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Consideration of scales in offshore wind environmental impact assessments

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ABSTRACT

Quality of environmental impact assessments (EIAs) has been criticized, in part due to a lack of accounting in these tools for differing spatial and temporal scales inherent in ecological data. In the United States, leases of outer continental shelf blocks for offshore wind projects and their construction and operation plans require EIAs in accordance with the National Environmental Policy Act of 1969 and the 1978 Council on Environmental Quality Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act. This study evaluated consideration of spatiotemporal scales of stressors, receptors (specifically cetaceans), and effects in eight federal offshore wind energy EIAs against 26 criteria extracted from federal regulations. The criteria analysis determined that EIAs do not consistently or comprehensively address spatiotemporal scales with respect to federal requirements. Deficiencies in addressing spatiotemporal scales may result from imprecise regulations, intent to simplify encyclopedic documents, or lack of data resulting in incomplete assessments, inappropriate mitigation actions, and projects delays. Recommendations to improve compliance with federal regulations include making federal guidance binding, focusing on non-trivial impacts of species, tiering information, and incorporating outcomes of marine spatial planning.

1. Introduction

The offshore wind energy sector in the United States is in its infancy, despite a final net technical resource of 2058 GW (Musial et al., 2016). Project delays have resulted due to litigation regarding challenges to the quality of biological data used in environmental impact assessments (EIAs; Public Employees for Environmental Responsibility, et al., v. Tommy P. Beaudreau, et al., United States District Court, District of Columbia; Fisheries Survival Fund, et al. vs. Sally Jewell, et al., United States District Court, District of Columbia). EIAs, used here to collectively refer to Environmental Assessments (EAs) and Environmental Impact Statements (EISs), have been criticized for failure to adequately account for spatial and temporal scales in environmental data (CEQ, 1993; João, 2002; Gontier, 2007). This is a critical shortcoming, as the issue of scale is a fundamental conceptual problem in ecology (Levin, 1992). Further, 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 amongst scales throughout an EIA can occur in processes, observations, models, and management decisions. Thus, scale issues in offshore wind EIAs are relevant to the completion of projects, and exploration of the role of scale would provide additional context towards improving the quality of EIAs and increasing the sustainable employment of offshore wind energy.

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 km^2), the estuary system plus its tributaries (4000 km^2), or the entire Scheldt river basin (20,000 km^2). The choice of spatial scale influenced several factors in the analysis including the stakeholders involved (e.g., local, regional, and federal governments of the

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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)[1] blocks and approval of site assessment plans by the Bureau of Ocean Energy Management (BOEM), formerly Minerals Management Service (MMS), for development of offshore wind energy projects are considered major federal actions requiring an EA or 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 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 and, for those threatened or endangered, under the Endangered Species Act. For example, the geographic range of the critically endangered North Atlantic right whale (*Eubalaena glacialis,* NARW) overlaps with proposed offshore wind energy project areas off the Atlantic coast of the United States (Hodge et al., 2015, Leiter et al., 2017). 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. 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. Despite this differentiation, the term 'effect' was exclusively used in the criteria of this analysis due to the unequivocal statement in U.S. federal regulation that effect and impact are synonymous (40C.F.R §1508.8(b) 1986). For example, the criterion regarding 'effects identified in all phases of the action' considers all possible effects, ranging in significance from behavioral change to death.

We 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 1; Fig. 1; USDOI MMS, 2007, 2009a,b; USDOI BOEM, 2012a, 2013, 2014a,b, 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 (40C.F.R § 1502.21986).

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.

These eight assessments were compared against 26 criteria (Table 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; 40C.F.R § 1500–1508 1986). In addition, Incorporating Biodiversity Considerations Into Environmental Impact Analysis Under NEPA (hereafter Biodiversity Considerations) 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 (CEQ, 1993).

Common temporal and spatial themes within the referenced federal regulations (Table 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).

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) 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. For example, in the 2012 EA of New Jersey, Delaware, Maryland, and Virginia seven species of cetaceans were identified, resulting in a score of 1 for criterion 11. However, the ranges of only four of these seven species were

[1] OCS blocks are small geographic areas that identify federal land ownership and support offshore resource management. A standard block is 2304 ha (4800 m × 4800 m), except in the Gulf of Mexico, where there are multiple standard sizes, none greater than 2331 ha (USDOI BOEM, 2012b).

Table 1
Federal offshore wind energy project National Environmental Policy Act (NEPA) documents reviewed for the current analyses.

