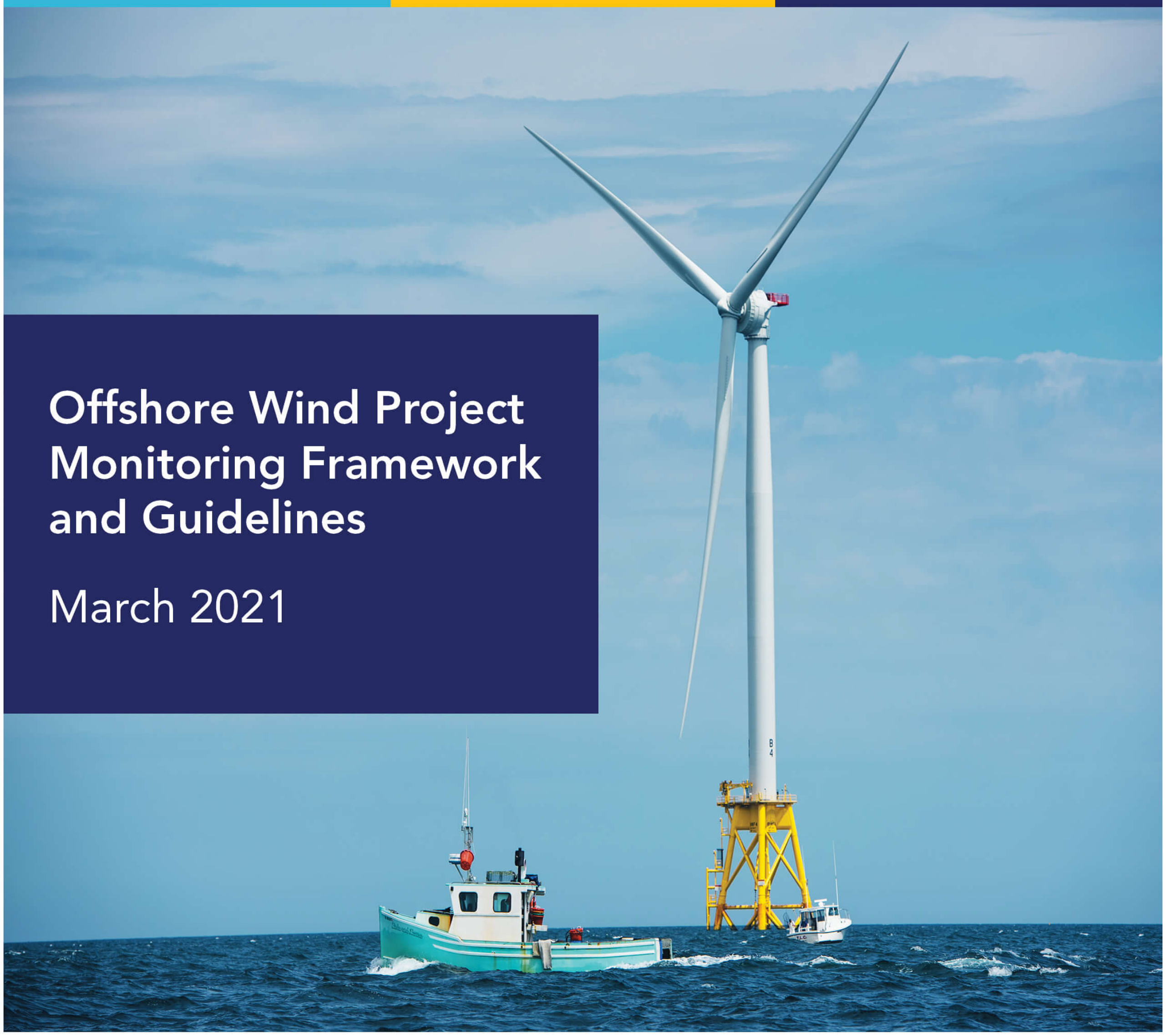

Offshore Wind Project Monitoring Framework and Guidelines

March 2021

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1. Introduction and Purpose

The Bureau of Ocean Energy Management (BOEM), National Marine Fisheries Service (NMFS), and states on the U.S. Atlantic coast are interested in and responsible for facilitating the development of offshore wind energy while minimizing impacts to marine resources and existing fishery uses. As part of the siting, design, and permitting process for offshore wind projects, BOEM and some states require developers to prepare various project monitoring plans to characterize, evaluate, and monitor the potential impacts to affected physical and biological resources (fisheries, benthic/habitat, protected species, etc.) and fishing operations from proposed offshore wind development. These project monitoring plans and associated studies help provide the scientific information BOEM and other agencies need to determine how wind farms may affect marine resources.

This document was developed by a working group representing several sectors involved in fisheries and wind development, including state and federal government fisheries managers, fisheries scientists, fishing industry representatives, and offshore wind developers. This framework and guidelines build on existing BOEM guidance, outlining the fundamental elements to include in offshore wind fisheries project monitoring plans and associated studies for commercial-scale offshore wind farms and identifying the primary resources to help draft and review such plans. Based on existing BOEM guidance and best practices developed to date, this document will help:

1. **Streamline project monitoring plan development and review** by providing comprehensive standardized recommendations for monitoring marine resources affected by offshore wind development projects
2. Ensure project monitoring plans and supporting studies are effectively designed to **provide necessary information that can be used to understand and minimize adverse impacts on marine resources from offshore wind development** consistent with established BOEM, NMFS, and state guidelines, best science practices, and decision maker and developer data needs
3. Encourage the use of **standardized protocols** to collect and analyze biological and environmental data that can be **integrated with existing survey data and other research**

4. Support the integration of monitoring efforts across **multiple spatial and temporal scales** (site-specific to regional/ecosystem and before/after construction)
5. Focus monitoring efforts on **important commercial and recreational species, habitats, and other resources that may be impacted** by or vulnerable to offshore wind development
6. Encourage **proactive engagement, collaboration, and involvement** among state and federal agencies, research institutions, wind developers, and fishery members and representatives

This guidance is a **living document** that will evolve and grow as Responsible Offshore Science Alliance (ROSA) members, including BOEM, NMFS, and states, continue to identify critical monitoring questions and refine existing guidelines, methods, and best practices. This document presents an overarching monitoring framework and guiding principles, with details for supporting studies on particular topics of interest, including fishery resources, habitat, and socioeconomic impacts. Further information regarding benthic habitat and socioeconomic monitoring studies will be included in future iterations of this document.

2. Monitoring Framework and Principles

A comprehensive offshore wind regional monitoring framework includes a process involving all affected entities (developers, state/federal agency scientists and managers, fishery participants, and researchers) that would ideally lead to universal agreement and coordination on the following elements:

- A conceptual framework about how wind farms affect marine resources and ecosystems;
- A description of how wind farm effects translate into impacts to marine resources;
- Prioritization of effects, impacts, species, and objectives/hypotheses/questions to be examined;
- Appropriate indicators of change for important effects/impacts within the marine environment;
- Metrics to evaluate change and thresholds/standards to evaluate the magnitude of the effects;
- Sampling designs to effectively assess anticipated effects and associated impacts;
- Standardized data collection, format, sharing, and access protocols; and

- Performance review processes to assess if monitoring efforts are achieving desired objectives.

The monitoring framework described in this section lays out the fundamental components and monitoring design principles that should be followed when developing offshore wind project monitoring plans and associated studies. This framework summarizes agreed upon study design approaches, standardized methods, and operational protocols that will help ensure monitoring plans collect the information necessary to assess the impacts (both positive and negative) of offshore wind development projects and associated mitigation measures on marine resources, including fish and invertebrate species of commercial/recreational interest, benthic and pelagic habitats, and fishery operations and associated fishing communities.[1] Additional efforts by ROSA and other entities will contribute to further developing a more comprehensive monitoring framework inclusive of the elements mentioned above, although some elements (indicators and sampling design) are discussed within the study-specific sections below.

Although monitoring plans/studies are generally focused on detecting impacts and monitoring changes from individual projects, it is essential that they consider and address the implications of wind energy projects on existing regional resource survey efforts. To the maximum extent possible, monitoring studies should be developed using the same or compatible survey methods and protocols such that the resulting data can be integrated with and compared to existing survey data. This will help supplement (add to) or complement (help complete) regional survey efforts and ensure that longstanding surveys can continue to inform marine resource assessments and management efforts given anticipated restricted access of existing survey platforms to wind farms and possible changes to sampling designs and methods once projects are constructed. In doing so, project monitoring plans and associated studies will contribute to efforts to understand the cumulative impacts of U.S. Atlantic offshore wind energy projects on marine resources.

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[1] Separate efforts are underway to explore effective ways to monitor impacts of offshore wind development on protected resources. When applicable, this document will identify issues relevant to protected species such as the Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA) permits and authorizations necessary to conduct fishery and habitat studies as part of a project monitoring plan.

2.1 Integrated Monitoring Approach

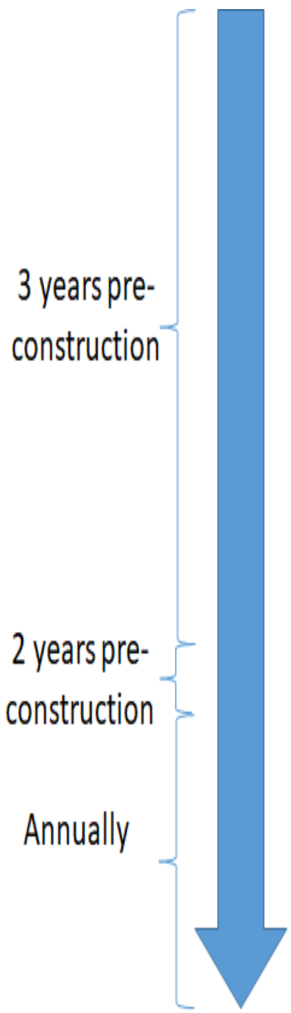
These guidelines are based on an **integrated monitoring approach** (Figure 1) where each component of the project monitoring plan is built around and influenced by the study's objectives and testable hypotheses and the effects the study will monitor.[2] Determining the effects to monitor influences the identification of relevant indicators/receptors to detect change; sampling design parameters; and sampling, data collection, and analytical methods. Testable hypotheses and explicit plan objectives are critical to the effective development and execution of a monitoring plan and associated studies because they maximize the utility and applicability of project-specific survey/monitoring data.

The integrated approach is based on an iterative process to develop and refine plan components as details are determined. Throughout the process, researchers should be continuously checking the plan components against the objectives, hypotheses, and research questions. This helps ensure plan components complement one another and continue to reflect underlying plan objectives and hypotheses. Linked components also allow self-correction in response to survey implementation, thereby improving project monitoring plan/study design, performance, and efficiency in subsequent years.

Figure 1: Integrated Monitoring Approach

[2] See Green, 1979, for guidance on how to develop effective hypotheses involving ecological data.

The fundamental steps to implement this integrated monitoring approach include:



1. Evaluate available data describing fishery, habitat, and socioeconomic resources and existing, future, and/or cumulative stressors within the project area (see Appendix B)[3];
2. Consult with state/federal agencies, researchers, and fishing industry participants on relevant species; existing, future, or cumulative stressors; indicators; and priority objectives, hypotheses, and questions;
3. Define and prioritize concise, appropriate, and testable monitoring objectives and hypotheses;
4. Identify research focus (species, habitats, etc.) and appropriate indicators/receptors to monitor;
5. Define appropriate and measurable indicator(s) and/or receptor change thresholds;
6. Develop sampling design to address research questions/hypotheses using identified indicators and/or change thresholds;
7. Identify sampling method to collect the appropriate data to address monitoring objectives;
8. Apply for appropriate federal and state permits/authorizations for selected monitoring activities;
9. Collect and record data using standardized protocols, as applicable, whenever possible;
10. Analyze data collected to achieve monitoring objectives and test hypotheses;
11. Evaluate the performance of a plan/study to determine how it achieved plan/study objectives;
12. Adjust sampling design/methods as needed to continue to address monitoring objectives; and
13. Store and share available data using standardized databases, as applicable, whenever possible.

