Recommended regional scale studies related to fisheries in the Massachusetts and Rhode Island-Massachusetts offshore Wind Energy Areas

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Introduction

The states of Massachusetts (MA) and Rhode Island (RI) are committed to diversifying the electric grid in New England with offshore wind while maintaining existing ecosystem function and services, including healthy natural resources and water quality, profitable multi-sector marine industries including commercial and recreational fishing industries, safe and efficient navigation, and public access and enjoyment within or adjacent to offshore wind development areas. In the Southern New England (SNE) Bight shelf region between New York Harbor and Nantucket Shoals, there are currently three wind energy areas: the Massachusetts Wind Energy Area (MA WEA), the Rhode Island-Massachusetts Wind Energy Area (RI-MA WEA), and the New York Wind Energy Area (NY WEA). Within these WEAs there are four development leases. At least one more WEA in New York and three more leases in the MA WEA are expected in the coming months. It is difficult to predict the total number of turbines that will ultimately be placed, but the range of initial estimates are based on individual farms that include 15-185 turbines, so a build-out in the next decade could be more than 400 turbines. There is an understanding that broad-scale development of offshore wind could result in ecosystem changes, but **there is uncertainty regarding the impact of these changes on the provision of ecosystem services**. From September to December 2017, three forums were held: the National Academies of Science Ocean Studies Board subcommittee, the Rhode Island Offshore Wind Science Forum, and the University of Massachusetts Wind Collaborative fisheries meeting at the School for Marine Science and Technology (SMAST). Additionally, there were multiple Massachusetts Fisheries and Habitat Working Group meetings and Rhode Island Fisheries and Habitat Advisory Board meetings. There is broad consensus in the northeast that in addition to wind farm-specific impact assessment studies, regional studies should also be undertaken to address the cumulative impact of wind farms expanding across the eastern seaboard on the marine ecosystem and on the distribution of both fish resources and the fishing industry[1]. Conducting regional studies to address the cumulative impact of wind farms at population-level scales is also being called for in Europe (Lindeboom et al. 2015; Willsteed et al. 2017). Further, the National Oceanic and Atomspheric Adminstration's (NOAA) Greater Atlantic Regional Fisheries Office (GARFO) and National Marine Fisheries (NMFS) Northeast Fisheries Science Center (NEFSC) have called for the establishment of a region-wide scientific research and monitoring framework with federal leadership following an ecosystem-based approach at the appropriate scales. This broader framework would complement sub-regional state efforts to most effectively address cumulative impacts and the known and potential future interactions of fisheries and offshore wind energy.

This document attempts to frame the research discussion so fundable studies can be prioritized and designed. In order to create such a framework, we started by identifying the management objectives as recommended in Wilding et al.'s (2017) review of European offshore wind monitoring programs:

> "The identification of spatially/temporally delimited metrics and thresholds, **in line with the overall management objectives**, are the critical components to a logically based monitoring programme" (emphasis added).

On a regional scale, we want to identify what matters, why it matters, whether it can be measured and how, and how the results will be used. The development of a research program is an opportunity to identify where multiple goals (e.g., needs of the wind energy industry, the fishing industry, and the regulatory community) can be met. This report provides information about management objectives in order to help further the development of effective and informative research. Three examples of specific studies that could be funded with a description of how the study could be done and how the results would be used are provided.

The definition of management objectives and the design of the research framework requires stakeholder input to be most effective and transparent. This document was disseminated to the Massachusetts Fisheries Working Group, the Rhode Island Fisheries Advisory Board, the New York Department of Environmental Conservation, the New England Fisheries Management Council Habitat Committee, the Responsible Offshore Development Alliance, the Massachusetts Lobstermen's Association, and the Center for Sustainable Fisheries for a four month public comment period from June to October 2018. Twelve individual responses were received and the response to comments is provided at the end of the document. We have designed this document to serve as a starting point for a regional fisheries science panel to clarify priorities and the appropriate scale at which to conduct various studies.

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[1] The National Offshore Wind Strategy (2016) states, "Continued broad-scale and site-specific baseline assessment will remain valuable as the offshore wind industry develops. Given the expense associated with baseline data collection, it is likely that agencies will need to take an approach that combines site-specific, developer-collected, preconstruction surveys with surveys conducted for other broader scientific reasons."

Overarching Principles

Define the spatial and temporal extent

The MA WEA and RI-MA WEA are the primary focus for this document. However, the fishing industry in this region utilizes fishery resources and fishing grounds between the Gulf of Maine and North Carolina, so has concerns about development along the whole eastern seaboard, and in particular wind energy development in New York. Additionally, fishermen from ports outside of the Southern New England region fish and transit through the MA and RI-MA WEAs. Efforts should be made to extend cooperative regional research related to offshore wind development to include a broad spatial extent across fisheries of concern in multiple states.

The spatial extents that are commonly discussed for regional, cumulative impact studies are the continental shelf from either New York to Nantucket or Block Island to Nantucket. It may be most appropriate to consider study area boundaries based on ecological units (large marine ecosystems), a fish stock boundary, or a fishery region. Wilding et al. (2017) recommends "eco/hydrologically defined boundaries that are relevant to the distribution of the species under investigation." Lindeboom et al. (2015) recommends that "Because the species that are affected are part of populations extending over larger areas, the focus of the impact investigation should be widened to consider the population level of those species." Cooke & Auster (2007) define the Southern New England ecoregion in terms of fish populations and assemblages, bathymetry, circulation and endemism as extending from the Hudson Shelf Valley northeastward to the Great South Channel). The fishery region can be considered the Canadian border to North Carolina, where the New England and Mid-Atlantic Fishery Management Councils develop fishery management plans and assess socioeconomic impacts. However, some potential questions may affect a smaller spatial extent, requiring the development of studies for specific metrics over different spatial extents.

In the temperate North Atlantic, many fisheries are characterized by seasonal migrations and reproductive activities unique to particularly times of year. Therefore, the need for annual, seasonal, or more frequent sampling to address various questions must be considered in study design.

We recommend that studies define the spatial and temporal scales for the metric or question being asked and use appropriate study designs.

Standardize monitoring protocols

Wind developers will be doing site characterization and impact assessment research as required by the Bureau of Ocean Energy Management (BOEM). In order to maximize the effectiveness of the research, minimize the duplication of effort, and leverage resources to get more out of individual projects, it is crucial to ensure that monitoring protocols are standardized for wind farm-specific studies. As long as standard protocols are adhered to, then individual studies can be used to compare wind farms to one another and to explore regional trends. Therefore, data collected by wind energy developers directly through their site specific studies require the monitoring protocols to be identical for all developers. Such standardization will also be necessary to develop Best Management Practices (BMPs) and modify current BOEM guidelines for surveys.

Other studies will require a broader spatial extent than one or two wind energy areas. Such studies will also require the definition of monitoring protocols to ensure that if separate research groups are conducting the work, the data will be appropriately collected and analyzed. These larger regional studies are expected to be supported through a joint funding mechanism.

We recommend that all related studies should be nested together using standard protocols to meet separate monitoring and impact assessment goals.

Leverage existing regional monitoring programs, procedures, protocols, and time series

The Northeast Fisheries Science Center (NEFSC) conducts and maintains fisheries monitoring and research time-series that may be helpful in future design and execution of research endeavors. For example, several topics related to fish condition and reproduction research overlap and dovetail with wind development sites. NEFSC has ongoing time-series that could serve as regional baselines to interpret effects of offshore wind energy development. In addition to the standardization of protocols, **we recommend coordinated sampling and collaboration of expertise** to increase the value of data collected to address formative questions and strengthen the conclusions across a broad regional scale.

Open data

We recommend that all monitoring and research studies commit to an open data policy and adhere to the following principles:

- Research will be communicated
- Data and information will be archived
- Data and information will be available to the public in accessible formats
- Design and execution of collaborative monitoring and research will follow best practices (e.g., Northeast Fisheries Science Center Cooperative Research Program)
- Data confidentiality for sensitive fisheries dependent monitoring data will be maintained

Fish & invertebrate species of interest

The MA WEA and RI-MA WEA encompass diverse communities of fish and other vertebrates, invertebrates, and habitats valuable to continued ecosystem health and exploitation, and worthy of monitoring and protecting. We recommend studies with integrated ecosystem approaches, but we highlight the importance of monitoring specific species as indicators as well. Rather than attempt to study all species potentially impacted by siting and operations of wind farms, we recommend focusing on species of particular interest and value to the region based on economic, biological, cultural or other criteria, as well as anticipated vulnerability to wind farm impacts.

In our consideration of how to select indicator species, we considered the following variables:

1. To have broad representation of the major species groups of commercial value in this area, we considered species in all of the major groups: groundfish, shellfish (including lobsters and crabs), highly migratory species including elasmobranchs, and pelagic forage fishes.
2. Dominance in the federal trawl survey, as indicated in Guida et al. (2017) for both MA and RI-MA WEAs (Table 1) was considered. We recommend focusing on more abundance species for statistical comparisons to be more robust. It may also be appropriate to focus on species found as dominant in multiple WEAs.

Table 1. Dominant species in the NEFSC trawl survey between 2003 and 2014. These species were indicated as dominant in the MA WEA (MA), the RI-MA WEA (RI-MA), or in both (both).

Cold Season (winter and spring)	**Warm Season (summer and fall)**
Little skate (both)	Little skate (both)
Silver hake (MA)	Silver hake (MA)
Winter skate (both)	Winter skate (MA)
Atlantic herring (both)	Butterfish (both)
Longhorn sculpin (RI-MA)	Red hake (MA)
Ocean pout (RI-MA)	Scup (both)
Windowpane flounder (RI-MA)	Longfin squid (both)
Yellowtail flounder (RI-MA)	Spiny dogfish (both)
	Northern sea robin (RI-MA)
	Sea scallop (RI-MA)

3. Species geographic range was considered, with a preference for species in the middle of their geographic range. These species are potentially less vulnerable to climate change, so isolating the effects of wind farms and climate change would be easier. Geographic range was assessed using the Northeast Ocean Data Portal (northeastoceadata.org) data explorer to view the individual species spatial distributions from the NEFSC trawl survey. This list was cross-checked with common species found in the trawl survey as indicated by the number of times the species was caught in the trawl survey between 1948 and 2008 (downloaded from the Ocean Biogeographic Information System). All fish presented in the data portal and all fish with a count in the trawl database of >1000 records were assessed for geographic distribution (see Appendix A).

