Center for Independent Experts (CIE) Independent Peer Review of the Stock Assessment Review Committee (SARC) meeting

– Red Hake Stock Structure Research Track –

March 9th - 12th, 2020
Northeast Fisheries Science Center (NEFSC), Woods Hole, Massachusetts

Individual Independent Review Report
Dr. Manuel Hidalgo, CIE Reviewer

April 2020

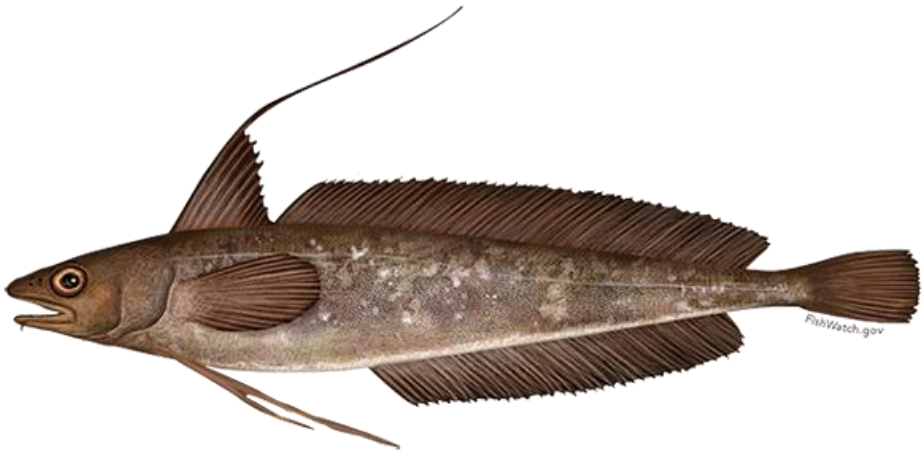

Photo: NOAA Fisheries

Contents

Executive Summary

The SARC review of the Red Hake Stock Structure Research was held at Woods Hole, Massachusetts, from the 9th-12th March as part of the SAW process, and it was reviewed by a panel of three CIE reviewers and chaired by Dr. John Wiedenmann. The most relevant background documents were available to the reviewer panel approximately two weeks before the meeting. All the presentations and documents were accessible online through a share-point available during the meeting. The panel had the opportunity to discuss numerous scientific and technical elements related to the process and the work included in each of the six Terms of Reference (ToRs), seeking additional clarifications, and discussed whether the ToRs were or were not met. In summary, ToR 1, 2, 3, 4 and 6 were fully completed, while ToR 5 was sufficiently met. Relevant recommendations are indicated mainly on ToRs 2, 3, and 5.

A comprehensive and organized review was presented for relevant literature on the existing stock structure of red hake in the northwest Atlantic (ToR 1). Past management assumed different stock boundaries for practical reasons, while more recent information generally supports the current management units (i.e., a northern stock including northern Georges Bank and the Gulf of Maine, and a southern stock including southern Georges Bank and southern New England) established in 1985. This stock structure was the null hypothesis to be assessed by the Working Group. A series of sub-regions were defined for this purpose within each putative stock.

The Working Group conducted a multidisciplinary approach, revisiting published information and applying a series of new analyses and models over different types of data including species' life history and ecology, morphometrics, otolith microchemistry, ocean connectivity, and assessment modeling (ToR 2). The main conclusions are: i) the presence of phenotypic stocks with independent dynamics supporting a two-stocks structure, mainly based on spatial changes in growth and in the spatial coherence of population biomass trends from surveys; ii) evidence of likely cross-boundary juvenile and spawning migrations that could support one complex stock that was mainly supported by larvae distribution, oceanographic connectivity patterns, and otolith microchemistry; and iii) well-founded evidence that species distribution by age, spawning activity, and migratory patterns have changed from 2013 to a new scenario. The working group considered that ii) and iii) need more evidence and further research. However, the phenotypic differences must be revisited, the misidentification between red and white hake should be solved, and time series information should be shortened removing the effect of information prior to ca. 1985. Information prior to 1985 corresponds to a contrasting scenario in terms of productivity to the observed in the recent decades and could have a high influence in the analyses conducted.

The uncertainty associated with the potential spawning and juvenile migration, along with the lack of genetics and tagging information, was an important concern for the WG, but it was not sufficient to reject the null hypothesis of two stocks (ToR 3). Therefore, a two-stock structure is currently the most practical management approach on the basis of the information used in the assessment: phenotypic traits (growth) and population temporal trend differences for each stock.

However, further research should investigate whether: i) stock-recruitment relationships work independently or not for each subunit, ii) phenotypic differences change when misidentification is solved and information from old periods is removed (i.e., prior mid-80s), and iii) trends in the recent years (from 2013) evolves or stabilizes in the near future.

Numerous experimental data on survey catchability of red hake have been revised as well as the eventual incorporation of catchability estimates into the assessment (ToR 4). This includes four sources of information: industry conversations and insights, HabCam (Habitat mapping Camera System) estimates of population density and behavior, a twin sweep efficiency study, and a twin net spread study. A lack of evidence that changes in the wingspread affects the efficiency in the catches was reported, while the analysis of the chain sweep study provided evidence that it is appropriate for estimating maximum catchability at length and minimum total biomass. HabCam and chain sweep catchability values were very similar giving an additional robustness value to these studies. HabCam analysis provides very relevant results being a line of research to be pursued in the future. Red hake was the first species analyzed, while many additional species are under ongoing evaluation for a more holistic and integrative understanding of catchability.

The two-stock structure was applied to the previous assessment model, An Index Model (AIM), and the associated reference points (ToR 5). This model was not significant and, consequently, the reference points not meaningful. An alternate assessment modeling framework and associated reference points were applied. The model was considered technically sound and must be used in the future if management track assessment of this species does not move to a more elaborate age-structured model. However, the reference points need further evaluation before they are used for management, and the qualitative evaluation of stock status in the southern stock as 'overfishing not occurring' needs to be revisited. An increase of the number of years in the assessment (excluding information prior mid 80s) was recommended. Complementing the empirical model used with simulation modeling would be useful to assess the potential diffusion of fish from the southern to the northern stock or alternative spatial heterogeneity across stocks.

Finally, a list of research recommendations and activities for future development was presented, focusing on the identified gaps of knowledge for red hake stock structure and a broad application of some of the approaches used for other species. In terms of the stock structure, the Working Group recognizes that the main gaps in knowledge in terms of the stock structure were: the potential migration of red hake spawners and juveniles, and recent changes in juvenile distribution from 2013 (and how this scenario would evolve in the future). From the activities presented, those that were highly recommended were: implementing population research genetics, natural tags (parasites, meristics and length-at-age), revisiting growth after misidentification of hake species is resolved, pursuing species aging and its eventual application to an age-structured assessment, and a broader study of otolith microchemistry in combination with stable isotope analyses.

Background

The SARC review of the Red Hake Stock Structure Research was held at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, Massachusetts, from the 9th-12th March as part of the SAW process. The most relevant background documents were available to the review panel approximately two weeks before the meeting. The review panel was also informed that additional information from the Red Hake Stock Structure Working Group (WG) was available at the web page[1], where information on the process of this WG, with several meetings and webinars from November 2019 until February 2020, is described. During the two weeks prior to the review meeting the panel was able to read and assess this material, with the opportunity to check final points in the appendices, being appropriately informed and prepared.

The first day of the meeting, 9th March, and shortly prior to the opening of the meeting, the reviewers (Dr. Haritz Arrizabalaga, Dr. Christophe Pampoulie and Dr. Manuel Hidalgo) and the SARC panel chair (Dr. John Wiedenmann) met with the Head of the Population Dynamics Branch at NEFSC (Dr. Russell Brown), the current Assessment Process Lead (Dr. Michele Traver) and the NEFSC Stock Assessment Workshop (SAW) Chairman (Dr. James Weinberg). During this brief meeting, the panel was informed on how the process and the review meeting will proceed, made a brief review of the Terms of Reference (ToRs), provided clarifications on the role of both the independent reviewers and the chair of the panel. The panel also had the opportunity to ask small details about the review process and the meeting over the next three days will function. Dr. Weinberg clearly indicated that the purpose of the review process was to assess whether or not the objective indicated in each ToR was achieved, not achieved, or partially achieved. In addition, he also stressed that we should include research recommendations on how to address the identified gaps in the future.

The review meeting opened with a brief introduction of the SARC processes by Dr. Brown and the review of the agenda by the panel chair, followed by the presentation of all the ToRs led by Dr. Dave Richardson, chair of the working group, with the assistance of members of the WG in charge of specific activities (Steve Cadrin, Rich McBride, Tim Miller, Larry Alade, Toni Chute and Kathy Sosebee). All the presentations, and documents received beforehand, were accessible online through a share-point available during the week of the meeting. The panel had the opportunity to discuss numerous scientific and technical elements related to the process and the work included in each ToR, seeking additional clarifications. During the first two days, the review panel went through the six ToRs. Shortly before to the start of the meeting on the third day, the review panel and the chair met with Dr. Michael Simpkins (Chief of the Resource Evaluation and Assessment Division at NEFSC) along with Dr. Brown, Dr. Traver and Dr. Weinberg to discuss issues associated with ToR 5. The first half of the third meeting day was devoted to continuing the discussion and further clarifications on ToR 5, with the rest of the day being used to discuss whether the ToRs were or were not met. The end of the third day and the fourth were used to start drafting the SARC summary report and final clarifying discussions on ToR 5. The review panel discussed each term of reference and agreed on the main to be included in the SARC summary report, which was finalized by correspondence prior to submission to

1 https://www.fisheries.noaa.gov/new-england-mid-atlantic/population-assessments/red-hake-stock-structure-working-group

NEFSC scientists for a final check. Each of the three CIE reviewers worked independently to prepare the individual reviewer report.