In this process, Steps 1 through 8 should occur up to three years before construction is expected to begin. Step 8 (applying for state and federal permits) should occur at least three months before such permits are needed to begin study operations and at least two years before construction is expected to begin. This would accommodate requirements for at least two years of pre-construction monitoring. Finally, Steps 9 - 13 should occur annually or on an as-needed basis.

[3] This step is important to inform the development of a project monitoring plan/study, but could be conducted as part of the development of a project's construction and operations plan if it preceded the monitoring plan/study.

2.2 Project Monitoring Plan Components

As noted above, the main objective of any project monitoring plan and associated studies is to detect change from an established baseline as a result of the construction and operation of wind turbines within a particular geographic area for a particular wind project. To do this, a project monitoring plan should include individual studies focused on monitoring anticipated effects to particular marine resources. Each study should follow the steps outlined for the integrated monitoring approach and include the following components:

1. Study objectives, testable hypotheses, and research questions;
2. Indicators of change that will be monitored;
3. Sampling design (what will be collected)
4. Sampling methods (how will data be collected, when, how often, and by whom)
5. Analytical methods (how will change be evaluated)
6. Data sharing approach
7. Performance evaluation methods (how did the study achieve its objectives)

2.2.1 Study Topics

Consistent with existing BOEM guidance, NMFS recommendations, and state suggestions and applicable regulations, each monitoring plan should include supporting studies focused on detecting changes and assessing impacts on at least three main topic areas:

1. Fishery biological resources
2. Essential fish habitat (EFH) and benthic resources
3. Fishery operations and associated communities (socioeconomic impacts)

Further detail on how to develop each of these components for the three main study topic areas is provided in the subsequent sections of this document.

2.2.2 Study Objectives

Ideally, studies associated with all projects would accomplish similar objectives and collect similar data. Without such consistency, it could be difficult to assign the causation of any observed changes and determine whether effects could be attributed to wind development projects or other factors. However, each wind development project will likely involve different species, operations, and expected effects. To maximize comparability across studies and the utility of resulting information, each study should accomplish the following objectives:

1. **Review existing scientific data** (fishery dependent/independent)[4] and available research relevant to the project area to identify fishery and marine resources affected, local/regional stressors, appropriate indicators of resource condition and important effects, and potential responses to project activities. This could also help characterize the site and inform or establish baseline conditions that study data collections can complement.
2. **Use standardized methods and established protocols** whenever possible to collect data.
3. **Assess changes from baseline conditions** within the project area, along the cable routes, and any adjacent areas that may be subject to impact-producing effects. Baseline conditions must be established before construction begins. Interannual variability of applicable indicators should be considered as part of assessing changes relative to baseline conditions.

Further information on topic-specific study objectives is provided in the sections below.

2.3 Review Process and Standards

Each project monitoring plan will be reviewed by relevant state and federal agencies with jurisdiction over managing/protecting marine resources as well as agencies with permitting authority. These agencies will review monitoring plans/studies for consistency with applicable law under its jurisdiction. It should be noted that state and federal resource agencies may not have permitting authority of wind energy projects or monitoring plans. However, state and federal resource agencies are typically consulted during the permitting process for review and comments by the applicable permitting authority. Thus, these resource agencies should be included in early coordination efforts. Preliminary review and consultation should occur as early as possible, and ideally at least one year before sampling operations would begin. This is necessary to ensure monitoring plans/studies comply with existing requirements/standards and are compatible with existing regional surveys to the extent possible. In many cases,

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[4] Existing fishery dependent data can be acquired by submitting a data request to the NMFS Greater Atlantic Regional Fisheries Office (GARFO) at nmfs.gar.data.requests@noaa.gov or by visiting the NMFS Offshore Wind Energy Development page. Federal fishery independent data can be accessed by searching for individual collections in InPort, NOAA's data management program. Other state and regional fisheries independent data collections also exist, such as through the Northeast Area Monitoring and Assessment Program (NEAMAP). See Appendix B of this document for information about available state and Federal resources.

monitoring studies will need specific permits/authorizations from state and federal agencies, which may take time to issue. Consider consulting the Marine Energy site to help identify the state/federal agencies and regulations may be applicable to offshore energy monitoring plan/study review.

2.3.1 State Review

All states require review and/or permitting of projects and monitoring plans/studies by multiple agencies. Although the agencies involved vary by state, most states require review by the environmental or marine resource management agency (e.g., New York Department of Environmental Conservation), coastal zone management office (e.g., Massachusetts Office of Coastal Zone Management), fishing industry advisory panel (Rhode Island Fisheries Advisory Board), and the public utility board (e.g., New Jersey Board of Public Utilities). The review includes an evaluation of the environmental impacts of project development and monitoring plan/study activities and consistency of the project at large with the ocean/bay plans and enforceable policies of a state's federally approved zone coastal management program. For example, the Rhode Island Ocean Special Area Management Plan includes regulations outlining site assessment and monitoring studies (see RI Ocean SAMP regulations), while New York has related requirements as part of its offshore energy procurement process. Although not every state has established regulatory standards for the content and scope of project monitoring plans/studies, the most restrictive state standards applicable to the project may dictate some elements of plan/study components, particularly for projects that may require multi-state and/or multi-agency review.

2.3.2 Federal Review

Federal agency review of monitoring plans will be conducted by BOEM and NMFS. Similar to state review, federal agencies will review project development and monitoring plans/studies for compliance with applicable law and the environmental impacts of such activities. BOEM will review monitoring plans/studies against its existing survey guidelines, including site-characterization, fisheries, and benthic habitat studies. NMFS will evaluate monitoring plans/studies for general scientific merit/best practices, including consistency with these guidelines and other known survey efforts by state/federal agencies or other wind development monitoring plans/studies, and consistency with the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA). Of particular interest to NMFS is the compatibility of proposed wind project developments and associated monitoring studies with NMFS survey efforts and whether the studies address gaps in NMFS survey coverage. For proposed benthic mapping and characterization surveys, NMFS will evaluate whether such studies are consistent with its recommendations for mapping fish habitat (NMFS 2021). NMFS will also review proposed benthic monitoring plans to determine if the monitoring plan follows established protocols and would result in robust scientific data collection that could identify potential impacts to essential fish habitat (EFH) and NOAA-trust resources. As part of NMFS EFH consultation for a project, NMFS may determine that specific resources or impacts necessitate targeted monitoring efforts to mitigate impacts to EFH as part of EFH conservation recommendations authorized under the Magnuson-Stevens FIshery Conservation and Management Act. Several offices within each agency will be involved in monitoring plan/study review.

2.4 Expectations and Priorities

This section describes expectations and priorities that have been identified by relevant state/federal agencies to date. This section will be updated, as appropriate, as such elements change. For example, revisions to regional survey integration expectations may be necessary if NMFS and BOEM are able to identify strategies that could mitigate the impacts of reduced access to wind lease areas by larger survey vessels and aerial surveys and related potential changes in regional survey design and methods. ROSA will continue to facilitate discussions about research needs and study priorities that could help plan/study coordinators identify existing and future monitoring needs.

2.4.1 Early Coordination and Consultation

Project monitoring plan/study coordinators should schedule consultative meetings with state and federal agencies as early as possible and at least one year before surveys would begin. This could be up to three years before expected approval of the project's construction and operations plan to allow for at least two years of pre-construction monitoring that may be required by some states. Review of project monitoring plans/studies often take longer than expected, as each study may present unique and complicated issues that must be resolved before sampling starts. Some activities may also require specific permits or authorizations. Study coordinators should expect to revise initial study proposals as consultations progress and agency input is incorporated. Additional consultations may be required to consider updates of study operations or to consider differences based on site characterization and longer term environmental monitoring efforts.

Early coordination with BOEM, NMFS, states, research institutions, and the fishing industry will help identify available data, affected resources, and research gaps to ensure the sampling design for each monitoring study meets existing requirements and permitting needs. To the extent possible and practicable, inter-agency meetings are encouraged to harmonize expectations and discuss potentially competing needs (e.g., industry interest in conducting trap surveys with NMFS needs to minimize take of marine mammals).

Pre-survey meetings should follow initial literature/data review by plan/study coordinators, including data available from regional surveys and on regional data portals[5]. Such meetings should discuss the area and resources affected, available data, overall sampling design, appropriate receptors and indicators, power analysis based on study objectives, anticipated survey methods and timing, and analytical approaches to be used. Discussions with NMFS should also include how the results of project-specific studies would be compatible and integrated with regional survey efforts. Project proponents should consult with state/NMFS survey leads and scientific experts to understand existing survey methods (also see Appendix B for references to existing protocols) and ways to enhance study equivalency with existing survey efforts. Finally, NMFS can provide input on the risk that study operations may interact with protected species and what specific permits/authorizations/consultations may be needed (see Section 2.8).

2.4.2 Study Priorities

Focus Species

For fisheries biological studies and socioeconomic studies, monitoring efforts should focus on species important to and targeted by the region's commercial and recreational fisheries[6], including any key prey species. In addition, other species that may not be the target of directed fisheries, but are potentially vulnerable to impacts from offshore wind development should also be evaluated (e.g., Atlantic sturgeon).

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[5] For example, Northeast Ocean Data Portal, Mid-Atlantic Ocean Data Portal, and Ocean Reports.

[6] The fisheries managed by the New England and Mid-Atlantic Fishery Management Councils and the Atlantic States Marine Fisheries Commission (ASMFC) are listed in Appendix C.

Each plan/study should identify priority species and habitats that will be the focus of monitoring/research efforts. Factors to consider include the value of fishery, vulnerability of the stock to mortality, sensitivity of species to potential effects (e.g. noise, EMF), high-value habitats (e.g. artificial reefs), and public concern. The following sources can help further narrow the list of important species to help develop project monitoring plan studies:

- Massachusetts Division of Marine Fisheries list of important species and research priorities for monitoring efforts within the Rhode Island and Massachusetts Wind Energy Areas
- NMFS summary reports of historic catch in each lease and project area
- NMFS fishing footprints
- NMFS Northeast Ecosystem Survey Reports
- A Vulnerability Assessment of Fish and Invertebrates to Climate Change on the Northeast U.S. Continental Shelf

Regional Survey Integration

In general, monitoring studies should focus on detecting project-specific impacts and measuring changes to species of concern in the project area, while also facilitating integration with regional survey efforts. Each project should assess if it will adversely affect NMFS and state long-term survey efforts. Absent a survey mitigation plan, monitoring plans/studies proposed by wind project developers should fill anticipated gaps in existing surveys and potential changes to survey design and methods resulting from the installation of offshore wind turbines caused by limited access by survey platforms. This could be accomplished by:

1. Using established survey protocols and data collection formats to maximize equivalency;
2. Providing detailed information on methods and operational practices to facilitate comparison;
3. Participating in calibration studies with NMFS, when appropriate, if using gear types that differ from compatible survey gear used by regional surveys; and/or
4. Implementing new regional survey techniques that are coordinated across offshore wind projects.

Monitoring studies may need to include multiple gear types, as a single gear type may not be appropriate to assess all effects and impacts, and not all gear types can be effectively used both before and after construction. Further, if new gear types and sampling techniques (e.g., eDNA, autonomous/drone surveys) are developed, additional consideration may be necessary for integrating such efforts into established survey methods/approaches. Therefore, although a calibration study for new gear types may not be practicable as part of an individual project-specific monitoring plan/study, it could be a component of regional research studies, a broader survey mitigation strategy, or future analytical work.

Other Important Issues

Evaluating the effects of electromagnetic fields (EMF) and impacts to habitat are two of several priority issues of concern identified for wind development monitoring plans/studies. Studies focused on EFH effects or impacts to habitat could be part of a project-specific monitoring plan, a separate research study, or in response to NMFS EFH conservation recommendations once a project is approved by BOEM. Evaluating project impacts to habitats, with a focus on impacts to sensitive life history stage EFH (e.g early juveniles) and sensitive habitats (e.g. SAV, hard bottom habitats), should be included in monitoring plans/studies. Monitoring plans/studies should also incorporate measures to assess direct and indirect impacts as well as the extent such impacts are detectable (e.g. soft sediment habitats that are converted to artificial hard habitats; soft sediment habitats adjacent to wind turbine foundations and scour placement). EMF and habitat studies should be developed in such a way that the results of a project-specific study could be applied to other species (e.g., study the impacts of EMF on species groups), to other projects (e.g. study impacts of scour protection at multiple turbines), or the region at large (e.g., shifts in species dominance over the project area).

