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Overcoming Biological Data Deficiencies in Environmental Permitting for Offshore
Wind Energy

A Dissertation Presented

by

KENDRA L. RYAN

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

May 2018

Intercampus Marine Science Program

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Overcoming Biological Data Deficiencies in Environmental Permitting for Offshore

Wind Energy

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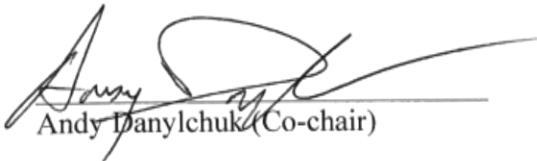
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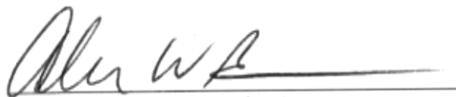
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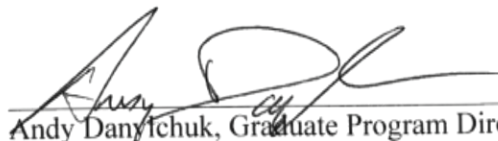
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ABSTRACT

OVERCOMING BIOLOGICAL DATA DEFICIENCIES IN ENVIRONMENTAL PERMITTING FOR OFFSHORE WIND ENERGY

MAY 2018

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The offshore wind final net technical resource of 2,059 GW in the United States is unrealized in part due to a cumbersome permitting process. In this dissertation, I examine the role of biological data in the permitting process, and explore frameworks for overcoming identified deficiencies. Criteria analyses and semi-structured interviews were conducted to understand how biological data impede impact assessments of offshore wind projects, which are required by the National Environmental Policy Act of 1969 (NEPA). In addition, spatiotemporal scales of biological data in NEPA assessments were evaluated against federal requirements. Case studies and semi-structured interviews were then conducted to evaluate how the marine spatial planning (MSP) process and its outcomes could address identified data impediments, how MSP could otherwise advance the offshore wind permitting process, what are the limiting factors of MSP, how limiting factors could be overcome, and how species distribution models could provide appropriate data to improve documentation.

The research conducted for my dissertation showed that scales of biological data are inadequate in impact assessments and insufficient biological data are impediments in the offshore wind permitting process. Data from species distribution models contribute marginal value to impact assessments, and should not be exclusively relied upon. MSP can improve data access and analyses in NEPA documentation, in addition to facilitating communications, minimizing conflict, and providing a common operating picture. However, the full value of MSP is limited due to lack of political support and methodological changes in implementation. Therefore, other initiatives to facilitate data management should be pursued, such as industry sponsored research and relaxing the proprietary nature of baseline biological data. The results of this project highlight the significance that biological data has in impeding offshore wind projects and suggest solutions to overcome this in order to responsibly advance the offshore wind sector in the United States.

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LIST OF ABBREVIATIONS

AERO	Accompanying Ecological Research on Offshore Wind Energy Deployment
AMAPPS	Atlantic Marine Assessment Program for Protected Species
BOEM	Bureau of Ocean Energy Management
BSH	Bundesamt für Seeschifffahrt und Hydrographie
CEQ	Council on Environmental Quality
COP	construction and operation plan
EA	environmental assessment
EBM	ecosystem-based management
EEZ	exclusive economic zone
EIA	environmental impact assessment
EIS	environmental impact statement
ESA	Endangered Species Act
gCO ₂ e/ kWh	grams carbon dioxide equivalent per kilowatt hour
GIS	geographic information system
GW	gigawatt
ICZM	integrated coastal zone management
JIP	Joint Industry Programme
kW	kilowatt
MDAT	Marine-life Data and Analysis Team
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MSP	marine spatial planning
MW	megawatt
NEPA	National Environmental Policy Act
nm	nautical miles
NMP	National Marine Plan
NOAA	National Oceanic and Atmospheric Administration
OCS	outer continental shelf
OSAMP	Ocean Special Area Management Plan
PEIS	programmatic environmental impact statement
RIWINDS	Rhode Island Winds Program
RPB	Regional Planning Body
SAP	site assessment plan
SEA	strategic environmental assessment
SST	sea surface temperature
UK	United Kingdom
USACE	United States Army Corps of Engineers
USDOI	United States Department of the Interior
WEA	wind energy area

CHAPTER 1

INTRODUCTION

Of all the forces of nature, I should think the wind contains the largest amount of motive power—that is, power to move things... And yet it has not, so far in the world's history, become proportionably valuable as a motive power... As yet, the wind is an untamed, and unharnessed force; and quite possibly one of the greatest discoveries hereafter to be made, will be the taming, and harnessing of it.

— Abraham Lincoln, 1860

1.1 Offshore Wind

Over the span of 2000 years, windmills evolved from their first uses by the ancient Greeks and Persians for pumping water and moving grinding stones to societies around the globe using them for milling timber and powering tools (Manwell et al. 2010). However, not until 1887 was the first windmill used to generate electricity, a 10 m tall structure that lit the holiday home of its Scottish academic inventor (Price 2005). Windmills, referred to as wind turbines when they generate electricity (Manwell et al. 2010), have evolved from small, individual-use structures to large commercial arrays. Wind energy is a renewable resource that can help nations reduce their greenhouse gas emissions in support of mitigating climate change (USDOE and USDOJ 2016). Its

median harmonized¹ life cycle greenhouse gas emissions is estimated at 11 gCO_{2e}/kWh, placing it lower than other renewable electricity generation technologies such as photovoltaic (44 gCO_{2e}/ kWh), bio-power (40 gCO_{2e}/kWh), and much lower than conventional electricity generation technologies such as coal (979 gCO_{2e}/kWh; NREL 2013).

Wind turbines are composed of a foundation, tower, blade assembly, and nacelle. The force of the wind against the blades causes the rotor to spin. The spinning rotor turns a driveshaft that is connected to a generator located in the nacelle. This assembly converts the kinetic energy of wind to rotating mechanical energy of the turbine to electrical energy. The generated electricity is then transported via cables to a transformer, a substation, and then further on to the grid for use by consumers. The amount of electricity a wind turbine is able to produce is primarily a function of the wind velocity (also called the wind resource), the height of the turbine, the size of the rotor, and the blade configuration (Manwell et al. 2010).

Global installed wind power capacity is approximately 486.8 GW; turbines installed on land produce approximately 97% and the remainder, approximately 14.3 GW, comes from offshore turbines (GWEC 2016). Turbines located offshore take advantage of a more steady wind resource, higher wind velocity, and close proximity to coastal demand centers (Manwell et al. 2010, USDOE and USDOJ 2016). More than 87% of the world's offshore wind power is installed in the waters off of northern Europe (GWEC 2016). Countries with significant installations include the United Kingdom

¹ Harmonization refers to a methodology developed and applied by analysts at the National Renewable Energy Laboratory to review the life cycle assessment literature, identify primary sources of variability and, where possible, reduce variability in greenhouse gas emissions estimates through the statistical combination of the results of multiple studies.

(5,156 MW), Germany (4,108 MW) and Denmark (1,271; GWEC 2016). The remainder of global offshore wind capacity is in China (1,627 MW), with smaller demonstration projects in Japan and South Korea (GWEC 2016).

The United States has one commercial offshore wind project installed, the 30 MW Block Island Wind Farm in Rhode Island; however, the technological potential for offshore wind production in the U.S. is great. The National Renewable Energy Laboratory predicts that the U.S. gross offshore wind technical resource is 4,000 GW, although the usable amount is approximately 60% less due to environmental and socioeconomic restrictions (Musial and Ram 2010). This potential could help achieve the Department of Energy's goal of producing 20% of the U.S. electricity through wind power by 2030 (USDOE 2015). In support of this goal, several leases were auctioned in federal waters by BOEM, unsolicited lease requests for projects in federal waters were received by BOEM, and advanced technology demonstration projects were funded in state waters² by the Department of Energy.

1.2 Barriers to Offshore Wind Development in the U.S.

Despite recognition of offshore wind benefits, significant challenges to implementation of offshore wind projects still exist. High capital costs, uncertain federal policy, stakeholder resistance, lack of manufacturing and supply chains, and a cumbersome permitting process are critical barriers to development (Van Cleve and

² In the United States, the federal Submerged Lands Act of 1953 (43 USC 1301 et seq.) grants to the states title and ownership of the lands beneath navigable waters and the natural resources located from the ordinary high water mark to three geographical miles (three marine leagues for Texas and the Gulf coast of Florida and to the international boundary for the Great Lakes). The Outer Continental Shelf Lands Act of 1953 (43 USC 1331 et seq) granted federal jurisdiction, control, and power of disposition over the resources beyond three geographical miles from the ordinary high water mark.

Copping 2010, Musial and Ram 2010, Tierney and Carpenter 2013, Navigant Consulting 2014, USDOE 2015, USDOE and USDOJ 2016). From 2004-2012, capital costs for offshore wind projects markedly increased, up to \$5,385/kW in 2012 (Navigant Consulting 2014), as projects moved to deeper waters, further from the coast, and industry recognized greater risks, thus more costly risk mitigation plans, of developing projects in technically challenging locations (USDOE 2015). These high development costs can be offset by stable federal policy support for industry investment. However, intermittent and short-term federal approval of tax incentives, such as the federal Production Tax Credit and Investment Tax Credit, have not encouraged industry to make long-term investments (USDOE 2015). In addition, stakeholder resistance, fueled by perceived negative aesthetics, adverse effects to wildlife, and potential conflicts with traditional marine uses have delayed offshore wind energy projects (Firestone et al. 2009, Musial and Ram 2010). Furthermore, development is hindered by restrictions in the manufacturing and supply chain, including those imposed by the Merchant Marine Act of 1920 (commonly referred to as the “Jones Act”) that require the use of U.S. built vessels, owned and operated by U.S. citizens in the transport of commerce between points in the United States (Kaiser and Snyder 2011). This document will focus on the cumbersome permitting process, specifically on data requirements in the environmental permitting process, as a barrier to development.

An arduous and slow permitting process is widely cited as an impediment to offshore wind development. Change of lead federal agency, uncertainty in the leasing process, complex paperwork, compliance with multiple laws, coordination with several agencies, lengthy reviews absent deadlines, and lack of adequate data contribute to this

perception (Van Cleve and Copping 2010, Musial and Ram 2010, Tierney and Carpenter 2013, Navigant Consulting 2014, USDOE 2015, USDOE and USDOJ 2016). Prior to 2005, the United States Army Corps of Engineers (USACE) led the offshore wind energy permitting process from the jurisdiction of Section 10 of the Rivers and Harbors Act, as amended by the Outer Continental Shelf Lands Act (Vann 2012). As such, in 2001, USACE initiated the environmental review of Cape Wind, the United States' first commercial lease to construct and operate an offshore wind facility. Three years later, USACE issued a nearly 4,000-page draft environmental impact statement (EIS; Cape Wind 2016). While the draft EIS was in review, the 2005 Energy Policy Act was passed, changing the lead for permitting offshore wind energy projects to the U.S. Department of the Interior (USDOJ). The Minerals Management Service (MMS; since renamed the Bureau of Ocean Energy Management, BOEM), an agency within USDOJ, assumed this role. MMS initiated another environmental review of Cape Wind, releasing the final EIS in 2009 - eight years after the initial applications were filed. The amount of time to complete each of the Cape Wind EISs and the length of the documents are evidence of the complexity of a process that involves coordination of several agencies and compliance with numerous laws. Navigating this process may take years from the initial project proposal to "steel in the water".

1.3 Permitting of U.S. Federal Offshore Wind Projects

The authorization process for offshore wind projects is divided into four phases: planning and analysis, leasing, site assessment, and construction/operation (Table 1.1; USDOJ BOEM 2015b).

Table 1.1. Offshore wind energy federal commercial leasing process.

Phase	Responsible Party	Activities
Planning and Analysis	BOEM	Publish call for information and nominations. Identify Wind Energy Areas (WEAs) ³ . Process unsolicited applications for lease. Conduct environmental review for lease issuance and site assessment activities.
		Determine existence of competitive interest: if interest exists, then lease sale if interest does not exist, then negotiate a lease.
Leasing	BOEM	Conduct site characterization studies. Submit a Site Assessment Plan (SAP) ⁴ . Assess site, if SAP approved.
		Review SAP
Site Assessment	BOEM	Conduct additional site characterization studies, if needed. Submit Construction and Operations Plan (COP). ⁵ Begin construction, if COP approved.
		Conduct environmental review of COP. Conduct technical review.
Construction and Operation	Lessee	Conduct environmental review of COP. Conduct technical review.
		Conduct environmental review of COP. Conduct technical review.

Environmental reviews conducted during this process are mandated by the National Environmental Policy Act (NEPA) of 1969 (42 USC §§4321-4370h 1992), which requires U.S. federal agencies to evaluate the adverse effects on environmental resources that may result from a major federal action. These evaluations are documented in either an environmental assessment (EA) or an EIS, which in this study will be collectively referred to as environmental impact assessments (EIA). Currently, NEPA reviews are conducted by BOEM at least twice during the process of permitting

³ WEAs are locations prioritized by BOEM for development of offshore wind energy projects on the Atlantic outer continental shelf.

⁴ A SAP describes the lessee's proposal for the installation of a meteorological instrument to assess the wind resource at the proposed wind energy site.

⁵ A COP details the lessee's plan for the construction and operation of a wind energy project on the lease.

competitive commercial offshore wind energy projects – first, in the leasing and site assessment phases, prior to the approval of the site assessment plan (SAP), and second, prior to the construction and operation phase and approval of the construction and operations plan (COP) (30 C.F.R. § 285).

In 2010, BOEM attempted to reduce the complexity of the application process by initiating the ‘Smart from the Start’ program. This zoning program designated wind energy areas (WEAs) along the Atlantic coast for potential wind energy development (Frulla et al. 2012). Intergovernmental Renewable Energy Task Forces composed of local, state, federal, and tribal partners conducted cursory screenings to identify areas that had the least conflict with other users and the highest wind energy potential (USDOE and USDOJ 2016).

In addition to NEPA reviews, developers must comply with numerous other environmentally related laws (Table 1.2; adapted from Musial and Ram 2010, Tierney and Carpenter 2013, Myszewski and Alber 2013).

Table 1.2: Environmental laws related to offshore wind energy projects.

Act	Topic	Lead	Documents
National Environmental Policy Act	Environmental effects of major federal actions	Council on Environmental Quality and the lead agency conducting each review	Environmental impact statement, environmental assessment, finding of no significant impact
Coastal Zone Management Act	Federal consistency provision	National Oceanic and Atmospheric Administration (NOAA)	Consistency determination
Outer Continental Shelf Lands Act	Marine resource extraction, lease issuance, and development plan approvals	Bureau of Ocean Energy Management (BOEM)	Lease
Endangered Species Act	Protection of threatened and endangered species and their critical habitats	National Marine Fisheries Service (NMFS, part of NOAA); U.S. Fish and Wildlife Service (FWS)	Biological Assessment, Incidental take permit, Habitat conservation plan
Marine Mammal Protection Act	Protection of marine mammals	NMFS; FWS	Incidental take permit, habitat conservation plan
Magnuson-Stevens Fishery Conservation and Management Act	Protection of essential fish habitats of federally managed fisheries	NMFS	Essential fish habitat assessment
Migratory Bird Treaty Act	Protection of migratory birds	FWS	Review requirement
Bald and Golden Eagle Protection Act	Assessment of impacts to bald and golden eagles	FWS	Review requirement
Rivers and Harbors Act	Regulation of structures located in navigable waters of the U.S.	U.S Army Corps of Engineers (USACE)	Individual permit

Act	Topic	Lead	Documents
National Historic Preservation Act	Protection of historic properties	National Park Service; Advisory Council on Historic Preservation; State or Tribal Historic Preservation Officer	Review requirement
Clean Water Act	Regulation of disposal of dredge and fill material; discharge of hazardous substances	Environmental Protection Agency (EPA); USACE; lead state agency (depends on jurisdiction)	Individual permit; water quality certification
Clean Air Act	Maintains National Ambient Air Quality Standards	EPA	Permit for vessel emissions
Federal Powers Act	Requires license for electrical power generation within or on navigable waters	BOEM; Federal Energy Regulatory Commission	License
Marine Protection, Research, and Sanctuaries Act (Ocean Dumping Act)	Restriction of dumping at sea	EPA; USACE	Individual Permit
National Marine Sanctuaries Act	Prohibits the destruction, loss of, or injury to sanctuary resources	NOAA	Review requirement
Ports and Waterways Safety Act	Protection of navigation and marine environment	United States Coast Guard	Navigation safety plan
Federal Aviation Act ⁶	Protection of U.S. navigable airspace	Federal Aviation Administration	Individual permit

⁶ http://www.e2tech.org/Resources/Documents/MOWII_Offshore_Wind_Roadmap_JAN2013.pdf

Compliance with all of these laws requires adequate environmental data at appropriate scales. Lack of information about specific issues related to the marine environment has slowed the NEPA process (USDOE 2015). The permit applicant must provide a majority of the data for the documentation (USDOE 2015); data required prior to the SAP include results of geological and geophysical surveys, hazards surveys, archaeological surveys, and biological baseline studies. Regarding biological data, existing information derived from literature reviews, government stock assessments, and other previous surveys are often consulted. However, reliance on these sources has led to criticisms including failure to define spatiotemporal scales, failure to adequately assess effects on biodiversity, lack of well-defined methods, an encyclopedic nature, poor quantitative natures of assessments, and difficulty in addressing cumulative effects (Thompson et al. 1997, Byron et al. 2000, Atkinson et al. 2000, Gontier 2007). Additional surveys may be undertaken to fill data gaps; however, they cost the developer additional time and expense, with no guarantee of project approval (Van Cleve and Copping 2010).

The permitting process for offshore wind projects differs between those located in state waters versus federal waters. Projects in state waters are subject to individual state regulations and processes. In addition, under the Coastal Zone Management Act of 1972 (16 U.S.C. §§ 1451-1464), states may enact a federally approved coastal management program to coordinate protection of habitats and resources in coastal waters. Offshore projects must achieve a balance between development and resource protection intended by these programs. Due to unique state regulations and a paucity of projects, this study will focus on projects in federal waters.

1.4 Cetaceans and Offshore Wind

Cetaceans are one order of animals for which data are needed to assess potential effects of an offshore wind project. Although a relatively small taxonomic group, cetaceans are an important ecological component due to their biomass and position in the food web (Kaschner et al. 2011), use as indicators of ecosystem health and productivity, and value in energy flux (Katona and Whitehead 1988). Furthermore, the conservation of cetaceans is an important policy objective in the U.S. as evidenced by their protection under the Marine Mammal Protection Act of 1972 (MMPA; 16 U.S.C. §§ 1361-1423 2007) and, for those that are threatened or endangered, under the Endangered Species Act of 1973 (ESA; 16 U.S.C. §§ 1531-1544 2003).

Non-lethal effects to cetaceans have resulted from activities associated with offshore wind energy projects, such as vessel operations and construction activities (e.g., pile driving, cable laying; Madsen et al. 2006, Tougaard et al. 2009). One of the most significant concerns for cetaceans is the noise produced by these stressors. Sound is a vital sense for cetaceans in the light-limited undersea environment. Cetaceans produce sounds to communicate the presence of prey, predators, and conspecifics in addition to their own identity, reproductive status, and location (Richardson et al. 1995). Furthermore, odontocetes (i.e., toothed cetaceans) use echolocation sounds to detect, localize, and characterize objects including prey, obstacles, and other animals (Au 1993). Increased levels of sound in the marine environment, for example due to pile-driving or vessel engines, can affect cetaceans through masking, or have direct behavioral or physical effects. Masking is interference in the ability to detect sound due to the presence of either natural noises such as waves, precipitation, and ice, or anthropogenic ones such

as vessel noise, construction activities, seismic exploration, sonar, and explosions (Richardson et al. 1995). Masking causes a reduction in the ability of cetaceans to receive vital communications, such as messages regarding the presence of a predator or the presence of a potential mate (Madsen et al. 2006, Southall et al. 2007, Nowacek et al. 2007). In addition, behavioral response studies show some species of cetaceans changing their diving patterns, foraging activity, and vocalizations in response to anthropogenic sounds (Tyack et al. 2011, Pirotta et al. 2012). Consequences of these behavioral responses are not well understood; however changes to life functions such as feeding, breeding, and migrating ultimately determine population growth rate and structure (Ocean Studies Board 2005). Physically, sound may affect cetaceans' auditory and non-auditory systems. Strong sounds may cause a temporary elevation of the hearing threshold (temporary threshold shift) or a permanent loss of hearing (permanent threshold shift) (Madsen et al. 2006, Nowacek et al. 2007, Southall et al. 2007).

Cetaceans must temporally and spatially overlap with stressors, such as anthropogenic sound producers, in order for an effect to potentially occur. Thus, it is fundamental to understand where and when cetaceans are present in relation to offshore wind projects to determine potential effects in environmental assessments of offshore wind projects. Large-scale efforts have been made by BOEM and other agencies to supplement existing cetacean data through new surveys (e.g., Atlantic Marine Assessment Program for Protected Species and the Biodiversity Research Study). BOEM's Environmental Studies Program also funds external data analyses and applications (USDOI BOEM 2016). Recommendations by the scientific community to increase the transparency and availability of existing data (Southall et al. 2007, Southall

et al. 2009, Bingham 2011, USDOE 2015) are also being heeded; data portals created by newly formed regional ocean planning councils (Mid-Atlantic Ocean Data Portal⁷, Northeast Ocean Data⁸), federal agencies (National Oceanic and Atmospheric Administration's (NOAA) Marine Cadastre⁹, NOAA's ERDDAP¹⁰, U.S. data portal¹¹), and universities¹² are available to the public online. Despite these recent developments, insufficient data still impedes offshore wind development in the U.S. This research focuses on cetaceans and their data as a proxy for how the data on other flora and fauna are incorporated into EIAs.

1.5 Research Questions

The environmental permitting process is a barrier to the successful implementation of offshore wind projects in the U.S. Delays in the permitting process may be attributed to lack of sufficient and appropriate biological data required for quality EIA documentation. This study explored the following questions:

1. How do U.S. federal EIAs of offshore wind projects include cetacean data as compared to federal requirements?
2. Could outcomes from marine spatial planning (MSP) yield appropriate scales of cetacean data for U.S. federal EIAs of offshore wind energy projects?
3. Could MSP prove useful to expedite offshore wind permitting process? What are limiting factors of incorporating these tools into the U.S. regulatory

⁷ <http://portal.midatlanticocean.org/ocean-stories/every-map-tells-a-story/>

⁸ <http://www.northeastoceandata.org/>

⁹ <http://www.marinecadastre.gov/>

¹⁰ <http://coastwatch.pfeg.noaa.gov/erddap/index.html>

¹¹ <https://data.gov/ocean>

¹² <http://seamap.env.duke.edu/>

process? How can these factors be overcome?

4. Could species distribution models provide appropriate scales of cetacean data to significantly improve the offshore wind permitting process?

In order to answer these research questions, the following methods were used:

1. EIA: Criteria analysis of published federal EIAs pertaining to offshore wind projects.
2. MSP: Case study analysis of three geographic regions that conducted MSP and developed offshore wind, to determine whether and how management of biological data in the MSP process helped advance offshore wind.
3. Regulatory Process: Semi-structured interviews of key informants knowledgeable in MSP or offshore wind NEPA process to determine the regulatory culture of understanding and acceptance of using species distribution modeling and MSP in NEPA documentation. Identification of potential issues in incorporating modeling and MSP into the regulatory process and recommendations on how to overcome these.

CHAPTER 2

CONSIDERATION OF SCALES IN OFFSHORE WIND ENVIRONMENTAL IMPACT ASSESSMENTS

2.1 Introduction

The issue of scale is regarded as a fundamental conceptual problem in ecology (Levin 1992). Understanding patterns of ecological processes that occur on different spatial and temporal scales is foundational to theoretical ecology and essential for applying science to management decisions (Levin 1992). Mismatches among scales of processes, observations, models, and management decisions may occur, creating a need for investigating scales in the environmental impact assessment process. The quality of environmental impact assessments (EIAs) has been criticized for failure to adequately account for spatial and temporal scales in environmental data (CEQ 1993, João 2002, Gontier 2007).