Label in Fig. 1	Document	Date	Location	Phase
1	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
2	Final EIS: Cape Wind Energy Project	January 2009	Massachusetts	Construction and Operation
3	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[a]; Leasing
4	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
5	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
6	EA: Lease Issuance for Wind Resources Data Collection on the Outer Continental Shelf Offshore Georgia	March 2014	Georgia	Leasing
7	Revised EA: Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore Massachusetts	June 2014	Massachusetts	Leasing
8	Revised EA: Commercial Wind Lease Issuance and Site Assessment Activities on the Atlantic Outer Continental Shelf Offshore North Carolina	September 2015	North Carolina	Leasing

[a] 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).

described, resulting in a score of 0.5 for criterion 12 (USDOI BOEM, 2012a). The scores of each criterion 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.

3. Results

Summed scores for each assessment ranged from 9 to 16 out of a possible 26, resulting in 35–62% of criteria being met (Fig. 2). The first published EA, in 2009, of four interim policy leases in Delaware and New Jersey least addressed criteria, with a score of 9 or only 35% of the maximum possible score (Fig. 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 or 62% (Fig. 2). A general increasing trend in percentage of criteria met was seen with assessments published later in time.

Examining the assessments by criterion showed which aspects of spatiotemporal scales were addressed more universally than others (Fig. 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.

The second set of criteria addressed whether temporal scales were applied to project stressors (e.g., vessels, cables, turbines), effects (e.g., collision, EMF, 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 (Fig. 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 (Fig. 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;*USDOI BOEM, 2013; USDOI 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 (USDOI 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

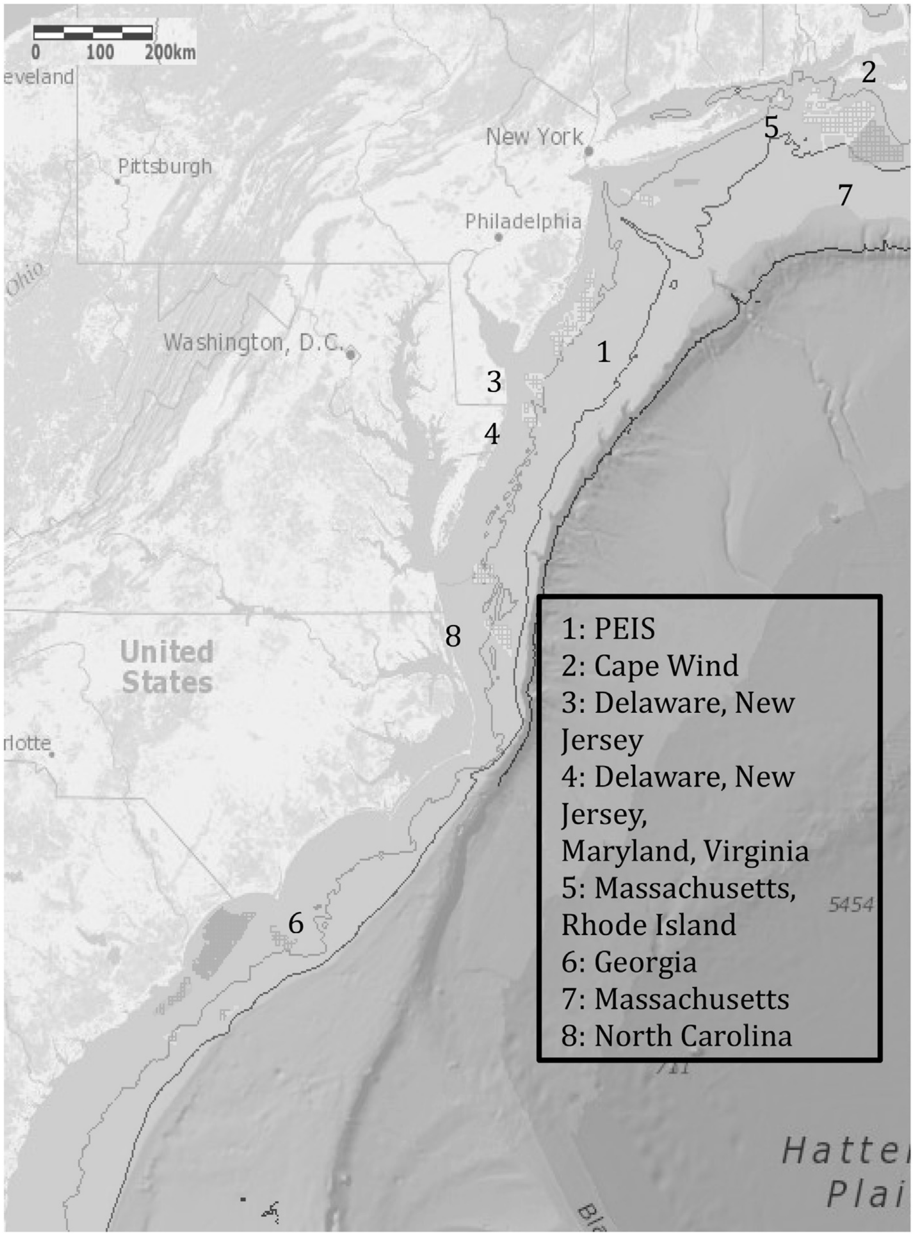

Fig. 1. Locations of potential offshore wind energy sites along the U.S. Atlantic coast in NEPA documents reviewed in this study (source: USDOI BOEM and USDOC NOAA, 2016).