4. Species with high economic and cultural value and habitat dependence as ranked in NOAA's Regional Habitat Assessment Prioritization for Northeastern Stocks (NMFS 2015). This is more fully described with the associated rankings in Appendix B.
5. Species with identifiable vulnerabilities to the adverse effects of wind farm construction or operation. These descriptions are available in Appendix B.
6. Species vulnerability to climate change was assessed with preference given to species less vulnerable to climate change in order to minimize the complicating effects of changes due to global warming. This assessment was informed by NOAA's Northeast Fish and Shellfish Climate Vulnerability Assessment, which is further described in Appendix B.
7. Species for which the WEAs may provide unique or sensitive habitat. This was assessed by considering what species are resident to these areas (as opposed to migrating through) and spawn in these areas. These descriptions are available in Appendix B.
8. Species recommended by migratory species experts. Consideration was given to the availability of baseline data to help select priority pelagic predators.
9. Species recommended from fisheries experts and public comment were considered.
10. We reviewed the BOEM-funded study that identified fisheries concerns related to offshore wind development, including species of concern and data gaps (Petruny-Parker et al. 2015). The report includes all species mentioned in a series of meetings and surveys of fishermen, managers, and other subject matter experts. The explanation of why each species was listed and basic characteristics of how the species uses the WEAs or might be particularly vulnerable to wind farm construction is identified in the report. The list of species from the report is provided in Appendix C. The list and species information in the report was used to help us prioritize our species of interest list.
11. We reviewed the report from the National Academies of Sciences, Engineering, and Medicine (NAS) workshop on fisheries in the context of the developing offshore wind industry (NAS 2018). The NAS workgroup considered indicator species and NMFS fisheries expert Vince Guida used four criteria for targeting species: (1) that a species is managed, and thus there is a mandate to protect it; (2) that it is limited to rare habitat features; (3) that it has a life stage that is immobile, or nearly so, such that it will be unable to leave an affected area; or (4) that the species is a "habitat engineer" that creates habitats for managed species (NAS 2018). The resulting list of species based on these criteria are Atlantic cod and black sea bass due to their habitat limitations, shellfish (Atlantic surfclam, ocean quahog, and Atlantic sea scallops) due to their immobility, and longfin squid due to their immobile eggmops. Additional species were also recommended by workshop attendees, namely flounder, skate, monkfish, and species involved in predator–prey relationships with key species (NAS 2018). We confirmed that our proposed list was consistent with the species identified in the NAS workshop by Guida and other workshop presenters.
12. We reviewed biological information described in species profiles from EFH source documents, The Fishes of the Gulf of Maine (Collette and Klein-MacPhee 2002), Atlantic Coast Fishes (Robins

et al. 1986), A Field Guide to Coastal Fishes: From Maine to Texas (Kells and Carpenter 2011), scientific literature, fishery management plans, and the authors' general knowledge.

Species we propose could be key assessment indicators for cumulative biological impacts associated with wind farms are Atlantic cod (*Gadus morhua*), summer, winter, and yellowtail flounders (*Paralichthys dentatus, Pseudopleuronectes americanus, Limanda ferruginea)*, monkfish/goosefish (*Lophius americanus*), ocean pout (*Zoarces americanus*), red hake (*Urophycis chuss*), black sea bass (*Centropristis striata*), longfin squid (*Doryteuthis (Amerigo) pealeii*), scup (*Stenotomus chrysops*), Jonah crab (*Cancer borealis*), American lobster (*Homarus americanus*), ocean quahog (*Arctica islandica*), sea scallop (*Placopecten magellanicus*), bluefin tuna (*Thunnus thynnus*), sharks, winter and little skates (*Leucoraja ocellat* and *Leucoraja erinacea*), and prey species (Table 2). The description of why a species might be a good indicator species is available in Table 2. Our interpretation is open to challenge, and this list is not meant to suggest other species never be studied or prioritized. Our development of this list illustrates a prioritization approach and provides additional context for species both on our final list in Table 2 and others as detailed in Appendices A and B. The Appendices describe the process in more detail and provide lists of species considered.

Table 2. Proposed species to monitor to assess adverse and beneficial impacts of wind farm development in the MA and RI-MA WEAs.

Species	Discussion
Atlantic cod	The RI-MA WEA has critical cod spawning habitat for the SNE region. The stock is doing poorly, particularly in SNE. Cod produce sounds, and aggregate to spawn. There are many potential vulnerabilities. In the NAS report, NEFMC staff indicated "that the New England WEAs overlap with the EFH of some species of concern due to their depleted status of lack of data, such as yellowtail flounder, winter flounder, Georges Bank cod, and ocean pout."

Species	Discussion
Flounders (summer, winter, yellowtail)	Winter flounder spawn in this region in the winter/spring and have demersal eggs, strongly demersal so they are more vulnerable to prey changes and damage to seafloor. This species is resident in the WEAs, so this is a good indicator species. Summer flounder spawn in this region in the summer and fall and are found in higher abundances in various places at certain times of year, but are present year-round. Yellowtail flounder spawn in this region. YT catches have gone down (the stock is overfished and overfishing is occurring), disrupting spawning could be more negative for this species. Flounder species were some of the only species to show correlations between the strength of electromagnetic fields from cables and increasing avoidance behaviors around cables, as their catches decreased around charged cables in Denmark (McCann, 2012). Flounders are captured with otter trawls. In the NAS report, NEFMC staff indicated "that the New England WEAs overlap with the EFH of some species of concern due to their depleted status of lack of data, such as yellowtail flounder, winter flounder, Georges Bank cod, and ocean pout."
Monkfish/goosefish	This is an abundant species with low vulnerability to other impacts. It is a directed fishery (i.e. it can be targeted specifically). There is relatively strong baseline data for this species including VMS for the fishery.
Ocean pout	Ocean pout have demersal eggs, strongly demersal so more vulnerable to prey changes and damage to seafloor. Adults congregate in rocky areas prior to spawning and eggs are fertilized internally. Spawning occurs in Sept-Oct in SNE. Spawning congregations and eggs masses could be very vulnerable to disturbance. Spawning occurs on rocky bottoms, so the addition of rock habitat may benefit this species. They are non-migratory. They are principally caught by otter trawls. This cold water fish has higher abundance to the north, and the center of its distribution has shifted north. Due to its potential vulnerabilities and benefits from wind farms, we kept this species on the list. In the NAS report, NEFMC staff indicated "that the New England WEAs overlap with the EFH of some species of concern due to their depleted status of lack of data, such as yellowtail flounder, winter flounder, Georges Bank cod, and ocean pout."
Red hake	A highly popular recreational fishery to our south but not in MA. Stock has been declining. Demersally-oriented. Red hake makes seasonal migrations from deeper water in the winter to shallower water in the summer. Spawning peaks in June and July. Abundant in the RI-MA and MA WEAs and on the shelfwaters to the south. Juvenile red hake live in scallops. Red hake are captured with otter trawls.

Species	Discussion
Black sea bass	Structure associated species that migrates from coastal waters in the summer to offshore waters in the winter. High potential to disrupt current spatial distribution if fish move into wind farm areas due to increased habitat associated with turbine foundations; indicator of reef effect; important management implications if spatial distribution is driven more offshore. Recommend this species be used to answer question if wind farms will affect migratory patterns. BSB have swim bladders so could be particularly sensitive to sound. They are captured with fish pots and handlines but are also captured in otter trawls targeting summer flounder, scup, and longfin squid.
Longfin squid	The WEAs are close to and partially overlap major squid spawning grounds. Squid lay demersally attached egg mops which are vulnerable to direct impacts. How squid spatial distribution might change with the introduction of structures, sound, and lights is unknown and likely. Squid are caught with small mesh trawls.
Scup	Scup are migratory schooling fish, moving offshore in the winter to northern and inshore waters in the summer to spawn. They may be sensitive to sound. Alterations to migratory patterns could impact state management.
Jonah crab	Very high catches in MA WEA area. It is found year-round and spawns in the area. Very little known about the life history and vulnerabilities of this species. Caught with pots.
Lobster	Not clear how lobsters use the area, they used to migrate inshore for spawning but inshore waters are too warm. Likely resident and spawning in the RI-MA and MA WEAs. Need more information about the spatial distribution of the fishery. The reef effect could benefit this species, and fishery spatial patterns are likely to change. Lobsters are known to be sensitive to EMF. Caught with pots.
Ocean quahog	Ocean quahogs are sessile and patchily distributed so potentially very vulnerable to physical impact if turbines and cables are placed in areas of high concentration. Changes to currents could impact spawning and settlement success for this species. Ocean quahogs are captured with hydraulic clam dredges.
Sea scallops	Sea scallops are predominantly fished for elsewhere, however the value of scallops landed from the WEAs still outweighs many other fisheries in this area. Since sea scallops are nearly sessile, they are vulnerable to impact. High concentrations of scallops are needed to support successful spawning and downstream settlement. Settlement could be adversely impacted by subtle changes in currents, including scour and habitat alterations around turbine bases. Scallops are captured with scallop dredges.

Species	Discussion
Bluefin tuna	Highly migratory species (HMS) are found in great abundance in the MA WEA in particular. The presence of new "islands" (i.e. the turbines) might greatly affect a) how long HMS stay in the area, b) foraging success of HMS, and c) how the recreational fishery fishes (currently by drifting and trolling). There is a relatively large amount of information on bluefin tuna so it would be a good indicator species for changes to HMS.
Sharks	Highly migratory species, including many shark species, are found in great abundance in the MA WEA in particular. In addition to the concerns listed for bluefin tuna, sharks may also exhibit unique sensitivity to EMF associated with offshore wind. The blue shark has been suggested to focus on.
Skates (winter and little)	Electrosensitive with potential sensitivity to EMF, their strongly demersal habits, their high abundance, and their geographic distribution south and north of the WEAs make them a good indicator species.
Prey species	Includes species such as sand lance, herring, menhaden, mackerel, epifauna including echinoderms, infauna including worms, gastropods, and amphipods, and plankton. Assessing changes in the food web through trophic studies including stomach content analysis and isotopic studies of predators, as well as oceanographic drivers, is a useful approach to examining shifts in prey species and ecosystem change.

Management Objectives & Research Priorities

Overarching management objective

The states of Massachusetts and Rhode Island are committed to supporting diversifying the electric grid in New England with offshore wind while maintaining existing ecosystem function and services, including healthy natural resources and water quality, profitable multi-sector marine industries including commercial and recreational fishing industries, safe and efficient navigation, and public access and enjoyment within or adjacent to offshore wind development areas.

