

Review of:

Improving the NEFSC Clam Survey for Atlantic Surfclams and Ocean Quahogs

By

Scientific and Statistical Committee, Mid-Atlantic Fishery Management Council

Subcommittee: E. Houde (Chair), O. Jensen, R. Latour, M. Wilberg

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Summary/Synopsis

A Subcommittee of the Scientific and Statistical Committee (SSC) of the Mid-Atlantic Fishery Management Council (MAFMC) reviewed the Report of the NOAA Northeast Fisheries Science Center's (NEFSC) Working Group (WG) on Improving the Surfclam and Ocean Quahog Survey Design. The Working Group's proposed design revises the current survey design, resulting in substantial reductions in area covered by the survey and proposing separate surveys for each species in contrast to the combined-species survey that is presently conducted. The Subcommittee was in overall agreement with the WG's recommended new design, but recognized that alternative design approaches could have been considered and evaluated. The new design proposes a survey frequency similar to that currently conducted for surfclam that will increase precision of the surveys, improve estimates of abundance, and is likely to improve management advice for this species. Improvements to abundance estimates for ocean quahog and utility for management are likely, but less certain because of reduced frequency of the proposed surveys for this species.

Alternative approaches to survey designs were noted by the Subcommittee and discussed relative to the design-based approaches proposed by the WG. The Subcommittee recommended model-based spatial simulations be undertaken to support longer-term consideration and research on survey design for the clam species. It also noted that the WG had not considered habitat and environmental variables (beyond location and depth) to optimize survey design. The WG argued that its recommended stratification largely avoids discontiguous strata, but the Subcommittee noted that such stratification had merit under some circumstances. The Subcommittee believes that multivariate techniques for survey

optimization (i.e., finding a design that minimizes some combination of the variances for both species) are available that could have been tested to define an appropriate base case against which to compare a survey design in which each species is surveyed separately.

Further research and in-depth consideration of alternative stratification schemes is recommended.

The Subcommittee believes there will be little loss of historical information if the new survey design is adopted. It also is unlikely that there will be a loss of biological data and information.

It is noted that, if the new proposed survey design is adopted, a change in stock assessment schedules for surfclam and ocean quahog will be necessary. Current assessments are conducted on a 3-4-year timetable. If the new design is adopted, assessment for surfclam would be conducted every 4 years and that for ocean quahog every 6 years.

The WG believes that a decadal reconsideration of survey design will be adequate for these species. This may be sufficient although some evaluation is desirable. The Subcommittee recommended that a new Term of Reference be added to the stock assessment protocol for these species that addresses the possible need for re-evaluation of survey designs during deliberations for each stock assessment.

Ten recommendations to the WG are put forward by the Subcommittee to conclude its review. Recommendations are categorized as those to be addressed in the WG Report itself or those that are better viewed as long-term or research recommendations.

Introduction

The surfclam and ocean quahog fisheries are conducted as limited entry fisheries in coastal waters from Virginia to Maine. Stock sizes of both species are presently high but shifts in distribution, especially of surfclam, apparently influenced by climate change and fishery removals, are occurring. The fisheries are managed as single stocks by the MAFMC and are supported by stock assessments conducted every three to five years by the NEFSC. Reliability of stock assessments depends on fishery-independent abundance surveys conducted by NEFSC under protocols that have evolved over the years but currently are based on designated areas and strata in which both species are sampled by a commercial clam dredge.

A WG consisting of NEFSC and MAFMC staff, academic partners, and interested stakeholders has proposed substantial revisions to the dredge survey design for both clam species. The WG's goals were to develop protocols to improve efficiency, precision and utility of survey data used in stock assessments and for using survey resources more efficiently. NEFSC requested that the MAFMC SSC review the comprehensive WG Report (NEFSC 2018). A Subcommittee of the SSC was charged to conduct the review. Results of that review are summarized herein.

