Coastal Shark Bottom Longline Survey Mitigation Plan

I. Purpose of the survey

The purpose of the Coastal Shark Bottom Longline Survey (CSBLLS) is to characterize the distribution and relative abundance for a variety of large and small coastal shark species in the western North Atlantic Ocean. CSBLLS data are used to generate fishery-independent indices of abundance for stock assessment and management. Additional objectives of the survey are to: 1) tag sharks for migration studies; 2) inject tagged sharks with tetracycline whenever feasible for age validation studies; 3) collect biological samples for age and growth, food habits, and reproductive studies; and 4) collect morphometric data, for a variety of species.

A history of the survey and overview of current methodology (unpublished) is available upon request.

What data is collected?

Individual species identification, length, weight (when possible), and sex of shark and bycatch species along with set-specific date, location, gear, environmental parameters, and species-specific catch per unit effort (CPUE) data are collected. Additionally, live sharks are tagged before release, and biological samples are collected from incidentally killed sharks. This information is used toward abundance, distribution, stock identification, migration, life history, diet, and genetics studies of large coastal shark species in the northwest Atlantic.

What specific products use this survey?

All National Marine Fisheries Service (NMFS) highly migratory species (HMS) Atlantic large coastal shark species assessments have used CSBLLS data, including those for sandbar (*Carcharhinus plumbeus*; McCandless and Natanson 2010, Courtney 2017), dusky (*Carcharhinus obscurus*; McCandless and Natanson 2010), and scalloped hammerhead (*Sphyrna lewini*; McCandless and Natanson 2021). Survey data has also been used for species- and stock-specific status reviews for the Endangered Species Act (ESA), most recently in 2020 for scalloped hammerhead (NMFS 2020).

Survey data and resulting assessment products are also used to inform the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) determinations. For example, the recent U.S. CITES Task Force reviewed position papers, which used the above assessment results, among other data, to suggest limiting some proposals to list sharks under Appendix II at the family level (Carcharhinidae, Rhinobatidae, Sphyrnidae).

Additionally, species-specific updates to the Consolidated Atlantic HMS Fishery Management Plan (FMP) and amendments thereof have referenced survey data to inform policymaking. For example, Amendment 10 to the 2006 Consolidated Atlantic HMS FMP: Essential Fish Habitat used survey data to define habitat use parameters by species.

Which assessments/science advice pathways currently use this survey?

All NMFS HMS Atlantic large coastal shark assessments use this survey index in stock status determinations. Shark assessments are conducted through the Southeast Data

Assessment and Review (SEDAR) process, through which 20+ federally managed small and large coastal shark species in the Atlantic are assessed. In addition to survey indices, age and reproductive data collected from this survey are used in nearly every shark stock assessment process and are difficult to obtain from other sources, especially given recent low numbers of fishery-dependent sampling opportunities. Survey data are also used for ESA and CITES determinations, and for various management decisions by NOAA Fisheries HMS Management Division. For instance, survey data informed a large part of a recent publication by Natanson et al. (2022) relating morphometric conversions for over 30 species of sharks, which was used by NMFS HMS to inform upcoming minimum size retention regulations.

Additionally, this survey provides a platform for deploying conventional tags and occasionally satellite and acoustic tags on juvenile and adult sharks across a variety of species, with more than 2000 sharks tagged on the most recent trip. Tag recapture data are used in every stock assessment and also inform essential fish habitat (EFH) designations used across the NOAA Fisheries enterprise.

Who are users of the survey data generated?

Users of these data include assessment analysts (NOAA and non-NOAA personnel who contribute analyses to assessments), fisheries managers (NOAA Fisheries Office of HMS), academic researchers (University collaborators working on various life history studies using survey samples), and industry.

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

This survey is highly dependent on timing due to the migratory nature of sharks. Standardized dates of the survey must be maintained (the first week of April to at least the last week of May) to coincide with timing of northward migrations of shark species and to remain consistent with historical survey data. Mainline length of 3-5 miles (depending on depth) consisting of 300 3/0 shark hooks is used, with the set mainline intersecting with the fixed-station location and a soak time of 3 hours. Longlining activity requires the ability to anchor the bottom longline without snagging cables and enough space around the set to allow for slight gear drift during the soak.

