Summary Report of the Stock Assessment Review Committee (SARC) meeting of the Research Track Assessment for Red Hake Stock Structure

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

Report prepared by SARC members:
John Wiedenmann (Chair)
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1. Introduction

The Red Hake Stock Structure Research Track SARC (Stock Assessment Review Committee) met in the Aquarium Conference Room at NOAA's Northeast Fisheries Science Center in Woods Hole, MA during March 9 – 12th, 2020. The review committee was composed of three scientists appointed by the Center for Independent Experts (CIE): Manuel Hidalgo, Haritz Arrizabalaga, and Christophe Pampoulie, and was chaired by John Wiedenmann as a member of the New England Fisheries Management Council Scientific and Statistical Committee. The SARC was assisted by the NEFSC Stock Assessment Workshop (SAW) Chairman, James Weinberg, Michele Traver, and Russ Brown. Documentation was prepared by the red hake Working Group (WG), and presentations were made primarily by the chair of the working group David Richardson (NEFSC), but other working group members and others involved in the process presented material and contributed substantially to the discussions on various topics, including Steve Cadrin (U.Mass Dartmouth), Tim Miller (NEFSC), Rich McBride (NEFSC), Larry Alade (NEFSC), Toni Chute (NEFSC), and Kathy Sosebee (NEFSC). Alicia Miller, Jon Deroba, Brian Linton, and Charles Peretti from the NEFSC acted as rapporteurs throughout the meeting.

A couple weeks prior to the meeting, assessment documents were made available to the SARC Panel through a repository on the NEFSC website. The SARC Panel met with James Weinberg, Michelle Traver and Russell Brown (NEFSC) to review and discuss the meeting agenda, reporting requirements, meeting logistics and the overall process. The meeting opened on the afternoon of Monday March 9, with welcoming remarks and comments on the agenda by Russ Brown, Michelle Traver, and SARC Panel chair John Wiedenmann, followed by introductions of the SARC, WG members and audience members. The first two days were devoted to going through Terms of Reference (TOR) 1-6. The first half of day three was devoted to continued clarification and discussion of TOR 5. The remainder of the meeting was devoted to discussing how the TOR were met, and to drafting the SARC panel summary report. The SARC Panel completed drafting the Summary Report by correspondence, evaluating each TOR that had been addressed by the WGs. The SARC Chair compiled and edited the draft Panel Summary Report with assistance from the CIE Panelists before being submitted to the NEFSC. Additionally, each of the CIE Panelists drafted and submitted an independent reviewer's report to the Center for Independent Experts.

The SARC Panel agreed that scientific and statistical analyses conducted by the Working Group were thorough and of high quality. A number of analyses were conducted to determine the stock structure of red hake, and although different analyses suggested different stock structure (i.e. one complex stock), the SARC Panel agreed with the WG conclusion that there was not sufficient evidence to deviate from the current two stock delineation of separate north and south stocks. The WG also calculated swept-area biomass and biological reference points (BRPs) for each stock. The SARC Panel agreed that the swept-area biomass estimates were robust, and could be useful for setting catch advice. However, the SARC Panel agreed that the BRPs, while scientifically well thought out, should not be used for management purposes yet.

The SARC Panel's views regarding the strengths and concerns for each TOR are discussed below.

2. Evaluation of the Terms of Reference for Red Hake

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

The SARC panel agrees that this TOR has been met. The WG effectively summarized the existing work that formed the basis for the previous three stocks and current designation of two stocks (north and south) for red hake, which was based on a combination of distribution in the bottom trawl survey, differences in phenology, growth, and meristics between regions as well as fishery dynamics. The WG noted that no studies on genetic structure or tagging of the stocks have been done. The WG also provided additional background information on red hake biology and history of the fishery, which the SARC Panel found very useful.

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.

