Scallop Survey Mitigation Plan

I. Purpose of the Survey

The Northeast Fisheries Science Center (NEFSC) integrated benthic/sea scallop (*Placopecten magellanicus*) survey collects data on invertebrate abundance, spatial distribution, and life history. The data generated by this survey are used to develop key inputs into quantitative stock assessments which are used to establish catch limits for the commercial scallop fishery. The scallop stock assessment and ultimately management decisions rely on annual data from both dredge and HABitat mapping CAMera system (HabCam) operations conducted during the NEFSC sea scallop survey. This survey has standardized operating protocols, and the dredge portion of the survey has a time series going back to 1979. HabCam operations began in 2012. Offshore wind installations are likely to change aspects of how this survey is conducted, but the survey objectives will remain the same.

II. Survey Details

Beginning Year: 1979

Frequency: Annual

Season: May/June

Geographic Scope: Delmarva to Georges Bank

Platform(s): University-National Oceanographic Laboratory System (UNOLS) vessel *Hugh R. Sharp* (UDel)

Statistical Design: Stratified Random (dredge), Transect (HabCam)

Methods: Fifteen-minute dredge tows (average speed 3.8 knots [kts], average distance 0.933 nautical miles) are conducted at randomly selected stations within defined NEFSC shellfish survey strata using a lined 8'-wide New Bedford style sampling dredge. Scallops are weighed and measured after each tow. Meat, gonad, and whole weights are recorded for scallops that will be saved for aging. Counts and weights of scallop predators (crabs and sea stars) are collected on specified tows. HabCam V4 is towed along pre-selected transects at speeds of 5-7 kts, capturing 5-6 stereo images of the seafloor per second. The vehicle is flown ~2 meters (m) above the seafloor. Images are sent back to the ship through fiber-optic cable, where they are stored on servers and annotated to determine scallop size and abundance. Other organisms, including finfish species and scallop predators, are also annotated during this process. HabCam and dredge operations are conducted separately, but both sampling tools are typically used during each survey leg. This requires a vessel that is large enough to accommodate 12 scientists as well as dredge sampling equipment, electronic data entry systems (FSCS), a fiber-optic winch with remote operation capabilities, multiple servers and monitors in an indoor work environment, and the HabCam vehicle.

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 unlikely that research vessel *Hugh R. Sharp* or a vessel of similar size will be able to conduct any scientific operations (dredge or HabCam) within wind energy areas (WEAs) (pers. comms. Jon Swallow). The vessel is 146' long and therefore has limited maneuverability. Both dredge and HabCam are "mobile" pieces of equipment that are towed behind the vessel with a considerable scope of wire (3.5:1 on the current research vessel, so in only 30 m of water, there would be approximately 100 m of wire out). Deploying mobile sampling equipment poses safety concerns within WEAs regardless of the type of installation (fixed or floating), especially in inclement weather or when unforeseen problems arise (such as vessel mechanical failure, dredge hang, HabCam entanglement, or collision). In addition to the turbines themselves, buried or covered cables pose an additional risk to dredge operations. Buried or covered cables also pose a risk to HabCam operations if obstacles are created by moving boulders or changing relief related to covering. In the case of floating wind installations, suspended cables pose an added risk to both dredge and HabCam operations due to the large scope of wire used during deployment.

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 dredge portion of the scallop survey uses a stratified random design. It will not be possible to sample random stations that fall within WEAs. Sampling in these regions will require restratification and may need to incorporate fixed stations and/or perimeter stations in a hybrid approach. WEAs would need to be treated as new strata.

   While not random, the HabCam survey will also be impacted since WEAs will create areas where HabCam operations are impacted. In the current HabCam survey design, long transects are positioned to characterize gradients of scallop density. The lengths of these long transects are alternated: one long transect extends to the boundary of the survey area, followed by a short transect extending to the edge of the middle high-density area. This design covers the middle higher density areas more intensely than the more marginal areas toward the edges of the domain in order to improve survey efficiency. Additionally, the sampling design has cross-transects near the high-density middle portion of the domain that facilitate estimation of spatial changes in density. The transects within WEAs will need to be adjusted if they are too close to turbines and will likely be adjusted in the longer term in response to changing gradients of scallops around wind farms. These specific decisions will depend on the density of turbines, response of the benthos, amount of fishing occurring, and size of WEAs.

   If fishing occurs within the WEAs without sufficient mitigation to survey methods and statistical approaches, stock assessments would experience increased uncertainty with impacts on assessments, such as poor model performance within WEAs. If fishing does not occur within the WEAs, the WEAs will be de facto marine protected areas (MPAs).