The NEFSC Working Group, in developing the proposed Survey Design, was guided by 14 Key Questions:

- 1) *Should clam surveys target surfclams and ocean quahogs separately rather than simultaneously?*
- 2) *Should sampling in poor habitat areas cease, particularly if the two species are surveyed separately?*
- 3) *Should new species-specific stratification schemes be used if the two species are surveyed separately?*
- 4) *Is it feasible to survey the entire stock (GBK plus south) for surfclams or ocean quahogs in one survey year if the species are separated and sampling area reduced?*
- 5) *What scheduling options (number, location and frequency of surveys for both species) should be considered if surveys for the two species are separated?*
- 6) *Can rough ground with risk to equipment damage be avoided?*
- 7) *Should new strata be constructed from current strata or built from scratch using smaller building blocks?*
- 8) *How heavily should location and depth information vs. survey catch data be weighted in developing new strata?*
- 9) *Should new strata schemes with discontiguous strata be considered or should strata be defined traditionally as single contiguous areas?*
- 10) *What are the recommended stratification options (method, location, shape and number of strata) for each species and area?*
- 11) *Will the recommended changes affect observation and estimation of biological characteristics, such as, length to weight relationships and growth rates?*
- 12) *How would potential changes in the clam survey (e.g. lower survey frequency and increased precision) affect management advice and stock assessment modeling?*
- 13) *How often should future changes in stratification be considered?*
- 14) *What types of additional research would benefit the clam survey?*

The MAFMC's SSC Subcommittee conducted its review in the period March to May 2018.

The Subcommittee's review was framed by six Terms of Reference (ToRs):

ToR 1A. Will the alternative survey design options recommended in the NEFSC report substantially improve 1) survey data, 2) stock assessment model results and 3) management advice for surfclams and ocean quahogs?

1B. Review the report's justifications, evaluations, and recommendations to conduct separate surveys for surfclams and ocean quahogs. Will the recommended design improve the Council's ability to assess and manage these resources?

ToR 2. Are recommended options for the redesign of the NEFSC clam survey appropriate based on 1) life history and biology of surfclams and ocean quahogs, 2) ongoing climate induced distributional shifts and 3) fishery patterns? Do answers differ for surfclams and ocean quahogs?

ToR 3. Critique the report's recommendations for surfclams and ocean quahogs, with respect to proposed changes in survey scheduling and the reduction in survey spatial coverage.

ToR 4. Review and evaluate proposed stratifications in the sampling design recommended by the NEFSC WG. Are the recommended strata, primarily defined by depth and location, appropriate or would an alternative stratification plan, e.g., based on clam abundances, be preferable?

ToR 5. Will the proposed changes in the surfclam and ocean quahog survey compromise ability to utilize the lengthy historical time series of survey data in future assessments?

ToR 6. Will the recommended changes in survey design affect observation and estimation of biological characteristics, such as length-weight relationships and growth rates? What are the likely effects?

Review Procedure and Timeline

The MAFMC requested its SSC to undertake a review of the WG Report in February 2018. A SSC Subcommittee was appointed to conduct the review. NEFSC scientists and principal authors of the WG Report presented the report's findings to the full SSC on 13 March. The Subcommittee and NEFSC principal authors (WG Co-chairs) held a conference call to discuss

the report and its recommendations on 13 April. The Subcommittee conducted its review and submitted its draft report to MAFMC staff on 2 May, subsequently presenting its findings to the full SSC on 9 May. A revised Subcommittee report, benefiting from SSC discussion, was submitted to the MAFMC on 15 May. Its final report was transmitted to NEFSC on XX May 2018.

The Review

In general, the Subcommittee agreed with the conclusions and recommendations in the WG Report. However, Subcommittee reviewers recognized that a limited number of alternative designs had been considered or proposed by the WG. The WG's principal authors argued that the recommended design was "pragmatic and robust." The current design targets both surfclam and ocean quahog in a combined-species survey. The proposed design would target the species in separate surveys, based on survey strata uniquely assigned to each species. In the WG's recommended design, surfclam would be surveyed at a frequency as in the current survey but ocean quahog would be surveyed at a frequency half that of the current survey. The proposed total areas to be surveyed for both species are substantially reduced (by 26 to 44 % for surfclam and 35 to 42% for ocean quahog) from the historical and current survey areas. The Subcommittee agrees that the new design will improve efficiency and utility of the survey for surfclam and is likely to improve the ocean quahog surveys.

