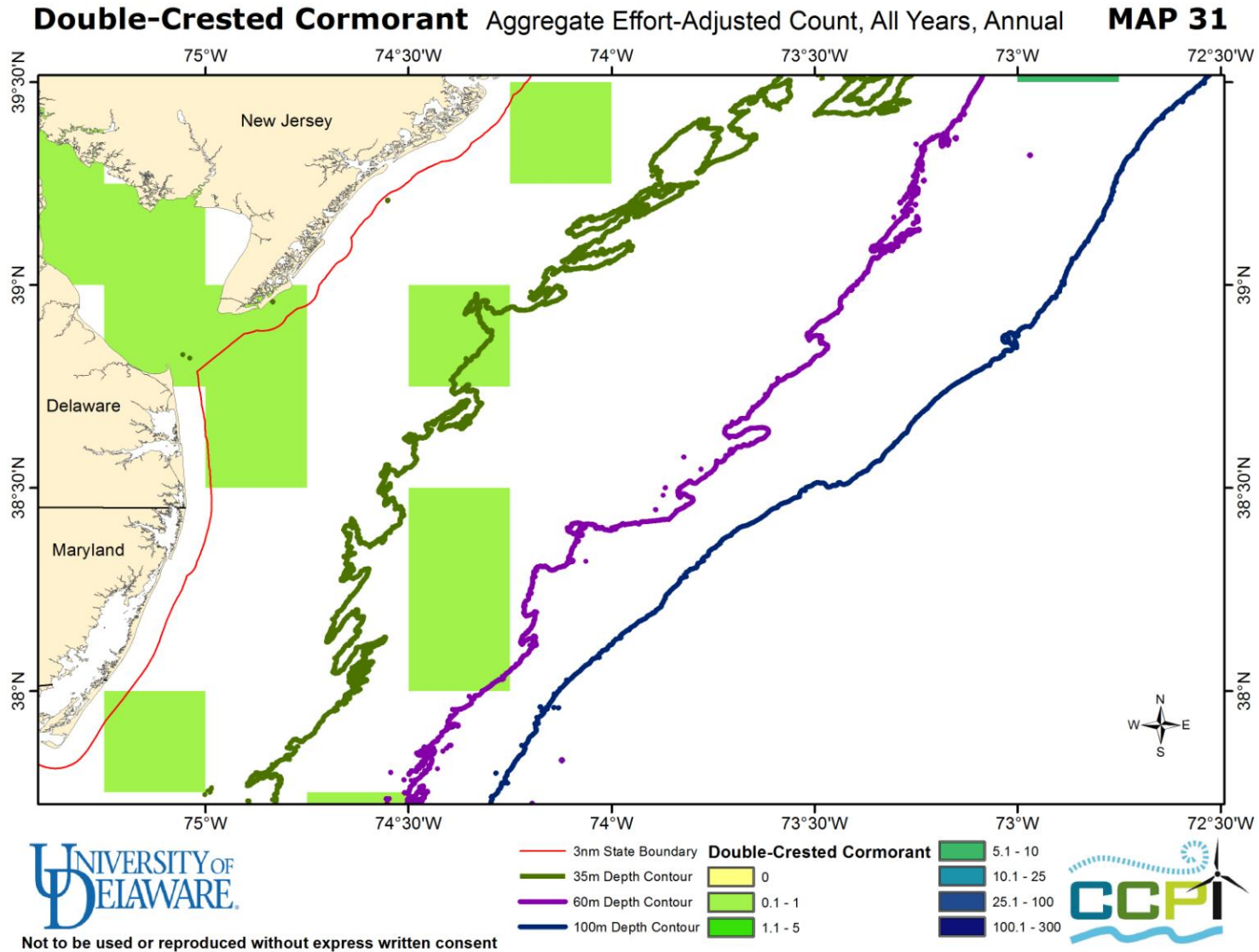


Map 30: Audubon's Shearwater

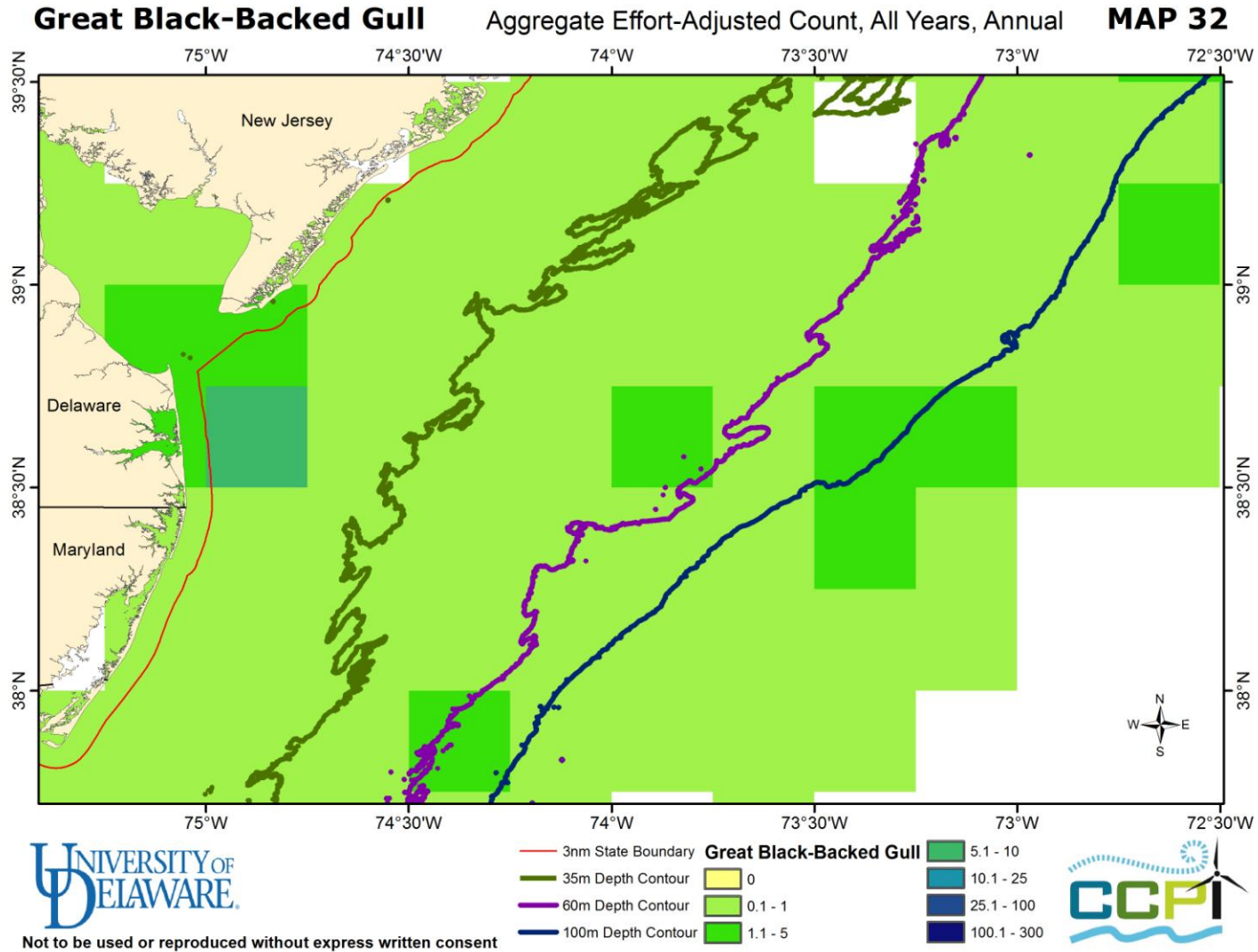




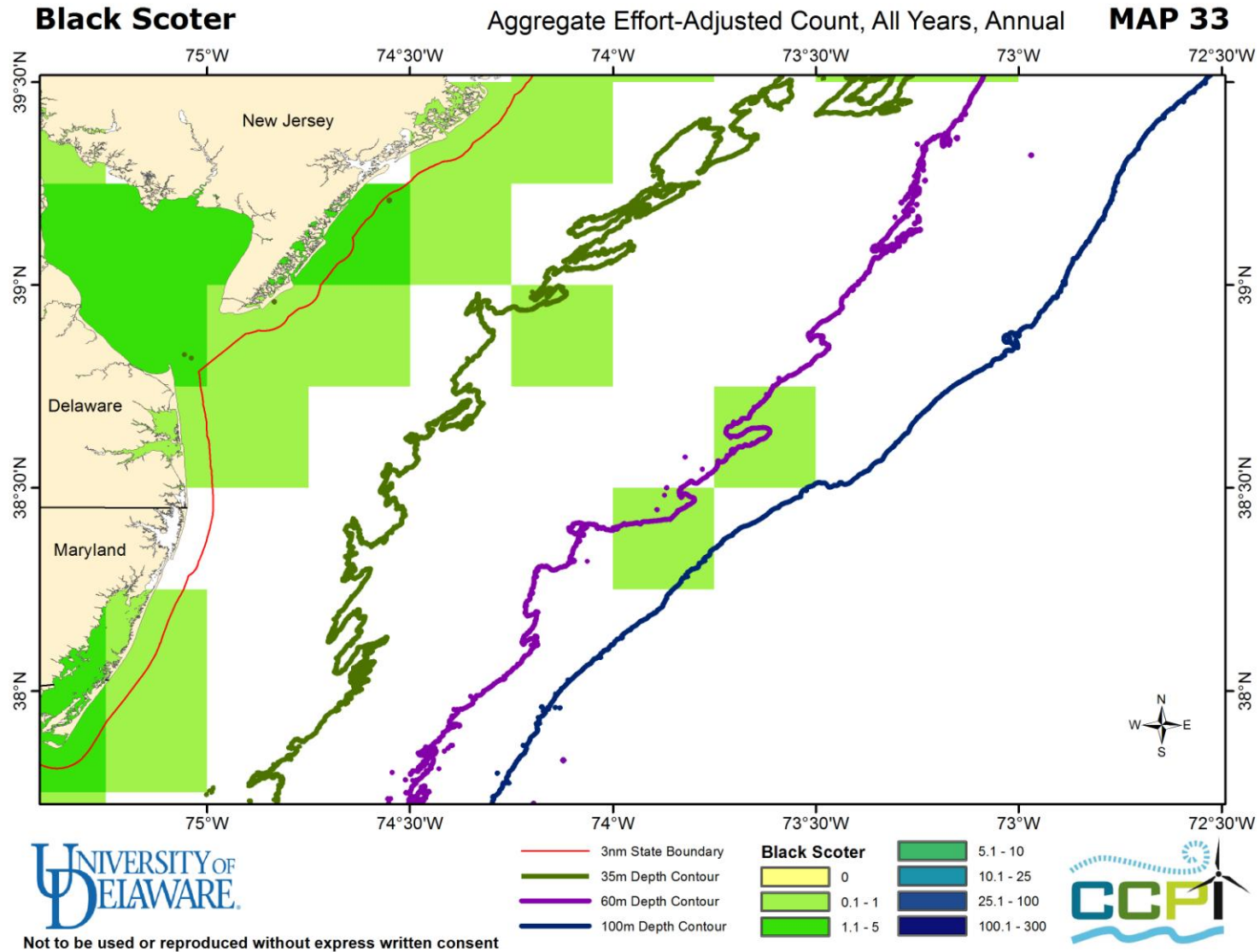
Map 31: Double Crested Cormorant



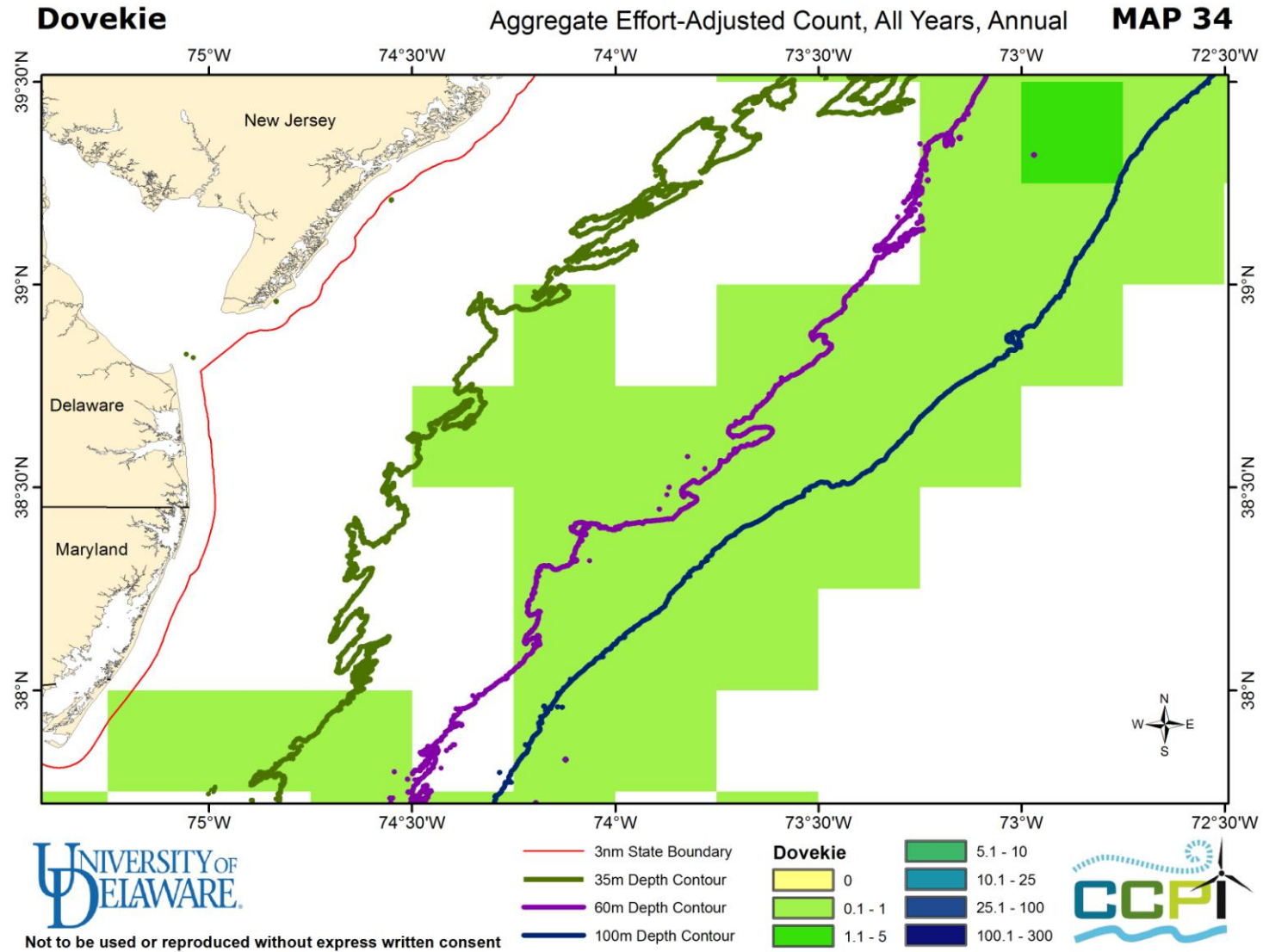
Map 32: Great Black-backed Gull



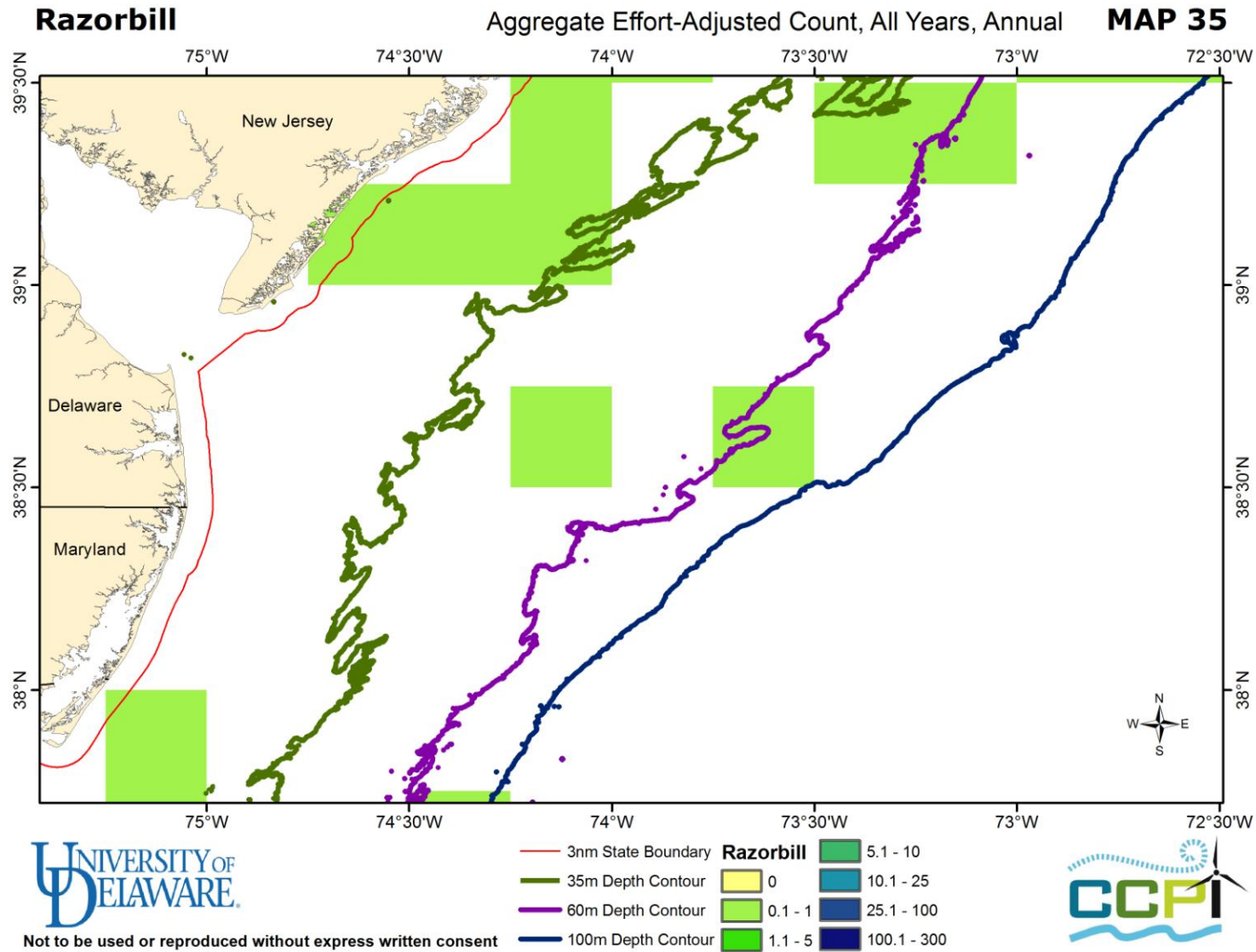
Map 33: Black Scoter



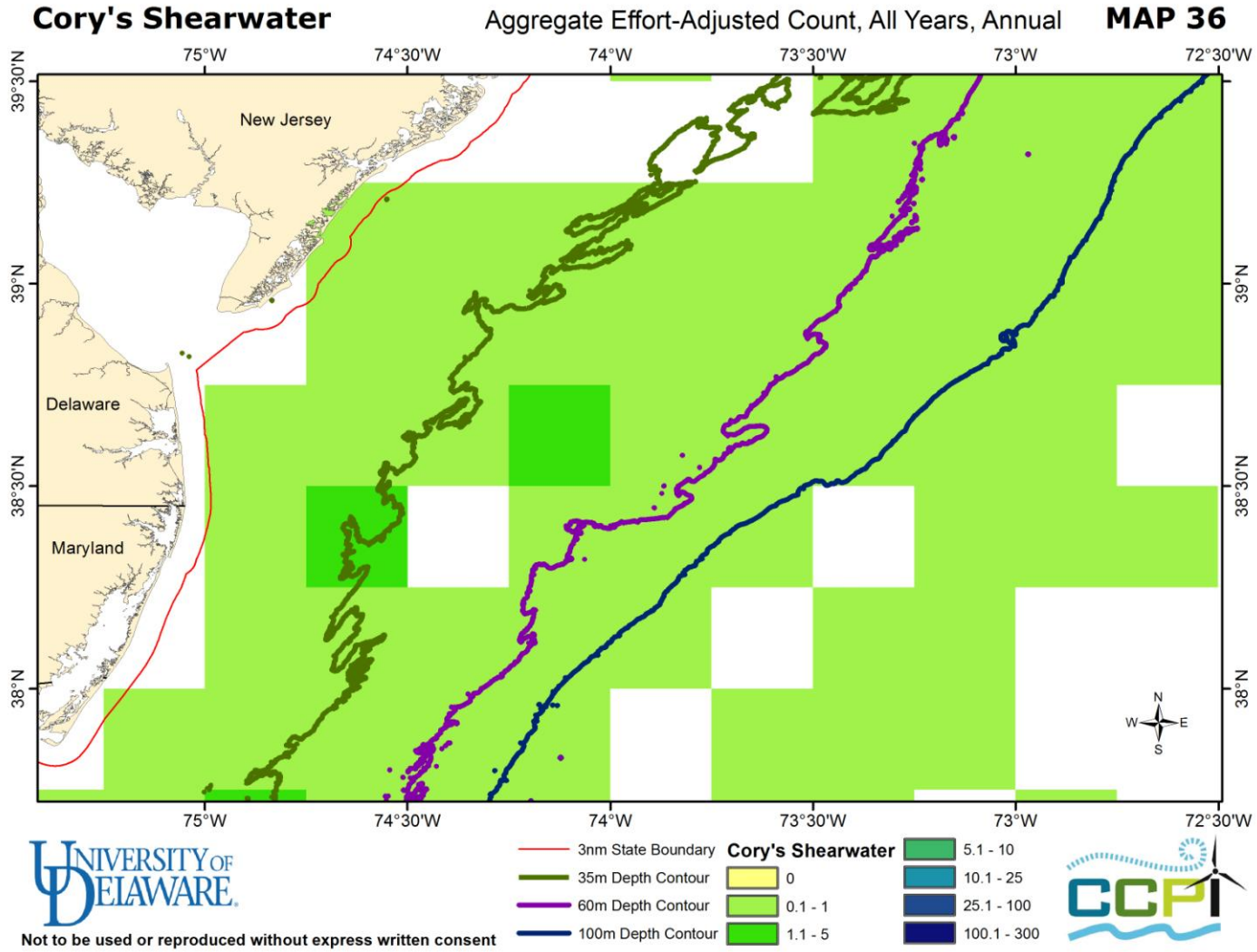
Map 34: Dovekie



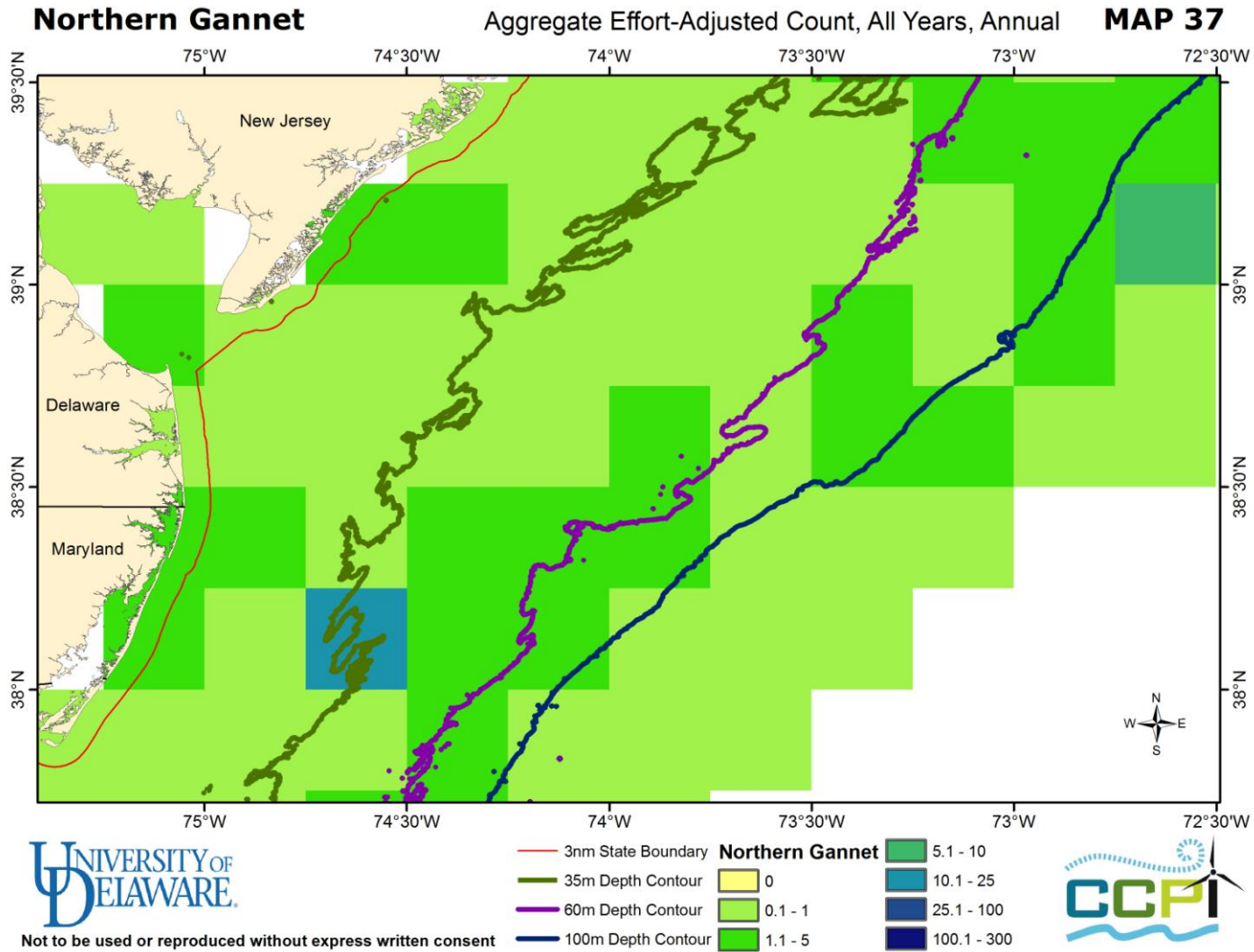
Map 35: Razorbill



Map 36: Cory's Shearwater



Map 37: Northern Gannet



## Bats

The state of Delaware has seven known bat species spending a portion of their lives in the state. These species are little brown bat (*Myotis lucifugus*), big brown bat (*Eptesicus fuscus*), tri-colored bat (*Perimyotis subflavus*), Eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), silver-haired bat (*Lasionycteris noctivagans*) and Northern long-eared bat (*Myotis septentrionalis*) (DNREC, 2012). The Northern long-eared bat has been petitioned for ESA listing. Biological studies at the University of Delaware coastal turbine in Lewes have identified Eastern red, hoary, big brown, tri-colored, and silver-haired bats in the vicinity of the turbine<sup>2</sup> (J. Firestone, personal communication, 23 February 2012). Bats have been found to utilize offshore environments, although the extent of this is not well published (Pelletier, 2011, Sjollema, 2011). Published research has shown that bats are impacted by wind turbines on land (Kunz et al., 2007a; Kunz et al, 2007b; Arnett et al., 2010), such as fatality from collision and barotrauma, or bats can be indirectly impacted by disruption to habitat, food sources, breeding behavior, and alteration of the landscape (Kunz, 2007a). Fatalities at land-based wind turbine facilities seem to be correlated with discernible factors (Kunz et al., 2007a; Kunz et al., 2007b; Arnett et al., 2010). Thus it is likely that migratory bats that roost in foliage or trees are more susceptible to fatality (Arnett, 2008). In addition to seasonality, fatalities are related to storms, either directly before or after a storm front passes and at low wind speeds, under 6m/s (Arnett, 2008).

Although bats are known to be impacted by land-based wind projects, very little is known about the effects of wind turbines on bats in the offshore environment. Limited research in the mid-Atlantic region has detected bats offshore of Delaware, Maryland and New Jersey, among other areas. The University of Maryland and Maryland Department of Natural Resources compiled data on the composition and abundance of bats offshore in the mid-Atlantic through opportunistic detections located aboard vessels (Sjollema, 2011). Bat detections were recorded out to 22 kilometers. A total of 166 detections were recorded over an 18-month period at an average of 8.67km from shore (Sjollema, 2011). The majority of sightings occurred from August through October, although year-round detections indicate that non-migratory bats might be utilizing the offshore environment as well (Sjollema, 2011). Furthermore, bat activity in the offshore environment is directly related to wind speed (Sjollema, 2011), with bat activity decreasing as wind speed, and hence, energy (MWh) and project revenues increase. Unfortunately, at the time of publication, coordinates of bat detections could not be obtained and therefore are not included in this report.

## Human Use

Areas of precaution for wind turbine development carry spatial use conflicts where development may be preferable, although developers and resource managers will have significant considerations and prioritizing in the areas represented. A variety of human uses exist in the study area, from ongoing activity to submerged obstructions.

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<sup>2</sup> Analysis of data collected on the presence of bat species in the vicinity of UD's Lewes wind turbine is expected to be available later in 2012 or in 2013.