Role in the reviewer activities

As a CIE independent reviewer, my role focused on conducting an impartial peer review of the work developed by the Working Group associated with the Red Hake Stock Structure Research Track, particularly on the six predefined ToRs.

I read all the documents that I received about two weeks prior to the review meeting. I also read the four appendices sent some days prior to the meeting. During the presentations, I was actively devoted to maximizing the time available to ask further clarifications and enrich the associated discussions between the review panel and WG members to ensure a well-founded basis to assess whether each ToR was met. I listened carefully to the presentations, which I also downloaded from the share-point, and asked for clarifications on the data structure, data coverage, and adequacy of each method, as well as some details on the methods used and model development for data analyses and the estimation of the biological reference points. I provided comments on the strengths and weaknesses (if any) on each ToR, particularly addressed to: i) reach an agreement on the ToR level of achievement and ii) providing research recommendations, which are mostly included in the ToR 6 section of the present report. Given my expertise and background as a fisheries oceanographer, and particularly on similar multidisciplinary stock delineation for Mediterranean fish stocks, I provided comments considering an integrative view of all the information provided. I also fully participated in intersessional discussions on the level of achievement of each ToR.

After the review meeting, I summarized the findings and recommendations associated with each ToR and contributed to development of the peer review summary report led by the SARC chair. I have prepared the present independent peer review following the instructions provided in Appendix 3 ('*Individual Independent Peer Reviewer Report Requirements*').

Summary of findings and recommendations for each Term of Reference.

Review of relevant literature (ToR 1).

i) ToR 1 Description:

"*Review and summarize all relevant literature on the existing stock structure of red hake in the northwest Atlantic*".

ii) Degree of achievement, findings, strengths and weaknesses of ToR 1.

This ToR has been **fully completed** with a very detailed review of all published and documented studies available to date on stock identity presented in a coherent chronological order.

The WG has provided a synthetic view of the technical and scientific basis in all studies for defining spatial management units for red hake. All the information presented evidence that revealing the stock structure of this species has been always challenging with the perception of stock identity having changed over time.

The WG provided a very complete and useful introduction to the biology and ecology of the species, fishery description, and the different periods of the history of the fishery before presenting the objectives associated with ToR 1. Once focused on the ToR, the WG presented that during the period when the International Convention for the Northwest Atlantic Fisheries (ICNAF) was in place, four international stocks were considered: Scotian Shelf (SS), Gulf of Maine (GM), Georges Bank (GB) and southern New England-Mid Atlantic Bight (SNE). This delineation was based on the studies by Richter (1968, 1970), which were reviewed by Anderson (1974). Richter (1968) and the extension of his study in 1970 analyzed samples of red hake collected in the fisheries during 1965-1968 using meristic characters (e.g., the number of rays in the first and second dorsal, pectoral and anal fins, and the number of vertebrae), site at age, and size and weight of otoliths. In the review of these studies carried out by Anderson (1974), he included updated information from surveys adding a description of the seasonal movements of the species between shallow and deep habitats. He concluded that there was not a sufficient basis to establish the stock structure and that separating northern and southern GB as separate stocks would be problematic in terms of fisheries assessment and management. In consequence, three stocks were recognized by ICNAF for US waters: GM, GB and SNE.

The WG reported that in 1985 the stock structure in US waters was revised and modified to the current and accepted division (the last benchmark assessment of the species by the NEFSC was in 2011): a northern stock (including northern GB and the GM) and a southern stock (including southern GB and SNE). While the reported arguments were based on the survey distributions and the similarity of these distributions between red and silver hake, the WG wanted to highlight the second NEFSC Stock Assessment Workshop conclusions that the previous stock definitions '*are currently thought to be incorrect*' (NEFSC 1986). The WG also reported additional studies reporting differences between the northern and the southern stocks in their spawning seasons, seasonality in the otolith patterns, growth patterns, seasonal habitats and movement patterns (Derry 1988, Steimle et al. 1999).

The reported differences in spawning phenology, and growth and morphometry, as a consequence of the colder waters experienced by the northern stock compared to the southern one, lead the WG to attest to the likely existence of two 'phenotypic stocks' as already suggested by Booke (1981). All the information reviewed was finally used by the WG to establish four putative stocks in further confirmatory analyses: SS, northern GB and the GM, southern GM and SNE. Finally, the WG also highlighted that, besides the strong continuous changes in distribution of red hake due to ocean warming towards the north (as also seen in other demersal species, e.g., Nye et al 2009, Klisner et al. 2016), the confirmatory analyses assessing the

geographic variation among putative stocks should consider temporal stability of the investigated differences.

While **no major weaknesses** have been detected, there are two issues that were initially brought up in the discussions of ToR 1 that were indeed recurring throughout the review meeting. First, the misidentification between red hake and white hake, both in fisheries monitoring programs and surveys. This mainly leads to the misidentification of young white hake as old red hake, as was pointed out by the members of the WG. However, there is not any quantification yet of the degree of the misidentification and its impact. This could certainly affect the phenotypic differences observed between the northern and the southern stock. Second, the ecosystems under study and the inhabiting species have shown clear directional changes in distributions over the last decades. The assumption that 'temporal stability should be considered with no effect in the confirmatory analyses' must be double-checked in the future (see more detailed comments in ToRs 2 and 3).

It is also important to highlight that, in the report, there is a summary of the recent assessments, which was not presented in the review meeting. This summary provides relevant information brought up in the last benchmark assessment for red hake that occurred at the Northeast Stock Assessment Workshop 51 (SAW 51) in 2010. Some of this information is related to the weaknesses aforementioned, for instance, the need for developing an accurate time series of catch that copes with the misidentification of red hake and white hake and the high levels of discards. It was concluded that catch data remained a significant source of uncertainty. Also, new information on temporal changes in the estimates of consumption rate was provided in that workshop, reporting an increase of ratios of consumption from less than 1 before the 90s to more than 6 from 2000-2010. This workshop also assessed the results of the assessment performed with An Index Model (AIM) for the northern and southern stocks as the basis to propose biological reference points. These last two elements are fully developed and commented on in ToR 5 (see below).

iii) Conclusions and recommendations

I do support the two main conclusions established by the working group: i) ICNAF assumed different stock boundaries (i.e., for practical reasons) and ii) current information and studies available on red hake generally supports the current management units (i.e., northern and southern stocks). However, further research efforts might be focused on investigating whether the levels of misidentification between red and white hake could be affecting conclusions established on the two phenotypic stocks. Finally, non-stationarity in the differences between the putative stocks must be also considered in the future, i.e., a change in the degree of phenotypic differences between stocks with the northward change in the species distribution.

Identify and evaluate new and existing data (ToR 2).

i) ToR 2 Description:

"*Identify and evaluate any new and/or existing data relevant to the stock structure of red hake including but not limited to the species' life history (i.e. spawning, distribution, abundance, growth, maturity and natural mortality), morphometrics, and genetics*".

ii) Degree of achievement, findings, strengths and weaknesses of ToR 2.

This ToR has been **fully completed** with a thorough identification and evaluation of all existing and new data of relevance to inform the red hake stock structure. To do that, the WG has conducted a multidisciplinary approach (e.g., Cadrin et al. 2014) with a series of new analyses of available data and models over different types of data that are here assessed separately. Prior to going through the results of each technique, the WG described the main limitations: lack of population genetics studies, lack of tagging effort, sporadic aging of red hake in the surveys and the fact that red hake is not a target species. In this sense, the evaluation of red hake stock structure was generally considered data poor. For analytical purposes, a total of 9 sub-regions in US were considered: 4 in GM, 2 in the GB, and 3 in the SNE.

- *Fishery-dependent information*:

The fishery-dependent information compiled by the WG was of different origin: observer program, study of self-reported fleet data and DMIS-reported landings data. Each type of data has different levels of coverage and potential biases. Discards and landed catches of different fisheries (targeting squid, whiting and other demersal species) were first presented with data available from 1994 to 2018. The data presented showed spatial discontinuities between north and south, based on the limited crossover of vessels landing red hake from the two stocks. It was also suggested that the effects of regulations and fish migrations are evident in the seasonal distribution of the observed catches for each of the current stocks. The WG pointed out that these patterns support a two-stock structure. Further analyses were developed using DMIS (Data Matching and Imputation System from the Catch data from the Greater Atlantic Regional Fisheries Office, GARFO) CPUE time series from 2010 to 2018. With this information, a hierarchical clustering and Multivariate Auto-Regressive State-Space (MARSS) models were developed to evaluate the coherence of the CPUE time series. These models, particularly the MARSS models, suggest that the model with the two-stock structure (GOM vs inner GB, outer GB and SNE) had the lowest AIC, pointing also to the same conclusion: the two-stock structure with the current boundaries had the most support. Despite the limitations of the fisheries-dependent data, I found the MARSS models very illustrative and complete, having tested for many stock structure combinations including the one-stock structure. In addition, the temporally coherent patterns observed are consistent with those shown for the surveys of the two stocks (Appendix 1 to the WG report). It would have been useful for these results to have received more emphasis and time during the meeting.

The specific findings provided by the fisheries-dependent data were valuable information. However, they present a **few weaknesses** that might undermine their value to support the conclusion of a two-stock structure:

- The spatial information of landings used is highly heterogeneous. Therefore, it might poorly represent the spatial distribution of the species within each stock.
- Fishery-dependent data are highly influenced by the fisheries dynamics, which are mainly affected by the dynamics of the target species (targeting squid, whiting and other demersal species). Therefore, it is not known (or at least not shown) to what degree the seasonal and the spatial segregation observed were driven by other species rather than red hake. The contrasting patterns of landings presented for each fishery points in this direction.

- Misidentification between red and white hake, with small white hake being classified as old red hake, and large red hake eventually being classified as small white hake, could also affect the patterns observed in each fishery.

