Environmental DNA Survey of Marine Communities of the Northeast U.S. Continental Shelf and Slope

I. Purpose of the survey

This survey will characterize the distribution and abundance of marine communities across the continental shelf and slope of the northeast U.S. exclusive economic zone (EEZ) using environmental DNA (eDNA). eDNA consists of degrading DNA from extracellular materials in the environment—in this case, seawater. Here, we propose a metabarcoding approach to amplify eDNA fragments from a filtered seawater sample and match such amplicons to reference databases—such as GenBank (https://www.ncbi.nlm.nih.gov)—to identify the species in each sample of seawater. Using a multi-marker approach to enhance the number of species that can be identified, our focus will be on vertebrates and select invertebrate taxa, particularly fishery, or protected marine species.

While the development of specific eDNA methods may still claim to be novel in the scientific literature, the basic use of eDNA is well established in microbial and forensic sciences. Here, we are focused on the operational use of eDNA—such as bits of epidermis, voided feces, or released gametes—to detect species, as has been used for well over a decade in aquatic environments (Ficetola et al. 2008; Lodge et al. 2012). eDNA metabarcoding has proven to be an effective method, as validated using an aquarium tank with known species (Kelly et al. 2014). The validity of the method has been demonstrated with marine fishes and marine mammals in our region both in the laboratory (Kirtane et al. 2021) and the field (Liu et al. 2019; Stoeckle et al. 2021; Alter et al. 2022). Development of the method continues, specifically to optimize reproducibility and other operational aspects (Stoeckle et al. 2022).

The Northeast Fisheries Science Center (NEFSC) has collected a baseline of eDNA data across the northeast shelf and slope in 3 seasons (i.e., fall 2019, summer 2021, and spring 2022) on three different ships (NOAA ships *Gunter*, *Pisces*, and *Bigelow*). We are now in the process of automating the most laborious parts of the bioinformatic workflows. It works.

Because eDNA does not have a typical gear bias, it will become an important, independent tool for broadly comparing marine faunal compositions—marine mammals, groundfishes, small pelagics, highly migratory species, and shellfishes—among Northeast NEFSC surveys. eDNA also has specific advantages to detect new or cryptic species (Stoeckle et al. 2020); to monitor species that are difficult to capture with traditional fishing methods because they are rare, solitary, and patchy (Pfleger et al. 2016), or because they occupy deep, structured, or otherwise unfishable habitat (Mercaldo-Allen et al. 2021); and to identify unexpected habitat use, including spawning or species on the move (Bylemans et al. 2017). There is no need to mitigate an eDNA survey because it is itself a fairly new survey; instead, an eDNA survey provides a complementary, consistent lens to interpret changes to other surveys going on at the same time during the development of wind energy in the northeast U.S.

In terms of calibration to the few years of baseline data (i.e., fall 2019, summer 2021, and spring 2022), no intra-survey calibration is proposed because we are using an existing sampling design (i.e., the Center's Ecosystem Monitoring [EcoMon] fixed-transect design).

The EcoMon spatial design has had relatively few alterations to it because of wind energy development, and there is simply not enough baseline data to design such a comparison.

In terms of inter-survey calibration, comparisons between eDNA sampling and bottom trawling have already demonstrated similar results in terms of fish diversity, seasonality, and relative abundance (Stoeckle et al. 2021); therefore, we do not propose to repeat an a priori calibration of eDNA and our bottom trawl. We do, however, specifically propose to calibrate eDNA results with acoustic sampling methods, using both passive and active acoustic data. One cross-validation study is comparing eDNA and passive acoustic monitoring (PAM) of large marine mammals in a southern New England wind energy area (WEA). The other cross-validation study is comparing eDNA and active acoustic data from 3 baseline surveys (2019-2022). The results of both of these study designs, if successful, should improve our ability to interpret community data from all of these sampling methods.

Adoption of the EcoMon fixed-transect sampling design does not concentrate sampling in any subregion of the northeast shelf or slope. Instead, as a federal fisheries agency, we regard our role as to monitor broadly across the northeast EEZ, including U.S.-Canadian transboundary waters in the Gulf of Maine (Cape Hatteras to Halifax). Many U.S. states and Canada will sample in more concentrated, jurisdictional areas, which will create a de facto nested sampling design. As the data grows from investments by these various eDNA surveys, we envision more coordination between ourselves and these entities to interpret the results at the appropriate spatial and temporal scales.

