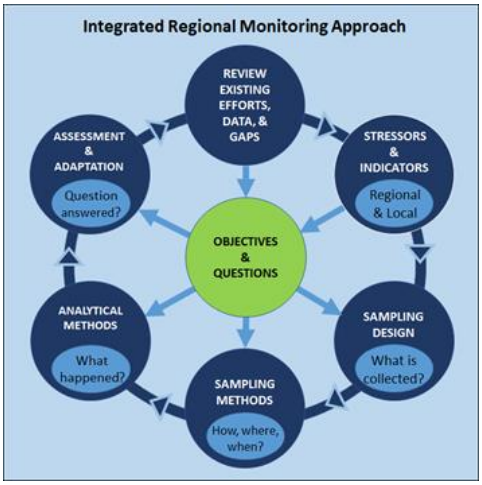
ROSA Interim Fisheries Resources Research, Survey, and Monitoring Guidelines

1. Introduction and Purpose:

BOEM, NMFS, and states on the 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 survey/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 survey/monitoring plans help provide the scientific information BOEM and other agencies need to determine how wind farms affect marine resources.

This document was developed by a working group representing various sectors involved in fisheries and wind development, including state and federal government fisheries managers, fisheries scientists, fishing industry representatives, and offshore wind developers. These guidelines build on and update existing BOEM guidance, outlining the fundamental elements to include in offshore wind fisheries survey/monitoring plans for commercial-scale offshore wind farms and identifying the primary resources to help draft and review such plans. Monitoring and research plans developed for smaller scale installations such as meteorological towers or buoys (standard FLiDAR buoys) could also be informed by these guidelines. Based on existing BOEM guidance and best practices developed to date, this document will help:

1. **Streamline survey/monitoring plan development and review** by providing comprehensive standardized recommendations for monitoring fisheries resources within offshore wind development areas
2. Ensure survey/monitoring plans are effectively designed to **generate meaningful results** consistent with established BOEM, NMFS, and state guidelines; best practices; and decision maker data needs
3. Address the need to **establish standardized protocols** to collect and analyze biological and environmental data that can be **integrated with existing survey data and other research**
4. Support integration of monitoring efforts across **multiple spatial and temporal scales** (area/site-specific to regional/ecosystem and before/after construction)
5. Focus monitoring efforts on finfish and invertebrates targeted by **commercial and recreational fisheries or other sensitive species 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



These guidelines are based on an **integrated regional monitoring approach** where each component of the survey/monitoring plan is built around and influenced by plan objectives and testable hypotheses. The integrated approach (see figure) follows an iterative process to develop and refine plan components as details are determined. 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 survey design, performance, and efficiency in subsequent years.

The fundamental steps to implement this integrated regional monitoring approach include:

1. Evaluate available data describing fishery resources and stressors within the project area
2. Define concise and appropriate monitoring objectives and hypotheses
3. Identify focus species (or groups) to monitor
4. Set indicators and define thresholds that are appropriate and measurable
5. Design a plan to collect the appropriate data to address monitoring objectives
6. Analyze data collected to achieve monitoring objectives and test hypotheses
7. Adjust sampling design/methods as needed to continue to address monitoring objectives

As noted in step 1 of the integrated regional monitoring approach, 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 survey/monitoring plan sampling design meets existing requirements and permitting needs, including potential risk of interactions with endangered/threatened species and marine mammals. Pre-survey meetings should include discussion of the area and resources affected, available data, overall sampling design, anticipated survey methods and timing, analytical approaches to be used, and risk of protected species interactions.