## *Shipping*

The mid-Atlantic region hosts high-traffic shipping routes that in many cases lie adjacent to the BOEM-designated wind energy lease blocks (WEAs) and proposed offshore wind projects. The shipping routes in the study area consist primarily of Traffic Separation Schemes (TSSs), which were designated by the International Maritime Organization (IMO) and incorporated into the 1974 International Convention for the Safety of Life at Sea (SOLAS) (IMO, 2011). The traffic separation schemes are routing measures that are meant to separate opposing streams of ship traffic through the establishment of traffic lanes. As a result of these regulations, traffic at the mouth of the Delaware Bay is orderly yet concentrated. Furthermore, to ensure safe navigation in the US waters, which is a priority of the US Coast Guard (USCG, 2011c), buffer zones will be established around the present TSSs to minimize the likelihood of shipping accidents when wind power projects are built in the vicinity. BOEM has suggested a buffer zone of up to 0.5 nautical miles (a potential increase from the initial 500 meter zone) around the Delaware TSS (DOI, 2011). Even with the currently established vessel routing measures and considerable amount of planning on behalf of BOEM and the USCG, potential conflicts between the shipping industry and offshore wind developers are likely and marine spatial planning can greatly aid with selection of appropriate wind development sites.

To determine the habitual vessel traffic patterns outside of the designated lanes and the general distribution of the shipping traffic in the study area off the coast of Delaware, the Automatic Identification System (AIS) dataset was analyzed. AIS is a maritime digital communication system that continuously receives and transmits vessel data over very-high frequencies (U.S. Coast Guard, 2011a). The system began operation in 2003 when the USCG implemented a vessel safety rule (Title 33 CFR 164.4, Automatic Identification System (AIS)) requiring all vessels 65 feet or greater and transiting U.S. waters to carry an AIS transponder.

The initial goal for AIS was to help vessels to avoid collisions and assist port authorities in ship traffic control. Today, AIS is programmed to transmit the vessel's name, call sign, dimensions, speed, destination and other parameters multiple times each minute on two VHF channels (Silber & Bettridge, 2010). Since 2003, requirements regarding which vessels must carry AIS transponders have been broadened. The initial goal for AIS was to help vessels to avoid collisions and assist port authorities in ship traffic control. Today, AIS is programmed to transmit the vessel's name, call sign, dimensions, speed, destination and other parameters multiple times each minute on two VHF channels (Silber & Bettridge, 2010). The USCG is currently establishing a National Automatic Identification System (NAIS), which is a network of land-based receivers and relayers that will provide coverage of normal movement of AIS-equipped traffic, help during rescue operations and aid in prevention and investigation of maritime incidents (USCG, 2011b)

## *AIS Data Analysis*

To determine the traffic patterns in the project study area, one year of data for 2009 (with a partial month of June) was obtained through confidentiality agreements with BOEM and NOAA. Thus, the data available represented slightly less than one year of ship traffic. This data allows for fine-scale

analysis of travelled commercial shipping patterns in the mid-Atlantic. To determine the routes travelled from a point dataset, a beta tool (AIS Data Handler for ArcMap 10) developed by NOAA Coastal Services Center (NOAA, 2011) was used to convert points to tracklines (polylines) linking broadcast data from unique vessel identification numbers for each month. Due to the very large amount of data, the monthly tracklines were not merged together to create an annual dataset, as ArcGIS 10 software was not able to process such amount of data. As a result, the data used in the analysis and presented in the report represent AIS data from months of December and July 2009. These two months were chosen to illustrate the winter and summer patterns in ship traffic in the study area off Delaware and can be used for the initial steps of the MSP process. Please refer to Maps 38 and 39.

For further data analysis, an open source GIS software package Quantum GIS (QGIS) was used. Although only monthly increments of data were used, the tracklines (vessel tracks in vector data format) for each month needed to be simplified. This was accomplished by reducing the number of nodes by a factor of approximately 10. The lengths of tracklines were summed in a 1-minute grid cell resolution to depict relative density of shipping traffic in the study area. The map does not portray the exact number of vessels per grid cell; rather, relative density was chosen to indicate areas of maximum spatial conflict. The resulting dataset was converted to raster to allow for viewing the data in a gradient and explicitly shows the intensity of vessel traffic throughout the study area.