The offshore wind energy sector in the United States is in its infancy, despite a final net technical resource of 2,059 GW (Musial et al. 2016). Project delays may partly be due to litigation that includes challenges to the quality of biological data used in assessments (Public Employees for Environmental Responsibility, et al., v. Tommy P. Beaudreau, et al., 2014; Fisheries Survival Fund, et al. vs. Sally Jewell, et al., 2016). Thus, scale issues in offshore wind EIAs are relevant to the completion of projects, and the role of scale should be explored to provide additional context to the discussion. Spatial scales combine grain (i.e., geographical detail) and extent (i.e., total size of an area) of collected information (Turner et al. 1989, Morrison and Hall 2002). Temporal scale, within the context of EIAs, refers to both the smallest unit of relevant time and the

total duration of time under consideration (Turner et al. 1989). Ambiguous or mismatched scales relating to administrative boundaries, ecological processes, data availability, or methodologies may ultimately influence the quality of assessments (João 2002, Gontier 2007). Furthermore, the choice of scale may benefit one stakeholder over another or set boundaries on analyses that influence the outcomes (Karstens et al. 2007). For example, a long-term vision study about deepening the Scheldt River (forms in France, travels across Belgium, and flows into the North Sea through an outlet in the Netherlands) involved a choice of spatial boundaries of either the estuary of the Scheldt River (400 km²), the estuary system plus its tributaries (4,000 km²), or the entire Scheldt river basin (20,000 km²). The choice of spatial scale influenced several factors in the analysis including the stakeholders involved (e.g., local, regional, and federal governments of the Netherlands, Belgium, and France), the issues considered (e.g., water quality, economic benefits), and timeframe for decision-making (e.g., more stakeholders equated to a lengthier process).

Issuances of leases for outer continental shelf (OCS)¹³ blocks and approval of site assessment plans by the Bureau of Ocean Energy Management (BOEM) for development of offshore wind energy projects are considered major federal actions requiring an environmental assessment (EA) or environmental impact statement (EIS) according to the National Environmental Policy Act of 1969 (NEPA). Furthermore, BOEM must conduct project-specific NEPA analyses prior to approval of construction and operation plans.

The purpose of an EA is to determine if a federal action has the potential to cause

¹³ OCS blocks are small geographic areas that identify federal land ownership and support offshore resource management. A standard block is 2,304 hectares (4,800 meters X 4,800 meters), except in the Gulf of Mexico, where there are multiple standard sizes, none greater than 2,331 hectares (USDOJ, BOEM 2012b).

significant environmental effects. If a project is determined to significantly affect the quality of the human environment, an EIS is conducted (CEQ 1986). Both processes involve the collation and analyses of biological, physical, and social data to determine levels of impact on various environmental resources.

The spatial and temporal scales of stressors, receptors, and effects should be clearly defined in EIAs and included in assessed impact levels and mitigation actions (Karstens et al. 2007; Boehlert and Gill 2010) for accurate environmental review (João 2002, Gontier 2007). Stressors are project activities that alter features of the environment; for example, vessels used for site exploration, construction activities, and maintenance during operations are stressors in an offshore wind project. Receptors are ecosystem elements, for example, cetaceans, fish, marine birds, or benthic habitat, which have a potential to form a response from the stressor (Boehlert and Gill 2010). This review focused on cetaceans as a proxy for receptors. Although a relatively small taxonomic group, cetacean biomass, position in the food web (Kaschner et al. 2011), and mobility make them of high ecological importance (Doughty et al. 2016). Furthermore, the conservation of cetaceans is an important policy objective in the U.S. with protection under the Marine Mammal Protection Act (MMPA) and, for those threatened or endangered, under the Endangered Species Act (ESA). The influence of a stressor on a receptor results in an effect. For example, increased vessel traffic (stressor) causes changes in the acoustic environment that may affect the hearing (effect) of cetaceans (receptor). This paper evaluates the inclusion of spatiotemporal scales regarding stressors, receptors (specifically cetaceans), and effects detailed in federal offshore wind energy EIAs against criteria extracted from federal regulations.

2.2 Methods: Criteria Analysis

A modified framework based on Boehlert and Gill (2010) was used to examine spatiotemporal scales of data regarding stressors, receptors, and effects in eight U.S. federal EIAs of proposed offshore wind energy projects. Boehlert and Gill (2010) distinguish between an effect and an impact, such that ‘effect’ does not indicate a magnitude or significance, but ‘impact’ implicitly does. However, the term ‘effect’ was exclusively used in this analysis due to the unequivocal statement in U.S. federal regulation that effect and impact are synonymous (40 C.F.R §1508.8(b) 1986).

I reviewed five EAs regarding lease issuance and site assessment activities for OCS lease blocks in Massachusetts, Rhode Island, New Jersey, Delaware, Maryland, Virginia, and North Carolina; one EA for wind resource data collection on the OCS of Georgia; one EIS for the Cape Wind Energy Project; and one Programmatic EIS (PEIS; Table 2.1; Figure 2.1; USDOJ MMS 2007, 2009a, 2009b, USDOJ BOEM 2012a, 2013, 2014a, 2014b, 2015). The PEIS describes potential environmental effects of renewable energy activities on the OCS of the Atlantic Ocean and recommends policies and management techniques. A PEIS provides a more comprehensive programmatic analyses, similar to those performed in Strategic Environmental Assessments (SEAs), common in Europe, while still allowing future project evaluations. Projects of more narrow spatial scale may incorporate information found in the broader programmatic document by reference in a process called tiering (40 C.F.R § 1502.20 1986).

The assessments included in this review were the only ones relating to offshore wind energy projects in U.S. federal waters at the time of analysis. BOEM, as the lead

agency, is the author of all assessments. These documents reflect different stages of development (from planning to construction plans), sizes of projects, locations, and types of documents (i.e., EA, EIS, and PEIS). Despite these differences, all documents were included due to the paucity of assessments of offshore wind projects in federal waters.

Table 2.1: Federal offshore wind energy NEPA documents reviewed for this analysis.

Document	Date	Location	Phase
Final EIS: Programmatic Environmental Impact Statement for Alternative Energy Development and Production and Alternate Use of Facilities on the Outer Continental Shelf	October 2007	Atlantic Outer Continental Shelf	Planning
Final EIS: Cape Wind Energy Project	January 2009	Massachusetts	Construction and Operation
EA: Issuance of Leases for Wind Resource Data Collection on the Outer Continental Shelf Offshore Delaware and New Jersey	June 2009	Delaware/ New Jersey	Interim policy ¹⁴ ; Leasing
Final EA: Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New Jersey, Delaware, Maryland, and Virginia	January 2012	Delaware/ New Jersey/ Maryland/ Virginia	Leasing
Revised EA: Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore Rhode Island and Massachusetts	May 2013	Massachusetts/ Rhode Island	Leasing
EA: Lease Issuance for Wind Resources Data Collection on the Outer Continental Shelf Offshore Georgia	March 2014	Georgia	Leasing
Revised EA: Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore Massachusetts	June 2014	Massachusetts	Leasing
Revised EA: Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore North Carolina	September 2015	North Carolina	Leasing

¹⁴ Minerals Management Service (MMS) implemented an Interim Policy for leasing in November 2007 to accelerate technology testing and data collection at potential OCS wind sites, prior to the adoption of final regulations. Leases under this policy had a five-year term and no development rights. Four Interim Policy leases were executed: three offshore New Jersey and one offshore Delaware (USDOI BOEM 2015b).

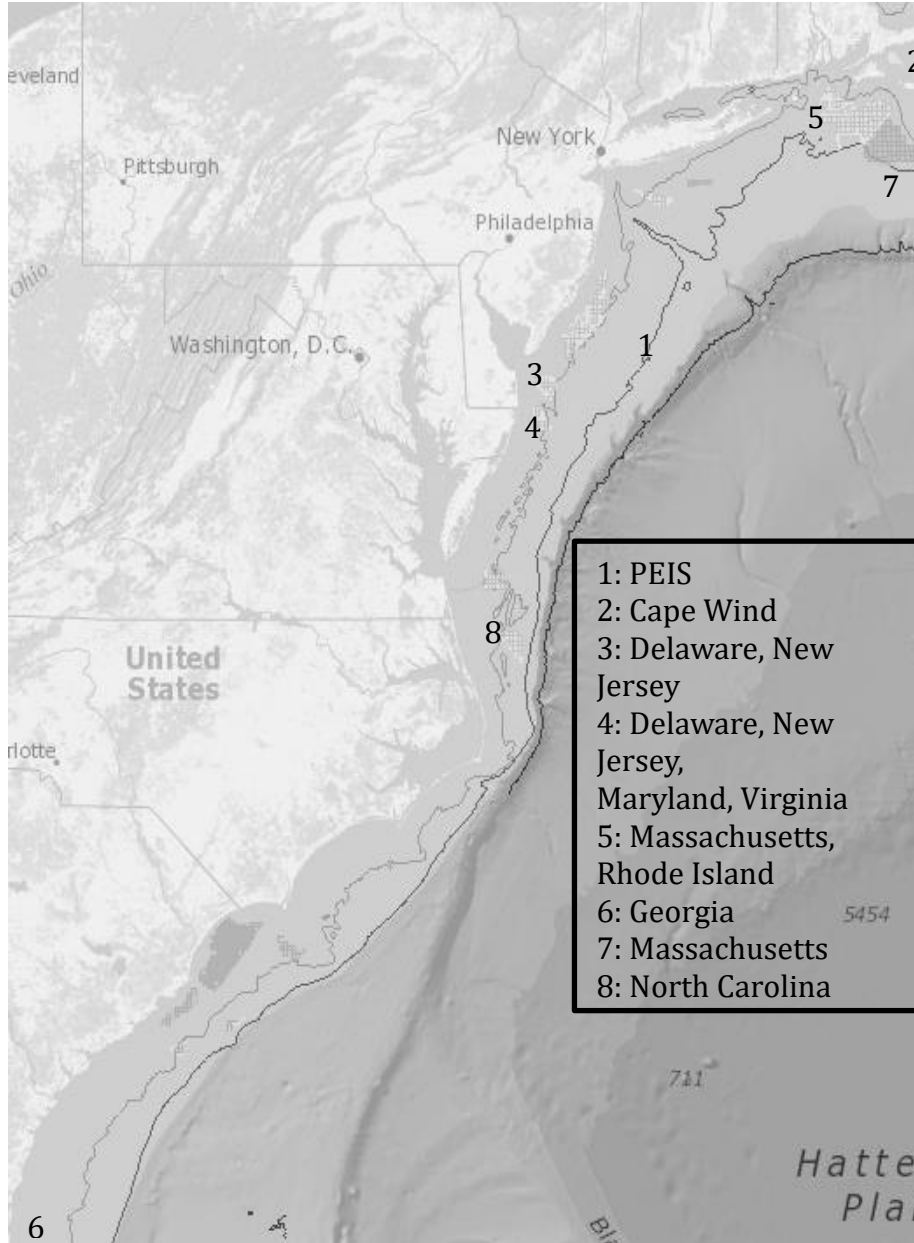


Figure 2.1 Locations of potential offshore wind energy sites along the U.S. Atlantic coast in NEPA documents reviewed in this study.

These eight assessments were compared against 26 criteria (Table 2.2) derived from references to spatiotemporal scales found in federal regulations: NEPA and the 1978 Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act (hereafter CEQ

Regulations; 40 C.F.R. § 1500 – 1508 1986). In addition, Incorporating Biodiversity Considerations Into Environmental Impact Analysis Under NEPA (hereafter Biodiversity Considerations; CEQ 1993) was consulted as a reference; however, it was not included in this analysis due to its explicit description as not being formal guidance or legally binding regulation.

Table 2.2: Criteria for analysis of federal offshore wind energy NEPA documents.

General References to Spatiotemporal Scale
Is appropriateness or importance of scale discussed?
Is the term spatial scale referenced to stressors?
Is the term spatial scale referenced to receptors?
Is the term spatial scale referenced to effects?
Is the term temporal scale referenced to stressors?
Is the term temporal scale referenced to receptors?
Is the term temporal scale referenced to effects?
Temporal Scales of Stressors and Effects
Are project stressors identified in all phases of the action (e.g., planning, construction, operation, decommissioning)?
Are effects (e.g., behavior change, injury, or death due to collision or noise identified in all phases of the action?
Are the temporal scales of stressors identified (i.e., short-term or long-term, intermittent or continuous)?
Spatiotemporal Scales of Receptors
Are receptors identified?
Are receptors' ranges identified?
Are receptors' habitats (e.g., coastal, offshore) identified?
Are receptors' biologically significant (i.e., mating, feeding, calving) habitats identified?
Is the use of project or effect area by receptor (e.g., transiting, feeding, calving) identified?
Is the use of project or effect area by receptor associated with temporal scale (e.g., monthly, seasonally)?
Has the range, habitat, or biologically significant habitat of the receptor changed over time (e.g., due to temperature, salinity, Chl <i>a</i>)?
Spatial Scales of Stressors and Effects
Are the spatial scales (extent, granularity) of stressors identified?
Are the spatial scales (extent, granularity) of effects identified?
Does spatial scale (extent) of the effects include possible range, habitat, or biologically significant habitat of receptor?
Other Topics Relevant to Spatiotemporal Scales
Are indirect effects of project stressors identified (i.e., those "caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable")?
Are cumulative effects discussed in relation to stressor spatial scale?
Are cumulative effects discussed in relation to effect spatial scale?
Are cumulative effects discussed in relation to receptor spatial scale?
Are cumulative effects discussed in relation to temporal scale?
Are mitigation actions identified for all phases of the action?

Common temporal and spatial themes within the referenced federal regulations

(Table 2.3) were used to develop criteria. Temporal themes that involve the 'need to

consider future generations' and 'long-term productivity' insinuate that potential environmental effects should include those that will happen in the short-term and those that may occur in the future. Thus, EIAs should thoroughly describe stressors (i.e., human's environment), receptors (i.e., productivity), and effects (i.e., the relationship between the two) in the short-term (i.e., planning phase) and long-term (i.e., through decommissioning). In addition, temporal scale is inherent in the assessment of cumulative impacts, those that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions (40 C.F.R. §1508.7 1986). Yet, definitions of scale are rarely stated in regards to cumulative impacts (Therivel and Ross 2007, Boehlert and Gill 2010).

Spatial themes found in the regulations include local effects and 'worldwide and long-range character of environmental problems'. These themes insinuate that effects may occur within the project footprint, its immediate surroundings, and may also extend beyond these defined areas. Consideration of extensive spatial scales is important when stressors have potential effects many kilometers away, as is the case with acoustic sources' influence on cetaceans (Madsen et al. 2006).

Table 2.3: Temporal and spatial scale references extracted from NEPA and CEQ Regulations.

Regulation	Scale	Statement
NEPA	Temporal	“it is the continuing responsibility of the Federal Government to use all practicable means...to the end that the Nation may fulfill the responsibilities of each generation as trustee of the environment for succeeding generations” (42 U.S.C. § 4331(b)(1))
NEPA	Temporal/ Spatial	“all agencies of the Federal Government shall include in every recommendation or report on... major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on the relationship between local short-term uses of man’s environment and the maintenance and enhancement of long-term productivity” (42 U.S.C. § 4332)
CEQ Regulations	Temporal	“discussion will include the ... relationship between short-term uses of man’s environment and the maintenance and enhancement of long-term productivity...” (40 C.F.R. §1502.16)
NEPA	Temporal/ Spatial	“recognize the worldwide and long-range character of environmental problems” (42 U.S.C. § 4332)
CEQ Regulations	Temporal/ Spatial	“which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable” (40 C.F.R. § 1508.8(b))
CEQ Regulations	Temporal	“reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action” (40 C.F.R. § 1508.20(d))
CEQ Regulations	Temporal	““Cumulative impact’ is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions” (40 C.F.R. § 1508.7)

The criteria analysis was conducted in accordance with methods outlined in Atkinson et al. (2000), Byron et al. (2000), and Khera and Kumar (2010). Criteria (Table 2.3) were grouped into five categories: general references to spatiotemporal scale,

temporal scales of stressors and effects, spatial scales of receptors, spatial scales of stressors and effects, and other topic areas relevant to spatiotemporal scales. Each assessment was assigned a score corresponding to whether no information (score of 0), some information (score of 0.5), or thorough information (score of 1) was provided for each criterion. The scores were then summed to produce a final score for each assessment. An assessment that thoroughly addressed each criterion would thus receive a score of 26.

2.3 Results

Summed scores for each assessment ranged from 9 – 16 out of a possible 26, resulting in 35-62% of criteria being met (Figure 2.2). The first published EA, in 2009, of four interim policy leases in Delaware and New Jersey addressed criteria the least, with a score of 9 or only 35% of the maximum possible score (Figure 2.2). The 2013 EA of Massachusetts and Rhode Island, and the 2015 EA of North Carolina addressed the most criteria, with a score of 16.0 or 62% (Figure 2.2). A general increasing trend in percentage of criteria met was seen with assessments published later in time.

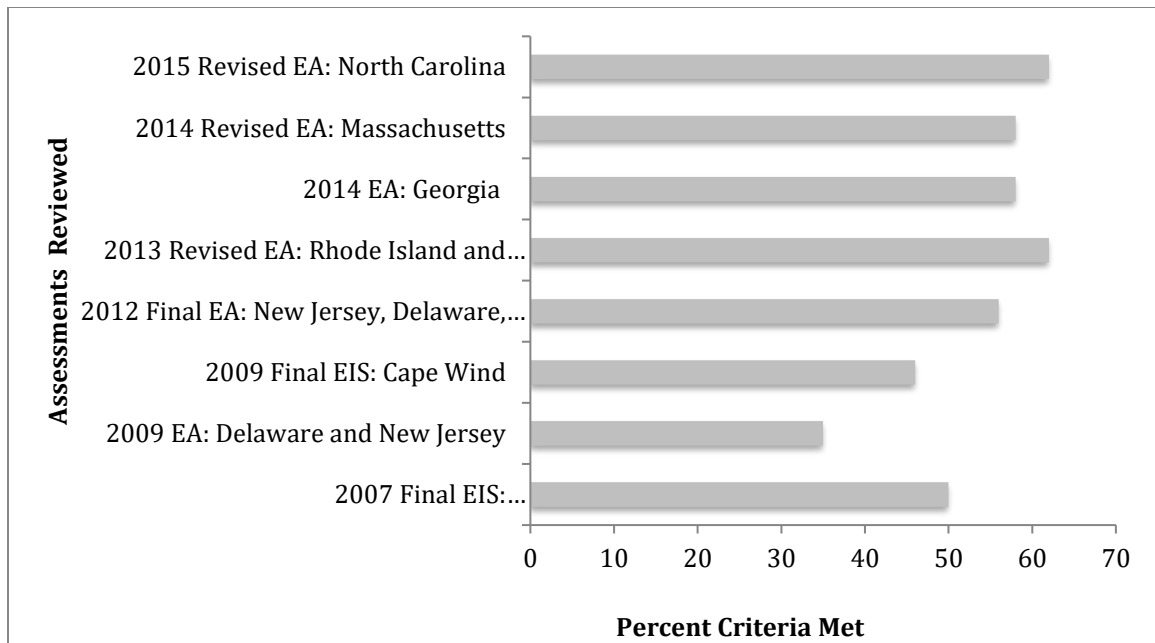


Figure 2.2 Results of criteria analysis of federal offshore wind energy project NEPA documents. Eight documents were reviewed against 26 criteria. A score of 100% would mean that all 26 criteria were satisfactorily met by the assessment.

Examining the assessments by criterion showed which aspects of spatiotemporal scales were addressed more universally than others (Figure 2.3). None of the assessments completely addressed the general concepts of spatiotemporal scales as described in the first set of criteria. The assessments lacked content describing the overall importance of scale in the scoping, evaluation, and outcome stages. Furthermore, ‘spatial scale’ was only referenced to stressors and receptors in one assessment, and never in relation to effects. ‘Temporal scale’ was only referenced to receptors and effects in one assessment, and never to stressors. The reader is thus left to interpret the context of spatiotemporal scales and whether scales are applied to stressors, receptors, and effects.

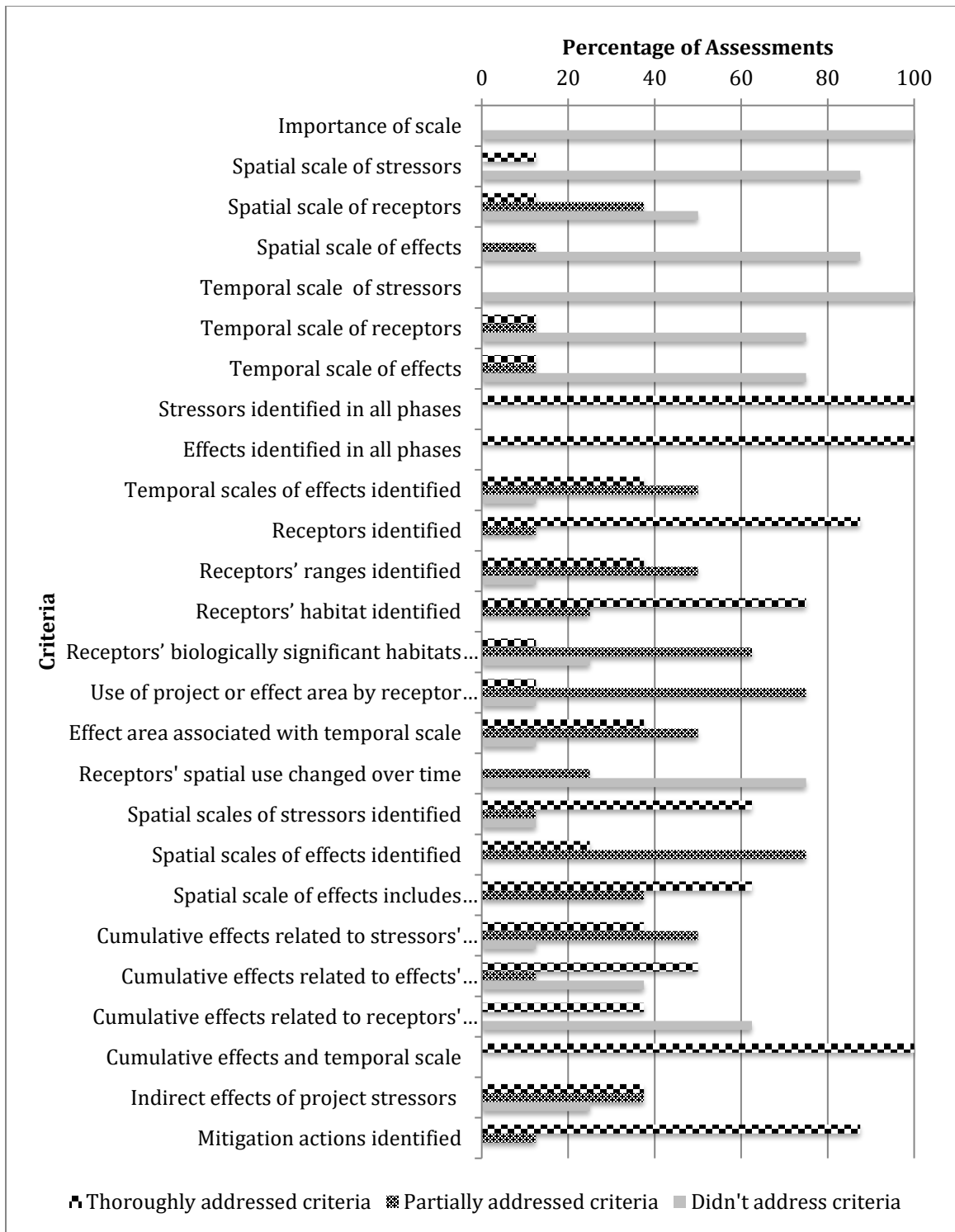


Figure 2.3: Criteria analysis results for the evaluation of offshore wind energy NEPA documents. Eight NEPA assessments were evaluated by 26 spatiotemporal scale criteria. Each assessment was assessed as either thoroughly, partially, or not addressing the criteria.

The second set of criteria addressed whether temporal scales were applied to project stressors (e.g., vessels, cables, turbines), effects (e.g., collision, noise), and receptors (e.g., cetaceans). In all assessments, project stressors and effects were identified in all phases of the action (i.e., planning, construction, operation, decommissioning), satisfying these two criteria. Temporal scales, which include the duration of an individual effect (e.g., single or multiple pile drives) and whether it is persistent or intermittent, were thoroughly addressed in two assessments, partially addressed in five, and not addressed at all in one assessment (Figure 2.3).

The next set of criteria addressed the spatial scales of receptors and factors that contributed to their understanding, including species, geographic range, general habitat (e.g., coastal, shelf, slope, deep), and biologically significant habitat (e.g., breeding, calving, feeding). All assessments either thoroughly or partially identified species in the project area and their general habitat (Figure 2.3). Partial scores were assigned to assessments that included habitat information of some species, but not of all those listed in the document. A majority of assessments partially addressed the receptors' geographic range, biologically significant habitat, how the receptor used the project area (e.g., transiting, feeding, breeding), and temporal scale of receptors' use of the project area (e.g., seasonal, year-round). None of the assessments thoroughly addressed whether receptors' use of the project area changed over time or was projected to change in the future due to such changes as prey availability, temperature, or anthropogenic effects. However, two assessments, Rhode Island/Massachusetts and Georgia, partially addressed this topic. Rhode Island/Massachusetts assessments stated that Sei (*Balaenoptera borealis*) and Humpback (*Megaptera novaeangliae*) whale abundances notably shifted in

the past decades, and in the later case, in association with the main prey, herring (*Clupea spp.*; USDOJ BOEM 2013, USDOJ BOEM 2014a). The Georgia assessment noted a recent northern shift in North Atlantic Right whale (*Eubalaena glacialis*) calving grounds, but an explanation was not provided (USDOJ BOEM 2014a).