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

Abundance indices derived from this survey are a central component of the HMS stock assessment process used for direct management of these species. The CSBLLS is the only survey that covers the Atlantic from southern Florida to the Delaware Bay area and is the longest coast-wide fisheries-independent time series for Atlantic large coastal sharks. Additionally, it is the only survey currently capable of monitoring shark abundance in the Mid-Atlantic Shark Closed Area area off North Carolina enacted to protect juvenile sandbar and dusky shark populations. Recently, CSBLLS data identified spatiotemporal changes in habitat use for scalloped hammerhead sharks during the SEDAR 77 research track assessment, the only survey to have captured this in the Atlantic. It also serves as a platform for life history sampling and tagging used in studies essential to the stock assessment process. These biological samples, in particular, are of high importance and not easily obtained from other sources. Recent reductions in commercial fishing effort and fishery-dependent sampling opportunities renders the samples collected during the CSBLLS even more valuable. The survey as a tagging platform is also uniquely important, accounting for over 2000 tag deployments per survey year.

How does offshore wind energy impact survey objectives going forward?

Wind energy areas (WEAs) and high-voltage cable locations will preclude fixed-station survey sampling in some areas. Currently, the overlaps are approximately 5-10% of the survey area, with increasing impacts as additional WEAs are leased. This will impact the overall survey objectives by jeopardizing the continuation of historic abundance indices developed from survey catch data. Even in places where historical fixed stations are technically outside of WEAs, temporary buffer zones set up for WEA cabling, maintenance, and increased vessel traffic around WEAs may also preclude setting gear in the standardized manner required for survey fishing.

Further, electromagnetic field (EMF) emissions from high-voltage cable used for transport from the WEA back to shore have been shown to be attractive to some elasmobranch species, including some sharks. The CSBLLS is designed to evaluate abundance of sharks along their migratory route during annual migrations, and therefore WEA activities could alter (delay or speed up) the migrations of all sharks, impacting the relative abundance of large juvenile and adult sharks. For example, females that use various nursery areas along the migratory route to pup may experience alteration in timing or homing behavior, impacting not only current survey abundance estimates but also reproductive success and recruitment and thus future abundance. Additionally, large juveniles/adults recruited to offshore seasonal migrations for mating or feeding opportunities may also be impacted (altered timing/habitat use/habitat expansion or contraction); therefore, relative abundance estimates based on survey catches could be affected across the full range of migratory individuals.

II. Survey Details

Beginning Year: 1996

Frequency: Biennial

Season: Spring (April-May)

Geographic Scope: Coastal waters of the U.S. Atlantic from Florida to Delaware/New Jersey border, out to 40 fathoms water depth

Platform(s): Commercial longline vessel (charter)

Statistical Design: Fixed-station survey design

Methods: Bottom longline sets are conducted biennially at up to 95 fixed stations in roughly geographic order from south to north, beginning in early April and concluding in late May. The mainline set intersects with the fixed-station coordinates. A vessel speed of 2.5-4.0 kts is maintained while setting and hauling gear, which comprises 3-5 miles of longline (depending on depth) with 300 3/0 shark hooks set on gangions 4 m in length. Set direction depends on prevailing winds, currents, and bathymetry observed at individual stations. A single sash weight is set every 15 gangions. Every 50 gangions, a triple sash weight and a marker buoy are deployed. Gear is anchored at each end with 4 sash weights, marked with a highflyer, and soaked for approximately 3 hours, after which the longline is hauled back in a continuous manner to minimize mortalities. Live sharks are tagged and released for migration studies, and biological samples are collected from any mortalities for life history and stock identification studies. Environmental data are collected with a conductivity, temperature, and depth (CTD) cast after each set.

III. Effect of Four Impacts

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

   This fixed-station survey will be severely impacted by preclusion, requiring abandonment of some historical stations, mostly in the northern half of the survey area based on current wind energy planning maps, but ostensibly all stations may eventually be impacted based on wind lease projections. This survey is depth-dependent, with gear, target species, and habitat selected for 5-40 fathoms (10-80 meters). The gear is 3-5 miles long with numerous droplines and buoys associated with the mainline, and the gear drifts slightly during soak. We do not anticipate being able to modify gear to allow fishing inside WEAs due to gear drift, soak time, and hazards of setting near buried cables. Maintaining a safe working radius around stations is required and may be challenging depending on proximity of wind areas/transmission cables to survey stations. Safe working distances are not yet known and will also depend on WEA requirements.

   A large number of historical stations will potentially be lost as wind lease areas expand not only due to placement of platforms but also of high-voltage cables. With potentially large swaths of areas being leased along the coastal shelf and changing along varying timescales, finding suitable alternatives for stations will pose an ongoing and dynamic challenge for the foreseeable future, likely requiring station adjustments on a rolling basis.