2.4.3 Monitoring Plan and Associated Study Scale

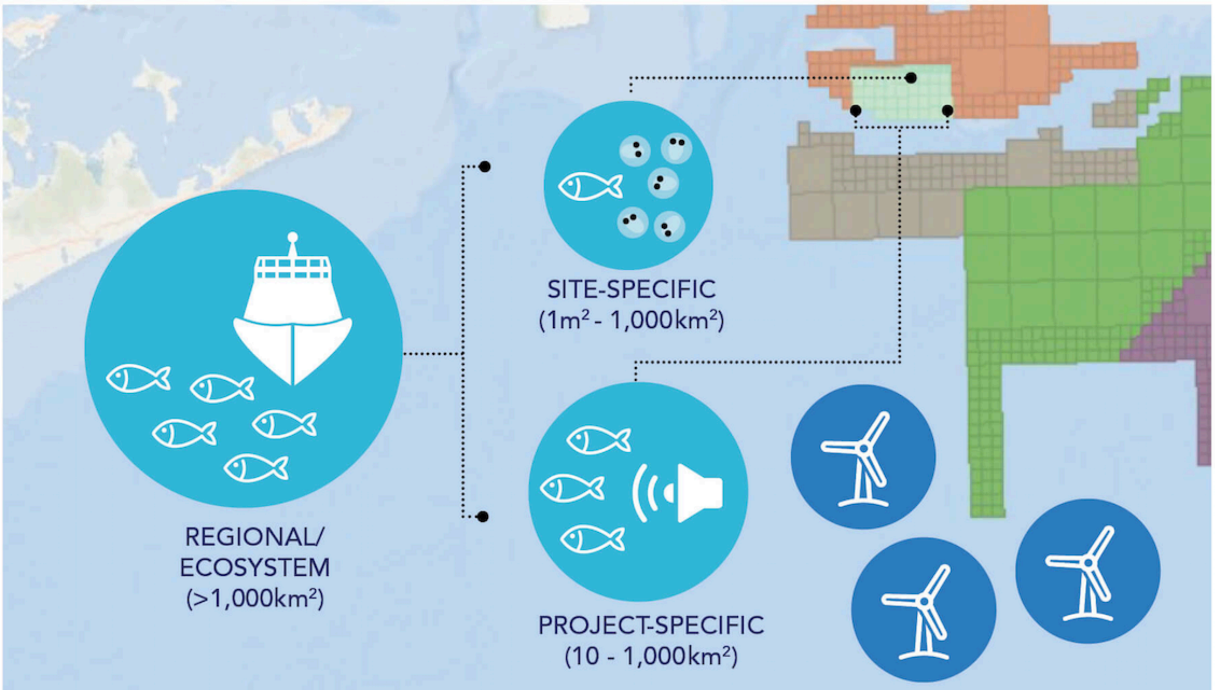
As noted above, project monitoring studies should be conducted within a regional context and complementary to longstanding regional survey efforts. Recognizing the importance of understanding potential impacts at multiple spatial scales, three classes of monitoring studies should be incorporated into project monitoring plans, as described below, whenever possible. All three classes of studies should be designed to measure changes over specified time frames (seasonal, annual, or project duration - see Section 2.5 below) to meet study design objectives and allow meaningful inferences. Studies should select and clearly specify the appropriate spatial scale for measuring the process(es) to be studied based on study objectives and testable hypotheses. While it may not be possible for each project monitoring plan/study to address all three classes, all plans/studies should identify how data would be collected in a way that facilitates answering regional/ecosystem questions. Further, study scale may be affected by the topic to be examined, as different scales may be necessary for particular study topics.

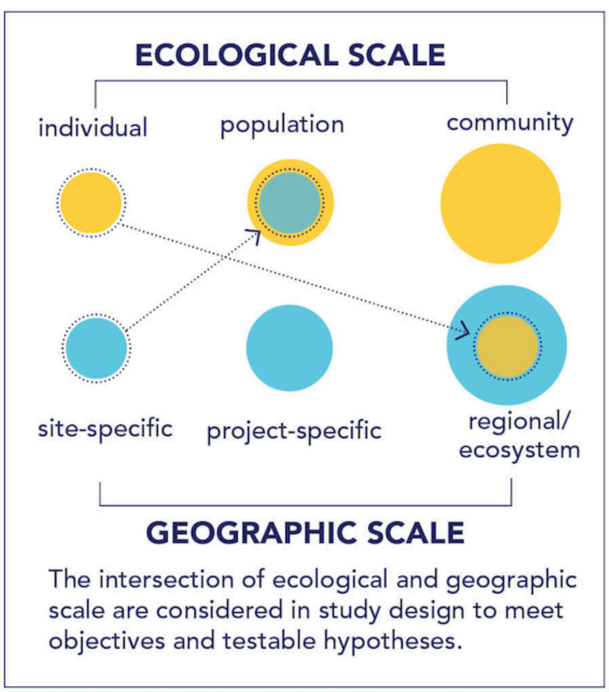
Study scale can be considered in both ecological and geographic scales, as follows (Figure 2):

1. Site-specific: These studies examine biological/environmental characteristics, stressors, or species behavior that are unique/inherent to a particular site. It is anticipated that these monitoring activities would be designed to measure changes over specified time frames at a specific site to meet study design objectives that allow for meaningful inferences. Site-specific studies are focused on a smaller geographic scale, such as the impact of a single turbine (on the order of 1 cm^2 - 10 km^2) acting on localized ecological processes such as the reef effect, spawning activity/habitat, or EMF impacts.
    - *Example:* Evaluating changes to Atlantic cod spawning aggregations at a particular location (e.g. Cox Ledge) within a project area.
2. Project-specific: These studies examine changes in various parameters, including species composition, abundance, biological indices, and other biogeochemical variables within a project area. Project-specific studies could research and monitor unique characteristics for that project such as how food web, reproduction, and migration behaviors work in a project area. Such studies may need to sample locations outside of the project area itself depending on the specific sampling design(s) selected. Project-specific studies focus on intermediate geographic scales such as those for a project or lease area (10 km^2 - 1,000 km^2) and local fish aggregations and communities scales instead of on whole populations.
    - *Example:* Evaluating changes to species distribution or abundance in relation to adjacent control regions.
3. Regional/Ecosystem: These studies focus on changes in species composition, abundance, and biological indices over time within the project area and those outside the area, including across multiple project areas within a defined region, throughout a species' stock area, or within the broader ecosystem, to determine whether changes observed within the project area are consistent with changes observed within the region before, during, and after construction. The integrated, consistent, and accurate collection of this data will be essential for federal and state fisheries science and management agencies to account for potential changes in stock, species, and habitats in regional assessment processes. Regional studies apply across a large geographic scale (>1,000 km^2) and on broad ecological issues such as fish stock populations or shelf dynamics.

- *Example*: Evaluating changes to a species population estimates throughout the Atlantic coast.

Figures 2: Examples of different studies at both ecological and geographic scales, respectively.





2.5 Sampling Timing and Study Duration

Sampling timing can vary based on what samples are being collected and what is being studied. For example, the regulations implementing the Rhode Island Ocean Special Area Management Plan (Ocean SAMP)[7] require assessments of commercial/recreational operations before, during, and after construction of the wind farm. The Ocean SAMP requires biological assessments of fish species to be conducted in all seasons of the year to evaluate the full range of potential effects throughout the year.

Study duration should reflect study objectives/hypotheses and ensure that project monitoring studies can evaluate the effects of a project compared to baseline levels. Sample collection should occur before construction begins to establish baseline conditions, during construction to evaluate the effects of construction activities themselves, and after construction to assess changes as a result of construction and operation of wind turbines and any associated mitigation measures. Studies focused on studying changes in local species abundance would likely have a shorter post-construction study duration than a study examining the effects of construction noise on spawning/recruitment success, for example.

The Ocean SAMP requires fisheries biological studies to be conducted before construction, during construction, and at two different intervals after construction, including one year after turbines have been installed. Research conducted at European wind farms suggest there is a period of ecological transition following the installation of turbines (Degraer et al., 2020; Danheim et al., 2019). Such studies can help inform the timing and duration of post-construction sampling, unless otherwise dictated by applicable regulation. Because not all reviewing agencies have such prescriptive regulations, plan/study coordinators should consult with each agency when developing studies to ensure sampling duration is consistent with applicable regulations.

[7] For project monitoring study requirements defined in the RI Ocean SAMP regulations, see Section 8.5.2(J) of the RI Ocean SAMP.

2.6 Data Sharing and Access [Under development by ROSA working group est. March 2021[8]]

To maximize utility of project monitoring plan data and results, each study should:

- Identify how data will be stored/archived and shared with others in accessible formats, using common mechanisms/databases if available (e.g., ICES Data Centre; Atlantic Coastal Cooperative Statistics Program, Ocean Biodiversity Information System, Mid-Atlantic Acoustic Telemetry Observation System)
- Collect and store data in format consistent with regional/survey standards or using similar data collection software when possible
- Prepare, present, or make available an annual report, status updates, or summaries of project monitoring plan activities and associated findings at regional forums such ROSA Advisory Council meetings, New England/Mid-Atlantic Fishery Management Council or ASMFC meetings, or another regional fisheries forum.

ROSA will continue to explore ways to standardize monitoring study data collection, storage, and access.

2.7 Performance Measures [*To be developed*]

Monitoring marine resources within offshore wind farms is a new enterprise in the United States, and so it is expected that adjustments may be needed as new information is gained and our knowledge of offshore wind interactions with fishery resources is refined. Developers are responsible for the evaluation of any performance measures developed for a project monitoring plan/study, with results shared with BOEM, NMFS, and states. However, developers are encouraged to consult with reviewing agencies and other groups such as ROSA and fishery management councils/ASMFC to facilitate reviewing the performance of monitoring studies.

Review of performance measures should occur regularly, and at a minimum on an annual basis. Routine assessment should:

- Identify, calculate, and review changes in direction and amplitude of an indicator or set of indicators, such as local abundance, diet, or benthic community diversity

[8] Contact ROSA staff directly or email info@rosascience.org for information.

- Assess whether the data collected are yielding information that address the study objectives, research questions, and hypotheses stated at the outset[9]
- Determine, apply, and document appropriate adjustments to the following year of project monitoring plan/study if performance measures indicate adjustments are needed

Each review of the project monitoring plan/study performance measures should consider important factors that may affect inter-annual variability in biological indicators, and the implications for study design. Short-term environmental variability, recruitment variability, regulatory changes, and shifting fishing effort, along with more long-term factors such as global climate change (e.g., change in water temperature, northward shifts in species distributions) should be considered.

ROSA is considering methods and approaches to develop, review, assess, and coordinate monitoring plan performance measures, which will be discussed at future ROSA meetings.

2.8 Permits and Authorizations

Project coordinators should engage with NMFS and state agencies to secure the permits and authorizations necessary to conduct research. Early coordination is critical, particularly to ensure compliance with the ESA and MMPA if interactions with such species could occur. Additional consultation with the U.S. Department of State may be necessary if foreign vessels are involved with project monitoring plan/study activities.

State Permit Requirements:

Each state may require individual permits to conduct study activities. For example, the Massachusetts Division of Marine Fisheries requires a letter of authorization for pre-lay grapnel runs to possess fixed gear/debris in state waters and a scientific permit for any collections of marine organisms in state waters. Consultation with each state with project components and/or monitoring studies directly in or adjacent to its waters is recommended to determine specific state permit requirements.

[9] See Wilding et al., 2015.