Spatial scales associated with stressors and effects were evaluated in the next three criteria to determine if both the spatial extent and granularity were defined in the assessments, and if these areas overlapped with those of receptors. All but one assessment thoroughly or partially identified spatial scales of stressors and effects (Figure 2.3). In addition, all assessments either thoroughly or partially addressed whether spatial scales of effects coincided with range, habitat, or biologically significant habitat of receptors (Figure 2.3).

All assessments addressed cumulative effects within the past, present, or future as outlined in the regulations (Figure 2.3). Spatial scales of cumulative effects in regards to stressors were only thoroughly or partially addressed in 87.5% of assessments; in regard to receptors in 37.5% of assessments; and in regard to effects in 62.5% of assessments (Figure 2.3). Indirect effects of project stressors on receptors, such as coastal wake erosion from increased vessel traffic and nonpoint source pollution, were thoroughly or partially addressed by all assessments but two (Figure 2.3). Mitigation actions were thoroughly or partially identified by all assessments in all phases of the projects (Figure 2.3). Mitigation actions in the planning phase included avoiding siting projects in areas of high cetacean density and mitigation actions in the construction phase included listing shut down criteria for pile driving activities if cetaceans were identified in the area by marine mammal observers.

2.4 Discussion

EIAs of offshore wind energy projects in U.S. federal waters insufficiently addressed spatiotemporal scales of stressors, receptors, and effects as guided by federal regulations. Inadequacies were determined through analysis of eight EIAs against 26 criteria derived from federal regulations. Defining the scales that constrain analyses is fundamental to an effective assessment. If scales are defined too broadly, analyses become unwieldy and if they are defined too narrowly, significant issues may be missed (CEQ 1993). CEQ Biodiversity Considerations (1993) emphasizes that determining the appropriate scale is the first step in using an ecosystem approach in impact assessments. Impact assessments are criticized for focusing on too narrow of spatial scopes that include only the project footprint (CEQ 1993). This analysis confirmed that this narrow focus persists in these assessments. The spatial extent of an offshore wind project should include not just the footprint of physical structures (e.g., meteorological tower), but also surrounding areas to include the range where receptors may potentially be influenced. For example, low-frequency noise generated by pile driving monopile foundations may extend kilometers beyond the monopile footprint, affecting the behavior and physiology of cetaceans (Tougaard et al. 2003, Edrén et al. 2004, Tougaard et al. 2005, Madsen et al. 2006). The spatial granularity of the project should refer to defined areas that are subject to particular stressors. For example, installation of a meteorological tower will disturb the benthic habitat in the immediate vicinity of the tower; however, the disturbance to benthic habitat in the remainder of the project footprint may be minimal. Impact assessments cannot adequately consider impacts on biodiversity at a regional ecosystem scale if these scales are not thoroughly described (CEQ 1993).

Temporal references in offshore wind projects should include two aspects: total duration and descriptive characteristics. The first aspect to be considered is the total duration of the project, sub-divided into four stages: planning, construction, operation, and decommissioning. All assessments in this review thoroughly addressed the two criteria regarding duration of projects. Distinctly defined, industry-standard project phases delineate time scales, thus allowing impact assessments to clearly describe stressors and effects within each phase. The second temporal aspect to be considered is the temporal characteristic of each stressor, to include extent (i.e., short-term or long-term) and frequency (i.e., intermittent or continuous). For example, sound produced from a single drive of a monopile is short-term and intermittent, but multiple drives may be successively repeated producing a more continuous sound, depending on sediment type and size of the pile, amongst other factors (Madsen et al. 2006). Variations in duration and frequency, as well as power, determine the degree of effect on biological species such as cetaceans or fish (Popper and Hawkins 2011).

Spatial use of the ocean by receptors is extremely varied and dependent on a number of biotic and abiotic factors. Some species display seasonal variations in spatial patterns coupled to major life events such as breeding and calving. Thus, it is important to define spatial scales, referring to both extent and granularity, of receptors. Even amongst a focal infraorder, such as cetaceans, high spatial variability exists (Redfern et al. 2006). Some species of cetaceans, such as the Harbor porpoise (*Phocoena phocoena*), prefer nearshore and coastal habitats inshore of the shelf slope (USDOI BOEM 2014c). Others, such as Cuvier's beaked whales (*Ziphius cavirostris*), prefer the shelf slope or deep offshore habitats (USDOI BOEM 2014c). Some species, such as the North Atlantic

right whale (*Eubalaena glacialis*), annually migrate thousands of kilometers between winter calving grounds in coastal waters of the southeastern United States to summer feeding and nursery grounds in New England waters and northward to the Bay of Fundy and the Scotian Shelf (USDOI BOEM 2014c). Others, such as the Bottlenose dolphin (*Tursiops truncatus*), have resident home ranges (USDOI BOEM 2014c). While non-migratory cetaceans do not exhibit such extreme movements, seasonal variations do exist in their geographic distribution (USDOI MMS 2007).

Migratory patterns of cetaceans are also changing due to anthropogenic influences, such as climate change (IPCC 2014). Climate change is altering the physical, chemical, and biological properties of the ocean, changing the geographic distribution and timing of seasonal activities of species (e.g., feeding, growth, development, behaviors, and productivity; IPCC 2014). These changes influence species composition, spatial structure, and functioning (IPCC 2014). Historical patterns of migration routes and feeding areas may no longer be relevant. If only these are examined in EIAs, without consideration for potential changes, impact levels that are partly assessed by determining spatiotemporal overlap of receptors with stressors and effects may not be accurate. Lack of detail regarding spatiotemporal scales in assessments may be attributed to imprecise regulations, intent to simplify the complexity of the analysis, or data deficiencies. The language in NEPA is lofty and poetic as seen by phrases such as "enjoyable harmony between man and his environment," and "a wide sharing of life's amenities"; rigorous boundaries for analyses are not prescribed. Thus, boundaries must be defined in each new assessment leading to consistency issues. Furthermore, language in regulations referencing temporal scale is generic (e.g., 'future generations'). Spatial scale

references are limited and emphasized less than temporal ones. NEPA does not state if the spatial scope of consideration should be based on stressors, receptors, or effects. Analyses that are based on scales of stressors may not sufficiently address the broader footprint of effects and are criticized as being too narrow in spatial scope (CEQ 1993). CEQ Biodiversity Considerations (1993) provides focused direction to preparers of NEPA documentation specifying that effects should be evaluated at the largest relevant scale, based on the affected resources and expected impacts. This implies that analyses should be performed on the scale of effects and not stressors. Furthermore, Biodiversity Considerations states that biological resources must be protected and managed at a geographic scale commensurate with the scale of the systems that sustain them (CEQ 1993). To improve the quality of analyses and assessment of impact levels, regulators should heed these recommendations and scope assessments accordingly, even though these considerations are advisory.

CEQ Biodiversity Considerations (1993) specifies that EISs shall be analytic rather than encyclopedic. It is a challenge to analyze all possible stressors, receptors, and effects of a large infrastructure project in an efficient manner. For example, the Cape Wind EIS is 800 pages in length, even without spatiotemporal scale information identified in this review as lacking. Tiering information in individual project assessments from related PEISs or SEAs would reduce the voluminous nature of these documents without sacrificing content. In addition, assessments could be streamlined to focus analyses on non-trivial effects of protected species, as opposed to detailing all possible effects to all receptors.

Details of spatiotemporal scales in impact assessments may also be lacking

because the underlying data may not be available. Offshore wind impact assessments require extensive data, assembled from various sources including published studies, numerical models, field studies, expert judgment, and traditional knowledge. Collection of these data may be resource intensive and challenging, especially when conducting field studies in remote locations and inhospitable seasons. Increased sharing of existing data through public data portals developed during regional or state marine spatial planning (MSP) processes and coordinated survey strategies would increase access to and transparency of data. MSP is often defined as the process of analyzing and designating the marine space for specific uses to achieve ecological, economic, and social objectives (Ehler and Douvère 2009). The analysis portion of MSP often involves the collation of existing data, identification of data gaps, and development of research (at suitable spatiotemporal scales) to fill these gaps.

2.5 Conclusions

Fifty years ago, lawmakers proactively incorporated references to scale in NEPA, a pivotal piece of environmental legislation in the U.S. This paper marks the first time that these references were used to evaluate EIAs. Eight U.S. offshore wind energy EIAs did not consistently or comprehensively address spatiotemporal scales of stressors, receptors (specifically cetaceans), and effects, with respect to requirements of NEPA and the CEQ Regulations. Deficiencies in addressing spatiotemporal scales may result from imprecise regulations, intent to simplify encyclopedic documents, or lack of data. Heeding recommendations in CEQ Biodiversity Considerations, or making this guidance binding, focusing on non-trivial impacts of protected species, and tiering information

may rectify the first two discrepancies; however, the problem of deficient data is a more comprehensive issue. The MSP framework includes the collation and spatial representation of data suitable for offshore wind assessments, which could improve data quality and availability.

Quality assessments should explicitly state the spatiotemporal scales (João 2002, Gontier 2007) of receptors, stressors, and effects, and detail which scales are used as the basis for impact level analysis. When this is not achieved, impact levels assigned in assessments may be inadequate resulting in incomplete assessments and inappropriate mitigation actions (João 2002). Early experiences of the U.S. offshore wind industry demonstrate that projects will be delayed if the scales of ecological processes and project activities are mismatched and impact analyses fail to adhere to federal regulations. This paper reveals that disregard for scale in offshore wind EIAs is not isolated to two projects involved in litigation, but is present in all EIAs to date. If this problem is not addressed, the U.S. offshore wind industry will languish and the U.S. will continue to lag in the global offshore wind energy sector.

CHAPTER 3

CAN MARINE SPATIAL PLANNING OVERCOME BIOLOGICAL DATA DEFICIENCIES?

3.1 Introduction

Despite accounting for over 17% of global energy consumption (BP 2016), United States' installed offshore wind capacity contributes fractions of a percent to the 14,384 MW of global installed capacity (GWEC 2016). Offshore wind technologies can provide both environmental (e.g., low carbon emissions over the life-cycle and negligible emissions of mercury, nitrous oxides and sulfur oxides) and economic (e.g., not subject to volatility in fuel costs and siting possibilities close to population centers; Snyder and Kaiser 2009) benefits. Factors contributing to the slow growth of the offshore wind sector in the U.S. include high capital costs, uncertain federal policy support, stakeholder resistance, lack of manufacturing and supply chains, and a cumbersome permitting process (Van Cleve and Copping 2010, Musial and Ram 2010; Tierney and Carpenter 2013, Navigant Consulting 2014, USDOE 2015). Improved data access for addressing uncertainties in ecological impacts would likely aid the permitting process and improve the speed and likelihood of development.

The permitting process for offshore wind projects in U.S. federal waters includes development of environmental impact assessments (EIAs) as required under the National Environmental Policy Act of 1969 (NEPA). Two phases in the planning process of offshore wind projects require NEPA documentation: the site assessment/ leasing of outer continental shelf lease blocks and approval of construction/ operation plans (30 C.F.R. § 285). NEPA assessments require technical, social, physical, and biological data to inform

analyses of potential effects on natural resources that may result from offshore wind activities. Details of the spatiotemporal presence of resources, characteristics of stressors, and effects of interactions are necessary to describe potential impacts to individuals and populations. However, uncertainty about or lack of fundamental data, including species presences in the study area, may eventually lead to more effort in the assessments of impact levels contributing to a cumbersome permitting process. Thus, any effort to streamline data access could help improve the permitting process and project outcomes, although this remains untested.

Examination of factors associated with operational offshore wind projects may provide insights into the U.S. federal system for permitting and approval. Marine spatial planning (MSP)¹⁵ has become the leading framework to integrate offshore wind energy with existing marine uses. It is often defined as the process of analyzing and designating the marine space for specific uses to achieve ecological, economic, and social objectives (Ehler and Douvère 2009). MSP was born out of a need to address potentially competing demands placed on the marine environment by fishing, oil and gas exploration, renewable energy projects, marine protected areas, navigation channels, anchorages, military exercise areas, unexploded ordnance grounds, dredge and fill areas, and recreation areas (Ehler and Douvère 2009). In addition, it provides a transparent decision-making process to encourage stakeholder coordination and collaboration through a common operating picture based on data compilation, decision support tools, and data visualization to achieve specified objectives and goals.

Types of data typically incorporated into MSP include:

1. jurisdictional and regulatory data, such as boundaries or outer continental shelf

¹⁵ Marine spatial planning is referred to as maritime spatial planning in Europe.

lease blocks

2. human use data, such as utility assets, military exercise areas, navigation channels, and commercial fishing areas
3. ecological data, such as habitats, locations of shellfish, presence of marine mammals, and migratory bird routes
4. physical oceanographic data, such as wind energy potential, current velocity, seabed geology, and bathymetry
5. demographic data, such as human population distribution, economically valued areas, and locations of historical interest.

These data are required in order to analyze existing conditions, define future conditions, monitor, and evaluate the performance of marine spatial plans (Ehler and Douvere 2009). Data collection, analyses, and management are key to supporting the place-based characteristic of MSP (Ehler and Douvere 2009, Shucksmith and Kelly 2014) and thus viewed as an important component of operationalizing ecosystem-based management (EBM; Young et al. 2007). Despite the significant role MSP could play in EBM, and in reducing conflicts in the ocean (Ehler and Douvere 2009), its application and structural characteristics have not been uniform (Gopnik 2015). Due to political, cultural, and historical differences, MSP in practice in the U.S. has evolved away from the theoretical framework first presented in Europe (Gopnik 2015). The central role of data is similar in both frameworks, and the ultimate goal to minimize conflicts over space through data centralization leads us to hypothesize that application of MSP could facilitate offshore wind development. A collective case study approach was used to examine how biological data was collected, analyzed, and presented in relation to MSP processes and offshore

wind development in Germany, Scotland, and Rhode Island. I focused on the following questions: whether this data supported the needs of the offshore wind industry and whether data compiled through the MSP process facilitated the implementation of offshore wind energy projects.

3.2 Case Studies

Germany and Scotland lead the world in offshore wind installed capacity and technological innovation; Rhode Island is the only U.S. state to successfully install an offshore wind project. All three areas incorporate marine spatial planning into their regulatory processes and were thus selected for analyses.

3.3 Scotland

3.3.1 Overview and governance

Marine Scotland, a directorate within the Scottish Government, is responsible for the integrated management of Scotland's territorial waters, those from the high water mark to 12 nm offshore (Scottish Government 2015). However, inside the Scottish territorial waters, the seabed is property of The United Kingdom Crown Estate, an independent commercial business that was created by an act of parliament and that manages land and property for the Crown (Marine Scotland 2011). The Crown Estate is responsible for allocating the rights to renewable energy from shore to 200 nm offshore, the exclusive economic zone (EEZ; Baxter et al. 2011). A lease from The Crown Estate Commissioners, the commercial managers of the seabed, is required in order to construct an offshore wind project anywhere in the U.K. (Marine Scotland 2011).

3.3.2 Offshore wind energy

Scotland has 25% of the offshore wind resource of Europe (Baxter et al. 2011). The Scottish Government is committed to developing this sector due to potential jobs and increase in revenues that will benefit the Scottish economy (Marine Scotland 2011). Currently, 66 turbines with an installed capacity of 221 MW are installed offshore in territorial waters (Marine Scotland 2017). The Crown Estate initiated Round 3 in 2010, resulting in exclusivity agreements to offshore wind energy developers for nine areas, including two zones in the Scottish EEZ, Moray Firth and Firth of Forth, that have a combined generating capacity of 4,800 MW (Figure 3.1; Baxter et al. 2011, Marine Scotland 2011, Marine Scotland 2017).

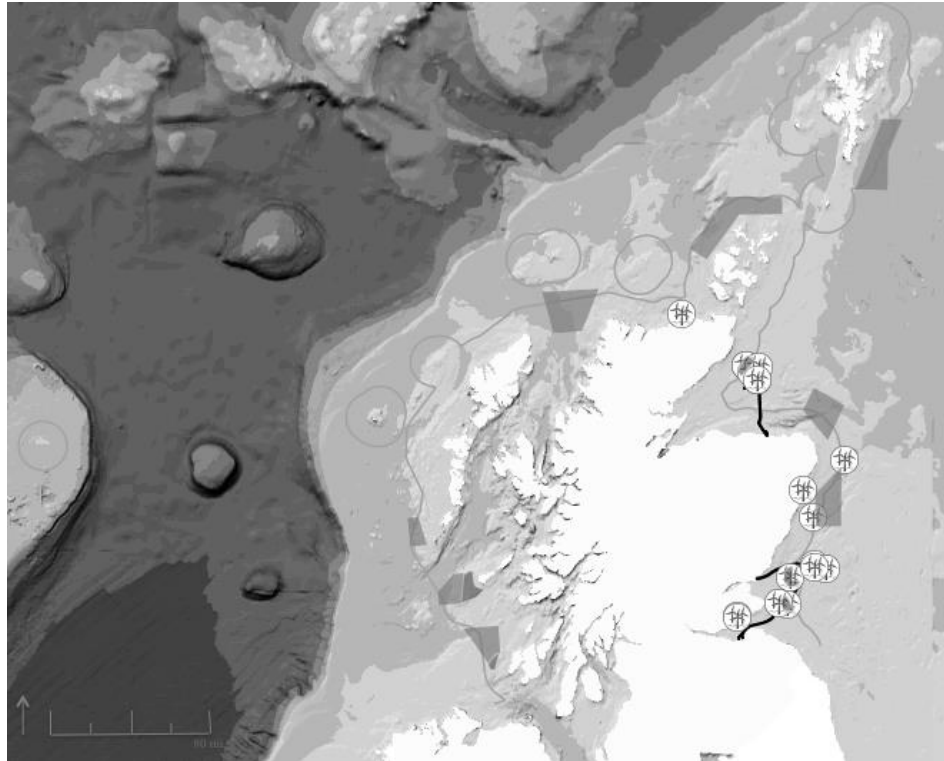


Figure 3.1: Potential and operational offshore wind sites in Scotland. Windmill icons represent regions where agreements are in place between the Crown Estate Scotland and developers for offshore renewables and associated cables. Light gray shaded regions were identified in the Draft Sectoral Marine Plans for Offshore Wind as potential sites for future offshore wind energy. Dark gray shaded regions were identified in Blue Seas Green Energy – A Sectoral Marine Plan for Offshore Wind Energy in Scottish Territorial Waters as options for offshore wind development up to 2020.

“Blue Seas Green Energy – A Sectoral Marine Plan for Offshore Wind in Scottish Territorial Waters” guides regional development of offshore wind in Scottish territorial waters (Marine Scotland 2011). The plan outlines 10 potential sites for development in the short-term (until 2020), supporting approximately 5 GW of installed capacity, and 25 additional sites in the medium-term (until 2030; Marine Scotland 2011).

3.3.3 Marine spatial planning

Oil, gas, aquaculture, marine renewable energy, commercial fishing, recreation, tourism, shipping, ports, carbon capture and storage, telecommunications, and defense have different spatial and temporal needs within the Scottish territorial waters and EEZ. The U.K. Marine and Coastal Access Act of 2009 and the Marine Scotland Act of 2010 provide the foundation for resolving conflict among these users through MSP (Marine Scotland 2011). The national act appoints Marine Scotland to oversee a new statutory marine planning system that outlines 11 regional planning efforts focusing on local stakeholders and smaller habitat units (Scottish Government 2015). At the national level, Scotland published a National Marine Plan (NMP), a lofty, national scale, anthropogenic-centric document that focuses on encouraging economic development of marine industries while incorporating environmental protection into marine decision-making (Scottish Government 2015). The plan spatially includes both the territorial waters (under devolved functions) and the EEZ (under reserved functions¹⁶). The offshore wind section includes recommended ‘Plan Options’, strategic development zones in which commercial scale offshore wind projects should be sited. These zones were identified through a multi-stage process involving a sustainability appraisal, a strategic environmental assessment (SEA), a habitats regulation appraisal and a socio-economic assessment. SEAs are impact assessments conducted at the policy, planning, or program level, as opposed to EIAs that are conducted at the project level. The comprehensive NMP was a successor to the sector specific Offshore Wind Plan of 2011.

¹⁶ The Scottish Parliament is part of a process known as devolution, a system of government that allows some governance at local levels. Under this system, Scotland is still part of the United Kingdom and the U.K. Parliament is sovereign. Devolved matters are those that are the responsibility of the Scottish Parliament. Reserved matters are those issues that remain the responsibility of the U.K. Parliament alone.

3.3.4 Data

Data management related to the offshore wind sector and MSP process in Scotland began in the early 2000s. The Robin Rigg Offshore Wind Farm Environmental Statement was one of the first notable data consolidation efforts for offshore wind (Natural Power 2002). Surveys in various topic areas were conducted and combined with existing studies to establish a baseline status of environmental, social, and physical aspects. Direct and indirect effects of the project were determined and mitigation measures were incorporated into the design. Monitoring programs, such as marine mammal surveys to compare use of the project area before and after construction, were implemented during the construction period and continued for three years post-construction (Natural Power 2002).

A broader, more strategic approach to data management was undertaken in the Scottish Marine Renewables SEA (Faber Maunsell and Metoc PLC 2007) and the SEA of the Draft Plan for Offshore Wind Energy in Scottish Territorial Waters (Offshore Wind SEA; Marine Scotland 2010). The Scottish Marine Renewables SEA assessed the potential effects of wave and tidal energy, but excluded wind in selected areas of the territorial waters of Scotland. The Offshore Wind SEA focused exclusively on the effects of offshore wind. Existing social and environmental data informed the assessments but additional surveys were not conducted for either SEA. Data gaps, such as cetacean, seal, and seabird distributions, were noted and viewed as limitations of the assessments (Faber Maunsell and Metoc PLC 2007). Surveys to fill these gaps were identified, prioritized, and recommended for future work. Other recommendations included requiring all

developers to make publically available data collected on the existing environment in their area of development and development of data management protocols to ensure consistency and compatibility of datasets.

Marine Atlas was the most comprehensive national effort to collate data about aquaculture, fishing, oil and gas, undersea cables, renewable energy, ports, shipping, waste, water abstraction, recreation, and defense in the Scottish territorial waters and EEZ (Baxter et al. 2011). Collaborative monitoring programs (e.g. those of the Scottish Environment Protection Agency), government reports, and previous EIAs informed the effort. Existing data sets were compiled, readjusted for scale, and displayed spatially to inform the NMP. No systematic review process of the Marine Atlas is defined; however, the Marine Scotland information data portal includes current information organized by theme, metadata, and maps as well as the content that informed the study.

3.4 Germany

3.4.1 Overview and governance

The democratic Federal Republic of Germany consists of a central federal government and 16 states (Länder). Individual Länder govern their adjacent territorial seas that are waters within 12 nm of the coast, while the federal government regulates the EEZ from 12 nm out to international limits. The EEZ of Germany spans approximately 33,100 km² of which 28,600 km² is in the North Sea and 4,500 km² in the Baltic Sea (Strehlow et al. 2012).

Within the federal government, several ministries and agencies are involved in the management of activities in the EEZ. The Federal Maritime and Hydrographic Agency

(Bundesamt für Seeschifffahrt und Hydrographie – BSH) provides oversight to ensure sustainable use of the oceans, approves offshore wind development projects, and conducts MSP in the German EEZ. Within the territorial sea, the Länder conduct licensing of offshore wind projects upon receipt of stakeholder inputs and EIAs (Kannen 2005, Köller et al. 2006, Thomsen 2014).

3.4.2 Offshore wind energy

Currently, Germany has 793 turbines installed representing 3.3 GW of installed capacity (Figure 3.2; South Baltic Offshore Wind Energy Regions 2017, German Offshore Wind Energy Foundation 2017). Current and proposed locations of offshore wind projects are limited to the German EEZ instead of its territorial sea due to the significant number of national parks that prohibit development and the numerous navigation channels in the territorial sea (Kannen 2005, Köller et al. 2006). In addition, Germany's comparatively short coastline and socio-political concerns contribute to the preferential siting of offshore wind in the EEZ, where potential sites are located almost exclusively in significant water depth far away from the coast (Köller et al. 2006).



Figure 3.2: German offshore wind projects in the North Sea and Baltic Sea.

