Ecosystems Monitoring Survey Mitigation Plan

I. Purpose of the survey

What data is collected?

- Vertical instrument profiles of temperature, salinity, dissolved oxygen, chlorophyll fluorescence, and photosynthetically active radiation.
- Discrete water column samples are taken for the measurement of dissolved inorganic carbon (DIC), total alkalinity (TA), nutrients, and pH.
- Bongo net tows to estimate, zooplankton abundance by taxon, and ichthyoplankton abundance by taxon.
- Surface visual surveys of marine mammals, birds, and turtles are also conducted.

What specific products use this survey?

- The annual Northeast Fisheries Science Center (NEFSC) regional State of the Ecosystem reports.
- The annual International Council for the Exploration of the Seas (ICES) Report on Ocean Climate published by the Working Group on Oceanic Hydrography.
- The Northwest Atlantic Fisheries Organization (NAFO) Scientific Council Standing Committee on Fisheries and the Environment report.
- The Atlantic Marine Assessment Program for Protected Species (AMAPPS).
- The National Seabird Program.
- Data synthesis products incorporating the Ecosystems Monitoring (EcoMon) data include the National Seabird Compendium, NOAA Marine Cadastre, National Center for Environmental Information (NCEI) World Ocean Database, NCEI Coastal Ocean Data Analysis (CODAP), and NCEI Ocean Carbon and Acidification Data System (OCADS).
- EcoMon data has been used in a range of environmental impact assessments including the Rhode Island Special Area Management Plan (RI SAMP), Neptune LNG and Deepwater LNG, and numerous ongoing wind energy development projects.

Which assessments/science advice pathways currently use this survey?

- Plankton data is used in environmental impact assessments related to construction and operation of wind development projects.
- Ichthyoplankton data are used in multiple stock assessment products including the Atlantic mackerel (*Scomber scombrus*), summer flounder (*Paralichthys dentatus*), yellowtail flounder (*Limanda ferruginea*), Atlantic menhaden (*Brevoortia tyrannus*), Atlantic cod (*Gadus morhua*), longfin inshore squid (Doryteuthis pealeii), and red hake (*Urophycis chuss*) assessments.
- Zooplankton data are used to monitor changes in diversity of the Northeast U.S. Continental Shelf.
- *Calanus finmarchicus* data from the survey are used in multiple modeling projects examining North Atlantic right whale (*Eubalaena glacialis*) foraging habitat including transboundary modeling efforts with Fisheries and Oceans Canada (DFO).

- Temperature and salinity profile data inform all of the assessments listed above, as well as the assessments for Atlantic Sea Scallop (*Placopecten magellanicus*), Northern shrimp (*Pandalus borealis*), and species sampled by the NEFSC Bottom Trawl Survey. The data are also used in the annual State of the Ecosystem Reports provided to the Mid-Atlantic and New England Fisheries Management Councils.

Who are users of the survey data generated?

- The EcoMon survey data is made publicly available at NCEI and from the Northeast Fisheries Environmental Research Division's Data Access Program (ERDDAP).
- Data has been used by researchers from multiple institutions and agencies, including but not limited to:
    - Woods Hole Oceanographic Institution (WHOI)
    - Gulf of Maine Research Institution
    - National Aeronautics and Space Administration (NASA)
    - Environmental Protection Agency (EPA)
    - Rutgers University
    - University of Rhode Island
    - University of Maine
    - University of New Hampshire
    - Old Dominion University
    - Stony Brook University
    - University of Connecticut
    - Duke University
    - The National Science Foundation (NSF)Northeast Long-Term Ecosystem Research (LTER) project
    - The Mid-Atlantic and New England fisheries management councils
    - RPS | North America
    - CSA Ocean Sciences, Inc.
    - The Bureau of Offshore Energy Management

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

The EcoMon program has established long-term datasets using standard methods to ensure the consistency of data across the time series. Maintaining the integrity of these time series permits analyses of trends and the detection of change. To the extent possible, an important principle of the EcoMon program has been that methods should remain consistent over time. However, the anticipated impacts of wind energy areas (WEAs) may prove incompatible with some existing sampling. In that event, the goal will be to minimize the effects, particularly with respect to application of the data to stock assessments, and ecosystem and climate science.