The Subcommittee notes that no cost analysis for the proposed or alternative survey designs was included in the WG Report. The principal authors of the WG Report, in a conference call, indicated that the proposed survey design had been reviewed favorably by the NEFSC survey operations office and is expected to cost about the same as the current survey. The Subcommittee believes that a cost analysis would have been a useful element for the survey design.

The Subcommittee's critical review was conducted by addressing each ToR and also being mindful of the Key Questions posed by the WG.

ToR 1A. *Will the alternative survey design options recommended in the NEFSC report substantially improve 1) survey data, 2) stock assessment model results and 3) management advice for surfclams and ocean quahogs?*

The strata in the current surveys for surfclam and ocean quahog are undoubtedly suboptimal as they "... were not designed for clams and are also used for Atlantic sea scallop surveys"

(NEFSC WG Report, p. 2). The WG Report makes a convincing case that the proposed new strata will reduce the estimation variance and thus improve precision of the surveys.

The new proposed design will improve survey data for both surfclam and ocean quahog. Separate surveys are proposed for each species on Georges Bank and in the more extensive Southern Area. The new design will confine survey sampling to the 9-80 m depth range and will reduce areas included in the surveys by 26-44% for surfclam and 35 to 42 % for ocean quahog relative to the current design. The proposed survey strata will adhere to a 1% occurrence rule based on historical survey data for each species. The proposed surveys will improve efficiency and precision of survey results. These benefits are almost certain for surfclam and may be beneficial for ocean quahog. Consequently, it is likely that stock assessment modeling will benefit and translate into better management advice.

The Subcommittee agrees that the bootstrapping approach used to evaluate survey design alternatives has merit, but it also has drawbacks, which are acknowledged (NEFSC WG Report, p. 14). A different approach that would eliminate many drawbacks would be to simulate spatial fields and sample these fields using the proposed alternative survey designs. These fields could be generated using co-kriging (regression against environmental covariates such as depth in combination with kriging) to represent the spatial distribution of the stock and its spatial autocorrelation properties (strength and scale of patchiness).

The Subcommittee notes that timing of update stock assessments, now conducted every three to four years for these species, will need to be adjusted if the new survey design is adopted. Under the new design, assessments may need to be conducted every four years for surfclam and six years for ocean quahog. The Subcommittee recommends that the probable change in assessment schedule be addressed explicitly in the WG Report and also communicated directly to the Council.

As noted above, the WG's argument that impacts of the new design on management advice and stock assessment for surfclam can only be positive was convincing. For ocean quahog, the testing of effects of alternative survey designs on stock assessment model results using linear regression was a clever simplification of the stock assessment process. The survey is the main driver of the process since it serves as an estimate of absolute abundance to scale the whole population. The parameter evaluated, trend in quahog abundance, is not a primary parameter of management interest such as an OFL, but it is clearly an important metric describing the status of the ocean quahog stock. As such, it contributes to the assessment process and provides guidance to management decisions and advice.

ToR 1B. *Review the report's justifications, evaluations, and recommendations to conduct separate surveys for surfclams and ocean quahogs. Will the recommended design improve the Council's ability to assess and manage these resources?*

The Subcommittee agreed that the WG's justifications and rationale that led to a recommendation for separate surveys are appropriate. The separate surveys will concentrate effort on strata that historically have yielded catches of each species and will lead to more precise estimates of abundance. The new proposed design has high probability to improve outcomes for surfclam while that for ocean quahog, while less certain, still is likely to improve overall survey estimates. The WG argued, based on simulation analyses, that the relatively low frequency of quahog surveys will not compromise utility of survey results for assessments, citing increased precision of the survey, the life history characteristics of ocean quahog, and the low probability of significant shifts in resource distribution within a decadal timeframe.

While generally in agreement with the WG, the Subcommittee notes that multivariate techniques for survey optimization (i.e., finding a design that minimizes some combination of the variances for both species) are available. These methods could have been tested to define an appropriate base case (i.e., single survey covering both species) against which to compare a survey design in which each species is surveyed separately. It is not clear that the WG considered such techniques.