- *Trawl survey distributions*:

Information collected by surveys in both the fall (1963-present) and spring (1968-present) were presented. The vessel used changed (from the 'Albatross' to the 'Bigelow') in 2008 to 2009 and a calibration study was implemented during the change-over including a change in the gear. Winter and summer surveys were also available, although with a smaller spatial and temporal coverage (1992-2007 and 1977-1983 respectively).

Spatiotemporal changes in the species distribution are generally consistent between seasons. A generalized decrease in biomass of red hake affects mainly the SNE and western GB region with a drastic shift in the middle 80s, while the biomass estimates for the eastern GB, south GM, and shallow-northwest GM were more fluctuating with greater seasonal contrast as those areas seems to be associated with seasonal migrations. The central and northern GM show a fluctuating increase in abundance, more apparent during the last decade. These results seem consistent with fisheries-dependent CPUE from DMIS (ToR 1), with a decline in the southern stock and an increase in the northern stock considering the current stock definitions. Along with the expected shifts in mean latitude and longitude as a consequence of a northward distribution, shifts in depth were also reported driven by a change of fish from sub-regions where they have always occurred at shallower depths to sub-regions where they occur at deeper depths (mainly from SNE to GM). The increase in temperature is more prominent and steadily observed in the fall, showing the effect of ocean warming with red hake inhabiting the SNE and GB region experiencing higher temperatures compared with those inhabiting in the GM. The WG also presented biomass-weighted average temperature that did not show pronounced trends as it integrates two opposing processes, a distribution shift from warmer to colder areas and a generalized ocean warming.

Size truncation was observed in all areas, being pronounced in the SNE from the mid 80s and associated with the big shift in biomass in this area. Besides that, there is also a gradient in mean length (90_{th} percentile and % of abundance by region for length classes presented) from the GM to SNE, with intermediate sizes in the southern GM and eastern GB. Seasonal comparisons of length data showed evidence of a movement to shallower areas in the summer and deeper in the spring, as well as suggesting seasonal movements across stock boundaries, at least between the south GM (sector D of GM) and the west GB (sector A of GB).

The information provided by trawl surveys provides the most accurate view of spatiotemporal variation of the species biomass across putative stocks and the different sub-regions. The WG has provided a very complete and elaborate synthesis of all the information available, which I do acknowledge. While I generally agree with the interpretation that the WG gives to this information, and I do **not identify major weaknesses,** I provide below a complementary view of some of the information provided:

- Based on the information and interpretation provided by the WG, the changes in abundance are more likely a consequence of displacement and movement of individuals than regional changes in the production of the species. Although the consequence is a different pattern of biomass for the northern region and stock abundance eventually supporting the current management structure, a better understanding of the processes behind the steady shift in the distributions is required.

If the red hake have been crossing management boundaries over the last one to two decades, a two-stocks structure could certainly be compromised.

- Further research on the causes of the generalized size truncation is needed. Beyond changes in distributions, size truncation is a generalized process attributed to environmental changes that was not convincingly proved. While fishing does not seem to be an important driver as for a target species, fishing impact can still have size-selective effect on non-target species. Also, truncation may also be the synergistic consequence of the combined effects of climate and fishing. This information would be useful for a potential future revision of the stock structure of red hake.

- *Spatial coherence in time series of abundance*:

The WG has applied a 'management unit estimator' technique developed by Cope and Punt (2009) that allows one to group spatial units that display similar population trends. The method has been applied to fall survey data, spring data, and the combination of the two using data from 1968 to 2018. This method assumes that areas clustered together behave as one stock with the same population dynamics. This assumption is consistent with the fact that abundance indices are incorporated into stock assessment models. The method uses K-medoids clustering to determine the best grouping of regions given a pre-defined number of clusters (k). The WG tested values of k from 2 to 8 and used a silhouette analysis to select the best model.

Regarding the results obtained, the WG concluded that the current stock definition generally got the greatest support, particularly when spring-fall and fall data sets are used. In most of the models, the most separated areas, SNE and northern areas of GM, are well and consistently separated, while regions in between do not always cluster consistently. The WG states that adding Scotian Shelf (SS) information provides a more complex scenario to interpret.

I believe that the 'management unit estimator' is one of the most valuable, powerful, useful and descriptive techniques used. One of its main strengths is the direct application of the survey indices into a traditional stock assessment. However, it presents a **few weaknesses** that might undermine its value to support the two-stocks structure:

- In my interpretation of the results, the models that support the two-stock structure are highly influenced by the dynamics and the spatial patterns prior to the mid-80s, when the dynamics of the GM and the SNE were strongly segregated. This old time period does not correspond with the spatial and temporal dynamics over the last three decades. The WG concludes that including the SS, which focuses on information from 1980, makes the results more difficult to interpret and more complex. However, this might be a more realistic scenario for these stock complexes in the recent period. Focusing on US information, I would recommend reanalyzing the data using only the last three decades if further analyses are conducted.
- If future analyses using other techniques (ToR 6) suggest significant movement of fish across the current stock boundary, this method could not, in my view, be applied.

- *Habitat analyses*:

The WG evaluated the specific models for red hake published in a recent scientific publication by Friedland et al. (2020) applying random forest models on both fall and spring survey data. The model includes both static (e.g., bottom substrate type) and dynamic environmental information (chlorophyll concentration and temperature). Results show consistent results

between seasons with a general decline in habitat suitability in part of the southern sub-regions and an increase in the most northern sub-regions.

As a result, the temporal trends resulting from the model predictions are consistent with those observed in the surveys in the GM and SNE, providing evidence of one of the processes behind the changing distributions. However, a **few weaknesses** might be considered when the results are used to inform about the species' stock structure:

- The model does not predict the temporal patterns in the GB, which has been an important area in recent years, and not only as the most relevant spawning area.
- It is also relevant that the model is exclusively environmentally driven, but other ecological interactions (prey-predator interactions) that have been suggested to be relevant in the last decades could be included in future spatial models.

- *Life history*:

Past results of an otolith morphometry study by Derry (1988) and information on age and growth (length-at-age data) were analyzed based on 20,000 fish from 1970-1985 and new information on 10,000 fish from 2008-2019. The analyses performed explored differences between the existing stock structure, sex, season (fall vs spring) and period. The WG applied different methods to examine the data, particularly those of mean length at age, such as ANOVAS, cluster analyses, direct comparisons of length ranges between key ages (age-2 and age-4), period and stock, and K-medoids clustering. The WG argued that, with differing levels of support, the different methods point in the same direction, showing that growth patterns are consistent with the two 'phenotypic' stocks, and that the fish inhabiting warmer waters grow faster at smaller ages (i.e., age-4), while they reach shorter length at larger ages compared with fish occurring in colder waters. These differences were much stronger in the period 1970-1985, while a generalized decrease in growth has been observed, but still maintaining the differences between the stocks.

The results provided by the growth analysis were among the most valuable for the WG as they support the established stock differences in key life history information that has a direct impact in the assessment. However, the interpretation has **some weaknesses** that might undermine its value to support the conclusion of the two-stock structure:

- The most relevant weakness is the unknown influence of the misidentification between red hake and white hake on the age readings. The WG members stated that they are relatively confident in a reduced misidentification in the recent period, while it could be more prevalent in the past. This can affect the strong support of growth to the two-stocks structure since it is mainly driven by the differences in the first period. Since stock structure before the 80s or 90s was in a period completely different in terms of the species' productivity, spatial structure and distribution, and environmental circumstances, all results associated with the earlier periods might be informative but not determinant about the stock structure.
- While table 2.1 shows the consistent differences in median length-at-age from age 4 to 7 consistent with the ranges shown in table 7B of Appendix 3 in the WG report, the growth curves presented in Figures 2.23 and Figure S1 of this Appendix 3 do not show such differences, or only at very old age classes that currently make a small contribution to the stock. It is recommended that, if the aging is revisited to support the lack of misidentifications, the significance of the differences in growth between the two current stocks also be revisited.

- *Otolith microchemistry*:

The WG presented results for a one-year study developed using 20 samples (core and edge in each otolith) in four regions during the fall bottom trawl survey in 2011: the east and west of the north GM and, in the mid-shelf and outer shelf of the Mid Atlantic Bight (MAB). The working group presented the results of the ratios of Sr/Ca, Ba/Ca, Mg/Ca, and Mn/Ca for both core and edge of the otolith, showing no difference between areas. These results suggest that early life stages of fish captured in the GM and MAB were exposed to the same environment. Also, the samples of the group were exposed to the same environment during summer 2011. While the results in the core might not be surprising because of the suggested primary spawning area in the GB (see below spawning areas), they were unexpected for the edge. The WG found the information valuable while it was characterized as a pilot project since only one year was used. Given that other studies on Atlantic cod revealed certain spatial differences, the WG recommended caution in the interpretation of the otolith microchemistry results.

I fully agree with the interpretation of the results by the WG and **no major weaknesses** are identified. I just provide here below a brief comment on the results:

- Since the otolith microchemistry information does not support a two-stock structure, pointing instead to a one stock structure, further research is needed applying this technique, including more years, areas (including Scotian Shelf samples) and combining information of oxygen stable isotopes that more closely track differences in temperature experienced by fish.

- *Spawning, early life history and larval connectivity*:

For the study of the early life history and spawning areas, the WG presented information from larvae observations obtained in two sampling programs (MARMAP from 1977-1988, and ECOMON from 1999 to present). A drifter probability model and a particle-tracking model were also used to assess larval transport, connectivity, and spawning aggregations applying backtracking models. Combining genetics and morphological traits, 27,591 *Urophycis* larvae were re-examined, resulting in 19,526 red hake larvae that were available for analyses.

In contrast to the changes in distribution observed in the adults of red hake, larvae distribution was generally persistent between periods, with larvae primarily distributed in the southern stock across the transition between west SNE and east GB in July/August and September/October. An emerging secondary area occurs in the western GM, but with a very small contribution to the larval abundance. Length and hatch date distribution were analyzed, showing that, within the spawning window July to September, spawning occurs earlier in the GM, followed by an intermediate hatch date distribution in the GB, and being later in SNE.