Each current EcoMon dataset has operational requirements for collection that may be impacted differently:

- The hydrographic dataset requires deployments of conductivity, temperature, and depth (CTD) instruments with attached oxygen sensors. CTD profiles are performed to within 3 meters of the surface or less and to within 5 meters of the bottom.The vertical resolution of measurements should be sufficient to bin-average the data to 1 decibar intervals. All instruments should also meet or exceed accuracy and precision of the instruments currently used on EcoMon surveys (Sea-Bird Electronics SBE-19plusV2 or SBE-911plus CTDs with SBE-43 oxygen sensors). Ideally, the CTD is

deployed using vertical profiles with CTD instruments from a suitable vessel; however, CTDs may be also towed or mounted on vehicles. This flexibility should allow CTD deployments to be adapted for operation within both fixed-foundation and floating WEAs.

- Marine chemistry measurements are taken on water samples collected at multiple depths. This includes measurements of DIC, TA, pH, nitrate, nitrite, ammonium, and silicate. There are currently no instruments that permit measurement of these parameters with the same accuracy and precision as can be achieved through the laboratory analysis of water samples. Collection of the water samples requires the use of 5- or 10-liter Niskin bottles which can be remotely tripped at a target depth, can be paired with real time CTD data to guide bottle firing, and can provide paired hydrographic data. This is currently done using an SBE-32 12- or 24-bottle carousel with an attached SBE-911plus CTD. As with CTD deployments, these methods should be adaptable for use in both fixed-foundation and floating WEAs.
- Zooplankton and ichthyoplankton are sampled using 333µm mesh 61 cm bongo nets. The nets are deployed on oblique tows to a maximum depth of 200 meters or to within 5 to 10 meters of the bottom and are towed at 1-2 knots. Net sampling is conducted with a telemetering CTD profiler deployed simultaneously on a conducting cable tow wire and winch. Attached flow meters allow calculation of total volume filtered by the net. Plankton catchability and gear selectivity is affected by net type, net mesh, and deployment speeds but is not affected by ship size or ship type. This makes plankton sampling adaptable to vessels but particularly sensitive to changes in methods (e.g., other net types or new technologies). There is currently no single method that can replace all of the information provided by plankton net sampling. If bongo net tows are precluded in any of the WEAs, it would require a suite of other techniques to partially replicate the level of scientific information provided. Any change to methods necessitates testing and cross validation experiments to identify differences that could impact analyses. We expect that bongo net tows can be adapted for use within fixed-foundation WEAs, but we expect there to be challenges with adapting them for use in floating WEAS.
- Visual survey teams collect broad-scale data on the distribution and abundance of seabirds, marine mammals (cetaceans and pinnipeds), and sea turtles using direct shipboard observations. The visual survey team uses similar methods to those used on Atlantic Marine Assessment Program for Protected Species (AMAPPS) surveys; standard strip transect methods are supplemented with distance data. Other observational measures of marine megafauna may be employed in WEAS (e.g., camera systems, drone surveys). However, shipboard observations of seabirds, particularly small species (migrating shorebirds) and species that spend most of their time on the sea surface (sea ducks, alcids, loons) may be underestimated with new techniques.

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

- The EcoMon survey, along with the NEFSC Bottom Trawl Survey (using EcoMon methods and equipment) are the primary sources of synoptic shelf-wide, multi-season, annually repeated CTD profiles and bongo net tows on the Northeast U.S. Continental Shelf. A loss of this dataset would interrupt a time series dating back to 1977. This time series is essential to monitoring:
    - changes in zooplankton and ichthyoplankton distribution, abundance, and phenology;

    - changes in subsurface hydrographic conditions and water masses;
    - larval and egg abundances for a number of managed species; and
    - changes in marine chemistry related to ocean acidification.

- Hydrographic data is provided in near-real time for use in oceanographic model validation.
- EcoMon data are used to develop indices used in Atlantic mackerel, summer flounder, yellowtail flounder, and Atlantic menhaden assessments and to provide additional context for a variety of other assessments and stock identification work.
- Zooplankton data provide information on prey availability to help understand endangered right whale distributions.
- The plankton, hydrographic data, and marine chemistry data are used to support a range of stock assessments and ecosystem-based management and climate advice produced by the NEFSC and external researchers
- The EcoMon survey is the only NEFSC survey that carries out multi-season, synoptic, annually repeated carbonate chemistry and nutrient profile data on the Northeast U.S. Continental Shelf. This data collection is essential to monitor ocean acidification and its potential impacts on managed species.
- In addition to core monitoring activities, the EcoMon survey serves as a platform to host scientific projects that leverage its activities. These include field experiments, supplemental measurements, and collaborations with external researchers. Past projects have included the validation of satellite algorithms used in remote sensing in partnership with NASA, the National Environmental Satellite, Data, and Information Service (NESDIS), and others; the Climate Variability on the East Coast (CLIVEC) project with multiple institutions; graduate student projects from the University of Maine, the University of Connecticut, and the University of Rhode Island; partnerships with NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML), the Northeast Long-Term Ecological Research (LTER) project, the Canadian Atlantic Zone Monitoring Program (AZMP) program, the WHOI Census of Marine Zooplankton, and eDNA sampling by other groups at the NEFSC.