In recognizing the importance of understanding potential impacts at multiple spatial scales, three classes of monitoring studies should be incorporated into individual survey/monitoring plans, all of which would be designed to measure changes over specified time frames (seasonal, annual, or project duration for regional/ecosystem studies) to meet study design objectives and allow meaningful inferences:

1. Area/site-specific: These studies examine biological/environmental characteristics, stressors, or species behavior that are unique to a particular area/site before, during, and after construction. It is anticipated that these monitoring activities would be designed to measure changes over specified time frames to meet study design objectives that allow for meaningful inferences.
    - *Example:* Evaluating changes to Atlantic cod spawning aggregations within the site
2. Project-specific: These studies examine changes in various parameters, including species composition, abundance, biological indices, and other biogeochemical variables within a project area before, during, and after construction. Project-specific studies may need to sample locations outside of the location of the project itself, depending on the specific sampling design(s) selected (see below).
    - *Example:* Evaluating changes to species distribution or abundance in relation to turbine locations within a project area
3. Regional/Ecosystem: These studies focus on changes in species composition, abundance, and biological indices over time within the project site compared to areas outside the site, including across multiple project areas, throughout a species' stock area, or within the broader ecosystem, to determine whether changes observed within the site are consistent with changes observed outside the site before, during, and after construction.
    - *Example*: Evaluating changes to a species population estimates across a stock area

This interim guidance is a **living document** that will evolve and grow as ROSA members, including BOEM, NMFS, and states, continue to refine existing guidelines, methods, and best practices. Further information will be included in more comprehensive guidelines to be developed.

2. Survey/Monitoring Plan Objectives:

Each survey/monitoring plan should clearly define its purpose, objectives, assumptions, and testable hypotheses[1] 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 of an endangered species), or by multiple metrics (e.g., abundance of black sea bass conditioned on season and temperature). Choice of indicators should be explicit in each survey/monitoring plan, connected to study objectives, and integrated into the survey design such that the indicators support survey/monitoring plan 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, to contribute to understanding the effect of offshore wind farms on finfish and invertebrate species across multiple scales (area/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) and Sampling Methods (Section 4) discussions below.

All survey/monitoring plans should accomplish the following objectives:

1. **Review existing scientific data** (fishery dependent/independent)[2] and available research relevant to the project area to identify fishery and marine resources affected, local/regional stressors, and potential responses to project activities. This could serve to characterize the site in terms of fisheries use and potential to help inform or establish baseline conditions that can complement additional data collected by the survey/monitoring plan.
2. **Use standardized methods and established protocols** when collecting data to maximize data compatibility across survey/monitoring plans for individual wind development projects and with existing regional scientific surveys (see Section 9 below).
3. **Assess baseline biological and 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[3].

   Addressing the three classes of study questions (area/site-specific, project-specific, regional/ecosystem) will require analyzing data within and across individual projects and comparing summary statistics with regional and ecosystem time series. This can only be done if data collection 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.

[1] The null hypothesis is that there is no change in biological indices or environmental variables at offshore wind farms between pre-construction, construction, or operational time periods.

[2] 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. See Section 10 of this document for information about available state and Federal resources.

[3] See the list of species of interest within the Massachusetts and Rhode Island wind energy areas compiled by the Massachusetts Division of Marine Fisheries, for example.

Survey/monitoring plans should measure the following throughout the year:

a. Indices of Abundance and Occurrence:
    i. Absolute abundance by species (estimate of the total number and weight within the sampling area)
    ii. Relative abundance by species (number or weight per standardized sample)
    iii. Presence/absence by species (percent frequency of occurrence)
b. Individual Fish Condition (e.g., length, weight, maturity, diet, age, etc.)
c. Environmental Variables (as appropriate):
    i. Oceanographic variables (e.g., temperature, depth, salinity, dissolved oxygen)
    ii. Electromagnetic field (EMF)
    iii. Ambient and development-related noise
d. Bottom type/benthic habitat that affect species or their vulnerability to change, consistent with existing guidelines[4], focusing on habitat usage versus mapping habitat within the area, which is a separate project development requirement

4. **Evaluate any changes from relevant baseline conditions.** Section 3 of these guidelines 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, survey/monitoring plans should be able to:
    a. Test whether statistically or biologically significant changes are the result of offshore wind development surveys, construction, or operations;
    b. Attribute variance in biological indices to environmental variables and specific stressors caused by offshore wind development surveys, construction, or operation; and
    c. Evaluate differences in resource impact and/or recovery associated with different construction techniques (e.g. pile installation, scour protection, cable installation, cable protection), including assessing the effectiveness and evaluate the performance of any adopted mitigation measures during and after construction, as applicable

Additional area/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. Assessing social and operational changes associated with wind development such as changes in fishery landings, fishery costs, fishery transit patterns, port dependence on fishing, operational costs, perceptions of wind development, or shoreside infrastructure could also be an objective with project-specific and regional benefits.