Particle tracking and drifter models provide similar patterns with the source region being in close areas upstream: juveniles recruiting in SNE are most likely from the same season, juveniles that recruit in the GB are the consequence of the retention due to clockwise mesoscale structure around GB and some local sourcing in the south of the GM, and juveniles recruiting in the north and western GM are likely spawned in the GM.

The information revealed by the models and the observations are consistent and **no major weaknesses are identified.** This information provides evidence that the main spawning area is associated with the southern stock, while the higher recruitment estimates (ToR 5) and young-of-the-year (below) occur in the north giving support to juvenile migration. Further research should investigate the dynamics of this migration to assess the implications on the stock

structure delineation and stock assessment. I also agree that further research needs to incorporate behavioral information in the dispersion models to better understand the juvenile distribution.

- *Young of the year and recruitment*:

Besides the numerous caveats presented for the information available for young-of-the-year (YOY) of red hake from the NESFC surveys (lack of complete information of association with scallops, lack of consistent age data or high uncertainty of the change of vessel calibration, or more shallow distribution of young fish), YOY have been historically found in the GB area (north GB and south GM) in fall at sizes 1-10 cm and later in spring in GM at sizes 11-18 cm. However, in recent years (2013-2019), a drastic change in the YOY distribution occurred with a decrease in the GB and an increase in the northern GM, consistent with an increase in recruitment from 2014 in the northern stock (TOR 5).

All results of YOY, recruitment, larvae distribution and modeling, point towards a spawning and juvenile migration that the WG has very well synthesized and presented. Red hake migrate to spawn in the GB area with settlement (YOY, juvenile nursery) also occurring in the GB area (including south GM); which is the southern stock. The young immature fish and adults after spawning migrate to feeding areas mainly located in the GM; which is the northern stock. This suggests a seasonal crossing of current stock boundaries consistent with otolith microchemistry information, giving certain support to a one- stock complex. An increase of recruitment in the northern GM since 2013 points to an increase in the spawning activity in this region that needs to be monitored in the future in terms of population dynamics and stock structure, as is clearly recognized by the WG. This pattern is also found in recent years by DFO in the Bay of Fundy.

I fully agree with the interpretation on the juvenile/spawning migration proposed by the WG and identified **no major weaknesses**. However, I do have **some comments** on the relevance and impact of this interpretation:

- While the change in the distribution of YOY after 2013 suggests a change in the spawning migration, the lack of larval information in this period precludes further confirmation. The stock seems to be highly spatially dynamic and non-stationary during recent years. If this change in spawning suggests a movement of spawning (and consequent recruitment success) from the south to the north around 2014, it would compromise a two-stock structure since a major component of the same spawning stock would be associated with the southern stock during the early period and switching to the northern stock in the recent period.
- The WG does not seem to give much credence to this synthesis in the delineation of the stock structure, stating that there is a lack of a second line of evidence for this migration. In my interpretation, its importance should not be undermined and the implications of the cross-boundary migrations should be revisited in the future (if it still persists), as it suggests a more complex stock structure.
- The consistent findings observed by DFO in the Bay of Fundy suggests a transboundary 'northern' stock in the recent years that should be further investigated.

- *Use of the AIM model*:

An Index Model (AIM) was used to assess the likelihood of different potential stock structures. Assuming that the exploitation rates are driving the stock dynamics, AIM was tested for 10

potential stock structure options including one-, two-, and three-stock hypotheses and tested for statistical significance. The approach assumes that if the appropriate stock structure is chosen and if exploitation rates are driving population trends, then the AIM model should be significant. None of the 10 models were significant, thus this approach did not provide useful insights into stock structure. Non-significance also suggests that fishing mortality is not driving abundance of this species, most likely due to changes in productivity or migration that lead to a lack of temporal relationship between fishing mortality and the index of abundance. The WG concluded that the AIM results do not provide insights on the most plausible stock structure nor should they be used in the stock assessment.

As the modelling approach is not useful, which I do agree with, **no major weaknesses are identified.** Further comments on the stock assessment approaches are given in the ToR 5 section.

iii) Conclusions and recommendations.

The work developed by the WG for the ToR 2 has been very thorough and complete, and I do support the general views and interpretations provided. Though very simplistic, three main conclusions can be established: i) the presence of phenotypic stocks with independent dynamics that would support a two-stocks structure; ii) evidence for cross-boundary juvenile and spawning migrations that could support one complex stock; and iii) well-founded evidence that the species' distribution by age, spawning activity and eventually migratory patterns have changed from 2013 to a new scenario. The WG considered that ii) and iii) need more evidence and further research. While this is true and more evidence is needed, I see there is certainly more support for this migration pattern than recognized by the WG. Also, the phenotypic differences may be revisited after a revision of the misidentification between red and white hake, as well as shortening of the time series by removing the effect of information prior to ca. 1985 that corresponded to a period that contrasts over the last decades in terms of the species' distribution and growth.

Recommend the most likely biological stock structure (ToR 3).

i) ToR 3 Description:

"*Recommend the most likely biological stock structure among a set of alternatives from TOR2. Consider the current management unit as null hypothesis*".

ii) Degree of achievement, findings, strengths and weaknesses of ToR 3.

This ToR has been **fully completed** with the results leading to the conclusion that, on the basis on the current available information, there is not enough information to reject the null hypothesis of the current structure of two stocks.

There was no evidence for any of the techniques used that there were three stocks or a further subdivision of the main three sub-regions (SNE, GB and GM). Therefore, most of the synthesis work and discussions of the WG and the review meeting focused on the basis for rejecting the null hypothesis in favor of a one-stock structure as well as the geographical location of the boundary.

The main arguments of the WG to maintain the current management units were: i) the occurrence of two phenotypic stocks and ii) the regional grouping of fish with common characteristics, particularly their common productivity trends. The techniques and/or information supporting the current stock structure were: fisheries dependent data, trawl survey distributions, trawl size structure, k-medoids clustering, growth, meristics and otolith morphology. Since variation of life history traits (mainly growth) and an abundance index derived from surveys have a direct impact on the stock assessment, the two-stock management structure is the most practical for integrating the main geographical differences observed in the stock assessment models. The WG also added that there were some considerations of the different groups responding coherently to fishing pressure and environmental variability, which was well supported for the later but not for the case of the fishing impact. An additional argument stated was that there must have been little exchange of adults between the two stocks given the long-term coherence in spatial differences in growth despite the temporal trends in the two areas. The WG also argued there was little exchange across the stock boundaries occurs once juveniles recruit in the different regions. Finally, the coherence in the population trends in the two stocks given by the management unit estimator was also considered meaningful.

The techniques and/or information supporting a one-stock structure were: larval distribution, young-of-the-year in fall, larval connectivity (although some of the results could be also applied to a two-stock structure), and otolith microchemistry. The main arguments suggesting a one-stock structure were the young-of-the-year distribution spread continuously across the management boundary and the lack of consistency between the long-term trend of increasing adult biomass in the north and the lack of a clear trend in the north-south ratio of young-of-the-year abundance. This would indicate that the stock-recruitment relationship is not independently operating in each stock. Although there is no information from natural or artificial tags, the WG acknowledges that there is an overwintering movement of juvenile fish from the shallow area of GB (both northern and southern stocks) to the deep areas of the GM. However, there was not any direct evidence of migration of red hake from GM to GB to spawn.

Although larval data observed in the northern area were observed in low density, demographically successful spawning activity was considered to occur in the two areas. Larval connectivity information gave the main support for a main spawning area in GB consistent with the observations, while it was also acknowledged that spawning activity in the north GM would be self-recruited or eventually recruiting in the Canadian waters. Finally, it was also argued that, if this spawning migration occurs, it is of short duration and there is little catch on the GB spawning grounds. In summary, information provided by early life stages of red hake suggests that the stock boundary 'was not absolute' with larval, ontogenetic and seasonal movements across the stock boundary, while there is not still enough evidence to reject a two-stock structure in favor of a unique stock unit. Further research was requested by the WG (see ToR 6).

The delineation of the stock boundary, assuming a two-stock structure, occurs in an area of no or very limited catch which is, from an applied perspective, very practical. For the WG, the established boundary was clear in terms of growth differences and the management unit estimator. Early life stages, including young-of-the-year, distributed across the boundary were not commercially exploited.

Weaknesses associated with this ToR are described above for each of the different techniques applied in the ToR 2. A relevant synthesis affecting stock delineation of red hake is reviewed in the sub-section below.

iii) Conclusions and recommendations.

I agree that the uncertainty of the spawning and juvenile migration, along with the lack of genetics and tagging information, were important concerns, but these results are not sufficient to reject the null hypothesis of the two stocks. With this scenario, I fully agree that maintaining the two stocks is the most practical management approach on the basis of the assessment information: phenotypic traits (growth) and population temporal trend differences for each stock. However, I do have **some comments** on the relevance and impact of this decision:

- The pivotal ecological and demographic cornerstone within the population dynamics and stock assessment is the stock-recruitment relationship (SRR). There is enough support to question whether the SRR is not independent for each subunit. If a future goal is to move towards an age-structured stock assessment, the impact of spawning and juvenile migration on recruitment success needs further research.
- Phenotypic differences might be revisited when misidentification is solved and information from historical periods (i.e. prior to the mid-80s) removed, as this information is driving most of the argument favoring the current stock structure.
- Also, further research is needed (ToR 6) to address the current lack of knowledge concerning the emergence of a new scenario in recent years (from 2013) and how it is evolving in the close future needs further attention. This could be indeed be related to the sharp increase in recruitment in the northern stock in 2014 reported in ToR 5 that corresponds with a decrease in the southern stock, making the combination of the two a relatively stable temporal pattern. Further research is needed to understand the processes associated with this change in 2013 and whether it was associated with a change in the local productivity, a change in the migration pattern, or a movement of fish from south to north. The latest two options would compromise the two-stock structure.