Federal Permit Requirements:

All project monitoring plan/study activities operating in federal waters (more than three miles from shore) must comply with existing fishing regulations (50 CFR 648 or 697) or be exempted from specific regulations. There are two options to document plan activities, depending on the type of vessel being used to conduct the work (see NMFS summary of scientific research and exempted fishing permits for more information):

- Activities conducted aboard scientific research vessels: A vessel that is chartered and controlled by a state/Federal government agency, university, or research institution that operates under a scientific research plan is exempt from federal fishing regulations. A commercial/recreational fishing vessel can serve as a scientific research vessel provided it is operating consistent with a fisheries project monitoring plan and under the direction of a state/federal agency, university, or scientific institution. While not required, a letter of acknowledgement (LOA) formally documents project monitoring plan/study activities and can minimize delay from any enforcement inquiries.
- Activities conducted aboard commercial/recreational fishing vessels: If not operating as a scientific research vessel as described above, a commercial/recreational vessel may need exemptions from existing fishing regulations (size/possession limits, gear requirements, etc.) to conduct project monitoring plan/study activities. Such vessels must request an exempted fishing permit (EFP) from NMFS.
- Contact the GARFO Sustainable Fisheries Division (978-281-9344) for additional information on the issuance of LOAs and EFPs.

Project monitoring study activities may impact threatened or endangered species of fish and marine mammals, depending on where and how survey activities are conducted. Efforts should be made to avoid or minimize interactions with these species and to avoid or minimize impacts to their habitat. Unless interactions are already covered as part of conventional fishing activities when operating under an EFP (NMFS guidance is under development and should be published soon on the Greater Atlantic Region's wind energy development page), you may need special permits or consultations from NMFS. Such permits may take several months or a year to be issued. Survey/monitoring plan coordinators should consult with NMFS well before study operations are expected to begin.

- For marine mammal questions, contact NOAA's Office of Protected Resources (301-427-8400)
- For endangered species questions, contact the GARFO Protected Resources Division (978-281-9328)

3. Fisheries Biological Monitoring Studies

3.1 Objectives and Testable Hypotheses

Each fisheries biological study should clearly define its purpose, objectives, assumptions, and testable hypotheses before initiating monitoring activities. Indicators are measures of status that connect objectives to hypotheses, or thresholds (Link 2005). They may be supported by single variable metrics (e.g., incidence or local abundance of a species), or by multiple metrics (e.g., several measures of fish community diversity). Choice of indicators should be explicit in each study and integrated into the survey design such that the indicators support study objectives, are reflected in data collections, and help answer testable hypotheses. Below is a minimum set of indicators (variables and indices) that should be monitored within each lease area during baseline, construction, and post construction time periods (see Section 3.2), to contribute to understanding the effect of offshore wind farms on finfish and invertebrate species across multiple scales (site-specific, project-specific, and regional/ecosystem levels). For details on methods to accomplish objectives outlined in this section, see the Sampling Design (Section 3.3) and Sampling Methods (Section 3.4) discussions below.

As noted above, all fisheries biological studies should accomplish the following objectives:

1. **Review existing scientific data** (fishery dependent/independent) and available research relevant to the project area to identify fishery and marine resources affected, local/regional stressors, and potential responses to project activities as part of establishing baseline conditions that can complement additional data collected by the project monitoring plan/study.
2. **Use standardized methods and established protocols** whenever possible to collect and record data.
3. **Assess changes to baseline biological and relevant environmental conditions** within the project area, along the cable routes, and any adjacent areas that may be subject to impact-producing effects, with particular focus on the spatial and temporal variability in managed fish and invertebrate species of

commercial/recreational importance[10] and protected fish species (e.g., Atlantic sturgeon).

Addressing the three classes of study questions (site-specific, project-specific, regional/ecosystem) will involve analyzing data within and across individual projects and comparing summary statistics with regional and ecosystem time series. This can most effectively be done if data collection, recording, and storing methods are standardized across individual projects and calibrated with existing regional scientific surveys, which would be needed to address regional monitoring objectives, but may not be necessary to address a site-specific monitoring objective. As noted above, consultation with state/federal regulatory agencies, fishery scientists, and fishermen may also assist with this effort.

Monitoring studies should measure the following throughout the year, as appropriate[11], to address plan objectives:

- Indices of Abundance and Occurrence:
  - Absolute abundance by species using efficiency estimates (estimate of the total number and weight within the sampling area)
  - Relative abundance by species (number and weight per standardized sample)
  - Presence/absence by species (percent frequency of occurrence)
- Demographic Indices such as length, weight, maturity, diet, age, physiological condition, etc.
- Environmental Variables such as:
  - Oceanographic variables (temperature, depth, salinity, dissolved oxygen, current speed/direction, turbidity, chlorophyll a, etc.)
  - Electromagnetic field (EMF)
  - Ambient and development-related noise
- Bottom type/benthic habitat that affect species or their vulnerability to change, consistent with existing guidelines and recommendations[12], focusing on habitat usage versus mapping habitat within the area, which is a separate, but related

[10] E.g., current Rhode Island's Coastal Resources Management Council regulatory standards (650 RICR-20-05-11 §11.9 and §11.10) require that developers "assess the relative abundance, distribution, and different life stages of [commercially and recreationally targeted species]."

[11] EMF and ambient noise may not need to be measured throughout the year, but could rather be measured once for reference values related to load, which could then be modeled to evaluate any changes (see Section 2.5).

[12] See BOEM's Benthic Habitat Survey Guidelines and NMFS Recommendations for Mapping Fish Habitat.

project development requirement (see Section 4 for more information on monitoring changes to benthic habitats)

Section 3.3 includes more detail on estimating the number of samples needed to detect a change from baseline conditions, given an assumed effect size and an acceptable level of precision. To evaluate changes, project monitoring plans should be able to:

1. Test whether statistically significant or biologically meaningful changes are associated with offshore wind development construction or operations;
2. Attribute variance in biological indices to environmental variables and specific stressors associated with offshore wind development construction or operation; and
3. Evaluate differences in resource impact and/or recovery associated with construction activities (e.g. pile installation, scour protection, cable installation, etc.), including assessing the effectiveness of any adopted mitigation measures during and after construction, as applicable.

Additional site/project-specific objectives could include stressor-, topic-, or project-specific research such as evaluating turbidity, spawning concentrations, habitat alteration, larval settlement/distribution effects, and recovery associated with different construction techniques (e.g. pile installation, scour protection, cable installation, cable protection) based on the needs of individual project areas, affected resources, or intended operations.

3.2 Spatial and Temporal Scale

Spatial Scale

Section 2.4.3 provides a summary of various spatial scales that could be employed by individual studies along with examples of each study scale type (site-specific, project-specific, and regional/ecosystem). The spatial scale should be consistent with study objectives/hypotheses and appropriate for measuring the effects to be examined. While it may not be possible for each fishery biological study to address all three spatial scales, each study should identify how data would be collected in a way that facilitates answering regional/ecosystem questions. Consultations with state/federal agencies will help identify the appropriate spatial scale for each study.

Temporal Scale

When and how often samples will be collected should be detailed in each project monitoring plan/study. As noted above in Section 2.5, the timing and duration of sampling activities should reflect the samples being taken, the study objectives/hypotheses, and the seasonal availability of the target species in a given area. Timing should coincide with the effects being studied and the factors influencing those effects. For example, a study sampling the presence/absence or abundance of a species in an area should sample throughout the year, while a study on spawning success could be limited to defined spawning periods identified by past research. Consistent with study objectives, sampling should overlap with existing regional surveys[13] to the extent possible. This helps maximize compatibility and comparison with existing surveys and assess use of the area by affected species throughout the year.

The specified duration should be, at a minimum, consistent with all applicable sampling requirements, including BOEM, state, and local regulations, permit conditions, and procurement requirements. For example, projects that occur or affect resources within the Rhode Island Ocean Study Area must be conducted in all seasons of the year and before, during, and at two intervals after construction, including one year after construction is completed. Studies focused on studying changes in species abundance would likely have a shorter post-construction study duration than a study examining the effects of construction noise on spawning/recruitment success, for example. Finally, the frequency and duration of sampling should also be reflective of any applicable power analysis to ensure sufficient samples are collected.

3.3 Sampling Design

The sampling design should describe the number, location, and timing (season, frequency, duration) of sample collections and how the sample size, location, and timing was determined (e.g. the sampling approach). Sampling design should directly address the objectives, hypotheses, and intended scale of the project monitoring plan/study based on the species likely to be affected, stressors within the project area, and need to validate any associated models. A detailed justification should be provided to facilitate review. Advanced discussion with BOEM, NMFS, and states before project monitoring plans/studies are submitted for review will enhance sampling design development, improve consistency with existing guidelines and established

[13] Northeast Fisheries Science Center Ecosystem Survey Schedule.

regional surveys, and expedite the review and permitting of project monitoring plan activities. It is anticipated that peer-to-peer communications through ROSA and other organizations will aid in developing sampling designs and associated power analyses.

A project monitoring study's sampling design should consider the following elements to help ensure that change in relevant baseline conditions can be detected:

- **Power analysis and sample size determination**:
    - Power analysis based on empirical or simulated data could be used for before-after-control-impact (BACI) studies or before-after-gradient (BAG) studies
    - Oversampling in the first year may be necessary to ensure sufficient samples are collected, provided such additional sampling can be conducted without compromising project monitoring plan objectives and other considerations
    - Sample size could be adjusted in future years as necessary based on a power analysis following the first year's sampling results. Previous years' data for the study area from other sources (e.g., NMFS regional surveys), if available and appropriate, may also be useful to include to help understand the magnitude of interannual and intra-annual variability
    - Power analyses should be focused on detecting change in the relative abundance of commercial and recreational target species
- **Survey coordination:** It may be helpful to coordinate project monitoring study operations with ongoing surveys, particularly geophysical surveys, to minimize the potential for such activities to affect species behavior and catchability of survey gear. At a minimum, projects should document known surveys (prior, ongoing, and/or planned) that could affect species or habitats in the study area.
- **Sampling location:** Sufficient sampling locations need to be available to enable sampling by strata (defined by depth, habitat type, or another factor of interest) and ensure adequate replication within each strata to allow for a robust analysis. Sampling location may also be affected and should consider future turbine and cable placement.
- **Sampling approach:** Sampling approaches are heavily influenced by survey/plan objectives and hypotheses (see Walters et al., 1988). Examples of sampling approaches include, but are not limited to, the following:
    - Before-After-Gradient (BAG)[14]: A BAG approach (Figure 3) typically is most appropriate when:

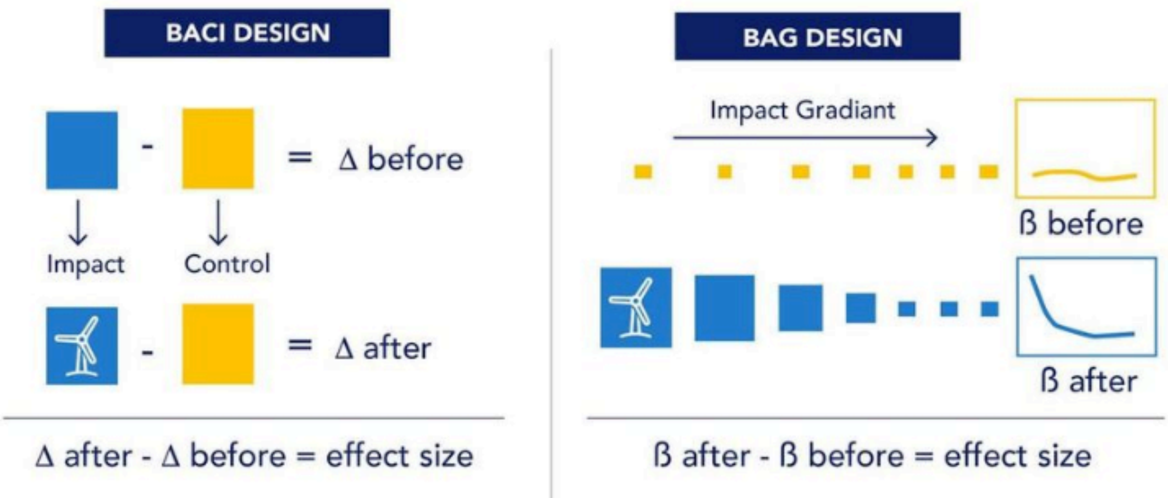
[14] See Ellis and Schenider, 1997; Brandt et al., 2011; and Methratta 2020.