It is important to note the difficulties and caveats of the presented AIS data analysis. The AIS data are not without faults, which can potentially be related to the beta-status of the NOAA's AIS Data Handler tool or of the data itself. The number of vessel tracklines that resemble straight lines and cross the land is significant. Many of the tracklines appear to connect two points, such as Montreal and Baltimore, but do not include data about vessels' starting time, cargo type, etc. These issues do not impede the usability of the data as a whole, but emphasize the need for a more detailed analysis, which are beyond the scope of this project.

Shipping data analysis sheds light on where the most densely trafficked routes are located and how offshore wind projects could be planned to minimize shipping conflicts. Maps for the months of December and July show that shipping traffic varies by season. The majority of the vessel traffic is concentrated within the TSS, near its exit and entrance, and in a few areas along the coast. Even though analysis for every month has not been completed, the routes that vessels most commonly choose while traveling close to the coast are discernible. Furthermore, it is important to note that there are some differences in the values and the smoothness of the color range shown in the rasterized datasets for the months of December and July. The December traffic areas are more pronounced than those in July, though the traffic is concentrated in the same zones in both periods. These variations are related to the number of recorded tracklines for the corresponding month, but are not surprising considering the seasonal variation in shipping. More specifically, the original dataset for December contains 4,710 tracklines, while July dataset is made up of 6,072 tracks. The clipped and simplified datasets contain 1,297 lines for December and 1,732 lines for July. The novelty of the AIS Data Handler tool and its point-to-trackline conversion methods can play a role

in the way this data was initially converted and represented, but do not suggest that the data is flawed.

### *Traffic Separation Schemes*

As a part of the shipping data layer, shapefiles for the TSS at the mouth of the Delaware Bay were added, and then extended by approximately 12 nautical miles to account for the fact that ships have to disperse into the Maryland waters, and adjusted for width with 0.5 nautical mile buffers on each side. Where buffering via GIS tool was not possible, the 0.5 nm buffer was drawn manually. The Maryland Energy Administration suggested this buffer width for the MD WEA to address concerns that had been expressed over navigational safety of ships entering and exiting the Delaware Bay (Wolff, 2011). Though not yet finalized, the 0.5 nm buffer was used in this analysis as a likely minimum buffer that BOEM and USCG will require (Wolff, 2011; DOI, 2011). Additionally, circles are shown to represent the most likely dissipation area after vessels exit/enter the TSS. TSSs and buffer areas around TSS's should be considered exclusion areas at this time.

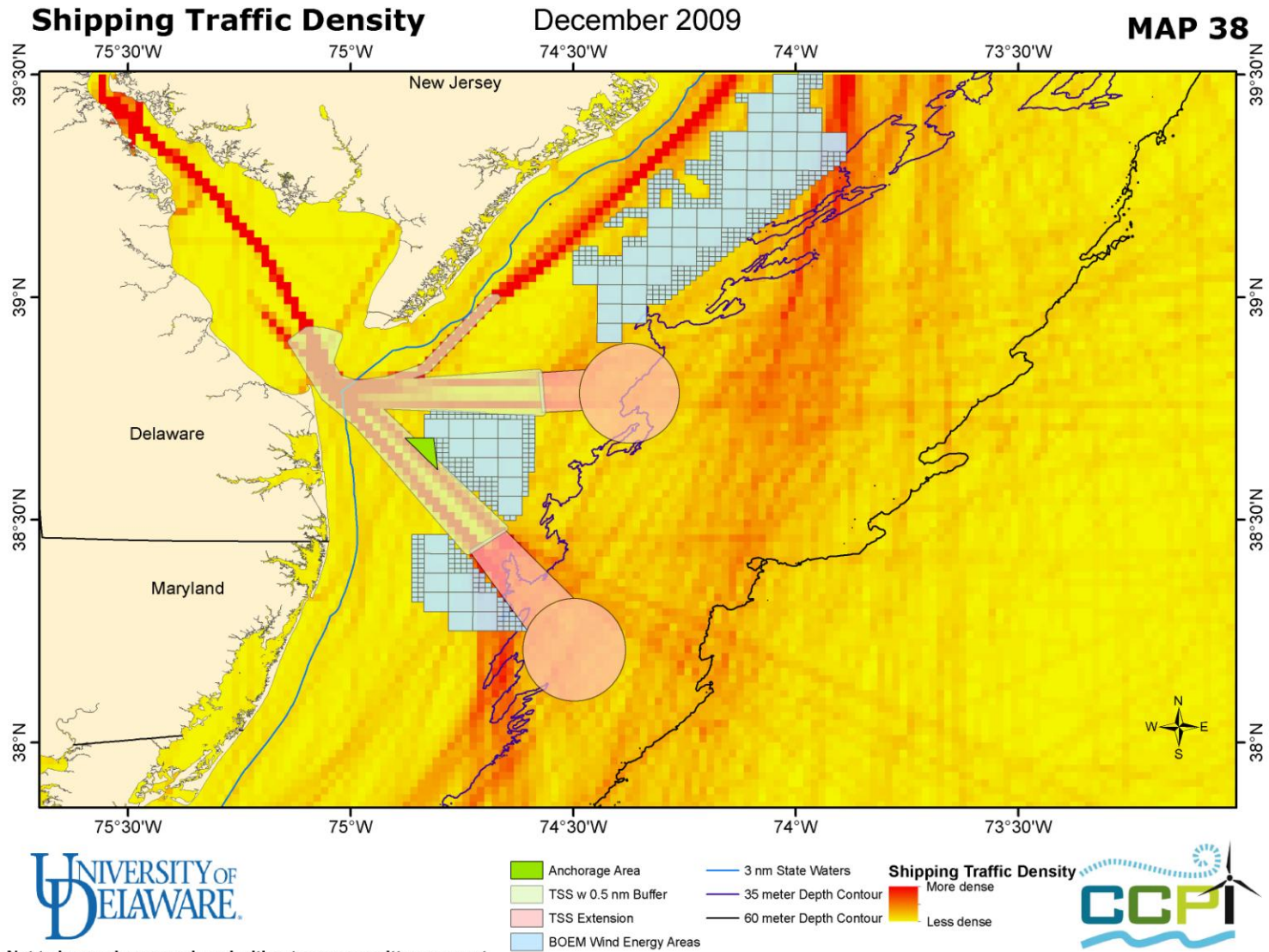
### *Anchorage Area*

Areas adjacent to USCG traffic separation scheme shipping lanes are commonly used as anchorage areas for ships entering or exiting ports through the Delaware Bay and River (BOEM, 2012). This major shipping passage is congested, and vessels often use an adjacent area to anchor for a period of time, albeit unofficially, while waiting to go to port. The USCG is considering designating this area an official anchorage ground and requested that the area be excluded from consideration for leasing (BOEM, 2012). If it is designated an official anchorage ground in the future, the area will be rendered exclusionary of activities that can occur on the water or on the seafloor, such as cable-laying (BOEM, 2011). The anchorage ground is bounded on its southern border by the southeast TSS approach to the Delaware Bay, on its northern border by the charted ordnance dumping ground, and on its eastern border by the 12 nm territorial sea line, and is equivalent to about half of an OCS block in size (see Map 38 and 39). A polygon was drawn in ArcGIS to delineate an approximate location of the anchorage ground.

### *Commercial Fishing*

Commercial fishing in the mid-Atlantic has a long history, actively managed by both the Mid-Atlantic Fisheries Management Council (MAFMC) and coordination of selected stocks with the Atlantic States Marine Fisheries Commission. Species managed include Atlantic mackerel, long-finned squid, short-finned squid, butterfish, bluefish, spiny dogfish, surfclam, ocean quahog, summer flounder, scup, black sea bass, tilefish, and monkfish (MAFMC, 2011). With planning authority delegated by the MSFCMA, the MAFMC prepares fishery management plans to be implemented by the Secretary of Commerce (MAFMC, 2011). Accordingly, the MAFMC receives input from state representatives, federal representatives, and the general public. The MAFMC also serves as an important venue for stakeholder engagement (MAFMC, 2008). Meetings are open to the public, allowing for comment (written and spoken) regarding fisheries policy.

Map 38: Shipping Traffic Density (December 2009)

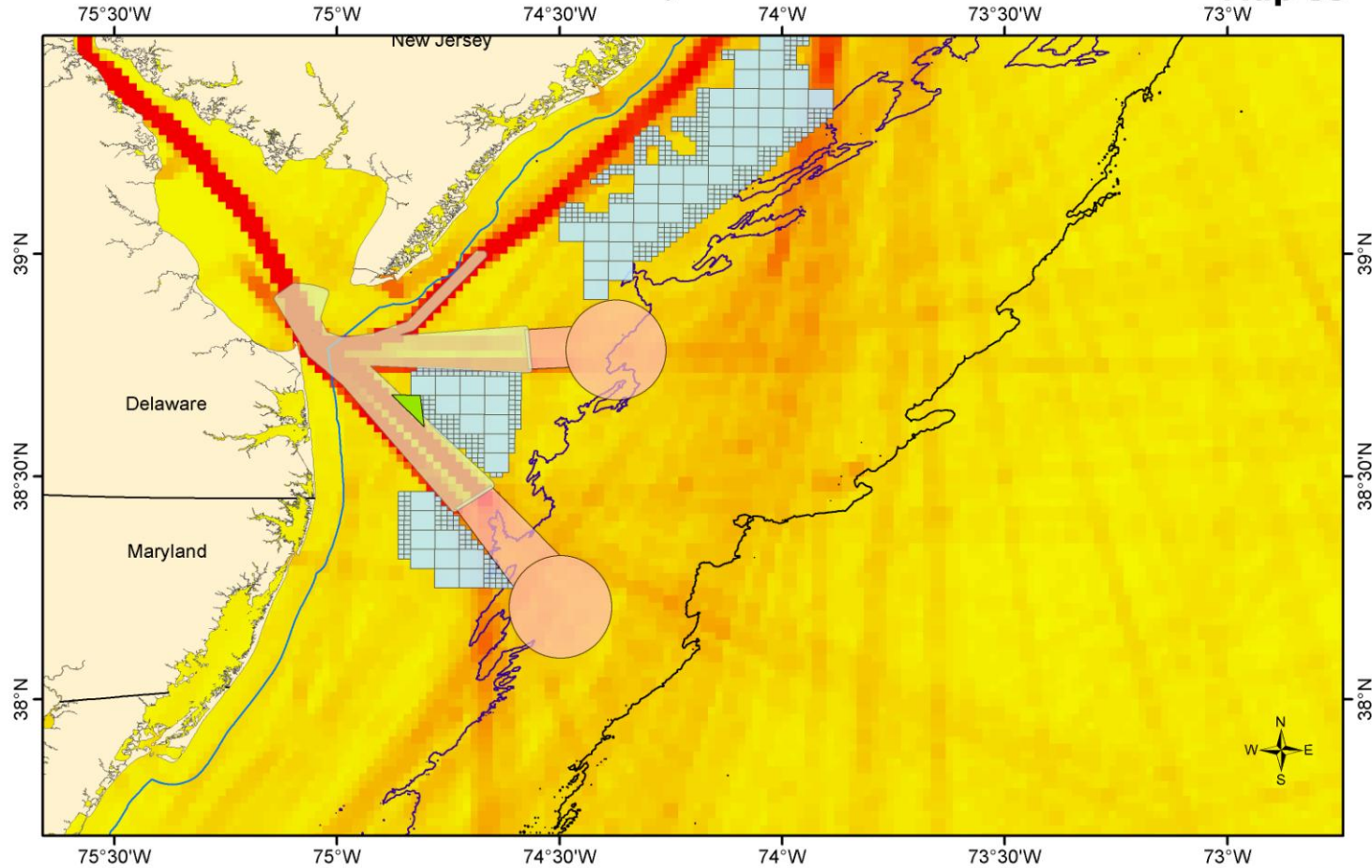


Map 39: Shipping Traffic Density (July 2009)

# Shipping Traffic Density

July 2009

Map 39



- Anchorage Area
- TSS with 0.5 nm Buffer
- TSS Extension
- BOEM Wind Energy Areas
- 3 nm State Waters
- 35 meter Depth Contour
- 60 meter Depth Contour
- Shipping Traffic Density
  - More dense
  - Less dense



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Commercial fishermen have traditionally had unrestricted access to ocean waters, although the fisheries management regime has been changing since the 1950s due to recognition of economic theory and conservation principles (Scott, 2008). The process of MSP has given rise to apprehension over space use conflicts among fishing groups, with fishing communities voicing concern regarding access to areas either currently or traditionally fished. Furthermore, offshore wind has come under scrutiny from fishing groups in Nantucket Sound, with expressed concern over the right to fish in areas leased for renewable energy development (Watson & Courtney, 2004). With historic use of the ocean, fishing groups may be expected to have space use conflicts with offshore wind development, and thus their usage of the ocean is important to consider in the mapping process. The Rhode Island Ocean SAMP engaged the commercial and recreational fishing communities extensively during the planning process to ensure important fishing areas were well represented (RI CMRC, 2010).

To identify areas of commercial (and recreational) fishing, several methods were implemented to measure catch and fishing activity. AIS and vessel monitoring systems (VMS) transmit the locations of vessels, and vessel trip reports (VTR) capture both catch and location. VTR data has been used as a proxy for important fishing locations, but is limited in utility due to confidentiality agreements that require some data to be omitted from the mapping process. Furthermore, VTR provides only one location for catch, although catch may have occurred over a larger area. Initiatives such as the Rhode Island Ocean SAMP and the California MarineMap (<http://marinemap.org>) have engaged both the commercial and recreational fishing community to identify important fishing areas. This method can access information not available by VTR, but was beyond the scope of this project.

To illustrate the location of fishing boats, commercial fishing data were obtained through vessel trip reports from NOAA-NMFS, subject to a confidentiality agreement. The confidentiality agreement dictates the display of catch in landings (in pounds) be depicted in 10-minute squares with a minimum of three unique vessels per square to protect proprietary data of the fishing community. This data compiles all self-reported landings throughout these years. Commercial fisheries in the states of New Jersey, Delaware and Maryland use a variety of gear types, both bottom-contacting and pelagic gear. These gear types include: trawl (benthic and pelagic), gillnet, trap, pot, seine, long line, hand line, rake, and dredge. Catch by gear type was summed over the years 2006-2010 to display the total number of trips to an area that resulted in landings, separated by benthic and pelagic gear types. Data were summarized in this manner to indicate the level of use in a given area rather than the quantity of the catch. The number of vessel trips reporting catch in specific areas offers an indication of intensity of use and where space use conflict may occur. Trips reported without longitude/latitude coordinates were removed from the dataset prior to mapping, comprising a total of 3% of the dataset. The dataset was also modified to display only records of three or more unique vessel identification numbers per 10-minute grid, resulting in 1% removal. One caveat with this data is that it does not factor in fish caught in Delaware, Maryland or New Jersey waters which came to port in another state. Point data were converted to raster in 10-minute grid cells, displayed as a sum of trips to a particular grid cell to portray relative intensity of fishing vessels in a given area.