The SARC Panel agrees that this TOR has been met. The WG compiled all available information on red hake and conducted a variety of analyses on the data, where possible, to make inferences on the stock structure of red hake. The WG explored distributions of fishery-dependent and fishery-independent data from the NEFSC bottom trawl survey, growth information (also from the survey), spawning and larval information from ichthyoplankton surveys and from oceanographic models, and a previous study on otolith microchemistry. Summaries for each category are detailed below.

Fishery Dependent Data

Fishery dependent data included a variety of sources, including the observer program, study fleet data, and reported landings data. In general across datasets, the data showed spatial discontinuities between north and south, based on the limited crossover of vessels landing red hake from the two stocks. The WG suggested that this pattern could support a two-stock structure. The SARC Panel agreed on the specific findings and the potentially valuable information provided by the fisheries-dependent data, but noted that other factors could explain the observed patterns. For example, the spatial distributions could be influenced by the individual fisheries and the species-specific dynamics of the target species. Also, misidentification between red and white hake could impact the patterns observed in the fishery-dependent data.

Fishery-Independent Bottom Trawl Survey Data

The WG evaluated the spatial distribution in the NEFSC bottom trawl survey. This included the 50+ years in the spring and fall survey, as well as the shorter duration summer and winter surveys. Spatial distribution in the spring and fall surveys showed separation between north and south areas, similar to the fishery data, and the WG suggested that this further supports a two stock structure.

Annual trends in survey abundance indicate opposing trends by stock, with increases over time for the northern stock, and decreases for the southern stock. The SARC Panel noted that this could reflect different stock productivity dynamics in each region, but it could also result from a single stock with increased movement from the southern area into the northern area over time. The WG also explored the Management Unit Estimator of Cope and Punt (2009, Can. J. Fish. Aquat. Sci. 66:1256-1273), which uses survey data at a finer spatial scale and aggregates spatial units into stock areas based on similarity in trends in abundance in each area. This analysis generally showed support for two stocks separated by the current stock boundary. However, the SARC panel noted that this analysis could not be conducted for one stock.

Growth

The WG presented length-at-age data originating from the NEFSC spring and fall trawl surveys. Ageing data were not continuous over time, with early data collected from 1970 to 1985 and a more recent period from 2008-2018. Despite the time series gap, the WG presented evidence of differences among the southern and northern stocks median lengths-at-age, which seemed to be persistent over time. It was further suggested that these differences were more pronounced in the earlier period. The analyses were suggested to reveal three specific findings within the period investigated, 1) female grow larger than males, 2) at ages greater than 3 years old the fish in the northern stock reach a longer length-at-age than fish in the southern stock, 3) size distributions have shifted over the decades in both stocks leading to reduced length-at-age. Although the SARC Panel agreed on the specific findings, there were some concerns about the possible reasons behind such results.

- Misidentification between red and white hake could potentially bias results, especially since the misidentification seemed to be more pronounced in the early-period data.
- The SARC Panel noted that the differences in length-at-age presented in Figure 2.23 might not support strong differences in growth between the north and the south for the period 2009-2019. It was noted that the differences were not statistically tested and the SARC Panel suggested fitting growth models (Von Bertalanffy,

Gompertz, etc.) to these data to quantify geographical differences in model parameters for both periods.

- The SARC Panel also noted that the reduced differences in length-at-age between stocks in recent years could be related to: a) improved identification of red versus white hake in the recent years, b) increased migration of the smaller, southern stock fish into the northern area, or c) density-dependent growth in both areas due to declines and increases in abundance in southern and northern areas, respectively.

Larvae and Young-of Year

The WG presented results from mainly two larval sampling programs (ECOMON and MARMAP surveys). Identification of red hake larvae has historically been an issue, but has largely been improved based on recent work. The WG used a subset of 6 years from 1985 to 2013 with accurate species identification for their analyses. Most of the larvae were observed in Georges Bank (GB) and Southern New England (SNE), primarily in the southern stock area, but some larvae are also found in more recent years in the northern stock area in the Gulf of Maine (GOM). It was noted that limited shifts in distribution over time were observed, contrasting with the distribution shifts observed for larger red hake in trawl surveys. Larval transport and drifter models were explored to assess potential larval sources (i.e., spawning locations) in different regions, though it was acknowledged that these models ignore larval behavior that could impact the connectivity results.