        - Sufficient data are available or can be collected to establish baseline conditions before construction begins (e.g., multiple years of data to address annual variation)
        - A spatial gradient in target indices is expected
        - Appropriate control sites (i.e., those that are outside the spatial extent of impact and similar to impact sites in terms of biological, habitat, and environmental variables that affect fish abundance and distribution) are not available
        - Impacts are thought to occur beyond the boundary of the wind farm (e.g., wind wakes effects, spillover effects, etc.) or along the cable corridor
        - Turbine and cable locations are known before collection of pre-construction data or post facto assignment of sites along a gradient can be made
        - Pre-construction data can be spatially modeled with sufficient spatial resolution to provide comprehensive “before” data
    - Before-After-Control-Impact (BACI)[15]: A BACI approach (Figure 3) typically is most appropriate when:
        - Sufficient data are available or can be collected to establish baseline conditions before construction begins
        - Spatial homogeneity in target indices is thought to occur in the area of study or can be achieved by stratifying the area, or by incorporating relevant environmental covariates (e.g., T, depth, habitat) into the abundance modeling
        - Appropriate control sites outside the spatial extent of impact are available and demonstrated to be appropriate (i.e., they are similar to impact sites in terms of biological, habitat, and environmental variables that affect fish abundance and distribution
        - Survey/monitoring plan focuses on site-specific or within-site studies, localized effects, and/or on sedentary species
        - Impacts are thought to occur only within the boundary of the wind farm or along the cable corridor
    - Sample selection:
        - Selection of sampling locations within each sampling approach could be conducted by a number of methods, including random stratified, simple random, and systematic sampling (see Krebs 1989)

[15] See Underwood 1991, 1992, 1993, and 1994.

- Any stratification of sampling locations should be based upon meaningful variables such as habitat type, depth, and distance from structures and be consistent with or more precise than existing strata developed for the Northeast Fisheries Science Center surveys, as appropriate

Figure 3: Comparison between a BACI and a BAG sample design



BACI and BAG designs both rely on baseline sampling (top rows) to assess impacts (bottom rows). BACI relies on careful control site selection, relying on the assumption that the wind tower influences along with other environmental forcing such as storms will influence control and impact sites similarly. BAG designs do not require control sites and rely on incorporation of key impact and environmental gradients (Secor 2018)

Sample and Effect Size Determination:

The sample size should be informed by the project monitoring plan objectives, research questions/hypotheses, and existing data and literature. In addition, sample size should be sufficient to detect effects. There are several important elements to consider during this process, and these depend upon a clear and concise exposition of the research questions, hypotheses, or monitoring objectives (see Section 3.1). Power analysis, a primary method for determining sample size, requires that the user inputs the expected effect size. Survey/monitoring plan coordinators should review the best available scientific information and select an effect size that reflects previous findings regarding the likely scale of a particular effect size. Note that larger effect sizes (e.g., a 10-fold increase) are more easily detected than moderate effect sizes (e.g., a 50% increase). If there is high uncertainty about the effect on a species/group, then a larger sample size should be used. A moderate effect size may be appropriate in many instances, but going through the process of considering the monitoring objectives/hypotheses, previous research, and other factors listed below is essential to making the final decision on what effect size to use in determining sample size.

The effect size used will depend on the hypothesis being examined, the scientific information available to support the hypothesis, and best professional judgement about what effects may be. Choosing the effect size should at minimum include a consideration of the following, although other factors may be appropriate as well:

- Functional/Taxonomic groups: such as demersal species, pelagic species, highly migratory species, planktivores, piscivores, benthivores, reef or soft-bottom-associated species, structure forming taxa, long-lived species, etc.
- Biological variables and indices: such as abundance, fish size, condition, recruitment, etc.
- Seasonal and Annual variability: Annual fluctuations of various biological and environmental parameters may necessitate multiple years of data to determine effect and sampling size.
- Spatial variability: How uniform biological variables and indices are for the species/group over a geographical area and the biological variables/indices to be studied
    - *Example:* Effect sizes for demersal fish are relatively large close to turbine structures (0-50m), but attenuate with distance from the turbines (Bergstrőm et al., 2013)
- Statistical significance and biological importance: Consider whether small, moderate, or large changes have the potential to be biologically important given applicable research questions and hypotheses. Small changes may be particularly important for endangered species or a species whose critical habitat, spawning grounds, nursery grounds, etc. overlap with wind development. Larger, widespread localized changes may cumulatively have important implications for species distributions and shifts.
- Natural disturbance: Effect size may be masked, enhanced, or otherwise changed by rapid changes in wind, flow, temperature and other environmental conditions, which are commonplace in US temperate shelf waters, or long-term natural changes such as global warming/climate change. Information gathered during baseline studies and BACI/BAG designs (where environmental covariates are included) can be employed to adjust effect sizes to account for such change.
- Other considerations: Sampling size should also consider the mortality of sampled species from the subject project, adjacent projects, and regional surveys; disruption to fishing and other uses of the project area; and potential interactions with protected species.

When existing data from other surveys or previous research are available, it can be useful to explore the sample size-power-effect size relationships and trade-offs therein by constructing power curves (e.g., Lu et al., 2017; Krzywinski and Altman, 2013; Castelloe, 2000) for a range of relative effect sizes. An effect size such as Cohen's d (the difference between the wind farm and control means standardized by a pooled standard deviation) or a relative percent change between the wind farm and the control with an associated confidence interval could be used. In the case of Cohen's d, relative effect sizes are generally considered as follows: small (0.2), medium (0.5), large (0.8)) (Cohen, 1988). Data used for power analysis should come from studies conducted in the same general area, using similar gear, and targeting the same biological indices. If existing data sets are small, then a bootstrapping/resampling approach could be used to amplify the data. When existing data from the site are not available, a comprehensive search for information from analogous studies, data from nearby areas, information about the biology of the species being studied should be gathered. This information should be evaluated in total to inform and justify the effect size based on the study coordinator's best professional judgement.

3.4 Sampling Method

Each project monitoring study should describe and justify how samples will be collected in as much detail as possible. Sampling methods should effectively carry out the intended sampling design based on the plan objectives and hypotheses to be tested, species known or expected to be encountered, and the environmental conditions at the site. Sampling methods should be standardized across individual projects and calibrated with regional scientific surveys to the maximum extent possible and plans should note which existing surveys or methods they are following. Given that it will not be possible to operate all existing surveys (e.g., Northeast Fisheries Science Center bottom trawl surveys) within wind development areas, if project monitoring plans propose to use new sampling methods, the plan should also describe how such new methods would/could be standardized with existing survey results, which may include calibration with existing survey gear types, as noted above in Section 2.4.2. This will allow data collected for an individual project to inform the three classes of studies (site-specific, project-specific, and regional/ecosystem) and maximize the utility of monitoring efforts.

Active and passive fishing gears and new technologies should be reviewed relative to their capability to address both site/project-specific and the broader regional/ecosystem monitoring objectives. In selecting the gear to be used, each study should evaluate the operational characteristics that will influence sampling protocols, including species selectivity of individual gear types, catch efficiencies that influence sampling intensity (replicates), sampling duration and frequency decisions that influence program costs and overall environmental impacts (incidental takes and sampling mortality), and the need to collect biological samples, as noted above. Practical issues to consider include whether a specific gear type, particularly mobile bottom trawl and dredge gear, can operate within the sampling area due to obstructions (wrecks, boulders, cable protection, etc.) and whether the research vessel has the capability of safely operating within the sampling area once turbines are installed.

Sampling methods should include the following components, with individual elements dictated by project monitoring plan objectives and hypotheses:

- **Gear types and sampling modalities, such as:**
  - Trawl (bottom, mid-water, otter, and beam)
  - Trap (ventless) and pots, including fish pots
  - Gillnet
  - Hook gear (jigs, pelagic and bottom longline, bandit gear, rod and reel, and tub trawl)
  - Dredge (single, double, hydraulic)
  - Benthic grab (Hamon grab, Van Veen grab, benthic sled)
  - Bongo net
  - Optical/Camera (drop camera, sediment profile imaging, baited underwater video, towed vehicle (e.g., HabCam))
  - Tagging (conventional and electronic) and any associated receiver networks
  - Vessel-based acoustic population survey
  - Autonomous underwater vehicles and gliders, including those with mounted video and high resolution acoustic camera (e.g., dual frequency identification sonar (DIDSON) and adaptive resolution imaging sonar (ARIS))
  - Moored buoys
  - Molecular sampling (e.g., e-DNA)

BOEM's Fisheries Monitoring Plan Guidance includes gear-specific sampling method considerations and advantages/disadvantages to using particular gear types. Table 1 provides an updated list of advantages and disadvantages associated with a list of current sampling gear types/modalities.

Table 1: Advantages/disadvantages of various sampling gear types/modalities.

	Otter Trawl Survey	Beam Trawl Survey	Midwater Trawl Survey	Ventless Traps	Gillnet Survey	Hook Gear (rod and reel)	Hook Gear (longline)	Dredge Gear (scallops)	Hydraulic Dredge Gear (clams)	BRUVs	SCUBA Diving	Drop Camera or Towed Camera	Acoustic Telemetry	Bongo Net	Acoustic Population Survey	eDNA
Comparable to other regional data collection efforts	++	-	- -	++	- -	- -	-	++	++	- -	- -	++	++	++	-	- -
NMFS permit concerns	+	+	+	-	- -	++	++	+	+	++	++	++	+	++	+	++
Collects biological data (e.g., weight, sex, diet, etc…)	++	++	++	++	++	++	++	++	++	-	- -	-	N	-	- -	-
Selects a wide range of commercial fish and invertebrate species	++	+	+	-	- -	-	-	-	-	+	++	-	+	+	-	++
Operable in any habitat	-	N	N	++	N	++	++	-	-	++	N	++	++	+	++	++
Familiar to industry or regulators	++	N	++	++	+	+	+	++	++	- -	- -	++	+	+	+	N
Interactions with developers site investigation activities or gear conflicts with industry	N	N	-	- -	- -	++	+	N	- -	++	N	++	-	+	+	++
Results in mortality to sampled animals or bycatch	- -	- -	- -	+	- -	-	-	- -	- -	++	++	++	+	+	++	++
Can be used for distance-based sampling	-	-	-	++	+	++	++	-	-	++	++	++	++	-	+	N
Can be used to sample in close proximity to foundations	-	-	-	++	++	++	++	- -	- -	++	++	++	++	-	++	++
Easy to standardize	++	++	++	++	- -	-	N	++	++	+	-	++	+	+	-	N
Can involve recreational fishing industry	-	-	-	-	-	++	N	-	-	++	- -	N	++	N	-	++
Innovative (NOAA strategy)	-	-	-	-	-	-	-	-	-	++	N	+	++	N	++	++
Other concerns	Variability in catch rates may reduce power.	Limited regional data for comparison.	Limited regional data for comparison. Can be paired with acoustic data. Pair-trawling may not be operable post-construction.	Most suitable gear for lobsters and crabs. Right whale concerns may affect permitting	Mutliple mesh sizes may be needed to improve selectivity. Permitting issues (protected species).	No sampling of invertebrate species	No sampling of invertebrate species	Can it be used after construction?	Primary option for clams and quahogs. Can it be used after construction?	Can also be used to collect benthic habitat information. Species ID will be a challenge in some cases. Data is saved permanently. Algorithms can be used for processing. Can be paired with other techniques.	Can also be used to collect benthic habitat information. Health and safety concerns may preclude the use of this technique.	Can also be used to characterize benthic habitat. Species ID challenges. Video review time and cost. Algorithms possible. Permanent data storage.	Data sharing needs to be worked out. Expense can limit sample sizes. Uncovers behavior and repsonse of individual animals. Metrics need to be defined.	Only samples certain life stages.	Species ID can be a challenge. Can be used to verify benthic habitat, in some cases.	Can also be used to sample for marine mammals. Species ID not always possible. Emerging field. Can be collected opportunistically.