ToR 2. *Are recommended options for the redesign of the NEFSC clam survey appropriate based on 1) life history and biology of surfclams and ocean quahogs, 2) ongoing climate induced distributional shifts and 3) fishery patterns? Do answers differ for surfclams and ocean quahogs?*

The primary argument related to life history and biology in the WG Report is that the slow changes in population dynamics of ocean quahog ensure that survey frequency can be reduced with little negative impact on the estimation of population trend. Ocean quahogs occur at depths deeper than surfclams. The WG argued that the differences in spatial distributions mean that (1) a survey designed for one species is not well designed for the other and (2) it is not feasible to survey ocean quahog at the same frequency as surfclam. The Subcommittee agrees and notes that these arguments are clear and convincing.

The WG was cognizant of ongoing effects of climate change, especially on the surfclam population. Considering climate-induced distributional shifts, no stratified random survey design is robust to distributional shifts that alter the relative variances among strata. The Subcommittee notes that if allocation of samples across strata is optimal in a current survey

design, it will be suboptimal in the future if the abundance and variance among dredge tows changes in some strata because of distributional shifts.

A separate but related question is how alternative survey designs impact ability to detect shifts in spatial distribution. This question is not explicitly addressed in the WG Report, but may be an important consideration with respect to the survey's ability to provide management advice in the future. Evaluating survey design with respect to detecting distributional shifts would require a different simulation testing framework than the bootstrapping approach conducted by the WG because the testing framework would require the ability to introduce spatial-temporal trends into the distribution. One such framework would be to simulate spatial fields and sample these fields using the proposed alternative survey designs. These fields could be generated using co-kriging (regression against environmental covariates such as depth in combination with kriging) to represent the spatial distribution of the stock and its spatial autocorrelation properties (strength and scale of patchiness).

The WG Report notes that the fishing industry uses survey results to locate new fishing grounds. However, it is not apparent that information from the fishery was used to evaluate alternative survey designs. This omission may represent a missed opportunity for two reasons. First, heavily fished locations are likely to show more rapid changes in abundance than those lightly fished or unfished. An optimal survey design that incorporated spatial information on fishing intensity would presumably allocate more samples to heavily fished locations because they are more dynamic (higher temporal variance). Second, a greater density of samples in heavily fished locations could provide more useful information to the industry. For example, higher sample density would allow the industry to better map the boundaries of high clam abundance areas. Alternatively, if the industry uses the survey primarily to identify new, previously unfished locations, higher sample density outside of currently fished areas could be more beneficial. In any case, the analysis in the WG Report does not directly consider how alternative survey designs might affect utility of the survey for the fishing industry.

ToR 3. *Critique the report's recommendations for surfclams and ocean quahogs with respect to proposed changes in survey scheduling and the reduction in survey spatial coverage.*

Scheduling

The current survey operates on a three-year schedule, with the Southern area being surveyed in year 1 of the rotation, Georges Back being surveyed in year 2, and the third year being reserved for testing and other experiments (such as dredge efficiency). The WG

considered a number of other survey schedules (WG Report, Table 4.1). Its recommended option proposes a change to a six-year schedule, with surfclam being surveyed in the South in years 1 and 3 and on Georges Bank in years 2 and 4. Ocean quahog would be surveyed in years 5 (South) and 6 (Georges Bank). On average, the proposed schedule generates the same number of stock size estimates for surfclam as in the current survey. However, the proposed schedule will reduce survey frequency for ocean quahog, providing a stock size estimate in each area every six years.

The WG conducted simulations to estimate the effect of changing the schedule of the surveys. In general, because increased accuracy is expected under the new survey design, the proposed schedule is projected to outperform the current schedule. For surfclam, because the proposed survey frequency is nearly the same as in the current survey, the expected estimates from the new survey design should result in an overall improvement of assessment accuracy. For ocean quahog, the proposed change in survey frequency would result in longer times between potential assessments (minimum of six years). The WG's simulation results suggest that the expected improvements in survey accuracy for ocean quahog will outweigh the decreased assessment frequency and, thus, result in an assessment with increased accuracy. These results correspond with other simulation studies on fisheries conducted in the Mid-Atlantic to explore the effects of assessment frequency and survey accuracy (Wilberg et al., 2015; Sylvia, 2015).