In 2014, renewables were Germany’s number-one source of electricity, with wind power leading generation (BMW 2015). However, as land-based sites reached capacity, Germany began to look to offshore wind to fulfill its national renewable energy goals (Portman et al. 2009). Key to meeting this goal was phased expansion, founded in the precautionary principle, whereby progression from phase to phase was dependent upon positive results with regard to environmental impacts (BMU 2002, Köller et al. 2006).

3.4.3 Marine spatial planning

Projected conflicts among marine shipping, nature conservation, and proposed offshore wind projects prompted MSP in Germany. The Federal Spatial Planning Act (Raumordnungsgesetz) established the legal foundation for MSP in Germany by extending existing planning guidance on land out to the EEZ and as amended appointed BSH as the lead-planning agency for federal MSP (Köller et al. 2006, Douvere and Ehler 2009, ROG 2015). In 2005, planning efforts began with data collation and a questionnaire on uses and interests in the marine space (Blake 2013). Shipping routes, pipeline

locations, and cable sites were included in the planning process; however, fishing grounds were notably absent (Blake 2013). The planning process concluded in 2009 with the approval of the Marine Spatial Plan for the German EEZ in the North Sea (BSH 2009a) and the Marine Spatial Plan for the German EEZ in the Baltic Sea (BSH 2009b).

An SEA was performed as part of the MSP process in order to evaluate the state of the marine environment and assess projected impacts caused by the implementation of the plans. It concluded that no significant effects on the marine environment would result from the adoption of the North Sea and Baltic Sea spatial plans. However, the environmental report of the SEA did recognize that given substantial environmental information gaps, a lack of criteria existed for evaluating the effects of anthropogenic activities on the living marine environment (BSH 2009c).

A notable aspect of the final marine spatial plans was the designation of three spatial zones (BSH 2009a, BSH 2009b): priority areas in which one use was given priority, reservation areas in which one use is given special consideration, and marine protected areas in which measures must be taken to reduce impacts on the marine environment. Within this framework, five priority areas for wind power were designated in the North Sea and two priority areas were designated in the Baltic Sea (BSH 2009a, BSH 2009b).

Regional marine spatial planning occurred separately from the national plans in two Länder. Mecklenburg-Vorpommern, bordering the Baltic Sea, developed a plan in 2005 to prevent conflict among new technologies (i.e., offshore wind), tourism, nature protection, shipping, and fishing (Douvere 2008). Also motivated by the development of offshore wind, Lower Saxony, bordering the North Sea, developed a marine spatial plan

in 2006 by extending their existing terrestrial spatial plans into the territorial sea (Portman et al. 2009, Drankier 2012).

3.4.4 Data

Data that inform assessments of offshore wind projects and marine spatial plans come from a variety of sources. In 2001, the federal German government recognized the possible environmental impacts of offshore wind and initiated a research project titled Accompanying Ecological Research on Offshore Wind Energy Deployment (AERO; Köller et al. 2006). The 2002 Strategy of the German Government on the Use of Offshore Wind Energy reinforced AERO, calling for ecological research and environmental monitoring in conjunction with the expansion of the offshore wind sector. At the conclusion of AERO in 2005, offshore wind power was still in its infancy in Germany with only a 4.5 MW pilot turbine installed. The initiation of focused ecological research so early in the development of a new industry was unique to their plan (Köller et al. 2006).

Regional scale investigations were also performed for the SEA for the Utilisation of Offshore Wind Energy and its associated environmental report, sponsored by the German Ministry for the Environment (Bundesministeriums für Umwelt, Schomerus et al. 2006). Detailed baseline data were collected over a four-year period from a series of monitoring platforms (Phylip-Jones and Fischer 2014). This SEA and its environmental report investigated potentially substantial environmental impacts (positive and negative), reasonable alternatives, proposed monitoring measures, and the concerns of the affected

public. It was broad in temporal scope, assessing potential impacts from inception of the program through the anticipated life span of individual projects.

Offshore wind EIAs and associated environmental impact studies that focused on the immediate geographic area of individual projects were also conducted. EIAs are required by German law (German regulation § 3 Abs. 1 Nr. 1 UVPG i.V.m. Anlage 1, Nr. 1.6), initiated and funded by the developer, and submitted to BSH as part of the authorization process (Portman et al. 2009). BSH provides explicit guidelines for developers, including a mandatory two-year baseline study period, and post-construction and operational monitoring for three to five years, all funded by the developer (BSH 2013).

3.5 Rhode Island, United States

3.5.1 Overview and governance

Rhode Island is the smallest state in the U.S., yet has jurisdiction over the third most water as percentage of total state territory (United States Census Bureau 2010). Numerous uses reflect the importance of the marine environment including commercial and recreational fishing, shipping, recreational boating and sailing, military operations, whale watching, and offshore wind energy. The Coastal Resources Management Council, a state agency within the Rhode Island government, manages the coastal areas and state waters of Rhode Island, designated as those from the shore to three nm (from the mainland and around any islands). U.S. federal laws are still applicable within this area, including Section 10 of the Rivers and Harbors Act (33 U.S.C. 403) and Section 404 of

the Clean Water Act (33 U.S.C. § 1344). The U.S. federal government manages the EEZ from three-200 nm from shore.

3.5.2 Offshore wind energy

In 2016, the Block Island Wind Farm became the first offshore wind project installed in the U.S. The project includes five - 6 MW turbines located in state waters, less than three miles from the coast of Block Island (Figure 3.3; TetraTech 2012, Marine Cadastre 2017). The Block Island Wind Farm was motivated by Rhode Island's Renewable Energy Standards of 2004, as amended in subsequent years (RIGL §§ 39-26). Its provisions include a requirement that 3% of Rhode Island's retail electricity sold in 2007 come from renewable-energy resources, incrementally increasing up to 1.5% per year until 2035 (RIGL §§ 39-26-4). The Rhode Island Winds Program (RIWINDS), initiated in 2006 to study the potential of wind energy to supply electricity, propelled offshore wind development further. The goal of RIWINDS was to find wind resource to supply 15% of Rhode Island's energy needs, or 400 MW of installed capacity, by 2012 (TetraTech 2012). A subsequent siting study assessed that achieving this goal would only be feasible with the inclusion of offshore wind resources (TetraTech 2012). A request for proposal for development of an offshore wind farm was initiated in 2008 and by January 2009 the State of Rhode Island and Deepwater Wind Rhode Island, LLC entered into a joint development agreement to develop the Block Island Wind Farm.

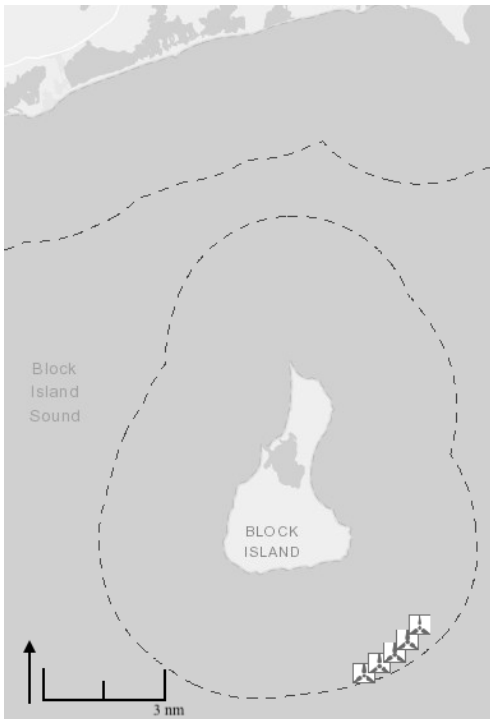


Figure 3.3: Block Island Wind Farm location in state waters of Rhode Island, United States.

3.5.3 Marine spatial planning

Rhode Island was one of the first U.S. states to develop a marine spatial plan. The Ocean Special Area Management Plan (OSAMP) is a planning tool, based on research, public engagement, and policy making that provides a framework for studying, monitoring, and planning in the OSAMP area in order to produce enforceable policies (CRMC 2010, McCann et al. 2013). The OSAMP study area includes approximately 1,467 sq.mi. in Block Island Sound, Rhode Island Sound and the Atlantic Ocean, starting 500 ft from the coastline in state waters out to 3 nm, and all federal waters within the boundary (CRMC 2010).

While the goals of the plan included comprehensive management of the marine space, offshore wind development was a primary concern (CRMC 2010, RIGL §§ 39-26-1). Practical outcomes of the OSAMP included an offshore development regulatory

framework, policies that protect natural resources and manage existing and potential future uses, new scientific research of the study area, and a rigorous stakeholder process (CRMC 2010). An example of the offshore regulatory framework was the designation of the Rhode Island Renewable Energy Zone, an area approximately 68 km² just east and south of Block Island. Development proposals within this zone that were received within two years of OSAMP completion could use data from OSAMP to complete the permitting for development, thus expediting the permitting process (CRMC 2010).

3.5.4 Data

The OSAMP process included a dedicated two-year effort to collect and collate data about human and environmental resources in Rhode Island waters. A team of scientists, federal and state agencies, environmental organizations, and users of the OSAMP area helped develop a research agenda to identify data gaps, research priorities, potential partners, and available funding sources. Over 100 scientists then implemented this research agenda, collecting and analyzing data with the assistance of local stakeholders. Concurrent data collection efforts by developers also took place at a finer spatial resolution than in OSAMP (TetraTech 2012). These outcomes were combined with previously conducted studies regarding species, habitats, economics, archaeology, and social issues to populate databases, inform stakeholders, and develop policy.

3.6 Discussion

Comprehensive supporting data is essential for impact assessments to inform decision-making during the regulatory approval process (CEQ 1986; Council Directive

2001/42/EC). Biological data collection, collation, and analysis conducted as part of MSP supported the needs of the offshore wind industry in varying degrees among the three case studies examined. MSP in Scotland and Germany did not affect initial development of the offshore wind sector because the MSP processes happened after offshore wind was already a part of their ocean economies (Figure 3.4). The aim of “plan-led marine management,” whereby marine spatial plans would inform siting decisions, was not achieved since a majority of the decisions were already made prior to approval of the plans (Scaff et al. 2015).

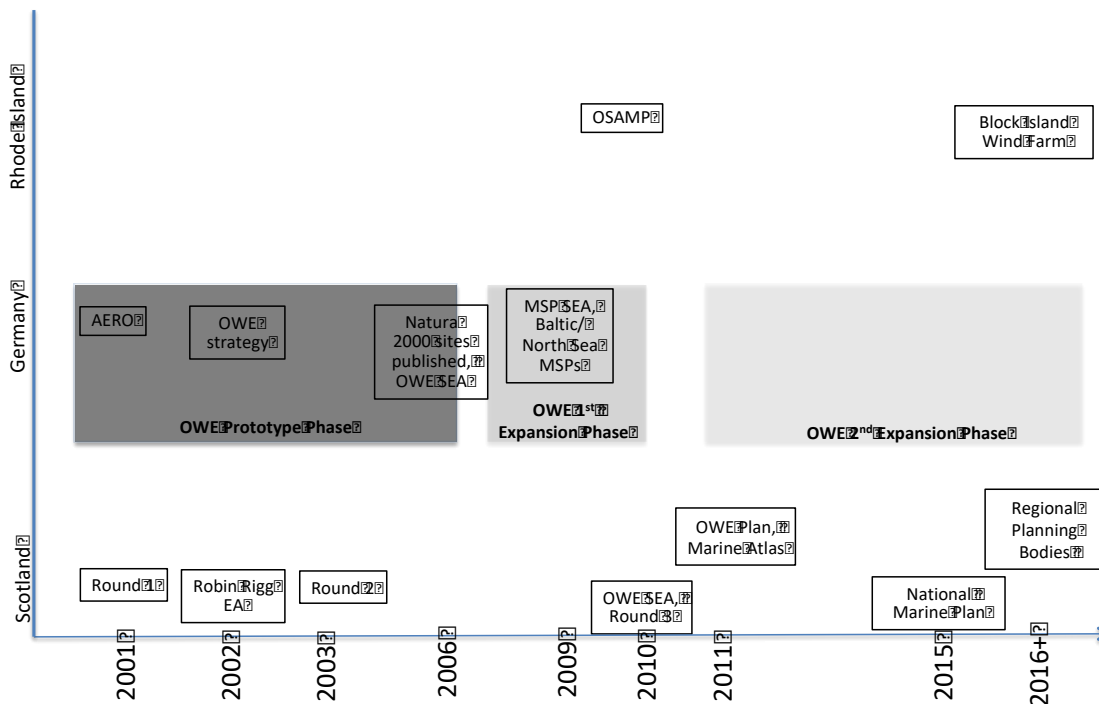


Figure 3.4: Timeline of significant events related to offshore wind energy development and marine spatial planning in Scotland, Germany, and Rhode Island.

Similarly, Marine Atlas, the national data initiative in Scotland, was initiated too late to influence offshore wind development. It was published in 2011, one year after the Round 3 leases, and in the same year as the publication of the sectoral offshore wind

plan. Offshore wind siting decisions were thus already made and informed the NMP, rather than being informed by the NMP. However, the Marine Atlas succeeded in its main objective to collate and spatially map data and uses of the marine environment in order to inform the NMP. Future offshore wind siting decisions may thus benefit from this effort and the resulting marine spatial plan.

In contrast, Germany focused intensive data efforts early in the process that streamlined implementation of the offshore wind sector. National research projects focused directly on the needs of the offshore wind industry, specifically collecting data with the intent of assessing possible impacts from offshore wind and establishing a baseline understanding of important environmental variables. Furthermore, although offshore wind development in Germany was not accelerated by MSP, it ultimately benefited from MSP. The plans increased the number of delineated sites available for development, reduced stakeholder conflict, and managed competing interests, which had previously inhibited the industry (Drankier 2012).

Despite the lack of clean connections between national data efforts, national MSP processes, and offshore wind siting, the offshore wind sector still established itself as part of the ocean economies in Scotland and Germany. Several factors seemed to enable this progress. First, the sector was guided by offshore wind spatial plans or strategies that were informed by SEAs and included stakeholder concerns, socio-economic conflicts, and habitat appraisals. While the plans were not integrated, a key element of MSP, they did fulfill other theoretical aspects of MSP (Ehler and Douvère 2009). The plans were: ecosystem-based in that they took into consideration the potential environmental impacts in the SEAs; place-based by allocating offshore wind energy zones (Table 3.1); strategic

and anticipatory by mapping out long-term development; participatory by consulting stakeholders; and, adaptive through reviews to include monitoring results and research updates. Second, success of the offshore wind sector may be attributed to the existence of national energy policies (e.g., Federal Renewable Energies Act of 2004) and renewable energy targets supported by public sentiment (Zucco et al. 2006). Finally, both of these areas allocated spatial zones for offshore wind energy (BSH 2009a, BSH, 2009b, CRMC 2010, Scottish Government 2015). Delineated areas give assurance to developers that they will be able to construct projects without contention from other marine users.

Table 3.1: Spatial allocations for offshore wind energy development identified in three case study locations: Scotland, Germany, and Rhode Island.

Location	Zoning Framework
Scotland	UK leasing rounds plan options - strategic development zones
Germany	priority areas reservation areas marine protected areas
Rhode Island	renewable energy zone

In Rhode Island, data collected as part of the marine spatial planning process directly correlated to development of the first offshore wind project in the United States. OSAMP is credited with saving two to three years of time in the planning and regulatory process of the Block Island Wind Farm due to the ability of developers to draw from existing data for use in the environmental reviews, knowing the methodologies were sound having participated in the planning process (Schumann et al. 2016). Jeff Grybowski, CEO of Deepwater Wind, echoed this statement in his keynote address at the 2015 International Marine Spatial Planning Symposium: Sharing Practical Solutions,

"Rhode Island's pioneering marine spatial planning work has helped to pave the way for America's first offshore wind energy project, the Block Island Wind Farm. Smart, transparent, and inclusive planning is essential to the offshore wind energy industry." Rhode Island's process followed a progressive path: data gaps categorically identified, data needs fulfilled through new surveys and existing sources, data incorporated into policy in a spatial planning process, and ultimately development of an offshore wind farm. However, the participants in the MSP process were emphatic that the OSAMP was not a renewable energy-siting plan, but rather a comprehensive ecosystem-based marine spatial plan (Schumann et al. 2016). Drankier (2012) echoed this sentiment, stating that it is a mistake to presume that a management plan is similar to a spatial plan. Management plans are frequently used for oversight of single sectors, such as fisheries or maritime transport, and are implemented through a top-down approach. MSP is ecosystem-based, area-based, integrated across sectors, and participatory. The OSAMP process and final plan adhered to these principles, balancing the needs of new users with existing ones.

Some believe that offshore wind development may have proceeded in Rhode Island without a marine spatial plan (Schumann et al. 2016). State legislation and renewable energy targets supporting the development of offshore wind may have been enough. However, the MSP process filled fundamental gaps regarding biological and geological data and public uses of the marine space. In addition, it created a forum for public input, deemed critical at a time when public opposition was high to an offshore wind project in the neighboring state of Massachusetts.

3.7 Conclusions

The lack of sufficient biological data to inform EIAs may contribute to a cumbersome permitting process that delays offshore wind development in U.S. federal waters. Marine spatial planning, a process that includes identifying and fulfilling data needs of marine users, may help to streamline the federal NEPA process. In this case study, three areas with offshore wind energy development and implemented marine spatial plans, Scotland, Germany, and Rhode Island, were examined to determine whether data management associated with MSP efforts aided offshore wind development. I found that initial development of offshore wind was not directly informed by MSP-related data efforts in all cases. However, in Rhode Island, a focused data effort during MSP, conducted prior to siting of offshore wind, directly informed NEPA and accelerated implementation. Impact assessments of future offshore wind projects in all areas may benefit from a similar comprehensive data effort.

Common to all these case studies was the existence of explicit renewable energy policies with targets and designation of spatial zones for offshore wind. Despite 71% public support for alternative energy as a solution to solve the nation's energy problems (Gallup 2017), the U.S. does not currently have a federal renewable energy policy with mandated targets to support the development of renewable technologies. However, 29 states, 3 territories, and the District of Columbia do have renewable portfolio standards including mandates to increase production of energy from renewable sources (Zhou 2015). These standards are credited with the advancement of the terrestrial wind energy sector (AWWI 2016) and could do the same for the offshore sector.

Identification of zones for specific uses is absent from U.S. policy and U.S.

regional MSP processes. Neither the National Ocean Policy Implementation Plan (National Ocean Council 2013a) nor the Marine Planning Handbook (National Ocean Council 2013b) includes the term ‘marine *spatial* planning’. (Although an earlier draft of the implementation plan (National Ocean Council 2012) defined *Coastal and Marine Spatial Planning* as a primary objective and referred to an allocation-planning tool, these references were removed in the final version.) At the state level, planners in Rhode Island, Massachusetts, and Oregon have designated specific zones for renewable energies (Oregon Ocean Resources Management Task Force 1991, CRMC 2010, Commonwealth of Massachusetts 2015). Despite the lack of political will at the federal level, proponents of zoning argue that such a framework would facilitate alignment of ocean interests and attainment of healthy ecosystems (Eagle et al. 2008, Yates et al. 2015), and the results of our analyses support this assertion.

For offshore wind resources to significantly contribute to the U.S. Department of Energy’s goal for wind to deliver 35% of U.S. electricity by 2050 (USDOE and USDO 2016), concerted data efforts should inform spatial plans in areas where wind is being considered, such as the West Coast and Hawaii. Data efforts during marine spatial planning have the potential to facilitate this growing industry and reduce time required during permitting. However, even with an effective MSP process, broader initiatives such as renewable energy policies and zoning appear to be critical to establishing the offshore wind sector.

CHAPTER 4

PERSPECTIVES ON THE VALUE OF MARINE SPATIAL PLANNING IN ADVANCING OFFSHORE WIND DEVELOPMENT

4.1 Introduction

4.1.1 Offshore Wind Energy

International acknowledgement that climate change is a common concern has led nations to invest in renewable energy sources in order to hold the increase in global average temperature to less than 2°C above pre-industrial levels (United Nations 2015). Producing energy from renewable energies, including offshore wind, is one method to help reduce greenhouse gas emissions in order to achieve this temperature objective. As of 2016, offshore wind turbines contributed only 14,384 MW of installed capacity (GWEC 2016), 0.7% of global renewable power capacity (REN21 2017), yet their potential is great as they take advantage of steady wind resources, high wind velocities, and proximity to coastal demand centers (Musial and Ram 2010). The National Renewable Energy Laboratory estimates that the U.S. offshore wind final net technical resource is 2,059 GW (Musial et al. 2016). Despite these benefits, to date the U.S. has installed only one offshore wind farm, consisting of five 6MW turbines at Block Island, Rhode Island.

Lack of development in the U.S. has been attributed to high capital costs, uncertain federal policy support, lack of manufacturing and supply chains, stakeholder resistance, and a cumbersome permitting process (Van Cleve and Copping 2010, Musial and Ram 2010, Tierney and Carpenter 2013, Navigant Consulting 2014, USDOE 2015). From 2004-2012, capital costs for offshore wind projects in other countries markedly

increased as projects moved to deeper waters further from the coast, and greater associated risks required more costly risk mitigation plans (Navigant Consulting 2014, USDOE 2015). Stable federal policies provide incentives for industry investment to overcome high initial costs. Yet, in the U.S., shifting short-term policies (such as the federal Production Tax Credit, in effect from 1992-2019, and the Business Energy Investment Tax Credit, available from 2009 – 2018) have deterred industry from making large, long-term investments (USDOE 2015).

Development of offshore wind energy is also hindered by restrictions in the manufacturing and supply chain. Specialized vessels are necessary to install and construct offshore turbines. The Merchant Marine Act of 1920 (commonly referred to as the “Jones Act”) requires the use of U.S. built vessels, owned and operated by U.S. citizens, to transport commerce between points in the U.S. (46 U.S.C. § 883). A fixed-bottom wind turbine foundation in U.S. waters is considered a point in the U.S. subject to the Jones Act. Feeder barges could be used to load components from U.S. ports and transport them to specialized foreign vessels at the project site, but this work-around requires additional logistics, risks, and costs (GustoMSC 2017). Constructing these specialized vessels in the U.S. is possible but requires additional financial investment, time for construction, and logistics considerations (such as the compatibility of these vessels with harbors and ports).

Stakeholder resistance, fueled by perceived negative aesthetics, adverse effects to wildlife, and potential conflicts with traditional marine users have also contributed to delays of several offshore wind projects (Firestone et al. 2009, Musial and Ram 2010). Cape Wind, a 468 MW project proposed in federal waters near Cape Cod, Massachusetts,

was in a prolonged planning stage since 2001, with many delays due to lawsuits filed by citizens (Cape Wind 2014). The project was finally cancelled in late 2017. Klain et al. (2015) suggest techniques, such as making mutual learning by developers and stakeholders accessible and developing community benefits, to improve the decision process and the quality of interactions between communities and developers to create better outcomes. These techniques involve extensive stakeholder engagements that require additional time and financial investments (Klain et al. 2015).

4.1.2 U.S. Federal Regulatory Process for Offshore Wind Development

The Energy Policy Act of 2005 authorized the Bureau of Ocean Energy Management (BOEM) to issue leases, easements, and rights of way for renewable energy development on the outer continental shelf. The authorization process for offshore wind projects is divided into four phases: planning and analysis, leasing, site assessment, and construction/operation (USDOJ BOEM 2015b). Environmental reviews conducted during the planning/analysis and construction/operation phases are mandated by the National Environmental Policy Act of 1969 (NEPA), which requires U.S. federal agencies to evaluate the adverse effects on environmental resources that may result from a major federal action. These reviews require extensive data, at appropriate spatial and temporal scales, that must be identified, assembled from various sources including published studies, numerical models, field studies, expert judgment, and traditional knowledge, then analyzed, shared, and applied. Proposed projects must also be reviewed by other state and federal agencies to receive permits, certifications, leases, or consistency determinations (Table 4.1; adapted from Musial and Ram 2010, Tierney and Carpenter 2013, Myszewski

and Alber 2013).