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.

   In addition to short term impacts of construction, there potentially could be oceanographic wind wake effects, predator prey responses, and changes of recruitment patterns long term. Benthic habitats directly surrounding turbines will accumulate changes over time, such as organic enrichment and shell deposition (e.g., Hutchison et al. 2020, reviewed in Hogan et al. 2023). Benthic habitat changes are expected within 1-3 years after installation (Hutchinson et al. 2020) and could be monitored with an optical system, such as an autonomous underwater vehicle (AUV). High-resolution sampling and before/after habitat comparisons would provide the most valuable information on potential changes to scallop habitat.

   Understanding the distribution of sea scallop relative to distance from turbines will be essential to estimate the abundance and size distribution of sea scallops in WEAs.

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

   The presence of wind energy developments will likely cause increased transit time in those areas, possibly requiring the need for more sea days to complete the annual survey. AUVs travel more slowly than HabCam, so they would require more time to complete the same length transect. There are currently 3 wind lease areas within or intersecting with Scallop Area Management Simulator (SAMS) areas. Assuming there is 1 turbine per nautical mile, there would be approximately 342 kilometers to cover within WEAs (both sides of each turbine). This would require approximately 200 hours of AUV survey time to cover and could likely be achieved over 2 multi-day deployments.

IV. Mitigation Planned, as per Six Elements

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

   We are quite certain that our current survey vessel, the *R/V Hugh R Sharp*, will not be able to sample within the WEAs using our traditional survey methods (HabCam V4 or dredge) due to the vessel size and the towed nature of the sampling equipment. Therefore, the presence of wind development will require us to change our survey operations in those areas. If fishing will not occur in those areas, they will not be included in assessments, and the effective population size of the stock will be limited to what we can estimate from the areas outside WEAs. It is possible the WEAs could serve as de facto MPAs, but it is also possible that WEAs could reduce scallop survival. Understanding scallop abundance and size distribution within WEAs is therefore relevant to fisheries management, and survey techniques need to be developed. Current practices treat closed areas as separate from the fished population.

   Fishing in the WEAs will make it more critical to survey within the WEAs in some capacity. Potential alternative survey designs (see next section) should be evaluated through survey simulation exercises.

2. *Identification and development of new survey approaches*

Ideally, we will survey within WEAs using alternative methods. If we are able to use optical methods that are similar to those currently being used by the NEFSC or our Research Set Aside (RSA) partners (i.e., HabCam technology on an AUV, dropcam system), the impacts to scientific advice could be minimized. AUV development is under way through a project with Woods Hole Oceanographic Institution (WHOI). This technology was tested in pilot surveys aboard the NOAA *R/V Henry B. Bigelow* in June 2023 and successfully captured clear images of organisms on the seafloor. The AUV is fitted with the same camera system as HabCam V4 but travels more slowly. The AUV can operate for long periods, potentially up to a week or more. There are also existing dropcam systems that we may be able to use on a smaller vessel within WEAs, but these would be more difficult to integrate with current NEFSC methods and would likely be used primarily by RSA partners. Smaller, more maneuverable HabCam systems have been developed in the past (e.g., WHOI V-fin) that could be manufactured and deployed from a small vessel, but this would still require considerable scope of wire. As the AUV tests were successful, there are no current plans for the NEFSC to evaluate the use of dropcam systems. The combination of AUVs within WEAs and Habcam outside WEAs would provide the best balance of efficiency and ability to safely survey near turbines.

There will be a need to obtain physical samples from the WEAs to provide data on growth rates and meat health, but this would not be necessary on an annual basis as these specific assessments do not require annual data. We are assuming that a small vessel towing a small dredge could operate in these areas in order to collect biological samples. If not, we will consider other methods that do not require towed fishing gear. For example, grab samplers are low efficiency but could be sufficient if used in areas known to have a high density of scallops. Remotely Operated Vehicles (ROVs) equipped with soft robotics (a newer technology developed by the Ocean Engineering Department of University of Rhode Island with support from NOAA Ocean Exploration) would allow precise sampling in areas with low or patchy scallop density. These methods would require resources and time to develop and test.