Individual management objectives and key research questions

This section lays out key research questions that would be useful to assessing impacts of wind farms on a regional scale and creating a quantitative assessment of compatibility with the fishing industries. There are three primary focus areas for research and monitoring: Fishing Industries, Fish Resources and Habitat, and Fisheries Management. Potential regional-scale studies are identified for each focus area to provide examples and additional context. We are not recommending priorities, but instead providing a starting point to consider potential topics and studies for prioritization. Several of the potential studies have design challenges that may limit their effectiveness. Before selecting priorities it is important to consider how the study would be done with existing or new data sources. It will also be useful to consider how each study would be used as an indicator for a management action or mitigation. In the section titled "Next Steps" we provide an example of how a study could be summarized for prioritization.

FISHING INDUSTRIES

Objective: Maximize compatibility of the offshore wind industry with the recreational and commercial fishing industries.

Principles:

- Sustain the economic value of fisheries on a per port basis.
- Sustain domestic and international fishery food products.
- Sustain economic and cultural diversity within fishing fleets and groups.
- Ensure fishing can occur in wind farm areas by mitigating risk of allision (a vessel hitting a fixed object), collision (a vessel hitting another moving object), and fishing gear conflicts with wind farm structures.
- Encourage use of fishing vessels in offshore wind research.

Key research questions and potential regional-scale studies:

1. Spatial and temporal distribution of fishing or revenue generation change:
    a. Where is fishing effort currently distributed spatially and temporally? How will/has fishing pressure change/d inside or outside of wind farms areas?
    b. Will there be /is there more fishing in some wind farm areas than others? Why?
    c. Will there be/are there direct or indirect prohibitions on fishing (e.g., insurance restrictions, turbine spacing, cable protection, radio interference)? What has been/can be done (e.g., develop new radio communications or other technological mitigation)?
    d. How will/has direct or indirect prohibitions on fishing affect/ed other fishing areas? Where will/has displaced fishermen go/ne to fish, and how will/has increased pressure elsewhere affect/ed non-wind farm displaced fishermen? Which fisheries are/were the most impacted?
2. Catch composition change in wind energy areas:
    a. Commercial fisheries target and non-target catch.
    b. Recreational fisheries target and non-target catch.
    c. Do/have some wind farms have/had less change than others (and why)?
3. Trip costs change:
    a. What are/will be the impacts of these changes? What is/will be the cost associated with these changes?
    b. Have/will insurance rates go up?
    c. Does/will fishing take longer?

        i. Do/will fishermen have to travel longer?
        ii. Has/will this impact CPUE?
        iii. Does/will the process of fishing take longer?
    d. Have/will gear conflicts occur? What are/will be costs associated with gear and lost fishing time/catch?
4. How have/will fishing practices change in response to fishing in wind farms, changes in species composition, or changes in trip costs?
    a. Innovation in gear, monitoring equipment, and operational handling associated with fishing in wind farms
    b. Training needs and opportunities (e.g., develop curricula at SMAST, Bristol Community College, Northeast Maritime, Mass Maritime, or Commercial Fishing Research Foundation (URI))
5. Are/will BOEM and wind energy developers communicating effectively with the fishing industry?
    a. Develop communication and tracking mechanisms such as a hotline for impacts, snags (especially on cables), lost gear, user conflicts. Do interactions with cables, allision, collision rates increase, what BMPs reduce rates?
    b. Enable opportunities for fisheries development and outfitting vessels (e.g., improved equipment and training for fishing within wind farms, fishing gear and protocol research).
6. Do wind farms impact economic value and diversity of individual ports?
    a. Determine if an acceptable economic baseline already exists or needs to be developed to describe fishing revenue associated with individual wind farms or Wind Energy Areas. Groundfish, scallops, surf clam/ocean quahog, squid, fixed gear (lobster, whelk, crab), recreational fisheries. Explicitly include linkages to shoreside revenue and job producing infrastucture required to support fishing. See RIDEM (2017) and Kirkpatrick et al. (2017).
    b. Describe fishing revenue including multiplier effects from each WEA as it pertains to individual ports.
    c. Describe economic diversity of each port.
    d. How will/have landings change? Has/will economic value of fishing shift from one port to another?
    e. Can new fisheries be promoted to augment or supplant fishing in wind energy areas? Can wind farms be used to augment fisheries resources (i.e., are there stocking or seeding opportunities for certain species)?
    f. Is financial or policy support needed to enhance the ability of fishing companies to include wind farm support services in their portfolio?
7. Will/have wind farms impact/ed the cultural identity in ports?
    a. Which ports will be/have been disproportionately affected by loss of fishing revenue?
    b. Will/have any ports experience/d a gain in revenue? What is the cause of discrepancies in revenue among ports?

c. Which ports will be heavily used by construction and operation – is there room/infrastructure to maintain access for both industries?

FISH RESOURCES AND HABITAT

Objective: Maximize benefits of offshore wind energy production (such as carbon-free energy sources and production enhancement from the artificial reef effect) while maintaining fish populations and biological community structure.

Principles:

- Do not disrupt or destroy high value resources, habitats, or events (e.g., spawning, aggregations) and minimize temporary disruption of these (resources and habitat are broadly defined and may include biological and non-biological aspects).
- Do not adversely affect water quality (including turbidity, chemicals).
- Prepare response plans for potential acute events such as a spill.

Potential studies should focus on how construction, operation, and decommissioning impacts (e.g., noise, vibration, turbidity and smothering, change in seafloor topography, scour, changes to currents, shading, electromagnetic fields (EMF), vessel traffic, direct impact from pilings and anchors) affect species and habitats of interest.

It will be beneficial to know the individual wind farm plans for site selection, baseline, and long-term monitoring to consider the scale of studies and the relative value of using before-after-control-impact and gradient study designs (Ellis and Schneider 1996; Petruny-Parker et al. 2015). Observational and monitoring studies should also have clear objectives and appropriate methodology to measure the phenomenon of interest and meet objectives.

Key research questions and potential regional-scale studies:

1. Will/have key biological indicators change/d?
    a. Measure species composition, biomass and abundance of at multiple scales (individual wind farms, WEAs, in gradients across the affected areas, and the region); examine changes. Do some wind farms have less of an impact than others? Why?
    b. Examine fish condition (stomach content/growth rate/fecundity/energy content/etc.) for species of interest.
    c. Examine spatial distribution of species of interest over time; focus on species with minimal spatial and temporal variability (i.e. the greatest persistence).
    d. Analyze impacts to pelagic to demersal ratio for individual wind farms and region-wide.
    e. Assess benthic biomass and species composition (including infaunal, epifaunal, and fouling) on a WEA and region-wide scale (e.g., Northwest Atlantic Ecoregional Assessment (Greene et al. 2010)).

f. Examine abundance and presence of invasive and/or opportunistic species across wind farms
    i. Do/will some farms have more or less invasive species? Why?
    ii. What is consistent across wind farms with respect to invasives, jellyfish, mussels, tunicates, other?
g. What is/will be the gradient of change as you move away from individual turbines and/or wind farm areas? What is the distance of detectable habitat changes?
h. Compare wind farms to determine if one wind farm has less impact than another? On what indicator? Can we elucidate why?

2. Has/will ecosystem/habitat change?
    a. Describe and quantify ecosystem/habitat by identifying the location, timing, quantity of key seafloor and water column habitat features, including moraines, bedrock outcrops, ledges and canyons, flats, depressions (e.g., the Mud Hole), location of fronts and tide rips, persistent high chlorophyll a areas, known spawning areas, corals, sponges, attached submerged aquatic vegetation (SAV), high densities of shellfish or echinoderms.
        i. Use video, grab, multibeam, and sidescan data from wind farm data collections to remap regional geoforms, bathymetry, and sediment texture; identify features that are unique and/or vulnerable.
        ii. Compare important ecological areas as defined for Ocean Planning to look at changes over time/before and after wind farms.
        iii. Consider additional technologies and parameters such as environmental DNA (eDNA) to augment extant data bases to elucidate impacts on ecosystem products and services.
    b. Will/have currents and sediment transport changed?
        i. Use oceanographic models to determine if the structures in the water column affect hydrodynamics on local and regional scales.
        ii. Use sediment transport modeling and bathymetric mapping to determine scour patterns.
    c. Run the NOAA integrated ecosystem model or EcoPath with EcoSim or Atlantis with clear objectives and informed with wind farm data and/or other data streams. Identify what additional data need to be collected to inform the models. See Pezy et al. (2018). Consider how wind farm effects will be isolated from climate or fishery-related impacts and the appropriate spatial scale at which to run the models.
    d. Determine spawning areas and habitat use by reproductive phase

3. Conduct focused research to further our knowledge of impacts of the construction and operation of wind farms on specific topics.
    a. EMF
    b. Noise
    c. Vibration

d. Anti-fouling
e. Scour
f. Aggregation/artificial reef effect

FISHERIES MANAGEMENT

Objective: Continue to meet fishery management standards under state and federal laws.

Key research questions and potential regional-scale studies:

1. Is/will be the management system (NEFMC, MAFMC, ASMFC, states) adequate to meet the needs at multiple scales? Studies should consider what data are needed to allow for any management action to be taken in response to wind energy development and what management actions can be taken to react to changes linked to wind energy development.
    a. Will/can WEAs or wind farms need to be put into Fishery Management Plans (FMPs) or the Habitat Amendment?
    b. Can Councils direct management actions in response to impacts from wind farms?
    c. Will specific changes to FMPs to mitigate impacts of wind farm placement (e.g., Demarcation Line adjustments, management/habitat boundary adjustments)?
    d. Will/have fisheries management organizations (NEFMC, MAFMC, ASMFC, states) implement/ed actions to address changes in removals or catch allocation; are/were these actions more necessary for some wind farms than others? Why?
    e. Will/have fisheries management organizations (NEFMC, MAFMC, ASMFC, states) implement/ed actions to balance use conflicts; are/were these actions more necessary for some wind farms than others? Why?
    f. Will/have fisheries management organizations (NEFMC, MAFMC, ASMFC, states) consider/considered how changes in fisheries-independent surveys that cannot access wind farms for sampling will affect stock assessments and the impact of additional uncertainty in management advice?
2. Develop, improve, and adapt management practices for fishing in wind farm areas.
    a. Optimize BMPs for construction and operation by comparing the various construction methods and timing across wind farms; update BOEM guidelines.
    b. Produce a report card that uses a mechanism such as a stoplight approach to integrate various indicators to communicate with managers. This could be developed to use specific tipping points or frame the determination of adverse impact. Should future expansion in WEAs be allowed? Should new WEAs be allowed?
    c. Determine what management actions should be taken in the face of adverse impact
    d. Develop and assess mitigation efforts (including compensatory mitigation) wind farms are using; are they effective (see Eco and Env 2014)?
        i. Develop compensatory mitigation framework, use a neutral party to respond to claims, framework should be the same for all wind farms

ii. Explore compensatory mitigation funds established in the UK and determine if they are worth pursuing here
iii. Track claims

e. Improve efficiency of wind farm permitting by establishing BMPs and communication systems, as well as identifying species that are not vulnerable to wind farm construction or operations and impacts that do not result in meaningful effects.