3. Sampling Design:

Sampling design should include the number of samples, timing of sampling (season, frequency, duration), and sampling design approach itself. The sampling design should directly address the objectives, hypotheses, and intended scale of the project's survey/monitoring plan based on the species likely to be affected and stressors within the project area. A detailed justification should be provided to facilitate review. Advanced discussion with BOEM, NMFS, and states will enhance sampling design development, improve consistency with existing guidelines and established regional surveys, and expedite the review and permitting of survey/monitoring plan activities.

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

A survey/monitoring plan'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** (see further discussion below):
  - Oversampling in the first year may be necessary to ensure sufficient samples are collected, provided such additional sampling can be conducted without compromising project or survey/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 year-to year variability.
- **Timing of sampling (season, frequency, and duration):**
  - Season/frequency: When and how often samples will be collected should be detailed in the survey/monitoring plan. Consistent with project or plan objectives, sampling should overlap with existing surveys[5] 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.
  - Duration: The duration of sampling (how many years of sampling before, during, and after construction) should be detailed in the survey/monitoring plan and consistent with both BOEM and any applicable state coastal zone management program or procurement sampling requirements (e.g., at least two years before construction begins).
- **Sampling location:** Sufficient sampling locations need to be available to enable sampling by strata (defined by depth, habitat, or another factor) and ensure replication.
- **Sampling approach:**
  - Before-After-Gradient (BAG)[6]: A BAG approach (see figure) is most appropriate when:
    - Sufficient data are available or can be collected to establish baseline conditions before construction begins
    - A spatial gradient in target indices is expected
    - Appropriate control sites (those that are statistically indistinguishable from 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 locations are known before collection of pre-construction data or post facto assignment of sites along a gradient can be made
  - Before-After-Control-Impact (BACI)[7]: A BACI approach (see figure) 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
    - Appropriate control sites are available and demonstrated to be appropriate (i.e., they are statistically indistinguishable from impact sites in terms of biological, habitat, and environmental variables that affect fish abundance and distribution

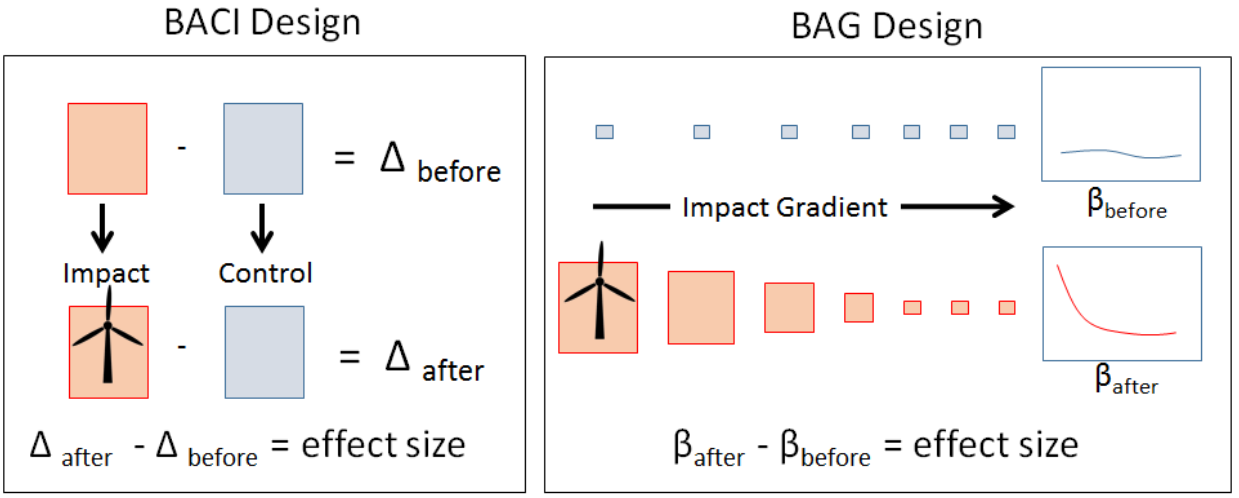
[5] Northeast Fisheries Science Center Ecosystem Survey Schedule.