++ Very positive

+ Slightly positive

N Neutral or unknown

- Slightly negative

- - Very negative

- **Gear configuration:** Gear parameters (mesh size, dredge width, etc.) and configuration should be noted for each project monitoring study. To facilitate standardization with existing data, gear configuration should mirror that used by existing surveys, particularly otter trawl, dredge, ventless trap, and some types of hook gear, whenever possible. For gear types that are not used in regional surveys, (e.g., gillnets), gear configuration should mirror local commercial fishing operations.
- **Operational protocols:**
    - Describe the amount of gear, number of tows/sets, tow/soak time, tow speed, gear performance metrics (net height, door spread, sweep height), spacing of fixed gear, and other operational parameters for each gear type/sampling modality. Project monitoring plans/studies should conform to existing survey sampling protocols unless the research and monitoring objectives are not applicable or established protocols do not exist. Existing survey protocols include:
        - Northeast Fisheries Science Center Bottom Trawl Survey Protocols[16]
        - Northeast Area Monitoring and Assessment Program (NEAMAP)[17]
        - State agency survey protocols
        - Cooperative research examples (e.g., Gulf of Maine Cooperative Bottom Long-line Survey)
    - Document any methods for collecting data, including sub-sampling, scale calibration, species identification, measuring species length/weight, recording sex, and stomach content analysis, as appropriate, to help compare results to other survey efforts and studies.
    - Operations should reflect best management practices to mitigate the risk of take of protected species to the greatest degree possible[18], including:
        - Time of year restrictions to limit interactions
        - Minimizing gillnet soak or trawl tow durations to the maximum extent practicable
        - Use vertical/buoy lines with a breaking strength of 1,700 lbs or ropeless gear

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[16] See Politis et al., 2014.

[17] Visit the NEAMAP nearshore trawl survey website or contact the ASMFC (info@asmfc.org, 703-842-0740) for further information.

[18] NMFS is finalizing guidance on best management practices and will make it available on the Greater Atlantic Region's wind energy development page. Contact the GARFO Protected Resources Division (978-281-9328) for additional information.

        - Unique gear marking (in coordination with NMFS Atlantic Large Whale Take Reduction Team coordinator), no wet storage of gear, and reporting lost gear to incidental.take@noaa.gov
        - Minimizing the number of vertical lines set in the water
        - Complying with ESA and MMPA Regulations (e.g., Marine Mammal Authorization Program requirements, Atlantic Large Whale Take Reduction Program, Harbor Porpoise Take Reduction Program, or Bottlenose Dolphin Take Reduction Program regulations)

Project monitoring plans/studies should consider developing a survey gear performance plan and a sampling methods calibration plan for each sampling method proposed, particularly gear other than bottom trawl, dredge gear, and pots/traps, to improve the integration of plan data with that from existing surveys. A gear performance plan describes standardized methods for evaluating gear performance, performance criteria, standardized reporting of gear performance for all sampling events, and data quality assurance. A sampling methods calibration plan describes methods and analysis to integrate data collected with regional data collection efforts, including plans for the design and execution of any necessary calibration experiments.

3.5 Data Collection

Each project monitoring plan/study should clearly articulate what information will be collected and how it would be collected consistent with plan objectives and hypotheses. Information collections should include, as appropriate, the following:

- **Species identification**, whenever possible, consistent with the Integrated Taxonomy Information System (ITIS), including marine mammals and threatened/endangered species
- **Biological parameters** of sampled species, for example:
    - Weight in kilograms (kg)
    - Length to the nearest centimeter (cm), consistent with the species-specific measurement type (e.g., total vs. fork) identified in the Northeast Observer Program Biological Sampling Guide
    - Age either through direct sampling (otolith/scale) or through age-length keys
    - Stomach content (prey items identified to lowest possible taxonomic level, counted, and weighed)

    - Sex and spawning condition (e.g., spent, ripe, ripe and running, etc.) consistent with Northeast Fisheries Science Center sex and maturity codes
    - Tissue/blood samples for molecular or stable isotope studies or health assessments
- **Environmental conditions** (collected simultaneously with biological samples) such as:
    - Temperature
    - Depth
    - Salinity
    - Dissolved oxygen
    - Oceanographic variables (e.g., current speed)
    - Turbidity
    - Chlorophyll a
    - Ambient sound
    - Electromagnetic fields (EMF)
- **Interactions with protected species** (i.e. marine mammals, sea turtles, sturgeon): Proposed fishery surveys may be authorized under a range of different permitting options (e.g., an Exempted Fishing Permit (EFP), ESA section 7 Biological Opinion). Depending on the type of permit obtained by the developer, reporting an interaction with a protected species may vary. Given this, once the developer has identified which permit will be pursued, coordination with NMFS is needed to obtain specific instructions for reporting interactions with protected species.
- **External factors:** The project monitoring plan/study should identify any other activities that may affect data collection and interpretation of results, including overlap with any project-specific or adjacent project surveys or other activities such as fishing pressure. Expertise from local fishing captains can help ensure that gear is deployed in a way that is consistent with local fishing practices, to help minimize gear conflicts and avoid the loss of sampling gear. Coordination with adjacent project monitoring plans may be necessary before finalizing your project monitoring plan.

Data should be subject to rigorous quality assurance/quality control protocols. Data collected should also be formatted according to accepted standards whenever possible, or in a format capable of conversion into the format used in existing surveys. Existing formats for data formats include:

- **Spatial data:**
    - BOEM's Spatial Data Submission Guidelines

  - BOEM's Benthic Habitat Guidelines
  - NMFS Recommendations for Mapping Fish Habitat
- **Fisheries data:**
  - NEFSC Bottom Trawl Survey Protocols
  - NEAMAP Trawl Survey Data Collection and Analysis

Project monitoring plan/study coordinators should consult with the fishing industry, states, and NMFS before finalizing the plan to help refine the sampling and data collection methods, employing fishery participants to conduct operations whenever possible.

3.6 Analytical Methods

Building on the sampling design and methods, each project monitoring plan/study should describe how the data collected will be analyzed. Analytical methods will depend on the class of study (site-specific, project-specific, regional/ecosystem) for each analysis and should produce results that address project-specific objectives and hypotheses. It is important to note that analytical results should be presented in a way that maximizes the utility of the data in impact assessment and facilitates its use in stock status/ecosystem assessments.

Project monitoring plan/study analytical methods should accomplish the following, as appropriate:

- **Evaluate the biological baseline** through calculation of summary statistics for parameters such as:
  - Absolute abundance by species (estimate of the total number and weight within the sampling area), noting any gear efficiency assumptions used and how they were derived (including by reference)
  - Relative abundance by species (number or weight per standardized sample such as catch per unit effort)
  - Presence/absence by species (percent frequency of occurrence)
  - Fish condition/demographics (length, weight, sex, sexual maturity stage, age, diet, signs of disease/parasites, etc.)
- **Assess changes** from the biological baseline that occur during and after construction using standard statistical methods, including providing confidence intervals on the estimated magnitude of effects. For example:
  - Before-After-Gradient (BAG) sampling design:

        - Conducting regression analysis may be appropriate if the relationship between independent and dependent variables is expected to be linear. Use of a generalized additive model (GAM) or other methods that accommodate nonlinearities may be appropriate if the relationship between independent and dependent variables is expected to be non-linear.
        - Assess the role of covariates, including environmental variables, habitat type, fishing pressure, turbine number/spacing, wind farm footprint, turbine foundation type and area and proximity to other wind farms
        - Benthic changes as a result of project construction should be assessed using habitat type as an independent variable
    - Before-After-Control-Impact (BACI) sampling design:
        - Conduct an appropriate analysis examining change in metrics over time compared to a baseline such as a general linear model (GLM) (see Christie et al., 2020 and Walters et al., 1988).
        - Evaluate analytical assumptions through simulation approaches, assess the role of covariates, including environmental variables conditions, fishing pressure, turbine number/spacing, wind farm footprint, turbine foundation type and area and proximity to other wind farms
        - Benthic changes as a result of project construction should be assessed using habitat type as an independent variable
    - At a minimum, project monitoring plans should evaluate changes for as many years as data are collected and available from that plan. Ideally, project monitoring plans, particularly those conducting broad scale (regional/ecosystem) studies, should strive to facilitate comparisons over a longer time series, including comparing plan indices to those from existing regional and shelf-wide scientific surveys.
    - Multivariate indices and non-parametric testing could be explored with appropriate multivariate methods depending on the assumptions being made and goals of the analysis (McGarigal et al., 2000).
    - Ensure that efforts to evaluate change are tailored to the nature of the system, context of the study, stressors being examined, assumptions made in the analysis, and the hypotheses to be tested.

Project monitoring plans should also consider additional analysis that could help inform future evaluation of project-specific impacts, including impacts to existing surveys and impacts associated with construction or mitigation measures. ROSA will continue to discuss such additional analysis, including steps that project monitoring plan/study coordinators could take to facilitate such analysis even if not conducted as part of an individual project's formal plan. Additional analysis could include:

- Evaluating the compatibility of project monitoring plan/study data with existing survey data:
    - Compare and prioritize biological indices (mean and variance) collected as part of project-specific monitoring efforts (i.e., indices of abundance and occurrence) with those of other wind development projects and existing regional surveys at various scales (site-specific, project area, lease area, sampling strata, stock area, or regional/ecosystem levels). This can only be done if data collection methods are standardized across individual projects and calibrated with existing regional scientific surveys. This would help to determine whether the patterns observed at the scale of individual projects or across multiple projects are due to offshore wind development or whether they are tracking regional or ecosystem level trends (e.g., population declines caused by climate change driven by increases in water temperature).
    - Assess spatial and temporal heterogeneity of biological indices
    - Identify the number of fisheries biological study survey stations located within each stratum used by federal resource surveys as a means to help determine whether plan data could augment federal surveys negatively impacted by development
- Evaluate survey designs for feasibility and statistical power across projects
- Analyzing differences in resource impact and/or recovery associated with different construction techniques (e.g. pile installation, scour protection, cable installation, cable protection)

4. Benthic Habitat/EFH Monitoring Studies [*To be developed*]

Due to the interconnectedness between fisheries and benthic habitat, project monitoring plans/studies should include a benthic habitat component. It is also likely that benthic habitat monitoring/studies will be recommended during state and federal project reviews. Baseline data collection of such information could be part of benthic habitat survey and EFH mapping efforts for site characterization[19], a component of fisheries biological studies referenced above in Section 3 (e.g., examining use of cobble as spawning areas and juvenile refuges by Atlantic cod on Cox Ledge), a directed habitat effects study (e.g., assessing habitat conversion due to scour protection), or in response to project-specific state or federal recommendations (e.g. EFH conservation recommendations provided by NMFS).

Similar to the biological monitoring studies identified in Section 3 of this document, this section will discuss how to integrate the following project monitoring plan/study components into benthic habitat studies:

- **4.1. Objectives and Testable Hypotheses**
- **4.2. Spatial and Temporal Scale**
- **4.3. Sampling Design**
- **4.4. Sampling Method**
- **4.5. Data Collection**
- **4.6. Analytical Methods**

5. Socioeconomic Monitoring Studies [*To be developed*]

Fishing operations may change as a result of offshore wind development projects, which could, in turn, affect individual fishermen, the fishing sector at large, and the coastal communities that are dependent on fishing. Monitoring such changes should be included in comprehensive monitoring plans for each project and may be required by some states. Such studies could include assessing social and operational effects associated with wind development, including changes in fishing location, fishery landings/revenue, fishing efficiency (catch per unit effort), fishing tactics/gear type used, fishery costs, fishery transit patterns, port dependence on fishing, operational costs, perceptions of wind development, and shoreside infrastructure scale/capacity.