How does offshore wind energy impact survey objectives going forward?

The core objective of EcoMon is to monitor biological, physical, and chemical oceanographic conditions on the Northeast U.S. Continental Shelf in support of stock assessments and ecosystem science. These objectives will not change, but WEAs will become a new component that will need to be integrated into the survey.

The requirements of operating vessels and sampling gear safely may require new methods and approaches to operate in and around WEAs. EcoMon will also continue to serve as a platform for short-term projects which may include studies specific to the effects of WEAs in the marine environment.

It is expected that the NEFSC Bottom Trawl Survey will adjust its sampling strata to account for WEAs. The EcoMon survey will adopt the updated trawl strata to maintain consistency between the 2 surveys. EcoMon-specific modifications to these trawl strata would be made as needed in order to account for potential hydrodynamic and plankton-specific habitat effects from WEAs. This would be informed by future modeling efforts. The Oceans and Climate Branch (OCB) has begun the process of recruiting a physical oceanographer that would support this analysis.

II. Survey Details

Beginning Year: 1977, originally as the Marine Resources Monitoring and Assessment Program (MARMAP) before becoming the EcoMon Program.

Frequency: There are 4 dedicated EcoMon surveys planned per year. There is bongo net and CTD sampling using EcoMon methods on the NEFSC bottom trawl survey an additional 2 times per year.

Season: All seasons, February through November

Geographic Scope: The continental shelf from Cape Hatteras, NC, to the Gulf of Maine, including the Bay of Fundy and the Western Scotian Shelf in Canadian waters

Platform(s): NOAA Ships including the *Henry B. Bigelow*, *Pisces*, and *Gordon Gunter*.

Statistical Design: EcoMon samples CTD profiles and bongo net tows from approximately 135 stations using a random stratified sampling design. There are also 35 strategically selected non-random monitoring sites, some of which are arranged in cross-shelf transects where chemistry sampling, bongo net sampling, and CTD sampling occur. Visual bird and mammal observations are conducted while the vessel is transiting between stations.

Methods: The EcoMon survey uses multiple methods to assess the physical, chemical, and biological oceanography of the Northeast U.S. Continental Shelf. These include:

- oblique bongo net tows to collect zooplankton and ichthyoplankton with attached CTD instruments and oxygen sensors;
- vertical CTD instrument deployments to measure vertical profiles of temperature, salinity, dissolved oxygen, chlorophyll fluorescence, and photosynthetically active radiation;
- Water samples collected at discrete depths for laboratory chemical analysis of DIC, TA, pH, nitrate, nitrite, ammonium, phosphate, and silica; and
- visual surveys of birds, turtles, and marine mammals.

III. Effect of Four Impacts

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

   It is expected that the current NOAA ships used to conduct the EcoMon surveys will not be able to safely navigate and/or safely deploy scientific gear and instruments within fixed tower WEAs. It may be possible to execute the survey within WEAs from smaller and more maneuverable platforms. These small vessel EcoMon surveys within the WEAs could operate in combination with a larger NOAA vessel operating outside the WEAs conducting the rest of the traditional EcoMon survey. The small vessels would be able to use the standard EcoMon sampling methods, maintaining consistency with the historical time series.

   EcoMon bongo net tow protocols have been used successfully from the 72-foot *R/V Gloria Michelle.* This work demonstrates the feasibility of using a smaller vessel for

EcoMon sampling in areas comparable in size to WEAs. Future test deployments within the Vineyard Wind WEA will be conducted from the *R/V Gloria Michelle* to demonstrate that this approach is also compatible with the presence of fixed-foundation WEA infrastructure.

Beyond 2030, floating wind energy areas are expected to be built in the Gulf of Maine. It is difficult to predict the effect these floating WEAs will have on EcoMon surveys since designs and locations have not been finalized, but the floating WEAs are expected to have mid-water cables and mooring tethers which could interfere with gear deployed in the water column.