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

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

- Survey/monitoring plan focuses on area/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

- Random stratified sampling:
  - Random stratified sampling should be considered when habitat features (e.g., depth, seabed type) affect biological indices
  - Initial stratification of sampling areas should be considered based upon plan objectives/hypotheses, which could include habitat type and depth, consistent with or more precise than existing strata developed for the Northeast Fisheries Science Center surveys



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 Size Determination:

The sample size should be informed by the survey/monitoring plan objectives, research questions/hypotheses, and existing data and literature. In addition, sample size should be sufficient to enable replication and 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 2 above). 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. If there is high uncertainty about the effect on a species/group, then a smaller effect 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.

Choosing the effect size should at minimum include a consideration of the following:

- Functional/Taxonomic groups: (demersals, pelagics, highly migratory species, planktivores, piscivores, benthivores, reef-associated, soft-bottom species, etc.)
- Biological variables and indices: (abundance, fish size, condition, recruitment etc.)
- 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 significance: Consider whether small, moderate, or large changes have the potential to be biologically significant 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.
- 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. Baseline studies and 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 each of three relative effect sizes ((e.g., Cohen's d: 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 the effect size based on the survey/monitoring plan coordinator's best professional judgement.

4. Sampling Methods:

Each survey/monitoring plan should describe 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. 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 survey/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. This will allow data collected for an individual project to inform the three classes of studies (area/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, the plan 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 survey/monitoring plan objectives and hypotheses:

- **Gear types and sampling modalities:**
    - 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))
    - Acoustic telemetry array
    - 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-DNA)

  BOEM's Fisheries Monitoring Plan Guidance includes gear-specific sampling method considerations and advantages/disadvantages to using particular gear types. See Table 1 in Appendix A for an updated list of advantages and disadvantages associated with each sampling gear type/modality.

- **Gear configuration:** To facilitate standardization with existing data, gear configuration should mirror that used by existing surveys, particularly trawl, dredge, ventless trap, and some types of hook gear, or by the commercial fishing operations when sampling with gillnets.
- **Operational protocols:**
    - Describe the amount of gear, mesh size, number of tows/sets, tow/soak time, tow speed, gear performance metrics (net height, opening, sweep height), spacing of fixed gear, and other operational parameters for each gear type/sampling modality. Survey/monitoring plans 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[8]

[8] See Politis et al., 2014.

        - Northeast Area Monitoring and Assessment Program (NEAMAP)[9]
        - 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, measuring species length/weight, recording sex, and stomach content analysis, as appropriate, to help compare results to other survey efforts.
    - Operations should reflect best management practices to mitigate the risk of take of protected species to the greatest degree possible[10], including:
        - Time of year restrictions to limit interactions
        - Limited gillnet soak or trawl tow durations to the maximum extent practicable
        - Use vertical/buoy lines with a breaking strength of 1700 lbs
        - Unique gear marking, avoiding wet storage of gear, and reporting lost gear
        - Minimizing the number of vertical lines set in the water
        - Complying with Endangered Species Act and Marine Mammal Protection Act Take Reduction Plan Regulations

Survey/monitoring plans 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.

Information Collections:

Each survey/monitoring plan 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** consistent with the Integrated Taxonomy Information System (ITIS), including marine mammals and threatened/endangered species
- **Biological parameters** of sampled species such as:
    - Weight in kg
    - Length to the nearest 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 samples for molecular or stable isotope studies

[9] Visit the NEAMAP nearshore trawl survey website or contact Sarah Murray (smurray@asmfc.org) for further information.