This eDNA survey will independently monitor marine communities before, during, and after the initial build-out of offshore wind energy development. Spatially, it will sample replicate 2-liter seawater samples from multiple depths (at least surface and bottom) at a minimum of 35 fixed stations along a fixed-transect sampling framework from Cape Hatteras to the Gulf of Maine. We are coordinating with, indeed piggybacking on, the Center's EcoMon survey during spring (May-June) and fall (October-November). To be specific, this proposal is to co-produce eDNA sampling, in addition to normal operations of the EcoMon Survey (i.e., multi-method measures of oceanography [conductivity, temperature, depth (CTD)], ichthyoplankton [bongo nets], water sampling [Niskin bottles], and observations of protected species [seabirds and marine mammals]) that the EcoMon program is renown for.

Options to piggyback eDNA sampling on the Center's Bottom Trawl Survey (BTS) have been discussed and rejected for several logistical reasons (e.g., berthing space, insufficient capacity for existing science staff to add a program of this scope, complexity of coordinating and prioritizing 2 major programs on 1 ship, repeated disruptions to BTSs that reduced sampling coverage in recent years).

Operationally, in adopting this existing EcoMon sampling design and adding water sampling for eDNA extraction and analysis, this new survey is designed as a collaboration between 2 NEFSC divisions: the Population and Ecosystems Monitoring and Analysis Division (PEMAD) and the Ecosystems and Aquaculture Division (EAD). We believe the synoptic oceanographic and faunal sampling as outlined in this proposal will strengthen our Nation's ability to evaluate how marine communities respond to the simultaneous stressors of fishing mortality, climate change, and offshore wind development.

Specific objectives

- Monitor trends in geographic distribution and relative abundance of marine fish, invertebrates, and mammals, as well as oceanographic and ecosystem changes by collecting associated environmental data (Stoeckle et al. 2021; Shelton et al. 2022, 2023).

- To do so with a new method, metabarcode eDNA in a manner comparable and complementary to other NEFSC surveys (e.g., Politis et al. 2014).

What data are collected?

Seawater is collected and filtered onboard a ship. Currently, the main collection method is by Niskin bottles from a rosette which sample at specified depths relevant to fish distribution (e.g., surface, Chlorophyll maximum, pycnocline, bottom). In early operations, a vacuum system with a pipeline manifold was used to filter more than 1 sample at a time. In recent cruises, we have tested a commercially available eDNA sampler, which has specific advantages in efficient use at sea as well as in containing the samples until they can be processed in the laboratory.

The NEFSC has demonstrated that eDNA from a water sample as small as 1 liter can identify biotic communities in marine ecosystems (Liu et al. 2019; Emily Speciale, 2022 Hollings Student Project). One-liter samples have been used in coastal waters off New Jersey by Stoeckle et al. (2021). NEFSC unpublished data show that more species and higher read counts are detected in increasing volumes of seawater (e.g., 1, 2, and 3 liters) and that deep stations will benefit in particular from larger volumes of filtered seawater. Sample volumes $\leq$ 3 liters depict similar distributions of flatfish species across the continental shelf and slope, whether using bottom trawl or eDNA (McBride et al. 2022). A 2-liter sample optimizes the number of taxa detected relative to at-sea filtration time.

A metabarcoding workflow is followed in the laboratory. DNA is extracted, amplified, and sequenced on Illumina MiSeq platform, then raw data are processed through a bioinformatics pipeline to be converted to a taxonomy table. This table contains all taxa detected and their read numbers—a measure of taxa's abundance—in a known amount of seawater. Our proposal budget will also allow adding an alternative workflow using quantitative polymerase chain reaction (qPCR) assays on DNA extracts, as appropriate. Targeted qPCR methods calculate a gene copy number of a specific taxon when 1 or a few taxa are prioritized for such treatment. Through occupancy modeling, gene copy numbers can be used to determine the likelihood of species presence/absence. We currently use a metabarcoding approach to maximize the amount of information we can get from a sample (multiple species for metabarcoding vs. one species for qPCR), but we can develop qPCR assays when there is a need to focus on 1 or a few select species.