   This will fundamentally alter the survey and reduce effectiveness of derived abundance indices to accurately characterize shark populations in relation to historical estimates.

   Beyond preclusion of fishing due to WEA structures, the sharks may also be precluded from accessing typical habitats and migratory pathways due to potential aversion to EMF, as there is limited EMF research across large coastal shark species. This uncertainty should be investigated. If pre-construction surveys for high-voltage cable placement and/or the actual laying and burying of high-voltage cable are conducted during the migration season, then this could affect ambient conditions in migration corridors and the associated water column (e.g., turbidity, EMF), ultimately precluding normal migratory behavior.

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.

   Because we anticipate that we cannot fish with the current gear requirements inside WEAs, the fixed-station survey design of the CSBLLS will be fundamentally impacted where WEAs preclude access to stations. In cases where access to historical survey stations is entirely precluded, new survey stations will need to be added nearby and precluded stations replaced, and the resulting impacts to historical abundance indices will need to be evaluated via modeling analyses and potentially data calibration. This is the most likely outcome where WEAs overlap survey stations, as shortening gear or making other changes to fishing operations in order to work within WEAs may render catch data incompatible with past station data and unsuitable for use in the historic

abundance indices. Ultimately, it may be necessary to move to a random stratified survey method for sampling or to incorporate random stratified stations in areas where ongoing wind development poses problems for maintaining fixed stations. If data calibration cannot overcome differences in pre- and post-WEA development abundance estimates, the time series for the survey will have to be split into pre- and post-development segments, which may hinder the overall effectiveness of management advice based on this index.

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.

   HMS such as sharks are at risk of being heavily impacted by the presence of offshore wind platforms and infrastructure due to the new structures themselves and to the presence of high-voltage cables/EMF. These are separate issues and may have disparate impacts on behavior and movement ecology for not only sharks but their prey species, as well.

   New structures may have an aggregating effect on shark movement and alter natural migration patterns due to well-documented tendency of structure to act as fish aggregating devices (FADs) as they concentrate prey species. This may be especially apparent in areas where no bottom structure was present before. Aggregating effects on sharks themselves may also occur due to changes in things like oceanographic conditions and current patterns. Additionally, EMF emissions from high-voltage cables used for transport from the offshore wind energy developments back to shore have been shown to be attractive to elasmobranch species, including sharks. Alternatively, increased noise, vessel activity, and preclusion of large areas to typical migratory movements may have a dispersive effect on sharks or their prey.

   Either of these types of impacts will change habitat use patterns and catchability of sharks, which will impact relative abundance estimates and potentially confound survey standardization. Additional secondary impacts on prey species may also affect relative abundance of target species.

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

   Transit times between stations will be altered, and therefore the timing of sampling will be impacted, confounding standardization of survey data. Increased transit times will require substantial increase in sea days to accomplish the same number of stations. This also increases labor needs and associated costs.

IV. Mitigation Planned, as per Six Elements

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

   It is unlikely that sampling at survey stations will be possible within WEAs given our survey methods. Evaluation will be needed to assess impacts on several fronts, including how loss of historical stations and other direct WEA impacts to survey protocols and design (e.g., fishing not possible at all vs. possible with changing gear/method, changing location of fixed stations, converting some/all stations to a

random stratified survey design, altering timing/navigation patterns to sample each station, reduction of gear length [100 hooks vs. 300]) will affect catch and relative abundance estimates provided to management. This will require data simulation modeling, as well as calibration surveys to assess real-time feasibility and quantify impacts on efficiency, operations, and catch under a new survey design. For instance, if no fishing is possible in WEAs, analyses will be required to determine impacts of reduced sampling areas on historical abundance indices. Any change in survey design and/or standardized methodology will require a data calibration to evaluate compatibility to the historical design with the new design and to make post-wind abundance indices comparable to historical indices if possible.

Additional studies will be needed to assess the impacts of WEAs on shark migratory behavior including timing of movement, overall migratory patterns, and spatial use of habitat, as well as that of key prey resources. Impacts to catchability of sharks due to WEAs will also need to be evaluated.

2. *Identification and development of new survey approaches*

New/alternative study platforms are needed to develop key understanding of the impacts of wind on shark abundance and migration, and to mitigate lost ability to produce abundance indices comparable to those produced historically. Further, it is also necessary to mitigate lost opportunities to collect biological samples from shark specimens due to offshore wind activities. The biological samples typically collected from the CSBLLS are of paramount importance to stock assessments, being a primary source of life history information such as age at maturity, growth, fecundity, and longevity. Reduction in sampling opportunity will hinder our ability to study these aspects of populations using traditional methods.