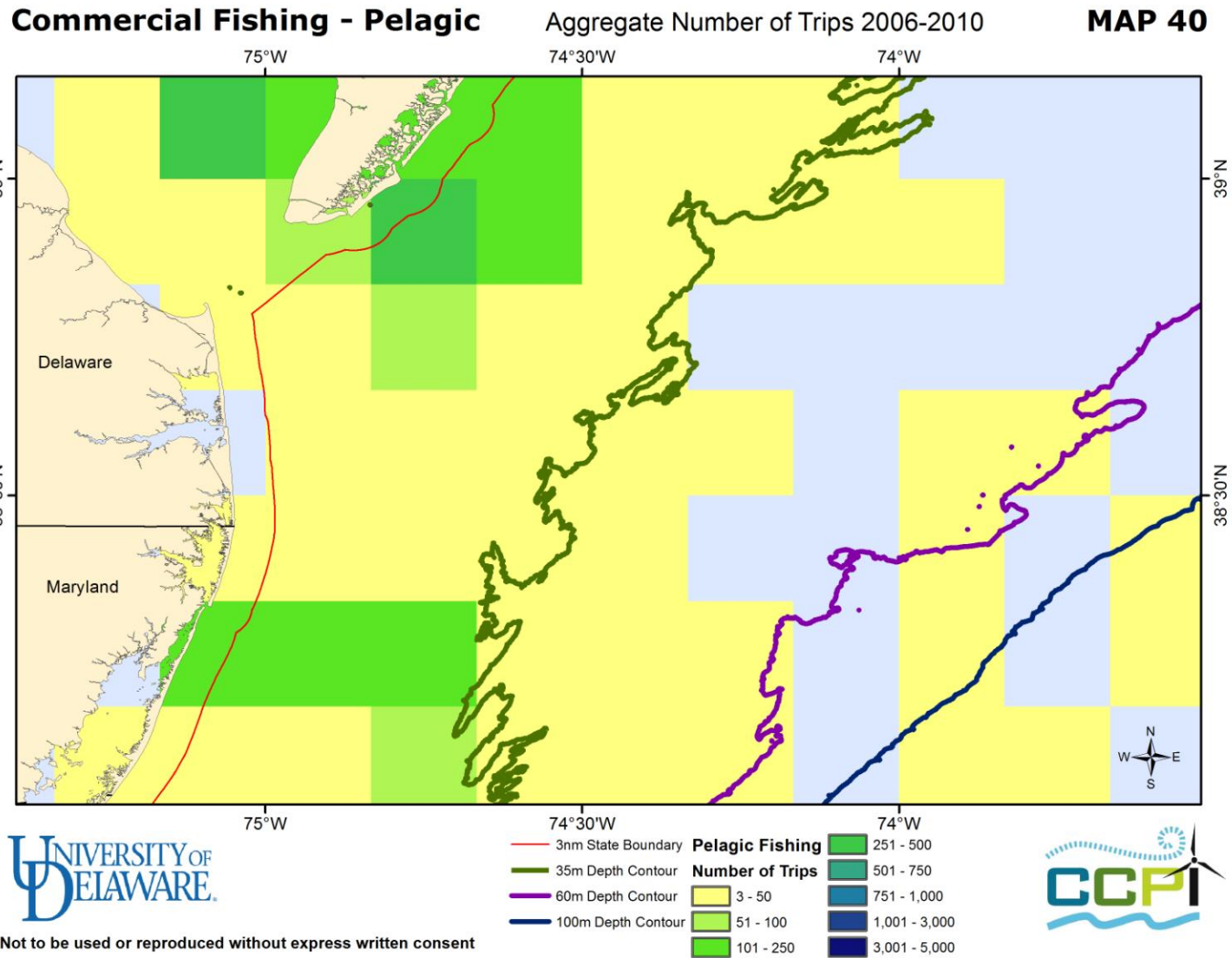
### *Pelagic Gear*

Pelagic fishing in 10-minute squares is demonstrated as the aggregate number of trips in which landings occurred using pelagic gear. These are displayed in 10-minute squares as a data restriction required by NFMS. Pelagic gear includes longlines (pelagic only), gillnets (drift, run-around), seines (danish, purse), and handlines. This display was chosen in order to display the frequency of fishing vessels in a given area, to determine the spatial conflicts between fishing vessels and wind turbine development. As evident, pelagic commercial fishing occurs most frequently near the coast, generally diminishing with depth. If pelagic fishermen are permitted to enter the wind project area, conflict may occur with towed gear that will be confined to the space between wind turbine foundations. If pelagic fishing is excluded from wind project areas, conflicts may arise if turbines are installed in the commonly fished areas. The reader is reminded that commercial pelagic fishing occurs elsewhere, however, it is not represented due to confidentiality restrictions. Therefore, any area harvested, but not represented spatially, is fished by less than three vessels. Areas displayed in blue should be given careful consideration in spatial planning due to the propensity of fishing vessels in such areas. However, as with recreational fishing and pelagic gear commercial fishing, consultation with fishing communities is recommended prior to selecting areas for siting offshore wind projects. Please refer to Map 40.

### *Benthic Gear*

Benthic Gear fishing includes all gear making contact with the seafloor. The vast majority - 94% - of landings in Delaware, Maryland and New Jersey use gear that is bottom contacting. This includes dredges, sink gillnets, bottom longlines, pots, traps, rakes, and otter trawl. The distinction is made between pelagic and benthic gear due to the potential interference between bottom contacting gear and submerged cables connecting the individual turbines and those running to shore, as well as the relative landings between the two. If those individuals fishing with bottom-contacting gear are permitted to enter wind project areas, conflicts may occur if gear has the potential to damage submerged electric cables. As evident in the Map 41, significant fishing takes place throughout the study area, although it diminishes beyond the 60-meter contour, which is also associated with some fishing restrictions for EFH. If benthic fishing is excluded from wind project areas, conflict may arise if turbines are installed in areas commonly fished. The reader is reminded that benthic commercial fishing occurs elsewhere, however, it is not represented due to confidentiality restrictions. Therefore, any area harvested, but not represented spatially, is fished by less than three vessels. Burial of cables at certain depths and continued vigilance by wind project developers during operation may help to mitigate these impacts and reduce conflicts, although consultation with the fishing community is recommended to minimize conflict. As in previous maps, fishing activity is displayed in 10-minute squares because of data restrictions required by the NMFS.

Map 40: Commercial Fishing – Pelagic Gear



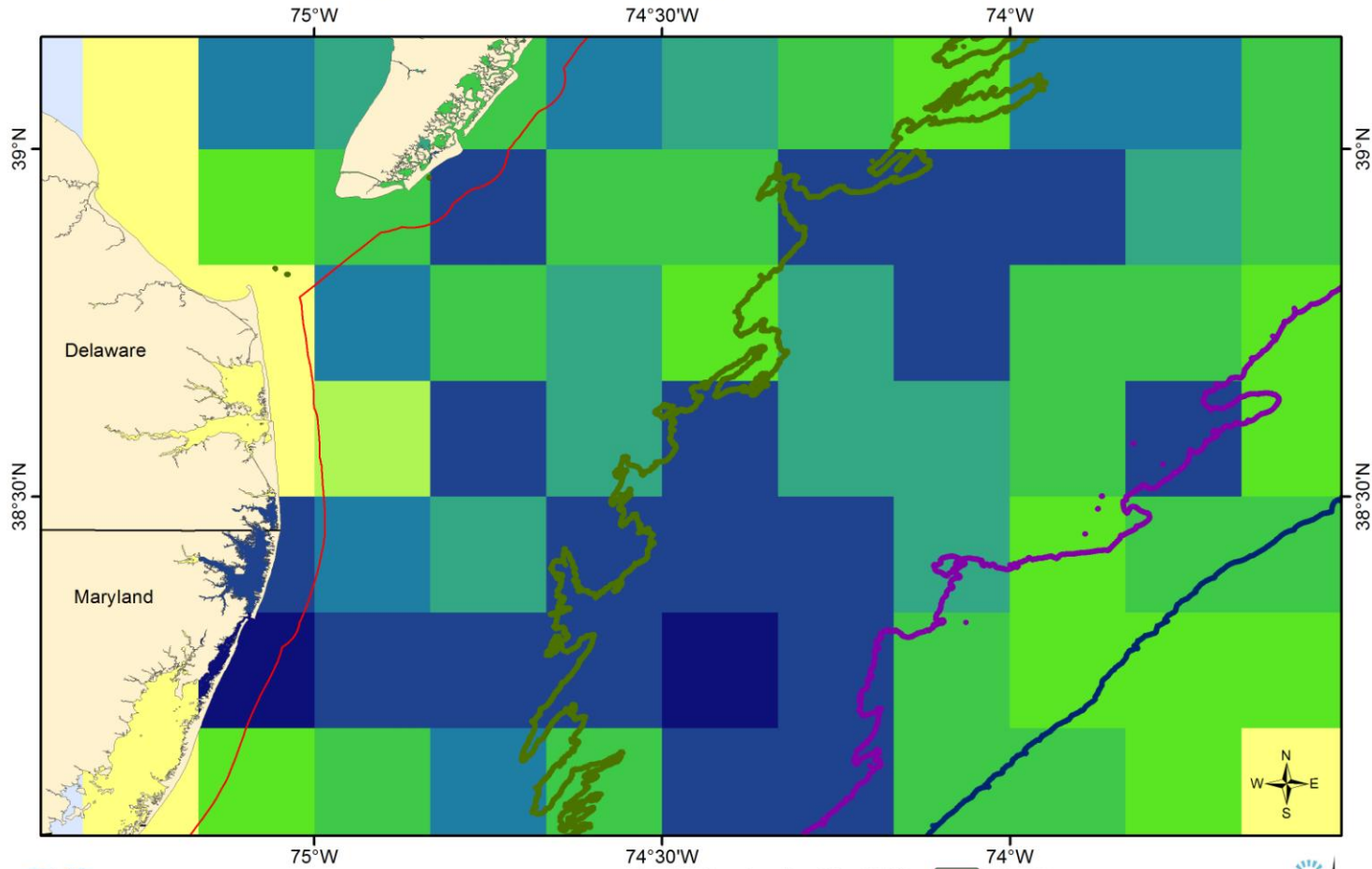


Map 41: Commercial Fishing – Benthic Gear

### Commercial Fishing - Benthic

Aggregate Number of Trips 2006-2010

### MAP 41



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### *Recreational Fishing*

Recreational fisheries also potentially have space use conflicts with offshore wind. Offshore wind turbines may serve as artificial reefs or attract/aggregate fish (Wilson et al., 2010), which may be considered favorable to the recreational fishing community. Access to areas around wind turbines will likely be a key consideration to these fishing groups. Both private boaters and fishing charters have been considered in this mapping process. Confidential data reporting the number of vessels from fishing charters was obtained from NOAA-NMFS, from the years of 2006-2010. The data were summarized and displayed in 10-minute grids per confidentiality agreements, removing 1.3% of the data with less than three vessels per 10-minute grid cell. Recreational fishing from charter vessels was reported for diving and hand line (rod/reel) fishing. An additional 2.5% of the records were removed because they lacked longitude/latitude associated with the catch. This point data was converted to raster and is displayed as a sum of trips with landings per 10-minute grid cell.

Recreational fishing areas indicated for private boaters were obtained by digitizing popular areas from Captain Seagull's Fishing Maps (with permission), Cape May to Cape Hatteras. NOAA Nautical Charts and then digitizing polygon locations of popular fishing areas were digitized. These areas are generally associated with benthic features. Please refer to Map 42.

Recreational fishing from charter vessels is displayed as the number of vessels reporting landings at a given location. The vessels reporting catch are aggregated, thus depicting popular locations for charter vessels to bring customers fishing. These are displayed in 10-minute squares as a data restriction required by NFMS. Overlaid are polygons of areas popular for private recreational vessels. These areas represent an accumulated knowledge of popular fishing areas, although they should not be considered comprehensive, as recreational fishing vessel crews may fish extensively throughout the study area. The reader is reminded that fishing charters utilize additional areas not represented due to confidentiality restrictions. Therefore, any area fished, but not represented spatially, is fished by less than three vessels. If fishing charters and private recreational fishermen are permitted to enter wind project areas, significant conflict with gear is unlikely to occur.

However, if recreational fishing is excluded from wind project areas, conflicts may arise if turbines are installed in areas commonly fished. (However, even in such an eventuality, the entire area within the circumference of the outer bounds of the wind project would effectively operate as a marine protected area (MPA), presumably enhancing fishing opportunities on the periphery. Therefore, recreational fishing may be compatible with offshore wind turbines (Fayram & Risi, 2007), and in a survey conducted by the University of Delaware (Lilley et al., 2010), respondents indicated that offshore wind projects would be an interesting tourism highlight. Thus, recreational fishing charters may have compatible space use with wind projects.

### *Sand Borrow Locations*

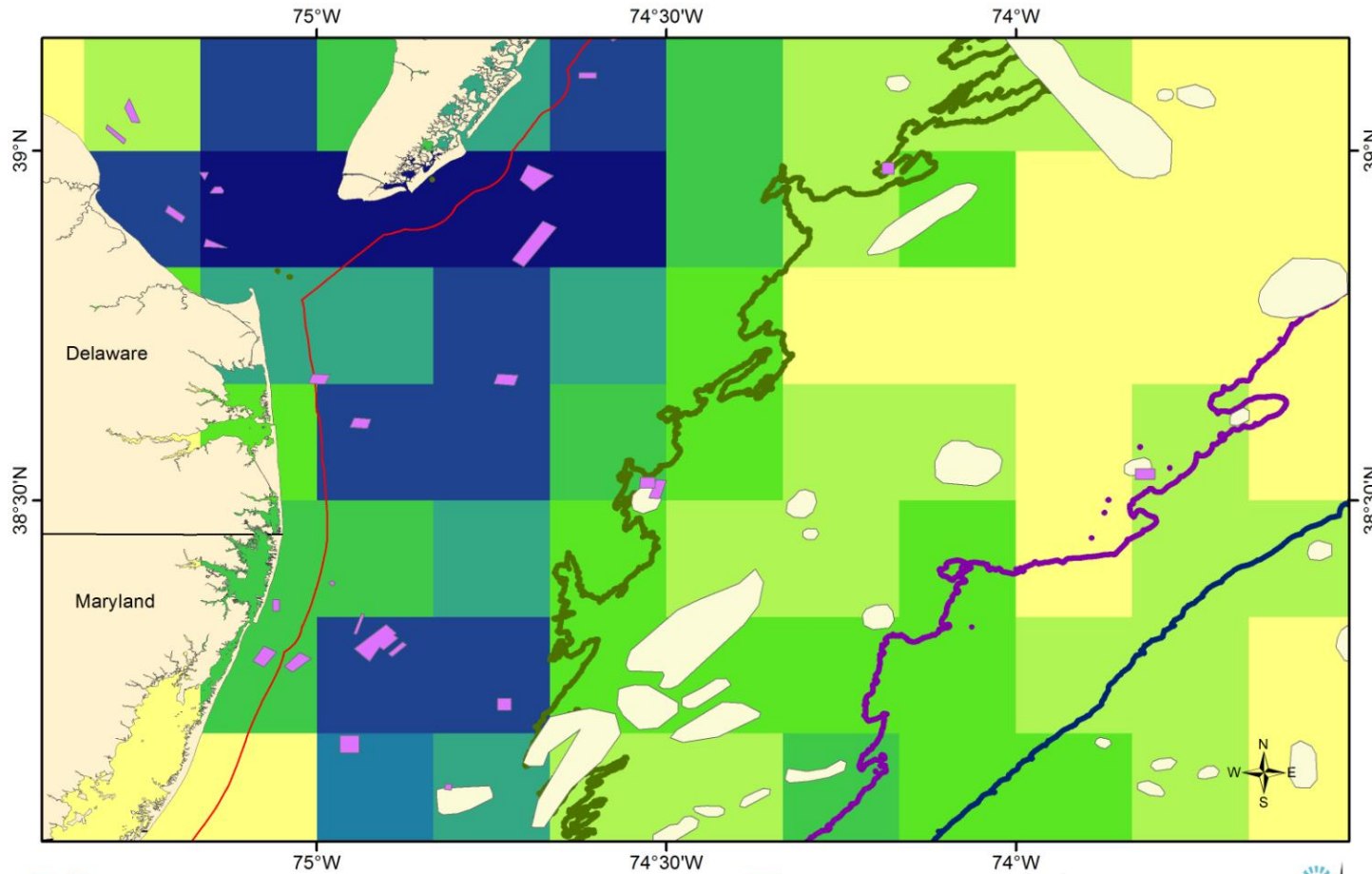
The USACE maintains an active sand replenishing program for beach nourishment. Beginning in the 1970s, eroding beaches prompted officials to seek millions of cubic yards of sand from offshore deposits for beach replenishment. The USACE has identified several locations for sand borrow

Map 42: Recreational Fishing

# Recreational Fishing

Aggregate Number of Trips 2006-2010

# MAP 42



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- 3nm State Boundary
- 35m Depth Contour
- 60m Depth Contour
- 100m Depth Contour
- Artificial Reefs
- Recreational Fishing Areas



sites which are currently in use. Furthermore, in 2007 additional sites were identified as potential future sand borrow locations. Sand borrow sites currently in use and those identified for likely future use were obtained through the Delaware Geological Survey. Vector data that indicate USACE's potential future borrow sites were downloaded from the Delaware Geological Society's data download website. In this process of determining sand borrow sites, several hundred core samples were taken over the past thirty years and are available as point data from the Delaware Geologic Society. Areas currently in use may be considered exclusionary to offshore wind development because an active dredging program is operational. Since a USACE permit is required regardless of whether a wind turbine is located in federal or state waters, proposals to develop wind turbines in potential sand borrow sites should consider USACE plans as well as requirements. Please refer to Map 43.