General environmental data is collected by the survey vessel (e.g., latitude, longitude, depth, surface water temperature, air temperature, wind speed and directions, dissolved pCO2, barometric pressure). More specific environmental data of seawater is collected by extended instrumentation such as a CTD cast at all sampling stations (e.g., temperature, salinity, dissolved oxygen). This research expects to characterize fish habitat from these environmental measurements.

Acoustic signals of fish and other biological organisms are collected by multi-frequency active acoustic measurements recorded throughout the survey. This proposal includes a plan to compare eDNA read counts with these acoustic signals to verify the use of read counts as a measure of fish abundance using baseline data collected in fall 2019, summer 2021, and spring 2022.

What specific products use this survey?

We anticipate regular products will use this survey, such as:

- Cruise reports

- Publicly available genetic databases such as the National Center for Biotechnology Information (NCBI)
- Publicly available code for addressing standardized summaries
- Indices for the NEFSC's regional Status of the Ecosystem Reports
- Summaries for the Northwest Atlantic Fisheries Organization (NAFO) Scientific Council Standing Committee on Fisheries and the Environment
- Stock assessment products that can use background information or data streams related to species distribution and abundance

Which assessments/science advice pathways currently use this survey?

This is a new survey, but operational workflows have been worked out from the results of 3 platforms (NOAA ships *Gunter*, *Pisces*, and *Bigelow*) in 3 seasons (fall 2019, summer 2021, and spring 2022).

With this past performance and our agency's mandate to conduct research throughout the U.S. EEZ, the NEFSC is in an ideal position to align our activities with the Bureau of Ocean Energy Management's (BOEM) interest in monitoring our region's living marine resources. Separating the effects of fishing, climate change, and wind energy development, while all these dynamics are occurring simultaneously, is a Gordian knot. eDNA offers opportunities to sample entire communities with each jar of seawater and has a particular advantage to identify species that are difficult to sample because they are rare, cryptic, very small, very large, very fast, aggregated, or inhabiting areas not accessible to nets. Establishing a baseline of eDNA data and information, when drastic changes are happening to the ocean and when traditional sampling methods will be unavoidably affected by these changes, becomes an urgent need, and it will advance our ability to monitor the status, trends, and resilience of economically important and protected species of the U.S. northeast continental shelf and slope.

Who are users of the survey data generated?

The EcoMon survey data is made publicly available at NCEI and meets other requirements for Publicly Available Research Reports.

Our eDNA stations include Long Term Ecological Research (LTER) sites in the Southern New England area, and this overlaps with our charter-based eDNA work close to wind farms. Therefore, eDNA data from the proposed survey can expand the temporal coverage of eDNA sampling in this area and enhance our ability to interpret temporal dynamics of species composition revealed by eDNA detection.

Key users expected are assessment analysts, fisheries managers, and researchers from governmental, industry, and academic institutions

Are there any formal quality standards (e.g., operational/gear requirements or standard operating procedures) for the survey that need to be considered?

The goal of simultaneously sampling mammals, fish, and shellfish with eDNA will require multiple genetic markers to infer abundance and distribution. We have the most experience with the 12S ecoPrimer identified by Riaz et al. (2011), which works well with teleost fish and other vertebrates. We have started discussions with the Southeast Fisheries Science Center (SEFSC) to co-select two additional primers so that future sampling results will be comparable across the U.S. east coast EEZ.

This survey will adopt the fixed-transect, fixed station design of the EcoMon survey and proposes sampling in the spring and fall seasons, which will show the extreme fauna

distributions associated with the coldest and warmest maritime seasons, respectively, and make the results comparable with the NEFSC BTS, in particular.

As noted above, although EcoMon surveys and bottom trawl surveys overlap in their spatial coverage, we chose not to add this proposed eDNA sampling to the existing mandate of the spring and fall BTSs. This idea of piggybacking our survey goals and requirements onto the spring and fall BTS does not work because of the already tightly packed operations on BTSs doesn't allow time or space to conduct eDNA sampling and the associated EcoMon sampling (i.e., bongo samples and hydrographic sampling). If choosing between two styles of sampling (EcoMon vs. BTS), we have adopted the EcoMon model because of its emphasis on deploying a rosette of Niskin bottles that invites water sampling, its relevant CTD casts that will characterize the oceanography, and to rapidly add biological samples of fish larva and zooplankton.