Evaluate existing experimental data on survey catchability (ToR 4).

i) ToR 4 Description:

"*Evaluate existing experimental data on survey catchability of red hake. Examine the sufficiency of catchability data and, if appropriate, incorporate the catchability estimates into the assessment*".

ii) Degree of achievement, findings, strengths and weaknesses of ToR 4.

This ToR has been **fully completed,** with the WG evaluating several sources of experimental information on red hake catchability and assessing the importance for incorporating this information into assessment procedures.

After the change of vessel (the '*NOAA Ship Henry B. Bigelow*') and gear ('*4-seam 3-bridle trawl equipped with a rockhopper sweep*') in 2009, a new net and survey operations protocol was needed with the objective of providing a representative sampling that allows unbiased indices of abundance for a suite of species rather than optimizing the capture of any single species. A rockhopper sweep was chosen to be used in the survey as it allows towing

over complex bottoms, increasing the credibility of abundance indices for species living over complex bottoms. However, unknown proportions of some species are able to pass underneath the net and there was then a need to determine species-specific catchability estimates to be used in the empirical estimates of stock biomass. An additional element of uncertainly was the changing wingspread with depth that triggered differences in the swept area, gear geometry and bottom contact, all affecting catchability. For the case of red hake, the WG gathered four sources of information: industry conversations and insights, HabCam (Habitat mapping Camera System) estimates of population density and behavior, a twin sweep efficiency study, and a twin net spread study.

The overall message of the conversations with fishermen was that red hake tend to have a similar behavior as flatfish in response to the gear, in contrast to the behavior of silver hake. For fishermen, the red hake's behavior of passing under the gear is positive as they reduce their catch while maintaining their silver hake catch.

HabCam, used to survey scallops in May-July since 2012 from Mid Atlantic Bight to GB, was used as unbiased estimates of red hake abundance (i.e., a catchability rate of 1) as some of the survey habitats of scallops are also the habitat of red hake. Due to the large number of images, only those from the survey of 2015 were used to be compared with trawl surveys, which had good coverage of the study area. The images with roundfish were then reannotated to identify red hake, which can often be easily distinguished from spotted hake. However, some fish can be difficult to distinguish if the photo is obscure, due to the orientation of the fish causing difficulty identifying the spots of the fish. Once the ratios of red and spotted hake were double-checked, the analyses of data indicated an efficiency of the survey gear of about 15%. It is worth noticing that this was based on data from only a single year of data and wingswept area.

The twin trawl chain experiment evaluated the efficiency of the rockhopper sweep for bottom tending species such as flatfish. The chain sweep is designed to maximize catchability (i.e., as close to 100% gear efficiency as possible). Using the twin trawl design, a rockhopper sweep was towed on one side and a chain sweep on the other side. These experiments were running from 2015-2017, but red hake was a target species only in 2017. Given the 100% catchability in the chain sweep net, the study provides conversion factors to convert trawl survey catches to absolute numbers. Since there is considerable evidence that red hake are closely associated with the bottom, the conversion factors need be used to derive total biomass estimates. The study established an established peer-reviewed methodology that has been used for various flatfish stocks.

The twin trawl net spread experiment was designed to test the consistency of gear catchability across depths, tested in terms of different wingspreads, and also tested for different red hake length ranges. The study found little difference in red hake catches, either across depths or length. The WG decided that no adjustments were needed for the catchability estimates.

No major weaknesses have been detected in the work for this ToR; a few recommendations already noted by the WG are stressed in the section below.

iii) Conclusions and recommendations.

I support the main conclusions established by the WG in terms of catchability. This includes: the lack of evidence that changes in the wingspread affects the efficiency of the gear, the analysis of the chain sweep study was appropriate for estimating maximum catchability at length and minimum total biomass and it can be used for other species, the HabCam and chain

sweep catchability values were very similar, giving additional robustness for values of this study. While no additional recommendations are given for this ToR, I do agree with the WG that the HabCam analysis provides very relevant results and is an emerging line of research to be pursued further and a future primary source of data for estimating catchability. Finally, I also acknowledge that the WG informed the review panel that while red hake was the first species analyzed, many additional species are undergoing evaluation for a more holistic and integrative understanding of catchability.

Apply the existing and alternative assessment models, and evaluate existing reference points (ToR 5).

i) ToR 5 Description:

"*Apply the existing assessment model framework to the stock structure based on TOR 3 and 4 to ensure its utility in subsequent management track assessments. Evaluate existing reference points. Consider alternate assessment approaches if existing model framework does not perform well, and consider alternate reference points as needed*".

ii) Degree of achievement, findings, strengths and weaknesses of ToR 5.

The WG has developed thorough and insightful work in this challenging ToR, and all the **technical developments have been sufficiently met.** However, in reference to the alternate reference points and their use in qualifying statements about stock status, these **reference points need further evaluation** before they are used for management and the status of 'overfishing not occurring' in the **southern stock needs to be revisited**.

In a first part, the WG assessed the northern and southern stock as decided in the ToR 3 (i.e. fail to reject the null hypothesis) applying the AIM (An Index Method) model, which was already described in the ToR 1 and applied as one of the techniques in the ToR 2. The AIM is based on the assumption that catches are driving stock productivity trends, and thus the relative F (catch/survey index) and the survey index are significantly related. Making use of the swept area biomass derived from ToR 4, the WG was able to estimate an absolute F and, consequently F_{MSY} (i.e. relative F at a replacement ratio of 1) as a reference point. The models were not significant for any of the stocks and, therefore, the reference points were not meaningful. As a consequence, the WG agreed that the AIM model used in previous assessments should not be used in future management track assessments.

In a second part, the WG applied an alternative method for the estimation of biological reference points. An empirical approach was used on the survey data from 1963-2019 and then from 2009-2019. The method has been successfully used in previous analyses (e.g. for butterfish, Miller and Rago 2012; Miller et al. 2013). The later period was considered to better capture the recent productivity of the stock. The WG reached a consensus that the methods presented were technically sound and I do agree. However, while all the assumptions taken for the model were well-presented (selectivity 0 below 19 cm, natural mortality of 0.4, different maturity ogives for each stock, and the stocks in equilibrium), their potential impact on the sensitivity of the reference points, in addition to other potential sources of uncertainty, challenge their use for the management of red hake.

The reference points selected were the equilibrium fishing mortality and SSB associated with the 40% ratio of spawning potential ratio (F_{40} and SSB_{40}); that is a reduction of the spawning potential ratio to 40% of the unfished level. This is a widely used and accepted approach for deriving proxies of MSY-related reference points. The SSB_{40} was calculated for each of the stocks by stock, multiplying the average of the recruitment estimates from the chainsweep-based numbers (2009-2019) with the equilibrium SSB per recruit at F_{40}. 1000 bootstraps were generated to obtain the distribution of these reference points.

The fishing mortality estimated by the models for the northern stock was 0.001-0.004, very low relative to the F_{40} value of 0.247, with the SSB also ranging above the SSB_{40}. For the southern stock, the fishing mortality was higher (0.02-0.05), but still low relative to the F_{40} of 0.333, with SSB also ranging above. Attending to these values, the WG stated in the report that the two stocks were estimated to be not overfished and overfishing was not occurring.

Since the exploitation rate has been very low during the last decades, it would be reasonable to think that overfishing is likely not occurring. In the case of the northern stock, estimates from surveys during the last period were indeed very similar to the values in the mid-80s and 90s, which, in addition to the low exploitation rate, makes the overexploitation status unlikely. However, I feel that the situation of the southern stock is certainly different. The current survey indices are at the minimum levels over the whole time series, and the exploitation rates obtained from the model were very low (ca. 10-14% in relation to F_{40}), and the stock has not been able to recover. Under this scenario, it is reasonable to challenge and question whether overfishing is not occurring. This lack of growth in the southern stock may have several but not mutually-exclusive explanations. First, very low recruitment survival or recruitment success (most likely environmentally driven). The model, which is appropriate for a data poor stock, does not include a stock-recruitment relationship which makes it impossible to include density-dependent forcing of the recruitment; it still requires further research. A second potential reason is the potential increase in the Natural Mortality (M). It was reported (ToR 1) and discussed during the meeting that the consumption rates by a suite of predatory fish has multiplied by a factor of 6-fold, at least, during the last three decades. In the 2010 assessment workshop, it was indicated that this information should be incorporated into the assessment. Higher M than 0.4 could result in higher estimates of F_{40}, thus challenging the use of spawning potential ratio reference points. The WG acknowledged that reference points are sensitive to changes in M and it was largely discussed in the meeting with some options suggested, such as the development of sensitivity analyses to a range of M calculated with a catch curve analysis based on the survey data. And a third explanation, challenging the equilibrium assumption of the model, is the potential diffusion of fish from the southern stock to the northern stock. The coherent asynchrony in the productivity patterns from 2009 to 2019 between the two stocks with a shift around 2014 is consistent with the change in young-of-the-year shift to the northern area reported by surveys (ToR 2). A potential explanation is a direct movement of fish from the southern to northern area stock as a consequence of the long-term change in fish distribution. Different approaches have been proposed to empirically test the occurrence of diffusion on the assessment models, with some of them requiring movement data and demanding age-structured models (Goethel and Berger 2017, Jardim et al. 2018).

Finally, two additional concerns were raised. First, the sensitivity of reference points to the selectivity assumptions (e.g., 0 catchability below 19 cm) was also discussed in the review meeting with a request for further evaluation. And second, there is a need to enlarge the time series used in the assessment prior to 200,9 because a time series of 11 years of recruitment

estimates would not be sufficient to calculate robust SSB_{40} values. This was acknowledged by the WG, which also expressed concerns associated with the change of research vessels and the associated change in the catchability from 2009. While I do agree with the WG that changes in catchability could affect reference points, the time series from surveys presented in ToR 2 do show significant differences in the biomasses, and I would recommend extending the length of the time series backwards, but avoiding the use of information before the mid-80s as it represents a contrasting productivity regime.