Towed bongo nets would need to avoid intersecting any mid-water cable infrastructure. Depending on the designs used by these WEAS, there may not be sufficient area within the WEA where net tows could be safely deconflicted from WEA infrastructure. This would require alternatives to oblique bongo net tows in order to sample zooplankton and ichthyoplankton. Such new plankton sampling techniques developed for floating wind areas are not likely to be fully equivalent to bongo net sampling and will create a break in long-term time series. Different plankton sampling techniques have widely varying catchability, gear selectivity, and species identification capabilities. The use of new plankton sampling methods would initiate new long-term monitoring time series for zooplankton and ichthyoplankton.

Vertical profiles of CTDs and water sampling should still be possible within floating WEAs since they can be deployed at a fixed location while a vessel holds station, but this will still require a safe radius from any suspended cables depending on depth and currents. As individual floating WEA construction plans become available, this will need to be confirmed.

We do not foresee any interference with the ability to conduct the visual surveys for birds, mammals, and turtles.

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.

   The presence of WEAs will require a reevaluation of sampling strata that contain wind turbines and adjacent areas that may be influenced by them. Because wind turbines and infrastructure could alter pelagic and benthic habitat or attract species, it may be necessary to define new strata that account for these effects. We will also need to study the sampling density required to adequately characterize the area within and adjacent to WEAs.

   The EcoMon survey will adopt the strata used by the NEFSC Bottom Trawl Survey as a starting point in order to maintain consistency between the 2 surveys. This would include WEA-related modifications adopted by the trawl survey. EcoMon-specific modifications to the strata would be made as needed. The approach results from EcoMon sampling being part of the NEFSC Bottom Trawl Survey operations, and in order to be standardized, the dedicated EcoMon surveys will also adopt this approach.

   EcoMon-specific modifications to the strata will be based in part on modeling efforts to characterize the scale of hydrodynamic effects in and adjacent to WEAs. It will also

incorporate information from statistical analyses to identify possible WEA-related changes in plankton species distribution, phenology, or community composition.

Fixed station sampling sites may need to be adjusted to keep a safe distance from wind infrastructure. We already allow adjustment of fixed stations within a 1 nautical mile radius due to conflict with other vessels, fixed fishing gear, or other navigational hazards, so this does not present a major concern.

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.

   WEAs may have effects on the oceanographic conditions, plankton, 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 WEAs, 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.

   The need to use alternative platforms risks reduced sampling productivity. Currently, NOAA does not have its own suitable platform capable of carrying out an EcoMon survey in all of the planned WEAs, necessitating the use of charter vessels. The limited availability of suitable charter vessels and the logistics necessary to support a synoptic survey distributed across multiple vessels operating in parallel could reduce sampling.

IV. Mitigation Planned, as per Six Elements

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

   It will be necessary to reevaluate the current EcoMon sampling strata to account for the changes in habitat that could be introduced by the presence of wind energy infrastructure in the water. There may also be differences in methods and survey platforms inside and outside of the WEAs that need to be accounted for in the strata design. Changes to habitat can include wake effects, aggregation effects, acoustic effects, and other effects.

   Restratification would be done with the intent that new strata should be consistent with those used by the NEFSC Bottom Trawl Survey, with modifications as needed to account for the differences in sampling gear used by EcoMon. We would consult with other groups at the NEFSC and external users of the data and related products in making restratification decisions.

   Potential Survey impacts:

   - Minimal
     1. Vertical instrument profiles of temperature, salinity, dissolved oxygen, chlorophyll fluorescence, and photosynthetically active radiation.

2. Discrete water column samples collected for the measurement of DIC, TA, and pH.
3. Surface visual surveys of marine mammals, birds, and turtles.
4. Bongo net tows to estimate zooplankton abundance by taxon and ichthyoplankton abundance by taxon. Minimal impact for fixed-foundation WEAs only.

Mitigation strategy: Carry out traditional EcoMon sampling in WEAs on a vessel that can safely operate within the offshore wind farms.

- Significant

1. Bongo net tows to estimate zooplankton abundance by taxon and ichthyoplankton abundance by taxon. Significant impact for floating WEAs only.

Mitigation strategy: Evaluate new technologies to provide similar data products for assessments or conduct research to develop new data products.

2. *Identification and development of new survey approaches*

General approach

New survey platforms and methods will be required to maintain the current scientific information provided by the EcoMon survey. Broadly speaking, this need can be divided into a near-term phase prior to 2030 associated with the construction of fixed-foundation WEAs and a post-2030 phase associated with floating wind as these will have different impacts on EcoMon sampling methods and platforms.

One advantage of the EcoMon surveys is that the gear is both portable and adaptable to a wide range of platforms from smaller fishing vessels to larger oceanographic research vessels. This will allow the survey to adapt to fixed-foundation WEAs while maintaining consistency with historical methods.