The maritime winter and summer seasons are chosen to standardize the seasonality of expected species communities since the middle Atlantic seaboard experiences very strong seasonality.

NEFSC staff are already involved in testing a standardized eDNA template, and we plan to adopt agency-wide guidance on best practices of data governance and data analysis.

Are there added values that cannot be met without this survey?

eDNA offers opportunities to sample entire communities with each jar of seawater and has a particular advantage to identify species that are difficult to sample because they are rare, cryptic, very small, very large, very fast, aggregated, or inhabiting areas not accessible to nets. When rapid changes are happening to the ocean and when traditional sampling methods will be unavoidably affected by these changes, establishing a baseline of eDNA data and information becomes an urgent need. Although eDNA will not replace any NEFSC survey, at least in the short-term ($\leq$ 10 years), its complementary nature will advance our ability to monitor the status, trends, and resilience of economically important and protected species of the U.S. northeast continental shelf and slope.

How does offshore wind energy impact survey objectives going forward?

We believe offshore wind energy impact will highlight the necessity of developing eDNA survey capacities at the NEFSC. Sampling of eDNA may be more feasible to monitor changes in distributional patterns of animals in WEAs and around high-voltage cable (HVC) locations because sampling can be envisioned from a variety of platforms.

Here, we propose a standard scheme to sample from oceanographic vessels following a statistical sampling design with Niskin bottles. However, sampling for eDNA from seawater can occur from stationary as well as automated sampling devices.

The NEFSC has also established eDNA sampling in the Southern New England (SNE) WEA (Marjorie Lyssikatos and Yuan Liu, pers. comm.), and these results will be more interpretable in the context of results from this proposed broad-scale, seasonal eDNA survey.

II. Survey Details

Beginning Year: 2019 (October)

Frequency: Annual

Season: Maritime winter (~May), maritime summer (~October)

Geographic Scope: Coastal waters of the U.S. Atlantic Ocean from Cape Hatteras, NC, to the Gulf of Maine, from nearshore waters to the continental slope (max 200 m).

Platform(s): Large ships capable of at least 21 days at sea and deployment of a rosette holding a CTD and at least 6 Niskin bottles

Statistical Design: Fixed stations along a fixed-transect survey design

Methods: Sampling eDNA from a rosette of Niskin bottles. Sampling at least surface and bottom in 2 replicate 2-liter samples. Additional replicate sampling when relevant vertical stratification occurs. Completing normal EcoMon station activity (i.e., oceanography samples using CTD and ichthyoplankton using bongo nets).

EcoMon surveys often host additional personnel to observe bird, mammal, and turtle distributions, which is possible but not a specific objective of this proposal. For details, see sampling design for EcoMon cruises.

III. Effect of Four Impacts

1. **Preclusion** of NOAA Fisheries sampling platforms from the wind development area because of operational and safety limitations.

   This eDNA survey will piggyback on the NEFSC's EcoMon spring and fall surveys, sampling at a minimum the 35 fixed stations allotted along a fix-transect design. The EcoMon program has already moved one fixed station that was inside South Fork (H. Walsh, Pers. Comm. Dec. 12, 2023) to the Revolution Wind lease area, but no additional changes are expected based on current leases.