Next Steps

We recommend holding a workshop to 1) prioritize studies, 2) understand what additional data collection is needed, and 3) develop a regional monitoring plan that leverages and expands upon existing programs and develops new data streams focused on answering specific concerns. We suggest that each major stakeholder be prepared to describe their recommended studies at that workshop. It will be useful to understand the fishing industry priorities with respect to specific needs to avoid fish and fisheries impacts, to improve safety of fishing in wind farms, and mitigation strategies. Similarly it will be useful to understand wind developer priorities with respect to how the timing of life history events, biofouling, or other physical or biological processes impact development and operation. The table below includes one potential study from each major focus area (Fishing Industries, Fish Resources and Habitat, and Fisheries Management) as examples. We recommend consideration of the key research questions and proposed studies in a holistic way.

Section	Key research question	Potential study	Sample hypothesis	Study method	Other thoughts	How would the study be used?
Fishing Industries	Does spatial and temporal distribution of fishing or revenue generation change (what scale is detectable, meaningful)?	Where is fishing effort distributed spatially and temporally? Does fishing behavior change in wind farms?	Fishing activity by trawls decreases after construction of a wind farm and is displaced further from shore between NY and Nantucket.	Use VMS data with Northeast Ocean Data portal approach to look at fishing distribution in 10-year time periods by season. (Also see Geret DePiper's VTR model.)	Resolution should be carefully considered. What fisheries does the study method miss, and how/if should that be captured?	Basic information to understand how the wind industry affects the fishing industry. Could result in different area management.
Fish Resources & Habitat	Do key biological indicators (abundance/biomass/condition/community structure/spatial or temporal distribution) change (what scale is detectable, meaningful)?	Measure spatial distribution of species of interest.	The spatial distribution of scallops will change from the distribution as measured between X and Y years between NY and Nantucket. (High concentrations of scallops will be found in different areas than before construction.)	Conduct a video survey to sample juvenile and adult scallops. (Individual wind farm video surveys combined with regional stock survey information.)	Include physical oceanographic work to look at changes in currents that might explain different settlement patterns, food availability.	Provides basic information to understand if wind farms create settlement areas for scallops. Could affect where people fish for scallops, could affect rotational area management.
Fisheries Management	Develop, improve, and adapt management practices for fishing in wind farm areas.	Produce a report card that uses a mechanism such as a stoplight approach to integrate various indicators to communicate with managers.	N/A	First examine existing ecosystem report cards, consider how/if to integrate with Ocean Plan Ocean Health Index. Generate score every few years.	Unclear how tipping points might be identified.	This could be an effective way to integrate many of the individual study/monitoring results for use by fisheries managers, BOEM, and state CZM directors to consider wind farm impacts.

Document history

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References

Bailey, H., K.L. Brooks, P.M. Thompson. 2014. Assessing environmental impacts of offshore wind farms: lessons learned and recommendations for the future. Aquatic Biosystems, 10: 1-13.

Collette, B.B., G. Klein-MacPhee. 2002. Fishes of the Gulf of Maine, 3rd Edition. Smithsonian Institution Press, Washington, D.C. 748 pp.

Cooke, R.R., P.J. Auster. 2007. A bioregional classification for the continental shelf of northeast North America for conservation analysis and planning based on representation. National Marine Sanctuaries Conservation Series NMSP-07-03. NOAA, Silver Spring, MD. https://sanctuaries.noaa.gov/science/conservation/pdfs/continental.pdf

Ecology and Environment, Inc. 2014. Development of Mitigation Measures to Address Potential Use Conflicts between Commercial Wind Energy Lessees/Grantees and Commercial Fishermen on the Atlantic Outer Continental Shelf Report on Best Management Practices and Mitigation Measures. A final report for the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewal Energy Programs, Herndon, VA. OCS Study BOEM 2014-654. 98 pp.

Ellis, J.I.,.D.C. Schneider. 1996. Evaluation of a gradient sampling design for environmental impact assessment. Environmental Monitoring and Assessment, 48: 157-172.

Greene, J.K., M.G. Anderson, J. Odell, and N. Steinberg, eds. 2010. The Northwest Atlantic Marine Ecoregional Assessment: Species, Habitats and Ecosystems. Phase One. The Nature Conservancy, Eastern U.S. Division, Boston, MA. 460 pp. https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/Documents/namera-phase1-fullreport.pdf

Guida, V., A. Drohan, H. Welch, J. McHenry, D. Johnson, V. Kentner, J. Brink, D. Timmons, E. Estela-Gomez. 2017. Habitat Mapping and Assessment of Northeast Wind Energy Areas. Sterling, VA: US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2017-088. 312 pp.

Kells, V., K. Carpenter. 2011. A Field Guide to Coastal Fishes: From Maine to Texas. Johns Hopkins University Press, Baltimore, MD. 446 pp.

Kirkpatrick, A.J., S. Benjamin, G.S. DePiper, T. Murphy, S. Steinback, and C. Demarest. 2017. SocioEconomic Impact of Outer Continental Shelf Wind Energy Development on Fisheries in the U.S. Atlantic. Volume I—Report Narrative. U.S Dept. of the Interior, Bureau of Ocean Energy Management, Atlantic OCS Region, Washington, D.C. OCS Study BOEM 2017-012. 150 pp. www.data.boem.gov/PI/PDFImages/ESPIS/5/5580.pdf

Lindeboom, H., S. Degraer, J. Dannheim, A.B. Gill, D. Wilhelmsson. 2015. Offshore wind park monitoring programmes, lessons learned and recommendations for the future. Hydrobiologia, 756: 169-180.

McCann, J. (2012). Developing Environmental Protocols and Modeling Tools to Support Ocean Renewable Energy and Stewardship. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Herndon, VA., OCS Study BOEM 2012-082, 626 pp.

Morrison, W.E., M. W. Nelson, J. F. Howard, E. J. Teeters, J. A. Hare, R. B. Griffis, J.D. Scott, and M.A. Alexander. 2015. Methodology for Assessing the Vulnerability of Marine Fish and Shellfish Species to a Changing Climate. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OSF-3, 48 pp. https://www.st.nmfs.noaa.gov/Assets/ecosystems/climate/documents/TM%20OSF3.pdf

National Academies of Sciences, Engineering, and Medicine (NAS). 2018. Atlantic Offshore Renewable Energy Development and Fisheries: Proceedings of a Workshop in Brief. 12 pp. https://www.nap.edu/login.php?record_id=25062&page=https%3A%2F%2Fwww.nap.edu%2Fdownload%2F25062

National Marine Fisheries Service (NMFS). 2015. Regional habitat assessment prioritization for northeastern stocks. Report of the Northeast Regional Habitat Assessment Prioritization Working Group. Internal report, NMFS White Paper. Office of Science and Technology, NMFS, NOAA. Silver Spring, MD. 31 pp. https://www.st.nmfs.noaa.gov/Assets/ecosystems/habitat/pdf/regional-habitat-assessment-prioritization-for-northeastern-stocks.pdf

Petruny-Parker, M., A. Malek, M. Long, D. Spencer, F. Mattera, E. Hasbrouck, J. Scotti, K. Gerbino, J. Wilson. 2015. Identifying Information Needs and Approaches for Assessing Potential Impacts of Offshore Wind Farm Development on Fisheries Resources in the Northeast Region. US Dept. of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs, Herndon, VA. OCS Study BOEM 2015-037. 79 pp. https://www.boem.gov/Identifying-Information-Needs-and-Approaches-for-

Assessing-Potential-Impacts-of-Offshore-Wind-Farm-Development-on-Fisheries-Resources-in-the-Northeast-Region/

Pezy, J-P., A. Raoux, J-C. Dauvin. 2018. An ecosystem approach for studying the impact of offshore wind farms: a French case study. ICES Journal of Marine Science, doi:10.1093/icesjms/fsy125.

Rhode Island Department of Environmental Management (RIDEM). 2017. Spatiotemporal and economic analysis of vessel monitoring system data within wind energy areas in the greater North Atlantic. 298 pp. http://www.dem.ri.gov/programs/bnatres/fishwild/pdf/RIDEM_VMS_Report_2017.pdf

Robins, C.R., G.C. Ray, J. Douglass, R. Freund. 1986. A Field Guide to Atlantic Coast Fishes. Houghton Mifflin Company, Boston, MA. 354 pp.

U.S. Dept of Energy and U.S. Dept of Interior. 2016. National Offshore Wind Strategy. https://www.boem.gov/National-Offshore-Wind-Strategy/

Wilding, T.A., A.B. Gill, A. Boon, E. Sheehan, J. Dauvin, J. Pezy, F. O'Beirn, U. Janas, L. Rostin, I. De Mesel. 2017. Turning off the DRIP ('Data-rich, information-poor') – rationalising monitoring with a focus on marine renewable energy developments and the benthos. Renewable and Sustainable Energy Reviews, 74: 848-859.

Willsteed, E., A.B. Gill, S.N.R. Birchenough, S. Jude. 2017. Assessing the cumulative environmental effects of marine renewable energy developments: Establishing common ground. Science of the Total Environment, 577: 19-32.

Appendix A: Abundance & geographic range

Species general abundance and geographic range was considered. Species were considered abundant if they were mappable in the Northeast Ocean Data Portal, which uses the NEFSC trawl survey, NEAMAP, and state survey data to map the most abundant species. Abundant species were also identified by the number of times the species name was recorded in the trawl survey between 1948 and 2008 (downloaded from the Ocean Biogeographic Information System). All fish presented in the data portal and all fish with a count in the trawl database of >1000 records (i.e. "high count") were assessed for geographic distribution. (All non-fish records except for lobster and sea scallop were discarded. These were primarily crabs and shrimp.) Geographic range was assessed using the Northeast Ocean Data Portal (northeastoceadata.org) data explorer to view the individual species spatial distributions from the NEFSC trawl survey. Only fall distributions were available. This was done in the portal's data explorer by selecting "Fish," selecting "View Individual Species," selecting the time period 2005-2014, and then selecting interpolated log biomass. Each species available in the list was viewed, and those with geographic ranges that extended south and north of the MA and RI-MA WEAs were identified. Species that were considered abundant based on the trawl database but not mappable in the Northeast Ocean Data Portal were reviewed for range and other geographic distribution information available in The Fishes of the Gulf of Maine (Collette and Klein-MacPhee 2002), Atlantic Coast Fishes (Robins et al. 1986), or A Field Guide to Coastal Fishes: From Maine to Texas (Kells and Carpenter 2011). Species were considered Possible Indicators if they are found north and south of MA and RI-MA WEAs and in shelf waters.