Near-term fixed-foundation wind mitigation

In the near term, prior to 2030, it is expected that the current large NOAA ships used to conduct EcoMon surveys will not be able to safely operate within WEAs. Smaller vessels with greater maneuverability and shorter maximum heights may be able to operate in these areas safely.

In the past, the core long-term EcoMon sampling using towed bongo nets and vertical CTD deployments have been scaled to operate from smaller vessels which should be able navigate and tow nets safely within fixed-foundation WEAs. These smaller platforms would allow the traditional sampling methods to continue, maintaining the integrity of existing time series.

NOAA currently lacks smaller vessels in the region with the capabilities to carry out the sampling within the projected WEAs. We propose to use small- to medium-sized charter vessels to carry out sampling in the fixed-foundation WEAs where NOAA cannot provide a suitable vessel. Since smaller vessels often have shorter endurance and a reduced ability to operate in rough weather conditions, it may be necessary to charter multiple

vessels from different ports located near each of the WEAs in order to complete a single synoptic survey. Ideally, these smaller vessels would sample inside the WEAs in parallel with a simultaneous survey, using a larger NOAA vessel to cover the remainder of the full EcoMon survey area. A full synoptic survey would then be patched together from each of the participating vessels. Calibration cruises will not be required where standard EcoMon methods are used as data consistency is not vessel-dependent but rather depends on consistent gear and deployment protocols. EcoMon protocols have already been successfully implemented on a wide range of vessels including smaller vessels, such as those proposed here.

We will evaluate the capabilities of the potential charter vessels available to determine which can meet the survey needs and to determine how many individual vessels would be needed. If NOAA constructs or purchases smaller vessels, these may provide a longer-term alternative, but such vessels will not be available initially. We would reevaluate vessel needs when and if such NOAA vessels become available.

Smaller charter vessels will need to have suitable deck equipment to carry out EcoMon sampling. This will include a hydrographic winch with conductor wire, or the ability to install a winch provided by NOAA, and an a-frame or boom capable of deploying a bongo net from the side rather than the stern of the vessel. A small charter vessel may not have the capability to deploy a larger CTD or water sampling carousel due to their weight and deck space requirements. In addition, smaller vessels may only have deck space for a single hydrographic winch, making switching between gear types— moving from a bongo net and CTD to a water sampling CTD carousel, for example—much more time consuming. In the event that a vessel cannot accommodate a larger CTD carousel, it may be necessary to collect water from a single bottle mounted on a wire with a CTD which will reduce sampling capacity. Lastly, due to the limited lab and berthing space, these vessels will have reduced capacity to support short-term experiments and research projects typically supported on EcoMon cruises. They may also lack certain technical capabilities present on larger NOAA vessels that are often leveraged by research projects during EcoMon cruises (e.g., thermosalinographs, acoustic doppler current profilers, internet connectivity). As a result, the primary focus of small vessel charters would be to conduct core CTD, bongo net tows, and visual surveys within the WEAs where larger vessels cannot operate, with larger NOAA ships potentially conducting the full scope of operations outside the WEAs.

If water sampling using carousels from smaller vessels within the WEAs is not possible, we may need to use alternative methods for carbonate chemistry sampling; however, developing improved carbonate chemistry sensors that could serve this purpose is already an existing goal of the EcoMon program, and we will continue to pursue this with the NOAA Ocean Acidification Program.

The need to support multiple platforms simultaneously will require additional staffing and equipment beyond what is currently needed to support the single-vessel survey. It will also require more resources to support the logistics of remote port operations and the maintenance and calibration of additional equipment.

This dependence on charter platforms poses an operational risk to successful sampling. Smaller vessels will be more susceptible to weather disruptions. Currently, there is also a limited availability of suitable charter vessels in the region. In the future, the need to

sample within the WEAs may create increased competition for vessel time, which could stress this limited resource and lead to surveys either being canceled or surveys not being conducted in the desired time windows.

Long-term floating wind mitigation

Beyond 2030, floating wind platforms are expected to be used in the deeper waters of the Gulf of Maine. This will pose a new challenge because floating wind platform designs have midwater cables and tethers which would make it hazardous to tow gear, such as bongo nets. It may still be possible to conduct vertical CTD sampling, but this will necessitate the development of new sampling methods.

Currently, there is no single technology or method that can provide the full scope of both taxonomic resolution and abundance information provided by bongo net sampling. Alternative net deployment methods, such as vertical ring casts, might be possible, but previous tests have demonstrated that ichthyoplankton are poorly sampled by this type of net, and in general, the difference of gear selectivity will create a break in existing plankton time series.