The frequency of surveys will have important consequences for management of ocean quahog. The reduced frequency of the ocean quahog survey would mean that assessment updates probably could be undertaken only every six years. Given the extreme longevity and low estimated fishing mortality rates for ocean quahog, the Subcommittee believes a six-year assessment frequency is adequate for management to respond to changes in abundance. The Fishery Management Plan, however, may need to be revised by the MAFMC to ensure that management is synchronized to the longer time interval between assessments. The Council needs to be aware of this requirement.

Reduction in Spatial Coverage

The proposed survey design includes specifying different strata to be surveyed for surfclam and ocean quahog (although there is substantial overlap between the two proposed surveys). The WG excluded strata from the survey domain that had less than 1% of the cumulative clam abundance for each species during 1997-2016, which substantially reduced the proposed survey areas. The analyses that were conducted by the WG indicate that this approach should not bias the estimates, given the distribution of surfclam and ocean quahog

in the test data set. However, a reduced survey area could be problematic if the range of either ocean quahog or surfclam shifts. In essence, a range shift outside the proposed survey area would result in underestimates of biomass and abundance. Given the relatively slow pace of changes in the spatial distribution of these species, substantial shifts in the range are not expected over a 1-2-decade period. But, it is possible that ranges of the species will shift, and this possibility should be considered if the new design is adopted. The Subcommittee recommends that NEFSC include a new Term of Reference in future stock assessments for each species to explicitly consider if the survey area remains appropriate. If the ranges shift substantially, the spatial strata of the surveys may need to be modified.

ToR 4. *Review and evaluate proposed stratifications in the sampling design recommended by the NEFSC WG. Are the recommended strata, primarily defined by depth and location, appropriate or would an alternative stratification plan, e.g., based on clam abundances, be preferable?*

The current surfclam and ocean quahog survey follows a random stratified design based on NEFSC strata developed in the late 1970s. The strata were not originally designed for clams. Since the current survey samples both surfclams and ocean quahogs simultaneously, decisions regarding allocation of survey tows to each stratum represent a compromise between optimal allocations for the two target species. Adjustments in the current survey are made *ad-hoc* to ensure a minimum number of tows in each stratum. The WG Report points out that the compromise tow allocation scheme is less than ideal for either species.

The WG argued that the current survey is over-stratified. In essence, the many small strata imply that sampling intensity in any given stratum is low, which can result in relatively poor precision of abundance estimates. Analyses conducted by the WG resulted in a substantial reduction in the overall number of strata for both clam species in the GBK and Southern areas. Cluster analysis and model-based procedures were used to evaluate the similarity among response variables (univariate: historical catch densities; multivariate: historical catch densities, depth, location) in 15-minute-square building blocks. Results of the WG analysis indicated that univariate clusters often were unstable while multivariate clusters achieved better stability. The univariate results suggested to the WG that creating discontiguous strata, which would be likely if strata were defined solely on clam density, is not recommended despite its intuitive appeal.

While the Subcommittee was in general agreement with the decision of the WG to not have discontiguous strata, an argument could be made to adopt a design with such stratification. The WG Report states that the WG had expected to use univariate cluster analysis based on

catch data alone or multivariate cluster analysis with higher weighting on catch but there was too little catch data (particularly for fifteen-minute-squares) to weight such data heavily without causing instability and discontiguous stratification patterns that were widely scattered over the survey areas. The Subcommittee notes that, in theory, weighting survey strata on abundance (catch) would be preferable, but data limitations apparently made this alternative unappealing. The Subcommittee points out that there is nothing inherently wrong with discontiguous strata and the WG Report acknowledges that such strata are used in other surveys of fisheries resources. The Subcommittee recognized that a decision to accept discontiguous strata in the new proposed design would make comparisons to abundance in historical strata more difficult.