Smaller young-of-the-year (YOY) collected in the fall bottom trawl survey were largely found around GB, mostly in northern and western areas. Interestingly, larger YOY were more abundant in deeper areas of the GOM, north of GB, suggesting a potential migration of YOY born in GB to overwintering areas in GOM.

Based on these findings, the WG presented a potential conceptual model where adults from the northern stock would perform a spawning migration to GB spawning areas. Larvae would be drifted/transported to shallow areas of GB and then YOY would perform the overwintering migration to the GOM. This conceptual model could support the single stock hypothesis, but could also support multiple stocks with a main shared spawning ground on GB. The SARC Panel noted that there was no evidence of site fidelity to northern and southern feeding areas for individuals sharing spawning grounds on GB, and that such information could help to discriminate between the two hypotheses.

Otolith microchemistry

The WG presented results for an unpublished, one-year study on otolith microchemistry (ratios of Sr/Ca, Ba/Ca, Mg/Ca, Mn/Ca in the core and edge) conducted in fall 2011 analyzing 20 samples in four regions in the GOM and

Mid-Atlantic Bight (MAB). This work showed no differences in ratios in neither the core nor edge of the otoliths between areas, suggesting that early life stages were exposed to the same environment. This result supports the suggested primary spawning area in GB, but the lack of difference in the edge of the otolith was unexpected. The WG found the information valuable but recommended caution in the interpretation of the results, as they noted a similar study on Atlantic cod in the GOM revealed clear spatial differences in otolith microchemistry. The SARC Panel agrees with the current interpretation of these results, but noted that further research was needed applying this technique across more years, areas (including Scotian Shelf samples) and combining information on oxygen stable isotopes that more closely track expected differences in temperature experienced on the putative two stocks.

AIM model comparison

The WG used the AIM (An Index Method) model to provide insights on stock structure. If the appropriate stock structure is chosen and if exploitation rates are driving population trends, then the relationship between relative *F* and changes in the survey index in AIM model should be significant. The WG tested multiple alternative stock structures, including one, two, and three stock hypotheses. None of the models were significant, thus this approach did not provide useful insights into stock structure. The absence of significance might suggest that fishing mortality is currently not driving abundance of red hake, which could also be due to changes in productivity or migration that lead to a disconnection between relative *F* and changes in the index of abundance.

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

The WG concluded that there is not enough evidence to reject the null hypothesis of a two stock structure. The SARC Panel agrees with their conclusion and agrees that the TOR has been met. The WG provided a summary table in a presentation of the various lines of evidence, and whether they suggested 1, 2 or more potential stocks. There were a number of lines of evidence that suggested 2 stocks, while others suggested one stock. While this ambiguity does not resolve the question about stock structure, there is not sufficient evidence to reject the current management units. The WG also concluded that even if red hake were a single biological population, maintenance of the two stock structure was still practical from an assessment and management perspective mostly due to differences in phenotypic traits (growth) and population temporal trends differences at each stock.