Table 4.1: Federal environmental legislation related to offshore wind energy projects

Act	Topic	Lead	Documents
National Environmental Policy Act	Environmental effects of major federal actions	Council on Environmental Quality and the lead agency conducting each review	environmental impact statement, environmental assessment, or finding of no significant impact
Coastal Zone Management Act	Federal consistency provision	National Oceanic and Atmospheric Administration (NOAA)	Consistency determination
Outer Continental Shelf Lands Act	Marine resource extraction, lease issuance, and development plan approvals	Bureau of Ocean Energy Management (BOEM)	Lease
Endangered Species Act	Protection of threatened and endangered species and their critical habitats	National Marine Fisheries Service (NMFS, part of NOAA); U.S. Fish and Wildlife Service (FWS)	Biological Assessment, Incidental take permit, Habitat conservation plan
Marine Mammal Protection Act	Protection of marine mammals	NMFS; FWS	Incidental take permit, Habitat conservation plan
Magnuson-Stevens Fishery Conservation and Management Act	Protection of essential fish habitats of federally managed fisheries	NMFS	Essential fish habitat assessment
Migratory Bird Treaty Act	Protection of migratory birds	FWS	Review requirement
Bald and Golden Eagle Protection Act	Assessment of impacts to bald and golden eagles	FWS	Review requirement
Rivers and Harbors Act	Regulation of structures located in navigable waters of the U.S.	U.S. Army Corps of Engineers (USACE)	Individual permit

Act	Topic	Lead	Documents
National Historic Preservation Act	Protection of historic properties	National Park Service; Advisory Council on Historic Preservation; State or Tribal Historic Preservation Officer	Review requirement
Clean Water Act	Regulation of disposal of dredge and fill material; discharge of hazardous substances	Environmental Protection Agency USACE; lead state agency (depends on jurisdiction)	Individual permit; water quality certification
Clean Air Act	Maintains National Ambient Air Quality Standards	Environmental Protection Agency (EPA)	Permit for vessel emissions
Federal Powers Act	Requires license for electrical power generation within or on navigable waters	BOEM; Federal Energy Regulatory Commission	License
Marine Protection, Research, and Sanctuaries Act (Ocean Dumping Act)	Restriction of dumping at sea	EPA; USACE	Individual Permit
National Marine Sanctuaries Act	Prohibits the destruction, loss of, or injury to sanctuary resources	NOAA	Review requirement
Ports and Waterways Safety Act	Protection of navigation and marine environment	United States Coast Guard	Navigation safety plan
Federal Aviation Act	Protection of U.S. navigable airspace	Federal Aviation Administration	Individual permit

In 2010, BOEM attempted to reduce the complexity of the application process through the ‘Smart from the Start’ program. It established wind energy task forces composed of local, state, and federal partners who conducted initial screenings to identify wind energy areas (WEAs) on the outer continental shelf of the Atlantic coast with the highest wind potential and the fewest conflicts with other users (Frulla et al. 2012). USDOE (2015) referred to the development of WEAs under ‘Smart from the Start’ as a broad marine spatial planning (MSP) process, although it was not integrated across sectors or participatory, two characteristics commonly associated with effective MSP (Ehler and Douvere 2009). Smart from the Start has also been criticized for not clearly communicating the role that each federal agency should play in the permitting process (Willers 2012) and for reducing the opportunity for public comment during the regulatory process (Frulla et al. 2012).

4.1.3 Marine Spatial Planning

Many uses compete for ocean space, including commercial and recreational fishing, oil and gas exploration, offshore renewable energy production, marine protected areas, navigation channels, anchorages, military exercise areas, unexploded ordnance grounds, dredge and fill areas, and marine recreation. A vast, seemingly limitless space is quickly saturated with potentially conflicting uses, particularly on the continental shelf. MSP has been described as “a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process” (Ehler and Douvere 2009) and is implemented to attempt to minimize conflicts among

competing uses. Because offshore wind is one of the newest industries, MSP may be valuable to integrate it into the existing fabric of ocean uses and streamline siting and permitting.

Integrated Coastal Zone Management (ICZM)¹⁷ and ecosystem-based management (EBM) are related approaches to multi-sector planning that pre-date MSP. Increased awareness of environmental impacts in the early 1970s led to the passage of the U.S. Coastal Zone Management Act of 1972 (16 U.S.C. §§ 1451-1466), one of the first formal efforts to plan and manage multiple uses in the coastal area (Cicin-Sain et al. 1998). Internationally, the concepts behind ICZM were adopted in the 1980s and 1990s at venues such as the United Nations Conference on Environment and Development in Rio de Janeiro of 1992 and the Coastal Zone Management Sub-group to the Intergovernmental Panel on Climate Change (Cicin-Sain et al. 1998). In the U.S., EBM, an integrated approach to management that considers the entire ecosystem, including humans (McLeod et al. 2005), first took root in the terrestrial space in the early 1990s. The National Oceanographic and Atmospheric Administration officially adopted the strategy in 1994, adapting the concepts of EBM to the marine space.

MSP builds on the idea of integrated management, but attempts to go further by framing a practical approach with defined outcomes to achieve the goals of EBM (Ehler and Douvère 2009) as exemplified in the often-used phrase ‘marine spatial planning for ecosystem-based management’ (Crowder and Norse 2008, Douvère 2008, Ehler and Douvère 2009, Council Directive 2014/89/EU). The definitions, goals, drivers, processes, and key elements of EBM, ICZM, and MSP are compared in Table 4.2.

¹⁷ Coastal Zone Management (CZM), Integrated Coastal Area Management (ICAM), Integrated Coastal Management (ICM), Integrated Marine and Coastal Area Management (IMCAM) are other names and acronyms associated with ICZM (Cicin-Sain et al. 1998).

Table 4.2: Comparison of Integrated Coastal Zone Management, Ecosystem Based Management, and Marine Spatial Planning definitions, goals, drivers, process, and key elements

	ICZM (Cicin-Sain et al. 1998)	EBM (McLeod et al. 2005)	MSP (Ehler and Douvere 2009)
Definition	Continuous, dynamic, multi-disciplinary process by which decisions are made for the sustainable use, development, and protection of coastal and marine areas and resources	Integrated approach to ocean management that considers entire ecosystem, including humans	Public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process
Driver	User-user conflicts, user-environment conflicts	Human activities disturbing ecosystems and their services	User-user conflicts, user-environment conflicts
Goal	Sustainable development, reduce vulnerability to natural hazards, maintain essential ecological processes, life support systems, and biological diversity all in coastal and marine areas	Maintain ecosystem in healthy, productive, resilient condition so that it can provide the services humans want and need	Comprehensive, adaptable spatial management plan that may include zoning maps and permit system
Process	Iterative process of issue identification and assessment, program planning and preparation, formal adoption, funding, implementation, operation, and evaluation	Ecosystem planning, cross jurisdiction goals, spatiotemporal zones, adaptive co-management, and monitoring	Identifying need and establishing authority, financial support, stakeholder participation, pre-planning, assess existing conditions, assess future conditions, develop management plan, implement plan, monitor and evaluate, and adapt plan
Key Elements	Area planning, promotion of economic development, stewardship of resources, conflict resolution, protection of public safety, proprietorship of public submerged lands and waters	Protecting and restoring ecosystems, cumulative effects, connectivity, uncertainty and dynamics, spatial scales, biodiversity, actions have no undue harm, stakeholders.	Ecosystem-based, integrated, place-based or area-based, adaptive, strategic and anticipatory, participatory

MSP¹⁸ was introduced into U.S. policy in 2010 with the declaration of a National Policy for the Stewardship of the Ocean, Our Coasts, and the Great Lakes, as described in Presidential Executive Order 13547. The newly created U.S. National Ocean Council expanded on this executive order through a National Ocean Policy Implementation Plan (National Ocean Council 2013a) and a Marine Planning Handbook (National Ocean Council 2013b). The Plan divides the U.S. into nine regions based on previously described large marine ecosystems (Northeast, Mid-Atlantic, Southeast, Caribbean, Gulf of Mexico, Great Lakes, West Coast, Alaska, and Pacific Islands), suggesting that a regional planning body (RPB) composed of federal, state, and tribal authorities be established for each region.¹⁹

In 2016, two regional planning bodies published marine plans - the Northeast Ocean Plan (Northeast Regional Planning Body 2016) and the Mid-Atlantic Regional Ocean Action Plan (Mid-Atlantic Regional Planning Body 2016). Several individual states developed marine spatial plans for the waters under their control, including Oregon (Oregon Ocean Resources Management Task Force 1991), Massachusetts (Commonwealth of Massachusetts 2015), Rhode Island (CRMC 2010), and Washington (Hennessey and Hart 2017).²⁰

Research Questions

This research focuses on the regulatory process for offshore wind development, including the evaluation of environmental impacts and broader issues concerning siting

¹⁸ Some U.S. government documents use the term Coastal and Marine Spatial Planning (CMSP) to describe this approach.

¹⁹ Planning documents, handbooks, and procedures put forth by the National Ocean Council hold an uncertain status within the U.S. legal and regulatory structure, exacerbated by the change in U.S. political leadership that took place in January 2017.

²⁰ State waters are generally from the mean high-water line to 3nm. Federal waters generally extend from 3nm to 200nm.

and public acceptance. Impact assessments should be based on biological, social, and technical data (as mandated by the National Environmental Policy Act (NEPA) of 1969 (42 USC §§4321-4370h); however, biological data at appropriate spatial and temporal scales may be lacking, thus impeding environmental impact assessments (EIAs). Some experts have suggested that the process of MSP might help fill data gaps and advance development of offshore wind in other ways. This leads to three questions: (1) does a lack of biological data impede EIAs for offshore wind in the U.S.? (2) could MSP help mitigate these impediments?, and (3) could MSP help advance offshore wind in other ways?

4.2 Methods

4.2.1 Interview description and design

To answer the research questions, I drew on telephone interviews with key informants involved in the offshore wind industry and/or the NEPA process, conducted between February and April 2017. A semi-structured interview style was selected to gather in-depth information about a sensitive topic, seek descriptive information, and try to understand underlying motivations and attitudes (Bernard 2011). In addition, this style of interview works well in projects dealing with high-level bureaucrats and elite community members with limited time (Bernard 2011). This type of research is limited though, by possible biases of the participants and of the interviewer (Weiss 1995). For example, the interviewer may give more credence to comments that support preconceived notions, known as hypothesis confirmation bias, or may try to search for coherence in disparate remarks by the participants, known as consistency bias (Weiss 1995). Yet, a

semi-structured interview allows flexibility in the conversation to let a wider range of information be introduced, leading to more in-depth responses and descriptions, rather than one-word answers (Kempton et al. 2005).

Questions in the interview guide were based on reviews of relevant literature regarding marine spatial planning and EIAs. Interview topics included: participants' experience with NEPA, offshore wind energy, and MSP; general perspectives on MSP; outcomes of MSP; how outcomes of MSP may be used in NEPA; benefits and drawbacks of MSP outcomes; and other ways that MSP outcomes may affect the regulatory process. In order to differentiate between the process of MSP and its results, participants were deliberately asked to describe the outcomes of MSP. Follow-on questions about the benefits and drawbacks of MSP and its use in NEPA referred to these outcomes. The style of questions was modeled after examples used in similar research (e.g., Bates and Firestone 2015) and the length of the guide was adjusted based on informal tests. Five iterations were edited among the authors prior to submission for review. The Human Subjects Institutional Review Board at the University of Massachusetts Amherst approved the interview guide that was used to ensure all topics were covered equally in each interview, thus providing more reliable, comparable data. Pre-tests of interview questions were conducted with five professional peers with subject matter expertise to gauge the clarity and effectiveness of the questions. Minor modifications were made as a result of the pre-tests and comments from the university review board prior to finalizing the interview guide.

4.2.2 Interviewees

Key informants included federal regulators, state regulators, fisheries council members, non-governmental organizations, industry members, consultants, and academics that are experienced with the offshore wind industry and/or the NEPA process. Potential interviewees were identified through attendance lists, presentations, and agendas at state task force meetings and public comments received from 2011 to 2017 as listed on BOEM’s Renewable Energy website (Table 4.3). As the lead agency for offshore wind projects in the U.S., BOEM’s website includes a comprehensive list of offshore wind energy activities. The list of names collected was filtered to include only those that included job titles or affiliations in order to confirm their status as key informants. The authors identified additional potential interviewees based on attendance at conferences and workshops. Interviewees themselves also identified other potential subjects, a sampling technique known as snowball sampling (Bernard 2011).

Table 4.3: Documents used to identify potential interviewees.

State/ RPB	Source
Delaware	Bureau of Ocean Energy Management, Regulations, and Enforcement (BOEMRE)/Delaware Renewable Energy Task Force Meeting, Lewes, March 24, 2011
Georgia	Public comments received on the Notice of Intent to prepare an Environmental Assessment, 2013
Hawaii	Bureau of Ocean Energy Management (BOEM)/ Hawaii Intergovernmental Renewable Energy Task Force Meeting, Honolulu, June 3, 2015
Maryland	5th Task Force Meeting, January 29, 2013
Massachusetts	Renewable Energy Task Force Teleconference, October 17, 2011) BOEMRE – Rhode Island/ Massachusetts Joint Task Force Meeting, New Bedford, May 2, 2011

State/ RPB	Source
	Request for the Taking of Marine Mammals Incidental to the Construction of the Block Island Transmission System, November 26, 2013
	Task Force Webinar, January 16, 2014
	BOEM Massachusetts Renewable Energy Task Force, April 29, 2015
New York	Public comment to the Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New York Environmental Assessment, June 2016
North Carolina	BOEM North Carolina Task Force Meeting Agenda, April 19, 2016
Oregon	BOEM Oregon OCS Renewable Energy Task Force Portland, April 12, 2012
	BOEM Oregon Renewable Energy Task Force Meeting Portland, June 28, 2013
	79 Fed.Reg. 30876 Notice of Intent To Prepare an Environmental Assessment for Proposed Wind Energy-Related Development Activities on the Pacific Outer Continental Shelf Offshore Oregon and Notice of Public Scoping Meetings
Rhode Island	International Marine Spatial Planning Symposium: Sharing Practical Solutions, Narragansett, October 2015
Mid-Atlantic RPB	Mid-Atlantic Regional Planning Body Webinar, July 11, 2016
Northeast RPB	Northeast Regional Planning Body Membership Roster, October 2016
West Coast RPB	Federal Marine Spatial Planning: West Coast Update Webinar, February 2, 2017
OCS	80 Fed. Reg. 189, Request for Information on the State of the Offshore Renewable Energy Industry—Request for Feedback, September 30, 2015

Email requests for interviews were sent to 110 persons of diverse occupations, genders, and geographical locations. Twenty-eight respondents agreed to be interviewed and 24 interviews ranging from 24-71 minutes were ultimately conducted (Table 4.4). All

interviews were confidential, and interviewees were assigned a number to protect their identity during analysis. Categories of interviewee affiliation included lead agency (e.g., BOEM; n=5), cooperating agency (e.g., National Marine Fisheries Service, U.S. Fish and Wildlife, Environmental Protection Agency, n=12), and non-agency stakeholders (e.g., non-governmental organization, academia, industry; n=7). Due to the low number of interviews, I combined numerous sectors into the category of non-agency stakeholder, recognizing that these respondents may have very different, and perhaps conflicting, perspectives.

Table 4.4: Demographics of interviewees including affiliation (i.e., lead agency, cooperating agency, and non-agency associates), years of experience, gender, and geographic location (east or west coast). Note that ‘years of experience’ may refer to the number of years a person has been in the current position and not the total number of years of related educational and professional experiences.

Interview #	Affiliation Category	Years of Experience	Gender	Location
1	Cooperating Agency	5	M	east coast
2	Cooperating Agency	4	M	east coast
3	Lead Agency	8	M	east coast
4	Non-Agency Stakeholder	20	M	east coast
5	Cooperating Agency	12	F	east coast
6	Non-Agency Stakeholder	5	M	west coast
7	Cooperating Agency	13	M	east coast
8	Non-Agency Stakeholder	3.5	M	west coast
9	Non-Agency Stakeholder	7	F	east coast
10	Lead Agency	7	M	east coast
11	Non-Agency Stakeholder	2	F	east coast
12	Non-Agency Stakeholder	21	M	east coast
13	Cooperating Agency	31	M	east coast
14	Cooperating Agency	6	M	east coast
15	Non-Agency Stakeholder	2	F	east coast
16	Cooperating Agency	9	F	east coast
17	Cooperating Agency	37	M	east coast
18	Cooperating Agency	7	F	east coast
19	Lead Agency	6	F	west coast
20	Lead Agency	2	M	east coast
21	Cooperating Agency	1.5	M	east coast
22	Cooperating Agency	1.5	F	east coast
23	Lead Agency	14	F	east coast
24	Cooperating Agency	20	M	east coast

4.2.3 Data analysis

Interviews were recorded, transcribed, and thematically coded using the qualitative data analysis software, Nvivo for Mac, Version 11 (QSR 2016). A total of 161 pages of transcribed data were analyzed. One researcher undertook all the interviews, transcriptions, and coding. Preliminary codes were developed based on literature reviews

and new codes and sub-codes were created as themes emerged during analysis. For example, within MSP, the codes of data, communication, and conflict resolution were initially determined. As interviews proceeded, the data code was further subdivided into identification of data, recognizing data gaps, and filling data gaps. This approximates the method of grounded theory, a general methodology to develop and generate theory based on the interplay of data analysis and data collection (Glaser and Strauss 1967, Strauss and Corbin 1998). It allows for the discovery of emerging patterns in data, the process used here to expand, consolidate, and create new codes based on the interviews. Once all interviews were complete, the researcher reviewed all of the coding again and merged similar themes. The final structure of the database included the main code of *MSP*, sub-codes of *general impressions*, *outcomes*, *benefits*, *drawbacks*, *challenges*, *personal involvement with MSP*, and *how MSP integrates into NEPA*, and three to twelve themes within each sub-code in which participants' statements were categorized.

4.3 Results and Discussion

Several recurring themes emerged from questions regarding general perspectives on MSP, outcomes of MSP, benefits and drawbacks of MSP outcomes, how the outcomes of MSP may be used in NEPA, and other ways MSP outcomes may affect the regulatory process. These are grouped into the themes of *consensus building* and *data* in the discussion below. In addition, the view of biological data as an impediment to EIAs was reviewed here. When participants were asked, "In your opinion, what are the outcomes of MSP?," twelve phrased the outcomes as potentialities (e.g., would be, should be, or ideal outcomes) while nine identified outcomes they believed had already occurred. Three responses were ambiguous. Furthermore, the distinction between *outcomes* of MSP and

the *benefits* derived from those outcomes seemed to blur for several participants. For example, some participants noted increased communication among stakeholders as an outcome, while others listed it as a benefit.

4.3.1 Consensus Building

Active stakeholder participation in the planning process and integration across sectors are two characteristics of effective MSP (Ehler and Douvère 2009). Key informants identified how these characteristics have been realized during MSP processes in the U.S. through increasing communications, developing shared datasets, minimizing conflict, and streamlining decision-making. These attributes also form the foundation of consensus building, a systematic practice that brings together stakeholders of different interests in face-to-face discussions to address a policy issue (Innes and Booher 1999). In the military, the phrase *common operating picture* is used to describe a shared understanding of a situation, achieved through collecting, displaying, and disseminating multi-dimensional information to facilitate collaborative planning for effective decision-making. This term is also useful in describing one of the outcomes of MSP.

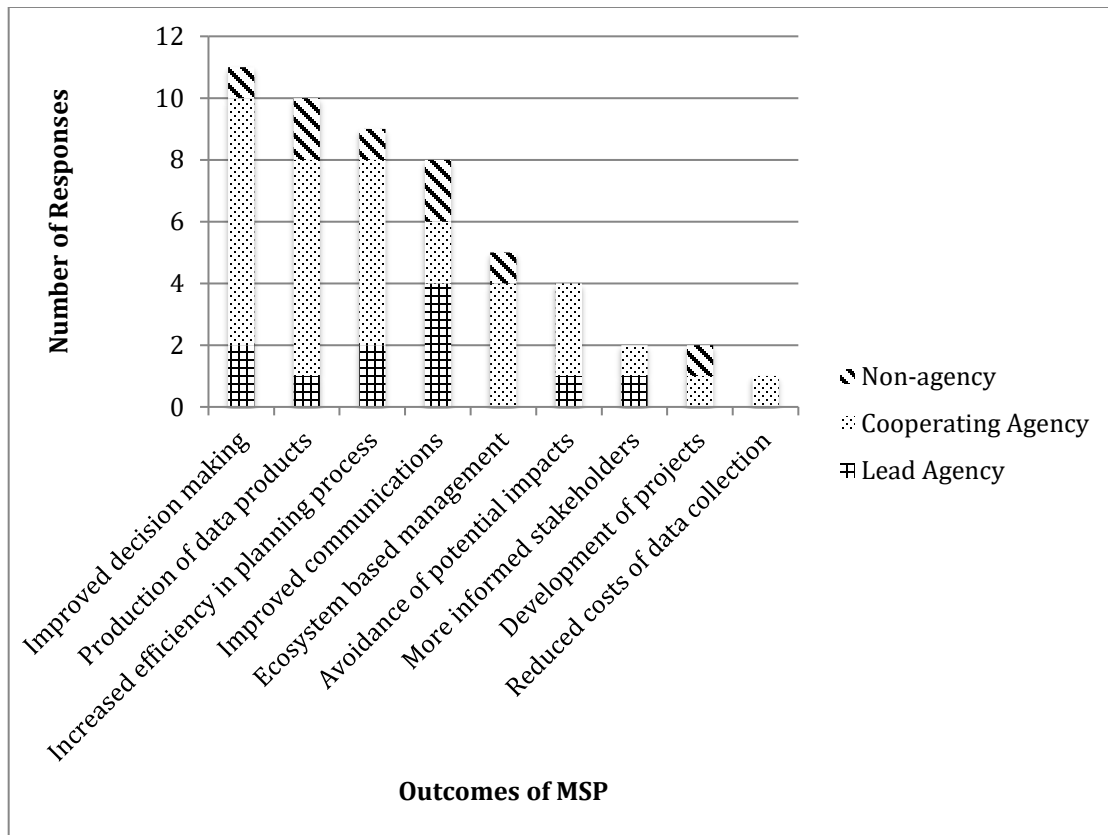


Figure 4.1 Identified outcomes of marine spatial planning, delineated by participants' affiliation with a lead agency, cooperating agency, or non-agency. Participants may have identified multiple outcomes.

Eight participants stated that improved communications among lead agencies, cooperating agencies, non-agency stakeholders, and the general public is an outcome of MSP (Figure 4.1) and four participants identified increasing communications as a benefit of MSP (Figure 4.2). Increased communications should facilitate coordination and compliance with the complex, multi-agency regulations that govern offshore wind development, discussed earlier. Face-to-face communication, fundamental to consensus building (Innes 1996, Innes and Booher 1999), encourages stakeholders from diverse backgrounds to establish personal, familiar relationships that lead to continued collaboration:

By virtue of these different forums in which I've gotten to know some of the state agency contacts, I feel comfortable cold-calling or emailing them and saying,

‘Hey, I know you are doing an MSP effort, we have a bunch of data on whales and birds and sea floor benthos and here is where you can find it.’ [Female, 6 years experience, lead agency]

Furthermore, discussions among agencies and developers initiated early in the planning process can help to develop strategies and mechanisms that, once established as part of the institutional processes, may lead to a better understanding of timelines and expectations in the regulatory process.

Nine participants described benefits of MSP that can be grouped under the term common operating picture. Some of their phrases included: “provide a good overall start”, “get everyone on the same page”, “give a common picture to start discussions”, “get everybody looking at the same data”, “are a jumping off point”, “allow everyone to see everything”, “are a common reference point”, and “summarize what is out there”. A common operating picture provides situational awareness to enable stakeholders to make accurate, informed decisions based on current or planned activities and pertinent factors. It is created by identifying relevant information, integrating data, and making it understandable and available to all stakeholders. Geographical information systems are frequently used to consolidate, manipulate, analyze, manage, and present spatially-informed data related to proposed projects. Colorful images of selected layers are incorporated into fact sheets, posters, and presentations to more easily describe environmental and physical features at proposed sites. However, greater efforts are needed to incorporate social, cultural, and behavioral data, which are included less frequently than other types of data and do not lend themselves as easily to GIS-based mapping (Gopnik 2015). Common operating pictures are provided through online GIS applications integrated into regional data portals, thus allowing queries and analysis of

particular layers of interest. Consensus building requires all stakeholders to have common information in order to explore interests, agree on facts, develop options, and make decisions. Thus, developing a common operating picture is important to deal with potentially controversial planning and policy tasks (Innes 1996).

Demands for ocean resources are increasing as population grows, technology changes, consumption escalates, and land resources become limited (Douvere 2008, Flannery et al. 2016). Conflicts among human uses may arise when different sectors seek to use the same space at the same time, but lack common objectives. Disputes among emerging users (e.g., offshore wind, marine renewables, aquaculture) who would like access to spaces typically used by traditional users (e.g., commercial fishing or shipping) are particularly noted. For example, some commercial fishers have expressed concern that development of offshore wind farms would restrict their access to traditional fishing grounds resulting in loss of profits and potential loss of heritage (Mackinson et al. 2006). Furthermore, human-environmental conflicts result from increased extraction of ocean resources that amplifies adverse effects on the natural environment, including over-fishing, loss and destruction of habitat, pollution, and acidification (Douvere 2008). Identifying and minimizing these conflicts is desirable and eleven participants stated that conflict resolution was a benefit of using MSP.