While collecting new information regarding fishing operations across all vessels that operate in a lease area may be difficult, it is possible to evaluate existing information on fishery operations and resulting landings and associated revenue. Summaries of existing fishing operations within a particular lease area are available on the NMFS'

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[19] See BOEM's Benthic Habitat Survey Guidelines and NMFS Recommendations for Mapping Fish Habitat.

Socioeconomic Impacts of Atlantic Offshore Wind Development website based on vessels that submit vessel trip reports (logbooks). In addition, vessel monitoring system (VMS) and automatic identification system (AIS) data identify vessel position and can be used to evaluate fishing activity for some vessels operating in some fisheries.[20] Data on commercial and party/charter operations may also be acquired by submitting a data request to NMFS.[21] Other resources include NMFS port agents, state/federal fisheries experts, and fisheries representatives and liaisons hired by developers. These resources could provide the foundation for the site characterization regarding socioeconomic issues.

When evaluating fishery operations, plan/study coordinators must consider the limits of the data, the influence of current and historical fishing regulations that affect(ed) where, when, and with what gear vessels can operate, and external factors (market price, species availability, fuel costs, etc.) that affect fishery operations. These factors may affect the ability to detect or associate causation with any changes to fishing operations that may be observed.

Similar to the biological monitoring studies identified in Section 3 of this document, this section will discuss how to integrate the following project monitoring plan components into socioeconomic studies:

5.1. Objectives and Testable Hypotheses
5.2. Spatial and Temporal Scale
5.3. Sampling Design
5.4. Sampling Method
5.5. Data Collection
5.6. Analytical Methods

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[20] VMS data are available upon request from the NMFS Office of Law Enforcement, while AIS data are available through various private service providers. Currently, the following fisheries require the use of a VMS: Atlantic herring, Atlantic mackerel, Atlantic sea scallop, Atlantic surfclam, butterfish, *Illex* squid, longfin squid, Northeast multispecies (groundfish), Maine mahogany quahog, and ocean quahog. Other fisheries may elect to use VMS (monkfish), or may be covered by VMS because of the issuance of another fishery permit requiring the use of VMS. VMS is not required for significant fisheries such as the lobster, whiting, and fluke fisheries, although their operations may be included if a vessel is issued other permits that require VMS. AIS is also only required for vessels over 65 feet long, so smaller vessels are not well represented.

[21] Submit a detailed data request to nmfs.gar.data.requests@noaa.gov.

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Glossary

Baseline: Reference condition yielding indicator response(s) absent the tested impact or stress. Baseline is a general term that includes, (1) Before treatments in BACI and BAG designs; (2) Control treatments in Control Impact and BACI designs; and (3) Empirical data or modeling products that give a representation of reference conditions. Monitoring plans should specify the type of baseline and how it will be used in a comparative and quantitative framework.

Before-After-Control-Impact (BACI): Impact evaluation procedure that controls for temporal confounders. The procedure simultaneously measures Before-After differences at selected Control Impact sites. Significant impacts occur when the Before-After difference is greater at the Impact sites than at the Control sites (see Figure x).

Before-After-Gradient (BAG): Impact evaluation procedure that integrates continuous (gradient) variables to (1) measure the response of an attenuating impact (e.g., percussive pile-driving strikes or artificial reef spillover effects), or (2) integrate continuous confounders into the procedure. Impacts occur when the Before-gradient function differs from the After-gradient function. Note that BAG designs do not include control sites. BAG and BACI designs are not necessarily exclusive: BACI designs can be designed to include key response and confounder gradients.

Bootstrapping: A statistical procedure that randomly resamples a single dataset to create many simulated samples. This method can allow an estimation of error associated with an estimated mean when sample sizes are small.

Bureau of Ocean Energy Management (BOEM): The United States federal agency that manages the development of U.S. Outer Continental Shelf energy including offshore wind development and mineral resources.

Catch per Unit Effort (CPUE): An indirect measure of fish species abundance that is calculated as the total amount of catch divided by the amount of effort used to harvest the catch.

Control: Selected reference sites or conditions that are isolated from, but otherwise identical (in the ideal) or very similar to impacted sites or conditions with regard to biological, physical, and environmental variables as well as other uses (e.g., commercial fishing, industrial development, etc.).

Cooperative Research: A partnership between the commercial and recreational fishing industries and the science community to conduct research, improve understanding of ocean ecosystems, and support sustainable fisheries management.

Development Area (see Scales, Project-specific): The area which include the footprint of wind development infrastructure and areas adjacent to wind farms that will be subject to impact-producing effects (e.g., soundscapes, areas that maybe perturbed by changes in oceanography)
Effect Size: Statistically determined direction and magnitude amplitude of an indicator's response owing to an impact or stress.

Endangered Species Act (ESA): As the primary law in the United States for protecting imperiled species, the ESA is designed to protect critically imperiled species from extinction as a "consequence of economic growth and development untempered by adequate concern and conservation"

Environmental Variables: See "variables"

Fish condition: Indicators related to growth, diet, reproduction, or other physiological responses of individual fish.

Fishery dependent: Data collected from commercial sources (fishermen or dealer reports) and recreational sources (individual anglers, party or charter boats) on the total amount of fish removed from the ocean (landings and dead discards) and the level of fishing participation (effort).

Fishery independent: Data collected by scientists conducting long-term resource monitoring projects in order to develop unbiased and independent indices of abundance.

Fork Length: The length of a fish from the tip of its nose to the end of the center of the caudal fin.

Greater Atlantic Regional Fisheries Office (GARFO)

Hypothesis: A testable explanation of expected response based upon best available science. Hypotheses begin as questions on offshore wind impacts for which expected responses represents the hypothesis. Expected responses can be derived from review of existing studies, analysis of existing data, expertise, experience, and consensus, and are tested in an indicator-performance measure framework.

Indicator: Variable that is responsive to hypothesized impact. Common variables include relative abundance (CPUE), incidence, growth, mortality, movement rate, fishing effort.

Geotechnical and Geophysical (G&G) Surveys: In the context of siting for offshore wind development, G & G surveys involve High Resolution Geophysical (HRG) studies in which sound waves are reflected off subsea structures to collect data on conditions both at the seafloor and the shallow subsurface. HRG equipment generally includes off-the-shelf marine sonars and survey equipment (e.g., multi-beam echo sounders, side scan sonars, sub-bottom profilers). HRG systems usually use higher frequencies than those used in seismic airgun surveys and image smaller structures with a higher level of detail.

Marine Mammal Protection Act (MMPA): Passed by the United States Congress in 1972, the MMPA is a national policy aimed at preventing marine mammal species and population stocks from declining beyond the point where they ceased to be significant functioning elements of the ecosystems.

National Marine Fisheries Service (NMFS): The principal U.S. federal government agency responsible for the stewardship of the nation's ocean resources and their habitat.

NorthEast Area Monitoring and Assessment Program (NEAMAP): NEAMAP is an integrated, cooperative state/federal data collection program whose mission is to facilitate the collection and dissemination of fishery-independent information obtained in the Northeast for use by state and federal fisheries management agencies, the fishing industry (commercial and recreational), researchers, and others requesting this information.

Northeast Fisheries Science Center (NEFSC): The scientific research center of NMFS for Northeast Continental Shelf Ecosystem which spans the region from the Gulf of Maine to Cape Hatteras. NEFSC studies fishery species and fisheries, monitors and models ocean ecosystems, and provide reliable advice for policy makers.

Northeast Fisheries Observer Program: The Northeast Fisheries Observer Program trains, deploys, debriefs, and oversees more than 120 observers each year. These observers are professionally trained biological scientists who collect catch data dockside and onboard fishing vessels. This data is used for in-season management, stock assessments, and ecosystems studies.

Oceanographic variables: See "variables"

Performance Measures: Hypothesized direction and amplitude of change in an indicator or set of indicators. Performance measures are often statistical in nature such as effect size, functional responses to impact, and statistical confidence in detecting expected change or rate of change. Performance measures can also be based on regulations such as limits associated with marine mammal protections and ocean noise.

Power Analysis: Statistical procedures that test for the minimum sample size required to detect a specified amplitude of change for a specified level of significance.

Project-specific scale: Aggregate offshore wind impacts and responses that occur within and immediately adjacent to the wind project footprint and transmission routes (>10 km2). Cumulative effects of multiple turbine structures, the transmission grid the combination of scour protection structures and the entire transmission grid. Responses at this scale include changed hydrology and physical transport, changed sessile communities, changed abundance and depth distributions of fishes, and altered fishing behaviors by fleets.

Regional/Ecosystem scale: Offshore wind impacts and responses that occur at > 1000 km2 including cumulative effects of multiple offshore wind projects, interactive effects of ocean forcing (e.g., warming, Cold Pool turnover), and greater vessel traffic. Responses at this scale included changed migration behaviors of migratory species, shifting fish distributions and food web structure, and changed ports and fishing grounds.

Site-specific scale: Offshore wind impacts and responses occurring < 10 km2 typically involving the effects of single or multiple turbines, scour protection structures, transformer substations, and transmission cables. Response at this scale could include lethality and movement, feeding, reproduction, and physiological responses to pile driving, EMF, or the reef effect.

Total Length: The length of a fish from the most forward point of the head, with the mouth closed, to the farthest tip of the tail with the tail compressed or squeezed, while the fish is lying on its side.

Variable: Any measured attribute associated with a monitoring program, inclusive of indicator and other response variables, impact variables (e.g., noise, EMF, increased structure), and confounder variables (e.g., bottom temperature, bathymetry, season).

Appendices

Appendix A: Offshore Wind Development Monitoring Studies Checklist Fisheries Biological Studies

This checklist will help offshore wind project coordinators develop project monitoring plans and associated studies consistent with the Responsible Offshore Science Alliance (ROSA) Offshore Wind Project Monitoring Framework and Guidelines. Adherence to this checklist should expedite the review of monitoring plans/studies and maximize the utility of study results for project monitoring and impact evaluation and regional marine resource assessment purposes.

- ☐ Evaluate Available Data
    - Review existing survey data, research papers, and socioeconomic impact reports (see Appendix B)
    - Identify fisheries and habitats within the project area and possible stressors affecting such resources
- ☐ Consult with State/Federal Agencies, Researchers, and Fishing Industry Participants
    - Schedule meetings to discuss plan/study parameters up to one year before sampling begins
    - Confirm important fisheries, habitats, stressors within the project area based on previous data review
    - Elicit any applicable regulations, required permits, and priority issues and concerns
    - Discuss plan/study objectives, hypotheses, and research questions and appropriate indicators
    - Evaluate potential sampling design, methods, data collections, and compatibility with regional surveys
- ☐ Define and Prioritize Testable Hypotheses and Monitoring Objectives
    - Define plan/study purpose, objectives, assumptions, and testable hypotheses
    - Ensure hypotheses and objectives reflect priority resources and stressors within project area
- ☐ Identify Monitoring/Research Focus and Indicators/Receptors and Associated Change Thresholds
    - Identify species/habitats to be sampled, focusing on commercially/recreationally important species
    - Integrate indicators necessary to achieve plan/study objectives into study design and data collections
    - Indicators include indices of abundance/occurrence, demographics, environmental variables, and habitat
    - Specify thresholds for each indicator/receptor to be used in evaluating change before/after construction
    - Consider factors that may affect inter-annual variability in particular indicators and influence results
- ☐ Describe Sampling Design(s)
    - Describe sampling approach (e.g., before/after gradient or control/impact) and sample selection method
    - Conduct a power analysis to determine sample size based on plan/study objectives and expected effect size
    - Ensure that it addresses hypotheses, research questions, and monitoring plan objectives
- ☐ Describe Sampling Method(s)
    - Identify sampling gear types to be used, gear size (dredge width), mesh size, number, and configuration
    - Specify operational protocols for each sampling gear (tow/soak duration, net height, trap spacing, etc)
    - Document any differences from established state/regional survey methods and operational protocols
    - Specify study spatial scale (site-specific, project-specific, regional/ecosystem)
    - Identify sampling timing (when), frequency (how often), and duration (how long pre- and post-construction)
    - Highlight any best management practices intended to minimize protected species take
- ☐ Specify Data Collection Protocols
    - Identify what information will be collected, including biological parameters (length, weight, sex, stomach content), environmental conditions (temperature, depth, salinity), and any protected species interactions
    - Identify how data will be collected (measuring tools, protocols, sub-sampling, standards, calibration, etc.)
    - Document metadata for each data collection, including metrics used (centimeter vs inch) and data format
    - Use existing data standards, formats, and protocols for similar studies/surveys whenever possible
- ☐ Describe Analytical Methods
    - Describe how plan/study will evaluate data collected consistent with plan/study objectives and hypotheses
    - Evaluate scale/significance biological baseline changes (abundance, presence/diversity, fish condition, etc.)
    - Analytical methods may differ based on sampling design and available data
- ☐ Describe Data Storage and Sharing Processes and Protocols
    - Identify how data will be stored, formatted, and made available to agencies, researchers, and the public
- ☐ Describe Performance Review Process and Metrics
    - Identify any performance metrics/process used to evaluate if results are achieving plan/study objectives
    - Review plan/study results annually, documenting any changes to plan/study operations and protocols