Assumptions

There is limited information available on turbine designs and configurations as well as their associated anchoring structures and cables for floating wind areas in U.S. waters at this time. These may vary among the leases and companies. This could increase or decrease the ability to implement new approaches, and it is dependent on the spacing and number of connecting structures. The CSBLLS deploys 3-5 nautical miles (nm) of gear at each station, which can drift to some degree during the 3-hour soak due to wind and prevailing currents. If spacing of wind turbines is closer than 3 nm, we assume this will result in total preclusion of sampling (current projections are 0.8-1 nm spacing). If spacing is technically wide enough to allow deployment of the full gear, it may not be allowed by the wind energy companies and their insurance providers. There is also an assumption that safe operation at night and a range of sea states is also feasible, consistent with current survey operations. Owing to all the above considerations, we are developing mitigation and calibration plans on the assumption of total preclusion at affected historical stations.

Modification of current survey and calibration studies

To maintain the usefulness of the current recruitment and abundance indices without breaking the time series, several impacts will need to be addressed through survey design and modeling.The survey will need to be extended in time and space to account for changes in shark migration due to the development and operation of WEAs as well

as to mitigate loss of efficiency in sampling. In addition to more sea days, this will also require increased labor, fuel, sampling supplies, and conventional tags. Additionally, once specific locations are identified for cables and wind turbines, any modifications to the fixed stations due to the loss of access to historical survey stations will need to be addressed. For replacement of fixed stations, sufficient time to conduct the survey with these changes should be given to allow for calibration studies. Calibration studies would require the use of an additional vessel, duplicate survey gear, time, and labor. For the omission of a fixed station without replacement, simulation modeling will need to be conducted to determine if the changes will affect the survey indices, requiring additional time and labor.

Therefore, we will need to expand survey coverage both temporally and spatially to fully assess the impact of WEAs moving forward. This expansion and the associated research studies need to be implemented now in order to inform future survey practices. However, we are extremely limited in staff (i.e., a single scientist) and cannot carry out any of these suggested studies without long-term increases to staff who can be trained to perform as field party chiefs aboard concurrently fishing vessels.

Satellite & acoustic telemetry studies

Satellite and acoustic telemetry studies are needed before, during, and after all stages of offshore wind development and operation to determine real-time spatial and temporal changes in habitat use in response to preclusions and attraction to high-voltage cable emissions and the presence of wind turbines within migratory routes. The existing survey platform can be used to apply telemetry tags, but there will be a need for additional labor and expertise, vessel time, equipment, and satellite time to accommodate the scale of satellite tagging that is needed to inform these studies. Further, the addition of satellite telemetry studies can mitigate some loss to biological sampling capabilities, as well as contribute to other aspects of life history research such as movement ecology related to life stage and monitoring of sandbar and dusky sharks in the Mid-Atlantic Shark Closed Area. The use of wind platforms to increase passive acoustic monitoring stations will further assist in producing data to mitigate some of these data losses.

Advanced life history research

Sharks are notoriously data poor with regard to maximum longevity and accurate growth rate models across the full lifespan. These data are key to generating accurate assessment models and to establishing biological baselines for monitoring changes due to climate and WEA effects. Much of the data and biological samples needed to evaluate these parameters are collected by the existing CSBLLS platform, and therefore increased priority should be placed on funding/executing studies to produce accurate baselines ahead of WEA impacts. These studies include mark-recapture projects (conventional tagging, injection with oxytetracycline, satellite and acoustic telemetry), proof of concept studies for non-lethal aging techniques such as DNA methylation, as well as age validation studies using bomb radiocarbon and other radioisotopes. Developing accurate baselines now will improve capabilities to evaluate WEA impacts and hence mitigate management response times.

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?