It goes right into the managing of the natural resources that are there and preventing the kinds of conflicts that arise when you are in a react mode, rather than a proact mode. [Male, 4 years experience, non-agency stakeholder]

Resolving conflicts early in the planning process may also reduce project costs and risk of litigation, a plague of the Cape Wind project (Cape Wind 2014).

Certainly that is the intent... is to streamline things and prevent Cape Wind kind of accidents from happening again. [Female, 12 years experience, cooperating agency]

Effectively managing conflict is necessary in order to reach consensus on final decisions. Better decision-making by developers and agencies was the most cited outcome of MSP (Figure 4.1). Participants expanded on the term 'better' to mean a more informed process, supported by best available scientific data that could balance and arbitrate between competing users:

If it is done properly, an equitable and consistent set of decisions in terms of how you are going to allow different activities and when and where and how you would allow different activities to take place. [Male, 37 years experience, cooperating agency]

For potential developers, better decision-making includes more informed project proposals being crafted and submitted for agency review. By communicating with other stakeholders and referring to common operating pictures and their data, developers can become informed about environmental concerns and other users within areas being considered for offshore wind projects:

Projects that were never going to see the light of day... our hope is that we'll get fewer, better projects that will not require as much time to go through the environmental review and permitting and licensing process. [Male, 13 years experience, cooperating agency]

...make good projects happen [so that we do] not start out with bad projects, being proposed bad, and having to work a lot to recraft them. [Male, 20 years experience, cooperating agency]

Participants also recognized the WEA identification process as an example of better decision-making. The area identification process is led by BOEM, but includes comments from the public, industry groups, interagency task forces, and federal, state, and local governments. Many WEAs on the east coast of the U.S. (e.g., Massachusetts,

Rhode Island, New Jersey, Delaware, Maryland, and Virginia) were established using the area identification process but were not informed by MSP. However, several states (e.g., Georgia, South Carolina, California, and Hawaii) have not yet designated WEAs in their state waters and could thus incorporate MSP into their decision-making if they move forward with that planning process.

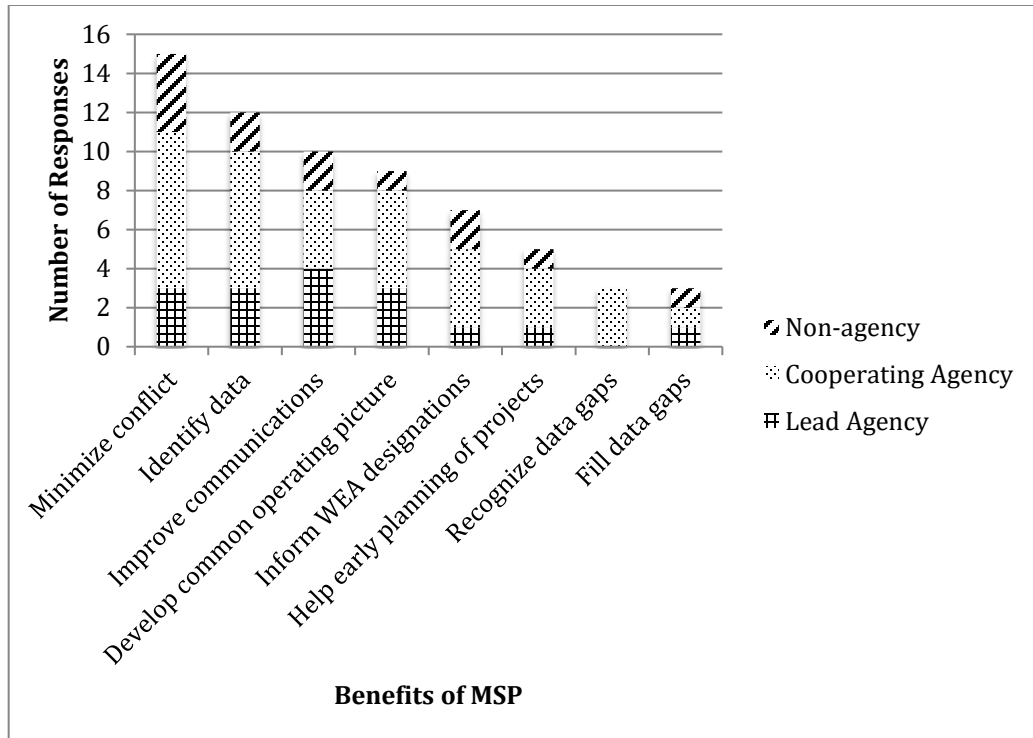


Figure 4.2: Identified benefits of marine spatial planning, delineated by participants' affiliation with a lead agency, cooperating agency, or non-agency. Participants may have identified multiple benefits.

4.3.2 Data

Data and understanding about underlying processes are critical for defining and analyzing existing and future conditions, two steps in a systematic approach to MSP (Ehler and Douvère 2009). Participants noted that creating data products, increasing data availability, identifying data gaps, and filling data gaps, are important benefits and outcomes of MSP. Ten participants identified data products (referring to portals, maps,

and modeling results) as key outcomes of MSP. Data portals, online repositories of biological data and decision support tools have been created through regional and state MSP efforts. The Mid-Atlantic and Northeast regional planning bodies each host their own portals - the Mid-Atlantic Ocean Data Portal²¹ and the Northeast Ocean Data Portal²². Jointly, BOEM and the National Oceanographic Atmospheric Administration sponsor the Marine Cadastre²³ to support the needs of the offshore energy and marine planning communities. Geographic coverage, spatio-temporal scales, and contributors of data vary among the portals.

It's definitely really nice to see how as a private industry, you can get onto a data portal and just find all this information in one point. You can see where there are buried cables. You can see where there are specific fishing grounds and stuff and I would imagine that it would just make life so much easier. [Male, 5 years experience, non-agency stakeholder]

The portals enable all stakeholders to access publicly available data from the same place, thus buttressing creation of a common operating picture, reducing potential conflicts, and encouraging submission of more informed project proposals by developers. However, some participants believed that data products should be seen as supporting tools for other outcomes of MSP (e.g., better decision-making and communications) rather than independent outcomes:

I view the portal as nothing more than a means to an end. What the portal does is provide a visual... that's all it does. It provides a visual of what is out there, how much is out there, what's important, that the general public doesn't have. [Male, 4 years experience, cooperating agency]

Whether data products are an end result of MSP or simply a means to an end, identification of data was the second most noted benefit of MSP (Figure 4.2).

²¹ <http://portal.midatlanticocean.org/ocean-stories/every-map-tells-a-story/>

²² <http://www.northeastoceandata.org/>

²³ <http://www.marinecadastre.gov/>

You often have a lot of different stakeholders around the table, involved in the conversation. They often bring [biological] data and share it amongst themselves, which is incredibly useful from a knowledge building perspective and a collaborative perspective. [Male, 6 years, cooperating agency]

Value placed on identification and sharing of data supports the significant efforts and investments being put into amassing, organizing, analyzing and displaying data in portals and other media (e.g., fact sheets, presentations, posters). Key informants believed that improved access to data expedites planning and applications for offshore wind projects by developers and better informs impact analyses by regulators. Dissemination of biological data to stakeholders facilitates more informed decision-making by providing science-based information about positive and negative environmental impacts. For example, Klain et al. (2015) discussed an initiative by Vineyard Power on Martha's Vineyard, Massachusetts, that included an interactive, offshore wind map viewer based on scientific data and traditional knowledge. It was used to inform stakeholders of environmental impacts and to solicit opinions on suitable project locations. A true understanding of environmental issues by stakeholders is critical to the success of offshore wind projects because some opposition may be based largely on uncertainties (Klain et al. 2015).

The identification of data is not enough though. The spatial and temporal scales of data must also match the objectives and needs of the planning process. Ambiguous or mismatched scales relating to administrative boundaries, ecological processes, data availability, or methodologies may influence the quality of assessments (João 2002, Gontier 2007). Furthermore, the choice of scale may benefit one stakeholder over another, or set artificial boundaries on analyses that influence decisions (Karstens et al.

2007). Key informants spoke to this issue and discussed how MSP can help identify data gaps at particular scales and prioritize additional research to fill these gaps.

I think there are some real questions about what scale and whose responsibility it is at what scale to collect what data. And I think that one of the benefits of marine planning is aggregating data and making sense of it and in some cases identifying where there are holes and having either federal or state initiatives help fill those holes. [Female, 7 years, cooperating agency]

The issue of which entities, government or industry, collect data at which scales was brought up by several participants. Most agreed that federal and state government agencies sponsor research at regional and coastal scales (e.g., Cetacean and Turtle Assessment Program and Atlantic Marine Assessment Program for Protected Species) while developers focus on site-specific research.

4.3.3 Biological data is an impediment in NEPA

The importance of data identification and data products, as noted by the key informants, supports the notion that a lack of biological data is an impediment in the NEPA process. Fifty percent of participants (one lead agency, eight cooperating agency, and three non-agency) identified insufficient biological data as a barrier in the environmental assessment process:

The lack of information about where marine mammals are and when is definitely a problem when it comes to deciding where these offshore wind farms should be. [Male, 1.5 years experience, lead agency]

Only three participants (one lead agency, one cooperating agency, and one non-agency) specifically stated that biological data are not an impediment in the regulatory process:

There is way too much of an emphasis in the U.S. on getting all the data perfectly. There's way too much of a focus on doing anything because there is uncertainty about X. And there's always an X that someone is uncertain about and I don't feel like that's a reason to not go forward and get something done, just because you

don't know everything you could possibly know about some kind of factor... It is ludicrous that people think we need more than what we already have. [Male, 5 years experience, non-agency stakeholder]

Some participants stated that federal regulations require the use of *best available science* in decision-making and thus a requirement to collect *additional* data does not exist. These participants may have been referring to provisions in the ESA (“solely on the basis of best scientific and commercial data available”) and Magnuson-Stevens Fishery Conservation and Management Act (National Standard 2; “Conservation and management measures shall be based upon the best scientific information available.”). However, NEPA does not include any such statement; rather, CEQ regulations demand information of “high quality” and “professional integrity” (40 C.F.R. §§ 1500.1,1502.24). Furthermore, debate exists among scientists, policy makers, managers, and stakeholders about what constitutes best available science and how it should inform policy. Informing this debate are perceptions and expectations of science – an organized body of knowledge or a rigorous, standardized method of collecting information. One view is that science is uncontested and universally applicable, the other holds that science is subjective and conditional (Sullivan et. al 2006).

Eight participants (three lead agency, three cooperating agency, and two non-agency) first stated that biological data is not a barrier, yet as the interviews proceeded, they contradicted this view.

Because there is actually quite a lot of information out there. Well, it depends on your time frame. The impacts would be another part that there might be some fuzziness about the impacts of various activities, but I'd say our knowledge is actually quite good. [Male, 7 years experience, lead agency]

Lead agency participants were more likely to answer in this manner than cooperating agency or non-agency stakeholders. Participants' reluctance to directly state that

biological data are an impediment to the NEPA process may be attributed to the political climate at the time of the interviews. Federal programs and agencies supporting the environment are facing severe resource cuts. Since January 20, 2017 (approximately the start of these interviews), several presidential executive orders have been issued attempting to reduce the scope of federal protection of environmental resources or habitats.²⁴ Furthermore, at the time of these interviews, the Environmental Protection Agency and the U.S. Department of Agriculture were under a gag order that prohibited the sharing of agency information with media and other outlets (Scientific American 2017). Potentially different answers to these interview questions may have been given if the interviews were conducted under a different political climate.

4.3.4 Challenges of MSP

According to Ehler and Douvere (2009), the principal output of MSP should be a comprehensive spatial management plan for a marine area or ecosystem that sets out priorities for the area in time and space. Yet, practical application of MSP in the U.S. differs significantly from this theory (Gopnik 2015) and the outcomes identified in this research differ as well. No participant identified a marine plan as an outcome of MSP. The difference in expectation of MSP outcomes may be partially explained by the governance structure in the U.S. According to federal guidance for MSP (Executive Order 13547 - Stewardship of the Ocean, Our Coasts, and the Great Lakes, the National Ocean Policy Implementation Plan, and the Marine Planning Handbook) existing mandates and authorities of federal agencies will not change to accommodate the goals of

²⁴ Executive Orders include: Implementing an America-First Offshore Energy Strategy (4/28/17), Review of Designations Under the Antiquities Act (4/26/17), Promoting Energy Independence and Economic Growth (3/28/17), Restoring the Rule of Law, Federalism, and Economic Growth by Reviewing the "Waters of the United States" Rule (2/28/17), Expediting Environmental Reviews and Approvals For High Priority Infrastructure Projects (1/24/17).

MSP. Six participants mentioned that there is a challenge in realizing the benefits of MSP while maintaining existing regulatory authorities. Without congressional support, authorizations to fund MSP are also lacking (Gopnik 2015), leading many to wonder:

What exactly are we doing here? What does a regional marine plan look like? Particularly, when nobody's authorities change. So, if everyone has the same legal authority and requirements and all that sort of thing, then what can you actually do? [Female, six years experience, lead agency]

However, another participant believed that, despite lack of authority and congressional buy-in, MSP could be a lasting framework used in ocean planning:

If the executive order gets rescinded or anything like that... there is a commitment... there is certainly a feeling of commitment around the table that this is good practice... these are good practices regardless of whether there is an executive order or not. So, this is the best way to make decisions, to be able to avoid and minimize impacts and... not just impacts to resources but conflicts in ocean space. Hopefully, either way, we are going to keep moving forward. [Male, six years experience, cooperating agency]

Although MSP is established in the regulatory process as one approach to minimize conflict and improve decision-making, other methods may also be considered. Ocean zoning, the allocation of ocean space to specific users is a common feature of MSP (Ehler and Douvere 2009). It has been incorporated into other marine spatial plans, including in Germany (BSH 2009a and 2009b), Scotland (Scottish Government 2015), and at the state level in Rhode Island (CRMC 2010). However, it is notably absent from U.S. regional plans:

I can't speak for all of the different regions, but for the northeast, we made a pretty conscious decision that [zoning] is not what we are talking about here. All we are doing here is providing the most up-to-date data on all these uses and resources that are out there to allow for a kind of venue to make the best decision possible. [Male, six years experience, cooperating agency]

Both the Northeast and Mid-Atlantic regional planning bodies removed the terms *spatial* and *zoning* from their final plans, referring to them simply as an ‘Ocean Plan’ and an ‘Ocean Action Plan’ respectively.

I think it hurts it. I think people will try to, from the science and regulatory sides, will still have to grapple with those issues, but those terms [spatial and zoning] were removed out of moral and political cowardice. [Male, 37 years, cooperating agency]

Traditional marine users, who may feel encroached upon by new users such as offshore wind, resisted attempts to zone at the regional scale and lobbied for this position at the federal level:

And [zoning] generated a lot of backlash from the Republican side in Congress. Particularly about perceived restrictions on business interests and so it became a bit of a flash point in terms of issues in how far these regional planning bodies were going to go at this stage in terms of having prescriptive management measures. [Male, 37 years, cooperating agency]

Despite the lack of political will in the U.S., proponents of zoning argue that such a framework would facilitate alignment of ocean interests and attainment of healthy ecosystems (Eagle et al. 2008, Yates et al. 2015).

4.3.5 Drawbacks of MSP

Participants seemed reluctant to identify any drawbacks to MSP (Figure 4.3). Flannery et al. (2016) note that comparatively little analyses of potential negative impacts of MSP have been undertaken, including potentially serious distributive impacts. However, the most frequently cited drawbacks in this study were associated with data: the apprehension that stakeholders may solely depend on data portals to inform environmental reviews, data in the portals would not be updated, and data products, such as maps combing multiple layers of data, are presented without adequate explanation of

assumptions or analyses. Additional interesting points were made by individuals, for example, MSP may lead to binding decisions and to increased development of offshore wind projects; social data was not adequately incorporated into the process; MSP framework is top down and not participatory; and MSP would lead to ocean zoning.

In a lawsuit to block the lease of the New York WEA to Statoil Wind of Norway (Fisheries Survival Fund et al vs. Sally Jewell, 2016), the plaintiffs argue that BOEM did not adequately consider the impact of wind power development on the region's fishery resource, relying on incomplete repositories of data to justify the analyses in the environmental assessment (the plaintiff's motion was denied). Furthermore, the Mid-Atlantic Ocean Action Plan states that data portals should be used knowing that data gaps, uncertainties, and limitations of datasets exist within it. As a result, developers and regulators should use all available sources of data, including peer-reviewed literature, grey literature, surveys, citizen science, traditional knowledge, and predictive modeling to inform impact analyses.

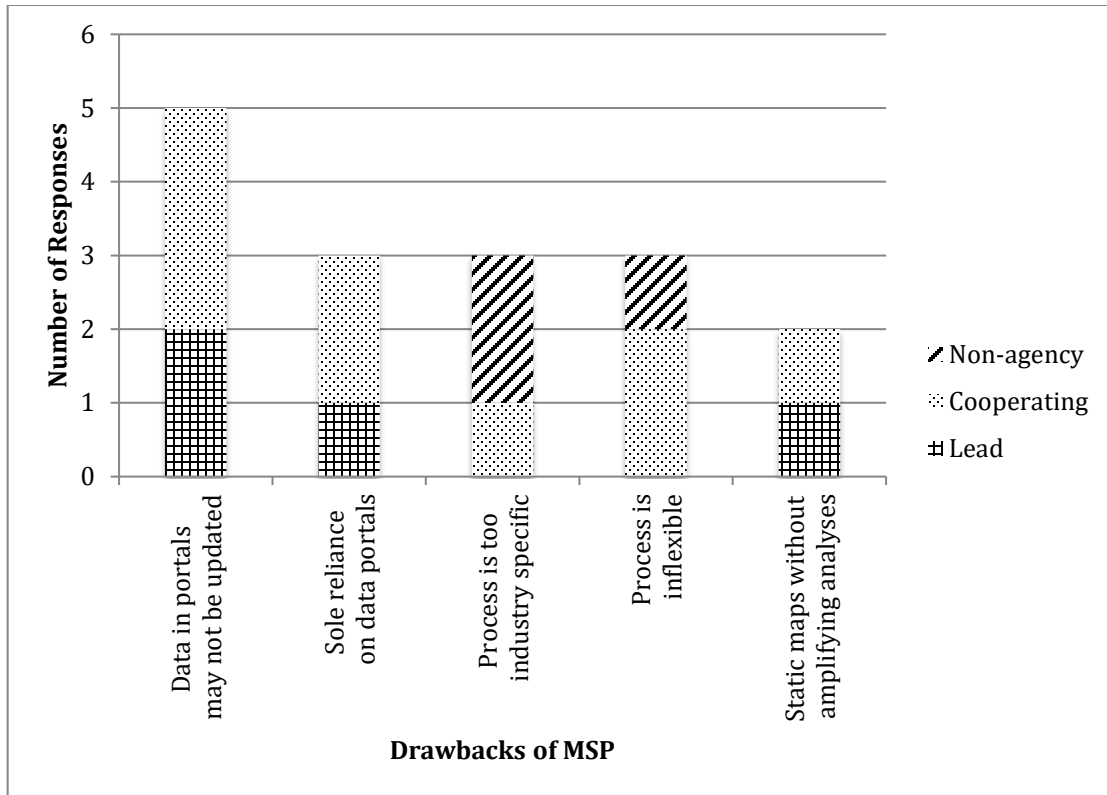


Figure 4.3: Most commonly identified drawbacks of MSP. Participants may have identified more than one drawback. Drawbacks identified by only one participant are excluded from the figure, but mentioned in the text.

Five participants, some of who serve as representatives on regional planning bodies, worried that data in the portals would not be maintained and updated after initial plan development:

That is a HUGE issue! ... you need it to be up to date in order to make good decisions, but also from a credibility perspective. First time someone goes in there and does something based on information that hasn't been updated in seven years, that is going to erode credibility in people wanting to use the data portal. [Male, 30 years experience, non-agency stakeholder]

The Mid-Atlantic and Northeast Ocean Plans include action items to develop and implement plans to sustain operations and maintenance to address the longevity of their data portals; however, some participants were skeptical that these action items would be implemented due to limited financial and personnel resources.

4.4 Conclusions

Semi-structured interviews with key informants in the offshore wind energy and marine spatial planning sectors were conducted to understand: (1) whether a lack of biological data impedes EIAs for offshore wind, (2) whether MSP could assist in mitigating these impediments, and (3) whether MSP could advance development of offshore wind in the U.S. in other ways. Most participants stated that a lack of biological data in EIAs for offshore wind was problematic. Incomplete species-specific data (e.g., seasonality of presences), uncertainty of data, mismatched scales, and incomplete understanding of how project activities affect species were cited as impediments in the impact assessment process.

Participants identified numerous outcomes of MSP, including the production of data products, such as data portals. These products may be helpful in the NEPA process to mitigate perceived problems in EIAs. However, participants cautioned that wind energy developers and regulators should not ignore other data sources and solely depend on MSP-related data portals for environmental reviews. Furthermore, processes must be established and responsible entities identified to ensure the data in those portals are updated regularly. Additional benefits of MSP that may be incorporated into the NEPA process include identifying data needs, existing data, data gaps, and methods to fill data gaps. Thus, MSP provides a strategic framework for the systematic identification, collection, collation, analyses, application, and management of data in the offshore wind environmental regulatory process.

Participants stated that other MSP outcomes may also advance development of offshore wind in the United States. Increased communication among stakeholders and a

common operating picture are foundations of consensus building, a systematic practice that brings together stakeholders of different interests. Consensus building could minimize conflicts among traditional (e.g., commercial fishing) and non-traditional (e.g., offshore wind) sectors, allowing better decision-making through an informed process that is supported by best available scientific data.

In order for potential efficiencies of MSP to be realized, it should occur prior to the designation of WEAs and finalization of NEPA documents. The Northeast and Mid-Atlantic ocean plans were issued after WEA designations and lease auctions were conducted in these areas. Nevertheless, offshore wind projects in these regions may still benefit from MSP during the scoping and analyses of the second EIA required prior to approval of the construction and operation plans. The west coast, Hawaii, and the Great Lakes have not yet designated WEAs, drafted NEPA documents, or undertaken MSP efforts. If MSP is implemented early, it may mitigate data impediments in the NEPA process and help advance the offshore wind industry.

CHAPTER 5

VALUE OF SPECIES DISTRIBUTION MODELS IN IMPACT ASSESSMENTS

5.1 Introduction

Understanding the distribution and abundance of species and the processes that drive these are fundamental questions in ecology (Levin 1992). Answers to these questions are used in management scenarios for planning, conservation, and mitigation. An increase in computer processing power, geographical information system tools, and statistical techniques allowed the development of species distribution models to help answer these questions (Guisan and Zimmermann 2000, Austin 2002, Redfern et al. 2006). Species distribution models, also termed habitat suitability models, species–habitat relationships, and habitat models, seek to relate species occurrence to aspects of the physical, chemical, or biological environment (Guisan and Zimmermann 2000). Sufficient accuracy helps to move beyond simple correlations to derive meaningful ecological insights and ultimately develop predictions of species’ distribution (Gregr et al. 2013).

Species’ distributions, as well as other life characteristics, are critical data used to conduct environmental impact assessments (EIAs) in compliance with the National Environmental Policy Act of 1969 (NEPA). EIAs evaluate potential effects of major federal actions on environmental resources such as cetaceans, fish, sea turtles, invertebrates, bats, and birds. These analyses require technical information about project components, or stressors, and life characteristics of environmental resources, or receptors, and the spatial and temporal overlaps among them in order to determine potential effects. For example, pile driving of turbine foundations is a stressor during the construction of

an offshore wind project that results in an increase in sound that may affect the hearing and behavior of cetaceans present in the affected area at the time of construction (Madsen et al. 2006, Nowacek et al. 2007, Southall et al. 2007). To understand the degree of sounds' effect, it is important to know such data as the likelihood of cetaceans present at the time of pile driving, which cetaceans are present, the specifications of the sound source, the bathymetry and bottom characteristics (to understand sound propagation), and the mechanism of impact to the animal.

Biological data used in EIAs of offshore wind projects are typically derived from literature reviews, past surveys, historical documents, and opportunistic information (USDOI MMS 2007, 2009a, 2009b; USDOI BOEM 2012a, 2013, 2014a, 2014b, 2015a) and are useful to develop a general understanding of spatial patterns and distribution boundaries; however, their use in analyses of potential impacts is problematic. Positive detections of species, termed presences, are typically just annotated on maps of the study area, and often segregated to reflect seasonal variations; inter-annual data of each season are grouped together (Figure 5.1, USDOI BOEM 2012a). Migratory species may not be accurately represented by static markings that do not reflect species' variable use of marine space. Furthermore, focusing on cetaceans, presence records are insufficient for most species (Kaschner et al. 2011).