The **weaknesses** in ToR 5 are associated with the further evaluation of the sensitivity of reference points to some of the assumptions of the model in addition to other potential sources of uncertainty presented. Also, the qualitative assessment of stock status of the southern stock needs to be revisited.

iii) Conclusions and recommendations.

I do support the conclusion that the AIM model used in previous assessments is not valid and the associated reference points are not meaningful, and the model should not be used in future management track assessments. The alternate method applied for the estimation of biological reference points is technically sound and must be used if a management track assessment of this species does not move to an age-structured model. However, I would recommend i) to develop further evaluation of reference points and sensitivity analyses to natural mortality and catchability, ii) to increase the number of years in the assessment but not before the mid-80s, and iii) to complement the empirical model used with simulation modeling to assess potential diffusion from the southern to the northern stock or alternative sources for spatial heterogeneity across the stocks.

Identify gaps of existing research and prioritize research recommendations (ToR 6).

i) ToR 6 Description:

"*Identify gaps in the existing research with respect to red hake stock structure. Develop a prioritized list of research recommendations to address these gaps. Comment on the feasibility and time horizon of the proposed research recommendations*".

ii) Degree of achievement, findings, strengths and weaknesses of ToR 6.

This ToR has been **fully completed**. with the WG having reviewed a list of research recommendations and activities to be pursued in the future, focusing on the gaps in knowledge for red hake stock structure identified in ToRs 1-5 and the usefulness of some of the approaches to be potentially applicable for other species.

The WG recognizes the potential migration of red hake spawners and juveniles, and the consequences of the recent changes in the distribution of juveniles from 2013 (and how this scenario would evolve in the future) in terms of stock structure were the main knowledge gaps in terms of the stock structure of the species. I will follow here below the same recommendations structure and numbering as it appears in the report and providing additional recommendations to some of them.

Red hake specific recommendations:

1) *Implementing population genetics study on red hake*: It was assigned as a high priority activity which I support. A genetic study including different ontogenetic studies (larval, juveniles and adults) in all the regions (and sub-regions including transboundary Canadian regions) is highly needed as it can reveal whether the stocks are genetically isolated or not. I do support the WG's view to look at genetic markers that can detect significant differences on fine geographical and temporal scales. This particularly requires use of markers able to detect adaptive differentiation rather than neutral markers. Thus, SNPs or moving to genomic approaches (if funding is available) would be valuable. All this has been detailed by the WG in the report.
2) *Analysis of natural tags to evaluate the hypothesis that red hake move from the Gulf of Maine (northern stock area) to Georges Bank (southern stock area) to spawn*: The working group proposed the use of meristics and further length-at-age analyses as a high priority to conduct new activities. I agree that this is of low cost, but the priority could be lower compared to other recommendations. I would also recommend considering parasites as a possible additional natural tag or provide more clarification on the additional meristic studies to be performed. In the case of length-at-age, previous analyses developed in ToR 2 might be revisited once the mis-identification problem between red and white hake is solved.
3) *Otolith microchemistry:* Additional analyses of otolith microchemistry would be needed as they were only developed using samples collected in one year. However, the WG considered that otolith microchemistry analyses would be of medium priority, expensive and a time-intensive option to be applied. In addition, such a study can provide important information on lifetime movements, and this method has been successfully applied in other species in this area. The available results based on one year did not show spatial differences. However, additional work is needed to reveal whether the results are the consequence of complex stock mixing or a low capacity of the technique to discriminate.

   In this context, I would recommend conducting further otolith microchemistry studies and recommend the following: i) sampling in more than one year and a more complete geographical cover, including samples in the Scotian Shelf, ii) obtain samples of other life stages such as larvae and young-of-the-year, so signals from the core and edge of otoliths could be compared across ontogeny, and iii) combine results of microchemistry with oxygen stable analyses that could better detect thermal differences between areas.
4) *Tagging study:* A tagging study was considered to not be practical due to the well-founded rebuttals, with which I agree.
5) *Continue aging of red hake samples.* It was recommended as a high priority to track the temporal changes in growth observed in the last period, which would contribute to the development of an age-structured assessment. I would add here the need to resolve the aforementioned mis-identification issue between red hake and white hake. The WG qualified the priority as medium, while I would prioritize as high.
6) *Explore age-structured assessment:* The WG proposes moving forward in this direction while it stresses the need for a full-time stock assessment scientist. However, while I agree with the WG that moving forward on an age-structured assessment in the short-term could be of medium priority, I do think that population simulation modeling studies to investigate the likelihood of a more complex and heterogenous population structure

is needed (see below). In this context, I would like to add the following recommendations: i) data quality requirements must be considered (particularly in the light of the discussion under ToR 5) to ensure data from each stock is model-resistant; ii) simulation testing should be considered to explore and assess the likelihood of alternative stock structure hypotheses (complex or heterogeneous) as it has been shown to be effective in other stocks in the same area (Cadrin et al. 2019) and other areas (Goethel and Berger 2017, Jardim et al. 2018), and finally, iii) further research is needed to investigate the scale-dependence of the environmental drivers shaping recruitment success in the northern and southern stocks to reveal whether the environmental influence is spatially structured; this will help to understand the ecological complexity of the stock dynamics.

General recommendations:

All the general recommendations proposed are pertinent and appropriate, and I do support them. These include: *i)* a broad application of the catchability estimation approach to other species as well as incorporating them into stock assessment methods; *ii)* extend the holistic approach to investigating the stock structure of other species; and *iii)* maintaining ichthyoplankton monitoring, to which I would add maintaining the time for ship availability of trawl surveys to ensure an efficient sampling of data-poor species.

Acknowledgments

I would like to thank the entire team of the Population Dynamics Branch at the Northeast Fisheries Science Center, especially Michele Traver, Dr. Jim Weinberg, Dr. Russell Brown and Dr. Michael Simpkins for facilitating and providing support during the review process. I also would like to thank all the Working Group members, particularly those presenting the work, with special thanks to Dr. David Richardson, for their informative presentations and for providing helpful responses to the questions of the SARC review panel. Many thanks also to the other scientists that participated at the meeting and contributed to the discussions. Last, but not least, special thanks to other members of the SARC review panel, Drs. Haritz Arrizabalaga, and Christophe Pampoulie, as well as to the panel chair (Dr. John Wiedenmann) for the fruitful and productive discussions.

References

Berger, A. M., Goethel, D. R., Lynch, P. D., Quinn, T., Mormede, S., McKenzie, J., & Dunn, A. (2017). Space oddity: the mission for spatial integration. Canadian Journal of Fisheries and Aquatic Sciences, 74(11): 1698-1716.

Cadrin SX, Kerr LA, Mariani S. (eds) 2014. Stock identification methods: Applications in Fishery Science-Second Edition. Elsevier, Amsterdam 589 pages.

Cadrin, S. X., Goethel, D. R., Morse, M. R., Fay, G., & Kerr, L. A. (2019). " So, where do you come from?" The impact of assumed spatial population structure on estimates of recruitment. Fisheries Research, 217: 156-168.

Cope JM & Punt AE. 2009. Drawing the lines: resolving fishery management units with simple fisheries data. Canadian Journal of Fisheries and Aquatic Sciences, 66: 1256-1273.

Derry DM. 1988. Red Hake. pp: 49-57 In: Penttila J, Dery LM (Eds) Age determination methods for Northwest Atlantic Species. NOAA Technical Report NMFS 72J.

Friedland KD, Langdon JA, Large SI, Selden RL, Link JS, Watson RA & Collie JS. 2020. Changes in higher trophic level productivity, diversity and niche space in a rapidly warming continental shelf ecosystem. Science of Total Environment, 704: 135270.

Jardim, E., Eero, M., Silva, A., Ulrich, C., Pawlowski, L., Holmes, S. J. & Citores, L. (2018). Testing spatial heterogeneity with stock assessment models. PloS one, 13(1).

Kleisner KM, Fogarty MJ, McGee S, Barnett A, Fratantoni P, Greene J, Hare JA, Lucey SM, McGuire C, Odell J, Saba VS, Smith L, Weaver KJ & Pinsky ML. (2016). The effects of sub-regional climate velocity on the distribution and spatial extent of marine species assemblages. Plos One, 11(2).

Northeast Fisheries Center (NEFC). 1986. Report of the eleventh NEFC stock assessment workshop, Fall 1990. NEFC Wood Hole Lab. Ref. Doc. 90-09.

Nye JA, Link JS, Hare JA & Overholtz WJ. (2009) Changing spatial distribution of fish stocks in relation to climate and population size on the Northeast United States continental shelf. Marine Ecology Progress Series 393: 111–129.

Miller TJ & Rago PJ. (2012). Empirical exploration of feasible bounds on butterfish stock size and fishing mortality rates, 1975-2011. Report to the Mid-Atlantic Fishery Management Council Scientific and Statistical Committee, May 2, 2012.

Miller TJ. (2013). A comparison of hierarchical models for relative catch efficiency based on paired-gear data for U.S. Northwest Atlantic fish stocks. Can. J. Fish. Aquat. Sci. 70(9): 1306-1316.

Steimle FW, Morse WW, Berrien PL and Johnson DL. (1999). Essential fish habitat source Document: Red Hake, Urophycis chuss, life history and habitat characteristics. NOAA Technical Memorandum NMFS-NE-133.

Appendix 1

Citations/Materials provided during the Red Hake Peer Review meeting

1. SARC Working Group Papers and documents.

DRAFT REPORT. Red Hake Stock Structure Working Group. By the Northeast Fisheries Science Center, 11 February 2019.

Appendix 1. Informing spatial structure of red hake (Urophycis chuss) stocks and the fleetsthat fish for them. Authors: Andrew Jones 1,2, Anna Mercer 2, David Richardson 2.