Calibration

WEAs that overlap CSBLLS stations will constitute total preclusion due to the length of the gear (3-5 miles long, in comparison to ~0.8 miles between wind platforms) and the tendency for bottom longline gear to drift once set, making it difficult to fish alongside WEAs in close proximity. Determining what is "close enough" for sampling will depend on the bathymetry and prevailing current patterns affecting fishing of the gear, but this cannot logistically be answered without an in situ exercise, and effects of WEAs on movement behavior and catchability of the sharks must be considered in any case. Ultimately, alternative fixed stations will need to be identified via consultation with bathymetry maps and then be tested for compatibility to original stations via calibration surveys. Further, additional research will be needed to evaluate the impacts of existing WEAs on shark behavior and catchability to produce necessary corrections for abundance indices that will inherently change if shifts in these metrics occur. The results of these calibration surveys will inform future permanent changes to survey design to ultimately, in combination with mitigation planning needed for life history studies, help mitigate impacts of WEAs on the CSBLLS. Each of these steps are vital to mitigation and will incur separate costs in addition to the existing survey budget.

Calibration surveys should be designed to answer 2 questions: 1)What is the equivalency of data from alternative survey stations relative to historical stations? and 2) What effect will WEAs have on shark behavior and catchability? Results of these calibration studies will also inform the scale of impacts of WEAs on collection of life history data and related samples. The extent of the current CSBLLS overlaps existing/proposed WEAs at ~ 5% of stations, but projected lease areas overlap a substantial number of stations further south. Hence, calibration studies need to be undertaken across 2 spatial extents: 1) the current survey footprint to answer the first question, and 2) an expanded footprint to include existing WEAs off New England to answer the second question.

These surveys could take different forms, but 2 scenarios are outlined here.

Objective 1: Effects of alternate stations on historical abundance indices

One option is to conduct paired sampling along the current survey footprint at historical fixed and alternative stations by having a second survey vessel fish concurrently to the traditional survey at a subset of alternative sites (n ~ 20 stations, requiring approximately 20 sea days). This will focus on the substitution of alternative fixed stations for those projected to be precluded by WEAs and the evaluation of equivalency to old stations per catch data and derived CPUE/abundance indices, designed to address Question 1 above. For stations already precluded by WEAs (~ 2% survey overlap with lease areas and ~5% overlap with proposed areas as of January 2024), fishing will be done as closely as possible to historic stations, whether that be inside WEAs (unlikely) or alongside them at a safe distance. This will help inform future surveys in terms of what is considered "close enough" for sampling stations.

Fishing concurrently is the only viable method for generating these data as timing of this survey (April through May) greatly influences catch due to seasonal shark migrations

captured by the survey. This objective would need a minimum of 2 instances to derive useful metrics for comparing historic vs. new stations, which will take 3 years to gain results if using the typical CSBLL biennial schedule. A faster option would be to run the survey in 2 consecutive years, but this would require a much larger investment in personnel to help carry out the survey, as we currently only have 1 chief scientist and no dedicated field personnel to staff vessels. Permanent full-time equivalent (FTE) positions for a ZP-3 fish biologist (will serve as second field party chief) and for 3 ZT-2/3 field technicians would be needed to staff additional field work, at a minimum.

The costs per sea day to contract a second comparable vessel for the calibration may greatly exceed what we pay now given the difficulty in finding suitable contract vessels at present. These difficulties are due not only to the small size of the commercial fleet but also due to the requirement that contract vessels be in good standing with no federal permit violations on record, which further limits the eligible vessel pool. In addition to costs for contracting, outfitting, and staffing a second vessel, we will also require funding for additional sea days on the traditional survey to ensure the northernmost stations (which have/are projected to have the most overlap with currently forecast WEAs) are accomplished despite weather days, which have consumed enough budgeted sea days in recent years to prevent sampling at approximately 30% of the historical stations.

Objective 2: Before-After Control-Impact (BACI) study to evaluate changes in behavior/catchability due to WEAs

One option is to survey paired stations near existing WEAs along the New England coastline in an effort to answer Question 2 via a BACI experimental design. This will involve identifying paired stations at each location to be surveyed: one inside/alongside existing or proposed WEAs (before/after or impact sites) and a characteristically similar station outside the WEA to act as a control site. Ideally, these would mostly be new survey sites in the New England area (NJ to MA) in order to capture effects of existing WEAs, although some areas will be in projected lease areas where construction has not yet begun. The current CSBLLS stations are mostly outside of existing wind leases (DE and south, 2% current overlap and 5% projected), and therefore we would need to collect data at new stations off New England to capture effects of currently operating WEAs. However, given the differences in species assemblages in the New England area and the unknown challenges of fishing inside WEAs, additional gear (i.e., pelagic longline and shorter strands of bottom longlines) and alternative gear configurations should be considered to ensure effects on all shark species are evaluated adequately both inside and outside the WEAs. This could also help inform whether alternative gear configurations could be fished successfully/interchangeably to historical gear within WEAs. This component would have a goal of sampling 10 paired stations for control/impact assessment, requiring 12 sea days each for 2 vessels. The before/after component of the experiment will be informed by use of historical CSBLL data in combination with ongoing data collection as WEAs are constructed incrementally farther south as is projected.