Papers	Findings	1/2/?
Fisheries dependent data	Catch is discontinuous across Georges Bank Mostly a unique set of vessels working in each region Catch trends consistent with two stock	2
Trawl survey distributions	Mostly discontinuous distribtuion that is shifting northward; habitt also shifting	
Trawl size structure	Different size structure in subregions (thought GB-A and GOM-D intermediate); Consisten size truncation everywhere through time	2 or Gradation?
K-mediods clustering	Moderate support for current two stocks in most clustering; strongest in the fall.	2 or 3 …
Growth	Differencs in growth between current stocks. Growth also chaning through time.	2
Meristics and otolith morphology	Meristics differ between regions: Otoliths in norther are checkier and more difficult to read	2
Spawning seasonality	Later spawning in SNE	
Larval Connectivity	GB->SNE connections, GB-A to GOM-D connections across stock boundary; limited connetions GOM A-c to GB	<=2
Larval Distribution	SNE and GB consistenlty highest abundance; fewer in GOM	1
Young of the Year fall	Georges Bank (GOM-D and GB-B) except since 2013	1
Otolith Microchemistry	Consisten with one stock	1
AIM models	No significant runs	No insights

Although the SARC Panel agreed with the overall WG conclusion with respect to this TOR, there were some instances where the Panel felt the interpretation of some of the evidence in support of two stocks could also not rule out the potential for a single stock, and vice-versa. We detailed some of these examples in response to the individual data categories in response to TOR 2.

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.
The SARC Panel agrees that this TOR has been met. The WG utilized data collected in the chain sweep catchability study performed by the Northeast Fisheries Science Center. This study used paired trawls on a single vessel, with one trawl using the existing bottom trawl survey net, and the other net with a chain sweep at the bottom to more effectively sample benthic fish. By assuming 100% catchability in the chain sweep net, length- and species-specific conversion factors were calculated to convert trawl survey catches to absolute numbers. The chain sweep study was previously peer-reviewed and the conversion factors have been used to calculate total annual swept-area biomass for a number of flatfish stocks in the region. The WG argued that red hake were closely associated with the bottom based on a number of lines of evidence, and the SARC Panel agreed that the conversion factors could be used for red hake, and that the swept-area biomass estimates were robust, and could be useful for setting catch advice.
The WG also used habitat camera (HABCAM) images from a scallop survey to enumerate red hake abundance, and compared it with bottom trawl survey estimates to obtain conversion factors for red hake. The WG noted that this analysis was more

exploratory in nature, and not intended for use in the assessment. The SARC Panel agreed with the WG, and found it comforting that the conversion factors from the HABCAM analysis were similar to those estimated in the chain sweep study.

The WG also presented information from a recent NEFSC net wing spread study aimed at evaluating the impact that the depth of the trawl has on the catchability. This study found little difference in red hake catchability based on the net wing spread, and no further adjustments were made to the catchability estimates. The SARC Panel agreed with this for the time being but supported the WG recommendation to, in future calculations of swept area biomass, explore directly accounting for measured wingspread rather than applying the average wingspread to all tows.

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.

This TOR has been sufficiently met. However, the SARC Panel agrees that the estimated reference points need further evaluation, and should not currently be used for management.

The SARC Panel agrees that the WG adequately explored the existing AIM model framework and evaluated the existing reference points for red hake. The AIM model assumes a relationship between relative F (catch / survey) and changes in the survey index (i.e., catch is driving trends in abundance). Because the WG calculated swept area biomass, they were able to convert relative F into an absolute estimate of F, and in doing so noted that the AIM estimate of F_{MSY} was unreasonably low for both the northern and southern stocks. Moreover, both models were not significant. As a result, the WG concluded the AIM model should not be used for estimating reference points and stock status for red hake, and the SARC Panel agreed with this conclusion.

The WG did consider an alternative method for calculating reference points for red hake, and although the SARC panel agreed that the approach was well thought out and potentially useful in future applications, there was sufficient uncertainty in the sensitivity of the reference point estimates to various assumptions made that the reference point estimates should not be used for management advice for red hake at this time. The WG calculated spawning potential ratio (SPR) reference points for red hake, which is a widely used approach for calculating proxies for the MSY-based reference points. The SPR approach first determines the fishing mortality rate that reduces the SPR to some percentage of an unfished level. For red hake, the WG calculated the F that reduced the SPR to 40% of the unfished level, and used the $F_{40\%}$ as a proxy for F_{MSY}. The resulting $SPR_{40\%}$ is then multiplied by a mean level of recruitment to obtain the spawning biomass proxy ($SSB_{40\%}$) for SSB_{MSY} that becomes the management target (and 50% of $SSB_{40\%}$ becomes the overfished

threshold). The SARC Panel agreed that SPR-based reference points could potentially be suitable for red hake (see below for caveats), and that the 40% proxy level was a reasonable, and commonly used assumption.