The Subcommittee notes that bottom type could have been a useful variable for defining similarity among strata building blocks (bottom mapping data exist, e.g., see MAFMC EAFM Guidance Document). The WG did not include this variable in its analysis, but consideration of bottom type and possibly other habitat variables may warrant additional thought and analysis.

The Subcommittee is generally supportive of the WG's newly proposed stratification plan and its recommendation to conduct separate surveys for surfclam and ocean quahog under species-specific stratification schemes. However, the Subcommittee notes that these stratification schemes are all conceived from a design-based philosophy. Geostatistical and other model based tools are available and can be useful for survey design and could represent an independent, comparative approach that also would extend consideration to less traditional survey designs (e.g., hybrid of stratified random and fixed station).

ToR 5. Will the proposed changes in the surfclam and ocean quahog survey compromise ability to utilize the lengthy historical time series of survey data in future assessments?

Estimates of abundance from the current surfclam and ocean quahog survey typically have been scaled by the area of the survey when they are included in the stock assessments. A change in the survey area should not affect the time series of the data. In essence, the survey is being redesigned to avoid locations or areas with zero or very low clam density (i.e., the 1% rule). If these locations of low density are known *a priori*, which the WG's design analysis indicates, then the survey can be optimized by avoiding low-density locations and assuming that abundance in them is zero. Accordingly, despite the change in the survey area, the Subcommittee believes that estimates of abundance and biomass for the proposed surveys will be comparable with the current survey. Furthermore, the survey design recommended in the WG Report relies heavily on current strata building blocks and thus will

minimize the difficulty and errors associated with comparing historical estimates at the stratum level.

The Subcommittee notes that while proposed changes should not impact the use of historical stock-wide abundance estimates in future assessments, variance estimates will change and may need to be incorporated into assessments, which should be a fairly straightforward exercise. However, proposed changes in survey stratification presume that stratum-level estimates will sometimes require post-stratification. To the extent that clam density is not homogenous within strata, such post-stratification introduces an additional source of uncertainty in comparisons at the stratum level.

ToR 6. Will the recommended changes in survey design affect observation and estimation of biological characteristics, such as length-weight relationships and growth rates? What are the likely effects?

The WG's new proposed design will have no negative consequences for observing and estimating biological characteristics of the clams, at least relative to the current survey. Adjustments to protocols that specify numbers of clams to be sampled at survey sites will be required. The WG Report is not explicit in addressing how ocean quahogs and surfclams will be sampled for biological characteristics in years when each of the species is not being surveyed. Presumably, this is not a concern because biological samples of the species not being surveyed in a particular year often will be available and could be sampled from the dredge tows for the species being surveyed in that year.

Regarding habitat and environmental data, the WG Report's principal authors noted in a conference call that, while there is apparent opportunity, there is insufficient time in survey cruises and no funding to obtain better data on habitat and biological communities. This is unfortunate because such information would help to document how long-term shifts or trends in abundance of surfclam and ocean quahog relate to ongoing environmental and habitat changes. Some shifts and trends will be attributable to changing climate but other environmental factors also may be involved.

Overall, it seems unlikely that the proposed changes in the survey would significantly affect estimates of biological characteristics of the clams, but the WG Report lacks detail in addressing this potential concern. The WG Report states that its recommended changes in design will improve collection of biological data and estimation of biological characteristics because a higher percentage of survey tows will catch the target species. However, the Subcommittee notes that additional factors are relevant but not included in the WG Report. For example, to accurately estimate growth rates and their variability, it is important to have

samples from a wide range of ages and, for these clam species, depths/environmental conditions. The reduction in survey area in the new proposed design potentially limits observing variability. The Subcommittee had insufficient knowledge about the spatial distribution of ages of the two species across the survey area to know if this concern is valid.

Recommendations

Based on its review, the Subcommittee provides several recommendations. Some recommendations can be addressed as edits to the WG Report. Others should be taken under advisement by the NEFSC and considered to improve survey design in the longer-term. And, some recommendations are Research Recommendations that could be added to those already identified by the WG.