This calibration study could potentially be added on to the work done as part of Objective 1. This might be visualized as having the concurrent fishing vessel join the traditional survey at a point somewhere off the North Carolina coast and completing concurrent fishing at alternative sites for the last portion of the traditional survey, with both vessels continuing on to sample sites off WEAs in New England once traditional survey sampling

has been completed. Alternative logistics may be considered; this is only one option. This scenario would be repeated in a subsequent year to complete all sampling needed.

Another option to evaluate effects of WEAs on habitat use could involve deployment of long-term satellite (5-year) and acoustic (10-year) tags on sharks around existing WEAs. This would inform movement/residency patterns around WEAs but not necessarily catchability differences, which would still require additional survey effort to elucidate. However, these types of data are extremely valuable for a myriad of shark research, and the cost of this type of tagging effort is included in the mitigation plan budget. Results would be long-term, and therefore a sufficient increase in staff to handle analysis would be needed.

Integration

Upon completion of data collection for calibration studies, data analyses including modeling and data simulations will need to be conducted to produce actionable results. This will require funding for IT and analytical personnel and resources. Funds are requested to hire a contract database manager for integrating data into existing infrastructure as well as hiring a contract data analyst to assist with these needs.

Mitigation of existing survey methods will proceed according to results of calibration studies. At a minimum, mitigation will require additional funds for the traditional survey to cover increased transit times to alternative stations and an increased number of sea days needed to ensure all stations are surveyed regardless of inclement weather days. As stated earlier, this additional effort will require an additional fish biologist and field staff. Further, additional surveying in areas north of the existing CSBLLS may need to be permanently implemented if it is determined that shark behavior and/or catchability are significantly impacted by WEAs and require different approaches for monitoring, to include alternative gear types and survey methods.

All work carried out for survey calibrations/mitigation must be carried out by Apex Predators Program staff and/or scientific personnel directly trained by APP staff to ensure equivalency of survey methods, including fish measurements, sample collection, and fishing methods.

4. *Development of interim provisional survey indices*

Unfortunately, there are no existing data streams suitable for developing interim indices. Even commercial catch and bycatch estimates for sharks are now jeopardized due to lack of directed effort and changes to fishery targets resulting from recent management actions, including the Shark Fin Sales Elimination Act of 2023. This Act prohibits the sale and possession of shark fins in the U.S., which greatly reduced the market for sharks in the U.S. and has thus effectively ended the direct commercial fishing of sharks except in limited capacities. Other methods that may eventually augment catch/survey data for estimating relative abundance (i.e., Close Kin Mark Recapture) have not been vetted and will require years of research before suitability can be determined. Sample collection for these types of studies can begin now but require increased sample storage capacity and personnel for processing, which are not currently available. While acoustic monitoring is carried out in a limited capacity for some shark species, there are currently not enough sharks tagged with transmitters and not enough receiver arrays in place throughout our survey area or existing WEAs to provide sufficient insights into habitat use changes at the population level over time. We hope that additional efforts to deploy acoustic tags, requested as part of this mitigation plan, as well as efforts to deploy large

scale acoustic monitoring arrays across WEAs can expand the capacity for this type of monitoring moving forward.

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

If calibration study results suggest regular surveying around WEAs/in areas currently impacted by WEAs is needed in order to capture changes in relative abundance (such as for pelagic species that are not currently monitored by the CSBLLS), then applicable survey effort should be stood up and maintained by the Northeast Fisheries Science Center (NEFSC) in line with other existing surveys.

Some data gaps could be filled by implementing a before-after gradient design around existing WEAs within the current survey footprint (e.g., using Virginia turbines as an "after" area and designating a separate control area as a "before" location). Again, this would require additional funding for the current survey to add sea days and personnel costs to the existing survey budget.

Ongoing acoustic monitoring to document HMS habitat use and movement ecology within/around WEAs (as mentioned above) is needed. Existing efforts to install passive acoustic monitors (PAMs) on wind platforms will greatly enhance these types of studies, and costs for deploying acoustic tags from our survey platform are included in this plan. This includes funding for 100 acoustic tags per year as well as data archiving/extraction costs.