The SARC Panel identified some issues with both the *F40%* and *SSB40%* estimates, such that they should not be used for management. First, the estimates of $F_{40\%}$ for both stocks were considerably higher than estimates of *F* since 2009. For the southern stock, which the survey indicates is at a low point relative to historical levels, exploitation rates were between 5-15% of the estimated $F_{40\%}$, yet the stock has not shown signs of increases in abundance. This lack of population growth could result from very low recruitment over the same time period, but could also result from an increase in natural mortality (*M*). The WG assumed M = 0.4 for the SPR calculations, but there is evidence to suggest that *M* could be higher in more recent years. The SARC Panel noted how changes in *M* could make the use of SPR-based reference points problematic, as a higher *M* results in a higher estimated F_{MSY} proxy. However, SPR-based reference points ignore the stock-recruit relationship, and a higher *M* would also result in lower spawning biomass impacting recruitment levels, which may result in a lower estimated F_{MSY}. The SARC Panel referenced the work of Legault and Palmer (2016, Can. J. Fish. Aquat. Sci. 73: 349–357; Dr. Legault of the NEFSC was in attendance and commented on his study), which provides some guidance on the issue of changing *M* and reference points. Because the estimated fishing mortality rates are currently very low in both areas, the Panel notes that a catch curve analysis on the survey data could be used to get an estimate of *M* in recent years.

SPR calculations also require information on the age- or size-based selectivity of the stock in the fishery. The WG assumed knife-edged selectivity, but the SARC Panel felt that exploration of the sensitivity of this assumption on the resulting reference points was warranted.

With an estimate of $SPR_{40\%}$ for each stock, the WG used mean swept-area estimates of recruitment in each area (2009-2019) to calculate the biomass reference point of $SSB_{40\%}$. The SARC Panel expressed concern over the limited number of years being used to calculate the mean recruitment, as that implies that recent recruitments are reflective of current equilibrium levels. The WG noted there was insufficient time to extend the swept area estimates of recruitment to years prior to 2009, but the SARC Panel felt that was not a sufficient justification for using only the most recent 11 years of recruitment estimates to calculate the $SSB_{40\%}$. The SARC Panel recommended expanding the time series of recruitment estimates over longer periods, and evaluating the sensitivity of the $SSB_{40\%}$ estimates to different recruitment time series.

While the SARC Panel agreed that the estimated reference points were not currently suitable for management purposes, there was some agreement amongst the Panel about qualitative statements about stock status. Because exploitation rates are currently very low in both stock areas, the Panel believes that overfishing is not likely occurring on either stock. For the northern stock, recent survey estimates

indicate that the population in recent years is near the highest levels since 1981. Because of this information, combined with very low recent exploitation rates, the SARC Panel agrees that it is unlikely that the northern stock is overfished. In contrast, however, the southern stock survey indices are near the lowest in the time series, but the Panel was not able to conclude whether or not the southern stock was overfished. As noted above, the limited change in the survey trends in recent years for the southern stock despite low exploitation rates suggests the current dynamics in the southern stock are unlikely driven by fishing. The SARC Panel noted similar decoupling between fishing pressure and population trends for other stocks in the region, most notably GB yellowtail flounder and witch flounder. Methods currently used for setting catch advice for these stocks, or other data-limited stocks in the region (e.g., the Plan-B approach) could be explored for both red hake stocks.

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.

The WG provided six recommendations for red hake, and the SARC Panel agrees that this TOR has been met. We provide additional comments below each of the WG recommendations.