NEFSC staff (Dvora Hart, Jui-Han Chang, Dana Morton, and Paul Rago) have conducted substantial work on restratification for the scallop survey and have developed the idea of moving to a Generalized Random Tessellation Stratified (GRTS) sampling design with restratification based on SAMS areas. GRTS is a spatially balanced sampling design, which distributes sampling effort to minimize clustering of samples in space (Stevens and Olsen 2004) with high accuracy and precision, and has been found to perform optimally in fishery-independent surveys relative to non-spatially balanced designs at a given sample size (Cheng et al. 2024).The proposed restratification aims to improve precision of biomass estimates, improve stratification of sampling within SAMS boundaries, minimize the number of strata, facilitate implementation at sea, and adapt to changing conditions. Future simulation studies could evaluate GRTS with new WEA strata added, similar to the Survey Simulation Experimentation and Evaluation Project (SSEEP) conducted for the NEFSC bottom trawl survey.

GRTS with restratification will easily accommodate WEAs because WEAs can be treated as their own strata, inclusion probabilities can be adjusted within WEAs, and fixed stations can be added as needed. These adjustments are easy to make over time as WEAs change. GRTS is also considered more adaptable and can easily address sampling problems in the field by generating the next random site if it is not possible to safely sample a site (such as due to proximity to turbines or cables).

The proposed restratification and move to GRTS will be reviewed by a subcommittee of the Scientific and Statistical Committee (SSC) this summer. After that, any formal plan will be communicated to the Scallop Survey Working Group (SSWG). This is a New England Fishery Management Council (NEFMC) working group that consists of RSA partners, industry representatives, NEFSC staff, and Council staff.

3. *Calibration and integration of new survey approaches*

We are moving forward with the plan to use AUVs or a smaller Habcam vehicle (V-fin) instead of Habcam V4 for optical surveys within WEAs. The AUVs and HabCam (V-fin) have the same camera and sensor system as Habcam V4, so calibration of optical equipment will not require any field work or charter vessel time. However, conducting “before” surveys within WEAs using AUVs prior to turbine installation would be beneficial in determining how important it is to sample in those areas and how long the surveys will take (e.g., if there are few scallops in WEAs before construction, then it is a lower priority). Having good baseline data using AUVs would allow easier integration of the 2 datasets and planning for future surveys. Calibration of cameras will be required and could be accomplished with current engineering staff and equipment purchased for survey activities.

Scallop dredge sampling will be conducted using our standard 8' dredge or a grab sampler to collect samples within WEAs for biological data only. No dedicated calibration work would be necessary.

4. *Development of interim provisional survey indices*

When possible, data from both dredge sampling and HabCam surveys are used in assessments, but multiple independent indices are already in use that use only HabCam or only dredge sampling (not all sites can be surveyed with both methods every year). Therefore, current models will be able to accommodate inputs from AUV surveys only. Once a WEA is established, a new time series will be created, and the WEA will be treated separately from areas outside the WEA. This is the same approach that is currently used for SAMS closed areas. AUVs have been successfully tested and will be ready to use by the time the WEAs are installed.

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

As discussed above, collecting pre-construction data using AUVs in the WEAs will also be beneficial. Once turbines are in place, we may also need to adjust transect design in response to gradients of fishing among turbines, gradients of scallops among turbines, how close the turbines are to each other and where cables are located.

Use of AUVs will be instrumental for monitoring within the WEAs and if scaled up, will effectively mitigate many of the largest impacts on the scallop survey. Wind areas would be monitored annually using a charter vessel and AUVs. The AUV would be deployed by the same charter vessel used for HabCam operations outside the WEAs. Dredging could be done using a small charter vessel, but it would only be necessary approximately every 3 years. Dredge stations would be fixed and only sampled to obtain biological data, so they could be set in response to fishing pressure within WEAs.

Alternatively, if no sampling were to occur within the WEAs but fishing was occurring, we would be forced to estimate scallop abundance within the WEAs based on perimeter stations or remove WEAs from assessments entirely. This would have the greatest impact on the information provided to management and would not mitigate the survey impacts due to offshore wind. This emphasizes the importance of surveying within WEAs.

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

Once draft changes to the survey design are finalized, the Council, NEFSC, and Greater Atlantic Regional Fisheries Office (GARFO) can determine what additional lines of review and communication are necessary.

The data storage and management needs for this survey are vast. We do not currently have the appropriate infrastructure to support the existing scallop survey system, let alone the ability to support the expanded data collection we expect to see as WEAs develop. This is outlined in detail in the SSWG's final report. In short, we need the ability to easily ingest data from external data sources (already in progress at NEFSC with the "Surfing the Data Pipeline" project). We also need to migrate our HabCam database from Postgres to Oracle to create a more stable database that will also support the AUV; develop the capacity to ingest, store, and process large volumes of optical data either internally or externally (i.e., cloud services); and develop an efficient way to serve image data to our collaborators and to the public.