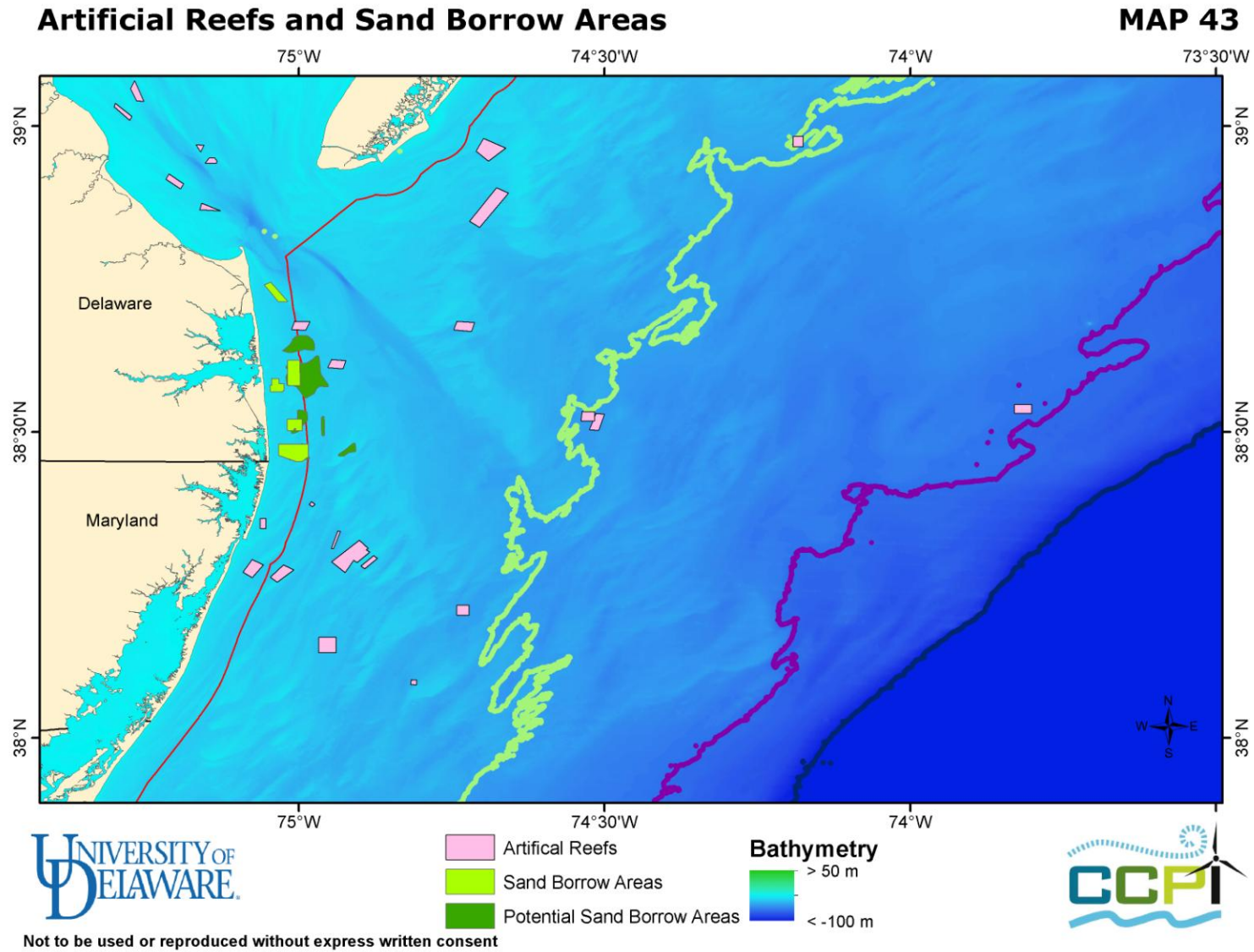
### *Artificial Reefs*

The states of Delaware, New Jersey and Maryland all have active artificial reef programs. Artificial reefs can introduce habitat complexity to the seafloor, which is otherwise relatively flat and featureless in the mid-Atlantic region. By adding complexity to the seafloor, artificial reefs are installed to introduce habitat for fish and benthic organisms. Artificial reefs may be comprised of recycled materials such as subway cars, concrete, rebar, tires, sunken ships, culvert pipes or other natural and man-made materials. The reefs provide food and protection for fish such as tautog, seabass, scup, spadefish and triggerfish, with aggregating potential for bluefish, striped bass and weakfish, as they are attracted to baitfish (Delaware Division of Fish & Wildlife, 2011). In addition to being a part of fisheries management programs, artificial reefs are popular fishing locations for recreational and commercial charter fishing operations and are heavily utilized throughout the mid-Atlantic.

Delaware's artificial reef program is managed by the Delaware Department of Natural Resources and Environmental Control, Division of Fish & Wildlife (Delaware Division of Fish & Wildlife, 2011). The Maryland Artificial Reef Initiative is a partnership of state, federal and private partners, although the Maryland Department of Natural Resources Artificial Reef Committee advises the management of the reefs in the state (Maryland Department of Natural Resources, 2011). New Jersey Department of Environmental Protection, Division of Fish and Wildlife, Bureau of Marine Fisheries manages the state's artificial reefs, all of which are considered to be fish havens (New Jersey Department of Fish and Wildlife, 2011). A total of 56 artificial reefs are maintained by the three states, 19 of which lie within the boundaries of the study area (Map 43).

Existing artificial reefs and sand burrow areas represent features that can be considered highly conflicting with offshore wind turbine installations. Artificial reefs are physical obstructions on the seafloor, precluding the placement of individual turbines. The reefs are maintained by the applicable state agencies as recreational fisheries resources, hosting diversity and abundance of recreational stocks. Therefore, these reefs form a significant conflict area for micro-scale siting of individual turbines. USACE sand borrow locations required significant resources to define and will

Map 43: Artificial Reefs and Sand Borrow Areas



presumably continue to be utilized as such in the immediate future. These additional sites have been identified for future sand extraction, indicated on this map. Although none of the areas identified are prohibited zones for wind turbines, it is expected that governmental resource managers would give utmost consideration to the current use of these areas, and thus, they may wish to be excluded from wind turbine development in the near future.

### *Firing Ranges*

The Delaware Atlantic coast was formerly home to two firing ranges from the early 20th century until the 1970's (USACE, 2005). These two ranges were known as the 'North Firing Range' and 'South Firing Range;' the Delaware National Guard utilized these sites as artillery ranges in the 1950s. The North Firing Range was located within the Delaware State Seashore, north of Indian River Inlet, affiliated with Fort Miles military site. Artillery with a 20-mile range was used at this location. The South Firing Range, also affiliated with Fort Miles, was located in the present Fenwick Island State Park (USACE, 2000). This area was used as a firing range for M60 machine guns, M79 grenade launchers, and 45-caliber submachine guns as well as for firing at aerial targets (USACE, 2000). Sand extracted from these areas has been found to contain unexploded ordinances (UXOs), which are potentially dangerous and should be carefully considered when commencing installation of offshore infrastructure. The northern firing range delimitation was digitized from the USACE (2005) report; the South Firing Range was digitized from a USACE (2000) report. These were imported from a PDF file and geo-referenced. Polygon features were drawn on the map corresponding with the firing locations. Please refer to Map 44. UXOs may be hazardous for persons or equipment if such an area is chosen for turbine installations. This may be overcome through use of a magnetometer to identify any UXOs and remove them prior to installation, however, due consideration of the risks should be given.

### *Potential Buffer Zones*

Even though these considerations are not depicted on the maps, it is important to mention the additional factors that potentially would need to be considered during MSP in the region. First, the NASA Wallops Flight Facility, created in 1958, is located on Virginia's Eastern Seashore. The facility currently launches primarily sounding rockets and super pressurized balloons (NASA, 2011). In addition, the Wallops Flight Facility has a research airport, which includes tracking radar and surveillance radar. It is feasible that an exclusion zone or buffer will be required due to the potential impacts of large-scale offshore wind projects on radar. In 2007, Department of Defense (DOD) analyzed potential impacts of offshore wind projects on the missile defense early warning radars, the Upgraded Early Warning Radar (UEWR) at Beale AFB, CA, and the PAVE PAWS radar at Cape Code Air Force Base, MA (DOD, 2007). The study found that offshore wind projects could potentially have a significant impact on radars and recommended the establishment of a 25-km offset zone within the effective "line-of-sight" of the radars, taking into account the direct, refracted, and diffracted signals from the radar (DOD, 2007, p. 1). It is difficult to estimate whether similar buffer zones would be required for the NASA facility, but such scenario is possible.

### *Historic Places*

The National Historic Preservation Act (NHPA) (16 U.S.C. 470 et seq.) is the primary federal law that governs the preservation of cultural and historic resources in the United States. The law established a national preservation program and a system of procedural protections to identify and protect cultural and historic resources of national, state, tribal and local significance. Under Section 106 of the NHPA, federal agencies must identify historic properties, consider the effect its proposed action will have on any identified sites, and then consult with the State Historic Preservation Officer (SHPO) regarding ways to avoid or mitigate any adverse effects. While the law does not mandate any particular result, it provides a meaningful opportunity to resolve potential conflicts.

For wind turbines to be in conflict with historic properties, according to Delaware's Department of State, Division of Historical and Cultural Affairs' interpretation of Section 106 regulations (36 CFR 800.5), turbines must either create "a demonstrable negative aesthetic effect" by diminishing the current visual aesthetics through the elimination of open spaces, or through the introduction of incompatible visual elements. Under 36 CFR 800.5, the SHPO/Tribal Historic Preservation Officer (THPO) evaluates whether a proposed action will have an "adverse effect" on historical properties. Submerged lands that were dry during the last ice age and were inhabited by tribal populations also may be considered under these regulations.

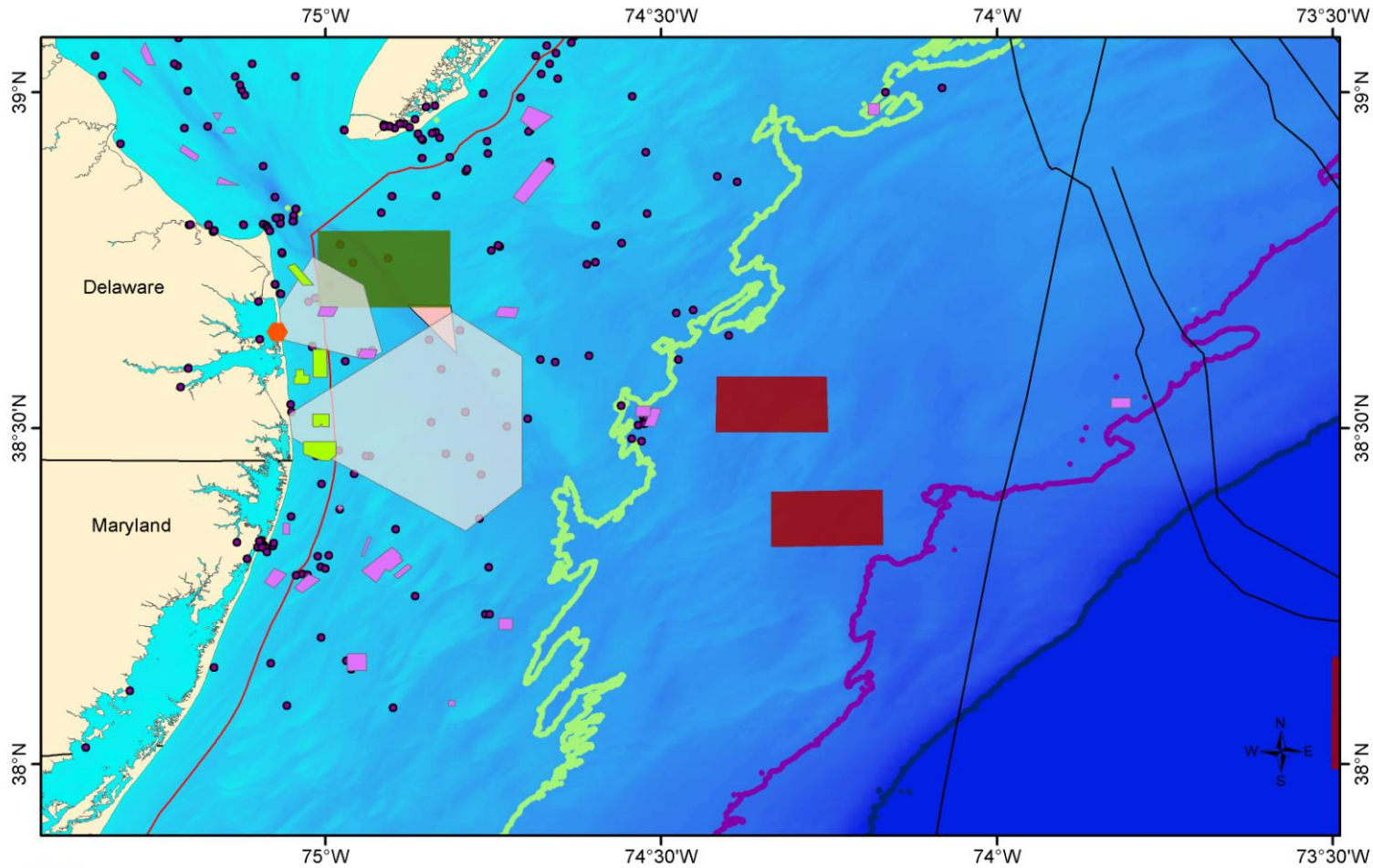
Several properties in coastal areas of Delaware have been determined historic. These include the Fenwick Island Lighthouse, Indian River Lifesaving Station in Rehoboth Beach (the Life-Saving Service is one of the precursors to the US Coast Guard), rebuilt to its original state of 1905, and the All Saints' Episcopal Church in Rehoboth Beach. In Maryland, St. Paul's by-the-sea Protestant Episcopal Church (Ocean City) is a historic listed property. This Gothic-style church on the beach is known for its unique architecture. The Indian River Lifesaving Station, as displayed on Map 44, is a historic property under the National Register of Historic Places. Under section 106 of the NHPA, all Federal Agency actions require consultation with the SHPO to assess adverse impacts to the historic property. Adverse impacts could include introduction of visual elements, although only to the extent that they "diminish the integrity of the property's significant historic features" (36 CFR 800.5 (a)(2)(a)(v)).

In addition to the properties on the National Historic Register, any effect on the view of the ocean from Assateague Island National Seashore off the coasts of Virginia and Maryland, extending just south of Ocean City, Maryland, is also likely to be considered during the MSP process. In 1964, Congress established Assateague Island National Seashore in order to protect and develop Assateague Island "for public outdoor recreation use and enjoyment" (16 USC § 495f). Congress subsequently directed the Secretary of the Interior to make a comprehensive plan for the protection, management, and use of the seashore that would include uses of waters adjacent to the seashore that would reasonably influence the use of the seashore (16 USC § 459f-11). In addition, other federal agencies that are considering issuing a loan, grant or license for a project that in the Secretary's judgment would "significantly adversely" affect Assateague are required to consult with the Secretary to determine if the proposed project is consistent with the Secretary's plan. More generally, a scenic

Map 44: Designated Areas of Existing Human Use of the Seafloor

### Designated Areas of Existing Use of the Seafloor and Coast

### MAP 44



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- Historic Property
- USACE Sand Borrow Areas
- Dumpsite
- Submarine Cables
- Historic Firing Ranges
- Shipwrecks
- Artificial Reefs
- Residual Mine Area
- Anchorage Area





buffer may be required under the National Park Service Organic Act of 1916 (16 USC 1), which governs all national parks, monuments and other reservations, and declares that fundamental purpose of said parks, monuments and reservations is “to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.” A scenic buffer would likely reduce the visual impact on Assateague Island National Seashore, and could be necessary if viewshed impacts are found to conflict with public outdoor recreation use and enjoyment.

#### *Archaeological Shipwrecks and Delaware Antiquities Act*

There have been a total 250 known wrecks along the Delaware/Maryland coast, fifteen of which were recorded at the Indian River Inlet (John Milner Associates, 2004). Most of these shipwrecks were recorded to have grounded onshore or the near-shore shoals.

Under the Abandoned Shipwreck Act of 1987 (43 USC 2101 et seq.), the U.S. government owns abandoned shipwrecks on federal lands. However, the act also guarantees public access to these (historic or non-historic) shipwrecks (43 USC 2103 (a)) for recreational uses. According to the Abandoned Shipwreck Act Guidelines (54 FR 13642, April 4, 1989) established by the Abandoned Shipwreck Act, Federal agencies must "have established programs to survey, identify, document, evaluate, protect, and preserve historic properties that are under their ownership or control or that may be affected by their programs and projects." If the Secretary of the Interior deems a shipwreck as historically significant, then the historic shipwreck must be preserved, and any action that may significantly alter or destroy the landmark requires consultation with the Advisory Council on Historic Preservation (ACHP). In addition, if access to any shipwreck is restricted, then it is mandatory to consult affected interest groups.