Recommendation 1: Implement a population genetics study on the red hake.

The SARC Panel agrees with the WG that the implementation of a genetic study is necessary for red hake. Uncertainties around the stock structure and dynamic of the red hake stock(s) in recent years might be resolved by such an approach. In this context the SARC Panel would like to make some recommendations.

In the view of the complexity of the stock dynamics of red hake, the SARC Panel highly recommend a genomic approach with a potential high number of produced SNPs, both neutral and under selection. The advance in Next Generation Sequencing and Genome approach allow for the genotyping of 1000's of SNPs at a reasonable price. It will also certainly affect the sampling scheme as the number of individuals per samples can be reduced to 40-50 individuals, and therefore might result in the possibility of doubling the sampled locations compared to microsatellite loci (where 100 individuals are needed). One of the reasons to implement a genomic rather than a genetic approach is the increasing number of evidences generated by genomic studies suggesting that "local adaptation" can occur in the face of gene flow and between/within very dynamic stock(s) in few generations (example of cod and herring on both sides of the Atlantic and across the North Atlantic). This would be unlikely to be detected with genetic markers such as microsatellite loci. These local adaptations are often attributed to chromosomal rearrangements leading to "gene-linkage groups" also called

"Genomic Islands of divergence," among which genes are often associated with environmental parameters such as temperature, salinity, and oxygen level. The SARC Panel believes that such an approach will be highly useful in the context of stock structure identification. In addition, if a genetic/genomic structure is detected, this approach could also be useful to assign larvae, juvenile and adults to potential spawning aggregations/stocks.

Recommendation 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 WG proposed the use of meristics and further length at age analyses as a high priority and low cost analyses to conduct new activities. In this context the SARC Panel generally agrees on this proposal while it would like to make some additional remarks. Additional clarification is required on the meristic studies to be performed, particularly on the length-at-age studies that could be repetitive with what is already done and presented in TOR 2. Length-at-age should be revisited once misidentification between red and white hake is revised. The SARC also suggested to consider parasites as a possible additional natural tag, if parasites' life cycle is sufficiently well known.

Recommendation 3: Continue ageing of red hake samples.

The WG agrees the temporal gap in age data should be filled in for red hake, as this will allow for the exploration of an age structured assessment (research recommendation 5) and assess whether spatial changes in growth persist in the future.

Recommendation 4: Otolith microchemistry study on the red hake.

The WG stated that otolith microchemistry analyses would be of medium priority and an expensive and time-intensive option to be applied, noting that it can provide important information on lifetime movements. The SARC Panel notes that otolith microchemistry has been a useful technique applied in other species to discriminate stock structure in the same areas, and the relative cost is not as high compared with other techniques, such as mark-recapture studies. Moreover, otolith chemistry studies can provide very useful complementary information when conducted together with genetic studies. The SARC Panel suggests to further conduct otolith microchemistry studies considering the following issues: 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 of core and edge of otoliths could be compared across ontogeny, iii) combine results of microchemistry with oxygen stable isotope analyses that could better detect thermal differences between stock areas.

Recommendation 5: Explore an age structured assessment for red hake.

The SARC Panel agrees that an age-based assessment would be useful, but cautions that the lack of relationship between relative *F* and changes in the survey index (as observed in the AIM model fitting) since 1981 could result in poor age-based assessment diagnostics. Similar dynamics observed for witch flounder and GB yellowtail flounder likely contributed to strong retrospective patterns, and these age-based assessments were rejected during peer review (i.e., "data rich but model-resistant" stocks). The SARC Panel adds the following recommendations: i) the necessary data requirements should be considered as well as the costs associated with new collection programs or analyses; ii) simulation testing should be considered to understand the impact of different population stock structure dynamics on assessment accuracy (e.g., Cadrin et al. 2019 Fish Res 217:156-168), and iii) investigations of the potential ecosystem drivers of stock productivity (recruitment, growth, and natural mortality) and the spatial scale at which they operate, and whether these drivers can be included within the assessment model fitting.