1. Recommendation. ToR 2. The analysis in the WG Report does not directly consider how alternative survey designs might affect utility of the survey for the fishing industry. The Subcommittee recommends that the NEFSC address this need and provide a brief discussion of benefits and utility of the new design to industry in the WG Report.
2. Recommendation. ToR 3. The Subcommittee recommends that a more explicit statement and justification of the proposed schedule for reconsideration of survey design be included in the WG Report. The WG Report proposed that reconsideration of survey design might be undertaken on a decadal basis. In a conference call with the principal authors of the WG Report they indicated this timeframe is a reasonable expectation of what they believe NEFSC can accomplish.
3. Recommendation. ToR 3. The WG Report should acknowledge that, under the new proposed survey design, schedules for stock assessments will change. Under the new design, stock assessments should be conducted every four years for surfclam and every six years for ocean quahog. The Subcommittee recommends that the change in assessment schedule be addressed in the WG Report and also directly communicated to the Council.
4. Recommendation. ToRs 3 and 4. The Subcommittee recommends that the WG Report recognize the need for NEFSC to include a new Term of Reference in future stock assessments for surfclam and ocean quahog should the proposed survey design be adopted. The new ToR should explicitly address the question of whether the survey areas are appropriate. If the distributions of clams shift substantially, the

survey strata may need to be modified. This recommendation is especially important for ocean quahog which, under the new survey design, will have updated assessments only every six years.

5. Longer-Term Recommendation. ToRs 3 and 4. The Subcommittee recommends that NEFSC consider and evaluate a broader range of alternative survey designs in future considerations of survey efficacy. The Subcommittee notes that the WG conceived new stratification schemes from a design-based philosophy. Geostatistical and other model-based tools now available can be useful for survey design and represent an independent comparative approach that also extends consideration to less traditional survey designs (e.g., hybrid of stratified random and fixed station).
6. Longer-Term Recommendation. ToRs 2 and 4. The Subcommittee recommends that NEFSC collect additional habitat and environmental data at survey sites. The WG Report's principal authors noted in a conference call that, while such information could be important, there is insufficient time in survey cruises and no funding at present to obtain better data on habitat and biological communities. This is unfortunate because such information would serve to document how long-term shifts or trends in abundance of surfclam and ocean quahog relate to ongoing environmental and habitat changes. Some shifts and trends will be attributable to changing climate but other factors also may be important.
7. Longer-Term or Research Recommendation. ToRs 3 and 4. The Subcommittee recommends that NEFSC and the WG conduct analyses to document changes or shifts in distribution and abundances of the clams. This would ensure that survey designs continue to support future stock assessments. Such evaluations may require a different simulation testing framework than the bootstrapping approach conducted by the WG. A recommended approach would be to simulate spatial fields and sample these fields using the proposed alternative survey design. These fields could be generated using co-kriging (regression against environmental covariates such as depth in combination with kriging) to represent the spatial distribution of the stock and its spatial autocorrelation properties (strength and scale of patchiness).
8. Longer-Term or Research Recommendation. ToR 4. The Subcommittee notes that habitat variables could inform decisions to define survey strata; however, except for depth and latitude/longitude, these were not included in the WG's analysis (excepting its recognition of untowable ground). The Subcommittee believes that bottom type may be a useful variable for defining similarity among strata building blocks. It notes that

bottom mapping data exist, e.g., see MAFMC EAFM Guidance Document, and recommends that this be acknowledged in the WG Report and considered as a longer-term or research recommendation.

9. Research Recommendation. ToRs 3 and 4. The Subcommittee notes that multivariate techniques for survey optimization (i.e., finding a design that minimizes some combination of the variances for both species) are available. These methods could be tested to define an appropriate base case (i.e., single survey covering both species) against which to compare a survey design in which each species is surveyed separately.
10. Recommendation. Although not a listed ToR, the Subcommittee notes that costs and economics of alternative survey designs were not evaluated in the WG Report. The principal authors of the report, in a conference call, indicated they did not believe the new design will reduce survey costs. The Subcommittee recommends that an analysis be conducted to provide a projection of proposed survey costs relative to the current survey design.

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