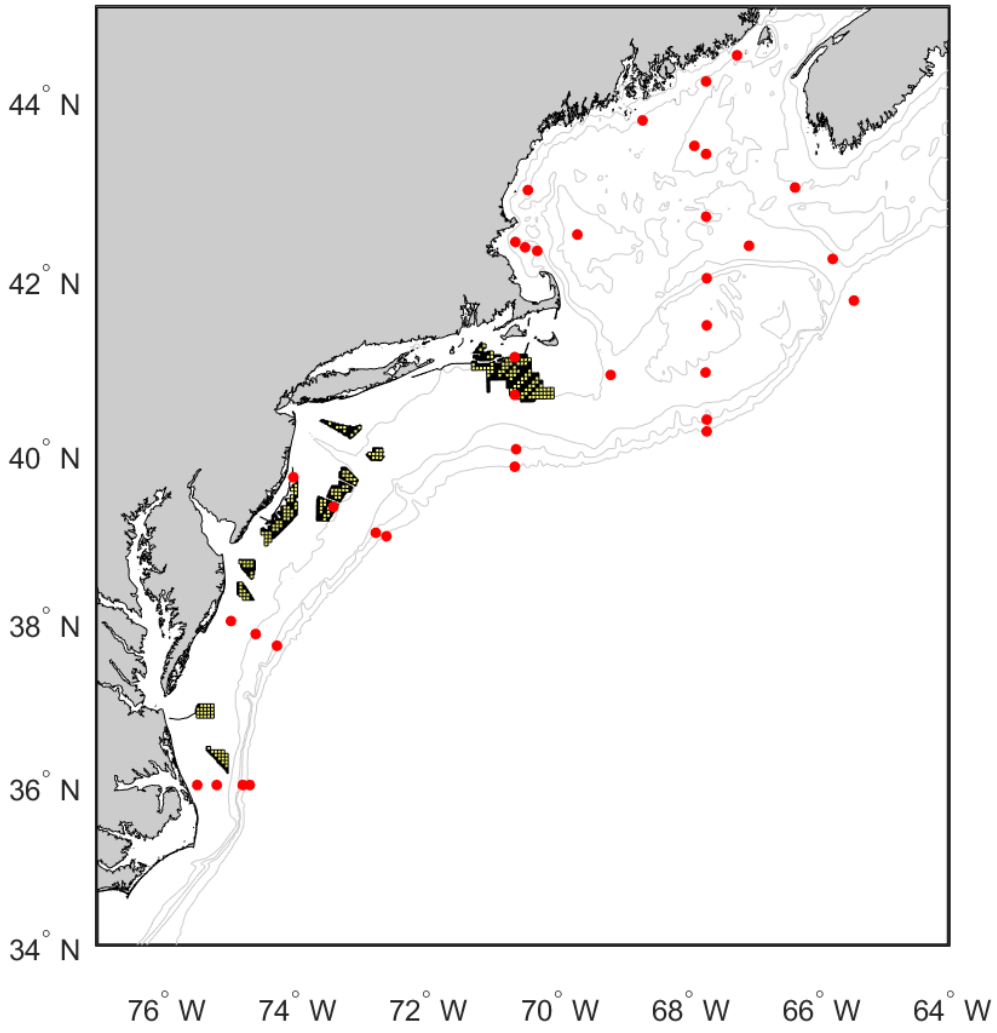

Figure 1: This map depicts the fixed stations sampled by the EcoMon program and their relationship to major wind energy development areas in the Northeast. These stations are laid out along fixed transects from 36◦N at the southern end of the sampling range, off of Cape Hatteras, to around 44◦N at the northern end of the sampling range, in the Gulf of Maine.

2. **Impacts on the statistical design of surveys** (including random-stratified, fixed station, transect, opportunistic, and other designs), which are the basis for scientific assessments, advice, and analyses.

   For fixed-transect stations, their availability for future sampling can be predicted from lease area maps. Fixed-station sampling sites may need to be adjusted to keep a safe distance from wind infrastructure. EcoMon sampling procedures already allow adjustment of fixed stations within a 1-nautical mile (nm) radius due to conflict with other vessels, fixed fishing gear, or other navigational hazards, and the dispersal eDNA is expected to be in the 100s to 1000s of meters (Baetscher et al. 2024), so this does not present a major concern.