Under the Delaware Antiquities Act (7 Del. C. 5303 et seq.), the Delaware Department of the State has authority to enhance, preserve and protect archaeological resources, and may take title to all archaeological resources on State lands, including those in or on subaqueous lands. The State has title to all shipwrecks embedded in subaqueous lands, and any person seeking to excavate or alter any archaeological resource must seek a permit under § 5309. According to data from NOAA's Electronic Navigational Charts, there are currently 17 shipwrecks that lie within the borders of the proposed study area (Map 44), seven of which are deemed "dangerous." Only one of the shipwrecks - the Roosevelt Inlet Shipwreck off of Lewes - is recognized on the National Register. It is unlikely that the offshore wind projects will be located so close to shore, therefore, projects would not likely have an impact on this historically significant shipwreck. Other sites are not listed and thus only a guarantee of public access or consultation with stakeholders when access is restricted is required.

#### *Native American Artifacts*

Under the Native American Graves Protection and Repatriation Act, any native artifacts inadvertently discovered during the construction of an offshore wind project must be reasonably protected, and construction must be halted until the items discovered are protected (25 USC 3002(d)). Removal of any archaeological resource requires a federal permit under the Archaeological

Resource Protection Act of 1979 (16 USC 470 et seq.). Notice must be given to any Indian tribe that may consider the site as having religious or cultural importance (16 USC 470cc(c)). Although Indians are known to have been living on the Delmarva Peninsula, specific sites containing artifacts are either unknown or unpublished.

### *Dump Sites*

Three former dump sites are located on NOAA Navigational Charts which are potentially problematic for turbine installations and cable-laying. Polygons indicating dump sites are located within the study area. These three dump sites were digitized from a NOAA Chart and added as polygon features (Map 44). The dump sites are a discontinued municipal sewage sludge site, a discontinued acid waste site, and a site where explosives were previously dumped, respectively west to east. Furthermore, a location of a potential residual mine dump area located close to the Delaware North and South firing ranges is described in a USACE Environmental Assessment (USACE, 2000). This area was imported as an image, referenced and digitized as a polygon feature. Dump sites, including a potential residual UXO mine area, are also considered areas where careful consideration must be given to the priorities of the region. Dump sites containing hazardous materials may be a health and safety concern.

### *Submarine Cables*

Cables and pipelines that have been installed undersea previously are included in this analysis in order to identify areas of the seafloor unsuitable for turbine installation and additional cable lines. Existing cables may include telecommunication cables or oil and gas pipelines, some of which are currently in use, while others are non-operational. The majority of hazard cables are buried in the eastern section of the study area. Existing subsea cable lines were downloaded as a shapefile of polyline features from the Multipurpose Marine Cadastre (BOEM-NOAA, 2011). Data came as a merged feature class from several disparate sources, provided through NOAA's Electronic Navigation Charts (Map 44). Through the data collection process, it was learned that many submerged cables are not accurately charted, and some may not be charted at all, including those that are privately owned and government owned (Personal communication, C. Creese, 14 November 2011). Identification of additional known cables is important for future research in this region.

## Infrastructure

### *On-Shore Transmission*

The location and capacities of on-land transmission is critical for optimizing siting of offshore energy projects. To bring electricity generated by wind turbines to the grid, power cables must be buried in the seafloor and run to shore. Typically, medium-voltage cables are used within a wind project array and then converted to high voltage at a substation. High voltage AC or DC cables are buried several feet deep within the sediment and then run to shore (Green et al., 2007). Ashore, either existing substations are the connection points, or new substations must be located and built. The cost of submerged transmission cables varies with manufacture, but costs of \$755-\$860/meter in 2007 dollars, with lower costs for cables that collect electricity within the wind farm (Green et al.,

2007). Ideally, cables should be placed from a wind project or hub, and run to shore to a grid connection in as short a distance as possible, to reduce costs of laying extraneous cable. This is not a simple task, due to variation in sediments and the complexities of bringing cables under or across the beach face to the substation. Furthermore, cable burial is limited by existing uses and hazard areas. Artificial reefs are areas to avoid, as are paleovalleys, which are likely unsuitable due to technical limitations of burying the cables. The decision of where to precisely locate submerged cables will be left to both the developer and regulatory agencies, with consideration of these conflicting areas. Please refer to Map 45.

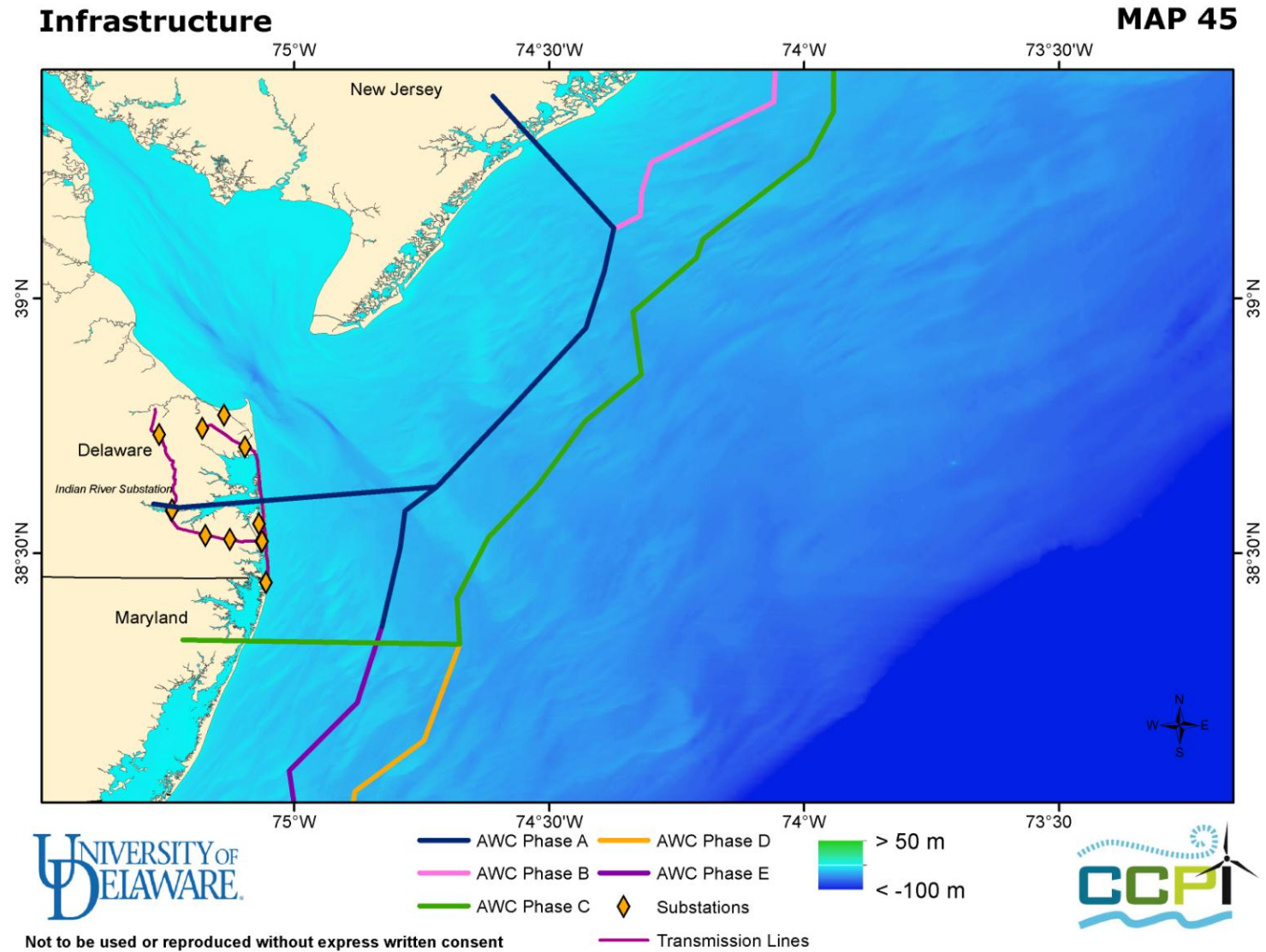
For the study, on-shore electrical transmission lines were compiled to represent transmission lines from both Delmarva Power and The Delaware Electrical Cooperative. Transmission lines, distribution lines and substations are mapped. The inclusion of this onshore infrastructure was chosen to assist in the determinations of areas that may be suitable for connection of offshore wind electricity to the existing grid. The Delmarva power lines and substations were digitized using Google Earth, and the Delaware Electrical Cooperative power lines and substations were downloaded as a shapefile from the source. One substation of particular importance is the high-powered tie-in at the Indian River substation as a potential on-shore connection point. In Delaware, existing substations are likely areas for electricity to connect to the PJM grid, and regional offshore transmission lines such as the Atlantic Wind Connection (AWC), which is discussed next, are likely to connect at the Indian River node. Therefore, it is likely that cables will come ashore near one of these stations to minimize the cost and disamenity of cables on land.

### *Undersea Electricity Transmission Hub*

Trans-Elect and Atlantic Grid Development have put forward initial plans for the construction of a subsea high-voltage transmission line. The Atlantic Wind Connection (AWC) will be designed to transport marine-based renewable energy to shore with few connection points rather than individual projects connecting to the grid independently. The AWC intends to connect up to 7,000 MW of power through high-voltage direct current (HVDC) transmission lines, making few landings on shore to minimize the number of landfalls necessary to bring offshore energy to the grid (AWC, 2011).

The initial schematic published by the AWC depicts one connection point within the bounds of the study area, to be brought onshore in southern Delaware and connect at Indian River (AWC, 2011). Onshore connection points at Piney Grove (Maryland) and Cardiff (New Jersey) are also locally relevant connection points (AWC Right of Way Request, 2011). Rather than bringing all projects to shore to connect to the Delmarva/DEC transmission lines, offshore wind generated electricity may connect directly to this line and come ashore accordingly. Therefore, the planned hub locations are a consideration for the siting of offshore wind projects in order to minimize shore-side disruptions and seafloor disturbance. Cable locations and on-shore tie-ins were digitized from the PDF map available for download from the AWC website (AWC Right of Way Request, 2011).

Map 45: Infrastructure



Transmission lines are represented on land in Delaware. There are several small substation points that could be used for small-scale development, such as 50 to 100 MW. For larger projects, a likely substation tie-in is identified at the Indian River substation. This is where the proposed Atlantic Wind Connection (AWC) - a high voltage direct current (HVDC) power line - could connect at Indian River. Substations, transmission lines, and the connection cables and points of the AWC are displayed, with the five distinct phases of installation differentiated.

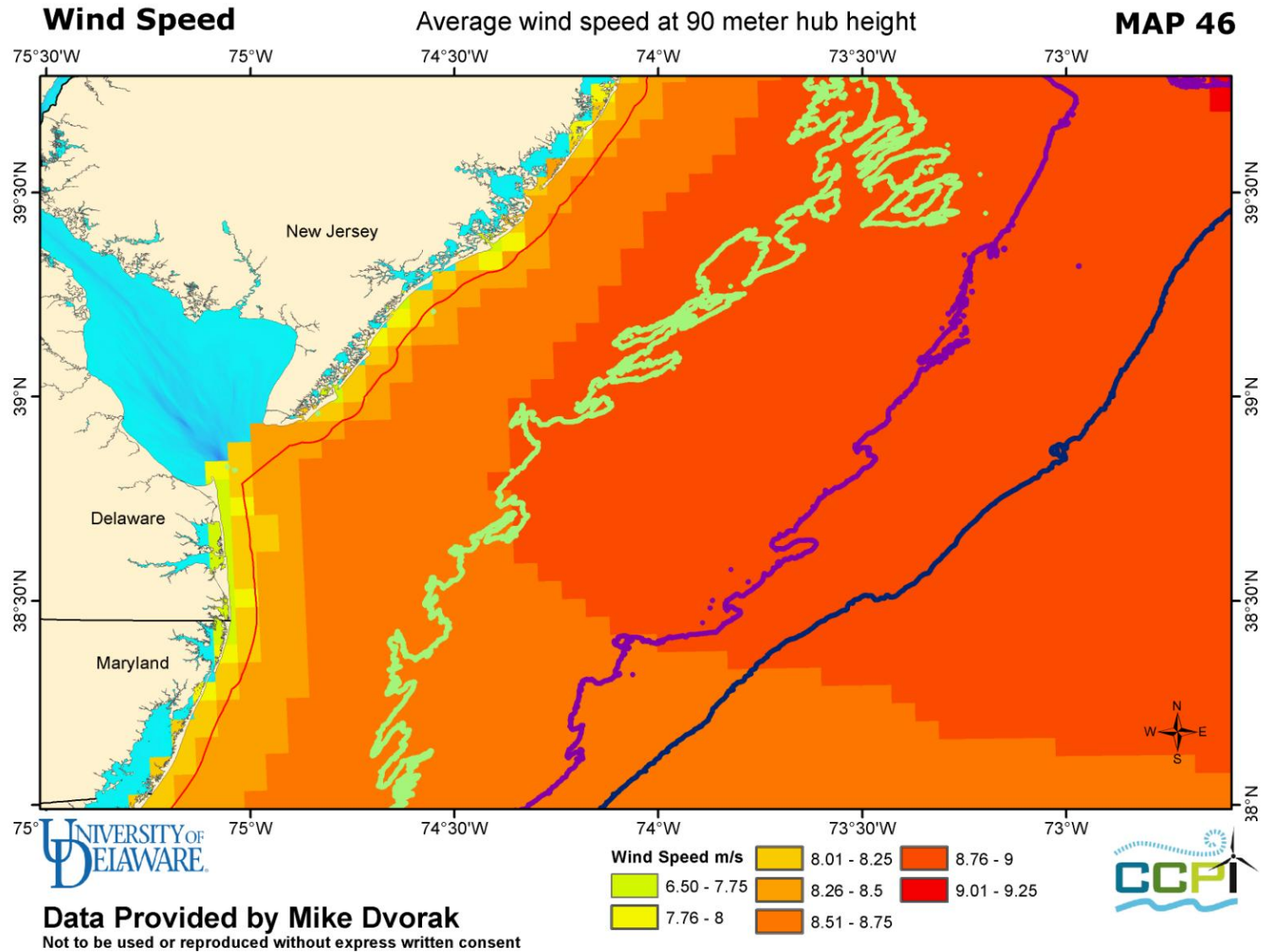
## Geotechnical Data

### *Wind Resource*

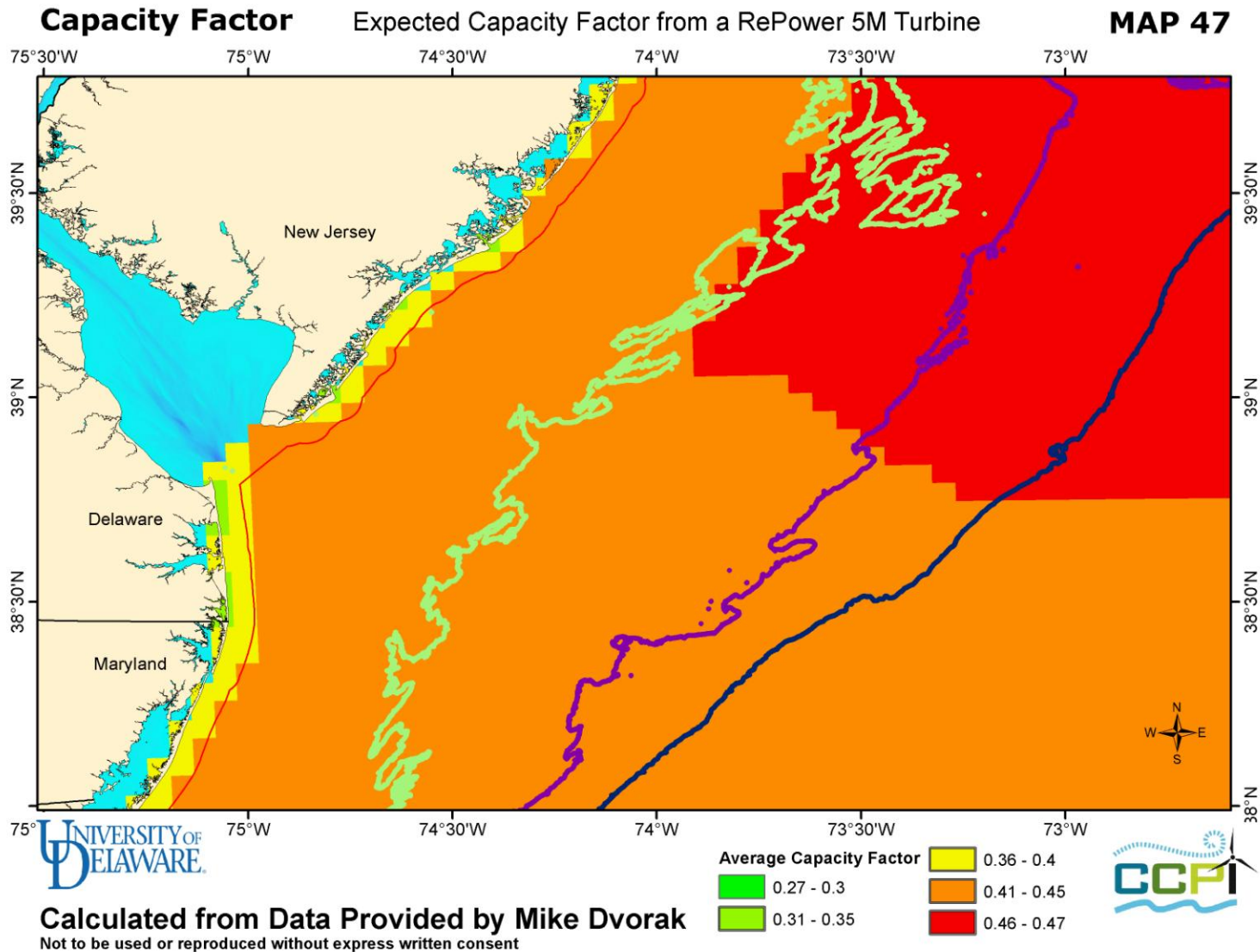
Wind speed is one of the most important factors affecting the cost of offshore wind power. The mid-Atlantic region has been identified as an area with excellent wind resources, coupled with relatively shallow waters (National Renewable Energy Laboratory, 2010). As wind power density is proportional to the wind velocity cubed (until the maximum output of a wind turbine is reached), increases in wind speed can provide large increases in power up to the designed cut-out speed of a given wind turbine (Manwell et al., 2009). By the same token, a linearly-scaled map of wind speed obscures differences, therefore two units of measurement are provided for wind resources. The wind resource is shown both as a velocity (meters/second) and annual capacity factor, a dimensionless ratio between 0.0 and 1.0 (the ratio of the energy produced over the maximum possible). In each case, color is used across the ocean area, with yellow, orange and red respectively indicating higher resource by either measure. Please refer to Map 46 and 47.