partially identified spatial scales of stressors and effects (Fig. 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 (Fig. 3).

All assessments addressed cumulative effects within the past, present, or future as outlined in the regulations (Fig. 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 (Fig. 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 (Fig. 3). Mitigation actions were thoroughly or partially identified by all assessments in all phases of the projects (Fig. 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.

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 identified throughout the 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). In the early stage of project development, scales may not yet be clearly defined due to uncertainty regarding technological details. Developers and regulators increasingly allow Project Design Envelope (PDE) approach in permit applications or EIAs, which allows for a reasonable range of project designs, including aspects of scale such as the footprint of individual foundations or of an array (USDOI BOEM, 2018). The PDE approach allows improved technologies to be incorporated into project design after the submission of initial applications. As project details are solidified, spatial and

Table 2
Criteria for analysis of federal offshore wind energy NEPA documents.

Criteria	General references to spatiotemporal scale
1	Is appropriateness or importance of scale discussed?
2	Is the term spatial scale referenced to stressors?
3	Is the term spatial scale referenced to receptors?
4	Is the term spatial scale referenced to effects?
5	Is the term temporal scale referenced to stressors?
6	Is the term temporal scale referenced to receptors?
7	Is the term temporal scale referenced to effects?
	Temporal Scales of Stressors and Effects
8	Are project stressors identified in all phases of the action (e.g., planning, construction, operation, decommissioning)?
9	Are effects (e.g., behavior change, injury, or death due to collision) identified in all phases of the action?
10	Are the temporal scales(i.e., short-term or long-term, intermittent or continuous) of stressors identified?
	Spatiotemporal Scales of Receptors
11	Are receptors identified?
12	Are receptors' ranges identified?
13	Are receptors' habitats (e.g., coastal, offshore) identified?
14	Are receptors' biologically significant habitats (i.e., mating, feeding, calving) identified?
15	Is the use of project or effect area by receptor (e.g., transiting, feeding, calving) identified?
16	Is the use of project or effect area by receptor associated with temporal scale (e.g., monthly, seasonally)?
17	Has the range, habitat, or biologically significant habitat of the receptor changed over time (e.g., due to temperature, salinity, Chl *a*)?
	Spatial Scales of Stressors and Effects
18	Are the spatial scales (extent, granularity) of stressors identified?
19	Are the spatial scales (extent, granularity) of effects identified?
20	Does spatial scale (extent) of the effects include possible range, habitat, or biologically significant habitat of receptor?
	Other Topics Relevant to Spatiotemporal Scales
21	Are indirect effects of project stressors (i.e., those "caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable") identified?
22	Are cumulative effects discussed in relation to stressor spatial scale?
23	Are cumulative effects discussed in relation to effect spatial scale?
24	Are cumulative effects discussed in relation to receptor spatial scale?
25	Are cumulative effects discussed in relation to temporal scale?
26	Are mitigation actions identified for all phases of the action?

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

Table 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…" (40C.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)

temporal scales may be more accurately defined. In contrast, 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). The present analysis confirmed a narrow focus in these assessments persists. 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

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 NARW, 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 truncates*), have resident home ranges (USDOI BOEM, 2014c). While non-migratory cetaceans do not exhibit such extreme movements, seasonal variations

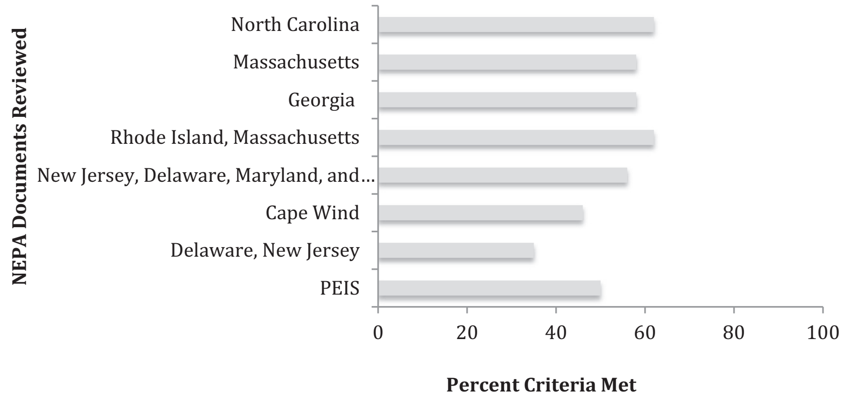

Fig. 2. Results of criteria analysis of federal offshore wind energy project NEPA documents that were reviewed against 26 criteria. A score of 100% would mean that all 26 criteria were thoroughly addressed in the NEPA document.