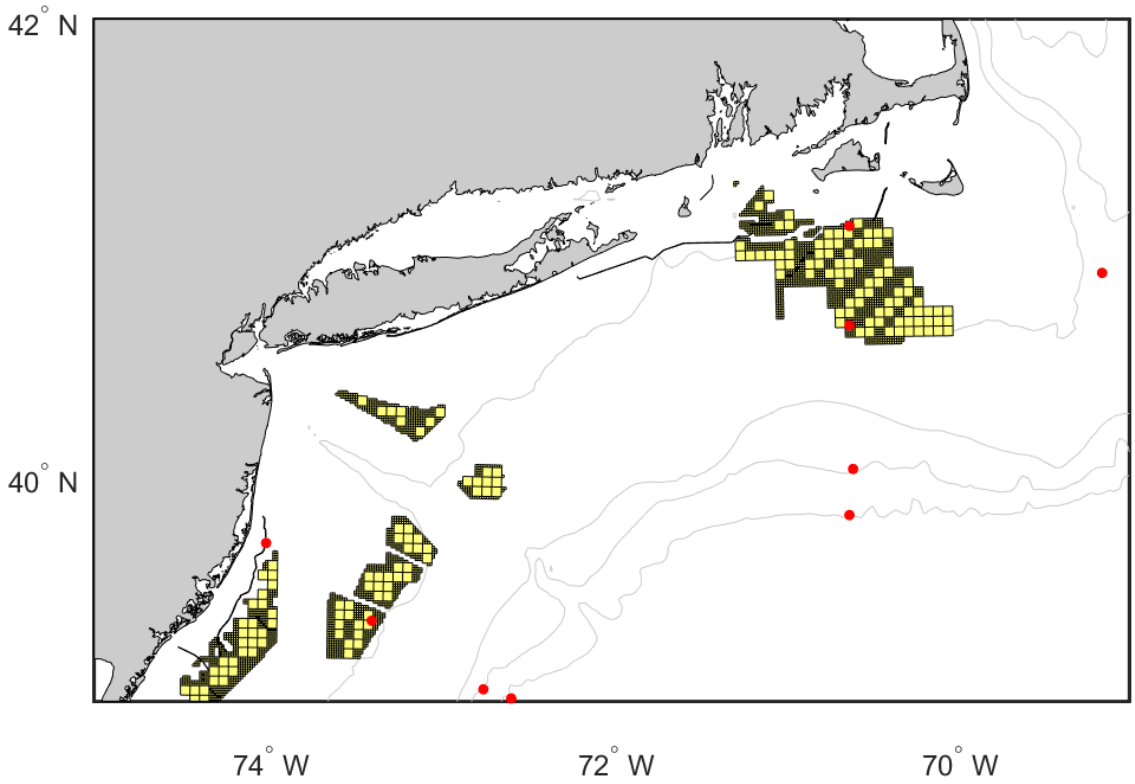

Figure 2: This map depicts a close-up version of Figure 1, between Cape May (NJ) and Cape Cod (MA: within a bounding box of 40◦N – 42◦N and 70◦N – 74◦W.

3. **Alteration of benthic and pelagic habitats and airspace** in and around the wind energy development, requiring new designs and methods to sample new habitats.

   Assessment of the fixed stations has been made, and only 1 station needed to be moved so far. Understanding the future impacts of floating WEAs will require periodic assessment. In particular, WEAs may have effects on the oceanographic conditions, plankton, and bird, mammal, and turtle distributions which are monitored by EcoMon surveys.

   We expect that existing EcoMon methods will be sufficient to observe these effects within WEAs. For fixed-foundation WEAs, these existing methods should be adaptable to vessels capable of operating in those areas. For floating wind areas, monitoring of zooplankton and ichthyoplankton may require new measurement techniques since these areas are incompatible with bongo net tows.

4. **Reduced sampling productivity** caused by navigation impacts of wind energy infrastructure on aerial and vessel surveys.

   Sampling at additional stations using the stratified, random sampling design is planned. These stations may be affected by wind energy infrastructure. The purpose of sampling at these stations will be more adaptive, so adjustments are expected.

IV. Mitigation Planned, as per Six Elements

1. ***Evaluation of survey designs***

   Changes to habitat can include wake effects, aggregation effects, acoustic effects, and other effects. The EcoMon Survey Mitigation Plan has a more comprehensive plan for such an evaluation, and there are concerns for that plan because of the much higher density of stratified random stations to sample.

   While we expect a formal evaluation of the suitability to continue sampling at current EcoMon fixed stations, as in relation to changes in habitat that could be introduced by the presence of wind energy infrastructure, this does not appear to be a major problem ahead for the eDNA proposal.

   The reduced number of fixed stations expected (~35) for eDNA sampling reduces the number of stations that need to be re-evaluated, and only 1 station has been identified in a proposed wind area and already moved. These fixed stations are identified as not just fixed in space but fixed in time, over years.

   We expect additional sampling at the stratified, random stations. At a minimum, water casts are taken at least once per day, so there could be up to an additional 21 stations sampled. Additional, special water casts are expected but are not pre-programmed at this time. This is something to work out in the first few years during the evaluation of survey design period. The objective is to find a standardized way to sample in a stratified, random way to address relevant ecological/fishery questions within the logistical constraints and opportunities of piggybacking on the EcoMon platform.