Imaging systems currently have limited ability to discern taxa, with no ability to identify certain eggs and larva used in stock assessments to species. Acoustic plankton methods provide even less taxonomic information. Molecular techniques, such as eDNA, can alternatively provide excellent taxonomic resolution but are lacking in the ability to measure parameters, such as abundance, age, and size.

Reproduction of the essential information provided by bongo nets in floating WEAs will likely require a suite of techniques rather than a single method. This change in methods will inevitably create a break in long-term monitoring time series.

We propose to use the near-term period prior to 2030 to evaluate alternative methods and technologies that would be suitable for deployment in floating WEAs. This evaluation would include identification of best practices and assessing the impacts of a change in methods to long-term time series.

We will also evaluate the use of alternative sampling platforms, such as autonomous vehicles, moorings, and platforms of opportunity, which might reduce dependence on charter vessels and increase the reliability of surveys relative to being vessel-dependent.

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

Where standard EcoMon sampling methods can be transferred to vessels capable of operating within WEAs, most sampling will not require intercalibration. Any vessel suitable for use will need to be able to safely maintain steerage at desired tow speeds and also achieve the winch payout and haulback rates specified by EcoMon protocols. These protocols are otherwise intended to be vessel-independent, and the EcoMon program has a long history of using a wide range of vessels and vessel types to carry out sampling. These have included everything from larger NOAA ships to commercial fishing trawlers.

For bongo nets specifically, the geographic arrangement of the individual wind turbines

will likely require tows in specific lanes to avoid conflict with wind infrastructure. This will set the tows along fixed axes rather than allowing them to be dynamically oriented in relation to currents and seas. It is possible that this could introduce systematic biases into the time series.

For the specific cases of CTD deployments, discrete water sampling, and visual bird and mammal surveys, no impact is expected, and no calibration is required.

In the long term, it may be necessary to employ new technologies to operate in WEAs, either because suitable vessels are not available or, in the case of floating wind technology, because in-water infrastructure prevents the safe towing of gear. This could include the use of novel sampling platforms, such as AUVs, gliders, or sail drones, and novel instrumentation, such as acoustic or optical plankton sampling technology and new types of chemistry sensors to measure parameters currently analyzed in the laboratory using discrete water samples (DIC, pH, TA, and nutrients).

For sampling of chemical parameters currently analyzed in the laboratory with new methods, it will be necessary to quantify any changes to the accuracy and precision of measurements and to conduct some initial intercomparisons between methods to ensure consistency, but measurements should be largely compatible. For parameters such as DIC, TA, silica, ammonium, and phosphate, suitable off-the-shelf profiling sensors do not yet exist, but there are technologies in development, such as the Chanalized Optical System II (CHANOS II) that could eventually fill this need. Initial testing of the CHANOS II began on the fall 2023 EcoMon cruise with further tests and improvements planned. We will similarly use EcoMon cruises as a platform for side-by-side comparisons as other future technologies become available.

Zooplankton and ichthyoplankton samples represent a unique challenge in that there is no available or currently in-development sensor that can provide data that will be fully compatible with the current bongo net time series. There will be some differences in methods that cannot be corrected or calibrated. The first limitation is that some taxa are not sampled quantitatively by individual techniques either due to mesh size, evasion, or differences in sampling volume. The second limitation is that optical or acoustic sampling techniques do not provide the same level of taxonomic resolution possible with a trained analyst looking at net-sampled plankton under a microscope. Where a species is not sampled quantitatively or identified to the same taxonomic level between methods, this will start a new time series that will not be fully backward compatible with historical measurements but will be used to inform similar analyses of species abundance trends.

In the event that we are not able to find suitable platforms or technologies to sample within WEAs as planned, we propose to carry out simulation experiments to determine how the exclusion of data collected within the WEAs impacts the interpretation of long-term EcoMon datasets.

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

The goal is to maintain the current long-term EcoMon indices for most of the region. A recent National Academy of Sciences review of offshore wind energy development in Southern New England highlighted the difficulty of distinguishing impacts of climate change and other influences on the ecosystem from wind development impacts. Therefore, consistent long-term indices are key to management efforts. However, we will

also evaluate new technologies and assess their ability to provide similar data products for assessments. In addition, we will conduct research to develop new data products.