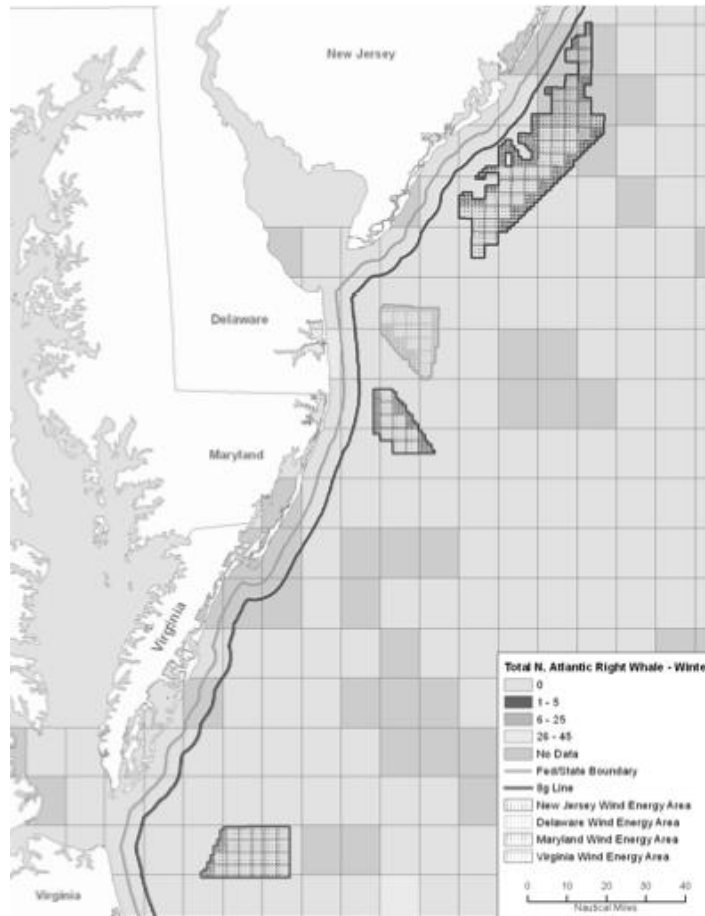


Figure 5.1: North Atlantic right whale sightings in winter (January-March, 1979-2007).

Of the 87 cetacean species listed by the International Union on Conservation of Nature, 45 are listed as data deficient, almost half of those in U.S. waters (IUCN 2018). Sighting surveys, either shipboard or aerial, are performed to fill data gaps; however, they are restricted in taxonomic and spatial coverage, resulting in undersampling (Kaschner et al. 2011). Descriptions of sampling effort, defined as either search time per area, search within a given distance of a reference point or line, or total number of sites or replicates needed to find a pattern, are often not included to describe the graphical display of presence data (Redfern et al. 2006). Thus, one does not know if species' absences are due to an actual lack of cetaceans or due to lack of surveying effort. All of these factors lead to misleading and difficult to interpret maps of species occurrence.

Species distribution models have been used in the terrestrial realm and for fish in rule making and in impact assessments required by NEPA (Bart 1995, Threatened Status for Southern Distinct Population Segments of North American Green Sturgeon 2006, Robinson et. al 2011, Designation of Revised Critical Habitat for the Northern Spotted Owl 2012). However, applications of species distribution models to other marine life are limited (Robinson et al. 2011). This project examined the utility and feasibility of using cetacean species distribution models in NEPA documentation of offshore wind projects.

5.2 Methods

Detailed technical reviews of modeling are given by Guisan and Zimmerman (2000), Guisan and Thuillar (2005), Redfern et al. (2006), and Elith and Leathwick (2009), thus will not be discussed here. The utility of models as perceived by key informants – those that are the nexus between model developers and policy makers – is analyzed here.

5.2.1 Document Analysis

A review of eight federal offshore wind environmental assessments and environmental impact statements (collectively termed EIAs here) was conducted to determine whether species distribution models of receptors were used to inform analyses (USDOI MMS 2007, 2009a, 2009b; USDOI BOEM 2012a, 2013, 2014a, 2014b, 2015a). This review focused on cetaceans as a proxy for receptors. Although a relatively small taxonomic group, cetacean biomass and position in the food web (Kaschner et al. 2011) make them of high ecological importance (Doughty et al. 2016). Furthermore, the

conservation of cetaceans is an important policy objective in the U.S. with protection under the Marine Mammal Protection Act (MMPA) and, for those threatened or endangered, under the Endangered Species Act (ESA).

5.2.2 Semi-Structured Interviews

Semi-structured telephone interviews of key informants involved in the offshore wind industry and/or the NEPA process were conducted between February and April 2017. A semi-structured interview style was selected to gather in-depth information about a sensitive topic, seek descriptive information, and try to understand underlying motivations and attitudes (Bernard 2011). In addition, this style of interviewing works well in projects dealing with high-level bureaucrats and elite members of community who are conscious of their time (Bernard 2011). This type of research is limited though by biases, including those of the participants and of the interviewer (Weiss 1995). For example, the interviewer may give more credence to comments made by the participant that support preconceived notions, known as hypothesis confirmation bias, or try to search for coherence in disparate remarks by the participant during the interview, known as consistency bias (Weiss 1995). Yet, a semi-structured interview allows flexibility in the conversation to let other information be introduced that may not have been otherwise, leading to longer responses and descriptions, rather than one-word answers (Kempton et. al 2005).

Questions in the interview guide were based on reviews of relevant literature regarding species distribution modeling and EIAs. Topics covered in the interviews included: participants' experience with NEPA, offshore wind energy, and species

distribution models; use of species distribution models in offshore wind energy impact assessments; benefits and drawbacks of species distribution models; and other ways that species distribution models may affect the regulatory process. The style of questions was modeled after examples used in similar research (Bates and Firestone 2015) and the length of the guide was adjusted based on informal tests. Five iterations were edited among the authors prior to submission for review. The Human Subjects Institutional Review Board at the University of Massachusetts Amherst approved the interview guide that was used to ensure all topics were covered equally in each interview, thus providing more reliable, comparable data. Pre-tests of interview questions were conducted with five professional peers with subject matter expertise to gauge the clarity and effectiveness of the questions. Minor modifications were made as a result of the pre-tests and comments from the university review board prior to finalizing the interview guide.

5.2.3 Interviewees

Key informants included federal regulators, state regulators, fisheries council members, non-governmental organizations, industry members, consultants, and academics that are experienced with the offshore wind industry and/ or the NEPA process. Potential interviewees were identified through attendance lists, presentations, and agendas at state task force meetings and public comments received from 2011 to 2017 as listed on BOEM's Renewable Energy website (Table 5.1). As the lead agency for offshore wind projects in the U.S., BOEM's website includes a comprehensive list of offshore wind energy activities. The list of names collected was filtered to include only those that included job titles or affiliations in order to confirm their status as key

informants. The author identified additional potential interviewees based on attendance at conferences and workshops. Interviewees themselves also identified other potential subjects, a sampling technique known as snowball sampling (Bernard 2011).

Table 5.1: Documents used to identify potential interviewees.

State/ RPB	Source
Delaware	Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) /Delaware Renewable Energy Task Force Meeting, Lewes, March 24, 2011
Georgia	Public comments received on the Notice of Intent to prepare an Environmental Assessment, 2013
Hawaii	Bureau of Ocean Energy Management (BOEM)/Hawaii Intergovernmental Renewable Energy Task Force Meeting, Honolulu, June 3, 2015
Maryland	5th Task Force Meeting, January 29, 2013
Massachusetts	Renewable Energy Task Force Teleconference, October 17, 2011) BOEMRE/Rhode Island/Massachusetts Joint Task Force Meeting, New Bedford, May 2, 2011 Request for the Taking of Marine Mammals Incidental to the Construction of the Block Island Transmission System, November 26, 2013 Task Force Webinar, January 16, 2014 BOEM Massachusetts Renewable Energy Task Force, April 29, 2015
New York	Public comment to the Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore New York Environmental Assessment, June 2016
North Carolina	BOEM North Carolina Task Force Meeting Agenda, April 19, 2016
Oregon	BOEM Oregon OCS Renewable Energy Task Force Portland, April 12, 2012

State/ RPB	Source
	BOEM Oregon Renewable Energy Task Force Meeting Portland, June 28, 2013
	79 Fed.Reg. 30876 Notice of Intent To Prepare an Environmental Assessment for Proposed Wind Energy- Related Development Activities on the Pacific Outer Continental Shelf Offshore Oregon and Notice of Public Scoping Meetings
Rhode Island	International Marine Spatial Planning Symposium: Sharing Practical Solutions, Narragansett, October 2015
Mid-Atlantic RPB	Mid-Atlantic Regional Planning Body Webinar, July 11, 2016
Northeast RPB	Northeast Regional Planning Body Membership Roster, October 2016
West Coast RPB	Federal Marine Spatial Planning: West Coast Update Webinar, February 2, 2017
OCS	80 Fed. Reg. 189, Request for Information on the State of the Offshore Renewable Energy Industry—Request for Feedback, September 30, 2015

Email requests for interviews were sent to 110 persons of diverse occupations, genders, and geographical locations. Twenty-eight respondents agreed to be interviewed and 24 interviews ranging from 24-71 minutes were ultimately conducted (Table 5.2). Sample size was determined adequate since after approximately 20 interviews the number of new concepts introduced by each successive interview approaches an asymptote (Morgan 2002, Bernard 2011). All interviews were confidential, and interviewees were assigned a number to protect their identity during analysis. Categories of interviewee affiliation included lead agency (e.g., BOEM; n=5), cooperating agency (e.g., National Marine Fisheries Service, U.S. Fish and Wildlife, Environmental Protection Agency, n=12), and non-agency stakeholders (e.g., non-governmental organization, academia, industry; n=7). Due to the low number of interviews, numerous sectors were combined into the category of non-agency stakeholder, recognizing that

these respondents may have very different, and perhaps conflicting, perspectives.

Experience with species distribution models varied among participants: two work for organizations that funded species distribution-modeling projects, four had developed models in the past and eleven (including the four developers) stated that they referenced species distribution models for impact assessments. Twelve participants claimed to only have general knowledge of species distribution models, specifying that they had heard about them in talks at conferences, read about them in literature, or studied them in their academic past.

Table 5.2: Demographics of interviewees to include affiliation (i.e., decision agency, resource agency, other federal agency, state agency, and non-agency associates), years of experience, gender, and geographic location (east or west coast).

Interview #	Affiliation Category	Years of Experience	Gender	Location
1	Other Federal Agency	5	M	east coast
2	Other Federal Agency	4	M	east coast
3	Federal Decision Agency	8	M	east coast
4	Non-Agency Stakeholder	20	M	east coast
5	State Agency	12	F	east coast
6	Non-Agency Stakeholder	5	M	west coast
7	Other Federal Agency	13	M	east coast
8	Non-Agency Stakeholder	3.5	M	west coast
9	Non-Agency Stakeholder	7	F	east coast
10	Decision Agency	7	M	east coast
11	Non-Agency Stakeholder	2	F	east coast
12	Non-Agency Stakeholder	21	M	east coast
13	Other Federal Agency	31	M	east coast
14	Other Federal Agency	6	M	east coast
15	Non-Agency Stakeholder	2	F	east coast
16	Other Federal Agency	9	F	east coast
17	Other Federal Agency	37	M	east coast
18	Other Federal Agency	7	F	east coast
19	Decision Agency	6	F	west coast
20	Decision Agency	2	M	east coast
21	Resource Agency	1.5	M	east coast
22	Resource Agency	1.5	F	east coast
23	Decision Agency	14	F	east coast
24	Other Federal Agency	20	M	east coast

5.2.4 Data analysis

Interviews were recorded, transcribed, and thematically coded using the qualitative data analysis software, Nvivo for Mac, Version 11 (QSR 2016). One researcher conducted all interviews, transcriptions, and coding. Preliminary codes were developed based on literature reviews and new codes and sub-codes were created as themes emerged during analysis. For example, in the code *drawbacks*, sub-codes

assumptions, validation, and approximating ecological theory were originally defined. As interviews proceeded, these sub-codes were consolidated into the single sub-code *approach*. This approximates the method of grounded theory, a general methodology to develop and generate theory based on the interplay of data analysis and data collection (Glaser and Strauss 1967, Strauss and Corbin 1998). It allows for the discovery of emerging patterns in data, the process used here to expand, consolidate, and create new codes based on the interviews. Once all interviews were complete, the researcher reviewed all of the coding again and merged similar themes. The final structure of the database included the main node of *Models*, codes of *benefits, drawbacks, familiarity, and used in*, and five to nine sub-codes within each code in which participants' statements were categorized.

5.3 Results and Discussion

This review of federal offshore wind EIAs found that cetacean distribution models were used in three of eight assessments (North Carolina, Georgia, and Massachusetts; USDOJ BOEM 2014a, 2014b, 2015a), but only models of North Atlantic right whales (*Eubalaena glacialis*) were referenced. North Atlantic right whales are endangered (IUCN 2018) and are the focus of numerous conservation efforts. The assessments that referenced species distribution models are the most recent ones published, which suggests that a lack of model availability limited their use in previous assessments.

Two federally-funded projects are attempting to fill this gap: the Marine-life Data and Analysis Team (MDAT), composed of the Geospatial Ecology Lab of Duke

University, the Northeast Regional Ocean Council, the National Oceanographic Atmospheric Administration (NOAA) National Centers for Coastal Ocean Science, the NOAA Northeast Fisheries Science Center, and Loyola University Chicago (Duke University 2017), and the Atlantic Marine Assessment Program for Protected Species (AMAPPS), composed of NOAA, BOEM, U.S. FWS, and the U.S. Navy (USDOI NOAA 2017). MDAT developed habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico that, according to a key informant, are considered best available science and used in other forms of assessments, such as incidental take authorizations required by the MMPA (Male, cooperating agency, 1.5 years experience). AMAPPS is developing spatially explicit density estimates that incorporate habitat characteristics of marine mammals in the western North Atlantic Ocean. It is a multi-year program that includes extensive annual aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters, finer scale surveys at several sites of particular interest, tag telemetry studies within surveyed regions, and additional data on habitat use and life-history, residence time, and frequency of use; models have not yet been published.

5.3.1 Benefits of Species Distribution Models

Key informants were asked what benefits species distribution models could contribute to offshore wind EIAs (Figure 5.2). Exposure of data was the most frequent benefit, given by ten of the participants:

It is another way to bring some of the empirical data to life and better project what is going to happen, I think that that makes a lot of sense - especially if it can be done in a timely fashion. [Male, 20 years experience, cooperating agency]

Outcomes of models are often presented in habitat suitability maps, making communication of data to regulators and stakeholders more clear through visualizations.

Informants also believed that models uniquely reveal interactions or couplings among environmental variables and species occurrence that are not otherwise apparent.

Collecting extensive biological data at sea at various spatial (e.g., large regional and smaller footprint of offshore wind project) and temporal scales (e.g., every season over multiple years) may be costly and technically challenging. Some participants stated that models could ease the burden of collecting empirical data; however, models fitted without these same extensive scales of data may reflect only a snapshot view of the expected relationships (Guisan and Thuiller 2005).

Climate change is expected to result in direct (e.g., reduced sea ice for haul-out sites) and indirect (e.g., geographic range shifts to track changes in sea temperature) effects to cetaceans (McLeod et al. 2005, Learmonth et al. 2006, Lambert et al. 2011). Data regarding cetaceans' ranges and migratory patterns (spatial and temporal) currently used in impact assessments may not be relevant in thirty years, the commercial lease term of submerged lands for renewable energy development on the outer continental shelf. Four participants commented that the predictive abilities of species distribution models are of benefit to the impact assessment process:

Some of these modeling techniques need to be used to project out seasonally, but we do have to project out into the unknown. [Female, 2 years experience, non-agency stakeholder]

Predictions of future cetaceans' distributions could better inform siting decisions and more accurately inform impact assessments. Limitations to predictive capabilities exist though. Species interactions may change in the future as adaptation responses and dispersal rates vary; models based on current interactions may be erroneous (Guisan and Thuiller 2005).

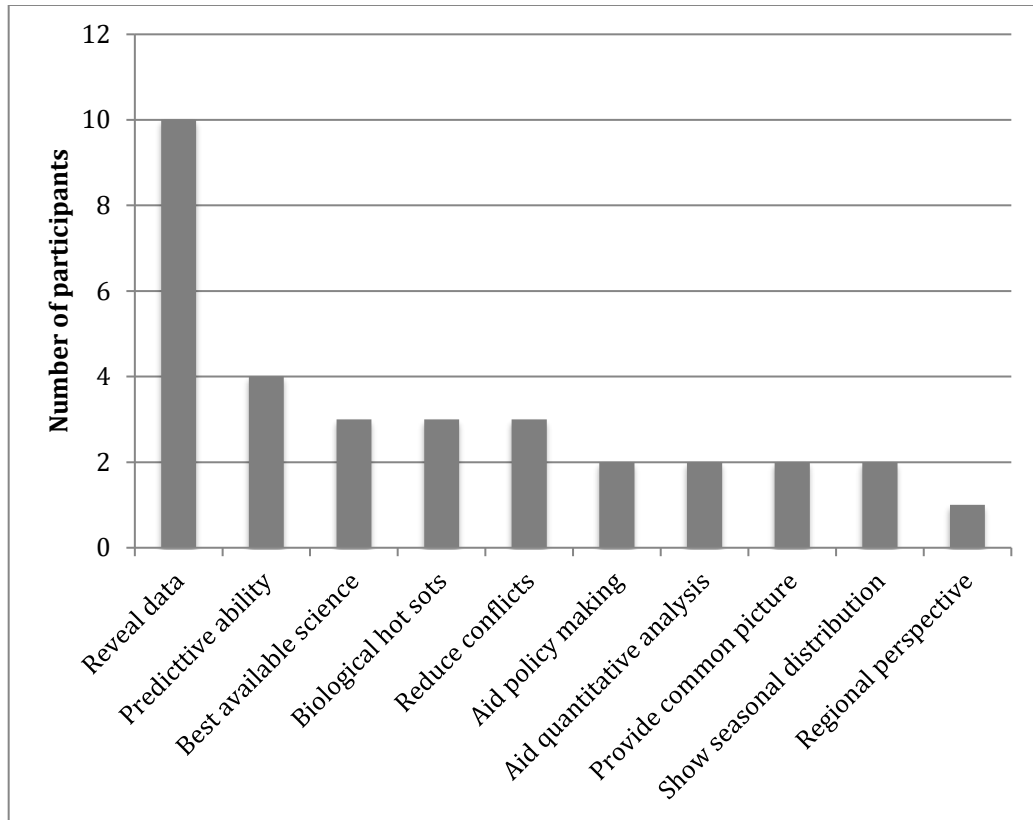


Figure 5.2: Benefits that species distribution models contribute to environmental impact assessments of offshore wind energy projects, as identified by interview participants. More than one benefit may have been given per person.

5.3.2 Drawbacks of species distribution models

Species distribution modeling is not without concern (Guisan and Zimmerman 2000, Guisan and Thuiller 2005, Austin 2007). A sequential approach to build species distribution models is offered to address some of these criticisms (Guisan and Zimmermann 2000, Guisan and Thuiller 2005): (i) conceptualization, (ii) data preparation, (iii) model fitting, (iv) model validation, and (vi) assessment of model applicability. Nine participants commented about how choices made in these steps of model development affect outputs:

And depending on what assumptions can go into a model, the outcomes can be very different. [Female, 1 year experience, cooperating agency]

Now we have two sets of these tools [referring to AMAPPS and MDAT] and which one do we believe or which one is more appropriate. [Female, 4 years experience, lead agency]

They are quite difficult to validate. [Female, 2 years experience, non-agency stakeholder]

Furthermore, the selection of predictor variables may be arbitrary and done to reduce complexity of the model instead of being based on biophysical processes (Austin 2007, Dick and Hazen 2011). Statistical models should be grounded in ecological principles; however, this is not universally done (Austin 2007). Straight-line relationships between predictor and response variables are often made without justification or consideration for unimodal or skewed responses (Austin 2007, Mackenzie et al. 2013). A final check should be conducted upon completion of the model to ensure results logically comply with ecological theory.

In addition to skepticism about approaches taken in modeling, participants identified several other drawbacks (Figure 5.3). Eight participants cited “garbage in, garbage out”, referring to the dependency between quality model outputs and quality inputs:

So, it goes back to the models are only so good as the information that goes into them and I think right now some of the areas that have been considered for offshore wind do not have some of that baseline information. [Female, 2 years experience, non-agency stakeholder]

This criticism may stem from several causes. In order to satisfy extensive data requirements, models often combine multiple surveys conducted with different sampling designs, using various survey techniques (e.g., shipboard, aerial, acoustic), and at different scales. Historic data are often incorporated, but have greater error and biases

due to shifting practices in data collection and cataloguing (Graham et al. 2004). In addition, ecological datasets are inherently complex and often characterized by missing values and data anomalies (Michener et al. 1997, Michener and Brunt 2009). Models that are fit with incompatible or inadequate data produce more ambiguous results (Elith and Leathwick 2009).

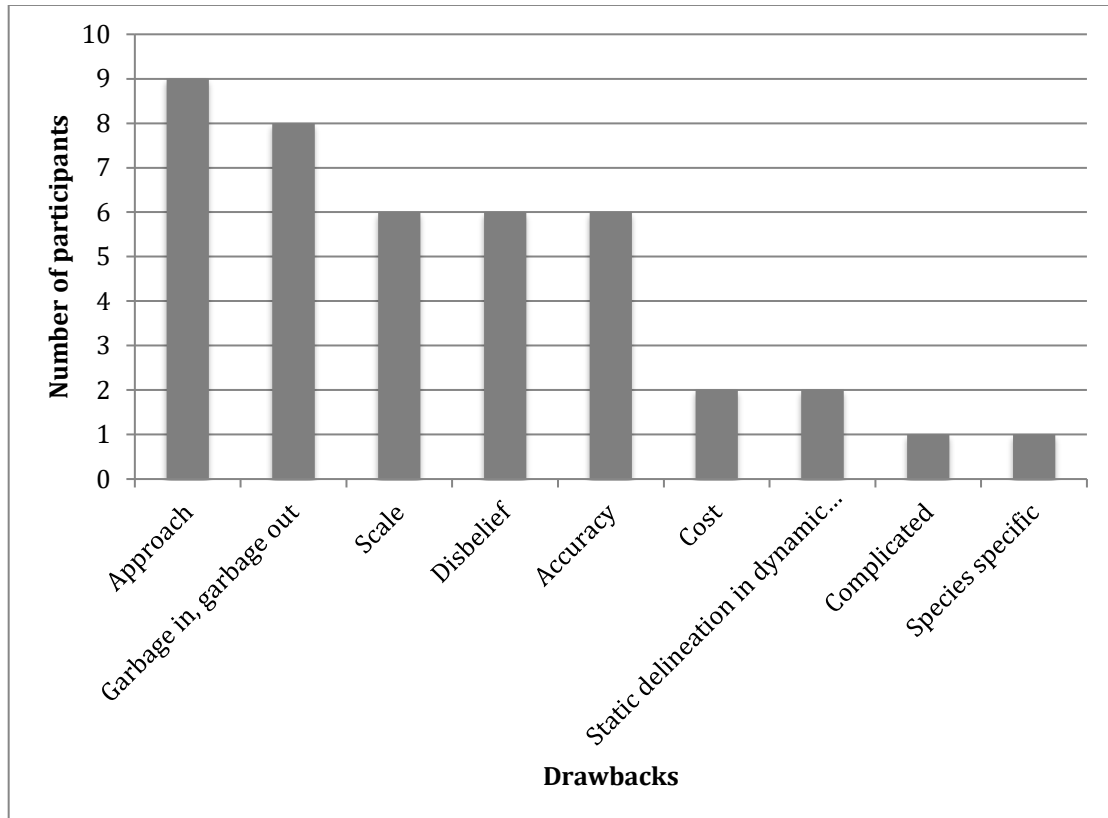


Figure 5.3: Drawbacks of using species distribution models in environmental impact assessments of offshore wind energy projects, as identified by interview participants. More than one drawback may have been given per person.

The importance of scale in species distribution modeling is frequently discussed in the literature (Guisan and Zimmerman 2000, Guisan and Thuiller 2005, Redfern et al. 2006, Elith and Leathwick 2009) and six participants expressed concerns in the interviews. It is critical that the scales of the predictor and response variables are in agreement to accurately represent patterns or processes (Mackenzie et al. 2013).