Satellite tagging/tracking of shark movement within/around WEAs is also needed (as mentioned above). This is another layer of tracking movement ecology necessary for calibrating survey abundance indices on an ongoing basis. Annual funding for deploying 50 satellite tags per year from our platform as well as funds for data analysis are requested.

Advanced life history studies are also recommended, and annual funding is requested for things like increased age validation, conventional tagging, and ongoing sample collection, which are needed to monitor populations for impacts of WEAs on growth, longevity, and age at maturity. Increased sampling effort from our survey platform is projected and will increase tremendously if additional calibration and survey efforts are funded. Hence, we anticipate needing additional funds for sampling supplies, equipment, sample analysis for advanced aging studies, and funds to develop more storage infrastructure for housing archived samples.

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

Communication with current end users of survey data and indices (SEDAR assessment coordinators, Office of HMS managers, assessment scientists) will be necessary, along with NOAA Fisheries HMS Management Division and science centers who fund the current survey, in order to align expectations and ensure the end product mitigates WEA impacts effectively to enable continued management advice based on survey results. Further, all survey teams impacted by WEA development should communicate with the Bureau of Ocean Management (BOEM) via their science centers to disseminate information on WEA impacts for future planning purposes.

Modification of current survey

New and modified data generated from this survey mitigation plan can be folded into current data streams but will require calibration and database modernization and in some cases the creation of new relational databases. In terms of data collected from the survey platform, there is a need to create a modernized at-sea data capture (i.e., electronic tablet) platform to accommodate increased volume of data and any new data streams and to enable real-time data capture at sea. Modernization of database infrastructure and overall APP data management will allow timely availability of data for assessments. These will require additional APP personnel and Information Technology Division (ITD) labor but should be stood up before implementation of additional survey effort and calibration studies to streamline data collection. The APP analyzes and incorporates its own survey data into the stock assessment process and would be heavily involved with the simulation modeling and calibration studies but would also benefit from outside expertise to assist in these activities.

It must be noted again that the APP is extremely limited in its capacity to enact any of these suggested mitigation strategies without a large investment in additional personnel and data management infrastructure. We currently do not have a survey database, nor do we have capabilities for electronic capture of any data at sea. A phased approach will be necessary to make any of this mitigation work possible, beginning with hiring a data manager; setting up a relational database to link catch, effort, and sampling data; designing at-sea data capture platforms and apps; and hiring 2-3 field scientists capable of overseeing survey effort on concurrently fishing vessels. The current staff cannot support additional work without these resources.

Satellite telemetry, advanced life history research, and mark-recapture studies

Each of these studies would constitute new data streams, requiring coordination with research partners (universities, other research institutions, and other government offices), management entities impacted by new data streams (e.g., SEDAR, HMS), and ITD labor support.

V. Proposed Schedule for Implementation

Table 1: Proposed schedule for survey mitigation implementation

Element	Task	Activities	Milestone
V. 1. & 2.	-Evaluate CSBLL historical station preclusion in current/proposed WEA's, identify alternative stations, run data simulations on potential gear/station changes, and design calibration studies and evaluate costs for expanding survey effort to include more stations outside of WEAs	-Hire needed personnel, develop calibration study designs, work on logistics and IT needs and secure contracts for carrying out calibration work -Purchase equipment/supplies to begin carrying out long-term satellite/acoustic tagging on current survey platform	-Hire staff -Finalize calibration study plans -Engage ITD and Operations, Management, and Information Division (OMI) personnel to finalize contracts and data Infrastructure -Purchase equipment and supplies -Carry out tagging

V. 3.	-Conduct calibration studies	-Staff, schedule, and carry out concurrent vessel and BACI design calibration surveys, in addition to traditional CSBLLS -Implement new data collection streams and adjust as needed based on conditions and needs that arise -Plan and conduct BAG studies	-Collect data inside and outside WEAs and at alternative sites, in addition to traditional data -Complete data analyses and identify mitigation needs, including funding implications and logistical concerns -Provide all data to assessments for complete vetting with historical data -Produce a document outlining calibration process and lessons learned
V. 4 & 5	-Produce survey indices with adjustments for new methods -Develop wind energy monitoring needs/plans	-Implement results of above analyses to ensure consistent data products -Develop logistics, budget, and overall mitigation requests for ongoing wind area monitoring to be conducted	-Provide data sets and indices to management and assessment teams -Analyze data and samples from WEA monitoring, data streams updated to incorporate these data
V. 6	Collaborate with partners, industry representatives, assessment staff to make necessary changes.	Conduct collaborative meetings and continue participation with partners	-Meet with partners and assessment staff to identify changes and needs -Communicate changes at existing assessment and relevant stakeholder meetings