Appendix B: Existing Resources, References, and Guidance Documents

The following resources have information relevant to the development of project monitoring plans:

- BOEM
    - Identifying Information Needs and Approaches for Assessing Potential Impacts of Offshore Wind Farm Development on Fisheries Resources in the Northeast Region (BOEM 2015)
    - Development of Mitigation Measures to Address Potential Use Conflicts between Commercial Wind Energy Lessees/Grantees and Commercial Fishermen on the Atlantic Outer Continental Shelf (BOEM 2014)
    - Guidelines for Providing Information on Fisheries for Renewable Energy Development on the Atlantic Outer Continental Shelf (BOEM 2019)
    - Developing Environmental Protocols and Modeling Tools to Support Renewable Energy and Stewardship (McCann, 2012)
    - Guidelines for Providing Benthic Habitat Survey Information for Renewable Energy Development on the Atlantic Outer Continental Shelf (BOEM 2016)
    - Current environmental studies
    - Guidelines for Providing Information on Fisheries Social and Economic Conditions for Renewable Energy Development on the Atlantic Outer Continental Shelf Pursuant to 30 CFR Part 585 (BOEM 2020)

- NMFS
    - Magnuson-Stevens Fishery Conservation and Management Act permitting requirements for research surveys
    - Socioeconomic Impacts of Atlantic Offshore Wind Development includes summaries of fishery effort and socioeconomic information by lease area
    - Fishery-dependent data requests should be emailed to NMFS.GAR.Data.Requests@noaa.gov.
    - Social Indicators for Fishing Communities
    - Community Snapshots
    - Recommendations for Mapping Fish Habitat
    - Stock Status, Management, Assessment, and Resource Trends: Provides applications to search, view, compare, and download the results of assessments for stocks managed by NOAA Fisheries. For more detailed

stock assessment reports, visit the Northeast Fisheries Science Center Stock Assessment Review Index Search page.

  - NMFS' Office of Science and Technology site contains links to many resources, including commercial/recreational statistics, socioeconomic data, and assessment information.

- States:
  - Atlantic Coastal Cooperative Statistics Program: Access to commercial and recreational fishery data off the Atlantic coast
  - Management Objectives and Research Priorities for Fisheries in the Massachusetts and Rhode Island-Massachusetts offshore Wind Energy Area
  - New Jersey Coastal Zone Management Rules
  - New York Offshore Wind Solicitation, including elements for a fisheries mitigation plan and an environmental mitigation plan
  - Rhode Island Ocean Special Area Management Program Regulations
  - Rhode Island Coastal Resources Management Council regulatory standards (650 RICR-20-05-11 §11.9 and §11.10) require that developers "assess the relative abundance, distribution, and different life stages of [commercially and recreationally targeted species] at all four seasons of the year"
- Others:
  - Northeast Ocean Data Portal and Mid-Atlantic Ocean Data Portal
  - International Energy Agency's Ocean Energy Systems State of the Science Report
  - A Practical Handbook for Determining the Ages of Gulf of Mexico and Atlantic Coast Fishes
  - Atlantic Coastal Cooperative Statistics Program
  - 2020 State of the Science Report
  - *Oceanography* Special Issue on Understanding the Effects of Offshore Wind Energy Development on Fisheries

Appendix C: Council Managed Species

Fishery Management Council	Fishery Management Plan
New England Fishery Management Council	Atlantic Herring
	Atlantic Salmon
	Habitat
	Monkfish
	Northeast Multispecies
	Red Crab
	Sea Scallop
	Skates
	Small-Mesh Multispecies
	Spiny Dogfish
Mid-Atlantic Fishery Management Council	Bluefish
	Golden and Blueline Tilefish
	Mackerel, Squid, Butterfish
	Monkfish

Fishery Management Council	Fishery Management Plan
Mid-Atlantic Fishery Management Council (continued)	Spiny Dogfish
	Summer Flounder, Scup, Black Sea Bass
	Surfclams and Ocean Quahogs
Atlantic States Marine Fisheries Commission	American Eel
	American Lobster
	Atlantic Croaker
	Atlantic Herring
	Atlantic Menhaden
	Atlantic Striped Bass
	Atlantic Sturgeon
	Black Drum
	Bluefish
	Black Sea Bass
	Coastal Sharks
	Cobia
	Horseshoe Crab

Fishery Management Council	Fishery Management Plan
Atlantic States Marine Fisheries Commission (continued)	Jonah Crab
	Northern Shrimp
	Red Drum
	Scup
	Shad & River Herring
	Spanish Mackerel
	Spiny Dogfish
	Spot
	Spotted Seatrout
	Summer Flounder
	Tautog
	Weakfish
	Winter Flounder

Appendix D: Guidance Document Development and Review Process

ROSA aims to utilize an inclusive, transparent process throughout the organization's cooperative work. This document was developed by a diverse work group that included representatives of various sectors involved in fisheries and offshore wind development, including state and federal government fisheries managers, fisheries scientists, fishing industry representatives, and offshore wind developers. Work group members included:

Dave Bethoney, CFRF	Andy Lipsky, NOAA Fisheries NEFSC
Crista Bank, Vineyard Wind	Julia Livermore, RI DEM
Morgan Brunbauer, NYSERDA	Elizabeth Marchetti, Equinor
Steve Cadrin, SMAST	Lisa Methratta, NOAA Fisheries NEFSC
Doug Christel, NOAA Fisheries GARFO*	Timothy Miller, NOAA Fisheries NEFSC
Louis Forristall, NOAA Fisheries GARFO	Daphne Monroe, Rutgers
Greg DeCelles, Ørsted	Christopher Roebuck, commercial fishing captain
Wendy Gabriel, NOAA Fisheries NEFSC	David Rudders, VIMS
David Goethel, commercial fishing captain	Robert Ruhle, commercial fishing captain
Lyndie Hice-Dunton, ROSA*	David Secor, UMCES
John Hoey, NOAA Fisheries NEFSC	Angela Silva, NOAA Fisheries NEFSC
Fiona Hogan, RODA	Ryan Silva, NOAA Fisheries GARFO
Brian Hooker, BOEM	Kevin Stokesbury, SMAST
Kathryn Ford, MA DMF	

*Working group co-chairs

The original intent of the work group was to create a short annotated outline of the main issues that should be addressed in fisheries monitoring plans/studies, building off of existing BOEM guidance and commentary from state/federal fisheries agencies. This "interim guidance" was scheduled for completion by October 2020, with a complimentary detailed guidance document following within six months. The guidance went through a public review process to allow for individuals and organizations outside the working group to comment on an early draft. The public process is outlined below. Based on this input, the work group reformatted the draft guidance into a more comprehensive monitoring framework document, with checklists serving as the original "interim guidance" to help develop monitoring plans/studies.

Document Drafting and Review Process

The ROSA Interim Fisheries Monitoring Work Group (IFMWG) held a kickoff meeting on June 10, 2020 and continued to meet roughly monthly through February 9, 2021[22] . On October 15, 2020, ROSA moderated a breakout discussion at the Synthesis of the Science: Fisheries and Offshore Wind Energy workshop titled "Interim Report of ROSA's Monitoring Working Group" to discuss the draft guidance, gather feedback from session attendees, and note the upcoming release of draft guidance for public comment. The document status and updates were also presented at public ROSA Advisory Council meetings on September 28, 2020, November 23, 2020, and March 5, 2021. General information and updates on the guidance document were provided June 2020 through March 2021 at various meetings, including:

- Mid-Atlantic Fishery Management Council (MAFMC) - June 17, 2020
- New England Fishery Management Council (NEFMC) - June 23, 2020
- Science Center for Marine Fisheries (SCEMFIS) Industry Advisory Board - July 10, 2020
- New York State Fisheries Technical Working Group (NYS F-TWG) - July 17, 2020
- Business Network for Offshore Wind's International Partnering Forum (IPF) on demand panel "Advancing Offshore Wind Environmental Effects Research Priorities" - August 2020
- ROSA outreach meetings with state regulatory agencies - throughout July and August 2020
- NMFS West Coast Offshore Wind Team - August 28, 2020
- MAFMC Scientific and Statistical Committee (SSC) - September 9, 2020
- Regional Coordination of Data Platforms & Offshore Wind Related Data Collection Webinar - October 2, 2020
- State of the Science Workshop on Wildlife and Offshore Wind Energy - November 19, 2020
- 2021 Partners in Science Workshop - January 28, 2021
- Oregon Coast Energy Alliance Network (OCEAN) - February 16, 2021
- NYS F-TWG - February 18, 2021

[22] Formal meetings were held on June 10, July 21, August 14, August 21, September 11, September 22, October 1, December 15, and February 9, while numerous smaller calls with portions of the work group were held in between.

The original draft guidance was released on October 29, 2020, for public review and was made available through the ROSA website. Announcements of the document's availability were made through the ROSA mailing list, at the Synthesis of the Science meeting, and through announcements by ROSA partners via their mailing lists. The public comment period was initially scheduled to close November 18, 2020, but was extended to December 1, 2020, in response to a request from several offshore wind developers.

Overview of Public Review

Over 225 individual comments and questions were submitted by 12 organizations including:

- American Saltwater Guides Association
- American Wind Energy Association
- Connecticut Department of Energy and Environmental Protection
- CSA Ocean Services, Inc.
- Inspire Environmental
- Massachusetts Division of Marine Fisheries
- New England Aquarium
- New England Fishery Management Council
- New Jersey Department of Environmental Protection
- NOAA Fisheries Greater Atlantic Regional Fisheries Office
- North Carolina Division of Marine Fisheries
- Special Initiative on Offshore Wind

The comments and questions focused on the following general topics and themes:

- Clarification of terminology
- General format/organization of the document
- Clarification of the various spatial scales presented
- Balancing specific versus general recommendations (e.g., species, types of research, time frames, etc.)
- Integration of general habitat or essential fish habitat studies
- Statistics and/or technical methods such as sampling design, analysis, and calibration
- Data management/sharing/hosting
- Roles and responsibilities of state and federal regulatory agencies
- Socioeconomic data
- Development of a strategic regional monitoring framework

All comments and questions received were tracked within the working documents of the IFMWG and can be provided on request (without attribution). Additionally, the IFMWG co-chairs held a follow up call with NOAA Fisheries, Bureau of Ocean Energy Management (BOEM), Rhode Island Department of Environmental Management, Massachusetts Division of Marine Fisheries, New York State Energy Research and Development Authority, and New Jersey Department of Environmental Protection on January 13, 2021, to clarify questions regarding the state and federal regulatory review process to ensure that it was accurately represented in the document. These discussions, along with the responses to the comments received, led to an overall restructuring of the document into a more comprehensive monitoring framework. The IFMWG worked throughout December 2020, January 2021, and February 2021 to update the draft. This working draft of the monitoring guidance was posted on the ROSA website for public use on March 31, 2021. It is intended to be a living document that will be reviewed and updated annually, or sooner if critical updates are needed.