Mismatches can occur between the resolutions at which environmental variables are sampled versus the resolutions at which species data are collected. For example, sea surface temperature (SST) data is often correlated to cetaceans' presence (Pendleton et al. 2012, Gowan and Ortega-Ortiz 2014, Roberts et al. 2016). SST is frequently collected using remote sensing platforms that use specific resolutions (e.g., MODIS uses 1 km, 4.6 km, 36 km, and 1°, AVHRR-Pathfinder uses 4km, and GHRSSST uses 5.5km, 27.7 km, or 55.5 km) that are different than those used for spatial analysis of species data (1km is used in Pendleton et al. 2012, 5.56km and 7.52km are used in Gowan and Ortega-Ortiz 2014, 10km is used in Roberts et al. 2016). Furthermore, a spatial scale mismatch may exist between the offshore wind EIA (i.e., the area assessed is often limited to the footprint of the project, approximately 37 – 187,000 acres; USDOJ BOEM 2016) and the species distribution models (i.e., modeled area is larger, at regional scales; Pendleton et al. 2012, Gowan and Ortega-Ortiz 2014, Roberts et al. 2016).

A lot of it is not at the resolution we like. Matter of fact, we could probably say that for a lot of models. They are very good at broad regional based planning and looking at hot spots but when we are getting down to very specific sites, the resolution isn't as good as we would like in some of those cases. [Male, 8 years experience, lead agency]

Scale is of particular concern when modeling highly mobile species, such as migratory cetaceans, that have different habitat requirements at various life stages (e.g. foraging, mating, or calving). Models must either: ensure all habitat types are included in one model by using larger cells or fit separate models for each type of habitat use (Guisan and Thuillar 2005).

Key informants also reported that stakeholders and regulators did not believe in species distribution models.

I think the drawbacks are everyone believing what the model says - even the regulatory agencies. We can ask for modeling and then if the modeling shows there is not going to be an impact, we have to move forward with that best information that we have to make a decision. And I think the regulatory community does have a lot of ... they are hesitant. They are hesitant to do that. To make decisions based on models as opposed to actual sampling. [Male, 6 years experience, cooperating agency]

This perception may arise from the increasing complexity of models, making them less transparent and understandable to laypersons (Hartley and Robertson 2006). In addition, model results may not represent actual environmental conditions visible to stakeholders, leading to suspicion and mistrust (Hartley and Robertson 2006). Skepticism may also derive from decision-makers who have had bad experiences with models in the past such that models overpromised and exceeded their actual abilities (Rose and Cowan Jr. 2003) or were believed to be actual representations of reality, instead of purposeful tools (Starfield 1997). Fisheries management has a long history of using population models to make management decisions, sometimes with debilitating consequences (Rose and Cowan Jr. 2003). According to one interviewee, this mistrust in modeling prevents decision-makers from using models as the foundation for regulatory rules:

I can see a scenario where we can be challenged if it is a situation where we are making decision on... where we're relying on habitat models... you know, because it is a model, I can see a scenario where that would be challenged by the industry, since it is a model. I think that would be a potential drawback. Not a drawback of the habitat modeling, but a drawback to the potential for us to rely on habitat modeling in our authorizations. [Male, 2 years experience, cooperating agency]

Drawbacks cited by participants could potentially limit the influence and utility of species distribution models in impact assessments. Methods of improving modeling approaches, to include incorporating quality data, are thoroughly detailed in the literature (Gusian and Zimmerman 2000, Guisan and Thuiller 2005, Elith and Leathwick 2009).

Similarly, recognition of the importance of scale and discussions of which scales should be developed in models is well discussed (Gusian and Zimmerman 2000, Guisan and Thuiller 2005, Redfern et al. 2006, Elith and Leathwick 2009). Sentiments of disbelief or mistrust reflect a larger issue of how science informs policy. Recommended steps may be taken by data gatherers, modelers, regulators, and funders (often federal agencies, which may or may not be the same ones as the regulators) to ensure that modeled outcomes inform regulatory decisions. Regulators and funders must clearly define their overall objectives and delineate expectations of how models will fit into the larger policy scheme. Data gatherers and modelers must adhere to sound approaches in survey design and model development and clearly explain operations and outcomes of models. Modelers should interpret results for regulators and funders, include uncertainties and limitations of the science, and guide how the information may be used (Sullivan et al 2006). Technical language should be simplified for understanding by laypeople without compromising functions of models. In some cases an interpreter may serve as an intermediary to ensure accuracy and that best use of the data informs assessments and management decisions (Bielak et al. 2008, Holmes and Clark 2008). Clear communication is essential to overcome this drawback of disbelief, as it is one of perception and not of a technical nature.

5.4 Conclusion

Species distribution models have been successfully used for designing ecological networks at large spatial scales (Bani et al. 2002), strategic conservation planning (Margules and Pressey 2000), and to a limited degree in impact assessments (Gontier et

al. 2010). Model use to characterize the distribution of species in EIAs is an improvement over traditional, simpler methods that rely solely on distribution maps and encounter rates derived from costly surveys with imperfect detection probabilities and limited coverage (Redfern et al. 2013). However, key informants identified species distribution models as another “tool in the toolbox” to reference in analyses of potential environmental impacts of offshore wind projects, and should not solely be relied upon to inform impact assessments. According to participants, they reveal data linkages not seen elsewhere and may provide predictive capabilities. Criticisms of modeling approaches, scale mismatches, and disbelief limit their impact and utility. Furthermore, confidence that predictions and projections of cetaceans’ distributions will hold for multi-decade projections in novel environments altered by climate change is limited (Silber et al. 2017). Skepticism of models revealed by key informants necessitates clear communication of expectations and outcomes among scientists, modelers, regulators, and funders in order to maximize the value that species distribution models may contribute to EIAs.

CHAPTER 6

SYNTHESIS

Renewable energy sources, such as biomass, hydro, wind, solar, and geothermal, are essential technologies for electricity production. Countries around the world are switching from fossil fuel technologies to renewables in order to reduce greenhouse gas emissions, improve public health, and diversify energy supplies (Ellabban et al. 2014, Buonocore et al. 2015). This switch has been made increasingly attractive due to declining costs (Lazard 2017). A mix of renewable technologies is required for a reliable and affordable energy supply, and wind energy can serve as one component. Specific environmental and economic benefits of wind power include low-carbon emissions over a life cycle, negligible emissions of mercury, nitrous oxides and sulfur oxides, and disassociation from volatile fuel costs (Snyder and Kaiser 2009). Offshore wind, a sub-sector of the wind industry, provides additional unique benefits. Wind speeds tend to be faster and steadier offshore than on land, yielding large increases in energy production and a more reliable source of energy (Manwell et al. 2010). Furthermore, offshore wind farms can be located close to densely populated coastal areas, meeting their higher energy needs (Manwell et al. 2010).

6.1 U.S. Offshore Wind and NEPA

Environmental, economic, and social benefits support the development of offshore wind; however, it should not be accomplished without thorough analyses of all potential impacts, both positive and negative. Environmental catastrophes during the mid-20th century - cities choked by toxic smog, rivers on fire from pollution, and crops

smothered by toxic pesticides – led to the passage of landmark legislation in the U.S., the National Environmental Policy Act of 1969 (NEPA; Caldwell 1998). NEPA established a national policy to protect the environment, created a Council on Environmental Quality, and required preparation of environmental impact assessments (EIAs; the collective term used here for environmental assessments and environmental impact statements). EIAs comprehensively describe characteristics of major federal actions, as well as possible effects on the surrounding environment, to include social, cultural, economic, and natural resources. Major federal actions may include construction projects, plans to manage and develop federally owned lands, and federal approvals of non-federal activities such as grants, licenses, and permits, such as the leasing of federal outer continental shelf areas for offshore wind projects.

Houck (2000) argues that the EIA is NEPA's greatest contribution – the one provision that demands research, awareness, and dialogue. EIAs have influenced environmental conservation efforts through improved decision-making and citizen participation (CEQ 2007). Prior to NEPA, major federal actions were not required to have a comprehensive review of their potential impacts (Caldwell 1998). Cost-benefit analyses and risk assessments incorporated some of the information now considered standard in an EIA, but EIAs expanded their scope and content to drive - not just inform - decisions (Caldwell 1998). NEPA documentation establishes boundaries, reveals information, attempts to understand processes and impacts, and assesses alternatives, all elements of effective decision-making (University of Massachusetts Dartmouth 2018).

Provisions of NEPA and associated Council on Environmental Quality (CEQ) regulations that require public participation in the EIA process have also advanced

conservation efforts. Covello and Allen (1992) argue that it is the right of citizens in a democracy to “participate in decisions that affect their lives, property, and the things they value”. The public’s knowledge, concerns, and attitudes contribute to more credible assessments that are developed through more informed decision-making (NRC 2008). In addition, the focus of conservation efforts over the last decades has shifted from single species or single issues to an ecosystem-based management (EBM) approach, defined as an integrated approach to ocean management that considers entire ecosystem, including humans (McLeod et al. 2005). This approach requires systems thinking and consideration of cultural factors (Wilkinson 1992) that are enhanced through public participation and collaborative learning (Daniels and Walker 1996).

Despite the positive influences of EIAs, they have also been criticized for their failure to define spatiotemporal scales, failure to adequately assess effects on biodiversity, lack of well-defined methods, encyclopedic nature, poor quantitative nature, and difficulty in addressing cumulative effects (Thompson et al. 1997, Byron et al. 2000, Atkinson et al. 2000, Gontier 2007). EIAs have also been viewed by some as documentation of decisions already made, without true consideration of alternatives and public concerns (Houck 2000). These criticisms result in delays in the permitting process as exemplified by two offshore wind projects that encountered legal challenges based on the failure of EIAs to properly consider potential impacts on biological resources, communities, safety, and navigation (Fisheries Survival Fund et al vs. Sally, 2016, Cape Wind 2014).

The U.S. offshore wind final net technical resource is estimated at 2,059 GW (Musial et al. 2016), but the vast majority of it remains unrealized. Numerous reviews

cite a complex permitting process, which includes NEPA, as one reason for lack of development (Van Cleve and Copping 2010, Musial and Ram 2010, Tierney and Carpenter 2013, Navigant Consulting 2014, USDOE 2015, USDOE and USDO I 2016). NEPA documentation requires baseline biological data such as the presence of threatened or endangered species, species' characteristics, and habitat descriptions to inform analyses of potential impacts of projects upon resources. The quality and availability of biological data to inform NEPA analyses may be key factors in deterring the development of offshore wind. This thesis employed a variety of approaches, including semi-structured interview, criteria analysis, and case studies, to answer the following questions:

1. Are insufficient biological data impediments in NEPA documentation for offshore wind projects?
2. How well do NEPA assessments of offshore wind projects include spatiotemporal scales of cetacean data, as compared to federal requirements?
3. Could the marine spatial planning (MSP) process and its outcomes address data impediments in NEPA documentation for offshore wind projects?
4. Could cetacean habitat models provide appropriate data to improve offshore wind NEPA documentation?
5. Could MSP prove useful to expedite the offshore wind permitting process? What are limiting factors of incorporating it into the U.S. regulatory process and how might these factors be overcome?

6.2 Biological Data Issues Exist

Semi-structured interviews of key informants in the offshore wind energy and MSP sectors identified the biological data that informs offshore wind NEPA documentation as insufficient. Participants cited incomplete species-specific data (e.g., seasonality of presences), uncertainty of data, lack of understanding of stressor effects on receptors, and mismatched scales as impediments in the impact assessment process. A criteria analysis of eight U.S. offshore wind energy EIAs found that spatiotemporal scales of biological data in published assessments for offshore wind were problematic. The EIAs did not consistently or comprehensively address spatiotemporal scales of stressors, receptors (specifically cetaceans), and effects, with respect to requirements found in NEPA and the implementing regulations. This study marks the first time that these guiding references were used to evaluate EIAs. Early experiences of the U.S. offshore wind industry demonstrate that projects will be delayed if the scales of ecological processes and project activities are mismatched and impact analyses fail to adhere to federal regulations. My analyses revealed that disregard for scale in offshore wind EIAs is not isolated to the two projects involved in litigation, but is a systematic issue that is present in all EIAs to date.

6.3 Approaches to Address Biological Data Issues

EBM is a widely discussed, place-based approach focusing on the chemical, physical, and biological interactions of all ecosystem components instead of focusing on a single species, sector, or concern. However, a review by the Convention on Biological Diversity found that EBM stagnated in the concept stage and was never fully

implemented due to barriers such as lack of operational tools, practical measures, and concrete guidance (Douvere 2008). MSP is a related concept that can achieve similar ecological objectives within a practical framework.

Specifically, MSP can be used to address data issues identified in EIAs of offshore wind, as well as to advance the offshore wind industry. MSP can also advance the ecological objective of reducing human-environment conflicts, such as over-fishing, loss and destruction of habitat, and pollution, by supporting a collaborative, cross-sector approach to planning (Douvere 2008). Emphasis is placed on stakeholder engagement to understand the spatial and temporal scopes of human uses. Finally, MSP enhances understanding of the baseline state and function of the marine environment through the steps of defining and analyzing existing and future conditions. Data initiatives undertaken to define these conditions have resulted in online databases and portals that increase access to data and analyses to understand ecological processes.

A case study approach was used to examine how biological data were collected, analyzed, and presented in relation to MSP processes and offshore wind development in Germany, Scotland, and Rhode Island. Biological data activities conducted as part of, or in association with MSP supported the needs of offshore wind in varying degrees among the three case studies examined. The national data initiative in Scotland, Marine Atlas, informed their national marine plan (NMP), but offshore wind development preceded both the Marine Atlas and NMP. The NMP did designate future areas for offshore wind development, supporting the growth of this sector. In contrast, Germany focused intensive data efforts early in the offshore wind planning process that streamlined integration of offshore wind. These data initiatives informed subsequent national MSP

efforts, which established areas for later phases of offshore wind development. In Rhode Island, data efforts as part of MSP directly correlated to development of the first and only offshore wind project in the U.S.

The utility of MSP to address the issues of biological data in EIAs was also examined through semi-structured interviews of key informants. These individuals identified several outcomes of MSP associated with data, including production of data products and reduced cost of data collection that could increase availability of data for analyses in EIAs. Other identified benefits included: identification of data (i.e., sharing and collation of existing data), recognition of data gaps (i.e., by analyzing collated data and comparing them to identified data needs), and fulfillment of data gaps (e.g., through identification of existing data or coordinated future surveys). Furthermore, participants identified other benefits and outcomes of MSP such as improved decision-making, increased efficiency in the planning process, reduced conflicts among stakeholders, improved communications, and development of a common operating picture. Increased communications among stakeholders and a common operating picture are foundations of consensus building, a systematic practice that brings together stakeholders of different interests. Consensus building could minimize conflicts among traditional (e.g., commercial fishing) and non-traditional (e.g., offshore wind) sectors, allowing better decision-making through an informed process that is supported by best available scientific data.

Most key informants agreed that MSP could help address data issues in NEPA documentation by providing a strategic framework for the systematic identification, collection, collation, analyses, application, and management of data in the offshore wind

environmental regulatory process. However, they cautioned that wind energy developers and regulators should not ignore other data sources and depend solely on MSP-related data portals for environmental reviews. Furthermore, processes must be established and responsible entities identified to ensure the data in portals is updated regularly.

The utility of species distribution models (also called habitat suitability models, species–habitat relationships, and habitat models) to address issues of biological data in EIAs was also examined through semi-structured interviews of key informants. Species distribution models seek to relate species occurrence to aspects of the physical, chemical, or biological environment (Guisan and Zimmermann 2000). Many key informants stated that species distribution models are just another “tool in the toolbox” for regulators to reference in their analyses of potential environmental impacts of offshore wind projects, and should not be solely relied upon to inform EIAs. Models reveal data linkages not seen elsewhere and may provide predictive capabilities. However, criticisms of modeling approaches, scale mismatches, and disbelief in their results limit their impact and utility. Skepticism of models disclosed by key informants necessitates clear communication of expectations and outcomes among scientists, modelers, regulators, and funders in order to maximize the value that species distribution models may contribute to EIAs.

6.4 Additional Approaches to Address Biological Data Issues

Development of offshore wind in the U.S. requires balancing environmental impacts including potentially adverse ones in local areas and advantageous ones on the global scale such as reducing greenhouse gas emissions to mitigate climate change. Future research and data collection regarding offshore wind should support our duty to

conserve the marine space, while allowing for the responsible development of offshore wind. This dissertation set out to examine MSP and species distribution models as two techniques to address data issues. However, during the course of this research, other ideas emerged that should be considered for follow-on study.

Historically in the U.S., federal and state government agencies sponsor research at regional and coastal scales (e.g., Cetacean and Turtle Assessment Program and Atlantic Marine Assessment Program for Protected Species) while developers focus on site-specific research in the area of interest for development. Baseline data, such as species or sea ice presence/absence, may be collected by multiple entities in the same area since each developer considers this information to be proprietary. A more collaborative process whereby basic data is held in a central repository would increase overall knowledge and advance the permitting process. Precedent exists for sharing of ostensibly proprietary information. For example, the Collaborative Alaskan Arctic Studies program was a partnership of Shell Exploration and Production Company, scientists, and village representatives who collaborated on studies related to baseline conditions and effectiveness of mitigation measures in the Chukchi and Beaufort Seas. When Shell withdrew from the area, study priorities remained with the Collaborative for use by other developers, federal and state agencies, and others (North Slope Borough 2018).

Applied research that specifically addresses data gaps to assist developers in navigating the permitting process should also be undertaken to address data issues in EIA. Directly addressing the needs of industry may also encourage their contribution of research funds, much needed in today's funding climate, as long as biases do not result. The Joint Industry Programme (JIP) is an example of such a program. A diverse group of

international oil companies and the International Association of Geophysical Contractors founded JIP to identify and conduct research that improves understanding of the potential impact of sound from exploration and production on marine life. JIP funds international scientists to conduct research regarding sound source characterization and propagation, physical and physiological effects and hearing, behavioral reactions and biological significant effects, mitigation and monitoring, and research tools. Scientists must submit papers to scientific journals and release their data to the public, thus increasing the transparency and application of the research. This industry-led initiative benefits other sectors as well, minimizes conflict, improves decision-making, and creates mutually supportive situations. A similar initiative, led by offshore wind developers in the U.S., could potentially streamline the data needs and permitting process toward development.

The Bureau of Ocean Energy Management (BOEM) recognizes the need to streamline the preparation, review and, analyses of environmental information required under NEPA (English et al. 2017). Some data gaps are being addressed through BOEM's Environmental Studies Program, which develops, funds, and manages scientific research regarding physical oceanography, atmospheric sciences, biology, protected species, social sciences and economics, submerged cultural resources and environmental fates and effects. Furthermore, English et al. (2017) conducted a systematic review and synthesis of European offshore wind monitoring efforts, impact analyses, and mitigation data to understand international best practices, reduce uncertainties, and identify critical data-gaps that require further study specific to the U.S. Europe is the global leader in offshore wind technologies, having installed the first turbines in Denmark in 1991. Many lessons can be learned from the Europeans' twenty-five years of experience, including

incorporation of the design envelope approach into the construction and operation plan (COP). In early 2018, BOEM adopted this approach in the U.S. permitting process, allowing lessees to include a reasonable range of project designs in a COP to account for potential project complexity, unpredictability of the environment, and the rapid pace of technological development within the industry (USDOJ BOEM 2018). The EIA associated with the construction and operation plan will then assess the potential impacts across the range of project designs by using a “maximum design scenario” process that analyzes the combination of design parameters that will cause the greatest impact for physical, biological, and socioeconomic resources (USDOJ BOEM 2018).

As the offshore wind energy sector expands, baseline information on biological resources will grow, data gaps will be addressed, and impacts will be better understood. If data support it, a categorical exclusion to portions of the NEPA process should be considered for offshore wind projects. Under this provision, a federal action may be "categorically excluded" from detailed environmental analysis if the federal action does not individually or cumulatively have a significant effect on the human environment (40 C.F.R. § 1508.4 1986). Federal agencies are required to substantiate the designation with applicable scientific data in a review process; therefore, categorical exclusions do not absolve industry or regulators from conducting thorough environmental studies. CEQ authorized the use of this provision to encourage efficiency in the NEPA process, reducing unnecessary time documenting routine activities (Moriarty 2004). Precedent exists for the use of categorical exclusions in major marine infrastructure projects. Certain activities related to the exploration of offshore oil and gas have been categorically excluded from NEPA documentation since the 1980s (USDOJ MMS 2004).

6.5 Advancing Offshore Wind

Although MSP in the U.S. can help resolve data issues in NEPA documentation for offshore wind energy, its current implementation differs significantly from common theoretical framework.²⁵ MSP was implemented through Executive Order 13547 - Stewardship of the Ocean, Our Coasts, and the Great Lakes, without congressional support, authorizations, or appropriation of funds (Gopnik 2015). According to federal guidance (the National Ocean Policy Implementation Plan and the Marine Planning Handbook, National Ocean Council 2013a, 2013b), existing mandates and authorities of federal agencies do not change to accommodate the goals of MSP. Furthermore, despite the original executive order that called for the development of coastal and marine *spatial* plans, current federal guidance for MSP does not even mention the term ‘spatial’. Both the Northeast and Mid-Atlantic regional planning bodies also removed the term from their final plans, referring to them as an ‘Ocean Plan’ and ‘Ocean Action Plan’ respectively. Furthermore, no key informant in the semi-structured interviews identified a marine plan or marine spatial plan as an outcome of the MSP process, focusing instead on data sharing and consensus building.

Ocean zoning is a fundamental feature of theoretical MSP (Ehler and Douvère 2009), was employed in numerous international plans (e.g., Germany, Scotland), and U.S. state plans (e.g., Rhode Island, Massachusetts), and should be considered in U.S. regional plans (BSH 2009a and 2009b, CRMC 2010, Scottish Government 2015, Commonwealth of Massachusetts 2015). Zoning could streamline integration of new

²⁵ The steps identified by Ehler and Douvère (2009) include: identifying the need and establishing authority, obtaining financing, organizing through pre-planning, organizing stakeholder participation, defining and analyzing existing conditions, defining and analyzing future conditions, preparing and approving the spatial management plan, implementing and enforcing the spatial management plan, and monitoring and evaluating performance. Few of these are included in the US approach.

users into the marine space, align ocean interests, and attain healthy ecosystems (Eagle et al. 2008, Yates et al. 2015). Zoning of ocean space does not necessarily limit use for a single purpose. Compatible uses may be possible, given spatial and temporal scale considerations. For example, offshore wind projects may be collocated with recreational fisheries, tourism activities, fishing exclusion zones, or aquaculture. In addition, zoning may be beneficial to industries by improving fisheries management (Janßen and Schwarz 2015) and allowing cost-benefit analyses of marine sectors to improve our understanding of their relative economic value (Jay 2017). Traditional marine users, who may feel encroached upon by new users such as offshore wind, resisted attempts to zone at the regional scale and lobbied for this position at the federal level (Interviewee: Male, 37 years, cooperating agency). Opponents to spatial allocation should be re-engaged to determine whether the concerns and attitudes that removed zoning from U.S. federal policy five years ago still exist. Cultural nuances of the U.S. political system should be considered in the context of these discussions. Even if this resistance is still present, the opportunity for zoning to be considered may be present in the future. The designation and leasing of Wind Energy Areas, identified through state task forces, is a zoning concept that should be continued in areas that have not yet designated them, such as the West Coast.

MSP legislation that details funding allocations and authorities should be reintroduced to strengthen the value of MSP in the remaining regional planning bodies. State-level examples, such as the Rhode Island Ocean Special Area Management Plan, show that a government-led and funded entity, in this case the Coastal Resource Management Council, working with resource users, researchers, environmental and civic

organizations, and local, state and federal government agencies, can conduct a traditional MSP process with success, even within the cultural climate of the U.S. Spatial planning has occurred for some time on publicly-owned lands. By recognizing the similarities and differences between marine and terrestrial spaces, lessons can be learned to adapt appropriate terrestrial governance structures and practices to the marine context (Gopnik 2015).

In addition to the potential benefits of MSP, this research revealed that offshore wind development is accelerated when nations have explicit renewable energy policies. Policy options include targets, feed-in policies, auctions, regulatory mandates, changes in building code, fuel efficiency standards, and grants, loans and subsidies (REN21 2017). Despite 71% public support for alternative energy as a solution to solve the nation's energy problems (Gallup 2017), the U.S. does not have a federal renewable energy policy to support the development of renewable technologies. However, 29 states, 3 territories, and the District of Colombia do have renewable portfolio standards including a regulatory mandate to increase production of energy from renewable sources (Zhou 2015). These standards are credited with the advancement of the terrestrial wind energy sector (AWWI 2016) and could do the same for the offshore sector.

Implementing innovative solutions that address U.S. specific issues and incorporating lessons-learned from other settings and nations can help overcome current challenges to advancing offshore wind in the U.S. MSP data portals, species distribution models, collaborative data collection, and industry-focused research are approaches that might overcome data challenges in NEPA documentation. Full implementation of MSP as originally envisioned, at the regional and state levels, could also accelerate the

development of offshore wind in the U.S., positioning the country to become a participant in the global shift towards renewable energies.

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