VI. Links to Other Surveys

The CSBLLS has no real overlap with other NEFSC surveys in terms of target species, spatial extent, or gear type. There are major overlaps with the Southeast Fisheries Science Center (SEFSC) snapper/shark survey in terms of similar gear (bottom longline but smaller hooks, shorter sets, different bait) and some spatial coverage (Florida to North Carolina), but timing is different and therefore captures different migratory/assemblage patterns. There may be some overlap with the Beaufort lab's deepwater tilefish survey in terms of spatial extent, but given very different depths and species targeted, no links or integration opportunities are likely to exist. The new NEFSC Cooperative Research Branch Hook and Line survey will have overlaps in spatial extent, but gear and target species are very

different. In the future, these may overlap in catch species if the Hook and Line survey transitions to larger hooks.

VII. Adaptive Management Considerations/ Opportunities

Adaptive opportunities may exist if alternative forms of surveying, such as use of shorter lengths of gear trialed inside WEAs, are identified as being equivalent to existing methods. Final siting and design of wind structures, vessel traffic, high-voltage cable placement, and other logistics associated with individual wind leases will also determine if changes need to be made to mitigation plans on a rolling basis. Our program staff will monitor changes and update the plans as needed.

VII. Statement of Peer-Review Plans

This plan will be peer reviewed in the same processes as the other mitigation plans in the NEFSC portfolio. It will also be presented to external groups such as the NOAA Fisheries HMS Division, SEDAR assessment panels, and other applicable stakeholder groups.

IX. Performance Metrics

The performance metrics for this plan will be based on the equivalency of resulting relative abundance estimates to those of the historical survey index. Uncertainty estimates in the form of coefficients of variation (CVs) for yearly abundance estimates produced for the survey can be used to monitor equivalency and will indicate significant changes in the quality of the data if they occur as a result of WEA impacts to the CSBLLS. Additionally, uncertainty surrounding life history estimates will continue to be evaluated and may be used to identify issues pertaining to production of sound growth metrics and life history parameters as a result of direct or indirect WEA impacts.

X. References

Courtney D. 2017. Example Implementation of a Hierarchical Cluster Analysis and Cross Correlations of Selected CPUE Indices for the SEDAR 54 Assessment. SEDAR54-WP-06. North Charleston (SC): SEDAR. 11 p. https://sedarweb.org/documents/sedar-54-wp-06-example-implementation-of-a-hierarchical-cluster-analysis-and-cross-correlations-of-selected-cpue-indices-for-the-sedar-54-assessment/

McCandless CT and Natanson LJ. 2010.Standardized catch rates for sandbar and dusky sharks from the NMFS Northeast Longline Survey. SEDAR 21DW-28. Prepared for Southeast Data Assessment and Review 21: Sandbar Shark. Narragansett (RI): Apex Predators Investigation. 19 p. https://sedarweb.org/documents/s21dw28-standardized-catch-rates-for-sandbar-and-dusky-sharks-caught-during-the-nefsc-coastal-shark-bottom-longline-survey/

McCandless CT and Natanson LJ. 2021. Standardized index of abundance for scalloped hammerhead sharks from the NOAA Northeast Fisheries Science Center coastal shark bottom longline survey. SEDAR77-DW28. North Charleston (SC): SEDAR. 9 p.

https://sedarweb.org/documents/sedar-77-dw28standardized-index-of-abundance-for-scalloped-hammerhead-sharks-from-the-noaa-northeast-fisheries-science-center-coastal-shark-bottom-longline-survey/

Natanson LJ, McCandless CT, Passerotti MS, Belcher CN, Bowlby HE, Driggers III WB, Frazier BS, Gelsleichter JA, Gulak SJ, Hendon JM, et al. 2022. Morphometric conversions for 33 shark species from the western North Atlantic Ocean. Mar Fish Rev. 84(3-4). https://doi.org/10.7755/MFR.84.3-4.1

[NMFS] National Marine Fisheries Service. 2020. Scalloped Hammerhead Shark (Sphyrna lewini) 5-Year Review: Summary and Evaluation. Report of the Office of Protected Resources. Silver Spring (MD): NMFS. 43 p. https://www.fisheries.noaa.gov/s3//dam-migration/scalloped_hammerhead_5-year_review.pdf