Scientific name	**Common name**	**High count**	**In the portal**	**Possible indicator**	**Notes**
Alosa sapidissima	American shad	Y	Y	Y	
Dipturus laevis	Barndoor skate	Y	Y	Y	
Centropristis striata	Black sea bass	Y	Y	Y	A few found in CCBay, mostly Nantucket and south
Pomatomus saltatrix	Bluefish	Y	Y	Y	Georges Bank is northernmost
Peprilus triacanthus	Butterfish	Y	Y	Y	
Hippoglossina oblonga	Fourspot flounder	Y	Y	Y	
Melanogrammus aeglefinus	Haddock	Y	Y	Y	Primarily further north in Gulf of Maine
Cancer borealis	Jonah crab	Y	Y	Y	
Leucoraja erinacea	Little skate	Y	Y	Y	
Doryteuthis (Amerigo) pealeii	Longfin inshore squid	Y	Y	Y	

Scientific name	**Common name**	**High count**	**In the portal**	**Possible indicator**	**Notes**
Lophius americanus	Monkfish/goosefish	Y	Y	Y	
Ammodytes dubius	Northern sand lance	Y	Y	Y	
Prionotus carolinus	Northern sea robin	Y	Y	Y	Primarily further south
Zoarces americanus	Ocean pout	Y	Y	Y	
Urophycis chuss	Red hake	Y	Y	Y	
Placopecten magellanicus	Sea scallop	Y	Y	Y	
Merluccius bilinearis	Silver hake	Y	Y	Y	
Mustelus canis	Smooth dogfish	Y	Y	Y	
Squalus acanthias	Spiny dogfish	Y	Y	Y	
Prionotus evolans	Striped searobin	Y	Y	Y	
Paralichthys dentatus	Summer flounder	Y	Y	Y	
Scophthalmus aquosus	Windowpane flounder	Y	Y	Y	
Pseudopleuronectes americanus	Winter flounder	Y	Y	Y	
Leucoraja ocellata	Winter skate	Y	Y	Y	
Limanda ferruginea	Yellowtail flounder	Y	Y	Y	
Morone saxatilis	Striped bass	N	Y	Y	
Sebastes fasciatus	Acadian redfish	Y	Y	N	Gulf of Maine
Alosa pseudoharengus	Alewife	Y	Y	N	Gulf of Maine
Homarus americanus	American lobster	Y	Y	N	Gulf of Maine and slope
Hippoglossoides platessoides	American plaice	Y	Y	N	Gulf of Maine
Gadus morhua	Atlantic cod	Y	Y	N	Gulf of Maine
Micropogonias undulates	Atlantic croaker	Y	Y	N	South
Clupea harengus	Atlantic herring	Y	Y	N	Gulf of Maine
Scomber scombrus	Atlantic mackerel	Y	Y	N	Gulf of Maine, some deep south of Nantucket
Anarhichas lupus	Atlantic wolffish	Y	Y	N	Gulf of Maine
Anchoa mitchilli	Bay anchovy	Y	Y	N	Long Island is northern extent
Helicolenus dactylopterus	Blackbelly rosefish	Y	Y	N	Deep
Alosa aestivalis	Blueback herring	Y	Y	N	Gulf of Maine
Raja eglanteria	Clearnose skate	Y	Y	N	South

Scientific name	Common name	High count	In the portal	Possible indicator	Notes
Tautogolabrus adspersus	Cunner	Y	Y	N	northernmost is Buzzards Bay
Brosme brosme	Cusk	Y	Y	N	Gulf of Maine, deep
Citharichthys arctifrons	Gulf Stream flounder	Y	Y	N	in the WEA area generally, not north or south, low numbers
Limulus polyphemus	Horseshoe crab	Y	Y	N	South
Myoxocephalus octodecemspinosus	Longhorn sculpin	Y	Y	N	some in WEA, mostly north
Sphoeroides maculatus	Northern puffer	Y	Y	N	South
Illex illecebrosus	Northern shortfin squid	Y	Y	N	Deep
Pandalus borealis	Northern shrimp	Y	Y	N	Gulf of Maine
Pollachius virens	Pollock	Y	Y	N	Gulf of Maine
Etrumeus teres	Round herring	Y	Y	N	northernmost is near WEAs
Stenotomus chrysops	Scup	Y	Y	N	northernmost is GSC
Hemitripterus americanus	Sea raven	Y	Y	N	Gulf of Maine, GSC
Malacoraja senta	Smooth skate	Y	Y	N	Gulf of Maine
Leiostomus xanthurus	Spot	Y	Y	N	South
Urophycis regia	Spotted hake	Y	Y	N	Deeper waters including slope
Anchoa hepsetus	Striped anchovy	Y	Y	N	South
Amblyraja radiata	Thorny skate	Y	Y	N	Gulf of Maine
Cynoscion regalis	Weakfish	Y	Y	N	northernmost is Long Island
Urophycis tenuis	White hake	Y	Y	N	Gulf of Maine
Glyptocephalus cynoglossus	Witch flounder	Y	Y	N	Gulf of Maine
Argentina silus	Atlantic argentine	Y	N	N	deeper waters of Gulf of Maine and Georges Bank (Klein-McPhee)

Scientific name	Common name	High count	In the portal	Possible indicator	Notes
Myxine glutinosa	Atlantic hagfish	Y	N	N	NC to Maine (Peterson Guide); Greenland to the coast of Florida (Klein-McPhee); fishery occurred in the Gulf of Maine (Klein-McPhee)
Menidia menidia	Atlantic silverside	Y	N	N	northern FL to Canada (Klein-McPhee)
Lepophidium profundorum	Fawn cusk-eel	Y	N	N	northern FL to Canada (Klein-McPhee)
Enchelyopus cimbrius	Fourbeard rockling	Y	N	N	Greenland to the Gulf of Mexico (Klein-McPhee)
Synodus foetens	Inshore lizardfish	Y	N	N	could be strays in the Gulf of Maine (Klein-McPhee)
Myctophidae	Lanternfish	Y	N	N	deep
Triglops murrayi	Moustache sculpin	Y	N	N	deep waters north of Cape Cod in the Gulf of Maine (Klein-McPhee)
Merluccius albidus	Offshore silver hake	Y	N	N	slopes and deep basins in Gulf of Mexico and Gulf of Maine (Klein-McPhee)
Stephanolepis hispidus	Planehead filefish	Y	N	N	tropical species occasionally as far north as Woods Hole (Klein-McPhee)
Decapterus punctatus	Round scad	Y	N	N	Atlantic coast neritic zone (Field Guide to Atlantic Coast Fishes)
Etropus microstomus	Smallmouth flounder	Y	N	N	Cape Cod Bay to Cape Hatteras inshore (Klein-McPhee)

Scientific name	Common name	High count	In the portal	Possible indicator	Notes
Rhizoprionodon terraenovae	American sharpnose shark	N	Y	N	South
Acipenser oxyrinchus oxyrinchus	Atlantic sturgeon	N	Y	N	South and north but low abundance
Tetronarce nobiliana	Atlantic torpedo	N	Y	N	South and north but low abundance
Larimus fasciatus	Banded drum	N	Y	N	South
Rhinoptera bonasus	Bullnose (cownose) ray	N	Y	N	South
Alosa mediocris	Hickory shad	N	Y	N	South
Lagodon rhomboides	Pinfish	N	Y	N	South
Dasyatis centroura	Roughtail stingray	N	Y	N	Primarily south, but also near WEAs
Carcharias taurus	Sand tiger (grey nurse) shark	N	Y	N	South
Dasyatis americana	Southern stingray	N	Y	N	South
Lopholatilus chamaelonticeps	Tilefish (golden tilefish)	N	Y	N	slope
Hypanus say	Bluntnose stingray	N	Y	N	South
Brevoortia tyrannus	Atlantic menhaden	N	Y	N	South
Menticirrhus saxatilis	Northern kingfish	N	Y	N	South
Syngnathus fuscus	Northern pipefish	N	Y	N	Georges Bank
Orthopristis chrysoptera	Pigfish	N	Y	N	South
Leucoraja garmani	Rosette skate	N	Y	N	deep, on the slope
Gymnura altavela	Spiny butterfly ray	N	Y	N	South

Appendix B: Economic and cultural value, habitat dependence, climate vulnerability, vulnerability to wind farms, and life history distinctions in RI-MA and MA WEAs

After the assessment of abundance and geographic distribution, existing ranking methodologies for economic value, habitat dependence, cultural value, and vulnerability to climate change were collated. The information was available in two NOAA reports: Regional Habitat Assessment Prioritization For Northeastern Stocks (NMFS 2015) and Methodology for Assessing the Vulnerability of Marine Fish and Shellfish Species to a Changing Climate (Morrison et al. 2015).

NMFS (2015) ranks a species as having high economic value if "The economic impacts of the commercial or recreational industry for the stock are in the top quartile (25%) of FMP stocks in the region." NMFS (2015) defined management value as "The commercial or recreational fishery for the stock has high resource management importance." In the ranking produced below (Table 1), "High" economic value high is assigned to species which NMFS (2015) scored as having commercial, recreational, and management value for either commercial or recreational fisheries. "Intermediate" economic value is assigned to species which NMFS (2015) scored as having commercial, recreational, or management value (one or two of the three). "Low" is assigned to species which NMFS (2015) scored as having no commercial, recreational, or management value. "NR" means the species was not ranked by NMFS (2015). Some species ranks were altered by the authors, these are described in parentheses in the relevant table cell.

Habitat dependence is defined by NMFS (2015) a "How dependent the species/stock was on a single, easily defined physical bottom habitat type versus a variety of habitat types. …A strong dependence on any kind of structured habitat (e.g., rocky reefs; cobble and boulder habitats; eelgrass, macroalgae, or other large attached epifauna; sand waves) or on a single sediment or substrate type resulted in a high score [5]. An affinity with two habitat types and no strong dependence on structure produced an intermediate ranking [3], while a species/stock found on three or more habitat types without any dependence on structure produced a low score [1]. Non-structured substrate types were considered to be soft sediment (silt, clay, and sand), coarse or "hard" substrate (gravel, boulder), "mixed" soft and hard substrate (e.g., sand with gravel or shell hash), and low relief biogenic habitat (e.g., mussel beds, amphipod tubes). …Scoring was based on the habitat requirements of the most specialized life stage. Thus, species which deposit their eggs on a particular habitat type or with early stage juveniles that inhabit inshore eelgrass beds, for example, received high scores, even if the adults occupy a wider variety of habitat types. As these rubrics depend on substrate, an exclusively benthic habitat attribute, pelagic stocks received scores of zero." We used the term "None" for zero scores. The NMFS (2015) rankings were used directly in the table below. Species not ranked by NMFS (2015) were left unranked.