Appendix 2. Application of the management unit estimator to red hake trawl survey data. David Richardson.

Appendix 3. What size at age says about red hake stock structure. Richard S. McBride, Woods Hole Laboratory, NOAA Fisheries. DRAFT, not for wide distribution, 2 January 2020.

Appendix 4. An empirical approach to assessing northern and southern red hake. Timothy J. Miller.

Figures_RedHakeSSWG_11February2020.docx

Tables_RedHakeSSWG_11February2020.docx

Text_FinalReport_Red Hake. SSWG. 11February2020.docx

Red Hake Stock Structure Research Track Terms of Reference (v. 2/27/2020)

Red Hake Stock Structure Research Track Assessment Peer Review Meeting. Clark Conference Room, NEFSC, Woods Hole, MA. March 9-12, 2020. Meeting Agenda.

Various ppt Powerpoint presentations, covering each WG TOR for this meeting.

2. Background material provided.

Northeast Fisheries Science Center. 2011. 51st Northeast Regional Stock Assessment Workshop (51st SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 11-02; 856 p.

Application of An Index Method (AIM) to Data Rich Situations: Can Simple Methods Capture Major Features of Complex Assessments? Paul J. Rago and Christopher M. Legault.

SARC 54 PANEL SUMMARY REPORT. 54th Northeast Regional Stock Assessment Workshop (SAW 54) Stock Assessment Review Committee (SARC) Meeting 5 - 9 June 2012 Northeast Fisheries Science Center Woods Hole, Mass.

Northeast Fisheries Science Center Reference Document 11-01. 51st Northeast Regional Stock Assessment Workshop (51st SAW): Assessment Summary Report (2nd Edition). Aug. 2011.

Northeast Fisheries Science Center Reference Document 12-18. 54th Northeast Regional Stock Assessment Workshop (54th SAW) Assessment Report. Dec. 2012.

Northeast Fisheries Science Center Reference Document 18-02. 2017 Northern and Southern Silver Hake and Red Hake Stock Assessment Update Report. by Larry Alade and Michele Traver.

Appendix 2

Performance Work Statement

Performance Work Statement (PWS)
National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Center for Independent Experts (CIE) Program
External Independent Peer Review

Red Hake Stock Structure Research Track

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards[2]. Further information on the Center for Independent Experts (CIE) program may be obtained from www.ciereviews.org.

Scope

The Northeast Regional Stock Assessment Review Committee (SARC) meeting is a formal, multiple-day meeting of stock assessment experts who serve as a panel to peer-review tabled stock assessments and models. The SARC peer review is the cornerstone of the Northeast Stock Assessment Workshop (SAW) process, which includes assessment development, and report preparation (which is done by SAW Working Groups or Atlantic States Marine Fisheries Commission (ASMFC) technical committees), assessment peer review (by the SARC), public presentations, and document publication. This review determines whether or not the scientific assessments are adequate to serve as a basis for developing fishery management advice. Results

[2] http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf

provide the scientific basis for fisheries within the jurisdiction of NOAA's Greater Atlantic Regional Fisheries Office (GARFO).

The purpose of this meeting will be to provide an external peer review of red hake stock structure. The requirements for the peer review follow. This Performance Work Statement (PWS) also includes: **Appendix 1**: TORs for the research track, which are the responsibility of the analysts; **Appendix 2:** a draft meeting agenda; **Appendix 3:** Individual Independent Review Report Requirements; and **Appendix 4:** Peer Reviewer Summary Report Requirements.

Requirements

NMFS requires three reviewers under this contract (i.e. subject to CIE standards for reviewers) to participate in the panel review. The chair, who is in addition to the three reviewers, will be provided by either the New England or Mid-Atlantic Fishery Management Council's Science and Statistical Committee; although the chair will be participating in this review, the chair's participation (i.e. labor and travel) is not covered by this contract.

Each reviewer will write an individual review report in accordance with the PWS, OMB Guidelines, and the TORs below. All TORs must be addressed in each reviewer's report. No more than one of the reviewers selected for this review is permitted to have served on a SARC panel that reviewed this same species in the past. The reviewers shall have working knowledge and recent experience in the evaluation of biological and ecological data commonly used in stock delineation for marine fishes including but not limited to life history traits, morphometric data, seasonal and spawning distribution data, otolith microchemistry data, and genetics. In addition, knowledge and experience with data limited assessment and population dynamics would be valuable.

Tasks for Reviewers

- Review the background materials and reports prior to the review meeting
    - Two weeks before the peer review, the Assessment Process Lead will electronically disseminate all necessary background information and reports to the CIE reviewers for the peer review.
- Attend and participate in the panel review meeting
    - The meeting will consist of presentations by NOAA and other scientists, stock assessment authors and others to facilitate the review, to provide any additional information required by the reviewers, and to answer any questions from reviewers
- Reviewers shall conduct an independent peer review in accordance with the requirements specified in this PWS and TORs, in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus.
- Each reviewer shall assist the SARC Chair with contributions to the Peer Reviewer Summary Report
- Deliver individual Independent Reviewer Reports to the Government according to the specified milestone dates
- This report should explain whether each research track Term of Reference was or was not completed successfully during the SARC meeting, using the criteria specified below in the "Tasks for SARC panel."

- If any existing Biological Reference Points (BRP) or their proxies are considered inappropriate, the Independent Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRPs are the best available at this time.
- During the meeting, additional questions that were not in the Terms of Reference but that are directly related to the assessments and research topics may be raised. Comments on these questions should be included in a separate section at the end of the Independent Report produced by each reviewer.
- The Independent Report can also be used to provide greater detail than the Peer Reviewer Summary Report on specific stock assessment Terms of Reference or on additional questions raised during the meeting.

Tasks for Review panel

- During the SARC meeting, the panel is to determine whether each research track Term of Reference (TOR) was or was not completed successfully. To make this determination, panelists should consider whether the work provides a scientifically credible basis for developing fishery management advice. Criteria to consider include: whether the data were adequate and used properly, the analyses and models were carried out correctly, and the conclusions are correct/reasonable. If alternative assessment models and model assumptions are presented, evaluate their strengths and weaknesses and then recommend which, if any, scientific approach should be adopted. Where possible, the SARC chair shall identify or facilitate agreement among the reviewers for each research track TOR.
- If the panel rejects any of the current BRP or BRP proxies (for B_{MSY} and F_{MSY} and MSY), the panel should explain why those particular BRPs or proxies are not suitable, and the panel should recommend suitable alternatives. If such alternatives cannot be identified, then the panel should indicate that the existing BRPs or BRP proxies are the best available at this time.
- Each reviewer shall complete the tasks in accordance with the PWS and Schedule of Milestones and Deliverables below.

Tasks for SARC chair and reviewers combined:

Review the Report of the Red Hake Stock Structure Working Group.

The SARC Chair, with the assistance from the reviewers, will write the Peer Reviewer Summary Report. Each reviewer and the chair will discuss whether they hold similar views on each research track Term of Reference and whether their opinions can be summarized into a single conclusion for all or only for some of the Terms of Reference of the SAW. For terms where a similar view can be reached, the Peer Reviewer Summary Report will contain a summary of such opinions. In cases where multiple and/or differing views exist on a given Term of Reference, the Peer Reviewer Summary Report will note that there is no agreement and will specify - in a summary manner – what the different opinions are and the reason(s) for the difference in opinions.

The chair's objective during this Peer Reviewer Summary Report development process will be to identify or facilitate the finding of an agreement rather than forcing the panel to reach an agreement. The chair will take the lead in editing and completing this report. The chair may express the chair's opinion on each research track Term of Reference, either as part of the group

opinion, or as a separate minority opinion. The Peer Reviewer Summary Report will not be submitted, reviewed, or approved by the Contractor.

If any existing Biological Reference Points (BRP) or BRP proxies are considered inappropriate, the Peer Reviewer Summary Report should include recommendations and justification for suitable alternatives. If such alternatives cannot be identified, then the report should indicate that the existing BRP proxies are the best available at this time.

Foreign National Security Clearance
When reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, country of birth, country of citizenship, country of permanent residence, country of current residence, dual citizenship (yes, no), passport number, country of passport, travel dates.) to the NEFSC Assessment Process Lead for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/ and http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance
The place of performance shall be at the contractor's facilities, and at the Northeast Fisheries Science Center in Woods Hole, Massachusetts.

Period of Performance
The period of performance shall be from the time of award through April 30, 2020. Each reviewer's duties shall not exceed **14** days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Schedule	**Deliverables and Milestones**
Within 2 weeks of award	Contractor selects and confirms reviewers
Approximately 2 weeks later	Contractor provides the pre-review documents to the reviewers

March 9-12, 2019	Panel review meeting
Approximately 2 weeks later	Contractor receives draft reports
Within 2 weeks of receiving draft reports	Contractor submits final reports to the Government

* The Peer Reviewer Summary Report will not be submitted to, reviewed, or approved by the Contractor.

Applicable Performance Standards
The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content (2) The reports shall address each TOR as specified (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel
All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $15,000.

Restricted or Limited Use of Data

The contractors may be required to sign and adhere to a non-disclosure agreement.

NMFS Project Contact
Michele Traver, NEFSC Acting Assessment Process Lead
Northeast Fisheries Science Center
166 Water Street, Woods Hole, MA 02543
Michele.Traver@noaa.gov Phone: 508-495-2195

Appendix 2.1. Red Hake Stock Structure Research Track Terms of Reference

1. Review and summarize all relevant literature on the existing stock structure of red hake in the northwest Atlantic.

2. Identify and evaluate any new and/or existing data relevant to the stock structure of red hake including but not limited to the species' life history (i.e. spawning, distribution, abundance, growth, maturity and natural mortality), morphometrics, and genetics.

3. Recommend the most likely biological stock structure among a set of alternatives from TOR2. Consider the current management unit as null hypothesis.