2. ***Identification and development of new survey approaches***

   Any new survey approaches would be in coordination with the EcoMon Survey's Wind Mitigation Plan so that our sampling of the fixed stations in spring and fall can be integrated into monitoring and analysis of EcoMon sampling in other seasons. Overall, we are addressing not only the need to have a new survey method (eDNA), but because this plan will involve sampling collaboratively to include EcoMon protocols (i.e., ichthyoplankton, CTD, water sampling), we are also addressing the need to increase sampling coverage that is outlined in the EcoMon plan.

3. ***Calibration and integration of new survey approaches***

   The main questions that need to be addressed regarding survey design are:
   1) Will fishing be totally precluded in WEAs? and 2) How close is "close enough" with regard to fishing near historical survey stations if WEAs preclude fishing on the actual survey site?

   Since the eDNA component only has a limited number of complete surveys to compare (fall 2019, summer 2021 spring, 2022), any adjustments to the fixed-station design will have only a minor impact on interpreting time series of data.

   EcoMon sampling procedures already allow adjustment of fixed stations within a 1-nm radius due to conflict with other vessels, fixed fishing gear, or other navigational hazards,

and the dispersal eDNA is expected to be in the 100s to 1000s of meters (Baetscher et al. 2024) so this does not present a major concern.

4. ***Development of interim provisional survey indices***

   Calibration of the eDNA methods is ongoing with active hydroacoustic sampling occurring synoptically on the same vessel and cruise. First-year results were largely successful in demonstrating an association between acoustic targets and eDNA metabarcoding read counts (Skylar Gering, 2021 NOAA Hollings Program intern).

   One major advantage of using eDNA technology is that we anticipate fewer data gaps because we are less affected by the types of sampling platforms. In fact, we started sampling water for eDNA analysis on a charter in the SNE WEA in September 2023. eDNA data collected from smaller sampling platforms such as a charter will help close data gaps when EcoMon is affected by wind energy development, weather conditions, personnel availability, or a pandemic.

   Cross-validation studies are also being conducted to compare eDNA and passive PAM of large marine mammals. This has been done twice onboard the previously mentioned charter. As we test the efficacy of an eDNA sampler on these trips, PAM detections can be used to assess the validity of eDNA detection. Knowledge acquired from cross-validation studies like this can also be used to further evaluate the strength and weakness of eDNA detections on proposed EcoMon trips.

5. ***Wind energy monitoring to fill regional scientific survey data needs***

   We need funding to conduct additional research/surveys now within areas slated to be WEAs.

   We are not anticipating further changes to the sampling design, but we can work with the plans of the EcoMon Survey mitigation team to move toward sampling from smaller platforms, as necessary. eDNA sampling can be done from a number of different ships and could even be conducted off autonomous underwater vehicles (AUVs), drones, and stationary devices.

   Again, the eDNA sampling of 35 fixed stations is not likely to be affected by the currently known spatial configuration of wind energy development. Funding the eDNA proposal is in fact a mitigation strategy for a number of other NEFSC surveys, as it will provide a single, independent source of monitoring data for marine invertebrate, fish, and mammal taxa.

6. ***Development and communication of new regional data streams***

   This is a multi-purpose survey design to include eDNA water sampling, ichthyoplankton, CTD environmental data, and other water sampling for environmental variables. Execution of this plan is based on a collaboration of the NEFSC EAD's Ocean and Climate Branch and PEMAD.

Execution of this plan will also require coordination with the NEFSC's Information Technology Division to lay a framework for program responsibilities for database development, data management, software applications, and IT workflows.

Communication with current end users of survey data and indices (NEFSC, the Greater Atlantic Regional Fisheries Office [GARFO], the New England Fishery Management Council [NEFMC], and the Mid-Atlantic Fishery Management Council [MAFMC]) will be necessary to align expectations and ensure the end product mitigates WEA impacts effectively to enable continued management advice based on survey results. Further, all surveys impacted by WEA development should communicate with BOEM via their science centers to disseminate information of WEA impacts for future planning purposes.

V. Proposed Schedule for Implementation

FY24-28 (Years 1-5)
The first 5 years have additional setup costs associated with equipment purchases and designing and establishing a database and data entry/access application.

FY29+ (Years 6+)
The next 25 years assume standardized, routine operations.

Survey seasons
Spring and fall every year, overlapping with the BTS period (target May and October).