Cultural value is defined in NMFS 2015 as "The stock has high social value, such as cultural importance or strong localized effects on community viability, or is necessary for subsistence." There were only two scores possible, zero or one, which are listed here as "Low" and "High" respectively.

To assess climate change vulnerability, Morrison et al. (2015) used information on species life history characteristics, species distributions and projected future climate and ocean conditions to estimate the relative vulnerability of fish species to changes in abundance (and to some extent distribution). Technical experts relied on species profiles, scientific literature, and general knowledge to rank the sensitivity (including adaptive capacity) and exposure to climate change for 82 fish and invertebrate species. For the species considered in this report, we accessed the website: https://www.st.nmfs.noaa.gov/ecosystems/climate/northeast-fish-and-shellfish-climate-vulnerability/index. Then we navigated to the species specific results and used the Overall Vulnerability Rank. The possible values are Low, Moderate, High, and Very High.

In cases where a public comment or in-house fisheries expert disagreed with a NOAA ranking, the ranking was changed and the change is described in the table in parentheses. For species not ranked in the NOAA reports, the category was left unranked (NR=not ranked).

The vulnerability to wind farms was done by the authors expert opinion and the reasoning is explained in the Discussion.

Whether or not the species was identified in the National Academies of Science (NAS) report (NAS 2018) is identified as "Yes," "No," and in some cases how the species was referred to in the report is provided using direct quotations from the report.

Lastly, life history distinctions were identified and a discussion of the species was provided. These fields relied on species profiles from EFH source documents, The Fishes of the Gulf of Maine (Collette and Klein-MacPhee 2002), Atlantic Coast Fishes (Robins et al. 1986), A Field Guide to Coastal Fishes: From Maine to Texas (Kells and Carpenter 2011), scientific literature, fishery management plans, comments in Petruny- Parker (2015), NAS (2018), and the authors' general knowledge. The distinctions were if the species is generally resident in or near the RI-MA and MA WEAs or is spawning or otherwise using the region in an important way or is particularly vulnerable to wind farm impacts based on life history or biological characteristics (e.g., sound sensitivity, demersal adhesive eggs).

After this process, Tautog was dropped since Black sea bass is of greater interest and can answer many of the same questions. Whelks and horseshoe crabs were dropped since they are not in the WEAs, however they should be considered as indicator species in Nantucket Sound and any wind farms building cables across Nantucket Sound should study these species. Butterfish, herring, and mackerel were dropped due to their higher priority in other regions. Dogfish were dropped due to their migratory nature and very patchy distribution. Individual prey species were not described because we think it is better to assess changes in the food web through trophic studies including stomach content analysis and isotopic studies, as well as oceanographic drivers, than select an individual prey species and assess its change. Some species could not be definitively identified as higher priority, including surf clam, red hake, and ocean pout. In these cases, other species might serve as adequate proxies, but without certainty we kept them.

Our interpretation is open to challenge, and this list is not meant to suggest other species never be studied or prioritized. Our development of this list illustrates a prioritization approach and provides additional context for species on our final list in Table 2 of the main document text.

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
Atlantic cod (Georges Bank)	Intermediate	High	High	Moderate	Yes	Yes	Spawning on Cox Ledge	The RI-MA WEA has critical cod spawning habitat for the SNE region. The stock is doing poorly, particularly in SNE. Cod produce sounds, and aggregate to spawn. There are many potential vulnerabilities. In the NAS report, NEFMC staff indicated "that the New England WEAs overlap with the EFH of some species of concern due to their depleted status of lack of data, such as yellowtail flounder, winter flounder, Georges Bank cod, and ocean pout."
SNE/MA Winter flounder	High	High	High	Very high	Yes	Yes	Resident and Spawning	Winter flounder spawn in this region in the winter/spring and have demersal eggs, strongly demersal so more vulnerable to prey
Summer flounder	High	Intermediate	High	Moderate	Yes	Yes	Resident	

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
SNE/MA Yellowtail flounder	High (increased from intermediate by authors)	High	Low	Moderate (increased from low by authors)	Yes	Yes	Resident	changes and damage to seafloor. This species is resident in the WEAs, so this is a good indicator species. Summer flounder spawn in this region in the summer and fall and are found in higher abundances in various places at certain times of year, but are present year-round. Yellowtail flounder spawn in this region. YT catches have gone down (the stock is overfished and overfishing is occurring), disrupting spawning could be more negative for this species. Flounder species were some of the only species to show correlations between the strength of electromagnetic fields from cables and increasing avoidance behaviors around cables, as their catches decreased around charged cables in Denmark (McCann, 2012). Flounders are captured

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
								with otter trawls. In the NAS report, NEFMC staff indicated "that the New England WEAs overlap with the EFH of some species of concern due to their depleted status of lack of data, such as yellowtail flounder, winter flounder, Georges Bank cod, and ocean pout."
Southern monkfish/ goosefish	Intermediate (increased from low by authors)	Low	Low	Low	Unknown	Yes	Migratory and resident	This is an abundant species with low vulnerability to other impacts. It is a directed fishery, can be targeted specifically. There is relatively strong baseline data for this species including VMS for the fishery.

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
Ocean pout	Low	High	Low	High	Yes	Yes	Resident	Ocean pout have demersal eggs, strongly demersal so more vulnerable to prey changes and damage to seafloor. Adults congregate in rocky areas prior to spawning and eggs are fertilized internally. Spawning occurs in Sept-Oct in SNE. Spawning congregations and eggs masses could be very vulnerable to disturbance. Spawning occurs on rocky bottoms, so the addition of rock habitat may benefit this species. They are non-migratory. They are principally caught by otter trawls. This cold water fish has higher abundance to the north, and the center of its distribution has shifted north. Due to its potential vulnerabilities and benefits from wind farms, we kept this species on the list. In the NAS report, NEFMC staff

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
								indicated "that the New England WEAs overlap with the EFH of some species of concern due to their depleted status of lack of data, such as yellowtail flounder, winter flounder, Georges Bank cod, and ocean pout."
Southern red hake	Intermediate (increased from low by authors)	High	Low	Moderate (increased from low by authors)	Unknown	No	Spawning in WEAs	A highly popular recreational fishery to our south but not in Mass. Stock has been declining. Demersally-oriented. Red hake makes seasonal migrations from deeper water in the winter to shallower water in the summer. Spawning peaks in June and July. Abundant in the RI-MA and MA WEAs and on the

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
								shelfwaters to the south. Juvenile red hake live in scallops. Red hake are captured with otter trawls.
Black sea bass	Intermediate	High	High	High	Could be beneficial impact	Yes	Migratory	Structure associated species that migrates from coastal waters in the summer to offshore waters in the winter. High potential to disrupt current spatial distribution if fish move into wind farm areas due to increased habitat associated with turbine foundations; indicator of reef effect; important management implications if spatial distribution is driven more offshore. Will answer question if wind farms will affect migratory patterns. BSB have swim bladders so could be particularly sensitive to sound. They are captured with fish

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
								pots and handlines but are also captured in otter trawls targeting summer flounder, scup, and longfin squid.
Butterfish, herring, mackerel (NOAA rankings for Atlantic herring given since it was the most conservative ranking)	Intermediate	High	Low	Herring low, mackerel moderate	Unknown	No	Migratory	These species and their fisheries are lucrative in this region and these fish are important prey species. How and what to study needs more discussion since they are patchily distributed schooling fish. The fisheries are mostly outside of the MA/MA-RI WEAs. NY should consider this document in their process for identifying regional scale studies in that region. They should be prioritized for studies that include the NY region.

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
Longfin squid	Intermediate	High	Low	Low	Yes	Yes	Spawning	The WEAs are close to and partially overlap major squid spawning grounds. Squid lay demersally attached egg mops which are vulnerable to direct impacts. How squid spatial distribution might change with the introduction of structures, sound, and lights is unknown and likely. Squid are caught with small mesh trawls.
Scup	Intermediate	Low	High	Moderate	NR	No	Migratory	Scup are migratory schooling fish, moving offshore in the winter to northern and inshore waters in the summer to spawn. They may be sensitive to sound. Alterations to migratory patterns could impact state management.
Tautog	NR	NR	NR	Very high	Could be beneficial impact	Yes	Migratory	Black sea bass will answer a lot of the same questions we would ask if we studied tautog. There is much less known about the offshore distribution of tautog, so a lot could be

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
								learned by targeting this species. Tautog have a swim bladder.
Channeled & knobbed whelk	NR	NR	NR	Very high	No	No	Resident and Spawning in Nantucket Sound	These species are in Nantucket Sound and they are a very important fishery there. They are almost sessile and produce egg mops anchored to the seafloor so could be particularly vulnerable to disturbance. Not in the WEAs. These are Nantucket Sound species, so not included in the wind farm impacts list, but would be relevant for cables crossing the Sound.
Ocean quahog	Intermediate (increased from Low by authors)	Intermediate	Low	Very high	Unknown	Yes	Resident	Ocean quahogs are sessile and patchily distributed so potentially very vulnerable to physical impact if turbines and cables are placed in areas of high concentration. Changes to currents could impact spawning and settlement success for this species. Ocean quahogs

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
								are captured with hydraulic clam dredges.
Sea scallops	High (increased from Intermediate by authors)	Intermediate	High (increased from Low by authors)	High	Unknown	Yes	Resident/ Larval Dispersal	Sea scallops are predominantly fished for elsewhere, however the value of scallops landed from the WEAs still outweighs many other fisheries in this area. Since sea scallops are nearly sessile, they are vulnerable to impact. High concentrations of scallops are needed to support successful spawning and downstream settlement. Settlement could be adversely impacted by subtle changes in currents, including scour and habitat alterations around turbine bases. Scallops are captured with scallop dredges.
Surf clam	Intermediate	High	Low	High	Unknown	Yes	Resident	Sessile and patchy, not as abundant as ocean