Recommendation 6: Further document fishermen's ecological knowledge for red hake.

Fishermen knowledge was used at various points by the WG, and the SARC Panel agrees that further collection of knowledge would be a low-cost exercise to increase information about this data-poor stock.

Materials provided during the Red Hake Peer Review meeting:

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.

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 fleets that 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

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

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

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 Wood's Hole, Mass.

Text_FinalReport_Red Hake. SSWG. 11February2020.docx

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.

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.

Appendix 1. Meeting Agenda

Contact: michele.traver@noaa.gov

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

Please call the number below for audio and mute your phone:
Conference Number(s): 877-653-6612
Participant Code: 8116908

To join the meeting:
https://meet.google.com/nor-gysm-vdv
Copy and paste the above link into your web browser.
Enter your name when prompted, then click on "Ask to Join Meeting."
Once you are in, please mute your computer microphone and turn
off your webcam in order to see the presenter's screen.
(v. 03/09/2020)

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, Assessment Lead and Russ Brown, PopDy Branch Chief John Wiedenmann, Chair	Alicia Miller (afternoon session)
1:30 – 2:30pm	Review of Current Assessment and Historical Designations (TOR #1)	Steve Cadrin, WG member Dave Richardson, WG Chair	
2:30 – 3:30pm	New Data and Analyses (TOR #2)	Toni Chute, Lead Analyst Dave Richardson, WG Chair	

3:30 – 3:45pm	Break		
3:45 – 5:00pm	New Data and Analyses (TOR #2) cont.	Toni Chute, Lead Analyst Dave Richardson, WG Chair	
5:00 – 5:30pm	Discussion/Review/Summary	Peer Review Panel	
5:30 – 5:45pm	Public Comment	Public	
5:45pm	Adjourn		

Tuesday, March 10th, 2020

Time	**Topic**	**Presenter(s)**	**Rapporteur**
8:30 – 8:45am	Welcome/Logistics	Michele Traver, Assessment Lead John Wiedenmann, Chair	Jon Deroba (morning session)
8:45 – 10:45am	New Data and Analyses (TOR #2) cont.	Dave Richardson, WG Chair	
10:45 – 11:00am	Break		
11:00 – 12:30pm	Catchability (TOR #4)	Tim Miller	
12:30 – 1:30pm	Lunch		
1:30 – 3:30pm	Stock Structure Proposals (TOR #3)	Steve Cadrin, WG member	Brian Linton (afternoon session)

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

Wednesday, March 11th, 2020

Time	**Topic**	**Presenter(s)**	**Rapporteur**
8:30 – 8:45am	Welcome/Logistics	Michele Traver, Assessment Lead John Wiedenmann, Chair	Charles Perretti (morning session)
8:45 – 10:45am	Model Proposals (TOR #5)	Tim Miller	
10:45 – 11:00am	Break		
11:00 – 12:00pm	Research Recommendations (TOR #6)	Dave Richardson, WG Chair	

12:00 – 12:30pm	Discussion/Review/Summary	Panel	
12:30 – 12:45pm	Public Comment	Public	
12:45 – 1:45pm	Lunch		
1:45 - 5:00pm	Assessment 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. Meeting Attendees

Jim Weinberg
David Richardson
Alicia Miller
Russ Brown
Michele Traver
Charles Perretti
Toni Chute
Larry Alade
Kathy Sosebee
Andy Beet
Katie Marancik
Brian Linton
Mark Terceiro
Richard McBride
Steve Cadrin
Charles Perretti
Jon Deroba
Brian Linton
Andy Applegate
Ariele Baker
Andrew Jones
Jennifer Couture
Nicole Lengyel Costa
Gary Shepherd
Chris Legault
Mike Simpkins