[10] Contact Nick Sisson (nick.sisson@noaa.gov, (978-281-9179)) for additional information.

- **Environmental conditions** (collected simultaneously with biological samples) such as:
    - Temperature
    - Depth
    - Salinity
    - Dissolved oxygen
    - Oceanographic variables (e.g., current speed)
    - Ambient noise
    - Electromagnetic fields (EMF)
- **Interactions with protected species (marine mammals, sea turtles, sturgeon)**: Although fisheries and benthic survey/monitoring plans are separate from any protected species monitoring plans, if such species are encountered during fishery surveys, the following actions should be taken:
    - The scientist on board should follow the sampling protocols described in the Northeast Fisheries Observer Program's Observer On-Deck Reference Guide
    - Report interactions with live or sightings of dead large whales and sea turtle species to NOAA's stranding hotline immediately as follows: In Maine-Virginia, call 866-755-6622, while from North Carolina-Florida, call 877-942-5343
    - Report interactions with sturgeon species to NOAA immediately by emailing incidental.take@noaa.gov
    - Report sightings of North Atlantic right whales via the Whale Alert App
- **External factors:** The survey/monitoring plan 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. Coordination with adjacent projects may be necessary before finalizing the 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

Survey/monitoring plan 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/feasible.

5. Analytical Methods:

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

Survey/monitoring plan analytical methods should accomplish the following:

- **Evaluate the biological baseline** through calculation of summary statistics for:
    - 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
    - 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 (length, weight, sex, sexual maturity stage, age, diet, etc.)
- **Assess changes** from the biological baseline that occur during and after construction using standard statistical methods.
    - 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) 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 analysis of variance (ANOVA) - the traditional method for examining change in metrics over time compared to a baseline with a BACI design
        - Evaluate ANOVA assumptions, including that the data are drawn from a normal distribution, that there are equal variances between treatments, and that samples are independent from one another
        - 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, survey/monitoring plans should evaluate changes for as many years as data are collected and available from that plan. Ideally, survey/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 could be explored with appropriate multivariate methods depending on the assumptions being made and goals of the analysis (McGarigal et al., 2000).

Survey/monitoring plans should also consider additional studies that could help inform future analysis of project-specific impacts, including impacts to existing surveys, essential fish habitat impacts, socioeconomic and fishery operational impacts, and impacts associated with construction or mitigation measures. ROSA will continue to discuss such additional analysis, including steps that survey/monitoring plan 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 survey/monitoring plan data with existing survey data:
    - Compare biological indices (mean and variance) collected as part of project-specific monitoring efforts with those of other wind development projects and existing regional surveys at various scales (area/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 survey/monitoring plan survey stations located within each strata used by federal resource surveys as a means to help determine whether plan data could augment federal surveys negatively impacted by development
- Assessing fishery operational and socioeconomic impacts by evaluating social and operational changes associated with wind development such as changes in fishery landings, fishery costs, fishery transit patterns, port dependence on fishing, operational costs, perceptions of wind development, and shoreside infrastructure
- Analyzing differences in resource impact and/or recovery associated with different construction techniques (e.g. pile installation, scour protection, cable installation, cable protection)

6. Data Maintenance and Sharing: [Under development]

To maximize utility of survey/monitoring plan data and results, each plan 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)
- 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 survey/monitoring plan activities and associated findings at regional forums such ROSA Advisory Council meetings, New England/Mid-Atlantic Fishery Management Council or Atlantic States Marine Fisheries Commission meetings, or another regional fisheries forum

7. Evaluation of Performance Measures: [Under development]

Monitoring fisheries resources at 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 fisheries resources is refined.

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

- Identify, calculate, and review performance measures (e.g., mean and variance per spatial stratum and time period, selectivity (e.g., species and size classes sampled), interactions with environmental variables and catchability)

- Assess whether the data collected are yielding information that can address the questions and objectives stated at the outset to avoid collecting data that do not inform plan objectives, questions, or hypotheses[11]
- Determine, apply, and document appropriate adjustments to the following year of survey/monitoring plan if performance measures indicate adjustments are needed

Each review of the survey/monitoring plan performance measures should consider important factors that may affect interannual variability and 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.