VI. Links to Other Surveys

The community compositions characterized by metabarcoding with eDNA will be highly relevant to other surveys of vertebrates and invertebrates, so we expect that there will be formal comparisons between the eDNA results and data from the following NEFSC operations:

Bottom Trawl Survey of groundfish and select pelagic fishes as operated by PEMAD's Ecosystem Survey Branch.

Shellfish Surveys of shrimp, clams, and scallops as operated by PEMAD's Ecosystem Survey Branch.

Coastal Shark Bottom Longline Survey of sharks and other large pelagic fishes as operated by PEMAD's Population Biology Branch.

Passive acoustic, ship-board, and aerial surveys of marine mammals operated by the recently reorganized Protected Species Division.

Gulf of Maine Bottom Longline Survey as operated by the Fishery Monitoring and Research Division's (FMRD) Cooperative Research Branch.

Ecomon's ichthyoplankton Survey as operated by EAD's Oceans and Climate Branch.

Note, in terms of field operations, these surveys, as outlined here, will restore sampling of the EcoMon fixed stations during spring and fall, and will be planned and staffed jointly by PEMAD and EAD.

VII. Adaptive Management Considerations/ Opportunities

The use of metabarcoding, as proposed here, is one giant adaptive opportunity to parse out the effects of wind energy, fishing mortality, and climate change on marine communities. It will be a new, independent method to track species distributions and abundance. Although it is hard to predict where this technology will be in 5-10 years, genomics is a rapidly developing field, with a clear, steady trend in improving its accuracy and precision while decreasing operational costs. The improving options for autonomous sampling platforms will also prompt periodic evaluation of our reliance on ship-based operations with a rosette of Niskin bottles.

VIII. Statement of Peer-Review Plans

We will request external peer reviews from within the National Marine Fisheries Service (NMFS), accessing genomic expertise at other science centers. We have already discussed the 3-marker approach with the SEFSC and will want to continue those discussions informally and, if appropriate, with a formal peer review. There are many other points of expertise at West Coast science centers which are familiar with the Northeast's operations because we coordinate genomics research and development as funded by a recently completed 5-year strategic initiative and a pending 3-year program funded by the Inflation Reduction Act.

Within the region, the state of New Jersey has funded a large eDNA program to address wind energy development, and this program's staff should be contacted for peer review, as appropriate. We do not view the continued development of both programs to be conflicting, as the state will be focused on high-density sampling within or in proximity to state waters, whereas our sampling design is at a reduced sampling density but spread out from nearshore to slope water from Cape Hatteras to Halifax. Indeed, the 2 programs, operating at different scales, will be complementary to each other.

There are a number of International Council for the Exploration of the Sea (ICES) working groups that may be suitable for further peer review (i.e., the Working Group on the Northwest Atlantic Regional Sea [WGNARS], Working Group on Northwest Atlantic Ecosystem Observations [WGNAEO], Working Group on Offshore Wind Development and Fisheries [WGOWDF], Working Group on the Governance of Quality Management of Data and Advise [WGQuality], and the Working Group on Application of Genetics in Fisheries and Aquaculture [WFAGFA]).

IX. Performance Metrics

Our first goal is to restore sampling of the fixed-transect stations in the spring and fall. These seasons are the coldest and warmest months, respectively, and bolstering environmental

data for these seasons and adding the eDNA sampling will depict the annual range of species distributions.

Partnering between the Center's Population Biology Branch and Oceans and Climate Branch in field operations is only the beginning of a win-win relationship. The genetics team will want to interpret their results in the context of oceanographic dynamics, benefiting from further collaboration on analyses and reporting.

More collaborations with other survey units—across a range of taxa including marine invertebrates, fishes, birds, turtles, and mammals—will be another metric, as the goal of using eDNA to mitigate a number of Center surveys will require data comparisons. eDNA will likely be a key source of data to identify species that are difficult to sample because they are rare, very small, very large, very fast, aggregated, or inhabit areas not accessible to nets whether influenced by wind energy development or not.

The ultimate goal is to use eDNA as contextual information to inform assessment and management of either specific fishery stocks or more broadly at the ecosystem level. Perhaps eDNA data can feed directly into a stock assessment. Characterizing marine communities from eDNA works, but we are in an early stage of application of genomics in managing living marine resources. If we are in this for the long term, genomics has an important role in it.

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