Species	**Economic value**	**Habitat dependence**	**Cultural value**	**Vulnerability to climate change**	**Vulnerability to wind farms**	**NAS report**	**Distinctions in RI-MA and MA WEAs**	**Discussion**
								quahogs.
Jonah crab	NR	NR	NR	NR	Unknown	No	Resident and spawning in or near MA WEA	Very high catches in MA WEA area. It is found year-round and spawns in the area. Very little known about the life history and vulnerabilities of this species. Caught with pots.
Lobster	NR (authors assume high)	NR (authors assume high, life stage specific)	NR (authors assume high)	Moderate	Could be beneficial impact	No	Resident, migratory, spawning	Not clear how lobsters use the area, they used to migrate inshore for spawning but inshore waters are too warm. Likely resident and spawning in the RI-MA and MA WEAs. Need more information about the spatial distribution of the fishery. The reef effect could benefit this species, and fishery spatial patterns are likely to change. Lobsters are known to be sensitive to EMF. Caught with pots.
Horseshoe crabs	NR (authors assume low)	NR (authors assume intermediate)	NR	NR	Unknown	No	Resident in Nantucket Sound, Spawning on beaches	Little is known about horseshoe crab sensitivity to EMF. In the winter hs crabs might be more vulnerable to direct impacts of cable laying

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
								due to slower movements in colder water. These are Nantucket Sound species, so not included in the wind farm impacts list, but would be relevant for cables crossing the Sound.
Bluefin tuna	NR (authors assume high)	NR (authors assume low)	NR (authors assume high)	None	Unknown	No	Migratory	Highly migratory species are found in great abundance in the MA WEA in particular. The presence of new "islands" might greatly affect a) how long HMS stay in the area, b) foraging success of HMS, and c) how the rec fishery fishes (currently by drifting and trolling). There is a relatively large amount of information on bluefin tuna so it would be a good indicator species for changes to HMS.
Sharks	NR	NR	NR	NR	Unknown	No	Migratory	Highly migratory species, including many shark species, are found in great abundance in the MA WEA in particular. In addition to the concerns listed for bluefin tuna,

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
								sharks may also exhibit unique sensitivity to EMF associated with offshore wind. The blue shark has been suggested to focus on.
Winter skate	Low	Low	Low	Low	Yes	"Skate"	Resident	Electrosensitive with potential sensitivity to EMF, their strongly demersal habits, their high abundance, and their geographic distribution south and north of the WEAs make them a good indicator species.
Little skate	Low	Low	Low	Low	Yes	"Skate"	Resident	Electrosensitive with potential sensitivity to EMF, their strongly demersal habits, their high abundance, and their geographic distribution south and north of the WEAs make them a good indicator species.

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
Dogfish (smooth and spiny) (NOAA rankings for spiny dogfish given since smooth dogfish was not ranked)	Low	None	Low	Low	Unknown	No	Migratory	Dogfish are very abundant and potentially vulnerable to the effects of EFH. These fish are very patchily distributed and move easily. They are not included since it would be difficult to identify spatial or temporal distribution effects or abundance trends.
Prey species	NR	NR	NR	NR	Unknown	"Species involved in predator-prey relationships with key species" "copepods and other plankton"	Resident	Includes species such as sand lance, herring, menhaden, mackerel, epifauna including echinoderms, infauna including worms, gastropods, and amphipods, and plankton. Assessing changes in the food web through trophic studies including stomach content analysis and isotopic studies of predators, as well as oceanographic drivers, is a useful approach to examining shifts in prey species and ecosystem

Species	Economic value	Habitat dependence	Cultural value	Vulnerability to climate change	Vulnerability to wind farms	NAS report	Distinctions in RI-MA and MA WEAs	Discussion
								change.

Appendix C: List of Species from Petruny-Parker et al. 2015

As Petruny-Parker (2015) describes, "This species of interest list was created using information from the National Marine Fisheries Service landings data from statistical areas 537, 539, and 612, as well as catch information from the National Marine Fisheries Service Northeast Fisheries Science Center's spring and autumn bottom trawl surveys (R/V Bigelow). Species were also added to this list through written responses and meeting discussions. Species were grouped into taxonomic and ecological categories including:

A. Crustaceans (e.g. American lobster, Jonah crab, etc.)
B. Shellfish (e.g. sea scallop, ocean quahog, etc.)
C. Demersal Fish (e.g. flounder, hake, scup, black sea bass, etc.)
D. Pelagic Forage Fish (e.g. herring, mackerel, etc.)
E. Pelagic Predators (e.g. striped bass, bluefish, tuna, etc.)
F. Elasmobranchs (e.g. dogfish, skates, sharks, etc.)
G. Short Lived Species (e.g. squid, butterfish, etc.)
H. Other"

A. Crustaceans (e.g. American lobster, Jonah crab, etc.)

American lobster, *Homarus americanus*; Jonah crab, *Cancer borealis;* Rock crab (peekytoe crab), *Cancer irroratus;* Spider crab, *Majoidea* spp.; Lady crab (calico or ocellated crab), *Ovalipes ocellatus;* Green crab, *Carcinus maenas*; Blue crab, *Callinectes sapidus;* Horseshoe crab, *Limulidae* spp.; Mantis shrimp, *Stomatopoda* spp.; Pandalid shrimp, *Pandalidae* spp.; Caridean shrimp, *Caridea* spp.; Bristled longbeak, *Dichelopandalus leptocerus*; Sevenspine bay shrimp (sand shrimp), *Crangon septemspinosa*

B. Shellfish (e.g. sea scallop, ocean quahog, etc.)

Sea scallop, *Placopecten magellanicus;* Ocean quahog, *Arctica islandica;* Atlantic surfclam, *Spisula solidissima*; Atlantic jackknife clam (razor clam, bamboo clam), *Ensis directus;* Moon snail, *Naticidae* spp.; Waved whelk (common whelk), *Buccinum undatum*; Knobbed whelk, *Busycon carica*; Channeled whelk, *Busycotypus canaliculatus*; Blue mussel, *Mytilus edulis*; Soft shell clam, *Mya arenaria*; Eastern oyster, *Crassostrea virginica*

C. Demersal Fish (e.g. flounder, hake, scup, black sea bass, etc.)

Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus* * Endangered species
Shortnose sturgeon, *Acipenser brevirostrum* * Endangered species
Atlantic cod, *Gadus morhua* * Overfishing in Gulf of Maine and Georges Bank * Overfished in Gulf of Maine and Georges Bank
Haddock, *Melanogrammus aeglefinus* * Overfishing in Gulf of Maine * Rebuilt in 2011 in Georges Bank
Polluck (saithe), *Pollachius* spp. * Rebuilt in 2011 in the Northeast
Scup (porgy), *Stenotomus chrysops* * Rebuilt in 2009 in the Atlantic Coast

Silver hake, *Merluccius bilinearis* * Rebuilt in 2007 in the Northeast
Wolffish, *Anarhichas lupus* * Overfished in New England
Ocean pout, *Zoarces americanus* * Overfished in New England
Monkfish (goosefish), *Lophiidae* spp. * Rebuilt in 2008 in the North and South
Atlantic halibut, *Hippoglossus hippoglossus* * Overfished in New England
Windowpane flounder, *Scophthalmus aquosus* * Overfishing in Gulf of Maine and Georges Bank * Overfished in Gulf of Maine and Georges Bank * Rebuilt in 2012 in Southern New England
Winter flounder, *Pseudopleuronectes americanus* * Overfished in Southern New England and Mid Atlantic
Yellowtail flounder, *Pleuronectes ferruginea* * Overfishing in Cape Cod, Gulf of Maine, and Georges Bank * Overfished in Cape Cod, Gulf of Maine, and Georges Bank * Rebuilt in 2012 in Southern New England and Mid Atlantic
Witch flounder (grey sole), *Glyptocephalus cynoglossus* * Overfishing in New England * Overfished in New England
Summer flounder (fluke), *Paralichthys dentatus* - Fourspot flounder, *Hippoglossina oblonga* - American plaice (dab), *Hippoglossoides platessoides* - Gulf Stream flounder, *Citharichthys arctifrons* - Smallmouth flounder, *Etropus microstomus* - Anglerfish, *Lophiiformes* spp. - Northern stargazer, *Astroscopus guttatus* - Toadfish, *Batrachoididae* spp. - Striped sea robin, *Prionotus evolans* - Northern sea robin, *Prionotus carolinus* - Sea raven, *Hemitripteridae* spp. - Longhorn sculpin, *Myoxocephalus octodecimspinosus* - Shorthorn sculpin, *Myoxocephalus scorpius* - Red hake, *Urophycis chuss* - White hake, *Urophycis tenuis* - Spotted hake, *Urophycis regia* - Whiting, *Merlangius merlangus* - Black whiting, *Sillaginodes punctata* - King whiting (kingfish), *Menticirrhus saxatilis* - Atlantic Tomcod, *Microgadus tomcod* - Red porgy, *Pagrus pagrus* - Black sea bass, *Centropristis striata* - Cunner, *Tautogolabrus adspersus* - Tautog, *Tautoga onitis* - Black drum, *Pogonias cromis* - Golden tilefish, *Lopholatilus chamaeleonticeps* - Blueline tilefish, *Caulolatilus microps* - Sand tilefish, *Malacanthus plumieri* - Planehead filefish, *Stephanolepis hispidus* - John Dory, *Zeus faber* - Conger eel, *Congridae* spp. - American eel, *Anguilla rostrata* - Fawn cusk eel, *Lepophidium profundorum* - Sand eel (sand lance), *Hyperoplus/Gymnammodytes/Ammodytes* spp. - Weakfish (squeteague, sea trout), *Cynoscion regalis* - Spot (spot croaker), *Leiostomus xanthurus* - Atlantic croaker, *Micropogonias undulatus* - Triggerfish, *Balistidae* spp. - Northern puffer, *Sphoeroides maculatus* - Leatherjacket, *Oligoplites saurus* - Acadian redfish, *Sebastes fasciatus* - Golden redfish, *Sebastes norvegicus* - Red snapper, *Lutjanus campechanus* - Spadefishes, *Ephippidae* spp. - Inshore lizardfish, *Synodus foetens* - Snakefish, *Trachinocephalus myops* - Pinfish, *Lagodon rhomboides* - Blue runner, *Caranx crysos* - Fourbeard rockling, *Enchelyopus cimbrius* - Wrymouth, *Cryptacanthodes maculatus* - Northern sennet, *Sphyraena borealis* - Dwarf goatfish, *Upeneus parvus* - Cornetfish (flutemouth), *Fistularia* spp. - Atlantic moonfish, *Selene setapinnis* - Short bigeye, *Pristigenys alta* - Spotted driftfish, *Ariomma regulus* - Silver rag driftfish, *Ariomma bondi* - Wreckfish, *Polyprionidae* spp. - Lumpfish (lumpsuckers), *Cyclopteridae* spp. - Three spined stickleback, *Gasterosteus aculeatus* - American silver perch, *Bairdiella chrysoura* - Sheepshead minnow, *Cyprinodon variegatus* - Seahorses (pipefish, sea dragons), *Syngnathidae* spp.