Although not directly related to survey mitigation, we are actively exploring the development of sensor technologies that could replace or augment the use of bottle samples for chemical analysis. This includes pH, DIC, and TA measurements to monitor ocean acidification. While there are currently no commercially available sensors that meet the needs of the EcoMon, it is an active area of research and development by the larger scientific community. A compact chemical sensor could eventually be easier to transition to a smaller vessel operating within WEAs than water sampling from a large rosette or carousel.

New technologies are also being tested for use in plankton sampling. These include plankton imaging and high-frequency active acoustics suitable for measuring biomass of small (copepod) taxa.

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

Phase one of the mitigation will be to migrate EcoMon operations within the Southern New England and Mid-Atlantic fixed-foundation WEAs to smaller platforms. The small platform surveys would sample within the WEAs and would operate in parallel with the existing shelf-wide EcoMon survey. The small vessel WEA surveys may consist of either charters or future NOAA-operated vessels capable of safely navigating within the WEAs. From such platforms, we anticipate being able to use existing sampling methodologies, although the WEAs themselves will likely be considered as new survey strata since they will represent a distinct habitat type.

A major risk and cost for this phase of the mitigation will be finding suitable charter vessels. If NOAA is able to provide smaller, NOAA-operated vessels to fulfill this need, it would help facilitate a successful implementation of this plan.

Phase two of the plan will consist of piloting new sampling technologies to operate within the expected floating WEAs that may be constructed in the deeper waters of the Gulf of Maine as well as side-by-side comparisons with traditional methods. Active acoustic and plankton imaging technologies currently being tested may be adaptable to sampling methods for monitoring across the shelf (e.g., gliders, AUVs), vertical sampling on CTDs, or moored platforms. We will also consider whether these new technologies could enhance sampling in fixed-foundation wind areas. This portion of the plan is likely to take place after 2032 and has the highest degree of uncertainty because the methods are untested and because the footprint, scale, and configuration of the floating WEAs are yet to be determined.

Deployment of new technologies like imaging or acoustics will require data storage capabilities. This could either be server- or cloud-based.

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

Changes and impacts to the EcoMon survey will need to be communicated to both internal and external research partners and stakeholders.

Communication with Stakeholders and Partners

Internal partners at the NEFSC notably include the Ecosystems Survey Branch and Protected Species Division who both coordinate with the EcoMon program on monitoring activities. Internal users of the data include the Resource Evaluation and Assessment Division, the Ecosystems and Aquaculture Division, and the Population and Ecosystems Monitoring and Assessment Division. In particular, the Population Dynamics, Population Biology, Cooperative Research, and Ecosystem Dynamics and Assessment branches and the Protected Species Division all actively use EcoMon data. We would also consult with the Operations, Management, and Information (OMI) Division on the contracting of potential charter vessel platforms and with the Information Technology Division (ITD) regarding data and logistics needs associated with new sampling.

NOAA partners outside the NEFSC include the NOAA Ocean Acidification Program and the NOAA Atlantic Oceanographic and Meteorological Laboratory, both of whom support ocean acidification sampling on EcoMon cruises.

Externally, we collaborate on monitoring with DFO Canada on sampling in the Gulf of Maine and Georges Bank with DFO carrying out similar sampling in the border region. We have also developed a joint index of mackerel abundance with DFO, using DFO sampling in the Gulf of St Lawrence and NOAA sampling in southern New England and the Gulf of Maine. Much of this coordination with DFO occurs through the ICES Working Group on Northwest Atlantic Ecosystem Observations (WGNAEO). We also work closely with the Northeast LTER program on sampling in New England waters.

External users of the data include researchers at the WHOI, Rutgers, the University of Maine, the Gulf of Maine Research Institute, Bigelow Laboratory, the University of Massachusetts, the University of Rhode Island, the University of Connecticut, Massachusetts Institute of Technology, and others. We would also need to communicate changes to various working groups that include NAFO and the ICES Working Group on Ocean Hydrography (WGOH).

Finally, we would coordinate with the NEFSC directorate to communicate changes to the regional fisheries management councils.

Note that this is not an exhaustive list of stakeholders but represents those with the greatest interest in the EcoMon sampling and data.

Data management needs

The primary new data management need will be associated with new technologies that are developed for use in the floating WEAs. Many potential technologies being considered are both computationally intensive and storage-intensive. This includes image recognition, image and acoustic data, and molecular techniques. Developer support may also be needed for new data collection and processing systems.

These needs would be phased in during the evaluation period with the full-scale need occurring post-2030, after the operational deployment begins. At this early stage, we are still evaluating candidate technologies and methods, so we are not able to provide specific data management needs beyond the near-term period.