The following method was used to develop the maps. The 90-meter wind resource in m/s was created from running Weather Research and Forecasting (WRF) model, specifically using the Advanced Research WRF (ARW), abbreviated WRF-ARW. This was run from 2006 through 2010 at 5-kilometer resolution, producing hourly output for the entire US East Coast out to 200-meter depth (Dvorak et al., 2011). These wind speeds are used for the wind speed map. Capacity factors are obtained from wind speed using hourly wind speeds and a REpower 5M turbine power curve to derive hourly power output. Both the hourly wind speeds and the hourly capacity factors are averaged over the five years to produce a single number for each 5x5 km cell. The 5x5 km resolution can be seen on the maps as the resolution of the model (e.g. the jagged diagonals). The wind speed map demonstrates the wind speeds in meters per second. As can be seen on the map, wind speeds over 7.5 m/s are abundant throughout the region, with the majority of the study area averaging wind speeds over 8 m/s. An excellent wind resource thus exists in the study area. The capacity factor map depicts the capacity factor that would be achieved as calculated on the power curve of a RePower 5M, a 5-MW wind turbine, although it would not differ significantly when compared with capacity factors of other wind turbines. Note that values on the map are given in decimal, not percent, ranging from 0.27 – 0.47 (27% - 47%) capacity factor. A capacity factor of 35% is a commonly referenced value to indicate desirable output. As can be seen from the map, a capacity factor of 41% is expected as close to shore as the 3 nautical mile state-federal waters boundary.

Map 46: Wind Resource: Wind Speed



Map 47: Wind Resource: Capacity Factor



### *Bathymetry*

Bathymetry and geologic settings are relevant for the siting of offshore wind installations because coastal marine areas have evolved under conditions of sea level rise and fall over the past several hundred thousand years (Madsen, 2011). The present and past sedimentary environments have been formed during this time. The importance of bathymetry comes into play when considerations of costs associated with turbine installations as well as feasibility of a particular foundation type are evaluated. As discussed, turbine installation is limited, among other features, by depth constraints. Bathymetry was downloaded as a digital elevation model from NOAA/NGDC Coastal Relief Model (<http://www.ngdc.noaa.gov/mgg/coastal/startcrm.htm>). Data is in the form of a digital elevation model at 3 arc-second (0.0008333 degrees) resolution.

### *Paleovalleys*

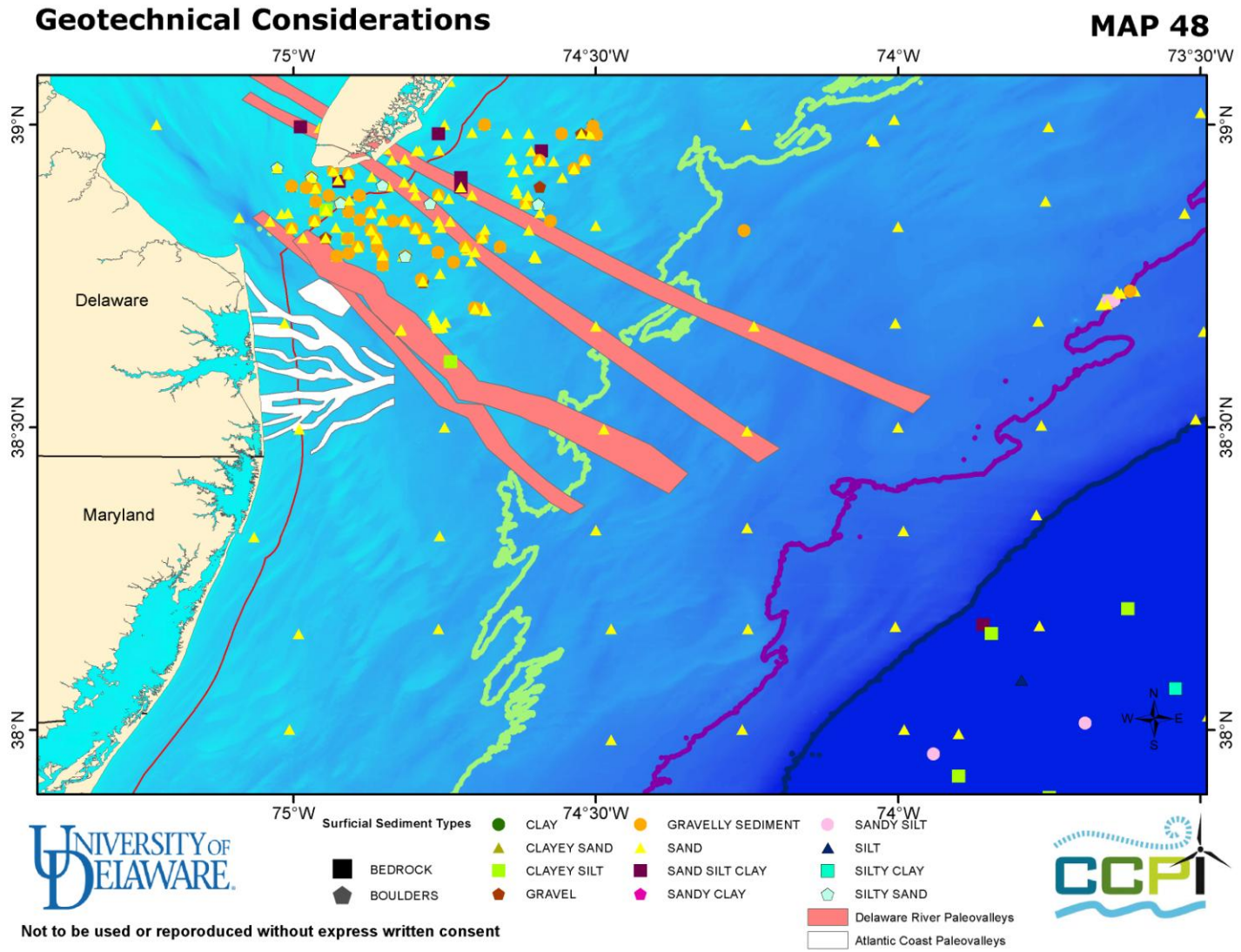
Offshore Delaware bathymetric features are varied and need to be considered during the siting of offshore wind projects. One of the most distinctive bathymetric features is the Delaware River paleovalley. The paleovalley is a well-defined bathymetric low that extends northwest to southeast from the mouth of Delaware Bay onto the inner continental shelf (McKenna & Ramsey, 2002). The paleovalley is the morphologic expression of the Delaware River when it flowed across the current area of the Delaware Bay and inner continental shelf when global sea level was lower and this area was exposed as a land surface. The deepest lows that reach to more than 50 meters are within the paleovalley on the Delaware inner continental shelf. These lows have been enhanced by strong flood and ebb tidal currents that flow into/out of the constricted mouth of the Delaware Bay eroding and transporting sediment across the bottom of this region. Please refer to Map 48.

Very little is known about the distribution of sediment-types in the subsurface in this region. The data are limited to rather sparsely spaced vibrocores and older seismic surveys (e.g., McKenna & Ramsey, 2002). Based on these available data, it is significant to note that the presence of paleovalleys have been identified in the subsurface, which are older in age than the Delaware River paleovalley. These paleovalleys are associated with river drainage systems of both the Inland Bays and Delaware River watersheds. Like the Delaware River paleovalley, they are associated with older time periods when global sea level was lower and major river systems flowed onto the exposed Delaware inner continental shelf. These paleovalleys were subsequently filled with sediment as global sea level rose. Thus, they mark areas where variable, both in a real- and vertical-sense, sediment types are present in the subsurface. Because of the variable nature of their infill sediments, knowing the position of these paleovalleys in the subsurface is critical in selecting foundation locations, and types of foundations, to use in developing offshore wind projects (Madsen, 2011). Additional paleovalleys off the coast of New Jersey and Maryland may occur but were not available for mapping.

In addition to the Delaware River paleovalley, the area can be delineated into several features by bathymetry, including: the Hen and Chickens Shoal, the Attached Shoal Field and Shoreface, the Inner Platform, the Outer Platform, the Detached Shoal Field and the Fenwick Shoal Field (McKenna & Ramsey, 2002). The shoal fields are notable for their abundance of sand, their



Map 48: Geotechnical Considerations



distinctive finger-like patterns, and their varying orientation relative to the modern coastline (McKenna & Ramsey, 2002).

### *Sediments*

Understanding the spatial variation of sediments and constraints on grain sizes is critical, as sub-bottom and bottom sediment types and their distribution play a role in selection of the wind turbine foundation type (gravity base, monopile, jacket, etc.) and choosing the best suited location for the foundation (Madsen, 2011). The data used in this analysis came from the U.S. Geological Survey Data Series 118 and its usSEABED: Atlantic Coast Offshore Surficial Sediment Data Release v. 1.0, released in 2005. The report contains a compilation of unpublished and published sediment texture and other geologic data about the sea floor (Reid et al., 2005). The sediment database, which presently contains data for over 23,000 samples, lists location, description, classification and texture of samples taken by numerous marine sampling programs. The majority of samples are from the Atlantic Continental Margin of the US, but some are from diverse locations around the globe. The database also includes texture data for approximately 3800 samples taken or analyzed by the Atlantic Continental Margin Program - a joint U.S. Geological Survey/Woods Hole Oceanographic Institution project conducted from 1962 to 1970 (description adapted from the file metadata by USGS). The data available for the offshore area of Delaware is somewhat unevenly distributed, with the majority of samples taken near the southern New Jersey coast, while the samples off the coast of Delaware were taken with approximately 28 km spacing between sites. The bottom sediment types are primarily sand, with gravely silt, clayey silt, silty clay, silty sand, and sand, silt and clay combination, with clays and silts being more prevalent near the continental shelf break near the easternmost side of the project study area.

Sediment-type subdivisions are based on the grain size diameter, where according to the Unified Soil Classification System, gravels have diameters larger than 4.75 mm but smaller than 76.1 mm; sands have diameters smaller than 4.75 mm but larger than 0.075 mm; particles smaller than 0.075 mm are denoted as silts and clays, with clays generally considered to have grain diameters less than 0.002 mm (Verujit, 2010). Knowing sediment grain size is critical as the geotechnical behavior of sediments varies as a function of grain-size. Sediment type will need to be considered when choices regarding turbine-supporting structures are made. For example, silts and clays generally possess low shear strength, are plastic and compressible, and undergo creep. Given their lagoonal to marsh origin in the Delaware region, they may also contain significant amounts of organic material that decays releasing gas, which may be present in pore spaces within the sediment. It is generally softer than sand and undergoes creep. In comparison, sands are stiffer and less prone to compression and creep. However, the presence of groundwater must be considered in terms of its influence on the effective strength of subsurface sands in the region.

Due to a significant amount of diversity of sediments off Delaware, further evaluation of these sediment properties at site specific locations where offshore wind installations will be placed will be needed to determine the most optimal and least costly ways to install offshore wind turbines. Furthermore, as the data on sediment types are surficial, not sub-surface, sub-surface sediments

would need to be evaluated to assess seabed suitability and the related cost of wind turbine foundation and installation.

Analysis of geotechnical data is critical to ensuring cost-effectiveness and prolonged service of turbine installations. As discussed, along with water depth, sediment types dictate the type of turbine foundation that can be installed. As noted earlier, there is a dearth of available sub-surface sediment data. Analysis of the current sub-surface sediment data has not been completed for the region, although important seafloor attributes have been compiled for this project (e.g., identifying the position of paleovalleys in the subsurface). Additional sub-surface data needs to be collected to enhance the understanding of the distribution and geotechnical properties of the surficial sediments. Extensive interpolation of the available data needs to be performed to fill in the data gaps and these results need to be coupled with site-specific analyses of the sediment characteristics before determinations of potential best-suited locations can be made. The resulting map indicates paleovalleys, which are less preferred from a geotechnical standpoint compared to other areas. Additionally, known sediments are displayed as sampled.

## DISCUSSION

The data collection and analysis presented in this report is an important step in furthering marine spatial planning efforts in the mid-Atlantic region. Before planning for any new development in the coastal zone or open ocean, best practices dictate that a comprehensive assessment of natural resources and conflicting activities be conducted. This report lays the groundwork for the State of Delaware to advance the planning for offshore wind infrastructure as well as consider other uses that may be conflicting. Next steps in this process might focus on assessing data gaps, evaluating future research needs, examining tradeoffs, and identifying a lead planning body to advance MSP from this present effort to a policy framework. In the sections below we summarize the results of this project's mapping effort, highlight obvious exclusion areas, and consider the role of stakeholder engagement, risk assessment for future analysis of impacts, and the benefits of offshore wind in the context of climate change and air quality.

### *Summary of the Mapping Effort and Obvious Exclusions/Areas to be Avoided*

The preliminary analysis of the suitable areas for offshore wind development has shown that some ocean space conflicts will exist, especially closer to shore where human uses have been established and represent significant commercial interests. The most obvious zones to be avoided include: designated commercial shipping lanes, anchorage areas, sections of the seafloor known to contain unexploded ordinances, designated sand borrow sites, artificial reefs, dump sites, shipwrecks, and residual mine areas. Also, special consideration should be given to establishing limited buffer zones around military radar installations such as the Wallops Flight Facility (VA). Additionally, a scenic buffer may need to be established around the Assateague Island National Seashore if it is determined that presence of wind turbines “significantly adversely” affects public outdoor recreation use and enjoyment. Areas with important human uses such as essential fish habitats, and known

biodiversity hotspots need to be considered and potentially avoided when ocean areas determined to be optimal for offshore wind development are selected. Lastly, dense areas of high commercial ship traffic may be considered for exclusion, although from an overall societal standpoint it may be preferable to re-route commercial ships further from the coast and to build offshore wind projects closer (Samoteskul, n.d.). Although national and state priorities and established policy frameworks ultimately may guide which areas to exclude, consideration of the multi-use nature of the oceans and engagement of stakeholders at the earliest feasible stage is advisable.

### *Stakeholder Engagement*

The process of engaging the public in a meaningful way is a vital step in planning for future uses of the ocean (National Research Council, 2008). For this study, stakeholders were consulted to help identify data gaps and research needs. Broadly, stakeholders are people who have an interest in the project, meaning that almost any person or group can be considered a stakeholder (NOAA, 2007). Stakeholders may be local citizens or institutions, with institutions often having better access to the decision-making process (Mcglashan & Williams, 2010). Engaging the public can include providing information, having a two-way consultation, or interactive participation. By simply providing information, large audiences can be reached quickly, but such communication does not usually leave room for debate and thus is limiting. To have a dialogue and foster consensus and interaction, activities such as meetings, committees, and workshops can be facilitated (Johnson & Dagg, 2003). For example, during the development of Rhode Island's Ocean SAMP, community meetings, presentations, participatory mapping, and direct communication were all incorporated to enhance public awareness, provide an opportunity for the public to be heard, and to gain insight into public preferences (RI-CRMC, 2010).