D. Pelagic Forage Fish (e.g. herring, mackerel, etc.)

Atlantic herring, *Clupea harengus* - Blueback herring, *Alosa aestivalis* - Round herring, *Etrumeus sadina* - Alewife, *Alosa pseudoharengus* - Atlantic mackerel, *Scomber scombrus* - Spanish mackerel, *Scomberomorus maculatus* - Chub mackerel, *Scomber japonicus* - Gizzard shad, *Dorosoma cepedianum* - American shad, *Alosa sapidissima* - Hickory shad, *Alosa mediocris* - Round scad, *Decapterus punctatus* - Rough scad, *Trachurus lathami* - Bigeye scad, *Selar crumenophthalmus* - Atlantic menhaden, *Brevoortia tyrannus* - Atlantic saury, *Scomberesox saurus* - Atlantic silverside, *Menidia menidia* - Bay anchovy, *Anchoa mitchilli*

E. Pelagic Predators (e.g. striped bass, bluefish, etc.)

Atlantic salmon, *Salmo salar* * Endangered species * Overfished in New England
Bluefin tuna, *Thunnus thynnus* * Overfishing in West Atlantic * Overfished in West Atlantic
Albacore, *Thunnus alalunga* * Overfishing in North Atlantic * Overfished in North Atlantic
Swordfish, *Xiphias gladius* * Rebuilt in 2009 in the North Atlantic
Bluefish, *Pomatomus saltatrix* * Rebuilt in 2008 in the Atlantic Coast

Striped bass, *Morone saxatilis* - Atlantic Bonito, *Sarda sarda* - Little tunny tuna, *Euthynnus alletteratus* - Bigeye tuna, *Thunnus obesus* - Yellowfin tuna, *Thunnus albacares* - Mahi mahi (dolphin), *Coryphaena hippurus* - Cobia, *Rachycentron canadum* - Wahoo, *Acanthocybium solandri* - King mackerel, *Scomberomorus cavalla* - White marlin, *Tetrapturus albidus* - Blue marlin, *Makaira nigricans*

F. Elasmobranchs (e.g. dogfish, skates, sharks, etc.)

Basking shark, *Cetorhinus maximus* * Vulnerable species
Spiny dogfish, *Squalus acanthias* * Rebuilt in 2011 in the Northeast
Winter skate, *Leucoraja ocellata* * Overfishing in Georges Bank and Southern New England
Thorny skate, *Amblyraja radiate* * Overfishing in the Gulf of Maine * Overfished in New England

Smooth dogfish*, Mustelus canis* - Porbeagle, *Lamna nasus* - Thresher shark, *Alopius vulpinus* - Bigeye Thresher, *Alopias superciliosus* - Great white shark, *Carcharodon carcharias* - Shortfin mako shark, *Isurus oxyrinchus* - Blue shark, *Prionace glauca* - Sandbar shark, *Carcharhinus plumbeus* - Dusky shark, *Carcharhinus obscurus* - Scalloped hammerhead shark, *Sphyrna lewini* - Little skate, *Leucoraja erinacea* - Barndoor skate, *Dipturus laevis* - Clearnose skate, *Raja eglanteria* - Roughtail stingray, *Dasyatis centroura* - Round stingray, *Urolophus halleri* - Bullnose ray, *Myliobatis freminvillii* - Atlantic torpedo ray, *Torpedo nobiliana*

G. Short Lived Species (e.g. squid, butterfish, etc.)

Butterfish, *Peprilus triacanthus* - Longfin squid, *Doryteuthis (Amerigo) pealeii* (formerly *Loligo pealeii*) - Shortfin squid, *Illex* spp. - Bobtail squid (dumpling and stubby squid), *Sepiolidae* and *Rossia* spp.

H. Other

Ocean sunfish, *Mola mola;* Common octopus, *Octopus vulgaris*

Response to comments

#	Name	Organization	Date received	Mode	Comments	Response
1	Annie Hawkins	Responsible Offshore Development Alliance	7/31/2018	Letter	Agree to principles, refine the document through direct engagement with our members and with other affected states and entities.	Direct engagement through meetings with the MA FWG, the RI FAB, and the NEFMC Habitat Committee. The definition of more specific studies is anticipated to include workshops with fishermen.
2	Jim Kendall	New Bedford Seafood Consulting	7/31/2018	Email	The "scale study" didn't seem to really address very well or completely. I'm referring to mitigation issues, particularly for gear losses, &/or damages. I have several times before, asked to identify an entity that would over-see & officiate any gear or other mitigation issues that will inevitably arise. As I mentioned previously, it needs to be an entity that has the respect & confidence of all the user groups & developers.	Compensatory mitigation was included as a research question under Fisheries Management (item 2.d. Develop and assess mitigation efforts (including compensatory mitigation) wind farms are using).

#	Name	Organization	Date received	Mode	Comments	Response
3	Mike Pierdinock	CPF Charters	6/27/2018, 8/2/2018, 8/3/2018	Email, phone call	I am very pleased by the issues of concern set forth in the summary tables. Now the studies to assess those concerns will be challenging. Page 6 needs to include Highly Migratory Species such as yellowfin tuna, bluefin tuna, white marlin a variety of sharks and mahi. Why are they not included in the list ? Primary phone call discussion was around which species might be best to study. A lot of unknowns--if we don't know why certain areas have such good fishing, how will we understand what drives any changes? Things have been changing already probably due to climate change.	HMS species were included in the list. These will be inherently difficult and expensive to study, so we thought one or two indicator species with abundant pre-existing data was enough to include. This approach can be challenged when specific studies are being discussed if other species are considered better for the study objectives. Vulnerability to climate change was included in the assessment. We mentioned it as a variable that might be hard to control for based on this comment.

#	Name	Organization	Date received	Mode	Comments	Response
4	Morgan Brunbauer	NY Department of Environmental Conservation	7/30/2018	Email	I had sent the document around to several folks here and we all agree it looks very good and it is a great start to try to address this very important issue. We do not have any specific edits to make but do have some questions that we hope you can shed some light on. I have listed the questions below for you to respond to in a follow up email or you can call me back if you would like to discuss further - either way is good with me.	
					1. Who (state, stakeholders, a combo of the two) will be involved in the decision making for what gets studied, how the study is designed, which entitles will be funded to complete the study?	There is a panel framework (process) document that Mass CZM drafted.

#	Name	Organization	Date received	Mode	Comments	Response
					2. What are the next steps in the process? What is the time frame/schedule for getting this rolled out?	Next steps were recommended at the end of the document.
					3. How will other states stay involved in your process? NYSDEC is very interested in the potential for this to be a success and would like to stay involved	There is a panel framework (process) document that Mass CZM drafted.
					4. Were any NY fishermen (or other state's fishermen) contacted to view this plan? Could we send it to some of our fishermen to see what they think? I know there was a deadline but even feedback after the deadline could be useful for the next phase of the process.	This comment led to an affirmative answer and an extension of our comment period to allow for more NY feedback.

#	Name	Organization	Date received	Mode	Comments	Response
5	Erich Stephens	Vineyard Wind	7/31/2018	Emailed a document with track changes. The track changes were in the panel framework document drafted by CZM. I forwarded it to Bruce Carlisle on 8/31/2018.		There is a panel framework (process) document that Mass CZM drafted that is a separate document from this one. This one is the research framework.
6	Beth Casoni	Mass Lobstermen's Association	7/26/2018	Email	I looked it over and there is SO MUCH information that is need and you and the others at the DMF did a great job covering all of it.	Thank you.

#	Name	Organization	Date received	Mode	Comments	Response
7	Michelle Bachman	NEFMC	6/28/2018	Informal email, not directly responding to the document	Do you have a sense that when BOEM says they are looking for New England and Mid-Atlantic regional efforts that the MA-RI and NYSERDA approaches are consistent with what they are thinking? It sounds like NMFS would prefer a single research and monitoring program for the northeast, but maybe that's just not feasible.	There is a panel framework (process) document that Mass CZM drafted.
8	John Quinn	NEFMC Chair	8/28/2018	Habitat Committee question	Learn from European experience	Some documents (e.g., Bailey 2014) and participation in the science forums, which included European participants, informed this document.
9	Peter deFur	Environmental Stewardship Concepts	8/28/2018	Habitat Committee question	Developers should be required to meet with stakeholders, including both commercial and recreational	This is outside of the scope of this document.
10	Ron Smolowitz	Coonamesset Farm Foundation	9/20/2018	Mass FWG meeting discussion	Focus on developing new fisheries; process concerns	Fisheries development is included in the document.

#	Name	Organization	Date received	Mode	Comments	Response
11	Bonnie Brady	Center for Sustainable Fisheries	9/20/2018	Mass FWG meeting discussion	Include butterfish, whiting, scup, and ling.	We included ling (red hake). Butterfish, whiting, and scup and their fisheries are lucrative in this region and these fish are important prey species. How and what to study needs more discussion since they are patchily distributed schooling fish. The fisheries are mostly outside of the MA/RI-MA WEAs. NY should consider this document in their process for identifying regional scale studies in that region. They should be prioritized for studies that include the NY region.
11	Mass FWG members	various	9/20/2018	Mass FWG meeting discussion	Many process questions and concerns, mostly supportive of Executive Committee and Science Panel concepts, but not full support. All supported more feedback from fishermen, stakeholder driven research and ideas.	There is a panel framework (process) document that Mass CZM drafted.

#	Name	Organization	Date received	Mode	Comments	Response
12	Kevin Stokesbury	SMAST	9/25/2018	Email	I've read it a couple of times, it is a large scope as you were saying in the meeting. I'm not sure I agree with all the species designations. For example why would "vulnerability to climate change" be a criteria? Also some of the "Cultural value" seems off to me, how can scallops be "moderate" given the value of the fishery and the historic references, refer to "The scallop: Studies of a shell and its influences on humankind" edited by Ian Cox 1957 for example. Seems like the selection of study species would be a good focus for your workshop. Also the studies are not clearly sorted into BACI or CI. How are you going to test that there are changes over the effect of natural change. One of the key issues is the lack of any kind of control area to	We explained more clearly why climate change was included, since it is a variable that might be hard to control. The comments relating to how the studies should be designed are good, but outside the scope of this document. Since there are many studies for which a BACI approach may not be appropriate, we decided not to include more language about appropriate control areas.

#	Name	Organization	Date received	Mode	Comments	Response
					help with this. People will always try to poke holes at a BACI but without any kind of control we are stuck. We've staked out a bit of area as you and I discussed but this document could make a strong argument for a more established on. Glad to talk and think about this more.	

#	Name	Organization	Date received	Mode	Comments	Response
13	Steve Cadrin	SMAST	9/28/2018	In-person conversation	Should cusk be a priority/indicator species?	Agreed, cusk was removed.