V. Proposed Schedule for Implementation

Element	Task	Activities	Milestone
V. 1. & 2.	-Develop an autonomous underwater vehicle (AUV) optical survey -Generalized Random Tessellation Stratified (GRTS) approach, restratification/redesign simulations	-Prepare logistics for AUVs -Sensitivity analysis of GRTS and restratification plans	-AUV tests completed -Restratification and GRTS approved in review.
V. 3.	-Calibration of AUV cameras	-Prepare logistics to calibrate AUV cameras	-AUV cameras calibrated
V. 4 & 5	- Produce survey indices with adjustments as necessary to account for observed WEA impacts (e.g., different data inputs, de facto closed areas)	-Implement results of above analyses to ensure consistency in data products	-Data sets and indices provided to management and assessments
V. 6	-Collaborate with Research Set Aside partners, industry representatives, NEFSC staff, and Council staff to make necessary changes	-Conduct collaborative meetings and continue participation with partners and stakeholders.	-All collaborators are informed of changes -All stakeholders are informed of changes

	-Develop appropriate data storage infrastructure -Migrate optical data to a more stable structure	-Work with the Information Technology Division to develop data storage infrastructure and optical data storage	-Data storage infrastructure is acquired and put in use -Optical data is stored in a stable and accessible structure

VI. Links to Other Surveys

There are shared data storage needs with groups that are collecting acoustic and optical data (such as Protected Species and Passive and Active Acoustics). There has been some discussion of possibly sharing servers for storage and processing with these groups.

Changes to survey design are being discussed with the Bottom Trawl Survey group (Dr. Paul Rago has been working with both groups) and the Ocean Quahog and Atlantic Surfclam Survey group. Similar approaches for sampling in WEAs (such as fixed stations) may be used. Information acquired in the future about areas that are unsafe to fish/sample will be shared among groups, but as the surveys use different methods, there will still be unknowns for each individual survey.

HabCam surveys are unique to scallop, but optical methods are being considered for the Ocean Quahog and Atlantic Surfclam survey as novel machine learning methods may be able to quickly identify clam siphons from imagery (identification is currently possible but not feasible to implement on large scale due to logistical constraints). AUVs also capture imagery of finfish and other benthic species (e.g., lobster, crabs), which could be of use to other surveys that are not able to sample within WEAs such as the Bottom Trawl Survey. This imagery will be made available for use by other programs as needed.

VII. Adaptive Management Considerations/Opportunities

There are many unknowns about the final siting and design of wind structures. Expansion of WEAs or increased density of turbines within WEAs will require additional adjustments to survey strata or sampling intensity, but these will be accommodated by GRTS. Shifts in scallop distribution in response to wind turbines may not be apparent immediately but will likely warrant changes to transect placement in the future to best capture distributions. Ecosystems Surveys Branch (ESB) staff will monitor these developments, identify how these changes could impact the survey, coordinate and discuss with partners, and revise the mitigation plan as necessary.

Further development of AUVs could lead to additional use outside of WEAs, as well, and to integration with other surveys, such as the Atlantic Surfclam and Ocean Quahog survey. In testing, AUVs have shown lower rates of avoidance by fish due to their slower travel speeds, so they may be more useful for finfish surveys than HabCam.

VIII. Statement of Peer-Review Plans

The proposed changes to the survey (restratification and GRTS) will be reviewed by the New England SSC. If automated image analysis is incorporated or future changes to the optical survey transects, that would need additional review by the SSC. If determined necessary by the SSC, further review by higher levels (e.g., the Center of Independent Experts [CIE]) could be conducted.

IX. Performance Metrics

Currently, data quality is assessed based on the completeness of the survey (e.g., number of stations/strata completed, percent of Habcam track completed). The coefficient of variance (CV) around estimates of abundance is used in stock assessments. If WEAs are removed from strata, the CV might go down due to the smaller area sampled, giving a false sense of confidence in assessments. If more stations are added into a smaller area, that could result in more precise estimates for that area but would not represent the entire stock. The survey should focus on the proportion of strata sampled as a key metric of survey quality.

Sensitivity analyses could assess the uncertainty that results from not sampling, similar to the SEEP study on the Bottom Trawl Survey. Simulations should be conducted to determine how much assessments change when a WEA is sampled or excluded.

X. References

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