Stakeholder engagement has long been a component of resource management, with the degree of inclusion varying greatly. Stakeholders are commonly consulted when a new, major program or initiative is proposed. In general, engaging a wider community of people can benefit resource planning, by highlighting alternatives and by bringing additional knowledge to the table (Johnson & Dagg, 2003). Early engagement in the planning process for resources management decisions is especially advantageous (Johnson & Dagg, 2003). As coastal areas are usually densely populated, an MSP process is likely to attract a variety of users who are highly knowledgeable about the coastal environment (Johnson & Dagg, 2003). In planning for offshore wind, examples of stakeholders include: citizens, electric utility providers, federal and state government employees, tribal representatives, NGOs, interest groups, resource users, residents of coastal areas, among others. Using MSP to plan for offshore wind infrastructure can serve as an excellent platform for public consultation, given the variety of users of the ocean.

For the present study, stakeholders were identified during three stages: formation of an advisory committee, organization of a stakeholder workshop, and comment on the draft MSP report. The expert advisory committee brought a broader perspective and knowledge base to the scope of this project, making initial recommendations on the scope, identified data gaps and providing suggestions on finding key data sources that enhanced the analysis and results. This committee was

comprised of individuals from DNREC, BOEM, USACE, Delaware Audubon Society, Oceana, Ocean Conservancy, Atlantic Wind Connection, Bluewater Wind LLC, Delaware Tidal Finfish Advisory Committee, and the State of Delaware Division of Historical & Cultural Affairs (see the inside front cover of the report for the names of the individuals involved). Further means of engaging the public include conducting surveys, creating focus groups, and citizen advisory groups. All of these methods and others should be carefully considered as this MSP effort unfolds, to ensure a transparent, participatory planning process is facilitated.

### *MSP Workshop*

On November 14, 2011, a workshop was held to bring together stakeholders and community members to discuss MSP framework, its strength and shortcomings, current developments on the federal and state levels and community, stakeholder engagement practices and to receive feedback on the Delaware MSP mapping effort. The workshop also focused on model state policies to advance and oversee the development of offshore wind power, which was the focus of separate research under a grant from DOE. Among the attendees were citizens and representatives of Atlantic Wind Connection, BOEM, DNREC, Delaware Economic Development Office, Delaware Finfish Advisory Council, Delaware Sea Grant, Delaware State historic Preservation Office, Delaware Nature Society, Delawind LLC, Delmarva Ornithological Society, Dewey Beach Mayor's Office, US FWS, EPA, Lenape Tribe of Delaware, Narragansett Indian Tribe, National Audubon Society, Natural Resources Defense Council, Navy, Bluewater Wind, Oceana, Ocean Conservancy, Office of Representative John Carney, Office of Senator Chris Coons, USACE, and Versar. During the first part of the workshop, speakers concentrated on setting the framework for offshore wind power development and for MSP and highlighting developments in Rhode Island. Later on, students and researchers affiliated with UD's Center for Carbon-free Power Integration (CCPI) presented the results of the Delaware MSP project, highlighting major uses of the ocean off the coast of Delaware and briefly describing methodology employed during data analysis and map creation. The presentations led into a lengthy discussion about the Delaware MSP project, major data gaps, and how future studies need to facilitate comprehensive and inclusive stakeholder engagement process at the beginning of the planning stage. Finally, CCPI researchers made presentations on model state offshore wind power policies (feed-in tariffs, model requests for proposals, and model state legislation). The workshop agenda is attached as Appendix 1.

Some of the data gaps and suggested improvements to methodology and process discussed during the session are highlighted below (see Appendix 2 for a more complete list of the major themes that emerged from the workshop).

- 1) Focus on stakeholder engagement and input gathering. Involving stakeholders is critical and engaging other members of the public based on their input is necessary for the MSP process to succeed.
- 2) Develop protocols to determine presence or absence of the now submerged ancient Native American settlements on the continental shelf. Every state is likely to develop its own protocol, but consulting with the members of the Native American tribes is likely to be a

critical piece of any successful MSP effort. Also, early and frequent consultations have been emphasized as critical to the successful resolution of issues when they arise.

- 3) Wildlife hot spots have yet to be determined, especially considering seasonal distribution of the species on the AOCS.
- 4) Subject matter experts are rarely satisfied with the amount of data they have available. Thus, non-subject matter experts are needed to identify areas that require further studies or should be the focus areas.

### *Data Gaps*

After completing data analysis and consulting with stakeholders through the workshop and distribution of materials, a few data gaps emerged as frequently discussed unknowns. One such data gap is the abundance, distribution, and behavior of bats in the offshore environment. With a growing body of literature describing impacts to bats from land-based wind turbines, studies should be undertaken to increase understanding of the distribution of bats offshore. Such an effort will shed light on which species frequent the offshore environment, their behavior while offshore, seasonality and other weather-related trends. This data should help to determine the potential exposure of bats to wind turbines in the AOCS.

Additionally, the locations of submerged cultural resources off the Delmarva Peninsula are not well known. Knowing the locations of buried artifacts or historically significant sites is important prior to building offshore infrastructure to maintain the integrity of these resources. As part of site investigation, an area that is being considered for offshore wind power development could be investigated for submerged cultural resources through, for example, use of a magnetometer to map features. Consultation with state, federal, and tribal stakeholders early in the process will be key.

Understanding more about migrations of avian, bat, marine mammal, sea turtle and fish populations along the AOCS would also be useful for determining the best locations for offshore wind projects. Project siting off the coast of Delaware is limited to a relatively narrow north/south terminus, but offshore wind projects are proposed from the Gulf of Maine into the southern Atlantic states, and thus development is likely to be far more spread out. When considering the larger picture of offshore wind deployment, the migration patterns of individual species should be taken into account to ensure that no one species is being effectively excluded from its migratory corridor. This requires coordination among agencies, developers, and research organizations and would benefit from additional data collection efforts.

While it is important to gather appropriate baseline data prior to initiating offshore development, it is also important to reach renewable energy goals that provide societal benefits in terms of job creation and economic development, diversification of the national energy supply, particularly in terms of home-grown energy sources, and CO<sub>2</sub> emission reduction. Given the effects of CO<sub>2</sub> on wildlife, sea level, and ocean pH, it must be remembered that there are environmental consequences not only from non-action on offshore wind power, but delayed action as well. Thus, while additional data collection is always desired, the regulatory agencies, with input from stakeholders, must

determine how much data is sufficient to make decisions about the siting of new ocean-based infrastructure. In fact, data collection and careful examination of environmental and socioeconomic impacts is ongoing and is emphasized in BOEM's Final Environmental Assessment of commercial wind lease issuance and site assessment activities on the AOCS off the coast of NJ, DE, MD and VA, which was issued in January 2012 (BOEM, 2012). These activities provide valuable data to state and federal government agencies, public stakeholders, and the offshore wind power industry and emphasize the importance of decision-making based on sound science and stakeholder input.

#### *Risk Assessment in the MSP context*

After the initial analysis of the categories of environmental impacts is performed, identifying which impacts may be potentially significant is a critical step. Risk assessment can facilitate that process as it helps place estimates on the likelihood and severity of positive or negative effects on human, biological and physical systems (Ram, 2008). Risk assessment also may assist stakeholders in understanding the interactions among multiple threats and measure change within complex, highly interconnected systems under conditions of uncertainty (Ram, 2008). The central principle of an integrated risk framework, which comprehensively and systematically evaluates the range of negative risks and impacts, is that risks (in this study, effects on different species) have to be compared with each other “to develop a transparent evaluation of temporal and spatial impacts on a site or a region” (Ram, 2009, p. 3-4). Within an MSP framework, risk assessment framework may be especially useful for effective siting strategies. These are based on avoiding irreducible risks, mitigating those risks that cannot be reduced, and applying adaptive, cost-effective practices when possible (Ram, 2009, p. 3-4). The risk assessment framework also has been mentioned in DOE's report *20% Wind Energy by 2030* as a step necessary to facilitate large-scale deployment of wind energy (DOE, 2008). Using the principles of the risk assessment framework would allow for the comparison of risks and stressors across different species to determine which of them are more impacted by construction and operation of offshore wind projects.

#### *Carbon Dioxide Emissions, Human Health, and Offshore Wind Energy*

An MSP framework is a powerful tool for ocean use planning and can assist with efficient offshore wind siting, ultimately contributing to climate change mitigation efforts. Even though the international post-Kyoto Protocol negotiations meant to reduce the level of CO<sub>2</sub> and other greenhouse gas (GHG) emissions and halt climate change have recently come to a standstill, the U.S. recognizes the dangers posed by CO<sub>2</sub> emissions, such as sea level rise and associated water contamination, land loss, changes in maritime storms, potentially more intense and frequent extreme weather events, ocean acidification, and biodiversity loss (Environmental Protection Agency (EPA), 2012a). Furthermore, climate change is expected to increase vulnerability of majority of U.S. birds in terrestrial and aquatic habitats, leaving oceanic birds especially vulnerable (The State of the Birds Report, 2010). Rising sea levels are expected to fragment or flood low-lying habitats, such as barrier islands and salt marshes. Rising severity and frequency of storms as well as changes in water temperatures will affect the quality and availability of coastal habitats, altering marine food webs (The State of the Birds Report, 2010). Development of renewable energy sources, including offshore

wind represents a step in the direction of reducing the severity of these climate-change related threats.

Another aspect of emissions that are produced during fossil-fuel combustion is related to their detrimental effects on human health. The largest stationary sources of GHG emissions in the U.S. in 2010 were power plants (2324 MMT CO<sub>2</sub>e), followed by refineries (183 MMT CO<sub>2</sub>e) (EPA, 2012b). The majority of the nation's electricity came from coal (45%), followed by natural gas (24%) (Energy Information Administration (EIA), 2011). In Delaware, in 2010, an even larger percentage of electricity that was consumed was generated by coal-fired power plants (49.7%), with natural gas and nuclear-generated power accounting for 11.1% and 34.9% respectively (Delmarva Power & Light, 2010). Such large quantities of coal-produced electricity in the national and state energy mixes account for lower air quality with associated health costs and represent the largest contribution to country's overall emission levels. In 2009, the National Research Council estimated the health costs as the result of emissions of four criteria pollutants from a typical coal plant are 3-4¢/kWh, with the dirtiest coal plants externalizing (not including in the wholesale or retail price) 12-13 ¢/kWh. More recently, Epstein and colleagues (2011) estimate when one consider that a full accounting of the life-cycle external costs of coal (that result from mining, transportation, generation/emission, etc.) would add on 17.8¢/kWh to the price of coal-generated electricity.

Offshore wind energy thus even at its present over-market retail price offers an alternative to conventional energy sources that, if all costs were accounting for, would be priced competitively, and that can significantly reduce GHG emissions and improve air quality. According to the market analysis completed by the regional grid operator PJM in 2010, as coal-fired power plants represent 68% of marginal resources (PJM, 2010), when offshore wind power projects come online, generation from coal-fired facilities for the most part would be replaced first, ultimately reducing environmental and health effects from this most emission-intensive energy source.

Recognizing the negative implications of climate change, there are numerous emission-reducing initiatives that are supported on federal and state level. The federal government manages a variety of public-private partnerships that focus on renewable energy, energy efficiency, agricultural practices and carbon sequestration to reduce GHG emissions levels (Environmental Protection Agency (EPA), 2012a). On the state level, 2009-2014 Delaware Energy Plan recommendations emphasize the importance of halting the growth of energy use in the state and achievement of energy self-sufficiency and carbon neutrality in the Delaware's built environment by 2030 (DNREC, 2009). Offshore wind resources off Delaware are vast enough to contribute significantly to the state's energy mix, satisfying additional aspirations of improved air quality, increased energy self-sufficiency and local job creation.

### *Conclusion*

Large sections of the ocean space off Delaware have favorable wind resources and host a number of overlapping uses. Based on the results of this study, most of these areas appear to be candidates for offshore wind development. The study also found some areas where offshore wind siting should in the first instance be avoided due to presence of biological resources, geotechnical considerations,



and some existing human uses. Decisions regarding offshore wind siting should be made by state and federal regulatory agencies based on input from stakeholders and wind developers, while balancing the cost considerations (costs tend to increase with water depth and distance from shore), and desire to minimize environmental and social impacts of offshore wind energy development. Through the National Ocean Policy, NOAA and other federal agencies are leading the overall MSP effort, with intergovernmental bodies such as MARCO implementing MSP on a regional scale. Due to multi-user and multi-stakeholder nature of the planning process for offshore wind, the fact that ecosystems pay no attention to artificial state boundaries and Delaware's comparatively short coastline, a regional body for the mid-Atlantic might be the most fitting for compiling data, managing the stakeholder engagement process and setting regional priorities. Such an approach may be most efficient in establishing a robust and sustainable offshore wind industry in Delaware and moving the MSP process ahead.

## APPENDIX 1: Public Workshop Agenda

### CCPI OFFSHORE WIND WORKSHOP, November 14, 2011

#### AGENDA

- 9:00 am Welcome, Jeremy Firestone
- 9:10-9:40 am Wind Power in the Offshore Environment
- 9:40-10:40 am MSP at the federal, regional and state levels  
Panel Discussion  
Moderator: Bonnie Ram, Ram Power, LLC  
Panelists: Amardeep Dhanju, BOEM  
Sarah Cooksey, DNREC (on MARCO)  
Annette Grilli, University of Rhode Island (RI SAMP)
- 10:40-11:00 am Coffee Break
- 11:00-12:30 pm Delaware MSP  
Presentations by UD Researchers, including Katya Samoteskul,  
Alison Bates, and Greg Shriver  
Facilitated Discussion: Bonnie Ram
- 12:30-1:30 pm Buffet Lunch
- 1:30-2:15 pm Continuation of Facilitated MSP discussion, Bonnie Ram
- 2:15-3:30 pm State Policy Measures to Advance Offshore Wind Power: Model Legislation,  
Feed-in Tariffs, and Mandated Request For Proposals  
Presentations by UD Researchers Dawn Kurtz Crompton, Blaise  
Sheridan, and Jeremy Firestone
- 3:30-4:00 pm Wrap Up, Jeremy Firestone
- 4:00 pm Reception

## APPENDIX 2: Summary of Public Comments and Suggestions

A partial list of comments and major discussion points from the November 14, 2011 public workshop. Discussion points are summarized and in some cases, combined for brevity. The second column indicated if the topic was addressed in this final report.

Comment	Addressed in this report?
Ancient submerged sites must be identified; consultation with tribes must occur early and often to ensure proper stewardship.	Yes
Additional consultation is required regarding historic status of shipwreck	Yes
New data must be integrated as it becomes available, e.g.: VTR Fishing data is flawed, new data from NMFS Marine Recreational Information Program will be available)	Yes
Offshore wind power development should be balanced without restricting recreational fishing through marine protected areas (MPAs)	No
Wind resource meteorological tower data should include horizontal and vertical data	No
Display transparent shipping fairways (TSSs) on future maps	Yes
Continue iterative assessment as areas are redefined through development process	No
Data should be layered (both during construction and operational phases) to identify “hot” spots and/or ideal locations for development	Yes, but not executed
Must determine how much data/data analysis is enough?	Yes
MSP efforts need to carefully consider appropriate spatial scale: grid, state, region, and ecosystem	No
Bat activity offshore is a data gap, although a 2-year BOEM study is underway	Yes
Stakeholder identification and involvement must take place early, and with considerable effort. Outreach by subgroup may be a more manageable task	Yes
Static avian studies do not fully represent species patterns. Suggestions include long-term monitoring, hot spot avoidance, and consideration of changes as a result of shipping patterns	No
Data gathering purposes vary, from siting recommendations to NEPA requirements	No
Leveraging federal resources and funding can help the data gathering process move along; requires partnerships	No
Subject matter experts are necessary stakeholders that should be included in MSP efforts. Experts can validate numerical data, highlight potential survey bias, and identify if data is sufficient.	Yes
Structured decision-making could be a useful strategy to take next steps in MSP	No

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### **Legislative Acts**

Abandoned Shipwreck Act of 1987, 43 USC 2101 et seq.

Archaeological Resource Protection Act of 1979, 16 USC 470 et seq.

Coastal Zone Management Act, 16 USC 1451 et seq.

Delaware Antiquities Act, 7 Del. C. 5303 et seq.

Endangered Species Act (ESA) (16 USC 1531 et seq)

Magnuson-Stevens Act Provisions, 50 CFR Part 600

Marine Mammal Protection Act (16 USC 1361 et seq.

National Historic Preservation Act (NHPA), 16 U.S.C. 470 et seq.

National Park Service Organic Act of 1916, 16 USC 1

Outer Continental Shelf Lands Act (OCSLA), 43 U.S.C. 1301