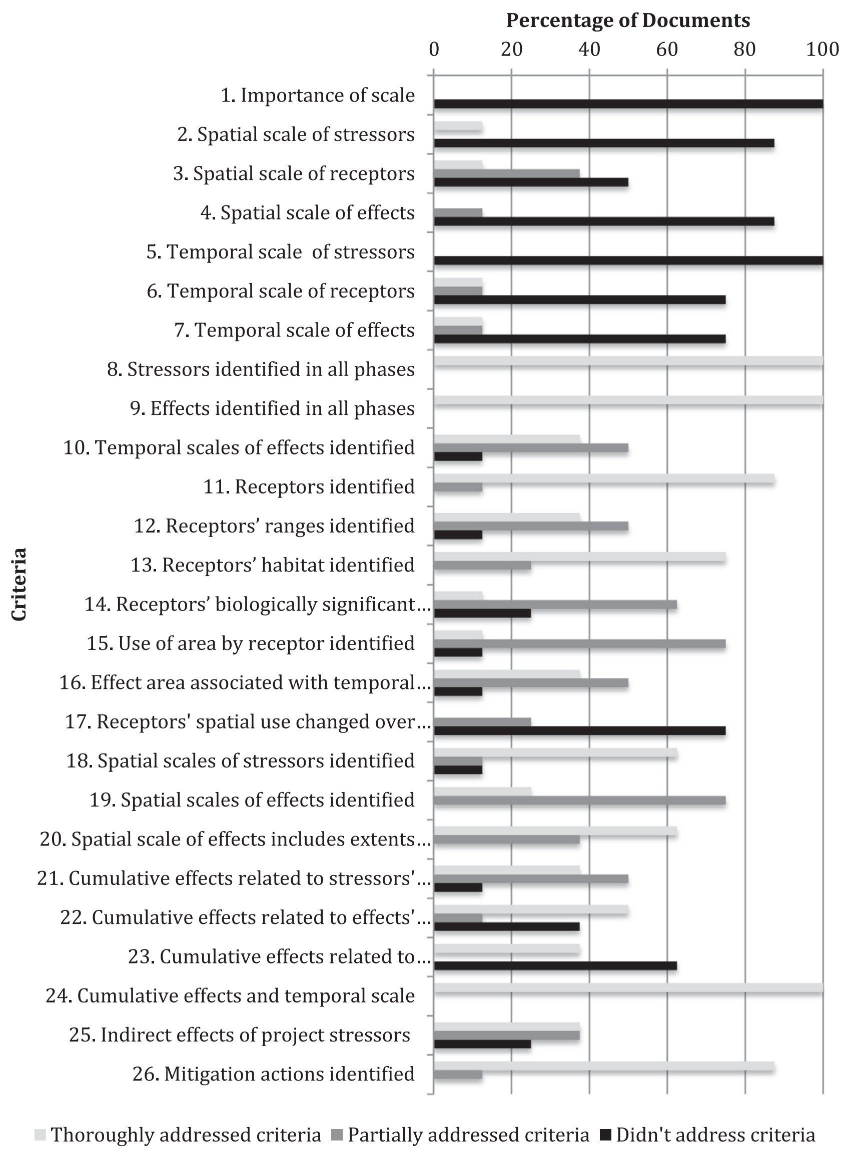

Fig. 3. Criteria analysis results for the evaluation of offshore wind energy NEPA documents. Eight NEPA documents were evaluated by 26 spatiotemporal scale criteria. Each document was assessed as either thoroughly, partially, or not addressing the criteria.

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 past data 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 while lacking spatiotemporal scale information. 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 Douvere, 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. MSP facilitated data efforts during the permitting phase of offshore wind projects in selected regions (Ryan et al., 2018).

5. Conclusions

Fifty years ago, lawmakers proactively incorporated references to scale in NEPA, a pivotal piece of environmental legislation. 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 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 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 experience avoidable delays, and the U.S. will continue to lag in the global offshore wind energy sector.

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