The data management needs to support traditional sampling for charter vessels in the near-term period would be similar to current surveys, except that there will be increased need to provide near real-time access to data from multiple platforms carrying out a synoptic survey. This capability has already been developed, but the capacity would need to be expanded.

V. Proposed Schedule for Implementation

2024

1. Purchase the additional equipment necessary to support operations on additional charters which would operate in parallel with an EcoMon survey.
2. Onboard and train survey technicians to carry out the new surveys.
3. Identify suitable vessels to carry out operations in WEAs in the Southern New England region, including the area near Long Island.

2024-2032

1. Evaluate new survey technologies to be used in future floating WEAs expected in the Gulf of Maine region.

2025

1. Establish a charter to carry out 4 seasonal EcoMon surveys in the WEAs located in Southern New England and near Long Island.
2. Onboard of an acoustic/optical zooplankton scientist to support the evaluation and future use of acoustic and optical plankton techniques in floating WEAs.

2026

1. Establish a charter to carry out 4 seasonal EcoMon surveys in the Mid-Atlantic Region.

2032

1. Establish a charter to carry out 4 seasonal EcoMon surveys in the Gulf of Maine Region.

Beyond 2032

1. Maintain and refine survey approaches.

VI. Links to Other Surveys

EcoMon plankton and CTD sampling methods are employed on both the spring and fall bottom trawl surveys, with the bottom trawl surveys each accounting for a seasonal EcoMon survey's worth of coverage. Other NEFSC surveys, most notably the protected species surveys, opportunistically carry out sampling using EcoMon methods.

These linkages provide opportunities for sharing of resources as survey mitigation efforts develop. This may include shared use of new survey platforms, shared equipment, and shared labor where common needs exist with respect to sampling within WEAs.

The EcoMon program will need to incorporate changes to bottom trawl survey strata that result from survey mitigation efforts given that the trawl survey is an important platform for the EcoMon time series.

VII. Adaptive Management Considerations/ Opportunities

This plan requires ongoing evaluation of both new technologies and sampling platforms to address both the longer-term survey mitigation challenges associated with floating wind technology and a general increased footprint in WEAs in the survey area. This ongoing evaluation of new methods and platforms will incorporate changing management and scientific concerns. As new technologies become available, or as new scientific or mitigation needs are identified, this plan will be adapted accordingly.

VIII. Statement of Peer-Review Plans

We will request external peer reviews from ICES working groups with interests and expertise relevant to the EcoMon data. This will include the ICES WGOH, WGNAEO, Working Group on the Northwest Atlantic Regional Sea (WGNARS), and Working Group on Atlantic Fish Larvae and Eggs Surveys (WGALES). Through these working groups, we will be able to solicit input from a variety of subject matter experts in the region. WGOH will be able to provide input relevant to the hydrographic monitoring; WGNAEO can provide input on the interactions and overlaps with other regional surveys by both U.S. and Canada; WGNARS can provide input relevant to plankton and ecosystem assessments; and WGALES can provide input on the egg and larval sampling.

We will also solicit input from groups within NOAA that have interests or expertise relevant to the EcoMon program. These will include the Southeast Fisheries Science Center's plankton group, the NOAA Ocean Acidification Program, the Atlantic Oceanographic and Meteorological Laboratory, and users of EcoMon data within the NEFSC.

We will separately solicit input from subject matter experts on specific questions as necessary.

IX. Performance Metrics

The primary performance goal will be that the EcoMon survey is able to maintain at a minimum similar levels of sampling as those achieved prior to construction of the WEAs.

Where standard EcoMon methods are used within the WEAs, we do not expect any significant changes or biases in the measurement of either the biological or physical parameters. Previous work has shown that the core EcoMon measurements are not vessel-dependent, as long as the sampling protocols are followed.

Where it becomes necessary to use new optical or acoustic plankton sampling technologies within floating WEAs, we do not expect the data to be fully compatible with historical EcoMon time series. Performance metrics will be developed as part of our efforts to evaluate new technologies, but we have not yet reached that stage. One element will be to identify the impacts of information that is lost when using new technologies, such as reduced taxonomic specificity with optical or acoustic plankton instruments relative to bongo net samples analyzed under a microscope. Another element will be to identify uses for information provided by acoustic or optical techniques that are not available with bongo

nets, such as the distribution of biomass within the water column. We will also work to identify quantitative criteria to evaluate differences in information that can be provided by both bongo net and new technologies.

Successful survey mitigation for EcoMon will support comparable analysis and scientific products to historical EcoMon methods. This includes stock assessments and the State of the Ecosystem reports.