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 Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA) if interactions with such species could occur.

Federal Permit Requirements:

All survey/monitoring plan activities 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 survey/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 survey/monitoring plan 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 limits, gear requirements, etc.) to conduct survey/monitoring plan activities. Such vessels must request an exempted fishing permit (EFP) from NMFS.
- Contact Ryan Silva (ryan.silva@noaa.gov, (978-281-9326)) for additional information on the issuance of LOAs and EFPs.

Survey/monitoring plan activities may impact endangered species 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 (see above), you may need special permits or consultations from NMFS.

- For marine mammal questions, contact Ben Laws (benjamin.laws@noaa.gov, 301-427-8425)

[11] See Wilding et al., 2015.

- For endangered species questions, contact Nick Sisson (nick.sisson@noaa.gov, 978-281-9179)

9. Additional Benthic Habitat/Essential Fish Habitat Considerations: [Under development]

Due to the interconnectedness between fisheries and benthic habitat, survey/monitoring plans should consider collecting certain benthic and essential fish habitat information, as noted in several instances above. We are working toward assembling additional information that will help integrate such considerations into the survey/monitoring plan, as appropriate.

10. Existing Resources and Guidance Documents:

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

- BOEM
  - 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)
  - Current environmental studies
- NMFS
  - Magnuson-Stevens Fishery Conservation and Management Act permitting requirements for research surveys
  - Summary of fishery effort and socioeconomic information by lease area
  - Fishery-dependent data requests should be emailed to NMFS.GAR.Data.Requests@noaa.gov.
  - NMFS 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 Regional Stock Assessment Workshop 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 York Offshore WInd Solicitation, including elements for a fisheries mitigation plan and an environmental mitigation plan
  - 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
  - Atlantic Coastal Cooperative Statistics Program

APPENDIX A: Tables

Table 1. Advantages and Disadvantages of Fisheries Sampling Gears and Methods

	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…)	++	++	++	++	++	++	++	++	++	-	- -	-	-	-	- -	-
Selects a wide range of commercial fish and invertebrate species	++	+	+	-	- -	-	-	-	-	+	++	-	+	+	-	++
Operable in any habitat	-	.	.	++	.	++	++	-	-	++	.	++	++	+	++	++
Familiar to industry or regulators	++	.	++	++	+	+	+	++	++	- -	- -	++	+	+	+	.
Interactions with developers site investigation activities or gear conflicts with industry	.	.	-	- -	- -	++	+	.	--	++	.	++	-	+	+	++
Results in mortality to sampled animals or bycatch	- -	- -	- -	+	- -	-	-	- -	--	++	++	++	+	+	++	++
Can be used for distance-based sampling	-	-	-	++	+	++	++	-	-	++	++	++	++	-	+	.
Can be used to sample in close proximity to foundations	-	-	-	++	++	++	++	--	--	++	++	++	++	-	++	++
Easy to standardize	++	++	++	++	- -	-	.	++	++	+	-	++	+	+	-	.
Can involve recreational fishing industry	-	-	-	-	-	++	.	-	-	++	- -	.	++	.	-	++
Innovative (NOAA strategy)	-	-	-	-	-	-	-	-	-	++	.	+	++	.	++	++
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
. Neutral or unknown
- Slightly negative
- - Very negative

Table 2. Goals (section II, page 2) and other key points laid out in the BOEM 2019 fisheries monitoring guidelines and comparison to goals and key points of the ROSA Interim Fisheries Resources Research, Survey, and Monitoring Guidelines.