4. Evaluate existing experimental data on survey catchability of red hake. Examine the sufficiency of catchability data and, if appropriate, incorporate the catchability estimates into the assessment.

5. Apply the existing assessment model framework to the stock structure based on TOR 3 and 4 to ensure its utility in subsequent management track assessments. Evaluate existing reference points. Consider alternate assessment approaches if existing model framework does not perform well, and consider alternate reference points as needed.

6. Identify gaps in the existing research with respect to red hake stock structure. Develop a prioritized list of research recommendations to address these gaps. Comment on the feasibility and time horizon of the proposed research recommendations.

SAW Research Track TORs:

General Clarification of Terms that may be used in the Research Track Terms of Reference

Guidance to SAW Research Track Working Group about "Number of Models to include in the Peer Reviewer Report":

> In general, for any TOR in which one or more models are explored by the Working Group, give a detailed presentation of the "best" model, including inputs, outputs, diagnostics of model adequacy, and sensitivity analyses that evaluate robustness of model results to the assumptions. In less detail, describe other models that were evaluated by the Working Group and explain their strengths, weaknesses and results in relation to the "best" model. If selection of a "best" model is not possible, present alternative models in detail, and summarize the relative utility each model, including a comparison of results. It should be highlighted whether any models represent a minority opinion.

On "Acceptable Biological Catch" (DOC Nat. Stand. Guidelines. Fed. Reg., v. 74, no. 11, 1-16-2009):

> *Acceptable biological catch (ABC)* is a level of a stock or stock complex's annual catch that accounts for the scientific uncertainty in the estimate of Overfishing Limit (OFL) and any other scientific uncertainty…" *(p. 3208) [In other words, OFL ≥ ABC.]*
>
> *ABC for overfished stocks.* For overfished stocks and stock complexes, a rebuilding ABC must be set to reflect the annual catch that is consistent with the schedule of fishing mortality rates in the rebuilding plan. *(p. 3209)*
>
> NMFS expects that in most cases ABC will be reduced from OFL to reduce the probability that overfishing might occur in a year. (p. 3180)
>
> ABC refers to a level of ''catch'' that is ''acceptable'' given the ''biological'' characteristics of the stock or stock complex. As such, Optimal Yield (OY) does not equate with ABC. The specification of OY is required to consider a variety of factors, including social and economic factors, and the protection of marine ecosystems, which are not part of the ABC concept. (p. 3189)

On "Vulnerability" (DOC Natl. Stand. Guidelines. Fed. Reg., v. 74, no. 11, 1-16-2009):

> *"Vulnerability.* A stock's vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce Maximum Sustainable Yield (MSY) and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g., loss of habitat quality)." (p. 3205)

Participation among members of a Research Track Working Group:

Anyone participating in SAW meetings that will be running or presenting results from an assessment model is expected to supply the source code, a compiled executable, an input file with the proposed configuration, and a detailed model description in advance of the model meeting. Source code for NOAA Toolbox programs is available on request. These measures allow transparency and a fair evaluation of differences that emerge between models.

Appendix 2..2. Draft Review Meeting Agenda

Red Hake Stock Structure Research Track Assessment

March 9-12, 2020

Stephen H. Clark Conference Room – Northeast Fisheries Science Center
Woods Hole, Massachusetts

DRAFT AGENDA* (version: December 3, 2019)

**All times are approximate, and may be changed at the discretion of the SARC chair. The meeting is open to the public; however, during the Report Writing sessions we ask that the public refrain from engaging in discussion with the SARC.*

Monday, March 9th, 2020

Time	Topic	Presenter(s)	Rapporteur
1:00 – 1:30pm	Welcome/Description of Review Process Introductions/Agenda/Conduct of Meeting	Michele Traver, Acting Assessment Lead TBD, Chair	
1:30 – 2:30pm	Review of Current Assessment and Historical Designations (TOR #1)	Toni Chute Dave Richardson, WG Chair	TBD
2:30 – 3:30pm	New Data and Analyses (TOR #2)	Dave Richardson, WG Chair	TBD
3:30 – 3:45pm	Break		
3:45 – 5:00pm	New Data and Analyses (TOR #2) cont.	Dave Richardson, WG Chair	TBD
5:00 – 5:30pm	Discussion/Review/Summary	Panel	TBD
5:30 – 5:45pm	Public Comment	Public	TBD
5:45pm	Adjourn		

Tuesday, March 10th, 2020

Time	Topic	Presenter(s)	Rapporteur
8:30 – 8:45am	Welcome/Logistics	Michele Traver, Acting Assessment Lead TBD, Chair	
8:45 – 10:45am	New Data and Analyses (TOR #2) cont.	Dave Richardson, WG Chair	TBD
10:45 – 11:00am	Break		
11:00 – 12:30pm	Catchability (TOR #4)	Dave Richardson, WG Chair	TBD

12:30 – 1:30pm	Lunch		
1:30 – 3:30pm	Stock Structure Proposals (TOR #3)	Dave Richardson, WG Chair	TBD
3:30 – 3:45pm	Break		
3:45 - 5:00pm	Stock Structure Proposals (TOR #3) cont.	Dave Richardson, WG Chair	TBD
5:00 – 5:30pm	Discussion/Review/Summary	Panel	TBD
5:30 – 5:45pm	Public Comment	Public	TBD
5:45pm	Adjourn		
7:00pm	Dinner Social		

Wednesday, March 11th, 2020

Time	**Topic**	**Presenter(s)**	**Rapporteur**
8:30 – 8:45am	Welcome/Logistics	Michele Traver, Acting Assessment Lead TBD, Chair	
8:45 – 10:45am	Model Proposals (TOR #5)	Dave Richardson, WG Chair	TBD
10:45 – 11:00am	Break		
11:00 – 12:00pm	Research Recommendations (TOR #6)	Dave Richardson, WG Chair	TBD
12:00 – 12:30pm	Discussion/Review/Summary	Panel	TBD
12:30 – 12:45pm	Public Comment	Public	TBD
12:45 – 1:45pm	Lunch		
1:45 - 5:00pm	Peer Reviewer Summary Report Writing	Panel	
5:00pm	Adjourn		

Thursday, March 12th, 2020

Time	**Topic**	**Presenter(s)**	**Rapporteur**
9:00 – 5:00pm	Report Writing	Panel	

Appendix 2.3. Individual Independent Peer Reviewer Report Requirements

1. The independent Peer Reviewer report shall be prefaced with an Executive Summary providing a concise summary of whether they accept or reject the work that they reviewed, with an explanation of their decision (strengths, weaknesses of the analyses, etc.).

2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each TOR in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the TORs. The independent report shall be an independent peer review, and shall not simply repeat the contents of the Peer Reviewer Summary Report.

   a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including a concise summary of whether they accept or reject the work that they reviewed, and explain their decisions (strengths, weaknesses of the analyses, etc.), conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each TOR even if these were consistent with those of other panelists, but especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the Peer Reviewer Summary Report that they believe might require further clarification.

   d. The report may include recommendations on how to improve future assessments.

3. The report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of this Performance Work Statement
   Appendix 3: Panel membership or other pertinent information from the panel review meeting.

Appendix 2.4. Peer Reviewer Summary Report Requirements

1. The main body of the report shall consist of an introduction prepared by the SARC chair that will include the background and a review of activities and comments on the appropriateness of the process in reaching the goals of the SARC. Following the introduction, for each assessment /research topic reviewed, the report should address whether or not each Term of Reference of the Research Track Working Group was completed successfully. For each Term of Reference, the Peer Reviewer Summary Report should state why that Term of Reference was or was not completed successfully.

   To make this determination, the SARC chair and reviewers should consider whether or not the work provides a scientifically credible basis for developing fishery management advice. If the reviewers and SARC chair do not reach an agreement on a Term of Reference, the report should explain why. It is permissible to express majority as well as minority opinions.

   The report may include recommendations on how to improve future assessments.

2. If any existing Biological Reference Points (BRPs) or BRP proxies are considered inappropriate, include recommendations and justification for alternatives. If such alternatives cannot be identified, then indicate that the existing BRPs or BRP proxies are the best available at this time.

3. The report shall also include the bibliography of all materials provided during the SAW, and relevant papers cited in the Peer Reviewer Summary Report, along with a copy of the CIE Performance Work Statement.

   The report shall also include as a separate appendix the assessment Terms of Reference used for the SAW, including any changes to the Terms of Reference or specific topics/issues directly related to the assessments and requiring Panel advice.

Appendix 3

Panel membership

SARC and CIE Reviewers

John Wiedenmann
Haritz Arrizabalaga
Christophe Pampoulie
Manuel Hidalgo

Presenters of the Red Hake Stock Structure Research Track

David Richardson (WG Chair)
Steve Cadrin (SMAST)
Timothy Miller (NEFSC)
Richard McBride (NEFSC)
Toni Chute (NEFSC)
Larry Alade (NEFSC)

Other participants and their affiliation (provided by NEFSC)

Jim Weinberg (SAW chair, NEFSC)
Russell Brown (Head of Population Dynamics Branch, NEFSC)
Michele Traver (Assessment process lead, NEFSC)
Michael Simpkins (Chief of the Resource Evaluation and Assessment Division, NEFSC)
Charles Perretti (Rapporteur, NEFSC)
Alicia Miller (Rapporteur, NEFSC)
Brian Linton (Rapporteur, NEFSC)
Jon Deroba (Rapporteur, NEFSC)
Mark Terceiro (NEFSC)
Kathy Sosebee (NEFSC)
Andy Beet (NEFSC)
Katie Marancik (NEFSC)
Brian Linton (NEFSC)
Andy Applegate (NEFMC)
Ariele Baker (NEFSC)
Andrew Jones (NEFSC)
Gary Shepherd (NEFSC)

Jennifer Couture (NEFMC)
Chris Legault (NEFMC)
Nicole Lengyel Costa (RI DFW)