BOEM 2019 fisheries monitoring guidelines	ROSA IFRMWG 2020 interim fisheries resource monitoring guidelines
Defined Goals	
(1) The overall purpose of the required information is to describe the key species and habitat within the survey area possibly affected by the proposed operations.	Plans should: Review existing scientific information; Assess baseline conditions of the biological community and representative species within the wind development area and along the cable route; Evaluate changes from baseline conditions; Collect data that is compatible with other scientific surveys in the region (Section 2).
(2) Identify and confirm which dominant benthic, demersal, and pelagic species are using the project site, and when these species may be present where development is proposed;	Particular focus should be on the spatial and temporal variability in managed and protected fish and shellfish species (Section 2)
(3) Establish a pre-construction baseline which may be used to assess whether detectable changes associated with proposed operations occurred in post-construction abundance and distribution of fished species;	Assess baseline conditions of the biological community and representative species within the wind development area and along the cable route, with particular focus on the spatial and temporal variability in managed and protected fish and shellfish species. (Section 2)
(4) Collect additional information aimed at reducing uncertainty associated with baseline estimates and/or to inform the interpretation of research results; and	Assess baseline conditions of the biological community and representative species within the wind development area and along the cable route, with particular focus on the spatial and temporal variability in managed and protected fish and shellfish species (Section 2)

(5) Develop an approach to quantify any substantial changes in the distribution and abundance of fished species associated with proposed operations.	Evaluate any changes from relevant baseline conditions. Power analysis should be used to estimate the number of samples needed to detect a change from baseline conditions, given an assumed effect size and an acceptable level of precision. The effects of global climate change on biological and environmental variables (e.g., change in water temperature, northward shifts in species distributions) and how this may affect study design should be considered during each iteration of the Assessment and Adaptation phase. (Section 2)
Other Key Points	
(6) For all projects, lessees should also describe the measures to be taken to minimize or eliminate potential impacts to fishery resources in their SAP, COP, or GAP. (Section II, page 2)	
(7) In addition, for projects involving the installation of wind energy turbines on the Atlantic OCS, the lessee should prepare a fishery survey plan that describes its methods for collecting sufficient information on the biology of the project area to allow BOEM and other agencies with jurisdiction to make well-founded decisions in context with the regional biology. (Section II, page 2)	These plans help provide the scientific information BOEM and other agencies need to determine how wind farms affect fishery resources and fishing operations. (Section 1)
(8) The amount of new information collected should match the scale and/or complexity of the proposed project. Example given compares the scales of a meteorological tower and a commercial wind farm. (Section V, page 4)	These guidelines are primarily meant to inform the development of research and survey/monitoring plans at commercial-scale offshore wind farms. Monitoring and research plans developed for smaller scale installations such as meteorological towers or buoys (e.g., standard FLiDAR buoys) could also be informed by these guidelines. This is because each step in the plan development cycle (Figure X) is

	underlain by explicit objectives and hypotheses which recognize that the spatial scale of an installation is inherent to its anticipated impacts. (Section 2)
(9) Developers are encouraged to use existing data where applicable to their proposed activities and associated area of potential adverse effect to characterize the natural resources present. (Section V, page 4)	One component recommended for all survey/monitoring plans: Review existing scientific data (fishery dependent/independent) and available research relevant to the resources affected, local/regional stressors, and potential responses to project activities (Section 2)
(10) The choice of which protocols to use will be defined by the characteristics of the project area and the protocols may need to be modified to accommodate a particular site. (Section V, page 4)	Each survey/monitoring plan should describe the sampling methods to be used in as much detail as possible. Sampling methods should be capable of effectively carrying 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. (Section 4)
(11) The survey specifications should state the issues to be investigated, hypotheses, assumptions, data collection techniques, standards, analytical and statistical techniques, and quality control. (Section V, page 5)	Each survey/monitoring plan should clearly define its purpose, objectives, assumptions, and hypotheses (Section 2). Survey/monitoring plans should describe the sampling design in as much detail as possible and its relation to the monitoring programs/objectives/hypothesis, and intended sampling methods (Section3). Each survey/monitoring plan should describe the sampling methods to be used in as much detail as possible (Section 4). Data should be formatted according to accepted standards (Section 4). Data should be subject to rigorous quality assurance/quality control protocols (Section 4).

Literature Cited

Bergstrőm, L., F. Sundqvist, and U. Bergstrőm. 2013. Effects of an offshore wind farm on temporal and spatial patterns in the demersal fish community. 2013. Marine Ecology Progress Series 485: 199-210.

Brandt, M. J., Diederichs, A., Betke, K., and Nehls, G. 2011. Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. Marine Ecology Progress Series, 421: 205–216.

Castelloe. J. 2000. Sample Size Computations and Power Analysis with the SAS System, Paper 265-25 in Proceedings of the Twenty-Fifth Annual SAS User-'s Group International Conference, Cary, NC: SAS Institute, Inc

Clarke, K.R., R.N. Gorley, P.J. Somerfield, and R.M. Warwick. 2014. Change in marine communities: an approach to statistical analysis and interpretation. 2nd edition. PRIMER-E, Plymouth, United Kingdom.

Cohen, J. 1988. Statistical analysis for the behavioral sciences. 2nd edition. Lawrence Erlbaum Associates, Publishers. 579 pp.

Ellis, J. I., and Schneider, D. C. 1997. Evaluation of a gradient sampling design for environmental impact assessment. Environmental Monitoring and Assessment, 48: 157–172.

Gaichas, S.K. et al., 2018. Implementing Ecosystem Approaches to Fishery Management: Risk Assessment in the US Mid-Atlantic. Frontiers in Marine Science, 5.

Krzywinski, M. and N. Altman. 2013. Power and sample size. Nature Methods. 10: 1139–1140(2013).

Lindenmayer, D.B. and G.E. Likens. 2009. Adaptive monitoring: a new paradigm for long-term research and monitoring. Trends in Ecology and Evolution 24: 482-486.

Lindenmayer, D.B., G.E. Likens, A. Haywood, and L. Miezis. Adaptive monitoring in the real world: proof of concept. Trends in Ecology and Evolution 26: 641-646.

Link, J.S., 2005. Translating ecosystem indicators into decision criteria. ICES Journal of Marine Science, 62(3): 569-576.

Lu, P., J. Liu, and D. Koestler. 2017. pwr2: Power and Sample Size Analysis for One-way and Two-way ANOVA Models. https://rdrr.io/cran/pwr2/

McGarigal, K.S., Cushman, S.A., Stafford, S.G., 2000. Multivariate Statistics for Wildlife and Ecology Research. Springer Verlag, New York.

Methrata, E.T. 2020. Monitoring fisheries resources at offshore wind farms: BACI vs. BAG designs. ICES Journal of Marine Science, doi:10.1093/icesjms/fsaa026.

Mid-Atlantic Fishery Management Council. 2019. Ecosystem Approach to Fisheries Management Guidance Document. Dover DE. 38 p. http://www.mafmc.org/s/EAFM-Doc-Revised-2019-02-08.pdf

PJ Politis, JK Galbraith, P Kostovick, RW Brown. 2014. Northeast Fisheries Science Center bottom trawl survey protocols for the NOAA Ship Henry B. Bigelow. US Dept Commerce, Northeast Fish Sci Cent Ref Doc. 14-06; 138 p. Available online at: https://www.fisheries.noaa.gov/new-england-mid-atlantic/northeast-fisheries-science-center-publications

Secor, D.H. 2018. Designing research and monitoring studies to detect impacts of offshore wind farms on coastal fishes. The State of the Science on Wildlife and Offshore Wind Energy Development (NYSERDA) Woodbury NY. https://www.nyetwg.com/2018-workshop

Underwood, A. J. 1991. Beyond BACI: experimental designs for detecting human environmental impacts on temporal variations in natural populations. Australian Journal of Marine and Freshwater Research, 42: 569–587.

Underwood, A. J. 1992. Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. Journal of Experimental Marine Biology and Ecology, 161: 145–178.

Underwood, A. J. 1993. The mechanics of spatially replicated sampling programmes to detect environmental impacts in a variable world. Australian Journal of Ecology, 18: 99–116.

Underwood, A. J. 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecological Applications, 4: 3–15.

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